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Prospects of Cooperation in the Eastern Nile Basin

The case of Experimental Game Application

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Mahsa Motlagh

aus
Teheran, Iran

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1. Referent: Prof. Dr. Janos J. Bogardi
2. Korreferent: Prof. Dr. Joachim von Braun
3. Korreferentin: Prof. Dr. Karin Holm-Müller
4. Korreferent: Prof. Dr. Lars Ribbe
5. Korreferent: Dr. Anik Bhaduri

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This dissertation is dedicated to the well-being of people in the Nile Basin.

Abstract

Tensions over the use of Nile waters have recently increased and no comprehensive agreement till date acceptable to all Eastern Nile Basin riparian countries exists. After years of escalating tensions between upstream and downstream countries of the Nile basin, mainly because of Ethiopia's construction of Grand Ethiopian Renaissance Dam (GERD), a sense of mistrust hangs over the dam's ultimate use. Preventing transboundary water conflicts cannot be realized without forming adequate cooperation in managing shared waters which through robust and equitable structures and institutions. Since conflict resolution is a political process to make decisions after a lengthy procedure of negotiations, cooperation at transboundary level needs much time, patience and persistence to have ampler chances to succeed if the drivers and interests of the riparian states are identified, quantified and shared with the help of diplomatic mechanisms. The nature of cooperative decision-making at the transboundary water scale is regarded as a complex system composed which cannot be forgone without diplomacy among parties to facilitate understanding of actors' interests by creating a transparent and confident environment. This study developed a series of laboratory game experiment as an approach to examine the impact of a set of incentivized compensation options to promote cooperation through trust building, reduction of decision makers' uncertainties and simplification of complexities. To test whether individuals have the ability to signal the economic gains expansion as a motive for cooperation, this study reports a laboratory game experiment in the form of non-binding, 3-player, trust games. Payoff schemes are calculated and provided using real-world data for the case of the Eastern Nile Basin under four different allocation scenarios. The analysis of exploring cooperation probability under each scenario aims to identify the likelihood of the "win for all" decisions, which could not be reached with the unilateral behavior of states, but through a stable integrative and collaborative framework. The results of the experimental games indicate that cooperation is indeed hard to establish in a strategic environment with a sense of uncertainty for the future, but it is still attainable. Since cooperation is mostly conditional, as long as a set of preconditions are available and certain ranges of incentives are ensured, cooperation continues. The result of the study demonstrates that basin-wide security requires regional cooperation while cooperative decision-making takes place in a transparent environment with a variety of compensation options, institutional reforms, and incentive-compatible considerations. In the end, key conclusions prove that sustained and open communication and information sharing can lead to collective actions. In order to establish joint decision-making for cooperation over the shared waters, recognition of all sorts of benefits cooperation brings in a short and long run, and fair distribution of those benefits among the riparian countries play a crucial role.

Zusammenfassung

Die durch die Verwendung von Nil-Gewässern ausgelösten Spannung erhöhen sich seit geraumer Zeit und nach wie vor wurde noch keine umfassende Vereinbarung getroffen, welche akzeptable Lösungsansätze für alle Staaten am östlichen Nilufer darstellt. Nach Jahren der immer wieder eskalierenden Spannungen zwischen Downstream- und Upstream-Länder im Nilbecken, insbesondere im Hinblick auf Äthiopiens Bau des Grand Äthiopien Renaissance Dam (GERD), schwebt ein Gefühl von Misstrauen über dem Damm und Nutzung. Da die Konfliktlösung einen politischen Prozess darstellt, mit Entscheidungen die nach langwierigen Verhandlungsverfahren getroffen werden, braucht die Zusammenarbeit auf grenzüberschreitender Ebene, viel Zeit, Geduld und Beharrlichkeit, sofern Entscheidungsgrundlagen und Interessen der Uferstaaten mittels diplomatischer Mechanismen bekannt und quantifiziert wurden, um letztlich eine höhere Chance auf Erfolg zu realisieren/erhalten/haben/in Aussicht zu haben. Das Wesen der kooperativen Entscheidungsfindung in einem grenzüberschreitenden Wassersystem wird als ein komplexes Netzwerksystem betrachtet, welches nicht auf Diplomatie unter/zwischen den Parteien verzichten kann, um folglich das Verständnis von Interessen, durch Schaffung eines transparenten und zuversichtlichen Umfeldes, zu erleichtern. Diese Studie trägt dazu bei, eine Reihe von Laborspiel-Experimenten zu entwickeln, welche eine Reihe von Anreizkompensationsoptionen untersuchen, die die Kooperation durch Vertrauensbildung, also der Minderung der Zweifel Entscheidungsträger und die Vereinfachung der Komplexität fördern. Um zu testen, ob Einzelpersonen fähig sind, ihre Bereitschaft zur Zusammenarbeit zu signalisieren, wodurch sie ihre ökonomischen Gewinne erhöhen könnten, zeigt die Studie eine Reihe von experimentellen Laboratorien in Form von unverbindlichen, 3-Spieler, Vertrauensspielen. Die Analyse der Kooperationswahrscheinlichkeitserforschung jedes Szenarios zielt darauf ab, die Wahrscheinlichkeit der "win for all" -Situation zu identifizieren, die zwar nicht mit dem einseitigen Verhalten der Staaten erreichbar ist, jedoch durch einen stabilen, integrativen und kooperativen Rahmen bewerkstelligt werden kann. Die Ergebnisse des experimentellen Spiels zeigten, dass obwohl Zusammenarbeit in strategischen Umfeldern mit ungewisser Zukunft schwierig zu implementieren ist, dennoch, sofern Vorbedingungen zur Verfügung stehen, machbar ist. Da die Kooperation meist unter Vorbehalt ist, schreitet die Zusammenarbeit nur voran, solange eine Reihe von Voraussetzungen gegeben ist und bestimmte Anreizbereiche sichergestellt sind. Das Ergebnis der Studie zeigt, dass ein Becken weite Effizienz, eine regionale Kooperation erfordert und eine kooperative Entscheidungsfindung in einem transparenten Umfeld unter einer Vielzahl von Ausgleichsoptionen, institutionellen Veränderungen und anreizkompatiblen Überlegungen, möglich ist. Die Schlussfolgerungen sind letztlich, dass eine nachhaltige und offene Kommunikation zur Zusammenarbeit führen und eine kooperative Entscheidungsfindung schaffen kann. Das Verständnis für den wirtschaftlichen Nutzen durch die Zusammenarbeit, die Kooperationsbereitschaft und die Vertrauenswürdigkeit der Entscheidungsträger stellen die zentralen Problemfelder dar.

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List of Acronyms and Abbreviations

AHD	Aswan High Dam
BCM	Billion cubic meters
BCM/a	Billion cubic meters per annum
CFA	Cooperative Framework Agreement
DOP	Declaration of Principles
EEHC	Egyptian Electricity Holding Company
EEPCO	Ethiopian Electric Power Corporation
ENB	Eastern Nile Basin
ENSAP	Eastern Nile Subsidiary Action Program Technical
ENTRO	Eastern Nile Technical Regional Office
EPDRB	Environmental Program for the Danube River Basin
FAO	Food and Agriculture Organization of the United Nations
GAMS	General algebraic modeling system
GDP	Gross domestic product
GERD	Grand Ethiopian Renaissance Dam
GIS	Geographical Information System
GWh	Gigawatt hours
ha	Hectare
HDI	The Human Development Index
HEM	Hydro-economic model
ILA	International Law Association
ILI	International Law Institute
ITT	Institute for Technology & Resources Management in the Tropics and Subtropics
IWMI	International Water Management Research Institute
Kg	Kilogram
Km	Kilometer
Km^2	Square kilometer
kWh	Kilowatt hours
kWh/a	Kilowatt hours per annum
m	Meter
m^2	Square meter
m^3	Cubic meter
MW	Megawatts
MWh	Megawatt hours
NBC	Nile Basin Commission
NBI	Nile Basin Initiative
NELSAP-CU	Nile Equatorial Lakes Subsidiary Action Program Coordination Unit

NELTAC	Nile Equatorial Lakes Technical Advisory Committee
NEOM	Nile Economic Optimization Model
NGO	Non-governmental organization
SAP	Strategic Action Plan
SPSS	Statistical Package for the Social Sciences
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Organization for Education, Science, and Culture
USD	United States Dollar
WEF	Water-Energy-Food Nexus

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1 Chapter 1: Introduction and Outline

1.1 Introduction

Transboundary Water Management through cooperation is one of the most successful means of bringing together multiparty stakeholders from riparian countries of a basin to share a common resource either through equitable allocation or by the fair distribution of the benefits of its exploitation. Cooperation over shared resources is particularly essential for food, water, and energy security, socio-economic development, and where applicable, transportation and defense. Transboundary cooperation through joint management is crucial especially in regions where tension over water scarcity is chronic.

In this dissertation, the likelihood of cooperation in the Eastern Nile Basin between Egypt, Sudan, and Ethiopia is investigated. The region has a long-standing history of cooperation mostly instituted by force or coercion rather than mutual cooperative arrangement. This dissertation explores the possibility and opportunity of developing a cooperative framework for mutual benefit sharing among the Eastern Nile Basin riparian states. For the first time, the cooperative game theory is applied to design a laboratory experiment for understanding the opportunities in decision-making processes with and without specific strategic parameters, e.g., the Grand Ethiopian Renaissance Dam (GERD) construction.

This study comes at a critical juncture of the Eastern Nile River Basin cooperation status as Ethiopia's ambitious infrastructure development plans will offset the physical (quantity and quality) water availability to the leading consumer of the Nile, Egypt. Since antiquity, Egypt has enjoyed unwavering and largely unchallenged dominance over the Nile river, and Ethiopia's GERD and upcoming development projects stand to threaten that position. The interdependencies of water issues with different decision-making arenas and geographical and temporal scales in the basin, make it difficult to steer an issue towards a certain solution. Hence new means and methods need to be explored to nurture and develop cooperation among the Nile River Basin riparian countries by making options transparent to increase the chances of building trust and confidence during the decision-making stage.

So far, all the attempts of cooperation among the Eastern Nile countries have not been entirely successful. The main reason for this failure is mistrust which has been caused by a lack of transparency, geopolitical imbalances, access to adequate and relevant data, and shifting development ambitions. Mistrust has played a major preventative role in reaching basin-wide cooperation and implementation of joint transboundary water management. Transparent data sharing (concerning national development priorities, social and economic benefits, and joint resource exploitation) increases the prospect for understanding each riparian's position, hence helps to build trust. Trust is crucial for open and fair negotiations on equal terms, and such negotiations eventually lead to mutual arrangements, binding legal contracts, pivoted on the principles of benefit sharing engagements and joint management.

The current dissertation explored different techniques (Laboratory experiments and hydro-economic modeling, expert survey) to make key information transparent based on real-world data (expert survey and secondary sources). By applying cooperative game theory to design an experimental game, this study aimed to understand decision-making processes based on transparent choices. The study explored the water allocation system in the current geopolitical situation, contracts and literature on the Eastern Nile case with developing a basic hydro-economic model of the basin, to identify the gaps and to learn from past mistakes.

The experiment simplified the real-world scenario of the Eastern Nile Basin into a controlled laboratory role-playing game, in which players assumed to play in the decision makers' role in a transboundary context. By conducting result-oriented laboratory games, the study simulated the actual decision-making for economic benefit sharing for four scenarios. The aim is that a sophisticated and context-sensitive understanding of long-term economic benefits on the part of negotiators, and national and international decision-makers, can help tackle the challenges that lie ahead in this highly complex arena of international relations. Finally, by developing the simulated real-life decision-making processes, the study concluded with transferring the knowledge on developing a cooperative framework for Eastern Nile River Basin riparian states.

1.2 Research question and objectives

The underlying research question of this thesis is: Does transparency lead to increase trust for negotiations on cooperation and benefit sharing decision-making?

The overall objective of this study is to develop a practical framework to promote cooperation by understanding the impact of economic gain maximization to encourage regional, economic and political cooperation between the Eastern Nile Basin countries by providing transparency and building trust techniques among decision makers to decrease the possibility of escalating conflicts.

This research objective includes the following sub-objectives:

o to develop a strategic hydro-economic model for building scenarios and analyze the outcomes of current and optimized water allocation in the basin

o to design a laboratory economic experiment in a role-playing game format based on the generated scenarios through hydro-economic model

1.3 Outline of the dissertation

Each chapter of the current dissertation is developed entirety with its own introduction, background, justification, and results. The broad outline of the six chapters is as follows:

Chapter 2 introduces the Eastern Nile River Basin's demography, geography, ecology, and biophysical status. Furthermore, this chapter looks at the geopolitical context of water-related cooperation and conflict in the modern era. It indicated the importance of the Nile to both the upper and lower riparian states and signified the reasons why the Nile will become a severe cause of conflict between its riparian states. The chapter presents the power dynamics underlying the relations between the lower and upper riparian states of the Basin. It studies the historic hegemonic role played by the downstream riparian. In the end, Chapter 2 deals with the current situation where Ethiopia, as the upper riparian state, attempts to expand hydropower generation by building new infrastructure on the Nile and at the same time Sudan plans to expand its irrigated agriculture.

Chapter 3 explores the vast literature on transboundary water management, cooperation, negotiation, water diplomacy, and international water law. It seeks to understand the literature on transboundary river management and review a selected successful experience in implementation of cooperative decision-making. Chapter 3 explores the strategic role of transboundary water resources management, descriptions of innovative thinking and tools applied to promote transboundary cooperation over shared rivers. By suggesting approaches for participatory management of shared water resources, this chapter focuses on trust building, transparency, altruistic motives, and compromises during the negotiation processes and decision-making.

Chapter 4 explains the means and methods employed for developing an expert survey questionnaire, data collection, data analysis, and plotting. Chapter 4, studies the process and the result of the expert questionnaire-based survey which was conducted in the Eastern Nile Basin. Interpretation and designing of the experimental games feature as the result of expert survey and face to face interviews of a number of native experts in the case study. The chapter explores the importance of basin-wide cooperation from the respondents' point of view. As a result of the expert survey, Chapter 4 illustrates that the main obstacle to cooperation is the lack of trust and transparency among the three countries due to the historical and current political situation.

In Chapter 5, we developed a hydro-economic model of the Eastern Nile Basin to understand the current and to calculate the optimal water resources allocation, focusing on upstream and downstream riparian states' tradeoffs for irrigation and hydropower generation. Four different water allocation scenarios have been developed by the model with different allocation and payoff structures for each of the three riparian states. The chapter concludes by comparing the economic gains of each country in the absence of cooperation and the presence of full cooperation. By analyzing the results of the hydro-economic model, considering the soon to be completed of GERD in Ethiopia, it seems renegotiation establishment of a cooperative arrangement in the basin can be Egypt's best alternative regarding economic and development concerns.

Chapter 6 outlines the steps taken to design the laboratory experiment based on the trust game algorithms. The experiment evaluated the four scenarios developed by the hydro-economic model in the previous chapter. The experiment consisted of 4 rounds of 3-player, a role-playing game experiment where players represented each Eastern Nile country's decision makers. By conducting the experiment, the probability of cooperation in each set of the game was examined by studying the effect of different factors influencing the negotiation process and the decision-making such as data sharing, transparent choices and role of diplomacy during the negotiation periods. The main contribution of Chapter 5 is the development of an analytical framework that facilitates impartial negotiation for cooperation based on information sharing and transparency, trust, and economic gain sharing.

Chapter 7 summarizes the results, findings, conclusions and original contributions of this research, and lists some recommended directions for future studies.

2 Chapter 2: Case Study Background Eastern Nile Basin

2.1 The Nile Basin

Most likely origin of the name Nile comes from the Semitic word "Nahl" which translates to a river valley, later "Neilos" in Greek and "Nilus" in Latin (Lewis, 2012). The ancient Egyptians called the mighty river "Iteru," and the Copts called it "Phiaro." The Nile has been at the center of several flourishing civilizations and most certainly played a famous role in the development of trade, economics, military, language, arts, and culture of its riparian settlements. The actual source of the Nile has been a much contested and debated quest throughout the history. Until recently that the modern technology such as GIS and satellite imaging proclaims the real source of Nile as Ruvyironza River (02°N16' 56" S and 029°N 19' 53" E) emerging from the mountains of Bururi province in present-day Burundi. The Nile is a confluence of two tributaries, namely the White Nile which is the headwaters of the river and it originates in Burundi and flows through Lake Victoria to merge with the Blue Nile at Khartoum. The Blue Nile supposedly originates at Gish Abay in Ethiopia and flows through Lake Tana (Abtew & Assefa, 2014).

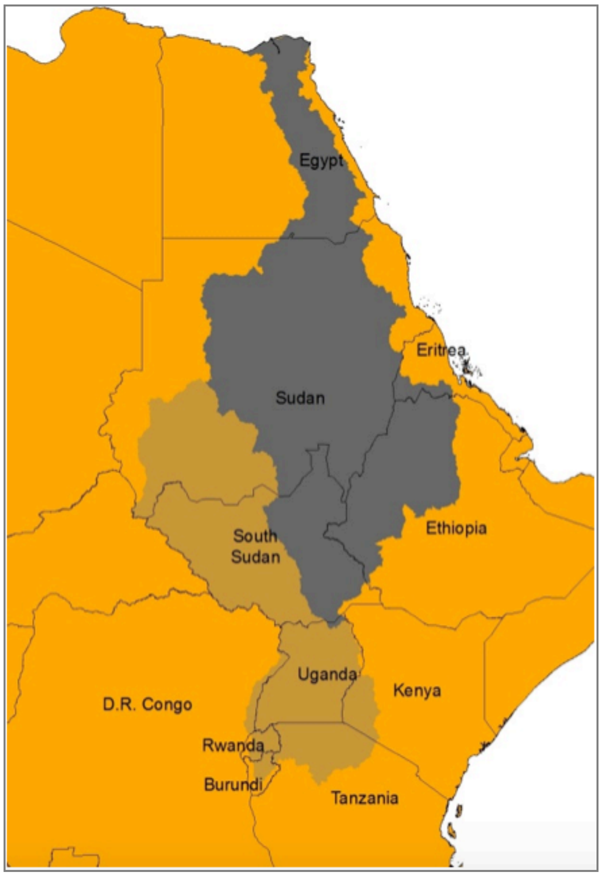

Figure 2-1 Nile & Eastern Nile Basin (Dark Gray)

The Nile is an international river shared by eleven countries with a total population of 437 million inhabitants (NBI, 2014). It is one of the world's longest rivers, stretching about 6825 km from the farthest source of its headwaters in Burundi, to the shores of the Mediterranean Sea. The Nile flows south to north reaching latitudes of 35°N, its network of tributaries traverses through 11 countries with the total watershed area of 3.17 million km2, i.e., approximately 10% of the area of the African continent (Figure 2-1 & Table 2-1) (Karyabwite, 2000). Despite its length, the second half of the river, i.e., beyond Ethiopian borders, it only receives less than 150 mm/ precipitation (FAO, 2011). The total annual flow volume is 2810 x 103 m3/a which typically 80-

85% of the discharge occurs in 4 months July-October. However, because of its vast watershed and its complex biophysical, topographical, climatic conditions the flow and discharge at any given point depending on a variety of factors. Global weather systems habitually affect precipitation in East Africa and consequently the Nile flow, e.g., El Niño years result in a severe extreme (Strategic Foresight Group, 2013) (FAO, 1997) (AQUASTAT, 2000).

Table 2–1 Nile Basin area

Country	Country Area (km2)	Area within the Nile Basin (km2)	% of the total Nile Basin Area	% of the country in the Nile Basin
Burundi	27,835	13,260	0	48
DR Congo	2,345,410	22,143	1	1
Egypt	1,001,450	326,751	11	33
Eritrea	121,320	24,921	1	21
Ethiopia	1,127,127	365,117	12	32
Kenya	582,650	46,229	2	8
Rwanda	26,340	19,876	1	76
Sudan	2,505,810	1,978,506	64	79
Tanzania	945,090	84,200	3	9
Uganda	236,040	231,366	7	98
Total	**8,919,072**	**3,112,369**	**100**	

Climate change is expected to increase the frequency and intensity of disasters such as prolonged droughts and floods, adversely affecting the food, water, and energy security of all of the riparian states' population. Today, the basin is characterized by poverty, political instability, rapid population growth, and environmental degradation. Four of the Nile riparian countries are among the world's ten poorest with per capita incomes in the range of USD 100-200 per year (FAO, 2007). The population is expected to double within the next 25 years, placing additional strain on scarce water and other natural resources (Zedan, 2014). With exception to Sudan and Egypt where the Nile is almost exclusively the only source of freshwater hence its vital for survival, the rest of the riparian states receive adequate annual precipitation (Kameri-Mbote, 2005).

The Nile is a shared resource that must be shared among all the upstream and downstream riparian states in a mutually agreeable sustainable design with equitable benefits, risks, and opportunities. Cooperative management of the Nile River basin is one of the most significant opportunity and challenge for international water agenda. It provides a chance to realize significant transboundary economic and environmental benefits from cooperation (NBI, 2014).

2.1.1 Climate and Precipitation

Because of its vast watershed, the Nile courses through several different climate zones ranging from tropical climate at the equator, temperate climate in the highlands, semiarid climate as it passes through northern part of South Sudan and Sudan, whereas for the rest its journey, i.e., north Sudan and Egypt up to the Mediterranean Sea Sahel and desert climate is observed, for example in Aswan the daily average temperature in June is 47°C (Karyabwite, 2000). In the great lakes' region, the mean temperature depending on altitude ranges from 16-27°C but stays stable throughout the year with mean daytime temperature of 24°C with on average 80% humidity. Only Cairo and Alexandria have a winter climate from November to March when the average maximum is 24°C, and the minimum is 10°C, respectively (Yohannes, 2008).

Table 2-2 Annual rainfall, Nile flows in each riparian of Nile Basin (FAO, 2006)

	Annual Precipitation (mm)		Annual Nile River Flows (Million m3/a)	
	Min	Max	Inflow	Outflow
Burundi	895	1,570	0	1,500
DR Congo	875	1,915	0	1,500
Egypt	0	120	55,500	10,000
Eritrea	540	665	0	2,200
Ethiopia	205	2,010	0	80,100
Kenya	505	1,790	0	8,400
Rwanda	840	1,935	1,500	7,000
Sudan	0	1,610	117,100	55,500
Tanzania	625	1,630	7,000	10,700
Uganda	395	2,060	28,700	37,000

The annual rainfall is recorded in (Table 2-2) most precipitation occurs in the Great Rift and Abyssinian valley. Moving north, the rainfall depreciates considerably, at Khartoum only 127 mm/a is recorded. The case of Egypt is very similar but another way around, Mediterranean coast of Egypt receives variably 203 mm/a to less than 3 mm/a at Cairo, moving south precipitation is less than 3 mm/a (Karyabwite, 2000). Potential evaporation rates in the Nile region are high, making the basin predominantly vulnerable to drought events. Total evaporative losses from constructed storage in the basin are estimated at around 15-20 BCM/a, more than 20% of flows arriving at Aswan (Kirby, 2010).

Climate change impacts the Nile river in different ways, including but not limited to evaporation, a decrease in rainfall, heavy downpours, runoff, erosion, and flooding. These events are difficult to forecast and even harder to realize the potential adverse effects. Climate change adaptation mechanisms are a function of building resilience toward these natural calamities regarding risk reduction and improving adaptive capacity however unless there is an imminent necessity, management practices are seldom changed to address the vulnerability (Blackmore & Whittington, 2008). This consequently increases the risk of economic loss and human suffering. The basin is characterized by enormous differences in the spatial and temporal distribution of precipitation, temperature and river flow (Batisha, 2011).

The topographic difference led to the Nile flowing from south to north following the elevation difference. The Great Rift Valley forms the base of the great equatorial lake plateau, which sits at an elevation of 1000-2000 m and has peaks rising to 5100 m elevation. The Rift Valley undisputedly is the source of White Nile consisting of Lake Victoria, Lake George, Lake Albert, Lake Malawi, Lake Edward and many smaller natural reservoirs (Yohannes, 2008).

2.1.2 Hydrological Regime

The Nile river system is believed to be almost 80,000 years old, and the link to the equatorial lake system supposedly happened around 12,500 years ago. The Yellow Nile is a former tributary that connected the Ouaddai Highlands of eastern Chad to the Nile River Valley c. 8000 to c. 1000 BC (Salama, 1997). Due to fractures in the tectonic plate, the magma is much closer to the surface crust underneath the Rift Valley, over epochs lava eruptions created a string of volcanoes and raised the entire landmass over 3.2 km creating a unique slope in the geography that slope gently toward north at a gradient of 1 m drop for every 20 km (Henze, 2000).

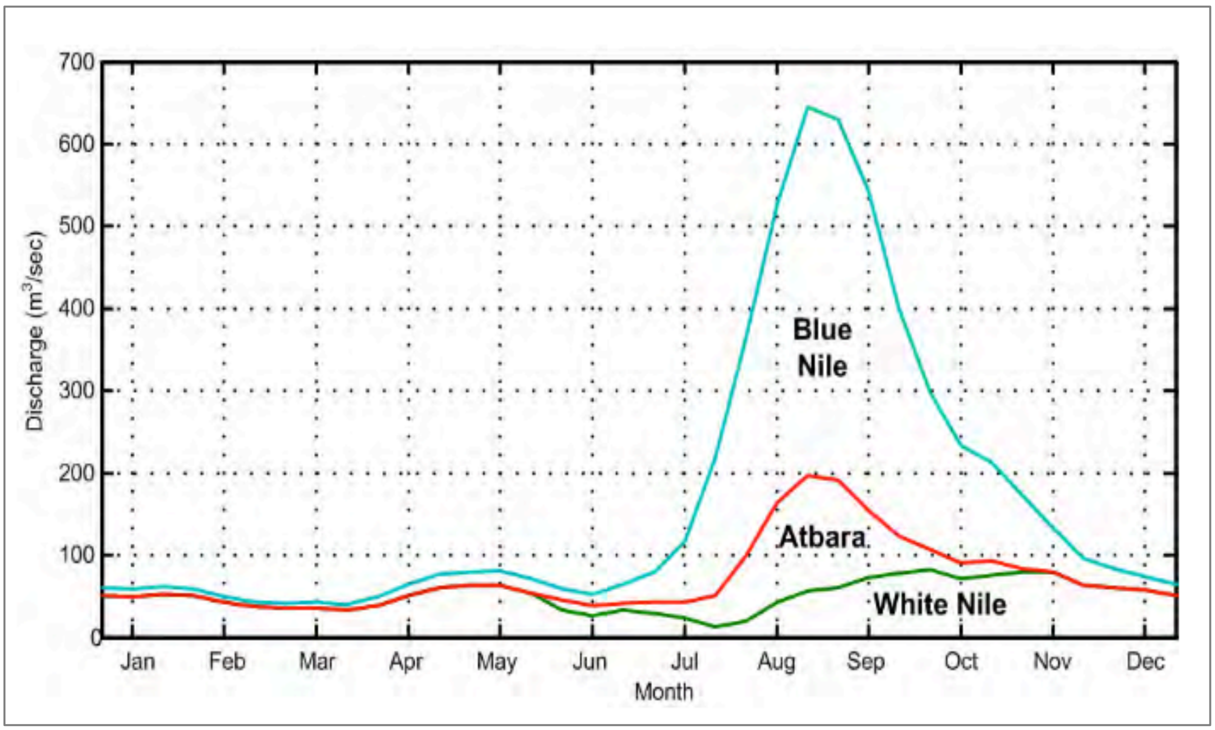

Figure 2-2 10 Days average water arriving Aswan from Blue Nile, White Nile and Atbara (2010)

After the retreat of the ice age, the sustained wet era was prevalent during which several rivers formed and course ways were eroded (Mulat & Moges, 2014). Following this several dry and wet periods alternated, causing lakes to form an overflow during a wet period, thus over several thousand years the Nile developed a gently flowing course (Karyabwite, 2000). Following this, the course reaches the marshlands of Sudd and central Sudan basins that gently slope (1m drop for every 24 km) stretching from Juba to Khartoum for 1800 km. The great bend follows, and the river coalesces with the Blue Nile (Henze, 2000). The second source lies on the Abyssinian plateau in the Ethiopian highlands, which rise to 3500 m in elevation and descends gently toward north eventually meeting the Sudan plains at 500 m. Here 200 km from the Egyptian border the river runs at an elevation of fewer than 500 m before it surges towards Alexandria (Figure 2-2). Roughly 200 km before it reaches the Mediterranean Sea it branches out to form the Nile river basin (Zeidan, 2013).

Table 2–3 Water Resources and Availability in Nile Basin Countries- (World Bank, 2006)

Country	Internal Renewable Water Resources (km3/a)	Actual Renewable Water Resources (km3/a)	Dependency Ratio (%)
Burundi	3.6	3.6	0.0
DR Congo	935.0	1,019.0	8.2
Egypt	1.7	58.3	96.9
Eritrea	2.8	8.8	68.2
Ethiopia	110.0	110.0	0.0
Kenya	20.2	30.2	33.1
Rwanda	6.3	6.3	0.0
Sudan	35.0	88.5	96.1
Tanzania	80.0	89.0	10.1
Uganda	39.2	66.0	40.9

Over millennia the river naturally has decreased in its capacity and vigor, the lion's share of contribution to the Nile comes from the Ethiopian highlands, accounting for upwards of 80-85% of the total water supply; the Blue Nile and Atbara (Mulat & Moges, 2014). From May to August heavy downpours in Abyssinian Plateau causes the river to regularly inundate surrounding plains in Sudan and Egypt, slowly receding thereafter-reaching low points in January to May.

One of the significant characteristics of the Nile river is the marshlands of Sudd, where the White Nile flows in at 1048 m3/second capacity and flows out with 510 m3/second, total volume equivalent to 15 BCM/a (Nicol, 2002). This flow loss is an enormous volume of water; however, it is worth comparing it to the amount of water lost to evaporation in the Aswan High Dam, which is roughly 10 BCM/a. The total discharge into the Mediterranean much lower than the combined inflow from White Nile, Blue Nile, and Atbara, this is attributed to the evaporation losses in the Aswan High Dam and very significant withdrawal for irrigation (International Water Management Institute, 2012).

99% of Nile's water is generated in only 20% of its watershed, 15-20% from the equatorial lakes of East Africa and the rest from the highlands of Ethiopia (Blackmore & Whittington, 2008). For countries like Democratic Republic of Congo, Kenya, Ethiopia and Tanzania, the Nile forms only a small part of their total water resource thus their dependency is much lower than for instance Burundi, Rwanda, and Uganda for whom the Nile is the primary source yet by no means the only one (Ashebir, 2009). However, for countries such as Sudan and Egypt, with dangerously high dependency ratio, Nile is the only source of water (Table 2-3); rainfall is negligible if any and constitutes only a fraction of the requirement (Yohannes, 2008).

Only a small proportion of the precipitation falling on the catchment area is channeled through the downstream and discharged into the Mediterranean. Vast quantities of water are lost to evaporation, seepage and overbank flows to the swampy lands on the fringes. Further, the carrying capacity of tributaries is limited thus allowing for a specific capacity to be maintained, but any additional input is spilled over the bank (Karyabwite, 2000). The current river systems feeding the main Nile does not carry more than 150 BCM/a beyond the confluence of Atbara. The equatorial lake system and its swamps hold immense quantities of water but almost impossible to quantify (Molden, Awulachew, & Conniff, 2012).

2.1.3 Livelihood and Socio-economic Characteristics

Although Nile River Basin is rich in natural resources, the riparian population have always been plagued with a variety of difficulties directly linked to the river. With exception to Egypt, many of the riparian states and their neighbors are classified as least developed, and the region is considered as one of the poorest regions in the world. Regarding GDP, a large proportion of the economy of Nile co-riparian states is dependent on the agriculture sector. Water scarcity and food insecurity are main challenges, which worsen by the incidence of any climate variability such as droughts and flooding. Environmental degradation, rapid population growth, disease, conflict, and unstable political conditions are overarching issues threatening inhabitants' security, social welfare, and livelihood within the Nile basin. Furthermore, the region's population is predominantly tribal pastoralist or smallholder farmers. They are illiterate, lacking access to finance and investment, infrastructure, technology, and information, this predicament leads the population into repeating patterns of food and nutrition insecurity because they are unable to establish viably, secure sources of income or economic activity (Nigatu & Dinar, 2011) (FAO, 2011) (Tollenaar, 2009).

According to AQUASTAT (2010), Egypt falls into the category of high-water stress, Sudan as medium water stress, Rwanda as moderate water stress and the other countries belong to the class of low water stress countries (Figure 2-3). A rough comparison highlights water withdrawal of each riparian state and the position of the country in its socio-economic development process. We see the more developed the country is, it has higher financial means and infrastructure to allocate more. Figure 2-3, shows the asymmetry between water availability in the different Nile riparian countries and levels of total water withdrawal. It clearly indicates that Egypt and Sudan, the two downstream countries, are currently the only two countries to have systematically utilized and developed water resources. This accordingly leads us to recognize another challenge the

Nile basin faces which are an uneven development and use of the river's shared waters (Paisley & Henshaw, 2013).

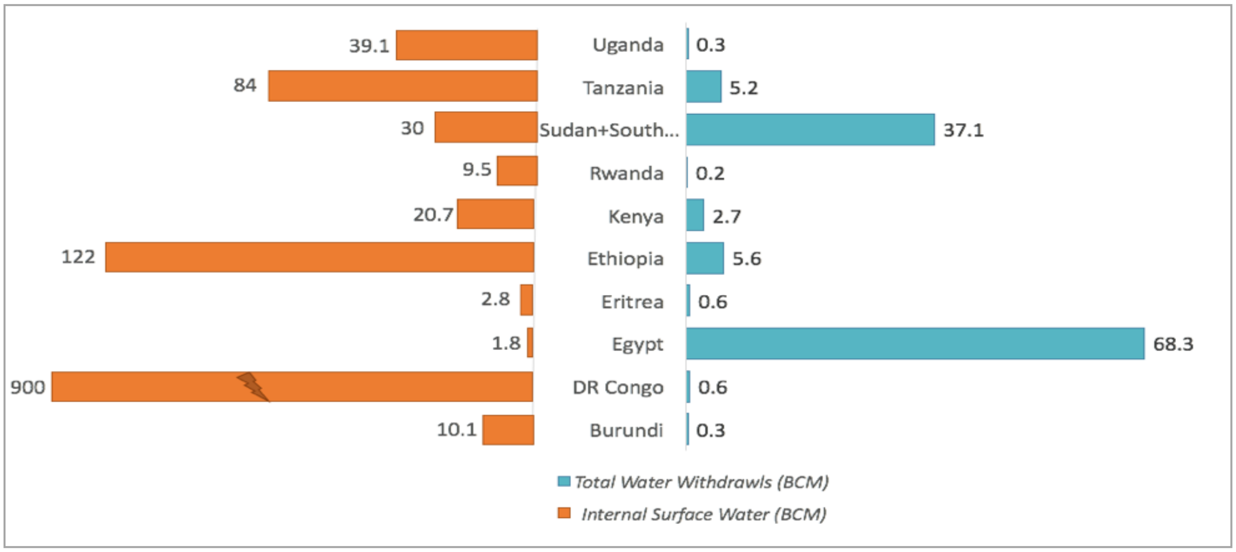

Figure 2–3 Nile countries water withdrawals comparison-(AQUASTAT, 2010)

There is a growing recognition of the vital role that water management plays in securing a society and enabling sustainable growth as water insecurity is ranked as the risk of most significant concern over the next ten years in the 2016 World Economic Forum's Global Risks Report (WEF, 2016). On the ground, it is increasingly apparent that water scarcity, water variability, and water pollution are fundamental challenges in reducing poverty and food insecurity. Growth, as a result of population upsurge, rapid urbanization, and economic development brings about changing consumption and water use patterns increasing considerable pressure on availability and quality of water resources. One of the components of sustainable growth depends on sustainable water resource management to ensure water security[1] (Wu & Whittington , 2006). The Nile riparian states' economic ambitions and population continue to grow; therefore, it is immanent to arrive at a joint understanding of current and future availability and impacts of interventions in the water system on food and energy in the region (Obeng, 2012).

To achieve a stable and sustainable level of economic growth each state has to manage its available natural resources and human capital to improve its infrastructure and industry to ensure food, water, and energy security and adequacy (Kirby, 2010). The Nile river basin countries are under rapid development and have some of the fastest growing economies in the world, e.g.

[1] *Water security is defined as the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability. (UN-Water, 2013)*

GDP growth rate of Rwanda, Ethiopia and Tanzania are consistently above 7%. Uganda and Kenya are also experiencing rapid growth of above 5.9% and 5.6% respectively (World Bank, 2006). Ethiopia is projected to grow at a rate of 11-14% in the near future (Figure 2-4). Sudan and South Sudan are struggling with internal civil conflicts and terrorism. However, there is a large population of returnees in both countries looking to establish themselves, once the governments have curbed the unrest and make land reforms these countries would also grow at 5% or above. Egypt, on the other hand, is well established in trade and international relations thus have a consistent growth pattern (Droogers, 2012).

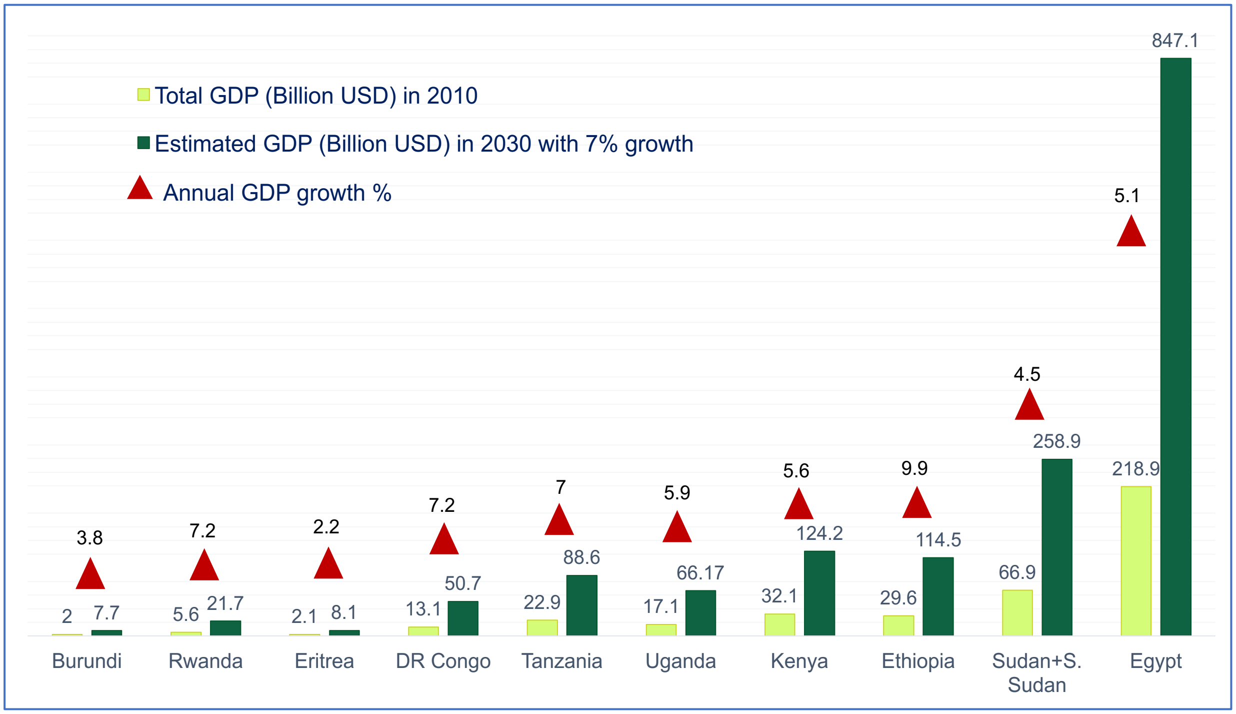

Figure 2–4 Nile Basin GDP growth rate (World Bank, 2006)

For growing economies within the Nile basin, water will be an essential determinant for their progress because all sectors of the economy directly or indirectly depend on water availability. Rapid and competing ambitions in economic developments will undoubtedly increase the pressure on water withdrawal whereas the availability would remain the same. This could, in turn, results in water-related conflicts very shortly (Wu & Whittington , 2006).

Water is the only limiting factor to development and survival. Rapid internal developments, and uncertain impacts of climate change, and almost certain to occur natural calamities demand an imperative and urgent need for basin-wide cooperative arrangements that reinforce resilience to natural and socio-economic shocks. Such cooperative arrangements would enable riparian states to manage risks and vulnerability in coordination instead of unilateral actions that may undermine the overall stability of the Nile Basin (Zeitoun & Mirumachi, 2008) (Batisha, 2011) (NBI, 2014).

Each Nile basin country has widely varying strategic and economic capacity to manage and control water resources within their boundaries in the context of agricultural use, power generation or municipal use. Such varied and unilateral approach determines the efficiency and optimization of water allocation consequently water availability for agriculture and hydropower. Much of this difference is due to power and capacity of each riparian state, which in turn is attributed to varying levels of infrastructure development, water storage capacity, energy production/access, and irrigation/ agricultural development (Nicol, 2002). Transboundary cooperative joint actions boost sustainable development in the Nile countries, featuring each country's national plans, guarantee power security and socio-economic development and stability. Although most Nile basin countries admit to advantages of regional joint planning, management, and development, however, political commitment to cooperation and integration has not seen much progress (NBI, 2011). The unique interdependency of riparian states on Nile waters offers a unique opportunity for cooperative development and management to realize the economic potential of the region by optimizing the development of its water resources particularly in agriculture and energy sectors (Wu & Whittington , 2006).

2.1.4 Agricultural productivity in the Nile Basin

Agricultural sector accounts for on average varies among 70 to 75% of total water consumed along the river (irrigated agriculture alone uses the equivalent of about 78% of the peak flow of the Nile at Aswan), and it is invariably linked to food security, income security, nutrition security, poverty alleviation, conservation of the natural environment and biodiversity (NBI, 2011). Because all riparian states are predominantly agrarian (approximately 75% of the population are directly employed in agriculture and agri-based industries), the Nile plays a pivotal role, and the agriculture sector is a significant contributor to GDP, employment, and food self-sufficiency (Figure 2-5) (FAO, 2007).

Farming systems in all of these states are prevalently rudimentary, even in Egypt most are smallholder farmers without access to information, technology and machinery. Although riparian states have experienced some degrees of improvements in the last decade concerning economic growth and infrastructure development and modern technology, most of the Nile riparian states are low-income countries with severe poverty and low Human Development Index[2]. The

[2] *The Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and having a decent standard of living. The HDI is the geometric mean of normalized indices for each of the three dimensions. As a poverty indicator, the Human Development Index (HDI) estimates deprivation of capabilities and opportunities*

industrial transition of these countries limited by many internal and external factors and the most crucial impeding variable is political stability (Skinner, 2010). Lack of investment and infrastructure remains a significant obstacle to shifting from subsistence-based primary production economy towards a sustainable, diversified economy with secondary production making use of available natural resources optimally (Pham, 2010).

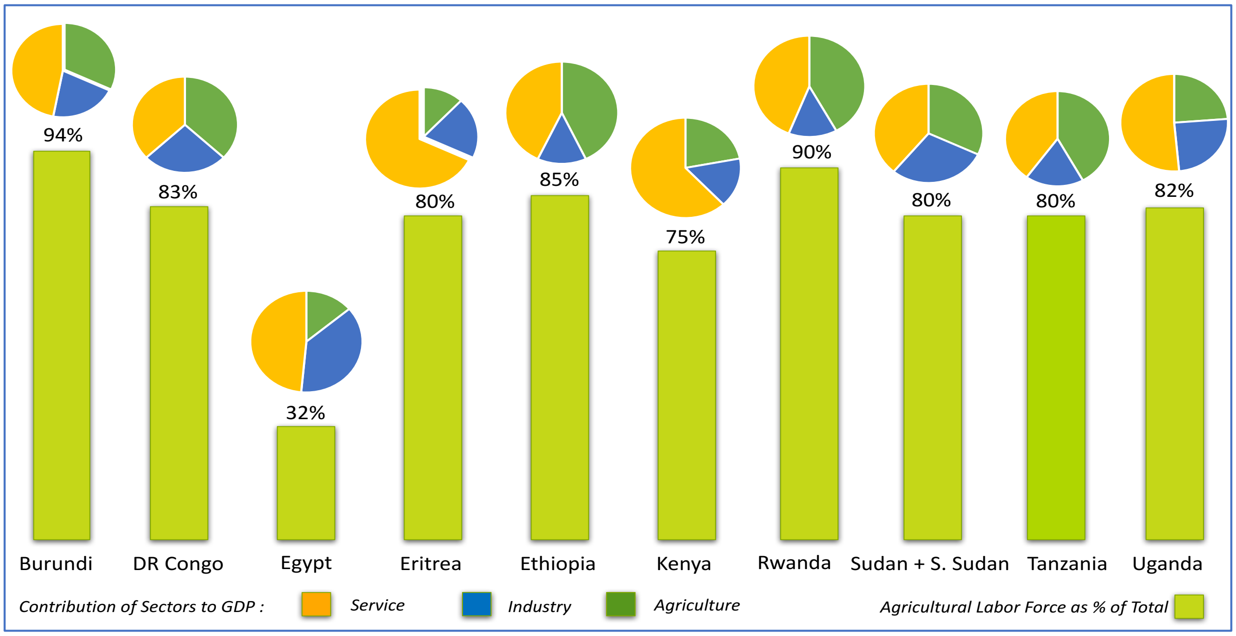

Figure 2–5 Nile Riparian Countries' Economic Profile (2010)

The agricultural sector is responsible for nearly 75% of the total water withdrawal in the Nile basin. In both Egypt and Ethiopia, agriculture accounts for 86% of water withdrawal, while in the case of Sudan it is 94% (Mason, 2005). According to the FAO (2007), approximately 5 million ha are irrigated in the Nile Basin, while the total potential area is about 10 million ha (Figure 2-5). Recently Egypt has started to irrigate lands in the Northern Sinai including Salaam Canal under Suez Canal and eventually will use additional 4.4 BCM of waters. Another new agriculture scheme, New Valley Project, will divert another 5 BCM of water yearly, starting from 2017 (Molden, 2007). Nowadays Sudan irrigates about 1% of its arable land which will increase to 2 million ha in 2020. Ethiopia, as well as Kenya, Uganda, and Tanzania, have plans to expand according to their irrigation potential (Arsano & Tamrat, 2005).

New irrigation projects in Egypt and Sudan pose a threat to upstream riparian countries by creating pressure for postponing their development projects due to growing demand for water

essential for human development. Economic well-being including the way in which natural and human conditions are linked, is a determinant of human development.

downstream and higher chance of any form of conflict (AQUASTAT, 2000). The sum of the irrigation potential of the Nile countries leads to a water deficit of over 26 km^3/a, without considering possibilities of reusing water as indicated by Egypt and Sudan in their water balance, but after deducting the water loss (FAO 2005).

Table 2-4 Nile Basin: Current & potential irrigation, Water requirement, Water availability (FAO, 2004)

Country	Potentially irrigable land in the Nile Basin (1000 ha)	Area under irrigation (1000 ha)	Irrigation Water Requirement per ha (m3/ha,a)	Actual Water inflow (km3/a)	Actual Water outflow (km3/a)
Burundi	80	0	13000	0.0	1.5
DR Congo	10	0	10000	0.0	1.5
Egypt	4420	3078	13000	55.5	Rest to sea
Eritrea	150	15	11000	0.0	2.2
Ethiopia	2220	23	9000	0.0	80.1
Kenya	180	6	8500	0.0	8.4
Rwanda	150	2	12500	1.5	7.0
Sudan	2750	1935	14000	117.1	55.5
Tanzania	30	10	11000	7.0	10.7
Uganda	202	9	8000	28.7	37.0
Total	**10192**	**5078**			

Concerning economic feasibility, not all but only some parts of the Nile region have great potential for agricultural expansion, in particular, Sudan, South Sudan, Uganda and parts of Ethiopia. This potential is increasingly catching the eye of foreign companies looking for arable land and available water resources to develop large-scale commercial agriculture schemes in these places (NBI, 2011). About 20% of the potentially irrigable area in the Nile Basin is found in Ethiopia (Table 2-4) where, 20000 ha of large-scale irrigation and 20000 ha of small-scale irrigation have been planned and started to be cultivated by 2016 (Arsano J. , 2004). According to (Table 2-4), upper riparian countries have the untapped potential of land to increase irrigated agriculture by 7 million hectares (FAO, 1997).

Egypt and some parts of Sudan are the exceptions of the Nile basin's low agricultural productivity. The large-scale irrigated agriculture dominates, and efficiency rates are far higher compared to other areas. This food deficit within the basin has created an urgent need for international food aid. Over 35% of the population in Rwanda, Burundi, and Ethiopia is food insecure and depends on food aid (Awulachew, Yilma, Loulseged, Loiskandl, & Alamirew, 2007). About 25% of Kenya's population is malnourished (Kameri-Mbote, 2005). Due to internal war and consequences of separation, Sudan and South Sudan's food insecurity is unclear, although it is estimated that the vast majority of the population, especially in western and central Sudan and along the disputed new borders are food insecure. Egypt has been receiving subsidized food grains as a part of its bilateral security relationship with the United States since decades (Chikozho, 2015). In recent years Uganda and Tanzania are less vulnerable to climatic uncertainties and are able to produce surplus food which meets regional food import demands for staples (Peden & Misra, 2007) (Future Water, 2011). Nevertheless, increase in some specific agricultural production does not directly result in food security in the region in the Nile basin, several countries have a long history of periods of food shortages, in some cases overlying chronic food production problems with not water-related causes which have negatively affected their economy.

Even if a considerable increase of food production by increasing water and land use efficiency, could be achieved within the Nile basin by closing the food production gap, it will not ensure food security for the projected population in 2050 alone (Arsano & Tamrat, 2005). Long-term food security will demand complementary food import from water surplus countries or tradeoffs among neighboring countries. This would, in turn, mean that the long-term regional planning will have to pay special attention to each country's need to generate economic power, political security and preventing conflict at national and international scales to secure inhabitants' livelihood in the long term (Lautze & Giordano, 2006).

2.1.5 Hydropower and energy security

As much as food security is crucial for survival, energy security is essential for development. The region is among the lowest in this respect. The current bilateral power exchange agreements, power generation units, and their capacity are all inadequate to meet the demands of their population. Consequently, the region has the lowest per capita electricity consumption in the world because merely people do not have access to electricity (Mekonnen, 2010).

Over 80% of the region’s population rely mainly on traditional sources of fuel such as firewood, charcoal, certain residues or manure for cooking and lightning, except for Egypt (World Energy Council, 2007). All the Nile countries with the exception of Egypt had a per capita electricity consumption of less than 200 kWh/a in 2010 which is less than 1/10th of the global average of 2,803 kWh/a (Todaro & Smith, 2012). Even Egypt's per capita energy consumption of 1,769 kWh/a only a 10th of 10,000 kWh/a per capita consumed in the industrialized world (Figure 2-6).

For instance, Egypt has almost total electricity coverage, but it remains scarce in countries such as Rwanda and Burundi, as well as South Sudan, where only 1.5% of people have uninterrupted access to such energy. Demand for energy in the Nile Basin region has been rising rapidly over the years. According to the World Bank database (2012), between 2000 and 2010, the demand raised by 100%, from 86,000 GWh to 180,000 GWh (NBCBN, 2005).

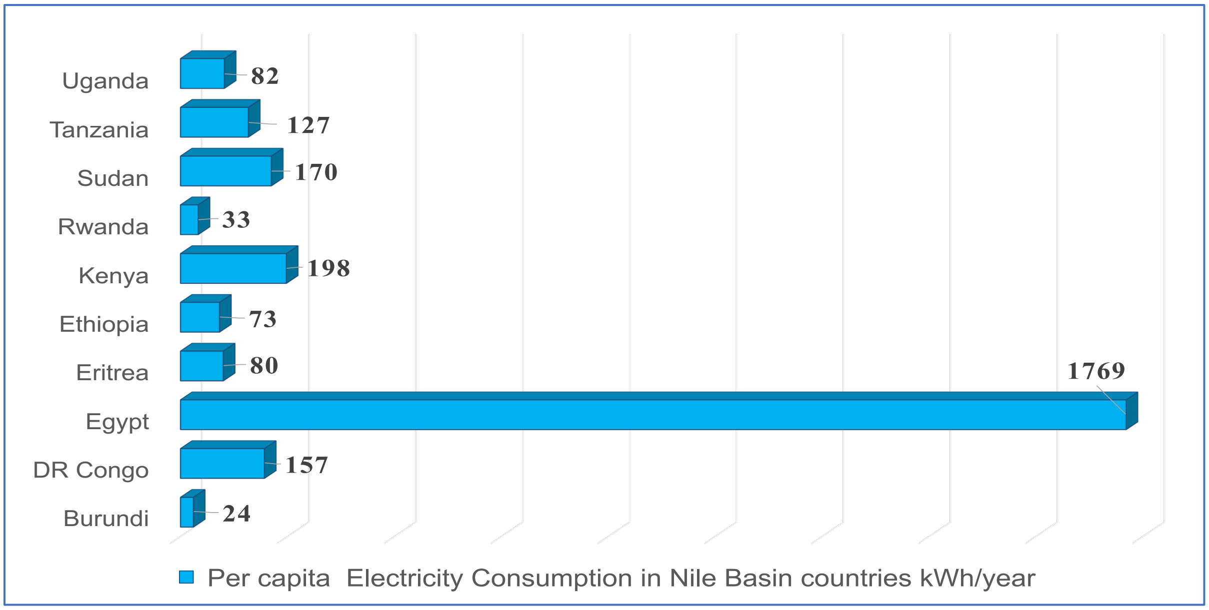

Figure 2–6 Nile countries Electricity Consumption Per Capita (NBI 2010)

The level of dependency on electricity being generated by hydropower as an energy source is different from country to country along the basin (Table 2-5). Hydropower is the largest source of electricity in DR Congo, Ethiopia, Burundi, and Uganda, and it provides a substantial share of total power production in Kenya, Sudan, Tanzania, and Rwanda. However, its contribution is relatively insignificant in Egypt, South Sudan, and Eritrea. The latter two countries rely almost entirely on thermal plants and operate no hydropower facilities, although South Sudan has enormous untapped hydropower potential (NBI, 2011). Current energy supply cannot be considered as energy availability per capita since there is a big difference among access in urban and rural areas in each of Nile riparian states. Currently, 83% of Ethiopia's population lacks access to electricity, with 94% still relying on fuelwood for daily cooking and heating (Tegenu, 2006). The Ethiopian government is, therefore, pursuing ambitious plans to develop hydropower in an effort to substantially reduce poverty and create an atmosphere for social change (Table 2-5).

With constant growing population and industrial or economic development, it is implausible to achieve self-sufficiency in energy security, especially in the context of developing nations of the Nile Basin. Access to a reliable source of energy is still shallow in urban areas (12% and 17% in Rwanda and South Sudan, respectively) and extremely low in rural areas (less than 2% and 3% in Tanzania and Burundi, respectively) (Strategic Foresight Group, 2013). Reliable electricity supply is now a priority in every Nile riparian state's strategic economic plan, and foreign investors are brooding on the potential opportunities (NBI, 2014).

Table 2–5 Projected energy demand and current supply in the Nile Basin (CBWS, 2011)

Country	Projected Energy Demand (GWh)	Current energy supply (GWh)	Hydropower as percentage of total installed capacity (%)
Burundi	525	245	89
DR Congo	13568	6911	99
Egypt	147273	146796	12
Ethiopia	6335	3823	95
Kenya	8292	5785	50
Rwanda	413	418	33
Sudan	7211	7499	49
Tanzania	6069	4792	47
Uganda	2819	2636	85
Total	**192505**	**178905**	

The potential for hydropower generation in the Nile basin exceed 23661 MW (including GERD) in addition to current production (Table 2-6). The White Nile drops some 500 m between Lake Victoria and Lake Albert, representing an estimated capacity of over 4000 MW, of which 380 MW is currently operational (NBI, 2011). In the Eastern Nile region, the fall of the Blue Nile (Abay) with 1300m high, between Lake Tana and the Sudanese borders could provide hydroelectricity over 8000 MW. The crucial additional potential exists along the Baro (2300 MW), Atbara (Tekeze) (450 MW) in Ethiopia, the Main Nile (3100 MW), and on the various smaller rivers in the upstream catchments, such as the Kagera (265 MW) and Semliki (100 MW) (Hamdy & Al Rasheedy, 2007).

Partial or full transboundary water cooperation in hydropower development would enable Nile riparian countries to unlock their enormous hydropower potential and allow for effective joint action for developing hydropower infrastructure and sharing the benefit. Projections in the growth of power demand indicate that the integrated system peak demand will equal the total hydropower potential in the region by 2030 (Table 2-5). Therefore, developing supplementary and diversifying non-conventional renewable resources such as wind and solar would help bridge the energy deficits and would ensure power supply less vulnerable, which is a subject for other studies to investigate on those opportunities (NBCBN, 2005).

The construction of Grand Ethiopian Renaissance Dam (GERD) in the Benishangul-Gumuz region of Ethiopia was begun in April 2011 with public and private investments. When completed, it will be the largest hydroelectric power plant and the largest reservoir in Africa. The dam is located in Ethiopia on the Blue Nile just upstream of the Ethiopian-Sudan border (Figure 2-7) with 170 m height the dam would provide storage 60 BCM, approximately 13 times more than Ethiopia's current total annual water consumption (Jameel, 2014). The Ethiopian government targets hydropower generation capacity from 6000 MW at peak output from GERD. This will almost double the amount of Ethiopia's electricity capacity, which currently stands at less than 1946 MW and bring additional 15000 GWh/a of hydropower production for Ethiopia (Jameel, 2014) (International Rivers, 2014).

Table 2–6 Nile riparian countries' existing & potential hydropower generation capacity inside and outside the Nile Bain (NBI, 2011)

Country	Existing Capasity in Nile Basin (MW)	Potential Capacity in Nile Basin (MW)	Potential Capacity in Other basins (MW)
Burundi	0	20	385
DR Congo	0	78	45722
Egypt	2862	40	0
Ethiopia	1946	15409	4699
Kenya	25	191	445
Rwanda	27	20	144
Sudan	1593	3280	0
Tanzania	0	280	3222
Uganda	380	4343	0
Total	**6833**	**23661**	**54617**

The potential impacts of the dam have been the source of regional debates and disagreements. The dam will control over 60–80% of the water resources that downstream countries, Sudan and Egypt, receive from the Nile and challenges the existing Nile water allocation (Mulat & Moges, 2014). Egypt with almost 97% dependency on Nile waters has the most to concern and has made its protests against the dam construction quite clear. Both countries claim rights to the Nile waters under the 1929 and 1959 Nile treaty. Ethiopian Prime Minister Helamariam Desalegn had declared the GERD's primary purpose is hydropower generation yet uncertainty remains about whether it will be used for large-scale irrigation schemes in the long-term (Sudan Vision, February 2014).

Ethiopian government also argues that the GERD will be a source of hydroelectric power for the entire region and will be a great contributor to the flood and sediment control for downstream states. In 2014, Ethiopia exported 100 MWh of electricity to Sudan, 35 MWh to Djibouti and 60 MWh to Kenya and earned USD 40 million from exports according to the Ethiopian Electric Power Corporation (EEPCO) (Yihdego, Rieu-Clarke, & Cascão, 2016). These numbers are expected to rise multifold by extending the export destinations to other Nile riparian countries when GERD is fully operational and will increase the venue for power trade along the Nile basin (NBI, 2012). The GERD could affect Egypt negatively in three ways. First, if the filling of the reservoir takes place during a dry year in which the Blue Nile flow is low, Egypt may not be able to have sufficient water supplies to meet its agricultural needs from Aswan High Dam. The second impact occurs after the GERD is completed. During a sequence of drought years, Egypt could have water shortage if the operation of the GERD was not coordinated with Aswan High Dam. Lastly, Egypt could receive less water due to upstream irrigation withdrawals (Mulat & Moges, 2014) (Cascão, 2009).

Figure 2–7 GERD Location (red square). Green area is the Eastern Nile without indicating South Sudan's border.

The GERD is a unilateral Ethiopian project, but with clear intent for coordination with downstream countries. In April 2014, Ethiopia's Prime Minister invited Egypt and Sudan to a series of discussions over then under construction dam. In August 2014, a Tripartite Ministerial-level meeting agreed to set up a Tripartite National Committee meeting. Finally, after two years of closed-door negotiations, Egypt, Ethiopia, and Sudan signed a declaration on 23 March 2015 demonstrating a step towards a prosperous era of formal cooperation over Nile waters outside of the standing Nile treaty (Ejigu, 2016).

The Declaration of Principles, which will be discussed in Section 2.3.4 of the current chapter, has promised to resolve issues over the GERD project, however, it left other questions open with regard to the conditions under which Ethiopia can adjust the agreed rules of filling and operating the dam, and the impact of the dam on Egypt's historical share in the Nile. Ethiopia has act amicably by cooperating and by agreeing to share benefits to attract regional and international support for the ongoing project, much doubt and discussion remain on how the GERD would be filled. It is in Ethiopia's advantage to fill the dam as soon as possible so that hydropower generation can commence and reach capacity as planned subsequently bringing in significant revenue.

However, meanwhile downstream countries will be interested in filling the reservoir more slowly to reduce any impacts in current water availability (Tawfik, 2015). Still, concrete steps for trust building among the Nile basin countries are required to create a cooperative political environment for future negotiations and developing joint projects with mutual benefits for all equitably (Zedan, 2014). The present study aims to contribute to developing a tool for enhancing cooperation among politicians.

2.2 History of Cooperation Among Nile Riparian States

2.2.1 Previous attempts at cooperation in the Nile Basin

Hydro-political cooperation in the Nile Basin is not a recent phenomenon. There are records of agreements and conflicts that date back as far as pre-Egyptian civilization. For the most part, cooperation was achieved by military might rather than mutual understanding and benefit-sharing, so the previous attempts at mutual cooperation among the Nile riparian have mainly been a failure (Ibrahim, 2015). The Nile attracted European colonial powers because it gave access to the center of Africa and its wealth. For most of the 19th and the 20^{th} century, most countries in the Nile region were under colonial rule. Egypt was colonized by Britain till 1937 and Sudan till 1956. Italy entered the "Horn of Africa" through Eritrea, and France and Belgium became colonial neighbors in Equatorial region of the basin. Although the colonialist had a varying degree of influence in its politics, Ethiopia was the only country to remain independent despite several attempts by various colonial powers to control it. Colonization formed many new states in the Nile region (Eritrea, Uganda, Rwanda, Burundi, Kenya, and Tanganyika) and set off new competition for resources and territory. Therefore, the first legal document of Nile is traced back to the 1902 agreement among colonial powers (Zeidan, 2013).

In the late nineteenth century, since control over the Nile and its vital resource were the key to African wealth, for Egypt control of Nile became a primary objective and priority. Therefore, the 1902 treaty served as a document to enforce water utilization policies that favored only Egypt at the expense of the whole basin. To this effect, the British concluded various agreements with those states of the Nile under their control to secure the unfettered flow of water to Egypt. The legal regime as of the "informal protectorate" of the British over the Nile basin resulted in series of treaties concluded by the British with the upstream states: they were border treaties, among colonial powers and Egypt or Ethiopia. With the end of British colonial rule in the area, Egypt pursued the same objective and claimed the whole of the Nile waters (Yohannes, 2008) (Obeng, 2012). This section of the study attempted to piece together a chronological history of Nile river basin cooperative agreements recording only the most significant ones.

Egyptian and Sudanese demand on a monopoly over the Nile waters in the past only served to worsen regional tensions and made cooperation more difficult. The Nile treaty is the only legal document to govern the development of water resources across borders in the Nile River basin, but it is contentious for 9 of the 11 riparian states. Mostly the Nile treaty gives 100% water rights to Egypt and Sudan (Asante, 1993).

Table 2–7 Nile treaties, agreements and development highlights during the Nile's Colonial period

3100 BC	Nile Valley and delta had coalesced into a single entity forming the first nation, laying the foundation for geo-political development and Egyptian thought
2125–1975 BC	Dams, Canals and supply pipes were built, to control flooding, supply water to settlements and to facilitate food production
1975–1640 BC	Basin irrigation was in practice; water flow was regulated and flood plains cultivated
1550–1070 BC	Construction of large dams, fortification and temples along the Nile (Baines, 2011)
1866 AD	Napoleon III opens Suez Canal and six years later in 1972 British prime minister Benjamin Disraeli bought 44% share from Egyptian ruler Ismail
1891: The Anglo-Italian Protocol	The treaty outlined the colonial territorial claims of Britain and Italy and their distinction in domains of influence in Eastern Africa
1898	Britain and France are almost in military conflict over the Nile waters when a French expedition tries to take control of the Nile headwaters of the White Nile. Later political settlements are made, the incident dramatized the Egypt's vulnerable dependence on the river and fixed the attitude of the policy makers ever since (Pacific Institute, 2013)
1902: Treaty between Great Britain and Ethiopia	Britain and Ethiopia signed an agreement on the May 15th that dealt with restrictions on construction of any dams or barrage across the rivers flowing from Ethiopia toward Sudan
1906: Tripartite Treaty	On December, 1906, the agreement between Britain, France and Italy was signed in London. without consulting Ethiopia. This tripartite treaty was considered by Ethiopia to be a sinister colonial ploy directed against the sovereignty of Ethiopia.
1925: Anglo-Italian Exchange of Notes	It aimed against Ethiopians concocted as a result of Britain's continued efforts to pursue its interests in controlling the headwaters of the Blue Nile in Lake Tana. As a result of discussions, Britain accepted Italy's offer and ensuing Anglo-Italian negotiations to make an agreement in the form of Note Exchange and the agreement never materialized
1929: Nile Water Agreement	First agreement of water use rights in the Nile basin treaty signed on behalf of its colonies by British government (Lewis, 2012). By this agreement, Egypt accepted Sudan's right to water adequate enough for its own development, as long as Egypt's "natural and historic rights" were protected
1932: Anglo-Egyptian Agreement, Construction of the Jebel Auliya Dams	Jebel Auliya Dam (upstream of Khartoum) was built with the capacity of 3 Km^3 south of Khartoum was built to improve the natural storage of Nile. The agreement allowed Egypt to regulate the flows of the White Nile to supply enough water for its winter crops by constructing a regulation dam at Jebel Auliya. It was a direct derivative of the 1929 Nile Water Agreement.
1934: Anglo-Belgian Treaty	The Treaty was signed in London between Great Britain and Belgium. This treaty addressed the distribution of the waters of the Kagera river in the colonies of Tanganyika and Rwanda/Burundi
1959: Nile Waters Agreement between Egypt and Sudan	• Egypt needed the support of Sudan for obtaining funds from international bank for reconstruction and development, for the construction of high priority Aswan high dam, thus inclusion of Sudan and compensation of relocation were issued. • Egypt took 55.5bn m^3/yr to irrigate 7.1mn/ha, whereas Sudan settled for 18.5bn m^3/yr. Together accounts for 74bn m^3/yr that is almost 100% of Nile flow measured at Aswan high, with 10 bn m^3/yr lost to evaporation. • Egypt and Sudan were only users of Nile waters and not contributors, but they signed the agreement of full utilization of Nile waters without the consent of the other 8 riparian states. • Egypt guaranteed development of Sudan's dams with finance and technical expertise. In agreement with Egypt, Sudan would construct dams along the Sudd swamps on the White Nile to harness and enhance the Nile flow. The cost and benefit to be shared between the two. • The agreement granted Egypt the permission to build Aswan High and Sudan to build the

The Nile Basin modern day problems are, just put a recipe for disaster here is why:

a) The 1929 Nile basin treaty involved only Egypt and Sudan (and South Sudan) and disregarded the other eight nations.

b) In 1958 Egypt sent an unsuccessful military campaign against Sudan with the intentions to unify Sudan and Egypt, this came to be after failed negotiations over Nile waters and Sudanese general elections. After a pro-Egyptian government was elected a second treaty was signed by Egypt and Sudan in 1959, once again neglecting all the other riparian states, the treaty dictated by the former apportioned the waters between the two nations with Egypt taking 55.5 BCM/a and Sudan 18.5 BCM/a of the 84 BCM/a with about 10 BCM/a lost to evaporation. Having secured a satisfactory position Egypt refuses to discuss these agreements, and naturally, the rest of the countries insist on contravening the colonial-era agreement that hampers their development (Pacific Institute, 2013).

c) Between 1929 and 1959, five dams were built in Egypt and Sudan, a mechanism to secure their position as rapidly as feasible. Many of the Sudanese dams were sponsored by Egypt (Yohannes, 2008).

d) Egypt has maintained the monopoly on technical expertise and hydrology of the Nile, and the status quo of last two decades had served Egypt's interest well, it does not want to budge.

e) Even though Egypt has more to gain from cooperation compared to any other riparian country, Unilateral water withdrawal by the others would leave Egypt with the fear of drying out.

f) Egypt has made several attempts to unify and consolidate the position of other diplomats on Nile water issues, but it has always been in the best interest of Egypt alone thus most of these arrangements have failed. Egypt maintains a position of open to discussion but only subject to acknowledgment and non-negotiable legitimization of 1959 treaty (Cascão, 2011).

g) Historically Egypt has led an insecure stance because 97% of its lands are barren with 82 million people concentrated in roughly 3% of its area, the need to protect the stable and steady supply of water is paramount. Egypt also claims that they have an annual water deficit of 10 BCM and that every additional 1 BCM reduction would cause 84013 ha to go out of production (Kingsley & Whittington, 1981).

h) Ethiopia on the other hand, with an annual population growth of 2.13% has high ambitions of development. Egypt is agitated over Ethiopia's plans for building Africa's largest hydropower plant, the GERD which some studies indicated that it would reduce the Nile flow by 27% of the annual share during the filling period (Kingsley & Whittington, 1981)

i) In June 2013, Egyptian President Mohammed Morsi said "We do not want war ... however, we did not accept threats to our security" and claimed that all possible responses to the dam remained open to Egypt – a line that has been interpreted as a threat of force. In response, Getachew Reda, official spokesman for Ethiopian Prime Minister said Morsi's speech was irresponsible and that "nothing is going to stop the Renaissance Dam. Not even a threat will stop it" (Kingsley & Whittington, 1981).

j) For Ethiopia, it is a matter of sovereignty and national pride as much as a strategic decision of development. Most Ethiopians feel that the Nile belongs to them and that none, let alone Egypt has the right to dictate terms (Kalpakian, 2015). Egypt, on the other hand, wants the international community, Nile riparian states including Ethiopia to act following the 1959 treaty, this is the crux of the problem.

k) Now Ethiopia having seen success with the GERD; 4.3 billion USD required was raised by sales of stock shares of the dam to the general public that would eventually earn 5-6% interest, supposedly wants to build 4 more dams that would together generate 11,000 MWh of electricity, work to begin after the completion of GERD in 2017.

l) Ethiopia also has plans to sign an agreement with at least five other riparian states on the use of Nile waters, effectively taking control away from Egypt. This further puts Egypt in a precarious situation (Kingsley & Whittington, 1981).

m) Sudan, however, has had many disputes with Ethiopia on matters of dam constructions, because as far as Sudan is concerned the 1902 treaty signed by the British colonial government restricts Ethiopia from building any dams without the permission of Sudan. Egypt has always sided with Sudan even though the agreement was made between colonial governments and is not valid any longer (Sanchez & Gupta, 2011).

Table 2–8 Post-colonial era agreements and development highlights

1981: Kagera Basin Organization	Signed among Burundi; Rwanda; Tanzania, United Republic of; Uganda. Accession of Uganda to the agreement pertaining to the creation of the organization for the management and development of the Kagera river basin.
1992: TECCONILE Project:	An Agreement was signed by Ministers from six countries (Egypt, Rwanda, Sudan, U.R of Tanzania, Uganda, and the now Democratic Republic of Congo). The other four countries (Burundi, Kenya, Eritrea and Ethiopia) participated as observers. They agreed that future co-operation on water resource matters should be pursued for a transitional period under the name "Technical Co-operation for the Promotion of the Development and Environmental Protection of the Nile Basin" (TECCONILE).
1993: Ethio-Egyptian Framework Agreement	An agreement as an attempt for general cooperation between Ethiopia and Egypt was signed on July 1st, 1993, in Cairo. It was not binding and just had symbolic value.
1994: The Lake Victoria Agreement	Signed by Kenya, Tanzania and Uganda regarding Lake Victoria. To adopted "The convention for the establishment of the Lake Victoria Fisheries Organization (LVFO)". It supposed to coordinate the fisheries policies and legislation among member countries.
1999: Nile Basin Initiative	All riparian states (except Eritrea) joined in a dialogue to design an institutional mechanism for cooperation. They jointly created an inclusive regional partnership, to facilitate the common pursuit of the sustainable development and management of Nile waters.
2010: Comprehensive Framework Agreement (CFA)	Signed by 6 Nile Riparians, the CFA establishes the principle that each Nile Basin state has the right to use, within its territory, the waters of the Nile River Basin, and lays down a number of factors for determining equitable and reasonable utilization
2010: GERD Construction	Started in 2010 and expected to finish in 2017
2015: Declaration of Principles	Among Eastern Nile Riparian Countries, Ethiopia, Sudan and Egypt.

Though the colonial era ended in the 1960s for much of the African continent, colonial hangover policies, such as the 1959 Nile treaty, still dictate resource distribution and use. The 1960s were considered as a new era in the continent by the emergence of independent states. Among Nile Basin, riparian countries, Tanzania became independent in 1960, DR Congo in 1960, Uganda in 1962 and Kenya in 1963. The other two former Belgian colonies, Burundi and Rwanda also became independent in 1962 (Adedeji, 1993). These countries inherited unfair and unbalanced treaties that were concluded on their behalf by colonial powers and other active third parties. Increased cooperation between upstream nations since 1960, has resulted in the binding CFA which is known as Entebbe Agreement as well, for restructuring allocations and control over the Nile's resources equitably and cooperatively (Obeng, 2012). The geopolitical shift in the region has led to a proliferation of upstream developments, including dams and irrigation networks.

These events are often met with condemnation and protest from Egypt, which is extremely protective over its decreasing share of the Nile's waters.

Egypt has been at the forefront of engagement and dialogue in sharing Nile waters, the negative aspects of such arrangements were that either it excluded the main contributor Ethiopia and/or that it, Egypt, never was willing to discuss the 55.5 BCM/a agreement, based on 1959 treaty. One may argue that if Egypt increased its efficiency, it could perhaps cope with the water allocation, but Egypt claims that it already recycles at least 20% of its water and water use efficiency is at maximum possible level. In the Early 80s Egypt formed a Nile consultative group called Undugu comprising all the riparian states, it presented long-term plans of Nile basin development and benefit sharing. It aspires to generate hydroelectricity from dams built along the Nile e.g. Inga dam in Uganda, Roseires in Sudan and Aswan in Egypt, for export to Jordan, Syria, Turkey and European nations via a single transmission grid. The benefits would then be shared among the Nile basin countries for irrigation projects (NBI, 2014). Furthermore, in 1987, Egypt began the North Sinai Agriculture Development Project (NSADP), 242,900 ha was to be irrigated by tunneling Nile waters to the North Sinai desert east of Suez Canal. The ultimate plan is to transport Nile waters as far as El Arish; a town just 40 km from the Gaza strip (Wolf A. T., 1998).

The upper riparian nations are demanding equitable and reasonable utilization of the Nile waters among all the riparian states in accord with the principles of international water law. They have challenged the validity of the 1902 and 1929 treaties, and have further indicated that they have not consented to the 1959 agreement (Pham, 2010). Upstream countries, such as Uganda and Ethiopia, have already started acting on development plans for harnessing their unofficial water shares, without any institution to harmonize these development actions across borders (Wolf A. T., 2005). March 2012, the Ugandan President Yoweri Museveni warned Egypt by saying "this egocentric monopoly on the uses of Nile waters must stop." Kenyan Government declared in 2012 that it would not accept any restrictions on the use of Nile water. Tanzania began work on a project to divert Nile waters to supply much-needed drinking and domestic use water to dry inland towns about 170 km from Lake Victoria. In response, the Egyptian government stated that it would be willing to provide technical and financial aid to Nile basin countries but refused to negotiate 1959 treaty; in effect declined to cooperate (Paisley & Henshaw, 2013).

Nevertheless, in the case of the GERD, as mentioned, the governments of Egypt, Ethiopia, and Sudan engaged in discussions from 2013 until March 2015 when they reached an agreement on Declaration of Principles on the GERD project. The whole process was taken outside any official institutional structure but instead seem to have positive effects on present diplomatic opportunities for future Nile basin development (BMBF, 2015). In addition to the complexity of the region's hydro-politics, the recent independence of South Sudan has changed the geopolitical balance in the region. Two months after its independence in July 2011, South Sudan began seeking to join the Nile Basin Initiative (NBI) and was admitted as a full member in the same month. The South Sudanese government currently controls 28% of the Nile's flow; however, it is likely that this allocation will require new arrangements between South Sudan and Sudan (NBI, 2011).

As far as the Nile basin is concerned, there is no single binding agreement to acknowledge that all riparian countries have rights to Nile water resources or state these rights and limitations in any way to create an environment for trust and equitable water sharing. The current water allocation needs to be rearranged, and the new model is required to optimize the benefits from the river and promote cooperation between the Nile riparian countries. Therefore, there is an urgent need to foster negotiation process on the utilization of the Nile and sharing its benefits to avoid a potential crisis arising from unilateral actions by riparian states.

2.2.2 Nile Basin Initiative (NBI)

"To achieve sustainable socio-economic development through equitable utilization of and benefit from, the common Nile Basin water resources" (NBI-2010)

In 1960, the Hydromet survey project was established for technical cooperation on Nile water use among the riparian states. After 45 years of operation, it was shelved, and TECCONILE was initialized with similar objectives, and it functioned for six years before it too was abandoned. In line with attempts to bring the Nile riparian states together to discuss and to resolve their differences, the World Bank and some other donors facilitated a formal setting for cooperation between all the Nile riparian in 1997, which was called the Nile Basin Initiative (NBI). Water ministers of Burundi, DR Congo, Ethiopia, Egypt, Kenya, Rwanda, Sudan, Tanzania, and Uganda, formally launched NBI as a regional intergovernmental partnership, in February 1999 while Eritrea served as an observer (Paisley & Henshaw, 2013).

NBI serves as a (transitional) institutional framework for managing transboundary trade-offs and opportunities, such as sharing hydropower benefits, stronger integration in agriculture markets and regional trade. NBI also explores the possibility of treating ecosystem services as public goods. Alignment of development policies with regional markets led by cooperation is good examples of an integrated approach to managing and govern limited resources." (Salman M. , 2013).

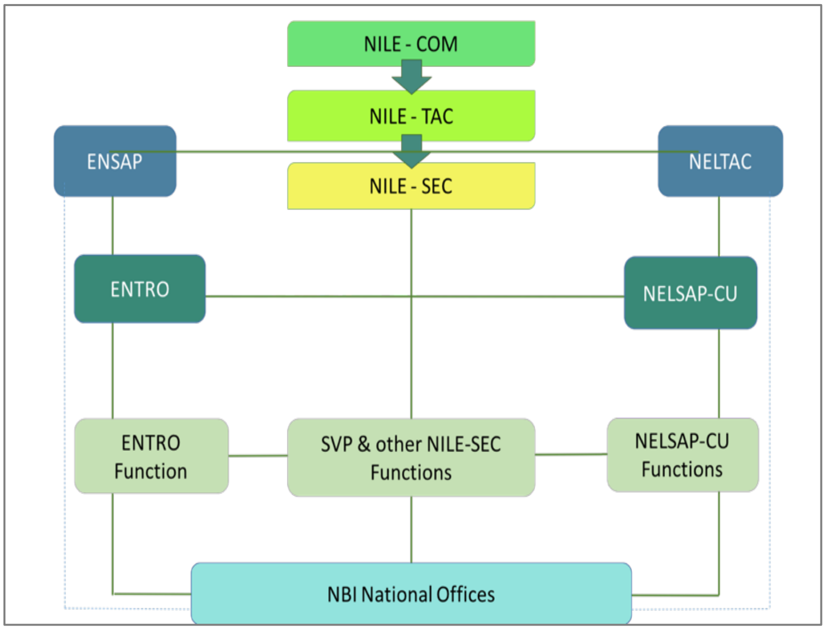

Figure 2–8 Nile Basin Initiative (NBI) institutional set-up in 2009

The Nile River Basin Cooperative Framework Agreement in 44 articles of NBI clearly define the intention, utilization, sustainability, optimization, benefit sharing and cost sharing principles of the riparian states (NBI, 2014). The operational structure consists of the Nile Council of Ministers of Water Affairs (Nile-COM), supported by a Technical Advisory Committee (Nile-TAC), which includes of two representatives from each country's water ministries and a regional secretariat. The chairmanship of both the Nile-COM and Nile-TAC have roistered annually on a rotational basis. Continuous administration of the NBI program is carried out by the NBI Secretariat, which is located in Entebbe. As it is illustrated in (Figure 2-8), by 2009, several other bodies had been merged since NBI's inception, such as Eastern Nile Subsidiary Action Program Technical (ENSAP), Nile Equatorial Lakes Technical Advisory Committee (NELTAC), Eastern Nile Technical Regional Office (ENTRO), and Nile Equatorial Lakes Subsidiary Action Program Coordination Unit (NELSAP-CU) and NBI National Offices (Figure 2-8).

The primary objective of the NBI is to conclude a basin-wide cooperative agreement that would incorporate the principles, arrangements, and institutions of the NBI. However, the process has run into some significant difficulties as a result of retracing back to the colonial treaties. Egypt and Sudan claim to their existing rights and uses of the Nile waters on the one hand, and the demands for equitable utilization of the Nile waters by the upstream riparian states on the contrary (Ahmed, 2006).

2.2.3 Cooperative Framework Agreement (CFA)

One of the significant failures of the past attempts at a cooperative framework in the basin revolved around the fact that the sensitive issue of the previous agreements had not been resolved. In the early 1990s, parallel to the workings of the NBI, technical experts, and international donors began to draft a new cooperative initiative, led by upstream countries requiring a new legal framework into cooperation negotiation process (Arsano & Tamrat, 2005). To achieve this, a series of negotiations began in 1997 and were completed in 2007. It has, however, not been accepted by all basin states as of yet.

In an attempt to address the demands of Egypt and Sudan, and the position of the upstream riparian states the CFA councils introduced the concept of water security. CFA defined water security as "the right of all Nile Basin States to reliable access to and uses of the Nile River system for health, agriculture, livelihoods, production, and the environment" (Salman M. , 2013). Once CFA is ratified and endorsed by all Nile Countries, it enables the establishment of a permanent cooperation institution calls the "Nile Basin Commission (NBC)" (Figure 2-9). CFA requires a two-thirds majority to ratify in establishing the NBC as the legal and institutional authority regarding Nile Basin management in the context of consumption, development, and protection for promoting and facilitating the implementation of the principles, rights, and obligations for cooperation between the riparian states (Yohannes, 2008). However, Egypt and Sudan have objections to the CFA document and have suspended this discussion in the NBI activities in 2010 (Cascão, 2009).

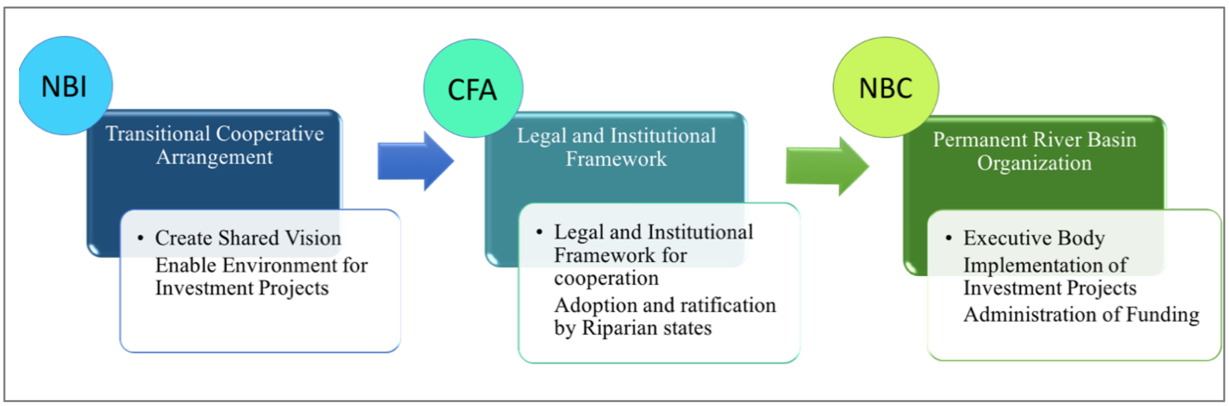

Figure 2–9 NBI and CFA co-relation (2010)

In 2010, CFA document was finalized, and six upstream riparian countries (Ethiopia, Kenya, Uganda, Rwanda, Burundi, and Tanzania) signed and endorsed it, following that in August 2014. Signature of the CFA is an intermediate step by which countries indicate their willingness to ratify the Treaty in the future, yet they are under no legal obligation to ratify. The CFA will only be adopted when six Nile Basin countries deposit the instruments of ratification at the African Union. Signature of the treaty puts countries under an commitment not to set any acts that would undermine the objective and purpose of the CFA. According to NBI (2017), only three countries of Ethiopia, Tanzania, and Rwanda have ratified the CFA up to date. Egypt and Sudan maintain their position. Once CFA has fully approved a trust funded by all the countries and institutions involved, would contribute to the development of Nile waters by financing various projects in riparian states that could benefit the entire region. Egypt maintains that the Cooperative Framework will destroy cooperation forged thus far through the NBI.

2.3 Eastern Nile Basin

2.3.1 Overview

The focus of this research study is the Eastern Nile River Basin composed of Egypt, Sudan, and Ethiopia. Because of the geopolitical status and low contribution to the river, Eritrea and South Sudan are excluded from the model.

The Eastern Nile Basin is a vital part of the Nile Basin system considering that two (Egypt and Sudan) of the three countries are almost entirely dependent on the river for survival and the third (Ethiopia) country has potentially exclusive control of the river since the river originates in its borders. There is an inherent volatile conflict situation waiting until explosion due to many internal and external factors that persistently aggravate the risks and uncertainty in the eastern part of the Nile Basin. It is imperative that cooperation for the management of the Eastern Nile be established to avoid disastrous socio-economic consequences (Nigatu & Dinar, 2011). The historic and strategic relationship between these countries has been bred on mistrust and exploitation however progress has been unhurried but steadily gaining ground on a win-for-all opportunity in cooperative development. Cooperative transboundary management of Nile is an intractable zero-sum game which is a guarantee for the success of the foreign policy, national security, and economic growth if it happens. Studies report that Eastern Nile is already a stressed system where multilateral cooperation is the rational choice, and the most sustainable and beneficial strategy for the whole Nile Basin eventually (Ibrahim, 2015).

Eastern Nile basin covers 1.7 million km^2 60 % of the Nile River basin in the watershed area. Eastern Nile Basin has a population of 240 million 54 % of Nile River basin, and the fact that most of the constructed and planned development projects exist in this region adds to its significance (Block, Strzepek, & Balaji, 2007). The average water availability in the Eastern Nile Basin is expected to decrease from 2000 m^3/capita per year in 2002, to 760 m^3/capita per year in 2030 (Strategic Foresight Group, 2013). The White Nile (including Sobat River) contributes about 28% (about 23 BCM) of the total Nile flow. The remaining 72% of the flow of the Nile (about 61 BCM) is derived from both the Blue Nile (59%, 50 BCM) and the Atbara River (13%, 11 BCM) (Swain, 2011).

Egypt's extreme reliance on the Nile for its electricity, water, and food security is the primary source of conflict in the river basin, but the fact remains that Egypt does not have an alternative.

A tenth of Egypt's electricity generation capacity comes from the Aswan High dam alone. Egypt already overdraws on its water allocation, but its increasing water demand along with shifting geostrategic alliances among upstream nations especially Ethiopia will result in a likely decrease in distribution and availability of water (Awulachew, McCartney, Steenhuis, & Ahmed, 2008). Unless it embarks on a large-scale refurbishment of its inefficient water networks, Egypt could experience major water crises in the coming years, which may trigger conflicts (Blackmore & Whittington, 2011).

Ethiopia argues that Egypt's development is constrained more by the lack of power than lack of water. Thus, a mutually beneficial arrangement would appear to be possible on water and power, whereby Egypt would agree to a higher water allocation for Ethiopia and to the construction of reservoirs on Eastern Nile, on the condition that a certain percentage of the electricity generated would be sold to Egypt at a specified price. Due to Egypt's growing demands for electricity, the Blue Nile reservoirs may be more valuable for their hydroelectric power generation than for water regulation and storage (Arsano & Tamrat, 2005). Reservoirs would also control Eastern Nile floods, which could be particularly beneficial to Sudan. Added upstream storage would facilitate the expansion of Sudan's gravity-fed irrigated areas, which in turn would mean greater crop production. It could be possible to negotiate an arrangement whereby Ethiopia would trade electricity to Egypt and Sudan in return for agricultural and/or industrial products (Awulachew, McCartney, Steenhuis, & Ahmed, 2008).

Given that the balance of regional structural power has changed in Ethiopia’s favor due to Egypt’s recent political instability. Another potential Ethiopian gain from cooperation is economic means since Egypt can prevent Ethiopian loans for hydro-development from international donors for projected development projects (Ashebir, 2009). Although Ethiopia has access to Chinese finances with a different interest rate, different payment conditions, and austerity, differences in repayment terms, access to other sources of loans could be beneficial as well. Finally, cooperation can ensure Ethiopian water security and resources even if the balance of power in the future happens not to be in their favor to the same extent as it currently is (Jameel, 2014).

Despite all mentioned, yet the Nile basin’s security question is how to resonate with the society regardless of the political motives behind framing it. Many Egyptians see upstream development and the challenge to the traditional water allocation status quo as a risk to their livelihood despite upstream assurances of compassionate intentions. Declaration of Principles provides assurance to some level even though it does not have legal enforcement power (Tsega, 2017). It should be considered by governments of the three countries that an essential part of security issues is the psychological aspect; the perception of insecurity and perception of the threat is the dominant factor for any conflict.

From the perspective of national security, it is strategically dangerous to become entirely dependent on one resource alone. However, Sudan and Egypt practically have no other alternative when it comes to water. Even if the international conflicts surrounding the Nile are disregarded, it is a fact that overdependence on the Nile Basin has been putting downstream countries in over-vulnerable position (Salman S. M., 2016). Beside water dependency, another issue threating the livelihood of inhabitants of Eastern Nile Countries is Food Insecurity. In the following sections, we focus on these two subjects.

2.3.2 Water Dependency

When the internal supply is below the national demand, then the country is dependent on external sources such as surface flow like rivers, lakes or in extreme cases imports or desalinization. In which case, the quantity of water imported or required from external sources is described as water dependency (Sadoff, et al., 2015).

Table 2–9 Water dependency ratio in the Eastern Nile States – AQUASTAT

Eastern Nile Countries	Water dependency ratio %
Sudan	96,13
Egypt	96,91
Ethiopia	0,00

Although Ethiopia does not have any dependency, the imprudent water use efficiency at 40% makes the Nile basin water sharing nexus more arduous (Hamdy & Al Rasheedy, 2007). As the basin's downstream countries of Egypt and Sudan are in the most vulnerable state as they have no contribution or control to the Nile but are entirely dependent on it (Table 2-9). It was considered clear that Egypt's water security would best be achieved through cooperation (Hamdy & Al Rasheedy, 2007). Egypt's interests in cooperation were acknowledged principally as pragmatic, namely: a) keep being alerted and try to take control over the development of upstream water infrastructure, even providing Egypt with veto power at the Nile Basin Initiative (NBI); b) to divert attention from the controversial 'water- sharing' paradigm towards a more consensual 'benefit-sharing' model, and delay potential renegotiations of existing water agreements and c) to be able to use a greater share of Nile flows, once these have been made available through cooperative' river engineering projects meanwhile in Sudan and Ethiopia.

According to many studies, alternatives to the Nile waters available to Egypt are desalinization, water recycling, water rations for households and water pricing to increase water use efficiency, and importing water, but cooperation with the other countries in the Nile basin is the most economical, feasible and most beneficial sustainable solution in the long term (Sadoff, et al., 2015), (Wolf A. T., 2005), (Arsano & Tamrat, 2005), (Cascão, 2009).

2.3.3 Food Self-Sufficiency

Since the last 7000 years, crop production has been continuous in the Nile Valley specifically in the floodplains of Egypt. Ancient Egyptians were one of the first civilizations to develop irrigation; they controlled and channeled water to fields of Wheat, Millets, Onions, Cotton, and garden vegetables using dams and channels (FAO, 2011). Agriculture accounts for roughly 80% of the Nile water consumption while at best, only 50% agriculture efficiency can be achieved (AQUASTAT, 2000) The general pattern followed in Egypt is cultivation of high water demand cash crops irrigated by surface flooding of basins or furrows, where evaporation reduces the yield per unit of water thus adds to inefficiency, drip, and sprinkler irrigation could improve the situation, but 70% of the farmers cannot afford these high-tech products (Figure 2-10) (Appelgren & Klohn, 1997).

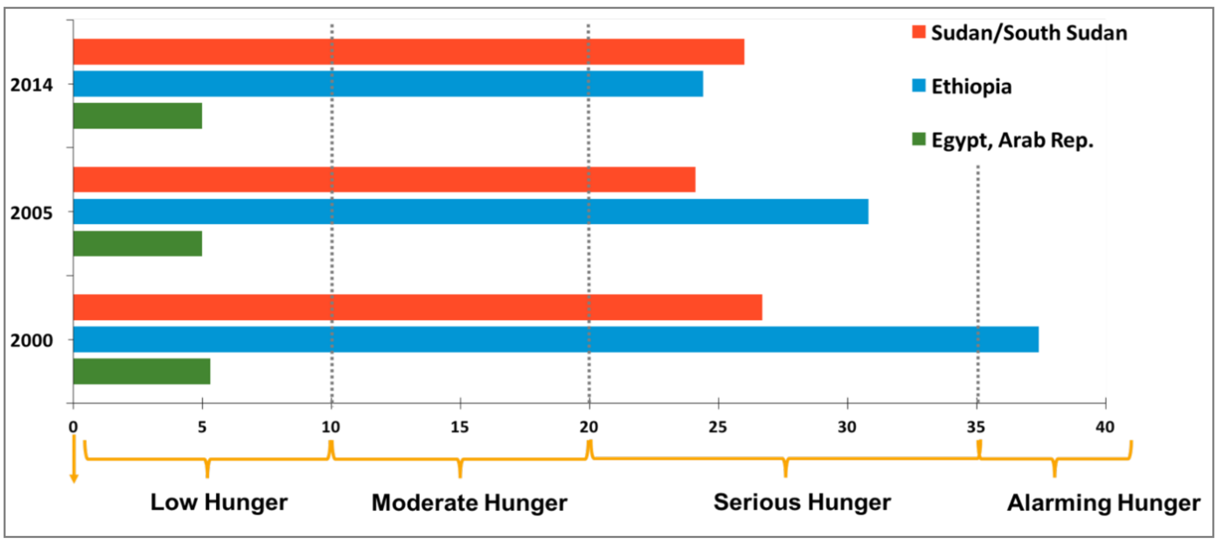

Figure 2–10 Food Security Index in the Eastern Nile Basin (IFPRI, 2015)

Further away toward the Nile downstream, almost all crop and horticulture production in Egypt is irrigated, i.e., 99.8%. Of the 3.5 million ha of cultivated lands in the country 3.27 million ha, lie within the Nile Basin and Delta; only 0.2 million ha is rainfed. Of this 3.27 million ha about 2.26 million ha are old lands[3] , and the rest reclaimed[4] land (El-Nahrawy, 2011). Egypt's per capita was availability in 1990 was at 1,123 m^3/a, in 2005 it was at 771 m^3/a, currently (2013) at 700 m^3/a and is projected to be at 582 m^3/a by 2025. Ipso facto, 82.5 million Egyptians are extremely water poor, ranks 8th in the world in the so-called "water security risk index" (Sustainable Water

[3] *Old lands refer to land that was traditionally under cultivation i.e. before 1950's when the desert reclamation programs were begun.*

[4] *Reclaimed is a term used for anti-desertification practice employed by Egypt. Where forcibly marginally fertile desert lands are irrigated and cultivated.*

Technologies, 2013). 81% of all the total renewable water resources are consumed by the agriculture sector with calamitous average 45% efficiency water use, although drip and sprinkler are being introduced (10% of total irrigated lands) lack of funds make it a lead-footed attempt to match the run of product demand and cultivation expansion (Abdin & Gaafar, 2009). The rest 90% of irrigation is either furrow or flood, which is an obtuse choice of practice considering its vulnerability. Egypt currently runs on a deficit of 15 BCM/a (70 billion m^3/a consumption) this is due to lifestyle changes and overambitious projects of reclaiming the barren lands by irrigation (Kingsley & Whittington, 1981). Sudan is also planning to increase the area irrigated in the Eastern Nile Basin. Further new projects and extension of existing schemes are anticipated to add an extra 889,340 ha by 2025. An additional 4,000 million m^3 of storage will be created by raising the height of the current Roseires dam by 10m (Figure 2-11) (Omer, 2011).

Sudan's agriculture ambitions are constricted by the 1959 agreement that allows for only 18.5 BCM/a of Nile water to be used. Previously the 1929 agreement has even a stronger stranglehold, that permitted only about 450000 ha to be irrigated, post-1959 the total irrigable areas are increased to 550,000 ha. Preponderantly the Sudanese government funds own and operate these irrigation projects such as Gezira Scheme[5] which funded and developed Sennar dam in 1913 to facilitate cotton production (Arjoon, Yasir Mohamed, Goor, & Tilmant, 2014). The Sudanese government undertook the project in 1950 and completed the Manaqil Extension on the western front of the Gezira scheme, which together with accounted for 460000 ha of irrigated fields in production. During the 1960's, Sudan built the Khashm el-girba dam in 1964 on the Atbara River and began the Halfa irrigation project, which irrigated 200000 ha without using either Blue or White Nile water. By 1990 the dam had 40% of siltation and was ineffective in providing irrigation to the project (U.S. Library of Congress, 2013).

In 1966, Roseires dam was completed with funding from Egypt and international organizations. It provided power and irrigation to the Rahad River irrigation project with the coverage of 63000 ha, by 1981, 80% of that area was under irrigation (International Water Management Institute, 2012). The Eastern Nile waters were pumped with the power from the Roseires dam via 8 km of canals to the Rahad river, passing the Dinar river. General practice of furrow irrigation was prevalent in the Rahad area, but with only 30 – 40% efficiency, furthermore, evaporation accounted for 20 – 30% loss. Sudan is blessed with an area of 120 – 150 million ha receiving precipitation above 1200mm/a in the southern half and close to 3 million ha of swamplands (Sudd) yet most of the irrigation projects and schemes planned are in the middle of the arid areas close to the Egyptian border, e.g., Halfa and Rahad (Figure 2-11) (Omer, 2011).

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[5] *Gezira project was initiated in the colonial era by the Sudan Plantations Syndicate (a private British enterprise) in the year 1911.*

South Sudan is claiming a share of the Nile waters allotted to Sudan to meet the needs of its agricultural projects that need rehabilitation as discussed earlier, and its existing and planned projects, as well as the growing requirements of the returning southern Sudanese. Work on the Bedden Dam on Bahr el Jebel, south of Juba, is already underway. This would mean that the competing demands of the two countries may not be easy to meet with the current allocation to the Sudan of 18.5 BCM (International Water Management Institute, 2012).

Figure 2–11 Existing & under construction dams on the Nile River

On the other hand, in upstream, Ethiopia managed a number of impediments to improving its agricultural development and productivity. It is well endowed with fertile volcanic soils rich in minerals and micronutrients; however, due to mountainous terrain, the topography is a significant issue in the highlands where water storage for irrigation is an exasperated issue. In the lowlands, animal husbandry is the primary form of production (Nigatu & Dinar, 2011). Feudal land tenure system was the major hurdle for agriculture development in Ethiopia until 1974 land reforms. In 1975, the Ethiopian government successfully implemented a national plan that allowed peasants the rights to own, maintain and cultivate up to 10 ha land. Ethiopia has 12 rivers with the discharge of 122 BCM/a and further 6.5 BCM/a of groundwater (Mellor & Dorosh, 2010). However, lacks civil and irrigation infrastructure to control, supply and use the water efficiently, an estimate by WRI[6] in 2010, suggests that only 3% of the total volume is used.

The total current dam capacity in the country is 5.56 BCM, the spatial and temporal distribution of precipitation is exceptionally uneven thus while some parts of the country endeavor 100+ days of rain other parts are drought stricken, e.g., a pipeline carries drinking water to Harar region from underground water source near Dire Dawa some 75 km away (NBI, 2011). Precipitation and temperature are determined by elevation, and seasonal shifts, e.g., highlands, i.e., above 1500m enjoy a pleasant climate of 16°C to 30°C daytime temperatures and cold nights coupled with an average of 848 mm/ rain. Whereas places like Danakil depression, the Ogaden in the southeast (Somalia), parts of southern (Kenya) and western borderlands (Sudan) experience temperatures between 30°C to 50°C with high humidity in the east and low humidity in the south and west (Mellor & Dorosh, 2010). Approximately 12.2 million ha is classified as agriculture land, of that 4.9 million ha is arable land, of that 350770 ha is under permanent crops, and 175,000 ha of the total arable land is irrigated. Approximately 80% of the entire population is employed in the agri-industry, agricultural output accounts for 89% of the exports and contributes 47.68% of the GDP (Jägerskog, Lexén, & Clausen, 2016). Agriculture is the backbone of the Ethiopian economy; development of physical and market infrastructure is imperative for the sector to progress.

Attaining food security in the region thus entails the agricultural industrialization which requires some significant aspects, including the deployment of sizable capital, modern farm machinery, heavy uses of fertilizers and pesticides, substantial amounts of energy, and construction of dams to continuously supply irrigation water. Dividing Nile water resources among the riparian states and impounding their respective shares for purposes of irrigation and hydropower generation does not guarantee food security (Yohannes, 2008). On the contrary, storing water resources throughout the basin can have enormous ecological and economic costs, unless accompanied

[6] *World Resource Institute – an autonomous non-governmental organization working at the intersection of the environment and socio-economic development.*

by a radical transformation of existing political structures and an open contestation of the prevailing mode of production.

2.3.4 The Declaration of Principles

On 3rd March 2015, the three Eastern Nile member states Egypt, Ethiopia and Sudan signed an Agreement on Declaration of Principles on the Grand Ethiopian Renaissance Dam Project (GERD) which spelled out modalities and core principles on how to cooperate and work together to use the Nile water more efficiently and effectively. In March 2015, the Foreign Ministers of the three Eastern Nile countries reached a preliminary agreement, which was signed two weeks later by the heads of state and government in Khartoum. Abdel-Fattah al-Sisi, who ousted Mr. Morsi in a coup, joined Hailemariam Desalegn, Ethiopia's prime minister, and Omar al-Bashir, Sudan's president, to sign a declaration that tacitly blesses construction of the dam so long as there is no "significant harm" to downstream countries (Mason, 2005). The agreement was declared in December when the three countries settled on two French firms to study the dam's potential impact. The three states agreed to cooperate in the implementation of outcomes of joint studies on the GERD. Specifically, they agreed on guidelines and rules for filling of GERD, the annual operation of GERD, and to inform downstream States of any unforeseen or urgent circumstances. Priority is also given to downstream states to purchase power generated by GERD. They agreed as well to work together on the dam safety (Salman S. M., 2016).

The most significant provisions of the "Declaration of Principles (DOP)" were drawn from the UN Convention on the Law of the Non-Navigational Uses of International Watercourses (hereafter, UN Convention). The Convention was adopted by the General Assembly of the United Nations on 21st May 1997 and was entered into force on 17th August 2014. The DOP is based on international guidelines or framework for such agreements between riparian states that share a common watercourse with varying degrees of historical use, need, and colonial period experiences (Tawfik, 2015).

Compromises were offered by both Egypt and Ethiopia to reach a mutually-agreed principle. Given its nature as a political statement that lacks technical detail and its silence on some crucial issues, the DOP has opened the door for various interpretations and expectations and left some outstanding matters to be resolved in future negotiations. Concerning the benefits of the project to downstream countries, the declaration gave priority to Egypt and Sudan in purchasing power generated by the dam, an article which seems of more significant benefit to Sudan than to Egypt. As for the project's contribution to regional integration, the declaration reflected the Ethiopian conception of 'generation of sustainable and reliable clean energy supply' as a cornerstone of trilateral cooperation which does not count for the potential environmental impact the dam projects. In the DOP, ten main principles were considered concerning the Grand Ethiopian Renaissance Dam (GERD):

(1) The principle of Cooperation
(2) The principle of development, regional integration, and sustainability
(3) The principle of not causing significant damage
(4) The principle of fair and appropriate use
(5) The principle of the dam's storage reservoir first filling, and dam operation policies
(6) The principle of building trust
(7) The principle of exchange of information and data
(8) The principle of dam security
(9) The principle of the sovereignty, unity and territorial integrity of the states
(10)The principle of the peaceful settlement of disputes

Ethiopia insists that it will only generate power and that the water driving its turbines (less some evaporation during storage) will ultimately reseases from the other side. However, Egypt fears it will also be used for irrigation, cutting downstream supply. Experts are skeptical. "It makes no technological or economic sense [for Ethiopia] to irrigate land with that water," as it would involve pumping it back upstream, says Kenneth Strzepek of the Massachusetts Institute of Technology (Block, Strzepek, & Balaji, 2007). The DOP is not a treaty; it can be considered in a court of law to show intent according to a valid claim by the suing nation (Salman S. M., 2016).

Although the DOP is a step towards cooperation and agreement in each riparian's development objective, however, it does not address all the uncertainties. It is only when the declaration is drafted into a comprehensive technical agreement, it would adequately determine whether the GERD would position three Eastern Nile countries better off, and thus whether the agreement would be a successful case of benefit-sharing. The DOP has not framed in a positive-sum game or "win-win" manner (Tawfik, 2015). Even though the current tripartite agreement seemed to have temporarily eased the recent tightness among the parties, and despite some of the positive aspects of the Egyptian diplomatic overtures and its intent to cooperate as spelled out in the DOP.

2.4 Perspectives of opportunities for cooperation in the Eastern Nile Basin

The attempt to institutionalize management and allocation of the Nile water resources in the last decade shows the importance of the resource for socio-economic development for each riparian, but it also reveals how the Nile is a politicized and vulnerable basin in general. The current outcome is still a mix of progressive cooperative processes and an enduring diplomatic and legal deadlock among upstream and downstream riparian states. The long-term stability of cooperation in the Nile Basin relies heavily on the outcome of the diplomatic negotiations between the Nile riparian states, namely the adoption or even rejection of the Cooperative Framework Agreement (NBI, 2011).

Over the last decade, national decision makers have frequently met in various regional forums, and other stakeholders (technicians, academics, legal experts, civil society) have become increasingly present and influential in the decision-making process. However, trust and confidence are difficult parameters to measure. On the one hand, riparian states are now keener to maintain dialogue on critical issues, which shows their increased understanding of a need for cooperation and advantages of benefit-sharing. On the other hand, their historical grievances remain decisive factor resulting in the lack of confidence in the context of negotiations and national media outputs (Zedan, 2014).

As discussed, there is no comprehensive agreement till date acceptable to all Eastern Nile Basin states, as well as in the entire Nile River basin exists. The absence of such an agreement has resulted in regional food-water-energy insecurity. It is the lack of a basin-wide agreement and the current situation in the basin that urges one to look for a legal and practical approach as a decision-support tool that could address the problems in the basin for future progress. Considering that several large hydropower projects are under construction along the Nile, and much more have been identified for immediate implementation, it is necessary that a basin-wide joint impact assessment need to be undertaken to identify related cost and benefits, possible risks and formulate mitigation measures. Implementing any projects with international implications without a well-defined regional framework is a complex task and makes it risky to guarantee long-term stability and even jeopardies it (Cascão, 2011). Additionally, without such a framework it is difficult for international institutions and companies to invest because the risks are too high, lack of regional framework means there is no accountability and any conflict could destabilize the entire region and consequently the projects. The aim of initiating cooperation in the Eastern Nile is to move away from controversial water-sharing agreements towards a more comprehensive understanding of transboundary water cooperation and its potential to generate additional benefits (Sadoff & Grey, 2002, 2005).

The benefits of regional shared water cooperation outspread to ecological, economic, political features, and also beyond the river for the good of all. However, these remarkable benefits can only be realized through genuine interested, well-planned and organized joint collective action. Indeed, only through such cooperation can the Nile Basin countries move beyond the narrow definition of the volumetric water security and develop into the realms of achieving sustainable food-water-energy security. From the perspective of Water-energy-food Nexus framework, the most relevant factors of equitable and reasonable utilization are the social and economic needs of the watercourse concerned, the population dependent on the watercourse and the availability of alternatives for a particular planned or existing use. While existing uses of the watercourse is also one of the factors to be taken into account when deciding on equitable and reasonable utilization, the nexus approach requires that States understand their common interests in enhancing water, food and energy security in a transboundary context and are willing to negotiate on the changes to existing use patterns (Bizikova, Roy, Swanson, Venema, & McCandless, 2013).

Also, it should be considered that it remains difficult for decision makers of Eastern Nile countries to understand entirely the range of economic, social and environmental benefits of cooperation and how they could be traded among the riparian states. The Eastern Nile Basin countries have invested momentous time, effort, and resources for regular negotiation over benefit sharing on the Nile and have experimented with different solutions to achieve progress. Even though divergences still exist today (NBI, 2014). The Eastern Nile Basin is witnessing a noticeable improvement in both the extent and quality of cooperation amongst member countries, with a sustained change from questioning whether a cooperative approach should be pursued, to asking questions on how cooperation could be prosecuted and whether the 'perceived benefits' will be sustained and equitable for all. The improved Eastern Nile Cooperation brought an enabling environment for joint water resources management, which could lead to joint planning and implementation of investment projects that would result in benefits to the citizens of all Nile riparian states.

3 Chapter 3: Transboundary Rivers and Basin-wide Cooperation

3.1 Introduction

"Water is a trigger for conflict but a reason to make peace." – Leif Ohlsson[7]

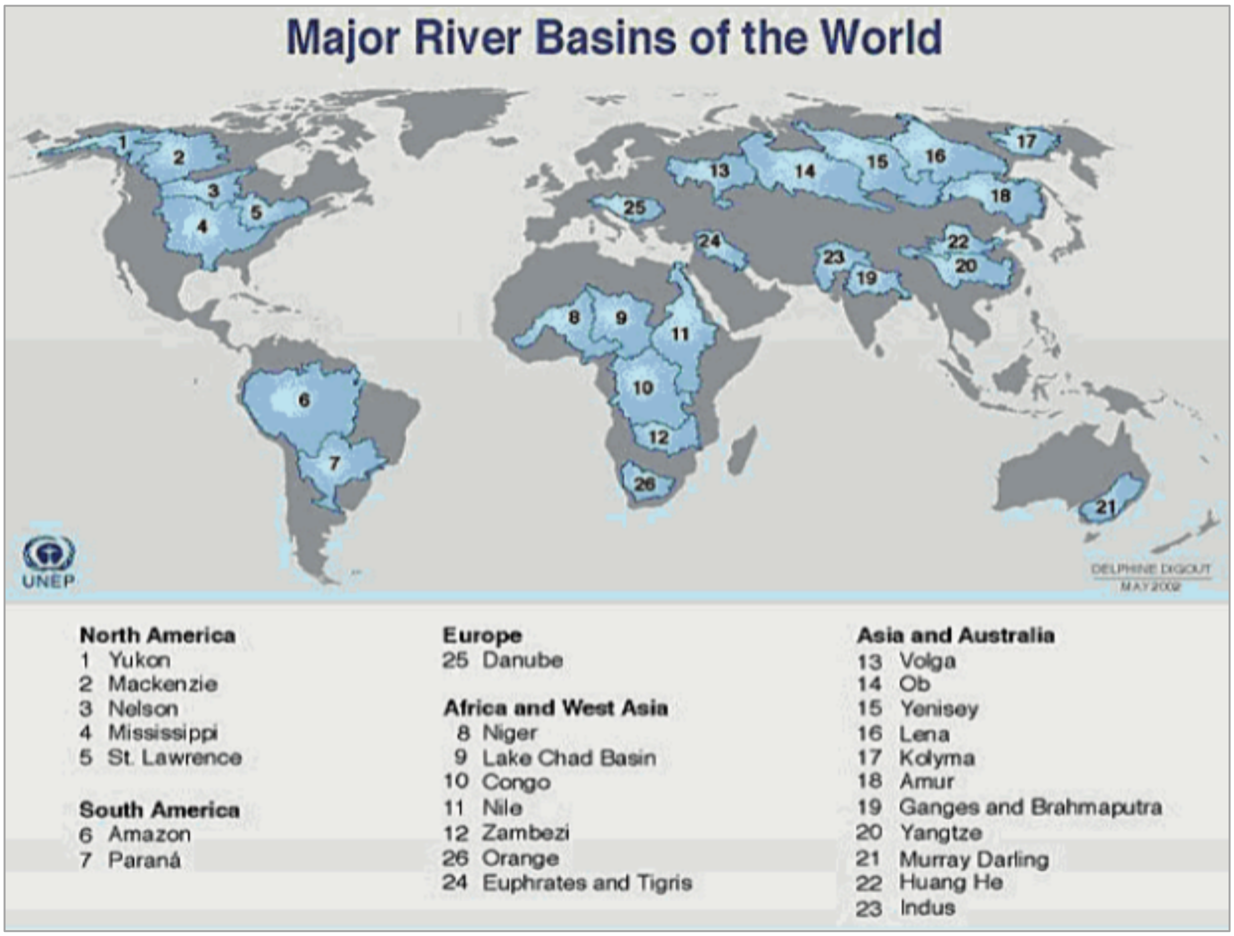

Figure 3–1 World's river basins location (Amu Darya and Syr Darya Basins are not included in the map) (UNEP 2008)

Natural systems usually do not coincide with human-made borders; more than 500 transboundary freshwater rivers, lakes, and aquifers traverse the imaginary geopolitical dotted lines of 151 countries. The 276 existing transboundary lakes and river basins cover nearly one-

[7] *Researcher, Department of Social Sciences, Orebro University, Sweden. Statement is from "water scarcity and conflict", in Security Challenges of the 21st Century, Bern/Frankfurt, 1999.*

half of the Earth's land surface and account for an estimated 60% of global water flow (Figure 3-2) (UNESCO, 2009). As (Figure 3-1) illustrates, there are 26 main transboundary river and aquifer basins around the world.

River basins such as the Nile, the Senegal, the Indus, the Ganges, the Danube, the Euphrates-Tigris, the Amu Darya and the Syr Darya, Amazon and the Mekong, are based in regions infected by inter/intrastate tensions over the shared waters, more often with a history of armed conflicts for different reasons. Diplomacy and cooperative foreign policy can help to improve resource management in this case management of shared water through transboundary governance, which could give decision-makers pertinent reasons to make progress on regional cooperation and conflict prevention (Moller, 2005).

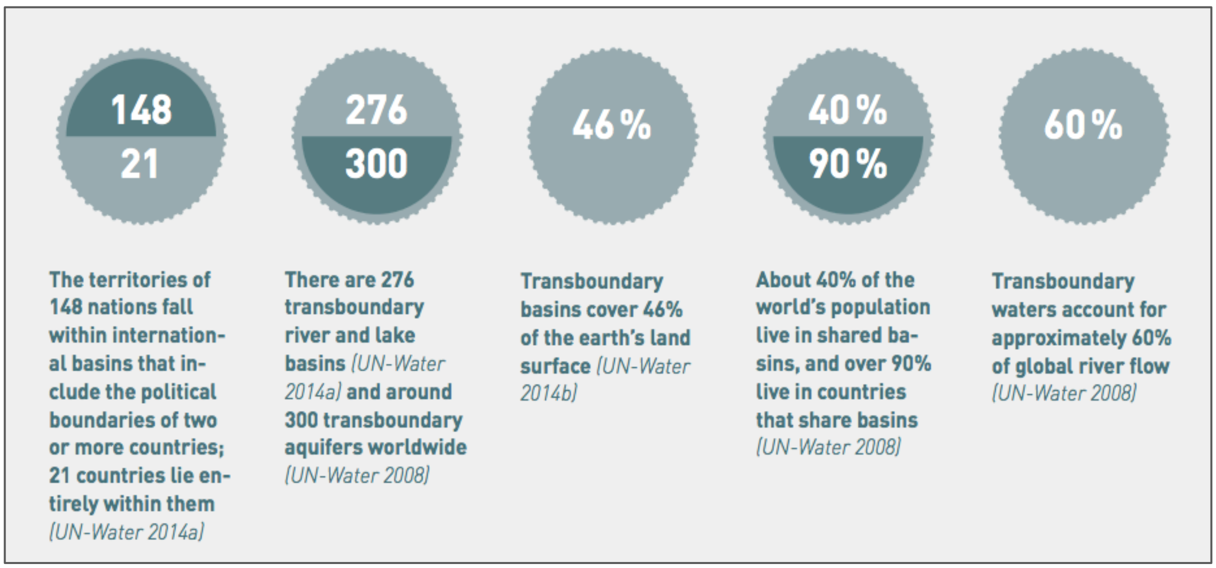

Figure 3–2 Global Transboundary Waters (UN Water, 2015)

Competition over water access in every transboundary basin is likely to increase because there is a general perception of immediate water scarcity caused by unsustainable extraction, ecosystem degradation, climate change, pollution, and population growth. This situation is turning unpredictable because people and governments feel threatened with famine and death in the case of denied access. Water scarcity to a state is of particular security concern and therefore strategic, especially when water-scarce nations rely heavily on transboundary flows (De Man, 2016). National boundaries make water issues political, and so the complexities of Transboundary Water Management multiply. This situation is a massive challenge for transboundary water governance, where each riparian state has its agenda filled with ambition, challenges, and threats. Building resilience[8] to water scarcity and drought requires sufficient collaboration across sectors and among stakeholders (FAO, 2016). Given the size and scale of the challenge, we need an effective governing framework that brings together actors from a range of sectors to work pro-actively to address these obstacles (Josef & Kipping, 2006).

While there is a potential for discourse and conflict, transboundary basins also provide more significant opportunities for cooperation in trade and security. Contemporary transboundary water management is a process combination of sharing water for different allocations and consistently resolving conflicts among its stakeholders. While cross-border cooperation has often been difficult, experience has shown that sharing a resource as precious as water can be a catalyst for cooperation rather than conflicts (Dinar A. , 2007). Transboundary water-related challenges force governments and other stakeholders towards closer cooperation to safeguard the availability of adequate water, and also to ensure that appropriate measures are taken in the interest of water security. Rhine river basin, in northwest Europe, is evidence of such cooperation (IWA, 2015). The nine Rhine riparian countries voluntarily decided and created a governance mechanism for continued cooperative transboundary management of its waters, which mainly focuses on quality and flood control since 1950 (Dombrowsky, 2008).

Across the world, hundreds of agreements have been signed in the course of history and even hundreds of institutions had been set up to manage water equitably and sustainably. However, fewer than half of the world's transboundary basins are subject to any formal agreement outlining how the resources are to be shared and managed cooperatively (Girando, Shira, & Wolf, 2003). There are even fewer water bodies (116 out of 276 transboundary basins) have ever had institutionalized cooperative practices (Schmeier & Gerlak, 2014). We have selected four basins (Mekong, Danube, Brahmaputra, and Senegal) as examples of successful cases in concluding and implementing cooperative agreements.

In bringing together diverging interests of riparian states, one creates a state of mutual economic interdependence, which could enhance interest in collaborative management through legitimate agreements. Transboundary river agreements act as capacity building measures to boost social and economic cohesion in the region and by extension peace and security (IWA, 2015). Nevertheless, such agreements must capture future uncertainties with foresight as much as

8 Definition: Because of the dynamic and evolving nature of water resource systems, proper consideration of uncertainty and associated information, whether obtained from well-defined numerical data or vague linguistic articulation, is essential for better understanding and proper management of their well-being. (Johannessen A., Rosemarin A., Thomalla F., Gerger Swartling T., Axel Stenstrom T., Vulturius G. (2014) International Journal of Disaster Risk Reduction).

resolving contemporary water-related issues. For example, even though the Indus water treaty is a successful cooperative transboundary water management agreement between India and Pakistan, it does not provision for environmental changes as such the current climate change may put the past successful institutions at risk (Zawahri, 2008). Such agreements must be flexible to adapt and change to external spurs whether there are variations in the ecosystem, climate or socio-economics of the population.

This study applies a broad perspective to transboundary water management and governance to help to achieve a sustainable basin-wide cooperative agreement. For doing so, this research assesses vital factors which are useful in enhancing cooperation among decision makers of the Eastern Nile Basin riparian countries. The aim is to contribute to the promotion of cooperative transboundary water management agreements through the negotiation process in compliance with the institutional and international legal framework to achieve cooperation in the Eastern Nile Basin. Here the emphasis is on rivers systems as a basin-wide economic resource through the development of a transboundary river all participating riparians can develop their economies. That involves the identification of appropriate control and management strategies to maximize performance, production, and economic gains. This chapter points to the range of additional economic benefits that can be derived from shared waters. The study also demonstrates that trust-building and transparency as fundamental requirements and are viable instruments for cooperation in transboundary decision-making and negotiations.

3.2 Managing Transboundary Water Resources: What has been done?

Recent literature on transboundary water management explored linkages between resource scarcity, population growth, political instability, and conflict. In conclusion, we find that limited and unfair distribution of water resources are leading potential areas for political, economic, and social tension. Recent research found that often a population's lack of access rather than supply leads to the notion of scarcity. Access to fresh water is more a function of social, political, or technological factors that influence the demand trend (UN-Water, 2013) (Allan & Mirumachi, 2010) (Cosgrove, 2003) (Josef & Kipping, 2006) (Dinar S. , 2009).

Water scarcity risks are classified into two primary domains: first, insufficient water to meet basic needs for survival and livelihood (as the consequence of political and development instability). Second, lost economic opportunities (the risks that result from inadequate policy responses) (Dinar S. , 2009) (Grey & Sadoff, 2007).

3.2.1 Water: A source of conflict or catalyst for greater cooperation

Bosen & Ravnborg (2004), predicted the possibility of the "water war," they argued that nations facing water scarcity would lead to international conflict. This statement is based on highly selective evidence from arid basins, i.e., Jordan, Tigris, Euphrates, Indus, and the Nile. A comprehensive study of transboundary water-related events between 1948 and 1999 by Wolf et al. (2003) exposed a more balanced reality: 67% of all water-related events on transboundary rivers were cooperative; 28 % were conflictive, and 5 % were neutral. Indus River basin, for instance, is the most often-cited example of international cooperation on the water in an otherwise hostile context. In 1960, the Indus waters treaty was concluded and signed by India and Pakistan. Given the war of independence and the ensuing need to resettle millions of refugees within the basin, negotiations over the Indus waters proved difficult, but eventually succeeded due to both states' interests in foreign aid for developing their water infrastructure and their dependence on reliable access to water (Zawahri, 2008).

Pereira et al. (2002), provided one of the first comprehensive analyses of water scarcity, where they identified natural causes, human activities, or intersections of both as triggers for physical water scarcity. With improved data collection and data sharing techniques, Brown & Matlock (2011) stated lack of water availability in one area could not be assumed as the overall condition of a larger scale, and it cannot be expected to remain water scarce forever. Likewise, water economist Menta (2003), defined water scarcity as the marginal value of one unit of water where a small change in the quantity of water and the associated values are based on human preferences and judgments that can vary considerably across the globe.

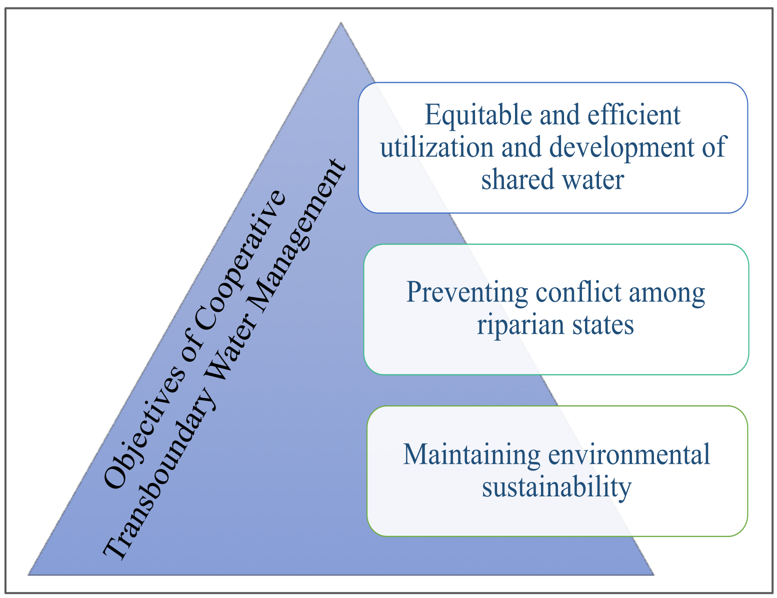

Figure 3–3 Transboundary Water Cooperation Pillars

Paradoxically the very water scarcity which often provokes conflicts is also an adamant motivation for cooperation (Kummu, 2010). As Deudney (1991) suggested, resource scarcity based on anthropogenic causes tends to promote joint efforts of neighboring states to halt such problems. Choucri & North (1975), have further indicated that countries that face high demands and limited resource availability would eventually seek to fulfill the need through trade or war. According to the "lateral pressure" theory proposed by Choucri & North (1975), when national capabilities and remedies cannot be achieved at a reasonable cost within national boundaries, they may be pursued beyond existing options.

Transboundary water management cooperation (Figure 3-3), is a combination of approaches to attain the objectives: 1) for equitable and efficient utilization and development of river basin including benefit sharing. 2) to prevent conflict and to foster basin-wide stability and security. 3) to provide environmental conservation by preserving and maintaining ecosystem balance (Wouters, 2013). Transboundary water management is a methodology for optimizing benefits for development and economic growth by clarifying trade-offs in transboundary water resources.

Islam & Susskind (2012), promoted the idea of water as a flexible resource in "Water Diplomacy Framework." Water scarcity is perceived and caused by drought, environmental changes, and unaccounted withdrawals, hence availability (Dinar & Dinar, 2005). Water scarcity may be intermittent and related to unstable political conditions or other situations such as terrorism and war (Tindall & Campbell, 2010), (Brochmann, 2006).

Creating a platform to develop a framework to understand and mitigate the risks of conflict is certainly one of the primary objectives of transboundary water management. It is also important to note that conflict prevention and resolution are highly political processes in which politicians make decisions on resource use, while political structures in the riparian countries affect related arrangements significantly (Chikozho, 2015). According to Earle et al. (2010), political borders divide the transboundary basins; politicians make decisions on transboundary water resources, and political structures of each of the riparian countries shape the status of transboundary water management in its unique way. In other words, the management of transboundary waters is heavily influenced by 'hydro-politics' and this must be taken into account when making capacity to achieve cooperation by the ratification of agreements at the basin level by all riparians (Kim and Glaumann, 2012). Kim & Glaumann (2012) stated that in practice, many transboundary basins lacked the required establishments to prevent and resolve conflicts and to coordinate resource sharing practices equitably.

3.2.2. From Conflict to Cooperation

UNDP (2010), stated that the prevention of water conflicts could not be realized without adequate cooperation in managing those waters through robust and equitable structures and institutions for collaboration at national and international levels. This cooperation should not be seen as a goal itself, rather an essential tool to meet the aims of each riparian country, improve water governance and attain clear progress towards security and sustainable development. For a long time, the view has persisted that in cases where multiple users share the same resource, water allocation was a zero-sum game in which one state's gain was equivalent to another's loss. New perspectives discount this perception for benefit sharing approaches by seeing it as a positive-sum game (Future Water, 2011) (Madani & Hipel, 2011).

From literature analysis, it is clear that transboundary river basins are characterized by profound economic and political asymmetries among the riparian countries which shape the nature of cooperative arrangements and some of the constraints that may emerge. Zeitoun & Mirumachi (2008) suggested an analytical method helping transboundary water initiatives respond to power asymmetry. They note that the most dominant riparian is often able to determine the outcome of any interaction with neighboring states towards its benefit as unilateral gains. There are two options: either find ways to strengthen the weaker players or level the playing field for cooperation. They also proposed strategies designed to enable effective cooperation by working to influence and challenge power asymmetry.

Grey & Sadoff (2002) and Connors (2006) reported on the advantages of practical cooperation at transboundary scale by leveling the playing field with political measures to justify why countries cooperate, and how this may be promoted. Adding political factors to the cooperation process makes the terrain for basin-wide negotiations more complex with different perception and expectation of the decision makers in the negotiation process. Since it is neither possible nor desirable to completely unbundle water's role from the complex dynamics of the relationship between riparian countries, diplomacy, benefit sharing, issue-linkage and international water law have to be considered as primary tools to pave the way for cooperative actions (Grey & Sadoff, 2007) (Jägerskog & Zeitoun, 2009).

Zeitoun & Mirumachi (2008), stated that conflict and cooperation co-exist. A set of power relations between riparian countries shape the transboundary waters which in turn may also contribute towards coexisting conflict and cooperation over the same waters. Often cooperation is measured in the form of existence of river basin organization or in the form of multilateral agreements where the political power that shows national interests are embedded. By assuming that conflict is the lack of cooperation, quantitative studies helpfully led us away from the threat of 'water wars' suggested by more environmentally determinist approaches. One common way to influence power asymmetry when it becomes challenging for cooperative actions is to derive positive-sum outcomes which promote "win-win" outcomes to satisfy all parties. The concept of "benefit sharing" is one of such methods. The idea is entirely rational from the perspective of the optimal use of a river, "win for all" solution is a reasonable perception (Sadoff & Grey, 2002).

In 2005, the United Nations (UN-Water, 2005) reported that even though the problems with transboundary waters were complex, it has been seen that water disputes can be mediated through diplomacy and equitable benefit-sharing strategies. Therefore, the effectiveness and sustainability of the cooperative arrangements is a key issue to concern beyond counting the number of agreements between states in a basin or the presence or absence of a basin management organization. In general, agreements that address the systematic complexity of the hydrological conditions, and provide a platform for the dynamic negotiation process are, in particular, more sustainable and ergo likely to be successful in the long-term (De Stefano, et al., 2012)

In summary, with the proper perspective, transboundary water resources can become a source of regional cooperation, peace, and security. Through the cooperative development of water resources, current tensions between riparian countries can be reconciled through political will and could bring economic, environmental, and social benefits to all the countries.

3.3 Cooperation: The keystone of success

The idea of "cooperation over transboundary rivers" to extract more benefits from the resource, has gained prevalence in the recent decades (Uitto & Duda, 2002). For instance, eleven European states collaborate on maintenance and development of the water resources of the Danube river. The Lesotho–South Africa collaboration on the Orange River basin demonstrates "even with power disparity; there is a possibility for agreement over water resources through economic benefits." Experience gained from South East Asia, Central Asia, Africa, and Latin America suggests that if appropriately orchestrated cooperation in transboundary water management can increase economic, environmental, and social benefits for the riparian states (Sadoff & Grey, 2002) (Chheang, 2010) (Crow & Singh, 2009).

A move from single-purpose to the multi-purpose planning of the river is necessary to capture the full range of potential benefits such as hydropower, irrigation, industrial, navigation, fisheries, etc. Phillips et al. (2006) indicated that joint development of shared water resources could provide additional benefits to all riparian countries by enhancing economies of scale, increasing planning horizons, bringing efficiency, reducing costs, and attracting the investments required for water resource development. Stakeholders cooperate when the perceived net benefits of cooperation are higher than that of non-cooperation, and when the distribution of the benefits seem fair (Phillips, Daoudy, McCaffrey, Öjendal, & Turton, 2006). The higher the perceived and potential gains, higher the possibility of cooperative management. A secure water future is likely to stem from some level of cooperation in transboundary management; it may be best served by information sharing alone, or together with coordinated action, or even with joint actions (such as joint infrastructure development). In all cases, this requires an appropriate joint institutional mechanism (Sadoff, et al., 2015).

Reliable updated information is often difficult to obtain, especially in developing countries which leads to misunderstanding and mistrust, thus impeding cooperation. In another word, the perception of cooperation is often discouraged by inaccurate information and lack of transparency, but that could be changed with more credible information sharing and trust building techniques (Wouters, 2013). A reliable database of water availability, allocation, and consumption, which includes meteorological, hydrological, and socio-economic data, is a fundamental tool for informed decision-making. According to Zeitoun & Mirumachi (2008), cooperation and regional agreements over water must satisfy several initial conditions; for instance, due to the impending influence of sovereignty on treaty formation, and cooperation in general, cooperative arrangements need to be "rational" for concerned individuals as decision makers. The idea of individual rationality presumes that countries decide independently whether to participate in a transboundary cooperation and negotiation process, with the ultimate aim of maximizing their individual benefits. The benefit structure of cooperative actions often affects the level and quality of cooperation.

Cooperation can take different forms, ranging from the initial level of communication to joint action and investment (Sadoff & Grey, 2002); similarly, there are different types and levels of incremental benefits such as economic, environmental, social and/or political. Effective cooperation can range from basic data sharing and hazard warning protocols to a fully integrated approach to developing and managing transboundary waters. The continuum of the cooperation can be conceived from unilateral and independent action towards coordination and collaboration to joint investment and managing development projects (De Man, 2016).

Successful transboundary water management requires a flexible and transparent decision-making process accounting for the diversity of knowledge, value, and interest. The complexity of interactions among population, geopolitics, and climatic conditions for transboundary cooperation over water is mirrored by the complexity of governance arrangements (Chikozho, 2015). Willis & Baker (2008), have presented conceptual models that can assist transboundary water management and stimulate national economic development. Building upon the benefit sharing concept, they offered the Transboundary Water Opportunity Analysis, which provided stakeholders with a framework to identify a variety of opportunities for a basin. Indeed, countries wish to understand the specific benefits of transboundary water cooperation which, though they may appear obvious, vary significantly according to many factors, including the upstream or downstream position, the levels of economic development and trade, and governance structures (Willis & Baker, 2008). Identifying and understanding the range of often interrelated benefits derived from the cooperative management and development of transboundary rivers is the pillar to better management of the basin. Creative combination of technical, economic and diplomatic approaches, being able to quantify the benefits of cooperation in the short and long-term in an equal and transparent manner motivates the riparian countries of every basin to build confidence and increase the willingness for higher quality cooperation.

3.4 Theoretical Approaches to Enhance Cooperation

While innovation in science and technology can expand the availability of quantity and quality of water, it cannot solve water problems that interconnect with the needs of individuals. To address these complex water problems at transboundary scale, approaches that go beyond applications of technology or the implementation of management policies are required to be considered and practiced. Such methods may provide a foundation for higher quality cooperation and avoiding conflict by giving the understanding of how the physical unit of the basin intersects with the economic, social and political aspects (Pham Do , Dinar, & McKinney, 2012). We introduce four methods as practical tools to promote and support cooperation in transboundary water management framework:

3.4.1 Benefit Sharing instead of water sharing

The use of benefits of water, rather than the allocation of water itself, provides by far the best scope for identifying mutually beneficial cooperative actions. The perception by all countries that a cooperative basin development and management plan which maximizes overall benefits are "fair" is essential to motivating and sustaining cooperation. Riparian countries should focus on optimizing the generation of basin-wide benefits at first, and secondly on sharing those benefits in a manner that is agreed as equitable.

From an economic perspective, benefit sharing is an efficient method to persuade cooperation as it helps riparian countries to apprehend win-win situations (Dombrowsky, 2008). While allocating transboundary waters; it has been more beneficial to focus on the benefits from the water, which means a zero-sum game of water sharing can be replaced by a positive-sum game of benefit sharing. Traditionally, transboundary water management involved allocating shared waters among countries. Most of the time fixed water allocation patterns can trap riparian countries in a "win-lose" situation with little room for compromise and no incentives for basin development and joint actions. Benefit sharing provides a more flexible basis that can intensely increase the range of cooperative opportunities and expand the economic gains in an equitable manner (UNESCO, 2013).

Efficient water resource management practices can increase the availability of water in the distribution system hence productivity. Consumptive and non-consumptive water uses are explored during the negotiation process, decision makers can decide on areas of benefits of cooperation and agree on the composition of available options. In most cases, sharing benefits will require some context-specific redistribution and compensation. Once a range of appropriate benefits is identified negotiation process can be structured around equitable distribution of those benefits among riparian states (Tilmant & Kinzelbach, 2012).

One approach to assessing the economic benefits of cooperation relies on hydro-economic modeling of a shared river (Whittington, Wu, & Sadoff, 2005). Hydro-economic modeling as a methodology presents various implementation strategies indicating the dimensions for cooperation. Another analytical approach to estimate the benefits of cooperation is game theory solutions such as the Shapley value and Nash equilibrium (Sechi & Zucca, 2015).

As yet there is no comprehensive universal benefit sharing strategy framework, therefore benefit sharing arrangements tend to be derived from case-to-case negotiations. Experiences from around the globe show that it is a lengthy process spanning many years especially if trust-building exercises are not initiated and established. Diplomacy can promote the speed and success of the negotiation processes.

3.4.2 Side-payments

In the transboundary cooperation context, side-payments are incentives, i.e., financial aid, trade preferences, technical assistance or access to an exclusive technology, etc. to induce cooperation among riparian states to join an agreement. The economic asymmetries between states (mainly wealthy and poor ones) will determine the forms of side-payments to encourage collaboration. Meanwhile, the geographic location of a riparian state on the river provides the other important variable in cooperation negotiations. In this study, by modeling the Eastern Nile river and designing an experimental game, the geographic location and economic power of each Eastern Nile riparian states form the combination of possible side-payments for decision makers.

It has been suggested that side-payments may be used to assist countries to choose cooperative actions, economically stronger states are, therefore, often able to provide weaker states with benefits or compensation to induce their cooperation to share natural resources (De Man, 2016). From cooperation and conflict perspective, the availability of side-payments makes cooperation looks more attractive and tackles problems of distribution and coordination of water use. In the latter situation, states cooperate when cooperation serves the interests of the most powerful country that takes the initiative in formulating a cooperative establishment (Young, 2005).

An alternative to side-payments may be the issue-linkage approach in negotiation. In literature, issue-linkage is introduced as a form of side-payment concept in which countries come up with non-monetary compensation models. Unlike side-payment which applies when policymakers use either direct monetary payments or quantifiable resources concessions, issue-linkage approach encourages cooperative actions by compensation on opportunities and issues related to the river directly or indirectly (Poast, 2013). As an attempt to avoid side-payment transfers and monetary exchanges among riparian states, issue-linkage may be employed not only to direct issues but also among unrelated and indirect matters, such as trade.

3.4.2.1 Issue-linkage

Issue-linkage is another approach that may be used to foster cooperation and modify payoffs for that cooperation. Issue-linkage mostly occurs when an upstream-downstream issue is linked to another aspect where the downstream state is in control and the upstream state is the demanding party. Given the geography of the Nile river, trade-offs among resources in the form of issue-linkage approach between riparian countries can bring a solution for cooperation. In this study, linkages among interests and preferences of decision makers of each Eastern Nile country, regarding water allocation and development plans took into consideration for designing the experiment.

Scholars highlight issue-linkage as a critical diplomatic tool enhancing bargaining strategy in the negotiation process. Notably, Martin (1995), defined issue-linkage as the simultaneous discussion of two or more issues to achieve a joint settlement. Wallace (2002), famously claimed: "linkage between unrelated or only slightly related issues to gain increased leverage in a negotiation is an ancient and accepted aspect of diplomacy." Thus, the prevailing view is issue-linkages can help states reach an otherwise hard-to-reach level of cooperation with side-payments, the motivation here is principally non-monetary (Martin, 1995) (Conca & Wallace, 2009).

In general, when states need to overcome problems that can appear during negotiations, such as resources distribution, financial enforcement, and a significant number of different interests, they may apply the issue-linkage approach to reach cooperative outcomes in the form of agreement and stay committed to receiving the benefit (UNESCO, 2013).

An understanding of hydrological processes of the river in its upstream-downstream linkages is the basis for the problem-solving in the basin and will serve as an appropriate input for effective and efficient planning for cooperative management strategies at international level. Furthermore, the negotiators must indeed recognize and accept that food-water-energy is an interconnected nexus on which economy, security, and political stability are based (Poast, 2013). Therefore, investigating and understanding the upstream-downstream linkages of the hydrological, social and environmental processes facilitates river modeling and data sharing among riparian states.

3.4.3 Water Diplomacy

Diplomacy is a mechanism frequently used within the consensus-building framework globally. It can be thought of as a "process of people coming together to build mutual understanding and trust across their differences, and to create positive outcomes through conversation" (De Man, 2016). Diplomacy may be used to achieve a range of results that are constructive even though they do not resolve the present dispute. These outcomes include building or strengthening mutual trust and understanding across differences; expanding participation around relevant issues; analyzing a problem or context jointly that is to develop a cooperative agenda for action (Islam & Susskind, 2013). Water diplomacy, therefore, is anticipated to play a progressively important role in preventing, mitigating and resolving the emergent water-related conflicts and creates room for cooperation.

The Water Diplomacy Framework developed by Islam and Susskind in 2013, offers a negotiated approach to managing complex water-related problems; building on the growing calls for using mutual gains negotiated criteria in transboundary disputes to overcome the historically zero-sum orientation towards innovatively resolving water issues at the basin scale. It focuses on positive-sum, or interest-based approaches to cross-border negotiations by challenging old-fashion thinking about water management in three assumptions: (1) water is a flexible, not a fixed resource (2) science, policy, and politics combine to create water networks (3) water networks are complex and need to be treated as open-ended and unpredictable rather than closed and predictable systems. These three fundamental assumptions embedded in the Water Diplomacy Framework have significant consequences for how water disputes solutions are approached (Islam & Susskind, 2013).

Zero-sum thinking emerges when people conceive of water as a fixed resource in quantity. One of the underlying principles of the Water Diplomacy is that water is a flexible resource in availability and riparian states need to use this insight to expand the probability of conflict resolution. It helps riparian countries shift focus away from allocating fixed quantities of water to "water flexibility" concept and to the overall advantages of assigning the benefits of cooperative water resources management (Islam & Susskind, 2013). Through a mutual gains approach, countries can brainstorm options for expanding the supply of water through conservation, wastewater recycling, technological advances such as desalination, and by imagining new agricultural or industrial processes that use water more efficiently, thereby freeing up more water for other purposes. Based on these assumptions, diplomats often focus on what share of the existing water will be given to each entity and how to share benefits are driven from cooperative development actions (Huntjens, Valk, Zhang, & Warner, 2015).

Although water diplomacy approaches may use technical methodologies and assessments as entry points, it is equally essential to design the process to engage politically with the highest levels of government so that they are fully aware of and buy into the process. Discussions between the heads of technical ministries while engaging academics and experts need to have support from top political leadership to ensure agreements are supported and implemented effectively (Alaerts, 2015). The framework recommends that a neutral facilitator is hired to conduct a stakeholder assessment; concluding an agreement for sharing a competing resource requires the mediator to be involved in the identification of mutual benefits and costs to the stakeholders, as well as devising the instruments of securing the benefits and minimizing the costs. Besides the value-creating method, Water Diplomacy has two other strategic analytical tools as described below.

3.4.3.1 Stakeholder Participation

One of the objectives of Water Diplomacy is to increase the knowledge and skills of stakeholders, actors and interested parties in negotiation skills to foster collaboration and win-win outcomes. Stakeholders can belong to one of these groups: Governments (national, provincial, municipal), businesses, academia, NGOs (national and international), communities (farmers, urban residents), etc.

Transboundary water management in many countries is characterized by overlapping and competing responsibilities among government bodies at national and international level. Disputes often arise when management decisions are formulated without sufficient participation by local communities and water users at all scales; failing to take into account local rights and practices. By tactics introduced by the Water Diplomacy Framework, stakeholders are encouraged to move beyond positions of interests, values, and practices, to come up with innovative ways of compensations and value creations. To meet common interests and to accommodate the needs of all involved parties (Islam & Susskind, 2013).

3.4.3.2 Joint fact-finding

According to Water Diplomacy Framework, the cause of many complex water problems lies at the intersection of multiple causal forces buried in observational signatures with often conflicting views and values related to who decides, who gets water and how? In such situations, neither numbers nor narratives will resolve the dilemma. One way to address these types of complex water allocation problems is to reframe them as joint decision-making from identifying and defining the problem to innovating and implementing mutual gains options for resolutions that can generate politically legitimate policies and projects based on science with the active participation of all stakeholders. In other words, rather than merely sending information back and forth, the Water Diplomacy Framework would encourage riparian states to collectively, through research collect data, assess benefits, values, and shared interests, conduct feasibility studies and develop a framework to address the outcomes (Islam & Susskind, 2013). Such fact-finding can be delegated to a group of technical experts to depoliticize the situation and discourage states from censoring information on national security-related issues. Such transparency in information gathering can contribute to trust building while creating an environment for cooperative negotiation.

It requires the states to work together to induce opportunities and develop responses to each alternative current and future issues. By promoting joint fact-finding in the negotiation process, it is possible to generate a deeper understanding of relevant topics by all decision makers. (See Appendix for Stakeholder Participation structure). Water diplomacy is a process which gives decision makers skills to identify opportunities for cooperation by reducing uncertainty around them, understanding incentives and to help in making participation politically more attractive than unilateral action (Islam & Susskind, 2013).

3.4.4 International Water Law

International water law obliges as a platform for facilitating transboundary cooperation. It provides a normative and institutional framework within which various aspects and drivers that affect the potential for cooperation can adequately accommodate issues of geography, resource availability and variability, governance, inter-state relations and power asymmetries, trade, colonial heritage, and diverse political regimes. International water laws address these matters at two levels: in most cases, policies are developed first, followed by laws which are specific and action-oriented (Beaumont, 2000). Meanwhile, negotiated agreements at all levels must be formulated in the context of the existing policy and legal framework.

Water diplomacy techniques, issue-linkages, and benefit sharing dialogue tools are needed to deal with the complex question of transboundary water management and having better leverages in solving its problems cooperatively; International Water Law brings together the legal and quasi-legal instruments of transboundary water agreements. Even though the law is not essential for cooperation, a legal framework can create a more predictable and stable environment which in turn can reduce any potential for conflict (UNEP, 2002).

Arrangements for collaboration within transboundary basins are founded upon principles of international water law, which defines a standard set of cooperative legal principles and specify the mandate of the institution set up to manage the resource. Although the underlying legal principles are similar across most basins, the accurate means of operationalizing an agreement may differ due to a range of factors, including the hydro-political context, security, sovereignty, trust, visionary leadership, development agenda, economic drivers, poverty, food security, etc. This is not to say that international law necessarily mandates value creation, but it provides the ability to move beyond just thinking about legal rights (Tanzi, 2000).

Most distinguished legal instruments in International Water Law Regime, are:

A. multilateral agreements, e.g., the Helsinki Rules of 1966
B. the 1997 UN Convention on the Law of the Non- Navigational Uses of Water Courses
C. the Kyoto Protocol on “Climate Change”
D. the bilateral agreements that are concluded between two or three riparian states

Although international water law provides a valuable framework for cooperation at the transboundary scale, yet it is currently insufficient to meet all of the challenges. The vast majority of countries have failed to reconfirm their commitment to cooperate over shared water by neither including this goal in the “World Summit on Sustainable Development Agreements" nor ratifying the UN Convention on the “Non- navigational uses of international watercourses" (Rieu-Clarke, Wouters, & Loures, 2007). Although International Law on the water offers a general and stable platform for protecting riparian rights and interests in shared surface waters, there is an urgent need for a set of binding legal and institutional mechanisms to manage and preserve riparian countries' interests for each river basin on a case by case basis.

3.4.4.1 Development of International Water Law from Right-based to need-based to the interest-based allocation

According to Wolf (1998), international water law was not formulated until after World War I. Since then, organs of international law focused on general guidelines which could be applied to the world's watersheds to provide a framework for increasingly intensive water use. The advisory bodies and private organizations developed and codified the general principles of water law which are not intended to be legally binding but to provide evidence of customary law and may help crystallize that law (Wolf A. T., 1998).

In 1893, International Law Association (ILA) and the International Law Institute (ILI), which were both founded. In 1911, the ILI promulgated the Madrid principles, while in 1967 the ILA adopted the Helsinki Rules, a close precursor to the current UN Watercourses Convention. The Convention on the Protection and Use of Transboundary Watercourses and International Lakes

(Water Convention) was adopted in Helsinki in 1992 and entered into practice in 1996. The Water Convention strengthens measures for transboundary water cooperation, ecologically sound management, protection of transboundary surface waters and groundwaters (Brels , Coates , & Loures, 2008). As a framework agreement, the Water Convention does not replace bilateral and multilateral agreements for specific basins or aquifers; instead, it fosters their establishment and implementation, as well as their further development (Tanzi, 2000).

In 1970, the Helsinki Rules of international water management was proposed to the United Nations, after deliberation it was not adopted for several reasons, including concerns about the drafting process and the "drainage basin" approach[9]. Subsequently, the UN appointed the ILC to codify and develop international water law. After 23 years, the ILC was finally able to agree upon draft reports; five rapporteurs and fifteen reports (McCaffrey, 2007). The Helsinki Rules list eleven hydrographic and socio-political factors which ought to be taken into account as a whole in water allocations; the 1997 Convention lists seven, but does suggest that the "requirements of vital human needs" be given "special regard." Neither set of parameters for measuring vital human needs has been explicitly used in any treaty to derive allocations. On a global scale, while most of the debates have been over trying to accommodate as many concerns as possible in an attempt to find generalized principles for all of the world's international water. Riparian states have, in the meantime, been negotiating agreements which focus on precise local concerns and conditions in their respective basin (Grimaud, 2004).

One of the critical aspects of Helsinki rules is that it shifts the legal precedence of water rights from allocation to beneficial use. Water rights in general fall in two broad categories, hydrographic rights, i.e., river originates and how much of that territory falls within a particular state or historic rights, i.e., who has been using the water the longest (Dinar S. , 2008). In the context of eastern Nile basin, both these water rights principles are exercised, the downstream countries claim historical rights based on the 1929 and 1959 agreements whereas the upstream countries claim their rights to the water citing hydrographic rights (Whittington, Wu, & Sadoff, 2005).

Over time, rights become toned-down with responsibility such that most countries eventually accept some limitation to both their sovereignty and to the shared river's absolute integrity. Once negotiations led to agreements signed by all riparian states and decided on specific allocation patterns, nonetheless of how they are determined, each riparian has legal rights to the

[9] *A drainage basin is an area of land where all surface water from rain, melting snow, or ice converges to a single point at a lower elevation, usually the exit of the basin, where the waters join another body of water, such as a river, lake, reservoir, estuary, wetland, sea, or ocean (FAO, 2002).*

agreed quantity in the agreement (McLaughlin , 2006). The shift from right-based to need-based and then to interest-based water allocation may be the product of psychology of negotiation and the fact that rights are not quantifiable as needs. Therefore, need-based allocations have been advocated in disputes after 1977 (Zeitoun & Warner, 2008). The only situations in which absolute water rights are yet considered is in agreements relating to some tributaries of international waterways in conjunction with broader boundary waters accords like the case of Mexico and US where each country keep absolute sovereignty to some internal tributaries of the Rio Grande river (UNESCO, 2013).

In the interest-based water allocation in a basin starts when riparian states are willing to consider cooperation on each other's interest and priorities over water allocation. The central theme of cooperative negotiation is that the negotiators focus on the parties represent the basic needs to be met. Understanding interests are the key to considerate "win-win" negotiation. Generally, in negotiation processes (before, during and after) the interests are not explicitly discussed. In fact, interests are usually kept secret, perhaps to aid an advantage in certain scenarios. However, for cooperation and successful "win-win" negotiation, countries require a way to disclose the interests without making the party vulnerable (IUCN, 2010). Interest-based negotiations begin with the assumption that a states' position is satisfying a need or interest, it may be singular and concrete or multiple and broad.

Multilateral and bilateral donors have facilitated and encouraged transboundary cooperation in many basins, along with the establishment of River Basin Organizations to support cooperative behavior and contain conflict over shared waters. Based on the 1997 UN Convention on the Law of the Non-Navigational Uses of International Watercourses, the international community has created a framework agreement that can serve as 'model legislation' for basin-specific agreements (FAO, 2010). For instance, the World Bank-sponsored, Indus Waters Treaty, the Mekong River Commission, and the Nile Basin Initiative are probably the best-known River Basin Organizations set up to promote cooperation between riparian states (Hefny, 2011).

Another international water law instrument is the UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes, which provides more detailed provisions about the former and includes in its scope both confined and unconfined transboundary water systems. Formerly a regional convention, it was signed in 1992, brought into practice in 1996 and its amendments opening it for accession to all UN Member States came into implementation in 2013 (Murthy, 2015). Asymmetric geopolitical relationships among riparian states necessitate the need for diplomatic tools that extend support beyond building basin institutions and promoting international water law. In other words, to support principles and codification of existing international water law water diplomacy can help improve transboundary water governance.

On 17 August 2014, the UN Convention on International Watercourses entered into practice, after its ratification by the 35th state party to the convention. It entitled to bring the world a step closer to achieving sustainable management of shared waters but the challenges today are how to make more countries accede to these global conventions and how to implement them in a way that encourages sustainability and international cooperation (Murthy, 2015). It is cited as evidence of customary law by the International Court of Justice in 1997 which will be discussed as a success story in the next section.

Accordingly, water diplomacy tools, techniques, and dialogue are needed to combine with water law to protect riparian's right and deal with the complexity of water cooperation. Indeed, transboundary water cooperation policy processes can be at different levels of reliability and will, therefore, offer various opportunities for including the results of a cooperative negotiation for decision-making in a strategic environment. Even when no formal transboundary water cooperation policy process is in place, informal dialogues may be regarded as early stage transboundary water cooperation. At the other end of the scale, a transboundary water cooperation policy process may be characterized by a well-established formal framework that includes legal agreements, institutional structures, and joint action programs. It is important to understand international water law as functioning to facilitate a culture of communication amongst riparian states, and to provide a common language and a starting point for the negotiation, adoption and further expansion of innovative problem resolution for transboundary water resources management.

Once a cooperative interest exists, the only problem which remains to be solved is the allocation of the associated joint costs or benefits of cooperation and international law to bind it. Benefit sharing and issue-linkages under diplomacy shelter are some of the most effective approaches which can be applied in the negotiation process for achieving a basin-wide long-term mutual agreement (Hefny, 2011). All the mentioned tools and methods are individually useful and investing in them often extends to better policies and decision-making. As helpful as they could independently be, their effectiveness will definitely increase by law, interest and right combination. Besides applying the precise set of approaches, it also requires internationally coordinated engagement to build on strong, political-level involvement by the foreign policy community and governments (Tawfik, 2015).

In summary, achieving an agreement for sharing a competing resource requires long, intensive and engaging negotiation process to be involved in the identification of mutual benefits and interests to the decision makers, as well as devising the instruments of securing the benefits and sharing it equitably. To keep the states engaged and ensure the long-term sustainability of the cooperative agreement, they need to explore additional gains options regarding creating economic, social, and environmental benefits for all as outcomes of the process (Islam & Susskind, 2013). Any means of water law development will be preceded by a stage in which international partners can express their interests and establish a platform to identify challenges, opportunities, bottlenecks as well as to formulate the necessary policies, strategies, and approaches (Murthy, 2015).

Learning from successful stories and comparing the applied approaches helps to find a practical way to link all instruments and initiatives in a coherent way to clearly and directly articulate common criteria and principles that can be adapted and applied to the uniqueness of each basin.

3.5 Examples of Successful Transboundary Water Cooperation

In this section, we highlight the use of introduced transboundary management tools in some examples of international experience to achieve international cooperation on shared waters. These examples were specifically chosen for their relevance for the comparative study of Benefit-sharing, Side-payments and Issue-linkages, Water Diplomacy and International Water Law. Thus, we selected the Brahmaputra River, the Danube River, the Senegal River, and the Mekong River. We aim to share general insights and lessons learned in the successful governance of transboundary cooperation in these basins, recognizing that each basin requires a context-specific combination of approaches. Each agreement must be customized to precise issues, location and actors.

3.5.1 Brahmaputra Sub-Basin: Case of Bhutan – India

Optimal water management and control of transboundary river system in Brahmaputra basin is an excellent example of a transparent and judicious framework for the collective development of all riparian countries with the approach of benefit sharing of the dam development projects (Figure 3-4) (Asian Development Bank, 2012). Applying benefit sharing method to this case study has promoted riparian countries to view the challenge as positive-sum outcomes associated with optimizing benefits rather than the zero-sum outcomes associated with dividing water.

Hydropower development in Bhutan has been the cornerstone of India-Bhutan cooperation. The model consists of India supporting Bhutan in building hydropower projects, by providing finance in forms of grants and loans along with technical assistance to construct dams (Premkumar, 2016).

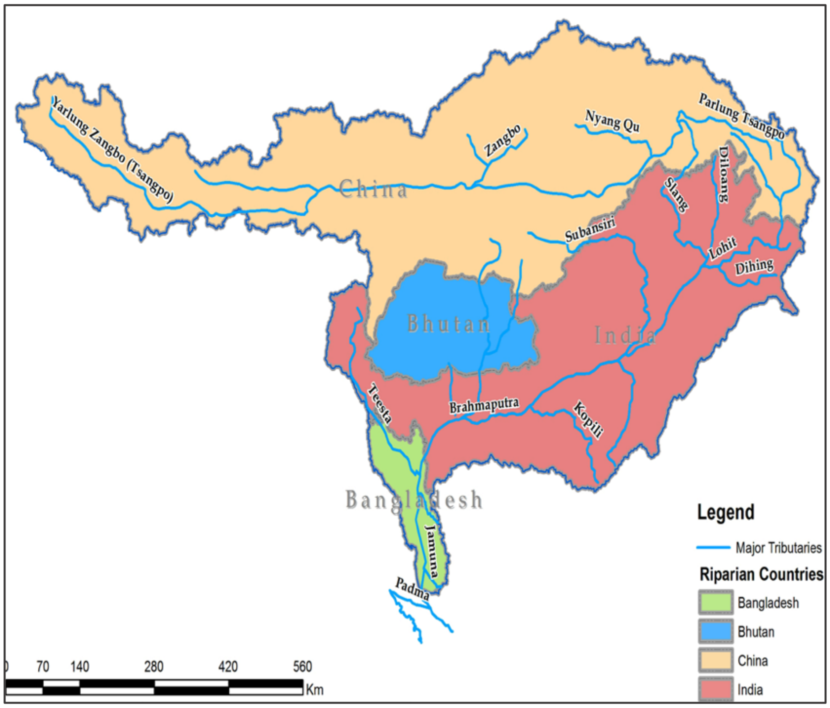

Figure 3–4 Map of Brahmaputra Basin

Bhutan only gets electricity for its use, plus exports the surplus generated hydropower to India and earns much-needed revenue. India receives relatively cheap power in return and has control over the river. Hydropower exports contribute around 40% to Bhutan's revenue from export and 25% of its GDP which shows the importance of this cooperation for Bhutan which is entirely dependent on India for its supplies and survival (AQUASTAT, 2011).

India has pursued bilateral agreements for hydropower generation with Bhutan while the extent of the benefits accrued to Bhutan, as a result of their contracts with India. Three agreements have been negotiated between India and Bhutan over hydropower generation. They have signed the 1974 Chukkha Hydroelectric Agreement on Wangchu River, the 1995 Kurichhu Hydroelectric Agreement on Kurichhu River, and the 1996 Tala Hydroelectric Agreement on Wangchu River. All the three agreements were pivoted on the exploitation of the hydroelectric potential of the shared rivers. The content of the agreements negotiated and the side-payment patterns reveal even more compelling information (Figure 3-4) (Premkumar, 2016).

In all three agreements, India has taken it upon itself to provide all the financing for the project which can be considered as side-payment for the cooperation. Bhutan is also the owner of these facilities, and as mentioned can trade surplus to any market player not restricted to India. However, the example of India–Bhutan hydro-politics, and the treaties negotiated between them, shows that in the exploitation of the upstream rivers for hydropower purposes, India has had to reward Bhutan for its strategic location (Elhance 1999). Hydropower projects implemented in Bhutan are mainly an outcome of political processes founded on economic rationale with a commitment from the heads of the two governments; the many particulars of which are veiled behind diplomatic relations and bilateral agreements. A matter for concern in this diplomatic relation among the two countries is that Bhutan has not developed expertise and resources of its own to develop hydropower projects or other energy sources (Hanasz, 2014).

Overall, India benefits from Bhutan's renewable hydroelectric energy resource to meet a part of its vast power demand while Bhutan will benefit from the revenues earned from the export of power.

The case of the Brahmaputra sub-basin illustrates the potential of basin-wide cooperation among all the riparian countries in conjunction with economic cooperation, allowing cross-sectoral collaboration and benefit-sharing. Such cooperation integrates all sectors involving water, ecology, and economy in its scope and can potentially create mutual gains for the riparian countries and bring solutions to manage the river basin sustainably. Any type of development within the basin, including infrastructure (in particular for hydropower, flood control, irrigation, and navigation), needs to be based on a whole-of-basin approach (Wirsing, Jasperro, & Stoll, 2013).

The hydropower development-based Bhutan-India cooperation model is to some extend unraveling over time and needs a substantial rethinking for improvements considering climatic variabilities and environmental efficiency. Addressing environmental and social issues associated with large-scale hydropower development will be a significant challenge for Bhutan in the future (Hanasz, 2014).

3.5.2 Senegal River Basin

Mali, Mauritania, Guinea, and Senegal provide a successful transboundary collaboration in the Senegal River Basin, in Africa (Figure 3-5). It is the second-longest river in Western Africa and forms a basin shared by Guinea, Mali, Mauritania, and Senegal. Periodical floods and droughts have threatened riparian populations since always and have been a significant cause of food insecurity and an impediment to socioeconomic development in the region. Most of the Senegal River basin has a sub-Saharan desert climate, which has been aggravated by more or less long periods of drought during the 1970s. Together, riparian states required the economic and financial means as well as the technical and human capacity to address these challenges and improve their management of the river (IUCN, 2014).

In response to particularly devastating droughts in the early 1970s, the three downstream states (Mali, Mauritania, and Senegal) decided to jointly engage in water resource exploitation projects that would exceed their respective unilateral capacities (FAO, 2010). To do so, in 1972, they established the "Organization pour la Mise en Valeur du Fleuve Sénégal" (OMVS), a supranational organization charged with the development of the river's resources to support the

Figure 3–5 Map of Senegal Basin

economic development of its riparian states as well as economic cooperation and exchanges among them (Vick, 2006). In the following years, the OMVS's efforts mainly focused on three sectors: irrigated agriculture, hydropower, and navigation (IUCN, 2014). Two dams were built, which increased the irrigated area and provided hydropower to the OMVS member states. The countries cooperated in developing the water and power potential of the Senegal River in West Africa and the management of water and energy resources harnessed by the construction of the Manantali and Diama dams in the 1980s (Magistro, 1993).

The two dams have delivered enormous benefits concerning dependable river water flows for irrigation, power generation, enhanced river navigability and flood control for the four cooperating countries, and in particular for the river basin populations living across the borders. OMVS has adopted a Water Charter and is a rare example of joint ownership of large dams (Tignino, 2016). It is an international institution based in Dakar which gathers Guinea, Mali, Mauritania and Senegal around common goals, including food self-sufficiency, economic development, and preservation of ecosystems in the region. All of these benefits have been made possible by an interlocking and pioneering web of inter-state agreements among the three Senegal river basin countries spanning some 30 years, from the signing of the Convention on the Statute of the Senegal River in 1972 to the adoption of the Senegal Waters Charter in 2002.

In general, OMVS aims to perform a regional strategic evaluation of options for hydropower development and of water resources in the Senegal Basin. Work is to include an analysis of energy needs; identification of electrification options; a cumulative impact assessment; analysis of effects of climate change; analysis of economic, environmental, and social risks; and comparative analysis of the alternatives of electrification, transportation, navigation, and development of water resources (Ayaa, 2012).

The Manantali Dam, which is located entirely in western Mali, was constructed by the Development Authority in the 1980s for hydropower, irrigation and navigation benefits to be distributed across all three countries (Mbengue, 2014). The scale of benefits derived and the perceived fairness of the benefit sharing arrangement, together with the political ideal of solidarity between the three countries, have sustained substantive cooperation and an active river basin organization on the Senegal River. Promoting cooperation over shared water resources therefore not only contributes to conflict resolution in a direct manner but can also improve development opportunities which ultimately provide the basis for long-term peace and stability (Tignino, 2016). Environmental and social challenges have arisen as a result of changes in the basin ecosystem due to the dams. Nevertheless, through cooperation, the countries have realized benefits, which they would not individually have been able to achieve.

3.5.3 Danube River Basin

The Danube basin covers 817,000 km^{2}, and it is shared among fourteen countries and, also, it collects the runoff from small catchments located in four other countries. Danube riparian states are Germany, Czech Republic, Slovakia, Ukraine, Moldova, Romania, Bulgaria, Serbia, Montenegro, Bosnia and Herzegovina, Croatia, Slovenia, Austria, Hungary and it is located from west to east Europe (Figure 3-6) (Baranyai, 2015).

Figure 3–6 Map of Danube Basin

Cooperation in the Danube River basin has a long history, dating back to the 1850s. Despite many potential or perceived gains through shifting from unilateral actions such as the invasion of pollutants, the exploitation of fish resources or the construction of water infrastructure, riparian states have expressed their continued will to cooperate throughout the centuries, even during wars (Komatina & Grošelj, 2015).

Domestic water supply, irrigation, hydropower generation, and navigation are the primary water uses in the basin. More than 40 huge dams and barrages have been constructed on the main river bank and its tributaries, exploiting the hydropower potential (UNESCO, 2013). Conflict over the Danube in the past rose as a result of disagreements in navigation and water supply. In the early 20th century, intensive agricultural, industrial, and urban allocation have created serious water quantity and quality problems, which in turn caused disputes among countries and stakeholders (Schmeier, 2013). The Treaty of Trianon signed in 1920, established the Hydraulic Commission for the Danube regulating non-navigational disagreements among riparian states including those related to irrigation, hydropower or fisheries (UNDP, 2006). Moreover, at the height of the Cold War, Germany and Austria joined the 1948 Belgrade Convention concerning the Regime of Navigation on the Danube (Stalzer, 2002).

Various other agreements were also signed subsequently, not only across national borders but also across ideological divides. Recognizing that new initiatives were needed to address the growing regional water management and related environmental problems in the Danube River basin, the riparian countries together with interested members of the international community met in Sofia in September 1991 (Aquamoney, 2009). The countries agreed to develop and implement the Environmental Program for the Danube River Basin (EPDRB) including priority actions and studies in preparation for the eventual agreement on a new convention. The countries formed a Task Force to oversee this program. In parallel, two conventions related to environmental problems in the basin were prepared, which was followed by the Convention and Cooperation for the Protection and Sustainable Use of the Danube River. It was signed by all Danube countries in June 1994. Countries that were historically on the main stem of the river participated in the 1948 Belgrade Convention focusing on navigation, which is implemented by the Danube Commission, whereas the Danube River Protection Convention.

The Danube River Basin, the nations of the Danube developed a strategic action plan for the period of 1995-2005 called "International Commission for the Protection of the Danube River (ICPDR)" aiming to enhance both sustainability and the fair and wise management of water resources. The ICPDR activities were generally on the environmental side of water resources management as well as newly emerging challenges such as climate change adaptation and flood risk management. Furthermore, the ICPDR also plays a crucial role in promoting cooperation by bringing together policy makers and water managers from the numerous Danube riparian states despite all the political, socioeconomic and cultural differences between them (UNESCO, 2013).

In the past decade, several bilateral agreements among Danube riparian countries have been signed, while a few international agreements are finalized. To improve collaboration and harmonize water management, all riparian countries agreed on general principles and criteria for formulating strategies and establishing a priority list of implementation measures. The Strategic Action Plan (SAP) was developed by a drafting group composed of experts from the World Bank, the Program Coordination Unit, and four participating Danube countries. An intensive consultation process ensured that the viewpoints and objectives of the riparian countries were adequately considered. The program is designed to assist implementation of the cooperative agreement, which is already agreed upon by the riparian countries. The case of the Danube River basin thus illustrates that water should not only be perceived as a potential source of conflict in the case of diverging interests in its use or protection but can also serve as a means for initiating cooperation despite an overarching conflict.

3.5.4 Mekong River Basin

The Mekong River Basin, the longest river in Southeast Asia courses through Myanmar, China, Cambodia, Laos, Thailand, Vietnam (Figure 3-7). The Mekong River legal regime demonstrates how cooperation built around an efficient and relatively well-funded institutional mechanism can successfully advance despite considerable differences in economic, social, and environmental diversity of the region (Mekong Delta Plan, 2013). The legal framework established by the Mekong Agreement further evolves as a powerful instrument through adopting additional implementing tools such as the "Procedure for Notification," which was raised proposing the Xayaburi hydropower project.

The Mekong Agreement, among four downstream countries, has similar procedures to be followed where there is a need to develop new or increased uses of the resource or where any dispute arises (Gupta, 2005). It has a well-structured system of checks and balances to validate and support or to refute any projects or allocation differences on an equitable basis for all riparian countries. This involvement of third parties has been instrumental in promoting cooperative arrangements in the Mekong. The United Nations Development Program (UNDP), in the Mekong River negotiations, played instrumental roles in facilitating cooperation between the parties and financially contributing to large projects necessary to make the cooperative agreement works (Chheang, 2010). Mekong riparian states linked water to other issues they could benefit from, which eased achieving the cooperative outcome. Institutional capacity building and stakeholder participation are actively promoted within projects of the actors working on the Mekong. Concerning information management, the activities in the Mekong River Basin are not only limited to standardizing and sharing data and information but also work to disseminate this information to decision makers. Investment needs in most cases exceed the resources available to riparian countries; therefore, various financing mechanisms were developed and employed.

Multiple sources of funding and fundraising mechanism were another major contributor to the success of the Mekong cooperation (Wouters, 2013) (UNDP, 2006).

In the Mekong negotiations, the four lower riparian countries reached a deal for sustainable water resource use, and China and Myanmar are still excluded. Since 1957, the Mekong River Commission, previously the Mekong Committee, acted as major driving forces to strengthen cooperation in the utilization of the shared resources of the Mekong River Basin. Building on the existing cooperation, Asian Development Bank established the Mekong Sub-Region Cooperation Program that functions since 1992. Since then, the program was able to improve active participation of all the member countries and increase collaboration of various prominent donors and a number of international organizations (Browder, 2002).

Figure 3–7 Map of the Mekong Basin

In 1995 Mekong Agreement, they agreed to a package including the principle of reasonable and equitable utilization. In particular, the countries wanted a flexible agreement that could adapt to future conditions but be accurate enough to ensure that their interests were met on each one's priority concerns (Jacobs, 2002). Thailand, initially worried that other countries might try to veto proposed developments, advanced the position that each riparian should unilaterally be able to use tributary waters within its territory without the approval of the other riparian countries. Vietnam, in agreement with Cambodia and Laos, was very concerned about maintaining flow levels in the mainstream during the dry season and advanced the position that the use of water from the mainstream should be agreed upon by a joint technical committee before any water was diverted. The countries tentatively agreed in principle on the requirements for water use during the wet season in the tributaries and the mainstream, pending resolution of conditions on water consumption from the mainstream during the dry season (MRC, 2011).

Today the Mekong basin faces several critical challenges. Among the causative factors are a rapidly eroding basin, presently affecting 21% of the area; deforestation; continued regional population growth and a deteriorating ecosystem and addition to all, climate change effects. All these factors could trigger social and economic instability for Mekong inhabitants who depend on the river system for their livelihoods, with likely environmental impacts (Wolf A. T., 1998). One of the primary constraints on the way of earlier cooperation among Mekong riparian states was a culture of riparian governments, in which key international organization and national governments were accustomed to deliberating with each other and international consultants, but still, a broader group of local stakeholders are left out (Wouters, 2013).

Despite all these problems, the cooperative agreement is still in operation. The current negotiation under the uncertain geopolitical situation is delayed, and the slow however process is steadfast toward an inclusive and integrated framework to address all of the issues mentioned above and future uncertainties.

3.5.5 Unique Combination of Approaches

Each river basin is unique in its geography, topography, ecology, hydrology and political economic and cultural aspects; thus, each transboundary water agreement is customized to its specific set of indicators. Each approach and tool has been argued in this dissertation, could contribute as a useful measure to the most efficient distribution either of water itself or the benefits brought about by its cooperative use or creating additional means for cooperation (Brels , Coates , & Loures, 2008). These set of tools were chosen from a wide variety of options to contribute most effectively for efficient distribution of water itself along with the benefits derived from its use through cooperation to be examined in the context of Eastern Nile River Basin in the next chapters.

Without adequate cooperative approaches to foster collaboration in transboundary water management, we face unilateral appropriation of water resources which often leads to tensions among riparian countries (Dinar S. , 2008). However, even with the best of intentions, it may become increasingly challenging to develop most appropriate policies, laws and management arrangements for transboundary benefits during prolonged water-related uncertainties or when there are tensions between national priorities and transboundary considerations (De Man, 2016). Therefore, there is a need for tools and approaches to help the negotiators and decision makers to understand some specific uncertainties with a clearer image, thus contributing to completing the bigger picture. Any agreement ratified among riparian countries of a basin today will change

with time and has to accommodate significant flexibility measures regarding checks and balances to ensure that future anthropological and natural changes can be accommodated.
In (Table 3-1), In each of the four basins, benefit sharing has different setting and mechanism. Probably the most successful cases with effective benefit sharing experience are the

Table 3–1 Successful case studies' comparison

Selected Basins	Approaches to Enhance Transboundary Cooperation			
	Benefit sharing	Side Payment / Issue Linkage	Water Diplomacy	Int. Water Law
Brahmaputra	√	√	√	√
Senegal	√	√	√	√
Danube	√	√	√	√
Mekong	√		√	√

Brahmaputra, Senegal, and Mekong basins (Table 3-1). These have high absolute levels of economic activity and the states that share them, therefore, have a strong incentive to develop benefit sharing strategies and improve integrated river basin management. In the case of Brahmaputra Basin and Senegal River basin, cooperation achieved with a focus on hydropower production and sharing those benefits plays the leading role. The Mekong basin's cooperation started with shared infrastructure and joint action which is the first structure for the benefit-sharing mechanism (Moller, 2005).

Cooperative agreements are a broad statement of intention for basin-wide cooperation for the equitable use of shared waters containing some principles based on the international water law. The presence of a third party during the negotiation of a cooperative agreement to facilitate the process is considered part of water diplomacy (Susskind L. A., 1994). The organizations or institutes act as third parties may continue work in each basin after concluding an agreement with a set of arrangements (FAO, 2010). The IWRM-based Mekong Basin Development Strategy established by the Mekong River Commission is an example of this type of institutional arrangement.

The analysis of four river basin cooperation experience shows that in all regimes, shared infrastructures such as dams, are a primary driver of cooperation among countries, including benefit-sharing both at the sectoral and transboundary levels. An equitable and fair distribution of costs and benefits among riparian states plays a significant role in the development of cooperation (Arjoon, Tilmant, & Herrmann, 2016). Joint actions provide both economic and non-economic benefits. Furthermore, the identification of the trade-offs in the distribution of the benefits to the riparian states reduces negative transboundary impacts and enlarge the number of benefits from the uses of shared water resources. The involvement of local stakeholders and different types of relevant organizations, at an early stage of the development of transboundary negotiations, may also contribute to preventing water conflicts (Huntjens, Valk, Zhang, & Warner, 2015). Conclusively, it is apparent that different socio-economic contexts need to find their unique set of indicators and befitting process to achieve cooperative transboundary water management. In section 3.6, we have explored the stages in which states are most likely to pursue an agreement over the shared rivers. These are the conditions under which cooperative negotiations are most likely to be successful.

3.6 Stages of forming cooperative agreements

As the global economy continues to raise and expand, bringing increased trade and other cross-border communication, cooperative agreements are increasingly necessary to counter associated problems and generate regional security benefits. Cooperation is based on mutual trust and understanding; the first step is to build trust through transparency and accountability (Grey & Sadoff, 2007). Cooperation among poor and wealthy riparian states will succeed if a more prosperous country provides economic and financial incentives to the poorer one. Also, mutually beneficial agreements between states with a combination of preferences may require side-payments and end up applying issue-linkage approaches, so heterogeneities in capabilities and interests create possibilities for trade-offs among riparian states (WWAP, 2015).

Realization of the existence of higher economic gain through cooperation is the courage for taking the initial step towards willingness for cooperation. What is often missing is the actual first step for establishing relations among water experts and policymakers from the different riparian countries and regions. Other elements needed include the awareness of the public and decision makers; the presence of mutually equitable political good will; and instruments for setting up joint institutions and mechanisms. New technologies and adequate data alone cannot establish any cooperative negotiation and creative solutions unless political goodwill exists (Swain, 2004). The water sectors in developing countries suffer from weak institutions, and in particular from the lack of democracy and good governance, the absence of political will, a relative lack of trained human capacity and insufficient financial and other support for the development of institutions to build trust and promote cooperation (Sadoff & Grey, 2002). The centrality of these institutions, effective transboundary water management approaches such as water diplomacy cannot be over-emphasized for creating fundamental pillars for cooperation towards regional security and stability. The stages of developing a cooperative agreement are (See Figure 3-8).

3.6.1 Initiation Phase

Where developing riparian countries share river basins any movement toward joint action or representative stakeholder involvement in the planning and management of transboundary flows can set the stage for cooperative transboundary water management (Dombrowsky, 2009).

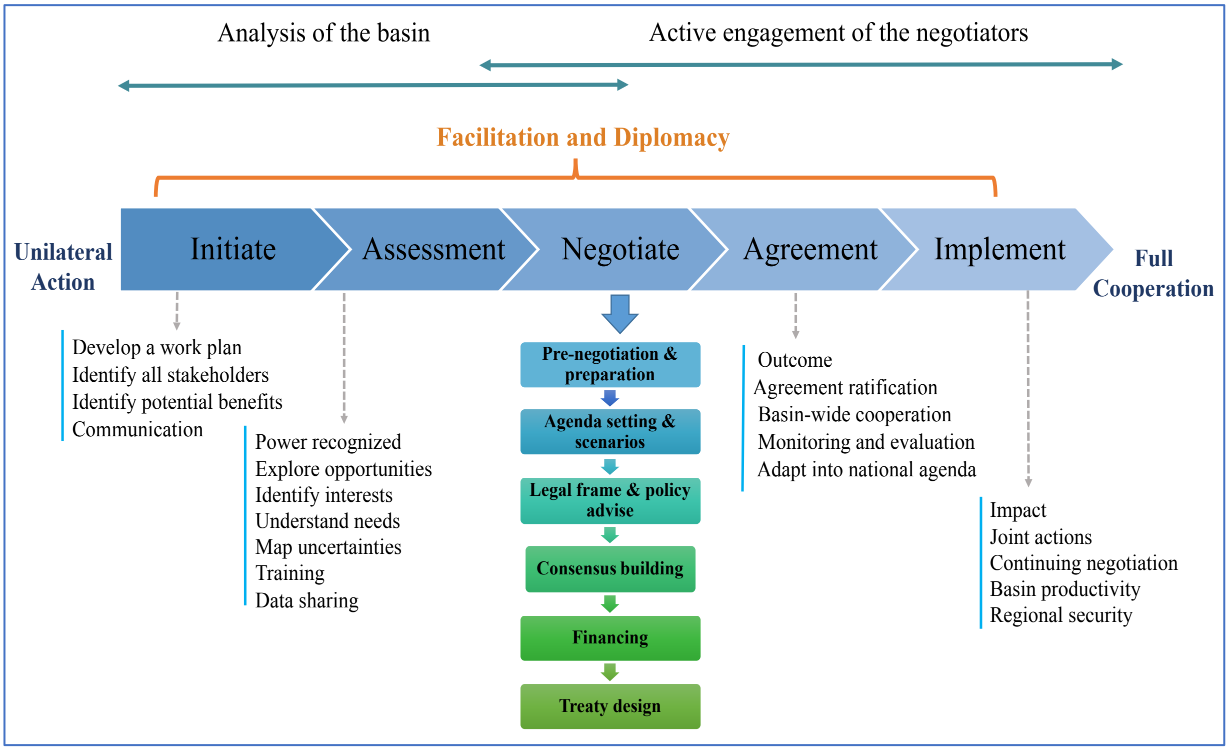

Figure 3–8 From unilateral decision making to cooperation

Countries engage in cooperation negotiations due to sensing their profitability and sometimes as an altruistic act (Axelrod, 1984). By understanding the potential benefits from transboundary water cooperation decision makers are able to identify additional opportunities which can be generated by deepening the level of cooperation and continuing negotiations to achieve a higher quality of a cooperative agreement (Svensson & Brounéus, 2013). Identification, assessment, and communication of quantitative and qualitative benefits are the initial stages of trust building and cooperation. However, in many cases, only certain advantages will be identified in the initial phase. Enhanced cooperation leads to further efforts to identify additional benefits, both because the countries are ready to enter into the identification process and some potential benefits appear feasible, after the basis for cooperation has been established (Dore, Robinson, & Smith, 2010). In addition to information sharing and communication, the drive to create extra value by discovering joint gains can require skillfulness and may benefit from a variety of techniques and attitudes of the negotiators (Poast, 2013).

Designers of cooperative negotiation processes should think carefully about which stakeholders to involve in the initial stage (UN-Water, 2013). Stakeholder analysis as one of the techniques of Water Diplomacy is part of the initial phase as it defines the influence and importance of local and macro actors in the success of cooperation. Once the stakeholder identification is over then, the negotiators need to analyze the strengths and weaknesses of each of the indicator factors or interests put forth by each of the stakeholder groups. By creating a priority-based list of factors, the negotiation process ensures fair consultation to establish and maintain the legitimacy of the process from the very beginning (Brels , Coates , & Loures, 2008).

3.6.2 Assessment phase

Many, but not all, benefits can undergo a quantitative assessment. Only in some cases can the economic value of the cooperation's benefits be assessed precisely. The assessment should map the river and try to understand the benefits that arise from it, issue-linkages, the livelihoods that depend upon benefits from the river and adverse impacts from resource exploitation. It is useful for negotiating to understand the supply and demand trends of water at different scales, as well as any related climatic variations and natural hazards, or effects of any future uncertainties.

If the assessment phase identified significant asymmetries in the negotiation or technical skills of the parties of a negotiation process, training might be needed to equalize the negotiating capacities and technical capabilities for the negotiator teams. Direct engagement with a range of stakeholders, is identified in the previous stage, is essential to ensure a clear and accurate understanding of the potential conflict, as well as effective and adequate representation of all relevant interests from all stakeholders through a prioritization (Elhance, 2000). The assessment should also gauge how effectively natural resources are governed and whether the governance structure is a source of conflict among stakeholders and coming up with a recommendation for improvements. There are several dimensions to consider: the legal and policy dimensions of current natural resource management; legal and customary mechanisms for managing shared resource and resolving disputes; specific legal provisions regarding benefit-sharing and level of transparency as well as an assessment of legal provisions (Dinar & Alemu, 2000). It should be mentioned that; assessment stage is directly affected by the availability of accurate and adequate data.

A training environment during the assessment phase provides an initial opportunity for the negotiators to explore the issues in a neutral space. The views and positions expressed during training are without prejudice to future negotiations and can, therefore, help the negotiators to speak their mind more freely (Dore, Robinson, & Smith, 2010). In some cases, joint training can begin building dialogue and confidence between the parties, albeit at an intimate or indirect level.

When the core technical facts are disputed, negotiators can invite impartial technical experts to conduct a scientific assessment aimed at introducing scientific data into the negotiation process (Jägerskog, 2003). The assessment can be done on an entirely independent basis, or jointly with the other parties by applying joint fact-finding approach (Alfonso, 2015) (Islam & Susskind, 2013). At the end of the assessment phase, it is essential that the methodology is agreed upon by all negotiators and that the data is independently verified to enter the negotiation phase.

The pre-negotiation phase lays the foundation for negotiations and is focused on establishing the best possible conditions for a successful negotiation process. The issues addressed in this phase usually relate to procedural matters about who should be involved, the timing and location of negotiations, the structure of negotiations, and the items on the agenda. To prepare for and design a negotiation, the various short-term objectives or long-term goals must be clear. While these may evolve over time, the parties should at least start with a clear view on what the process intends to achieve (Arjoon, Tilmant, & Herrmann, 2016). Building capacity in cooperative transboundary management techniques, such as water diplomacy by mediation and facilitation, as well as in stakeholder participation, helps mitigate competition in the negotiation process and prevent disputes from emerging during decision-making. Objectives may include creating a safe space or building a relationship among the negotiator teams or proposing solutions to a problem. The longer-term goal may be to achieve a legally binding final decision on an issue.

3.6.3 Negotiation phase

The negotiation phase is where the terms of the agreement as well as detailed contents and its framework are addressed. During the negotiation procedure, selected and neutral mediation helps the negotiators come to a mutually acceptable agreement.

Negotiation helps to shape cooperative decision-making processes by bringing on a broader range of perspectives on needs, impacts, and options. The setting in which the negotiation process takes place such as how facilitation, meeting structure, and venues influence the openness of conversations that can happen, has an extraordinary influence on the outcomes (Song & Whittington, 2004). It should be considered that states' decision makers can learn cooperative behavior as the result of notation skills in the case of repeated negotiations and training in the initial stages to form symmetrical interests (Zartman, 2001). Engaging in cooperative negotiation is an entry point to build confidence between countries.

Even with differing interpretations, once all negotiators mindsets become optimistic about existing the possibility of their minimum quantitative needs, and make sure their primary interests are being met, negotiation eventually turns into soft bargaining which leads to cooperative decision-making (McGinty, 2007). To offer a legitimate way forward for dealing with differences of interests, negotiations over complex decisions need to be transparent and inclusive. Negotiation must be approached in a considerate and constructive manner, to encourage understanding and joint problem solving, greater mutual regard for diverse interests and values, and to integrate into a sustainable, rewarding and workable outcome (Susskind, Moomaw, & Gallagher, 2002).

There are different approaches applied by negotiators which shape the way negotiations are set up; processes are designed, and types of possible outcomes are mapped (Wolf A. T., 1998). Negotiators must learn, what is jointly possible and desirable for the whole basin. To do so, it requires some advanced degrees of cooperation while at the same time, some levels of competition may exist for the expansion of their individual interests (Poast, 2013). That negotiation includes cooperation and competition over shared and conflicting interests. There is a central, inescapable tension between cooperative moves to create value jointly and aggressive moves to gain an individual advantage. This tension affects virtually all strategic choice of decision makers. Here is where water diplomacy approach comes to the picture and promotes cooperative negotiation by lowering the pressure. Facilitators and negotiators need approaches to negotiation that are suited to constructive engagement (Kolstad, 2007).

3.6.3.1 Types of Negotiation

In practice, competitive and cooperative stances co-exist during negotiation (Dinar S. , 2008). The negotiation process should be structured and directed by cooperative principles while competing and cooperative behaviors encouraged and moderated by peers.

There are two styles of negotiation (UN-Water, 2013):

- Competitive (or positional)-based negotiation: which places greater emphasis on trading, hard bargaining and distributing. The long-term consequences of competitive negotiation may be unfavorable yielding reduced enthusiasm and commitment as well as damaged relations with opposite sides of the negotiation.
- Cooperative (or interest-based) negotiation: which places greater emphasis on collaborating, seeking consensus and integration. It is an opportunity for mutually respectful exchange to enable outcomes that are beneficial to all involved parties.

Ultimately both cooperative and competitive styles of negotiations aim to resolve problems or to exploit potential undetermined gains. In the cooperative multilateral form of negotiation, the decision makers seek a win-win or win for all situation. This technique should be applied by facilitators and negotiators to achieve an agreement which can sustain long-term (Susskind, Moomaw, & Gallagher, 2002).

Negotiators have to determine how cooperation will affect each party's cost and benefit status. Given that individual negotiators may be made worse off by cooperation compared with unilateral action, introducing side-payments and issue-linkage tactics by facilitators or a team of water diplomats during the negotiations can assist (Dinar S. , 2008) (Klaphake & Scheumann, 2006). It should also be considered that successful water negotiations often necessitate substantial compromises across several sectors. In the end, issues are linked when separate areas of negotiation are discussed simultaneously to intending to a joint settlement being reached. After compensating for potential losses incurred by individual negotiating partners, they can share and distribute the benefits of cooperation (Priscoli & Wolf, 2009).

3.6.3.2 Process of Negotiation

Rothman (1998), points out that negotiations ideally move along three stages: the adversarial stage, where each side defines its positions and interests; the reflexive stage, where the needs of each side bringing them to their positions is addressed; and finally, to the integrative stage, where negotiators brainstorm together to discuss each side's underlying interests and move towards addressing terms of agreement (Rothman, 1998). As it is developed in this study, the stages of a negotiation process over transboundary waters can be defined as:

- Pre-negotiation and preparation
- Agenda setting and scenarios
- Legal frame and policy advise
- Consensus building
- Financing
- Treaty design

These stages of the negotiation can take place parallel or overlap with other phases of the whole cooperation arrangements. In such cases, joint procedures to gather, validate, and analyze the information can be beneficial for establishing a common understanding and for building trust between them. However, common approaches such as joint fact-finding have to be designed carefully, especially when there are asymmetries in technical capabilities to collect and analyze information. The design of joint procedures needs to be based on a solid understanding of what each side of the negotiation considers relevant information and appropriate approach (Dinar A. , Dinar, McCaffrey, & McKinney, 2007).

The content of negotiation matters as much as the process for whether meaningful conversation takes place, and how decision makers learn about each other's perspectives on critical issues and interests. The quality of information provided to decision makers in all stages of negotiation is essential to the effectiveness of the process (IUCN, 2010). To overcome this problem, participants of a formal negotiation require access to effective use of scientific and experience-based knowledge and imply up-to-dated researches by involving local and international experts as well as research institutes. Preparing adequate background information and transparent knowledge sharing for negotiators and decision makers have an enormous influence on the quality and substance of the discussions and hinder the process of transparency to building sufficient confidence among them (De Man, 2016). Forming the terms of reference for an agreement is the last stage of negotiation, the negotiators agree on at least some of the following items: mandate, terms of reference, issues of representation or staffing, benchmarks and milestones, the location of offices, the source of funding, and dispute resolution process.

3.6.4 Agreement

An agreement is the direct, tangible desired outcome of the negotiation that encapsulates collective decisions, and outlines the steps for implementation. There are many types of agreements in the context of water management exists policies, laws, charters, codes of conduct, contracts or other agreements to manage and allocate water. Agreements can be guiding in nature or set laws or specific rules while being formal or informal, legally binding or voluntary, verbal or written (IUCN, 2010). They can apply at various scales and levels, from local to international, from wells to micro-watershed to river basins. The type in this study is a basin-wide agreement signed by all riparian countries.

In transboundary water management, international agreements define rights and responsibilities among riparian countries. Plus, agreements stimulate investment by reducing risks of disputes and clarifying costs and benefits of national and transboundary actions in the basin. The agreements may be reached by following principles including absolute sovereignty, absolute riverine integrity, limited territorial sovereignty, and economic criteria (Wolf A. T., 1998). Although international water laws assert that the water should be equitably allocated, there are no clear, transferable and measurable criteria for water rights allocation, and few models concerning legitimate water rights for transboundary basins exists (Josef & Kipping, 2006).

An agreement must anticipate and address critical concerns that will arise during implementation; this should include clearly defined roles and obligations of the different parties and stakeholders; a timetable for implementation, including clear benchmarks; a monitoring and reporting regime; an amendment mechanism; and, a dispute resolution clause (McGinty, 2007). If appropriate, external mediation support can be useful to resolve certain implementation disputes. The roles and accountabilities of all actors regarding the governance of the agreement should be stipulated. An existing institution may be selected to manage the implementation of the agreement, or a new institution could be formed. Agreements are often used to create new water management bodies, such as a river basin organization or commission (Murthy, 2015).

3.6.5 Implementation phase

Establishing regular institutionalized cooperation between countries can significantly contribute to successful implementation of the agreement or other arrangement establishing a joint body should expressly address, among other things, its areas of operation, objectives, functions, tasks and powers, legal status, geographical scope, organizational structure, financial implications, and reporting mechanisms (IUCN, 2010).

During the implementation of an agreement a range of challenges, stresses, and disputes can emerge that may seriously affect the agreement's sustainability. The durability of an agreement hinges on whether such problems were anticipated and how they plan throughout the implementation process. Riparian states may feel frustrated, disgruntled, or tricked if problems during implementation are not expected and addressed adequately (Zeitoun & Jägerskog, 2011). An agreement may even collapse if serious implementation problems persist. In many cases, ongoing mediation is needed during the implementation phase of a negotiated agreement to address issues such as the establishment of the governance mechanism specified in an agreement; monitoring and reporting to inform parties about progress in implementation; grievance mechanisms and/ or dispute resolution processes; and, the adjustment of the terms of an agreement in response to unforeseen implementation occurrences (Sadoff & Grey, 2005).

When significant power imbalances exist between the parties, enforcement mechanisms and continuous consensus-building processes should be used throughout implementation to promote and maintain a collective approach to resource management. Other mechanisms that need to be incorporated into an agreement to address asymmetries of power may include future dispute resolution and arbitration processes; implementation alternatives for different field contingencies; the use of external observers to monitor compliance and promote greater transparency; and, joint site management, monitoring, and reporting. Building an adaptive approach into an agreement is also very pertinent when power imbalances are significant because adjustments can be made in response to political, social, or ecological changes that may play out over time. Key aspects of effective implementation are the mechanisms established to bring parties together to monitor progress, learn from implementation and adapt as necessary. It is important to clarify who has responsibility for overseeing implementation, whether this is an existing organization or a body formed from representatives of participating stakeholders (Aquamoney, 2009).

For decades, dialogues about transboundary water cooperation centered around water allocation, conflict mitigation or resolution, notification, and data-exchange (Jägerskog & Zeitoun, 2009). Around the world, we find examples of where cooperation-whether guided by loose principles or formal conventions-has led to concrete benefits in economic growth and regional security. In conclusion, cooperation in transboundary water management should take place on both the international and the regional level. The former level is most suitable for coordination of the implementation of the agreement and the coordination of river basin management plans and agendas. The latter is better appropriate for executing water policy in practice.

In the next chapter, this study explores the possible applications of theories into practice and studies the cooperation framework in the case of the Eastern Nile Basin. To understand the basin better, this study conducted an expert survey in the form of face to face interviews with decision makers, academics and specialists in the three countries of the Eastern Nile Basin.

4 Chapter 4: Understanding the cooperation opportunities among Eastern Nile riparian states: an expert survey

4.1 Introduction

This chapter explores both enabling factors and barriers to transboundary cooperation in Eastern Nile Basin and measures the willingness to form a basin-wide agreement over Nile waters from native experts' points of views. Also, the chapter documents experts' opinion and vision towards the future of the Nile region on the subjects of collaboration, development, governance, trade, and stability. The purpose of the expert survey[10] was to identify each country's current challenges, perception about neighboring countries and future needs with respect to the Nile river. Therefore, by understanding the challenging issues and study the capacities of each riparian to address those issues to improve the likelihood of achieving sustainable, fair and robust conditions for encouraging the basin-wide cooperation.

The analysis in this research is based on an in-depth literature review as well as quantitative and a qualitative evaluation of semi-structured experts' interviews. A combination of the hydro-economic model simulating of the basin and the experts' survey results were translated for designing the experimental game on riparian states' preferences, strategic/cooperative interactions and perspective of future water-related scenarios in next chapters.

Fundamentally, survey findings are grounded on two levels: (1) a questionnaire-based survey ranking on a six-level Likert-type scale[11] to collect quantitative data and statistics and (2) a face-to-face interview-based survey with 18 selected experts from the three countries to discuss a qualitative analysis of Nile River Basin cooperative arrangements and future prospects.

By valuing experts' judgment based on their experience, this chapter reflects on each country's perception about cooperation in general and the willingness to cooperate with each other while knowing what they think of their neighbors, in designing our experiment. The expert interviews allowed the study to triangulate some emerging conclusions, including some insights that went

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[10] *The questionnaire can be found in the Appendix.*

[11] *A Likert scale type of question is a commonly used set of responses for closed-ended ones which are usually preferred in questionnaires because of the ease of counting the frequency of each response. Likert-type data are commonly used to measure attitude providing a range of responses to a given question or statement. It is an essential tool in psychology and social surveys and is an ever-present method of collecting attitudinal data (Dittrich, Francis, Hatzinger, & Katzenbeis, 2007).*

beyond themes in the literature and suggested potential future directions for developing the methodology of the current study.

Informed by this framework, this chapter pursues to understand the future normative preferences of the experts who oversee the major activities involved in water decisions. Consequently, the survey was constructed to assess water decision-makers' preferences and preferred cooperation on the future of the water system in the Nile Basin across five categories of (a) water allocation (b) cooperation challenges (c) economic benefits, (d) available transboundary tools, and (e) activities that cut across these themes.

The results indicate that the main obstacle to cooperation is a lack of trust stemming from the lack of transparency regarding hard data, policies and political agenda among the three countries due to the historical and current political situation. Although they share borders and many of the natural resources, the socio-cultural and geopolitical aspect of each of these countries is different from another. Transparency in this context is described as a complex decision-making process in which the benefits of cooperation are unknown and effective diplomatic approaches are lacking. The survey outcomes also indicate an urgent need to develop a platform for regional cooperation while promoting the existing facilities and infrastructures. The capacity to address these requirements and the flexibility and willingness in diplomacy would ultimately lead to negating misunderstanding, building trust and eventually succeed in achieving basin-wide cooperation.

4.2 Questionnaire Survey and Interview Method

Survey data is generated in forms of qualitative, quantitative or a combination of both. Quantitative data often comes in the format of perception of the respondents through direct expert surveys. This information defined as experts' judgments or insights on a subject, awareness or levels of satisfaction (Ressurreicao, Simas, Santos, & Porteiro, 2012). Qualitative research involves examining and reflecting on the less tangible aspects of a theme such as values, attitudes, and perceptions (Keller, Kirkwood, & Jones, 2010). Edwards (1999), described survey methods as being like an onion, with data from questionnaires similar to peeling off some outer layers of skin, but is supplemented by interviews to get to the deeper layers. This study used a combination of qualitative and quantitative questions incorporated in questionnaire sheets and as well as in the interviews to gain in-depth details and to learn the patterns of a more significant target group in general.

In all fields of study, the knowledge of local experts is based on context-specific experiences and provides local insights related derived from their daily professional activities, which can only be obtained by expert survey methods (Edelenbos, van Buuren, & van Schie, 2011). Dong et al., (2013), reviewed the existing research on scenario development and capacity building for cooperation in water-related management practices and reported, despite the wide variety of settings, scales, and geographic characteristics considered in the reviewed articles there is a general tendency to rely on expert judgment and scientific involvement when defining focal questions and main driving forces in identifying significant sources of uncertainty.

The current study took into consideration some of the obvious limitations, i.e., terminology, local vernacular, etc., during the design phase based on expert advice. Research design measured such as offering a "no opinion / don't know" options helped to safeguard the quality of responses (Cooper & Schindler, 2003). It was also incorporated into the questionnaire i.e. no option means that the respondent's response is not listed in the options, whereas "I don't know" is chosen when the respondent is unaware of any rightful opinion, the lack of such options forces the respondent to choose one of the available choices which can then result in inaccurate conclusions and/or statistically deviate or decrease the value of findings. Further to this, the survey added a neutral option as "Not Familiar" if the questioned term or approach needed particular expertise.

The survey was pretested with a small set of water-related fields' experts which is not included in the full study, in order to test relevance, accuracy, time taken and response characteristics. Based on the results, the survey was revised and fine-tuned to capture precise and concise answers that would lead to the development of laboratory games, i.e., to apply real decision makers' perception as a practical tool to familiarize with the real-world situation.

4.3 Objectives of the Survey

The survey targeted to collect quantitative and qualitative data on the transboundary inter-relations and issues among eastern Nile River riparian countries in participating in a cooperative arrangement, to improve the process of negotiation for cooperation.

The experts interviewed in this survey vary in professional background and field of expertise from policy makers/advisors at national, regional, local government levels, decision influencers, consultants to academics and scientists, primarily those responsible for the development, implementation or control of solutions/strategies/policies. The designed questionnaire aimed to obtain answers to 5 groups of questions:

- What is the importance of a basin-wide agreement to the riparian states and how enthusiastic they see each other towards achieving it?

- What are the significant problems in the way of achieving full cooperation over Eastern Nile waters, from each country's point of view? What can be improved to tackle them?
- What are the most significant milestones in the negotiation process? What tools can be used to foster the process?
- What are the primary interests and priorities and inter-linkages of each country concerning Nile waters allocation and trade-off among sectors in comparison to each other?
- To what extent does "GERD" and "DOP" facilitate the regional cooperation in Eastern Nile?

4.4 Survey instruction and procedure

The following process is an outline of the survey structure adapted in this study.

4.4.1 Step 1: Design and development

The questionnaire was subdivided based on the thematic/subject areas. At the preliminary stage, a mind map was developed for connecting the issues that needed to be assessed in the questionnaire. The process of translation and adaptation of survey instrument followed the World Health Organization's guidelines recommending the steps of forwarding translation; expert panel back-translation; pretesting and cognitive interviewing (Daouk & McDowall, 2013). For the multiple evaluating questions, the rating based on evaluation form from 0 to 5 (0 = strongly disagree; 5 = strongly agree) were designed, and the respondents were asked to answer closest to describing their opinion. The rating system was chosen in order to be able to code plenty of responses to measure, compare and analyze[12]. In classical survey design and approach, it is quite common to leave respondents free to identify issues through open-ended questions and mention the summary of what they recommend at the end (Cooper & Schindler, 2003). However, to avoid any bias in results, the design of the questionnaire and the question route for interviewing were carefully constructed considering following issues (1) planning the content (2) questions' layout and wording (3) piloting and pretesting (4) covering letter.

[12] *For bipolar scales (running from positive to negative with neutral status in the middle), reliability and validity are highest for about 7 points. In contrast, the reliability and validity of unipolar scales (running from no importance to very high importance) seem to be optimized for a shorter range, approximately 5 points long (Gibson, 2006).*

Once the pilot survey was ready, interview sessions were simulated, and the questionnaire was reviewed and filled by six researchers and experts at ITT[13]. Based on the results from mock interviews the questionnaire was refined further for ease of understanding,

4.4.2 Step 2: Piloting the questionnaire stage

To improve the validity of the survey, the questionnaire was pilot tested, for the second time by a group of experts from different countries and of expertise. During the UNESCO conference, after giving a detailed presentation on this study concept, the pilot design of the questionnaire was distributed among participants. It was filled, tested and reviewed by 32 international and native experts who had attended the "3rd Open Water 2015" symposium by UNESCO-IHE[14].

4.4.2.1 Structure of questionnaire

The questionnaire was accompanied by a one-page description of the study and its goals as a covering letter; explaining the aims of the research and survey along with asking permission to use the respondents' insights for scientific purpose. The questionnaire had three main parts that follow right after the introduction section: At first respondents were asked to specify their background information, including nationality, educational attainment, professional responsibilities, particular area of expertise and demographics along with two questions (see Appendix 9.1) asking to determine the type of respondent's involvement in water-related matters and their authority to make decisions.

Some of the questions in the questionnaire and interview sessions were overlapping in content, and thus in many instances, our approach has been to amalgamate the responses to groups of similar items, thereby also increasing the robustness of the data. Interviews along with expert survey gave a more comprehensive result to questions. At the request of respondents, while conducting the pilot survey, extra space was provided for additional free-text comments so that participants could add opinions or comment on some issues addressed in the survey.

4.4.3 Step 3: Sample Constituency

Because the objective of the survey was to elucidate the views and perceptions of experts in water management and/or water policy-related work in these three countries, respondents were selected from a pool of the Eastern Nile River riparian states only. The secondary selection criteria were occupation, technical expertise, and experience. Since access was limited to a fraction of

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[13] *Institute for Technology and Resources Management in Tropics and Sub-tropics at University of Applied Sciences, Cologne, Germany.*

[14] *"3rd Open Water 2015" symposium by UNESCO-IHE, held at IFPRI Campus in Addis Ababa, Ethiopia from 14 to 17 September 2015.*

the total number of professionals working in the transboundary water-related field in the eastern Nile Basin, the final selection was limited to 63[15]Native professionals composed of international and national policy makers, policy advisors, academics and researchers, intermediaries, consultants, water-related NGOs' and international development organizations' members, consultants and specialists.

Before the survey process began, lists of the key water resources experts from the three countries were provided.[16]Arranged and facilitated most of the interviews conducted in Ethiopia and helped to identify and contact fundamental experts in other riparian countries' experts who were available in Addis Ababa during the field visit.

The validity of a survey can be initially assessed based on its representativeness. Although the study does not claim that those who responded to the surveys formally constitute a "representative" sample of all stakeholders and experts involved in issues related to water, decision-making, and development in the Eastern Nile River Basin. The survey demonstrated that the sample of selected respondents encompasses a broad range of expertise and type of institutions.

4.4.4 Step 4: Implementation

To conduct this study, affiliation with University of Sharm El Sheikh, University of Cairo, University of Khartoum, and University of Addis Ababa, ENTRO and Hydraulic Research Center (HRC) was necessary to be able to conduct the expert interviews, collect data and to understand the context first hand. The interview sessions aimed to gather factual information in a friendly environment along with understanding perceptions from different positions, background and nationalities. From the pool of experts contacted for the survey, 18 natives of the Eastern Nile Basin agreed to an interview session to provide their critical opinions on issues related to their particular expertise on Eastern Nile Basin. Interviews were conducted either at the office of the interviewees or conference venues or hotel lobbies or through Skype meetings.

Semi-structured interview design allowed some comparable data to be collected but also allowed the individual interviewee have the chance to expand and emphasis on points they chose to elaborate. This data was mainly qualitative and, although subjective, gives some

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[15] *82 experts from all three countries received the questionnaire, and 63 experts returned completed questionnaires.*

[16] *ENTRO – Eastern Nile Technical Regional Office, Addis Ababa, Ethiopia. Throughout 2-month field visit for data collection and survey conduction, I operated from ENTRO office, whom kindly provided me basin study reports, the literature on the Eastern Nile Basin and granted access to the library and specific software programs.*

triangulation to other data from the questionnaires and case studies. Even though the interview questions were the same as some of the survey's questions, the interviews were more detailed and included descriptive commentaries. Each meeting provided a narrative story of the situation in each country. It helped deepen the understanding of outcomes, impacts priority and challenges in transboundary water issues in the basin and provided illustrative examples. The interviews provided an opportunity to tap into the contextual knowledge of the interviewees and capture the human side of the answers.

Interview sessions started with an introduction process[17] Although primary questions were pre-planned, the semi-structured design allowed the sequence of the questions to flow naturally, based on information provided by each respondent. At the end of the meeting, respondents were handed over a printed questionnaire to fill up at their convenience and send it back in 2 days. The interviews, which typically lasted 45 minutes were recorded in audio/visual form, and where technology was not available, detailed notes were taken.

The questionnaire was also distributed by partner organizations to target experts who were not available during the field visit. However, despite the decent distribution of respondents and the relatively good overall distribution of their professional background and position, all three countries were not equally represented due to lack of access to experts from Egypt[18]. Interviews with Egyptian experts were mostly conducted via Skype or emails.

4.4.5 Step 5: Data analysis and evaluation

In order to make proper comparative analysis between countries and different groups of respondents, first of all, it was necessary to create Likert scale items by calculating a composite score (sum or mean) using parametric statistics such as mean for central tendency and standard deviation for variance (Cooper & Schindler, 2003). To identify underlying components that explain the pattern of correlation within the observed items, survey results were compiled and analyzed following descriptive methods using SPSS application[19]. Thus, for the analysis of central tendency and variability median, mode, range, and interquartile range were used. Results were then compared in different categories among nationality groups of respondents to find significant patterns and recognize differences. Qualitative responses to the open-ended and interview questions regarding the suggestion for improvement of the current situation and perspective towards the future of the Nile basin were coded in two rounds in SPSS. The first

[17] *Introduction consists of getting to know each other, setting up recording equipment and explaining the purpose of the interview and the research concept.*

[18] *Due to my nationality, my visa application to travel to Egypt was rejected two times.*

[19] *"IBM SPSS Statistics" is a software package used for statistical analysis, data management, and data documentation which is commonly used for survey data entry and analysis.*

round of data analysis used open coding, identifying and grouping responses based on origin. The core coding process emerged as cross-sectional analyses ensuring all aspects of responses were represented by themes, category and respondents' specifications. The frequency of the replies aligned with each question category was translated into numbers and calculated. A similar protocol was followed for the interview question requesting information about the strengths and weaknesses of the countries in achieving regional cooperation.

In practice, data gathered from 18 expert interviews were documented in the form of transcripts. The interviews recorded were also replayed to capture some critical issues raised by the experts. The transcripts were coded, and codes were checked independently for objectivity and completeness and differences were discussed, and adaptations were made accordingly. Since all the interviewees filled the questionnaire, there was no need for coding the overlapped questions in the interview and extract separate data unless there were discrepancies. In the end, chosen "Not Familiar" options in the questionnaire were excluded from the result report to prevent inflation of the actual resulting responses.

4.4.6 Step 6: Survey Findings

The results from analyzing expert survey were used to develop the hydro-economic river model and scenario-based experimental game design. Following is the summary of the results and considerations according to the objective of the survey:

4.4.6.1 Characterization of Respondents

All survey respondents were requested to complete “Section 1” of the questionnaire which aimed at categorizing the respondents. Among 63, 25 respondents were from Ethiopia, 22 from Sudan and 16 from Egypt.

There was a 9:1 ratio of male to female representation which correlates accurately with the overall female employees in proportion to male employees in higher positions in these countries. The average age of respondents was 56 years of age, with a mean 20 years’ experience in their expert field of study. 46% of them were technical scientist/academic, 16% policy advisor, and politician, and the remaining 38% are active both as academic and policy advisor.

Table 4–1 Respondents' occupation distribution

Background and Expertise of Respondents					
Field of Profession	Number of respondents	% of Total	Nationality		
			Ethiopian	Sudanese	Egyptian
Policy	34	54%	16	9	9
Hydrology	46	73%	16	16	14
Economics	27	42%	8	10	9
Engineering	41	65%	13	15	13
Environment	36	57%	13	13	10
Sociology	21	33%	8	7	6
Chemistry	14	22%	5	5	4
Note: Total number of respondents: 63					

Table (4-1), illustrates the occupational distribution of the 63 responses. Since water-related issues are multidisciplinary in nature, most of the respondents have more than one area of proficiency. Respondents' background of expertise and discipline is spread among 46 hydrologists, 41 water engineers, 36 environmentalists, 34, 27, 21 people with politics, economics, and sociology respectively.

Table 4–2 Distribution of respondents between policy-makers and academics

Overview of Respondents					
Sub-groups	Numbers	% of Total	Nationality		
			Ethiopian	Sudanese	Egyptian
Researcher/scientist	29	46%	9	10	10
Policy advisor	10	16%	6	3	1
Both	24	38%	10	9	5
Note: Total number of respondents: 63					

A high number of respondents also had a technical qualification, i.e., the high-level decision makers (Table 4-2). Based on the survey results it is safe to assume that most decision-makers in these countries are highly-qualified with post-graduate specialist degrees and/or doctorates in their field of study.

4.4.6.2 *Perception of experts on the necessity of basin-wide cooperative agreement*

The survey shows that a high percentage (94.9%) of participants favored the formation of a basin-wide cooperative agreement to manage water resources equitably, furthermore, they also stated it as an urgent priority. The results indicate (Table 4-3) experts from Egypt showed lower-level of urgency to create a basin-wide agreement compared to Sudan and Ethiopia. Even though, they all agreed on the importance of achieving a cooperative agreement.

89% of the interviewees agreed that effective transboundary water management techniques could enhance cooperation among Ethiopia, Sudan, and Egypt and lead to peace and improved welfare in the region.

One of the experts from Ethiopia, explained his concerns about the importance of achieving cooperative agreement, as:

Table 4–3 Survey on necessity of basin-wide agreement

Statistics

Basin-level Cooperation

Ethiopia	N	Valid	25
		Missing	0
	Mean		4.80
	% Mean		96%
	Std. Deviation		.645
Sudan	N	Valid	22
		Missing	0
	Mean		5.00
	% Mean		98.2%
	Std. Deviation		.294
Egypt	N	Valid	16
		Missing	0
	Mean		4.44
	% Mean		88.7%
	Std. Deviation		.964
Total	N	Valid	63
		Missing	0
	Mean		4.74
	% Mean		94.9%

> *"Any delay in reaching a comprehensive agreement is a backfire and harms regional security and stability. Therefore, reaching cooperative agreement late is counterproductive and as the time goes on, reaching the agreement becomes harder and more complicated."*

All the experts interviewed and surveyed in this study categorically agree upon the fact the cost of non-cooperation is very high and also it is highly detrimental to continued peace and security, economic and social development in the region.

4.4.6.3 Factors impeding transboundary cooperative agreement

Based on data analysis of the survey 18 major impeding factors to achieve transboundary cooperation in Eastern Nile Basin were identified. The results are represented in (Table 4-4). Yet, the most significant options concerning the importance and urgency of the 18 are the following three factors:

(1) Problem No. 8: Lack of transparency in data sharing (overall mean: 4.60/5): 92%
(2) Problem No. 9: Lack of trust and transparency in decision-making (overall mean: 4.50/5): 90%
(3) Problem No. 7: Unclear long-term benefits of cooperation (Overall mean: 4.15/5): 83%

The other significant selected problems are:

(4) Limited or inefficient exchange of data and information, (5) Competing for claims and perceived national independence essentials, (6) Negative past experiences (7) Misleading political leadership, (8) Unknown and unclear prospects of benefit-sharing.

On the other hand, surprisingly cost and management were among the options mentioned as the least significant impeding factors: (18) High cost of transition and implementation of cooperation, (17) Cultural differences among decision-makers, (16) Legal and institutional difficulties.

84% of interviewed experts strongly believed that basin-wide cooperation is feasible and plausible despite all the 18 constraints. They stated that all the differences are resolvable and transboundary cooperation is achievable.

Table 4–4 Obstacles to achieve transboundary cooperation in the Eastern Nile Basin

Descriptive Statistics: Problem Assesment

	List of problems	Riparian Countries								
		Ethiopia			Sudan			Egypt		
		N	Mean	Variance	N	Mean	Variance	N	Mean	Variance
1	Lack of political willingness for cooperation:	25	4.64	1.32	22	4.32	2.99	16	4.19	1.83
2	Political and economic power imbalance among Eastern Nile riparian	25	3.68	1.31	22	3.36	2.53	16	2.75	2.20
3	Misleading political leadership	25	3.64	2.32	22	3.32	2.99	16	3.19	2.83
4	Competing claims and perceived national independency essentials	25	3.40	1.75	22	4.09	0.94	16	3.13	1.32
5	Limited or non-effective exchange of data and information	25	3.32	1.56	22	3.91	0.94	16	4.00	1.60
6	Miscommunication among scientists and decision-makers	25	2.72	1.29	22	2.95	2.05	16	3.50	1.73
7	Unclear long-term benefits of cooperation	25	4.36	0.57	22	4.41	0.73	16	3.69	1.96
8	Lack of transparency in data sharing	25	4.72	0.46	22	4.59	0.63	16	4.50	0.27
9	Lack of trust and transparency in decision making	25	4.52	0.51	22	4.59	0.44	16	4.38	0.38
10	Negative past experiences	25	3.88	1.86	22	3.55	1.88	16	2.88	1.18
11	Non-participation in basin initiatives by some riparian countries	25	3.32	2.06	22	3.05	2.05	16	2.25	1.67
12	Competition for a finite supply of water	25	3.52	2.59	22	3.59	2.16	16	2.63	1.58
13	Unknown and unclear prospects of benefit sharing	25	3.32	1.48	22	3.55	1.21	16	3.25	1.40
14	Cultural differences among decision makers	25	2.24	3.11	22	2.32	3.56	16	1.50	1.47
15	High cost of transition and implementation of cooperation	25	1.96	2.04	22	1.73	2.97	16	1.69	1.43
16	"Only me " attitude in decision making processes	25	3.44	2.09	22	4.09	1.04	16	2.50	2.80
17	Historical and geographical legacy	25	3.36	1.91	22	3.64	2.34	16	2.19	2.70
18	Legal and institutional predicament	25	3.1	1.3	22	3.2	1.5	16	2.5	2.4

Note: Total number of respondents: 63

One interviewee from Egypt, stated the following concern, emphasizing the importance of trust and transparency during the negotiation process and decision-making stages, first of all, political will for cooperation should be in the place:

"A couple of decades and lots of resources wasted for the sake of building trust among the riparian countries. We have not seen much progress on basic principles. Particularly, there is no consensus about 'historical' water rights and value of water. We have witnessed progress on decision-support tools and monitoring and data-sharing strategies. However, the political will is still lagging behind. So, we should work on common principles such as the value of water, and enable political desire. The international community should not revolve around the fundamental issues. They should follow a direct and transparent negotiation approach."

According to the results of (Table 4-4) and (Table 4-5), one of the highest ranked options among the 18 obstacles identified from the questionnaire, is "Lack of political will for cooperation." The result of respondents shows that they believe that their country is the most cooperative compared to others. Experts from Sudan and Ethiopia think of Egypt as the most non-cooperative country in the region while Egyptians think of Ethiopia as the least cooperative concerning political wills.

However, the result shows that Sudan is the most cooperative country willing to peruse cooperation at the political level in the Eastern Nile Basin and Egypt still withholding from initiating or participating in cooperative agreements. We refer to an explanation of the situation from one of the interviewed expert's statements from Ethiopia:

Table 4–5 Riparian's Lack of political will for cooperation

Statistics Riparian states perspective of each others' cooperative mode

Country			Ethiopia	Sudan	Egypt
Ethiopia	N	Valid	25	25	25
	Mean		1.44	1.76	3.76
	Variance		2.340	1.190	1.273
Sudan	N	Valid	22	22	22
	Mean		2.18	1.55	3.77
	Variance		2.442	2.926	2.374
Egypt	N	Valid	16	16	16
	Mean		3.88	2.88	2.94
	Variance		1.450	1.183	2.063

"In a case of Egypt, in very early time, they were cooperative and willing to sign treaties, but after some years when the cooperation was not in their favor, they stepped back and wanted no change in the river flow and allocation patterns. Due to internal political instability in the last decade, Egypt did not show any interest in cooperation, but now that the new government is reaching to a stable point, they started to see the cooperation as an undeniable opportunity. Nowadays, they become more cooperative day after day and willing to negotiate recently but with slow and delaying manner."

Additionally, an expert from Egypt explained his concern about issues on the construction of

GERD and future of the basin:

> *"The attitude of ignoring the demands of the Nile riparian countries has led opposing, and strong reaction by the upstream countries and consequently some demands from the upstream countries were inflated. The GERD plan and construction created concerns about the safety of the dam suspect about the Ethiopian plans in both Egypt and Sudan. In order to improve the current situation, there is an immediate need to enhance trust and regional cooperation by sharing the benefits of the basin."*

In the end, the overall result of the interviews and questionnaire analysis shows that all the respondents agreed that their countries have the same shortages in transboundary water management but with different priorities and needs. Indeed, all of the respondents agreed that Eastern Nile basin-related problems in their country would affect other riparian countries and most think that this effect would be harmful and they should cooperatively take actions to solve or prevent such eventuality.

4.4.6.4 Milestones to the Negotiation Process

The respondents were asked to evaluate 18 factors contributing to the improvement of the negotiation process for a cooperative agreement on management of Nile waters. The following factors were rated as the most relevant and crucial to promote cooperation during the international negotiation procedures (Table 4-6):

(1) Option No. 12: Trust building especially in initial stages of the negotiation process (total mean: 4.74/5): 94.8%
(2) Option No. 3: Finding the balance among actual options of each riparian states through Water Diplomacy (total mean: 4.35/5): 87%
(3) Option No. 1: Providing transparency in all steps of the decision-making process (total mean: 4.29/5): 85.8%
(4) Option No. 9: Sharing information and conducting joint data assessments (total mean: 4.17/5): 83.4%

The least significant option to promote cooperative decision-making in negotiation, "the role of third parties in facilitating the cooperation." Local experts from the Eastern Nile region do not think placing international facilitator is one of the priorities for finding common ground.

Table 4–6 Milestones to promote cooperation in negotiation process

	List of Milestones	Riparian Countries								
		Ethiopia			Sudan			Egypt		
		N	Mean	Variance	N	Mean	Variance	N	Mean	Variance
1	Providing transparency in all steps of decision-making process	25	4.36	0.66	22	4.32	0.99	16	4.19	0.70
2	Recognizing and assessing the benefits of joint actions	25	4.28	0.38	22	4.14	1.74	16	4.06	0.86
3	Finding the balance between the interests of riparian states through Water Diplomacy	25	4.44	0.42	22	4.41	1.11	16	4.19	0.16
4	Finding the balance among actual options of each riparian states	25	3.96	0.79	22	4.18	1.11	16	3.88	0.65
5	Covering norms of equity and fairness	25	4.04	0.79	22	4.27	0.78	16	3.63	0.52
6	Resolving disputes between riparian countries	25	3.64	1.07	22	4.14	1.08	16	3.50	0.93
7	Rooting discussions in technical and scientific evidence than emotions or ideology	25	4.26	0.67	22	4.36	1.00	16	3.63	2.65
8	Existence of intergovernmental cooperation	25	4.28	0.71	22	3.55	1.31	16	3.25	2.07
9	Sharing information and conducting joint data assessments with transparency	25	4.36	0.56	22	4.33	1.43	16	3.83	1.32
10	Offering and scaling incentives for cooperation	25	3.68	1.73	22	3.50	1.60	16	3.50	1.20
11	Facilitating the access to financial resources	25	3.32	2.31	22	3.68	1.85	16	3.56	1.06
12	Trust building specially in initial stages of the negotiation process	25	4.72	0.21	22	4.86	0.12	16	4.63	0.38
13	Considering the effect of climate change on the future water demand trend in each riparian countries	25	3.60	1.75	22	3.23	2.66	16	3.38	1.45
14	Considering the effect of population growth on the future water demand of each riparian countries	25	3.88	1.11	22	3.45	2.93	16	3.13	1.18
15	Considering the costs of no-cooperation for each riparian country	25	4.16	1.56	22	3.95	1.19	16	3.69	1.30
16	Building mutually reinforcing networks and coalitions	25	4.12	0.78	22	3.23	1.61	16	3.38	1.45
17	Clear understanding of the basin and future opportunities	25	3.80	1.42	22	4.00	1.52	16	3.94	0.86
18	The role of third parties facilitating the cooperation	25	2.88	1.53	22	3.00	2.19	16	3.38	1.72

Note: Total number of respondents: 63

4.4.6.5 Practical Tools to Promote Basin-wide Cooperation

All 63 respondents of the questionnaire were asked to estimate the effectiveness of 17 tools presented in this question (Table 4-7). The three most useful tools as rated are:

(1) Tool No. 12: Transparent information sharing (total mean: 4.38/5): 87.6%
(2) Tool No. 12: Cost and benefit sharing mechanisms (total mean: 4.23/5): 84.6%
(3) Tool No. 12: Scenario analysis approaches (total mean: 4.20/5): 84%

The overwhelming majority (88.5% of the experts), indicated that it is important to obtain information/data jointly and share it transparently.

Table 4–7 Practical tools for promoting basin-wide cooperation

Descriptive Statistics: Tools Enhancing Regional Cooperation										
List of Tools		Riparian Countries								
		Ethiopia			Sudan			Egypt		
		N	Mean	Variance	N	Mean	Variance	N	Mean	Variance
1	Cost and benefit sharing mechanisms	25	3.96	0.86	22	4.22	1.05	16	4.50	0.93
2	Institutional re-arrangements	25	3.52	2.18	22	3.91	2.85	16	4.13	0.78
3	Developing joint projects to increase common benefits	25	4.12	1.69	22	4.23	1.61	16	4.00	0.53
4	All principal stakeholders involvement	25	4.40	0.42	22	4.00	2.00	16	4.56	0.80
5	Improved mediation and dispute resolution mechanisms	25	4.64	0.99	22	3.95	1.38	16	3.63	0.92
6	Balance flexibility and stability	25	4.28	1.63	22	4.59	1.78	16	3.56	1.33
7	Incentives for cooperation	25	3.60	1.50	22	4.09	1.13	16	4.13	1.18
8	Transparent information sharing	25	4.36	0.74	22	4.73	0.30	16	4.06	0.86
9	Legal frameworks	25	4.68	0.48	22	4.50	0.83	16	3.94	0.86
10	Scenario analysis approaches	25	4.12	1.11	22	4.41	1.11	16	4.06	1.13
11	Employ political symbols and prestige effects	25	3.96	2.87	22	4.05	3.95	16	3.06	2.20
12	Equitable Investment	25	4.10	2.25	22	4.60	2.22	16	3.81	0.96
13	High-Level Engagement with the Governing Authority	25	4.00	1.25	22	3.86	2.41	16	3.25	1.27
14	Risk assessment tools	25	3.88	1.53	22	3.73	2.02	16	4.38	0.38
15	Considering all actors interests	25	4.04	2.29	22	3.64	2.05	16	4.25	0.33
16	Alternative future problem formulation and assessment	25	3.72	0.96	22	3.95	1.28	16	3.88	0.52
17	Availability of relevant new technologies	25	3.92	1.83	22	3.45	2.64	16	3.56	1.33
Note: Total number of respondents: 63										

One of the interviewees expressed his concern about the importance of data sharing for trust building as:

> *"Exchanging data and information can be the result of cooperative agreements and sometimes without sharing information transparently, during the negotiation phase, you miss the chance of trust building."*

4.4.6.6 Water Allocation

Developing scenarios for the experimental game required an assessment based on a quantitative mathematical calculation, qualitative evaluation and the process relied on preferences expressed by experts in the questionnaire. Table (4-8), shows choices concerning the relevant sectoral water use for each country of the basin.

The color-coded schematic below represents priority in water allocation in each of the three countries of the Eastern Nile Basin. The stacked bar diagrams shown throughout the report provide a graphical presentation of the responses within each group of national experts. Each color code displays a different level of importance from Red (Highest priority) to Pink (Least priority)[20].

In countries with large-scale hydropower production and irrigated agriculture, most decision makers find it tough to determine which of the two is more important, but in the case of Ethiopia hydropower is the priority. In countries without large-scale hydropower production potential, experts apparently prefer consumptive to a non-consumptive use of water, like in the case of Egypt.

Table 4-8 Preferences in Nile water allocation among water sectors for the Eastern Nile riparian countries as derived from the expert survey. 1= High importance to 5= Lowes importance

National Priority	Ethiopia	Sudan	Egypt
Water for agriculture	2	1	2
Water for hydropower	1	3	5
Water for domestic consumption	3	2	1
Water for industry	5	4	4
Water for environment	4	5	3

Highest priority
Second highest priority
Important
Some how important
Lowest priority

Results indicated that Ethiopia's strategic preference over Nile waters is: (1) Hydropower generation, 2. Food production, (3) Domestic use, (4) The environment, and last (5) Industrial consumption. Since hydropower is a non-consumptive form of water use, Ethiopia's priorities do not pose any threat to downstream countries.

Similarly, Sudan's priorities are (1) Agriculture, (2) Domestic use, (3) Hydropower generation, (4) Industry, and the last (5) The environment. By planning to expand agricultural production in the near future, Sudan will increase its irrigation water withdrawal from the Nile, which is a direct threat to downstream countries. However, for Sudan food security is of strategic national importance and priority.

Meanwhile, Egypt prioritizes the Nile waters: (1) Domestic and municipal use, (2) Irrigation, (3) The environment, (4) Industrial use, and lastly (5) Hydropower. Due to pollution and low water quality of the Nile reaching Egypt, access to clean water for domestic use is Egypt's biggest concern and immediate highest priority. Since Egypt has already exploited the hydropower potential within its borders, and with access to other sources of energy, hydropower is not a

[20] *SPSS descriptive report of interest and priorities is provided in the Appendix.*

national interest.

All experts agreed on the necessity of measuring trade-offs in different water allocation scenarios and using interest-based negotiation approaches in order to increase numbers of options for future cooperation:

> *"Even though to some extent, benefits of the cooperation have been clear to all upstream and downstream riparian states of the Nile, politicians make the situation confusing and push the cooperative agreement further away. Trade-offs and interests of countries should be translated into numbers, and a model should be created to measure and compare each option."*

A model to support decision-making can be developed identifying the trade-offs in allocating water in the Eastern Nile Basin among competing users. These trade-off preferences can be used for simplified decision-making procedure for formulating the experimental game in the next chapter.

4.4.6.7 Impact of GERD on basin-wide cooperation

Scholarly analyses usually frame the GERD as a significant game changer representing the beginning of a new era in the Nile basin and focus mainly on potential impacts of the GERD on transboundary progressions (Pham Do , Dinar, & McKinney, 2012). However, there is still much uncertainty concerning GERD's positive effects on the hydro-political relations between Nile riparian states (Tawfik, 2015).

Table 4–9 GERD influence on prospects of cooperation

Statistics

GERD influence degree in cooperation

Ethiopia	N	Valid	25
		Missing	0
	Mean		3.72
	Variance		.793
	Percentiles	25	3.00
		50	4.00
		75	4.00
Sudan	N	Valid	22
		Missing	0
	Mean		3.64
	Variance		1.290
	Percentiles	25	3.00
		50	4.00
		75	4.25
Egypt	N	Valid	16
		Missing	0
	Mean		1.69
	Variance		1.163
	Percentiles	25	1.00
		50	1.00
		75	2.75

Table (4-9) illustrates the answers evaluating the impact of GERD in decision-making on cooperation. Results of the survey categorically state that GERD's construction has promoted and adopted different cooperation norms and had been potentially a key to changes in transboundary interaction across the Eastern Nile countries.

According to the survey result (Table 4-9), experts from Ethiopia and Sudan believe that GERD has a high positive influence on the trend of cooperative activities in the region, while experts from Egypt disagree.

Overall, Ethiopian experts responded with an average of 3.72 degrees to the effectiveness of GERD on a 0 to 5-scale (74.4%) and Sudanese with an average of 3.64 (72.8%). On the other hand, experts from Egypt evaluated the effectiveness of GERD with 1.69 on a scale of 0 to 5 (33.8%), which is comparatively very little. Additional insights from the comments in one of the interview session about downstream countries' concerns towards GERD:

"High fluctuation in water levels creates problems for irrigation pumps downstream of the GERD. It is important to make sure cooperation is genuine and based on mutual trust and confidence among the cooperating parties. Supplementary focus on the establishment of the legal and institutional mechanism for cooperation is vitally necessary."

The results clearly indicate that GERD is a source of conflict and the leading cause of tension between Ethiopia and Egypt.

4.4.6.8 Declaration of Principles (DOP)

On 23rd March 2015, the DOP for the GERD was signed in Khartoum by the three heads of state. The declaration was considered a historical deal, bringing together for the first time, the three major Eastern Nile countries around guiding principles on cooperative relations. However, it was only a non-binding agreement unique to the eastern Nile riparian states alone with no legal validity (Salman S. M., 2016).

Statistical analysis of the level of concern from experts in the context of DOP is shown in Table (4-10). Ethiopian experts perceive DOP at the level of 3.72 degrees out of 5 (72.2%) for effectiveness to promote cooperation. Sudan and Egypt's perception is much less favorable compared to that of Ethiopia. Overall, Sudanese experts find DOP 3.09 degree effective out of 5 (61.8%) and Egyptians found it only 2.19 out of 5 (43.8%) effective. One of the experts expressed his point of concerning hyper-coverage of the DOP deal in the local media as:

Table 4–10 DOP & basin agreement

Statistics

Nile DOP contributation to cooperation

Ethiopia	N	Valid	25
		Missing	0
	Mean		3.61
	Median		4.00
	Percentiles	25	3.00
		50	4.00
		75	4.00
Sudan	N	Valid	22
		Missing	0
	Mean		3.09
	Median		3.00
	Percentiles	25	3.00
		50	3.00
		75	4.00
Egypt	N	Valid	16
		Missing	0
	Mean		2.19
	Median		2.00
	Percentiles	25	1.00
		50	2.00
		75	3.00

"The declaration of principles of GERD' has been wrongly used by the riparian countries to make political gains out of it. I am deeply concerned that the political game may derail the agreement for its intended purpose. So, the riparian countries should show a genuine interest in the long-term benefits of cooperation, not for short-signed political gains in their respective countries."

4.5 Discussion

The survey sought to clarify the relationship between current issues, existing approaches and political will from the native experts' perspectives. The expert survey was designed and conducted focused mainly on existing problems, predicting a certain future, incorporating uncertainty derived from a historical range of variability, and planning to understand and promote optimized transboundary decision-making.

The native experts from all the countries regardless of their position as an academic or politician or as engineers or combination of these, they all unanimously, rated highest or most desirable, agreed that a basin-wide cooperative agreement is crucial and imperative. The results show that experts agree that transparency in data sharing, benefit-sharing and open list of priorities increases trust which in turn improves the negotiation process and political willingness to reach an agreement. In other words, the findings of this study suggest that water experts within the field of water management desire to and feel the urgency to address issues jointly and move forward cooperatively.

In the case of an agreement, Egypt prefers the presence of a third party to play a mediator role in the management of the Nile to support its position and enforce legal and institutional rights accurately as agreed upon in earlier years (BMBF, 2015). However, the question remains concerning what are those universal agreeable terms and conditions which can be ratified by all parties and put into effect by a third party or neutral management.

This survey helped to understand each country's current situation, future needs, and interests concerning water management in the Eastern Nile Basin. However, most individual interviewees regardless of their country of origin were very positive about the likelihood of full transboundary cooperation in the near future.

5 Chapter 5: Eastern Nile Basin Hydro-economic Model (HEM): Water and Benefits Allocation

5.1 Introduction

All countries map risks and vulnerabilities of food-water-energy security for uncertain future scenarios and measure the cost-benefits of policies and its implementation (Heinz, Pulido, Lund, & Andreu, 2007). In this particular context, economic models that project long-term costs, benefits and risks of different options is a tool that could aid decision makers to be fully aware of all the opportunities and uncertainties. Mapping a river into a model to illustrate interlinkages among its components provides a framework for policy design, implementation, and evaluation in especially water-stressed basins (Dinar & Nigatu, 2013). The hydro-economic model (HEM) developed for this study simulates the transboundary river system through a simple framework to identify hydrologic and economic impacts of different patterns of water allocations for irrigated agriculture and hydropower generation in the main sites along the Eastern part of the Nile River.

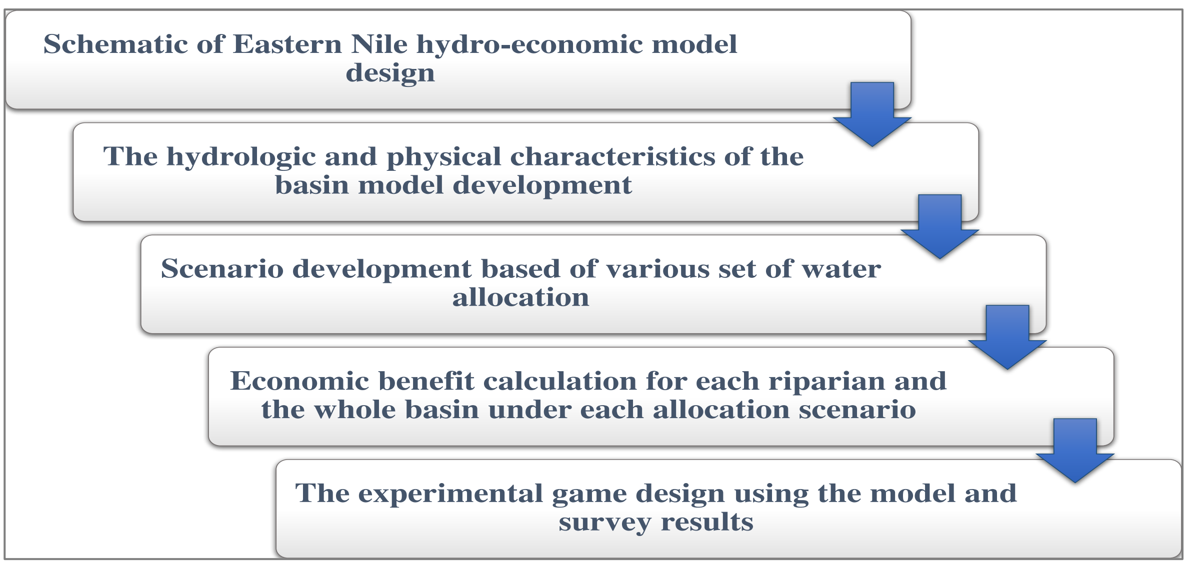

Figure 5–1 Methodology structure: from modeling the basin to game design

This chapter describes the processes and development of the HEM of the Eastern Nile River; this model would map the network, water balances (demand and supply) under different scenarios, inter-sectoral competition for water, and actual values for economic activities based on transboundary water allocation. This research attempts to understand and incorporate this information into the overall study to comprehensively decipher the importance of reaching an agreement among the Eastern Nile riparian states for full cooperation in sharing the river basin resources. From HEM results, this work can infer benefits and non-benefits of cooperation and non-cooperation. As the next step of the methodology, this study developed and conducted laboratory experiments in the form of games (Figure 5-1) using a HEM, based on the real-world scenario that replicates cause and effect of decision-making. The results can ascertain benefits and consequences that are relevant and applicable for cooperation. Four scenarios with different economic benefits combination for each riparian state was developed to be tested in the HEM (Figure 5-2). The benefits and non-benefits produced under each scenario became the main components laboratory experimental game; where three players would try to maximize their options while trying to reach a cooperative agreement with and without clarity on benefits and non-benefits (Figure 5-1).

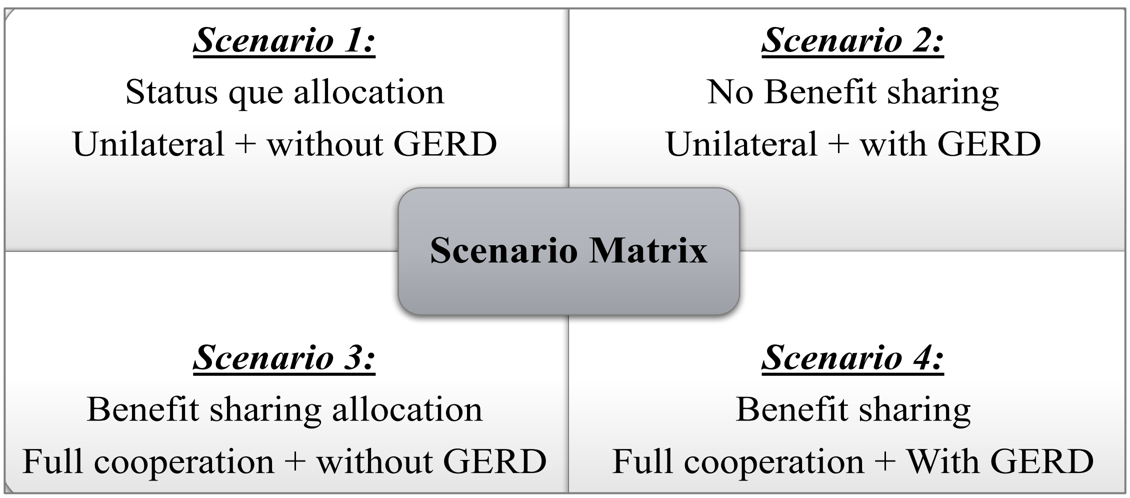

Figure 5–2 Scenario Matrix of the HEM

The HEM allocates water resources in two steps: initial water allocation and water use based a) abstracted node-link river basin network and b) historical water rights agreements (McKinney, Cai, & Rosegrant, 1999). Four allocation schemes were developed quantifying each riparian's economic gains with emphasize on their potentials, priorities, and efficiency under four different management situations. These four scenarios (Figure 5-2), i.e., two of them with GERD and the other two without it in the river network, and two scenarios with unilateral (country-specific) actions and two with cooperative arrangements are the results of combining expert survey results and the HEM.

The river basin is acknowledged to be the appropriate unit of analysis to address challenges in transboundary water governance. Hence modeling at this scale is essential to make transparent a) cause and effect, together with b) benefits and losses, so that policymakers can make informed decisions on allocation of resources and equitable benefit sharing, by using the knowledge generated from models (Kucukmehmetoglu & Guldmann, 2010). It is at the basin level that these four scenarios are mapped to cover hydrologic, agronomic, and economic values and tradeoffs with GERD and without under unilateral action and cooperation. The results offer a clear understanding of if cooperation needs to be pursued and if a riparian state is better off taking unilateral action.

However, river basins are inherently complex systems with many interdependent factors. Efficient and comprehensive analytical tools are necessary to make appropriate strategic decisions to achieve sustainable water use (Ward & Pulido-Velázquez, 2008). Such informed policy decisions produce a more efficient and sustainable level of water-related economic benefits. By using optimization algorithms, models help decision-makers understand and formulate resources management alternatives. It provides more transparent vision by analyzing the function of each component in the model, its impact and inter-relations to select the most appropriate and relevant options for implementation considering future water demand (Heinz, Pulido, Lund, & Andreu, 2007). One of the advantages of applying simulation algorithms to a hydro-economic model of a basin is that the performance and statistical distributions of selected indicators, such as hydropower generation or cross-border flows, can be derived and the risk of economic benefits and costs for each riparian country can be assessed (Dinar & Nigatu, 2013). Results from each water allocation scenario and each policy choice require separate calculation and investigation under a different set of assumptions (Mayer & Muñoz-Hernandez, 2009).

An experimental laboratory game is designed to find the best values under different water allocation patterns along the river so that the benefits can be divided and shared satisfactorily and equitably among various stakeholders in the Eastern Nile countries. By combining the ideal options with data regarding the interests and priorities of the riparian countries generated from the survey, this study investigates the optimum solution within the basin. Therefore, the developed experimental game based on the HEM of the Eastern Nile basin simulates the strategic environment by considering the hydropower generation potential of GERD and signed economic benefits with it, incentives for cooperation and compensation, power trade and, food import and export within the basin. Therefore, the combined methodology of this study seeks a "win-win-win" range of options that could promote cooperation in the Eastern Nile Basin.

If each riparian presented as A, B, or C (Figure 5-3) with three players could unlock the development and economic potential into the further dimension of a win for all situations. By identifying the long-term benefits to be shared from win-win-win solutions made available as a range of options during negotiation, the study aims to make cooperative options more attractive and create greater gain for all participating states by choosing them. For the transboundary water cooperation process to be sustained, each riparian needs to be satisfied that what it gains by continues cooperation is more than what it can achieve by abandoning cooperation (Johnston & Smakhtin, 2014) thus it is a natural choice of cooperation over unilateral action.

5.2 Historical overview of hydro-economic modeling

Since the mid-20th-century hydrologists have researched optimal operating rules of hydrologic systems, economists have been applying methods of optimization in water allocation, and sociologists have been examining community behavior and processes relating to the formation and support of local and upper-level governments making decisions about water management practices. Several studies were carried out in the mid-1980s on basin modeling to develop optimum operating policies for river systems considering both water quantity and quality. These studies can be classified into two groups: downstream water quality control without taking into account water quality in reservoirs (Jaworski , Weber, & Deininger, 1970) (Martin Q. W., 1983) (Harboe, 1992) and water quality control considering both reservoirs and downstream flows (Ikebuchi & Kojiri, 1992) (Dandy & Crawley, 1992) (Nandalal & Bogardi, 1995).

HEMs are decision-support tools for exploring opportunity-based strategies to advance efficiency and transparency in water use. The goal is to investigate promising water management schemes and policy insights (Rose & Liao, 2005). Basin-scale models use hydrologic data including historical, stochastic, or assumptions, and simulate the process of various aspects of hydrology, water quality, economical, or other variables under a fixed set of water allocation and infrastructure management policies. Such models have been widely used to assess the performance of water resources systems (Brouwer & Hofkes, 2008). Bear et al. (1966) and (1970), established the conceptual framework for basin-wide integrated water management models where water is allocated and managed to maximize net benefits derived from economic water demand curves.

McKinney & Karimov (1997), developed hydrology-inferred policy analysis tool to be used for water allocation decision-making at the basin scale. They developed an optimization model for the Aral Sea Basin using GAMS[21] and Arc View GIS[22] software. Their work introduced a regional water resources management concept to the basis for making informed decisions. While the model addressed many factors, some aspects such as stakeholder participation, water rights, and equal allocation were not explicitly included. Nandalal & Bogardi (1999), improved upon, the aforementioned work of McKinney & Karimov (1997) to include combined water quantity and

[21] *The General Algebraic Modeling System (GAMS) is a high-level modeling system for mathematical optimization (https://www.gams.com/).*

22 Geographic information system (GIS) is a system designed to capture, store, manipulate, analyse, manage, and present spatial or geographic data (https://www.gislounge.com/).

quality equations into an optimization model that successfully considered both inflow and outflow regulation. They emphasized the vital role of performance reliability measures in building a multi-objective model within reservoir management and planning analyses.

Bouchart & Goulter (1998), developed risk analysis methods for the improved reservoir for irrigation withdrawal. They also reported on the publication of the inclusion of different aspects of water management in optimization design models for water distribution networks. Ravikumar & Venugopal (1998), illustrated a stochastic dynamic programming model to analyze optimal reservoir operation for agricultural use in India. Their simulation model was used to study the degree of failure associated with the adoption of the optimal operating policy for different reservoir storages at the start of the cropping seasons. They addressed only decision-making mechanisms for reservoir operation and irrigation water allocation. Lund & Guzman (1999), derived operating rules for reservoirs in series or in parallel for optimizing tradeoffs between hydropower, water quality, and water supply. Simultaneously, linear programming and network flow models have been used extensively to model prior water allocation practices for each time-sequence of the refill season.

Rapid development in information technology and supercomputing have led to tremendous progress in river basin modeling techniques. Traditional simulations are enhanced with interactive and advanced graphical user interfaces, allowing real-time configuration of the simulations, and on-screen display of results. The RiverWare[23] program, prepared by a consortium of European Union-sponsored research institutes, integrated Geographic Information System (GIS) functions and incorporated embedded expert systems with various simulation models and tools and is one of the successful river basin modeling software available today. For addressing water allocation, conjunctive use, reservoir operation or/and water quality issues, MIKE BASIN couples the power of ArcView GIS with extensive hydrologic modeling to provide basin-scale methodological solutions (DHI, 2001). As the next step of modeling improvement and due to the complexity of water allocation at the regional or basin level, three-level or three-layer optimization models based on economic efficiency criterion were proposed by Shangguang et al. (2002).

In more recent years, hydro-economic river basin models are applied to analyze a wide variety of water issues, including spatial and inter-sectoral water allocation patterns, water quality control, environmental management, flood damage, and regulation, also including the introduction of water markets, infrastructural development, and climate change adaptation. This type of model aims to identify more efficient water management schemes and examine water

23 RiverWare is a river system modeling tool developed by Center for Advanced Decision-Support for Water and Environmental Systems, University of Colorado.

use policy strategies to provide sustainable use of water resources (Harou, et al., 2009) (Mirchi, Watkins, & Madani, 2010).

The economic efficiency of transboundary water allocation has been cited in the literature on hydro-economic modeling (Calzadilla, Rehdanz, & Tol, 2011) and game theory (Ansink & Weikard, 2012). Some HEMs have addressed efficient water allocation in river basins for irrigation and storage as well as hydropower generation by showing uncooperative equilibrium produces inefficient outcome (Madani & Dinar, 2012) (Madani & Hipel, 2012). Ringler (2004), investigated the impacts of upstream hydroelectric power development and basin water transfer on the economies of upstream and downstream water users in the Mekong River basin. Bhaduri & Barbier in (2008), analyzed the potential for cooperation on water sharing and negotiable transfers between India and Bangladesh on the Brahmaputra and Ganges river basins. They developed a market-based water transfer model for an inter-linked river, where water deficient state has the option to buy more water to meet its excess demand from a water surplus state. This model described how water allocation between an upstream and downstream country is prejudiced if it has an option to buy water from a third country.

All the above findings present significant advances in the understanding of conflicts over equitable water allocation, policy implication, and decision-making in river basins. However, few of these studies have explicitly quantified tradeoffs among sustainability, efficiency and economic benefits through cooperation.

5.2.1 Literature review of the Nile River modeling

There is ample research on Nile basin and its sub-basins' transboundary river management and modeling, e.g., a) designed to study the impact of cooperation on the relationship among Nile riparian countries and prevent conflict (Whittington, Waterbury, & McClelland, 1995), b) water allocation modeling by cooperative and non-cooperative game theory applications (Wu & Whittington, 2005) (Dinar & Nigatu, 2013), c) assessment of the dam construction projects in upstream and the impacts on downstream states (McCartney & Menker Girma, 2012) (Strzepek & Block, 2010) and d) water resources allocation patterns under climatic uncertainty (Jeuland & Whittington, 2014) (Mohamed, van den Hurk, Savenije, & Bastiaanssen, 2005).

Jeuland (2010), presented a basin-wide hydro-economic framework that integrates a hydrological simulation model and an economic model for the Nile Basin. His analysis showed that varying specific economic and physical parameters combine to have a substantial impact on net income from the river. To deal with climate change issues, Jeuland used a well-developed stochastic simulation and optimization model. Jeuland & Whittington (2014), presented a long-term hydropower investment options within Ethiopia under varying hydrological conditions. By using simulations, the authors developed performance metrics for different options and showed results are dependent on the decision makers' risk preference.

The Nile Economic Optimization Model (NEOM), was presented by Whittington et al. (2005), is one of the most comprehensive studies modeling the Nile river using GAMS software. It is used to assess the economic implications of various infrastructural developments within the basin and aimed to maximize basin-wide economic benefits from irrigation and hydropower production. The model included all the existing and planned reservoirs and irrigation schemes at the time, and quantified the economic benefits of cooperation overall. They found that cumulative economic benefits for all states are more than doubled when the nations fully cooperated.

Many hydrological models were developed to evaluate the impacts of GERD and other planned dams. These models reveal that Ethiopia's development of the Eastern Nile waters for hydropower production would not affect water supply significantly to downstream countries, even after consideration of filling stages of the dams. Goor et al. (2010), presented a dynamic reservoir optimization model of the Eastern Nile that employed a stochastic dual dynamic optimization program that identified the most economically efficient policies for large reservoirs (Arjoon, Mohamed, Goor, & Tilmant, 2014). Block & Strzepek (2010), focused on the Ethiopian Blue Nile, to calculate the economic benefit of proposed development under changing climatic conditions. Their HEM developed optimal scenarios for transient filling stages of the reservoirs, under climate variables. Later on, Block & Strzepek (2012), applied their model to climate change analysis and found that the omission of the temporary period of filling used in models resulted in an overestimation of total net benefits for the GERD and other dams' projects.

Knowing that the Nile is a data-scarce region, mostly the question of best possible input data for a given model causes research gaps (NBI, 2014). There are considerable gaps in attempts to identify economically and/or politically suitable measures for benefit sharing and joint management among the riparian states. Therefore, this study addresses the gaps through testing cooperation probability games in the laboratory experiment, specifically designed to reflect on the subject of how to cooperate, who gets how much water and what variables to include in the benefit-sharing scenarios.

5.3 Eastern Nile: Hydro-economic modeling

The model is optimized based on non-linear programming to determine patterns of water consumption that maximize the sum of economic benefits of irrigated agriculture production and hydropower generation in the Eastern Nile Basin. For a given scenario or set of assumptions, the model is designed to determine an optimal set of strategic options by combining hydrological and agricultural data to formulate a model with GAMS, considering available data, the status of various options, proposed scenarios and the decision to be made. The description of the model is demonstrated through the equations in this section.

Policy consideration in the model consists of three measures: 1) improvements in the efficiency of irrigation systems, 2) developments of hydro-infrastructure facilities through construction of GER dam and future projects and 3) expansion of cultivated land under irrigation. The payoff tables are developed based on the result of the optimization model under different situations for each of the four scenarios.

5.3.1 Schematizing a river basin

Mapping a river basin is the first phase in the model development. It is essential to reflect the overall natural conditions (Kitissou, 2004). Figure (5-3), depicts a node-link river basin network as an abstracted graphical model of a river basin. The graph is a symbolized representation of a physical component such as inflow, natural or human-made junction, intake structure, water losses, and allocation components. A link represents a natural or human-made water conduit such as river channel, canal or pipeline between two different reservoirs, but also stands for any flow of water.

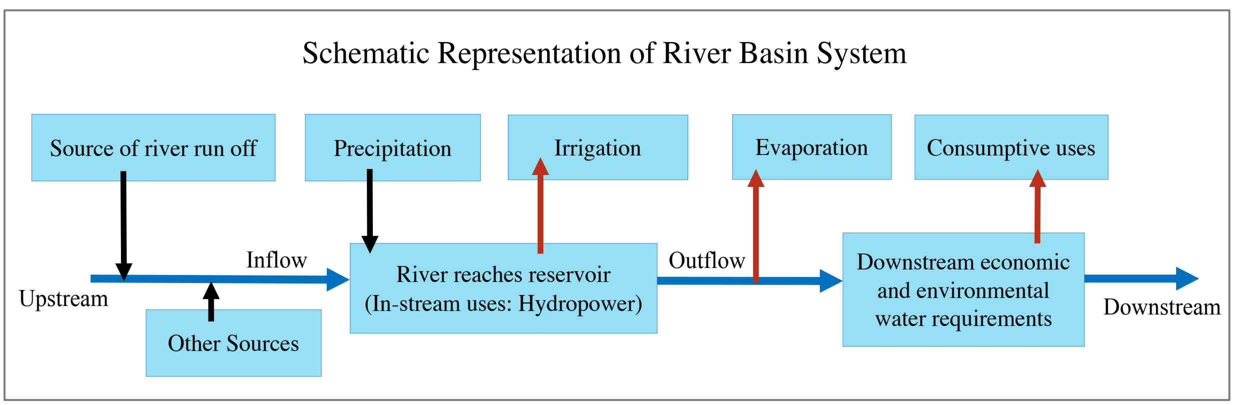

Figure 5-3 Schematic representation of the selected river system framework adapted for this study

Figure (5-3), is a representative illustration of the essential network and connectivity of the river basin, including its hydrology, existing and proposed water use, and existing and proposed infrastructure. Upstream is the starting hydrological node where flows enter the system; other sources node represent primary sources of groundwater; reservoir node, which includes dams and any hydropower sites; demand nodes are those for environmental, urban, rural, industrial, and irrigation water consumptions; downstream connections represent the repeated system along the river towards drainage. Note that the link losses of evaporation and leakage node gains from local catchment's drainage, and losses of evaporation and consumption at demand nodes are not explicitly plotted in the river basin network model but are included in the mathematical algorithms for calculation in the extended model of Eastern Nile Basin (Figure 5-4). Typical policy constraints, such as hydrological, economic and social restrictions governing water allocations, set the demand limits for storage nodes or links, together with capacity limits forming the upstream and downstream capacity for storages and flows.

Based on the schematic graph of the river network, the HEM of Eastern Nile was developed including the main dams and irrigation plans as a node-link river basin network, plotted in Figure (5-4). The HEM contains all the major sites: Lake Tana/Tana-Beles and Tekeze dam project in upstream Ethiopia; the Sennar, Jebel Aulia, Khashm El Girba, Merowe and Rosaries dams and reservoirs in Sudan; and High Aswan Dam (HAD) with formed Lake Nasser in Egypt. The GERD and its hydrologic inputs are included in the model only under scenarios after its completion.

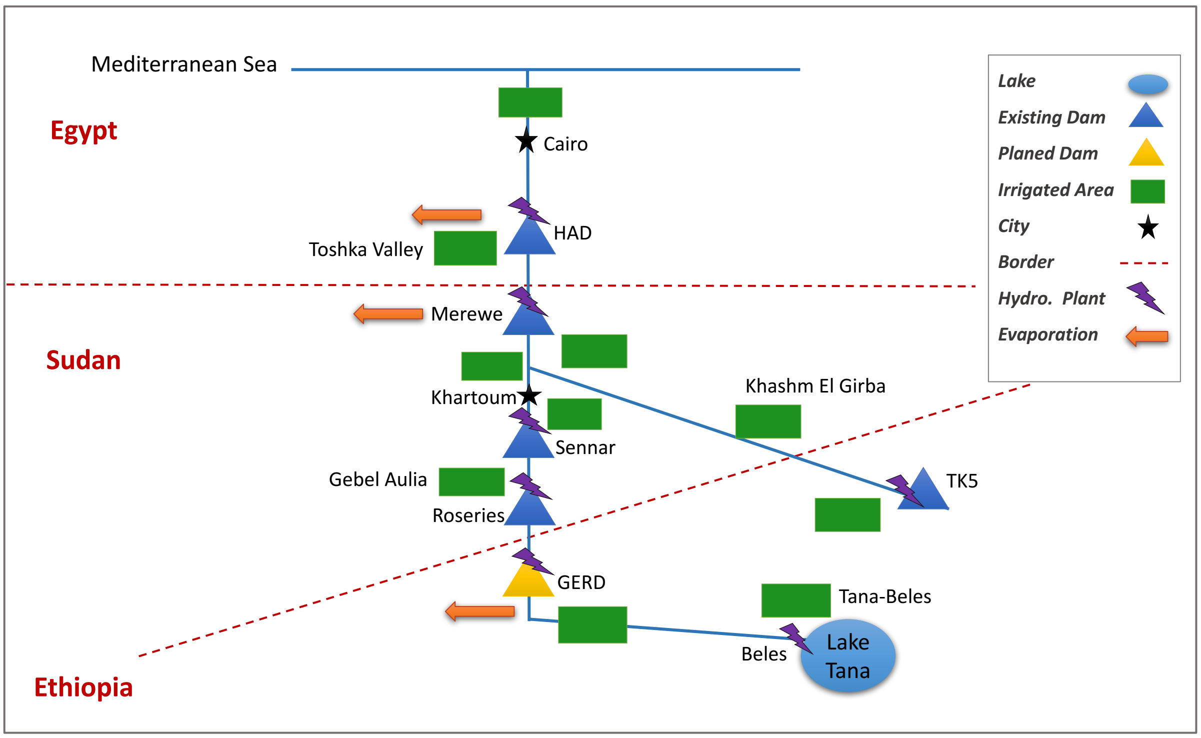

Figure 5-4 Eastern Nile schematic model (self-made)

Depending on the management situation, the GERD is added to the model and irrigation areas are increased to reflect future irrigation plans in Ethiopia, Sudan, and Egypt as well as the hydropower generation expansion for the whole basin.

The study only includes economic benefits directly derived from use of water for hydropower and/or irrigation; it excluded other economic advantages, i.e., domestic use, industrial, recreational, and navigational use of the Nile water. The main contributor to GDP of Eastern Nile states is the agriculture sector (ref. Chapter 2, Section 2-4-1), 48% in Ethiopia, 28% in Sudan and 15% in Egypt (FAO, 2015). The share of electricity generated from hydropower compared to other renewable sources is much larger, i.e., 99.4% in Ethiopia, 70.15% Sudan and 90% in Egypt. Since all three countries face enormous challenges in socio-economic development, rapid population growth, uncontrolled urbanization, and refugee immigration, etc., the demand for electrification is far greater than the current supply. In fact, only 28% of Ethiopia and 44% of Sudan are electrified in 2014 (Ecofys , 2016) (World Bank, 2015). Further to this, electrification is crucial for competitive industrial growth.

Currently, these countries either import fossil-based energy sources like coal and petroleum or use biomass in the form of wood and charcoal for cooking and heating. Ethiopia and Sudan have tremendous untapped hydropower potential, mainly due to the undulating topography and the rate of flow in these countries, in particular in the Ethiopian highlands. Egypt in comparison is relatively flat and has a gradual inclination toward the Mediterranean. The installed capacity in both Ethiopia and Sudan is well below the current demand, meeting only about 10-20% – however both these countries could potentially reach 80-90% of their energy needs through hydropower sources which would place these nations at par with Norway and Finland in terms of renewable power production, use and dependency (NBI, 2014). At the same time, there is also significant growth potential in the basin for power trade, between these three countries and their neighbors beyond the Eastern Nile subsystem (ENTRO , 2016).

Since the economic aspect of water use is the primary focus of this study, direct human health and survival characteristic of water allocation such as municipal use is not considered. It also must be noted that benefit-sharing in its broadest sense considers all actions that change the distribution of costs and benefits of water associated with transboundary cooperation. The study does not consider how to share the cost of existing infrastructures such as GERD, which is financed mainly by public equity initiated by the government of Ethiopia (UNESCO, 2015).

5.3.2 Integrated water allocation

Because water exchange causes the benefactor to lose potential income, yet the beneficiary stands to gain a fair amount of benefits either monetarily or in kind, the second type of cooperative water allocation without side payments cannot provide an incentive for parties to participate in the cooperation since it is a zero-sum situation (Jeuland & Whittington, 2014). The model objective function consists of two components. The first element represents the net irrigation water profitability considering the efficiency of irrigation in each country, in addition to estimating total water consumption per year by that country. The second component of the objective function represents the hydropower generation in dams and the sum up of entire present and potential production for each country and the inferred income thereof. The total water loss to evaporation and seepages is deducted from the full benefit at each node with a fixed rate for each of the three countries. Optimization of the objective function is maximizing the net benefit of both components of the model and minimizing losses. The objective function is expressed as a simple pattern of water use formulated to calculate economic net benefits in any transboundary river basin (Mahjouri & Ardestani, 2011).

The setup of the model is similar to the approach applied in (Whittington, Wu, & Sadoff, 2005). However, the model in this study describes only the eastern part of the Nile basin, including all existing irrigation schemes and hydropower reservoirs, and most of the confirmed future hydropower plants. Water gets transmitted through a network of rivers and channels in the routing system. Variability in storage is dependent on the dynamics of large water bodies (swamps, reservoirs), where use in one location could limit options elsewhere. This study adopted the fixed universal value of water for hydropower, electricity, and water for irrigation described in the research by (Whittington, Wu, & Sadoff, 2005).

The mean annual flow used for the measurement and estimation of various allocation scenarios in this study is calculated from the last 25-year flow data. The primary choice variables are irrigation water released, land irrigated, hydropower water released, electricity generated and the volume of water transferred. Values are expressed in 2014 USD. The term payoff is used to indicate economic benefit derived from the discharge of water from upstream to downstream for irrigation use and hydropower generation. The basic mathematical formulation of the objective function of the model is as:

$\text{Max} \sum_A \{P_{irr}{}^A \sum_i IRR^{i,A} + P^A{}_{hy} \sum_i HY^{i,A}\}$

- A=Ethiopia, Sudan, Egypt
- i=Each water storage or allocation site in each country
- Non-negativity constraint: $HY^{i,A}$, S^i , $IRR^{i,A}$, $OF^i \geq 0$

Where:

- $P_{irr'}{}^A$: The economic value of water for irrigation in country A (USD per m^3)
- $IRR^{i,A}$: Mean quantity of water withdrawal for irrigation in country A (MCM)
- $P^A{}_{hy}$: The electricity price for country A (in USD/kWh)
- $HY^{i,A}$: Mean annually hydropower generated at site i for country A (GWh)
- S^i : Mean reservoir storage for reservoir j (MCM)
- IF^i: Average inflow to site i (MCM)
- OF^i: Average outflow from site i (MCM)
- EV^A: Average percentile evaporation loss in Country A (%)
- e^A: Evaporation rate at Country A (MCM)

- R^A: Addition to flow in country A from annual precipitation (MCM)
- S^i_{Min} and S^i_{Max}: Minimum and maximum storage for reservoir i (MCM)
- μ^A : Efficiency of irrigation in country A
- CWR^A: Crop water requirement in country A (cm/ha/year)
- AI^A: Current area under irrigation in country A(ha)
- AI^A_{Max}: Maximum irrigable area in country A (ha)
- $f(S^i_t, S^i_{t+1})$: Function determining average productive head at site i
- α^A: Hydropower efficiency in country A
- $HyMx^{i,A}$: Maximum hydropower that can be generated at site i (GWh)
- $Z_{irr}{}^A$: Country A's payoff from irrigated agriculture (USD)
- $Z_{Hy}{}^A$: Country A's payoff from hydropower generation (USD)
- $Z_{sum}{}^A$: Country A's total payoff from hydropower and irrigation (USD)

The model uses progressive time increments of 30 days change in each i site storage as the mean values of the decision variables of S_t^i, OF^i, IF^i and $f(S_t^i, S_{t+1}^i)$. $IRR^{i,A}$ and $HY^{i,A}$ is calculated for one year to determine the combination of average monthly releases from each hydropower generation site and average annual allocation for irrigation schemes.

5.3.2.1 Irrigation allocation: pattern and constraints

In this model, areas under rain-fed agriculture were not considered. Each existing irrigated area is represented as a consumption node. IRR^A is total water withdrawal for irrigation in country A, which is dependent on irrigation efficiency in that country μ^A, crop water requirement CWR^A and the amount of land under irrigation AI^A in country A. The average water requirement for major crops in each of the three countries were considered for the model. The main crops considered for this study are sorghum, wheat, sugarcane, and vegetables. The irrigation efficiency is dependent on the rate of irrigated agricultural output, and average economic value of irrigation water for food production in country A is $P_{irr}{}^A$. Therefore, total benefit from irrigation for each country annually is calculated based on of as:

Irrigation water withdrawal is estimated as:
(Irrigation efficiency in country A x area under irrigation in country A x total production in irrigated lands): $IRR^{i,A} = \mu^A . AI^A . CWR^A$
The current irrigated area in each country is considered lower than cultivable lands for irrigation in the model: $AI^A \leq AI^A_{Max}$

Economic benefit or payoff (Z_{irr}^{A}) of Country A from irrigation is calculated as (Total irrigation water withdrawal x irrigation water value in country A): $Z_{irr}^{A} = P_{irr}^{A} \sum IRR^{i,A}$

The model analyzed the economic significance of hydrological variability on irrigated agriculture by using a simulated situation in which variability is effectively suppressed by assuming that water storage and delivery capacity do not limit the maximum use of available water in each node. Irrigation area is assumed to remain constant annually. When the model was optimized for scenarios with cooperation and joint basin management, along with the simplification of the situation, the calculation respected the constraints on water availability but supposed that the available water can be stored and delivered efficiently to existing users to enable agricultural production.

Return flow rate from irrigation sites was not taken into consideration in this model because the water reuse system has not been adequately developed. Furthermore, it depends on too many unknown/unknowable variables such as drainage network, cropping intensity, cropping patterns, leaf area index, evaporation, percolation, etc.

5.3.2.2 Hydropower generation: pattern and constraints

At each reservoir node S^{i}_{t} (i = 1,2, 3, …) (t = 1, 2, …, 12), water storage function is as below, which is equal to total inflow IF^{i} to the reservoir and average precipitation R^{A} in country A, minus water outflow OF^{i}, water loss (evaporation) and irrigation water withdrawal:

Water storage is calculated as: $(S^{i}_{t}, S^{i}_{t+1}) = IF^{i} + R^{A} - OF^{i} - EV^{A} - IRR^{i,A}$

The reservoir capacity is restricted as: $S^{i}_{Min} \leq S^{i}_{t} \leq S^{i}_{Max}$

Water availability in reservoir S^{i}_{t} is formulated by calculating the volume of water available for discharge in the next month which in turn depends on the volume of water available in the current month at the given reservoir after accounting for evaporation losses, and allocation for irrigation. The two kinds of release from a reservoir site are a) hydropower release, and b) non-hydropower release. Hydropower release indicates discharge of stored water specifically to generate electricity regardless of downstream demand or storage capacity of downstream nodes. Whereas non-hydropower release refers to the expulsion of excess water either due to overflow or due to downstream demand, both releases go through hydropower turbines, but power is only generated during hydropower release.

Hydropower generation quantities are the result of functional changes in the reservoir's water storage, water release from the dam and efficiency:

Hydropower generation at site i in country A is calculated as $HY^{i,A} = \alpha^{A} OF^{i} f(S^{i}_{t}, S^{i}_{t+1})$

The model considered the hydropower generation in country A never exceeds the maximum potential. Therefore, it is always: $HY^{i,A} \leq HyMax^{i,A}$

Total annual hydropower benefit for each country is dependent on the price of electricity P^{A}_{hy} and the sum of electricity produced at all dam locations.

Total annual hydropower benefit in country A is hydropower payoff for all hydropower generation sites inside the country:

$$Z_{Hy}^{A} = P^{A}_{hy} \sum HY^{i,A}$$

The objective function, illustrated below, represents the maximum economic benefits from irrigated agriculture and hydropower sectors. Initial dam infrastructural cost, the cost of energy transmission and the cost of dredging is not included in the objective function.

Total payoff for country A: $Z_{sum}^{A} = \sum_{A} \{P_{irr}^{A} \sum IRR^{i,A} + P^{A}_{hy} \sum HY^{i,A}\}$

$$Z_{sum}^{A} = Z_{Hy}^{A} + Z_{irr}^{A}$$

However, using data from the International Hydropower Association Projection (IHA, 2016), this model illustrates the proportion of hydropower potential that is yet to be exploited in the Eastern Nile countries, note that this reflects physical potential but not necessarily environmental desirability. Also, the effect of the constructions of new dams except GERD, for regulating river flow were not considered in the model. Some other limitations to the model formulation were such as neither water quality nor sediment transport was considered. Also, the model did not include the economic benefits of flood control. Moreover, this is an annual model and did not address the seasonal complexity of storage issues. The mentioned formulation can be easily modified to include additional options, decision variables, objectives, and constraints.

5.3.3 Solving the model: scenario development

The HEM is applied to a set of hydrological, development and governance scenarios, to determine the value of basin-wide cooperation on economic of the river and position of GERD towards downstream riparian countries. As a result, four scenarios were formed. These scenarios represent either different levels of development of the river basin, regarding water usage or alternative transboundary strategies as full or no cooperation among the riparian countries. In other words, under the status quo scenario, no beneficiary agreement exists, and irrigation water is allocated to individual riparian countries approximately as in current allocation pattern. The degree of economic power, which affects trade and political relationship between states, is an important factor to understand whether a cooperative outcome will be successful or is bound to failure, which is added to the design of the game experiment in Chapter 6 of this dissertation.

The study included volunteer side-payment options into the game design to motivate willingness to cooperate with other representatives in the design of the experiment. Scenarios are as:

5.3.3.1 Scenario 1: Unilateral management without GERD

This scenario approximates current water withdrawal and infrastructure conditions in the basin. Status quo allocation can be used as a first reference point for calibrating economic benefit of the current water consumption scheme. The baseline scenario is where countries manage the river unilaterally without compensation of any sort towards their riparian neighbors.

5.3.3.2 Scenario 2: Unilateral management with GERD

The construction of GERD would certainly affect the entire system regarding physical water availability and economic benefits derivable especially for downstream countries. So, for the second scenario, GERD is included as a fully functional system and keep all other parameters unchanged. Scenario 2 aims to evaluate the impact of the GERD on the water distribution and economic structure of riparian countries while they are still non-cooperative. In other words, the model estimates water allocation and the resulting economic benefits for each country and the region once GERD becomes fully operational with unilateral arrangements for development in the basin.

Comparing scenario 1 and 2, reveals the impacts of GERD on the rest of the river system, in particular on agricultural and energy sectors in all NRB riparian states. The situation is a common strategy pursued by riparian countries because of the lack of basin-wide cooperation.

5.3.3.3 Scenario 3: Cooperation without GERD

Scenario 3 is an efficient allocation model of Nile River water by restructuring the current allocation system assuming basin-wide cooperation. In this scenario, Nile water is allocated to the activity within the riparian basin that generates the maximum economic benefit i.e., either for agriculture and hydropower generation regardless of where it is located within the territories of the three riparian countries. The basin is considered a single system and the benefits generated are considered as one system output and are shared optimally.

The study optimized water allocation by applying maximization approach to Scenario 1's physical structure to explore the optimal probable regional economic gains. Countries' economic payoffs for Scenario 3 are different from Scenario 1 since water distribution is changed in the basin based on countries' potential water use productivity and efficiency. As a result, Scenario 3 examines the impact of cooperation on the baseline situation (scenario 1) to show how benefits could be increased by cooperation in using the available natural resource optimally for most economically productive activities.

5.3.3.4 Scenario 4: Cooperation with GERD

The fourth scenario corresponds to a situation in which the GERD would be operated to add to current energy production in Ethiopia, only with cooperative arrangements. Comparing scenario 4 with scenario 2 discloses the extent of the risks and associated cost faced by downstream countries in the case of the unilateral operation of the GERD.

Scenario 4 examines whether GERD has the potential to foster cooperation by offering a sharp increase in economic benefits to the whole region. It tests if GERD has the possibility as a basis for a new era of cooperation in the Eastern Nile Basin as a catalyst for future change and side-payment arrangements as compensation options for joint management of the basin.

The grand coalition in the model is described as the full cooperative development situation, in which all proposed infrastructure projects would be completed and operated to optimize the total economic benefits for the entire basin. In the case of scenarios 3 and 4, full cooperation is assumed, meaning that there is the coordinated operation of basin's infrastructure to optimize the total basin-wide economic benefits of efficient allocation of water for irrigation and hydropower generation. This follows Whittington et al. (2009), who demonstrated that full infrastructure development on the Nile, and to operate these to maximize economic benefits, would not be feasible without full cooperation among the riparian countries. In scenarios 1 and 2, it is assumed that no cooperation and unilateral development in 1 as the current situation and 2 when GERD is fully operational in the basin.

5.3.4 Data and parameters

This study obtained and compiled historical hydrologic data from a variety of sources including ENTRO (Eastern Nile Technical and Regional Office), NBI (Nile Basin Initiative), relevant ministries of the Eastern Nile riparian states, Food and Agricultural Organization (FAO), the World Bank Development Indicator Database (World Bank) and Global Runoff Data Center (GRDC), as primary sources of agriculture, hydrologic and economic data.

For this modeling, a present-day spatial distribution of land use systems was developed according to FAOSTAT (2009), consistent with country-specific FAO regional statistics (FAO-Nile, 2011) on the actual cropped area in each state. Crop production, costs, and benefits across the basin, the gross agricultural margin of the water-limited production was calculated for the irrigated crop (Awulachew, Rebelo, & Molden , 2011).

Current reservoir operations and hydropower data such as capacity, dam characteristics, technical efficiency, and reservoir volume were sourced from Nile Basin Initiative (NBI), ENTRO and The Global Energy Observatory (GEO, 2010). Some analytical data on various existing models were obtained from (Mulat & Moges, 2014), (Dinar & Nigatu, 2015) and (Jeuland , 2010). These studies gave a better understanding of the data processing and measures comparison for our methodology. Block and Strzepek (2010), reported on proposed future and current projects in Ethiopia, Sudan and Egypt, their work was used for reference on data accuracy, i.e. for cross-checking and verifying the data collected during this research. Kirby et al. (2010), report was used as a source for key locations time-specific data throughout the Nile basin (reservoirs, irrigation demand sites, power stations, river reaches) such as additional Nile River flow, its seasonal variability, evapotranspiration and the current Nile River water use, which also was a source of data for the current study.

The length of the simulation period was selected to be 25 years for baseline scenarios (obtained from ENTRO database) an additional ten years of projection for hypothetical scenarios after the construction of GERD. This allowed the model to reach equilibrium so that calculations can be made on long-term economic benefits of the river system after filling of GERD. See Chapter 2, for a detailed description of the infrastructure and irrigation areas included in the model along with the parameter value.

The model used global standard electricity prices for the three countries of Eastern Nile Basin; 0.08 USD/KWh taken from the ENTRO and the Egyptian Electricity Holding Company (EEHC, 2009). Also, it was assumed that the economic value of water in agriculture is consistent with international experience and the same in all three riparian countries, i.e., 0.05 USD/m^3.

In the early 1990s, Egypt's total water use was 65 km^3/a, with 55 km^3/a being withdrawn from the Nile River. By the year 2000, water demand increased to 73.3 km^3/a, of which 43.2 km^3/a were used for agricultural demand. It is projected that, by 2025, Egypt’s agricultural water demand will be 54.7 km^3/a out of total water demand of 86.9 km^3/a. The New Valley Project, currently under construction in the Western Desert, is designed to irrigate 250,000 ha of cash crops, which will be fully irrigated by withdrawing water from Lake Nasser (Swain A. , 2011). Whereas in Sudan only 16.7 million ha out of a potential 105 million ha are cultivated.

Moreover, only 1.2 million ha of this land is irrigated, out of irrigation potential of 2.8 million ha due to lack of infrastructure and inadequacy of water transferring system (Dinar & Nigatu, 2013). It is estimated that by the year 2025, Sudan's increased irrigation demand will be in the order of 32 km^3/a. Irrigation in Sudan is organized around six major schemes. Along the Blue Nile, water is pumped between the Roseires and Sennar dams for the irrigation of about 300,500 ha of crops. The Sennar reservoir feeds the Gezira–Managil scheme, which is found on the left bank of the Blue Nile. This is the largest irrigated area in Sudan (870,000 ha) and the only gravity irrigation scheme along the Blue Nile (Satti, Zaitchik, & Siddiqui, 2014).

Water is pumped from the Blue Nile, between Sennar and Khartoum, to irrigate 74,500 ha of crops. On the White Nile, about 180,000 ha are currently being irrigated by water pumped from the Jebel Aulia reservoir (Swain A. , 2011). The New Halfa scheme (113,000 ha), located downstream of the Khashm El Girba reservoir, was established for the resettlement of Sudanese farmers as a result of the filling of Lake Nasser. The last significant scheme is located along the main Nile, downstream of Khartoum, with 80,000 ha of cultivated area (Elamin, Saeed, & Boush, 2011).

Ethiopia currently cultivates only 4% of its potentially irrigable land in the country and only 1% of the irrigable land in the Nile Basin (Block, Strzepek, & Balaji, 2007). Ethiopia has regularly experienced significant shortfalls in food production, leading to increased import of strategic grains and a growing dependency on food aid. In the last 45 years, the country has seen two severe famines and series of droughts which affected food production severely (Abraham, 2004). The Ethiopian government insists that the utilization of the Nile river waters be essential for socio-economic development and poverty reduction. According to the national security program, Ethiopian government's goal is to achieve self-sufficiency in food production, ipso facto national food security at any cost (Jeuland & Whittington, 2014).

The highly variable topology of the Ethiopian highlands, with steep slopes and deep canyons and valleys, limits the possibilities for cheap irrigation (Block & Strzepek, 2010) but is naturally suited for gravity fed hydropower production. Consequently, except for small areas, none of the proposed irrigation sites take water directly from the Blue Nile.

5.4 Results

The results indicate the current situation in the eastern Nile as baseline scenario 1, is the lowest in gaining economic benefit compared to the other scenarios. According to scenario 1 and 2, the economic value for the whole Eastern Nile Basin from unilateral use with and without GERD could reach 5.145 billion USD and 7.83 billion USD per annum, respectively (Table 5-1).

Table 5–1 Results of HEM for each scenario

Scenario 1: Unilateral management without GERD

	Water Use	Evaporation	Total Economic Benefit	Hydropower generation	Irrigated Land	Hydropower price	Irrigation water price
	BCM	BCM	MUSD/a	Billion KWh	1000ha	USD/KWh	USD/m3
Egypt	52.4	15.2	3541	9.11	3078	0.08	0.05
Sudan	35.7	5.7	1114	5.42	1935	0.08	0.05
Ethiopia	10.4	1.3	490	4.18	350	0.08	0.05
Eastern Nile Basin	98.5	22.2	5145	18.71	5363		

Scenario 2: Unilateral management with GERD

	Water Use	Evaporation	Total Economic Benefit	Hydropower generation	Irrigated Land	Hydropower price	Irrigation water price
	BCM	BCM	MUSD/a	Billion KWh	1000ha	USD/KWh	USD/m3
Egypt	45.9	13.4	2958	7.6	2780	0.08	0.05
Sudan	28.9	4.1	2224	6.19	2575	0.08	0.05
Ethiopia	23.7	2	2648	16.02	1428	0.08	0.05
Eastern Nile Basin	98.5	19.5	7830	29.81	6786		

Scenario 3: Cooperation without GERD

	Water Use	Evaporation	Total Economic Benefit	Hydropower generation	Irrigated Land	Hydropower price	Irrigation water price
	BCM	BCM	MUSD/a	Billion KWh	1000ha	USD/KWh	USD/m3
Egypt	66.8	17.6	6235	10.25	4320	0.08	0.05
Sudan	17.7	2.1	2652	6.11	2110	0.08	0.05
Ethiopia	14	1.1	1480	3.67	765	0.08	0.05
Eastern Nile Basin	98.5	20.8	9367	20.03	7195		

Scenario 4: Cooperation with GERD

	Water Use	Evaporation	Total Economic Benefit	Hydropower generation	Irrigated Land	Hydropower price	Irrigation water price
	BCM	BCM	MUSD/a	Billion KWh	1000ha	USD/KWh	USD/m3
Egypt	62.6	15.4	5734	8.22	3180	0.08	0.05
Sudan	15.7	2.3	3110	6.6	1955	0.08	0.05
Ethiopia	19.6	1.4	2180	14.31	1784	0.08	0.05
Eastern Nile Basin	98.5	19.1	11024	29.13	6919		

The 35% increase in benefit shows the profitability of construction of GERD from the economic perspective. Unilateral water use among the three riparian countries with GERD would reduce the current economic benefit of Egypt and increase the benefit of Sudan as compared to without

GERD scenario. This indicates that the enormous size and potential of GERD will change both the economic standing and geopolitical power balances within the riparian countries and it will give Ethiopia and consequently Sudan, more advantage in using Nile waters for development and expanding irrigated agriculture production.

To test the prospective economic benefits of increased irrigation land, the study has modeled these scenarios in which the area of irrigated agriculture is increased by 25% (1.83 million ha) in Scenario 3, in which countries cooperate on extracting the most value for water without the presence of GERD. In scenario 3, GERD does not exist, the basin-wide benefit of this increased area of irrigation is calculated to be 3.8 billion USD per year which shows the high economic potential for cooperatively exploring irrigation potential efficiently (Figure 5-5). While an increase in the total benefit of the basin is very significant in scenarios with cooperative arrangements, they represent a rather narrow interpretation of the potential benefits of water security for agriculture, because the analysis relates only to irrigated agriculture, not to rain-fed agriculture.

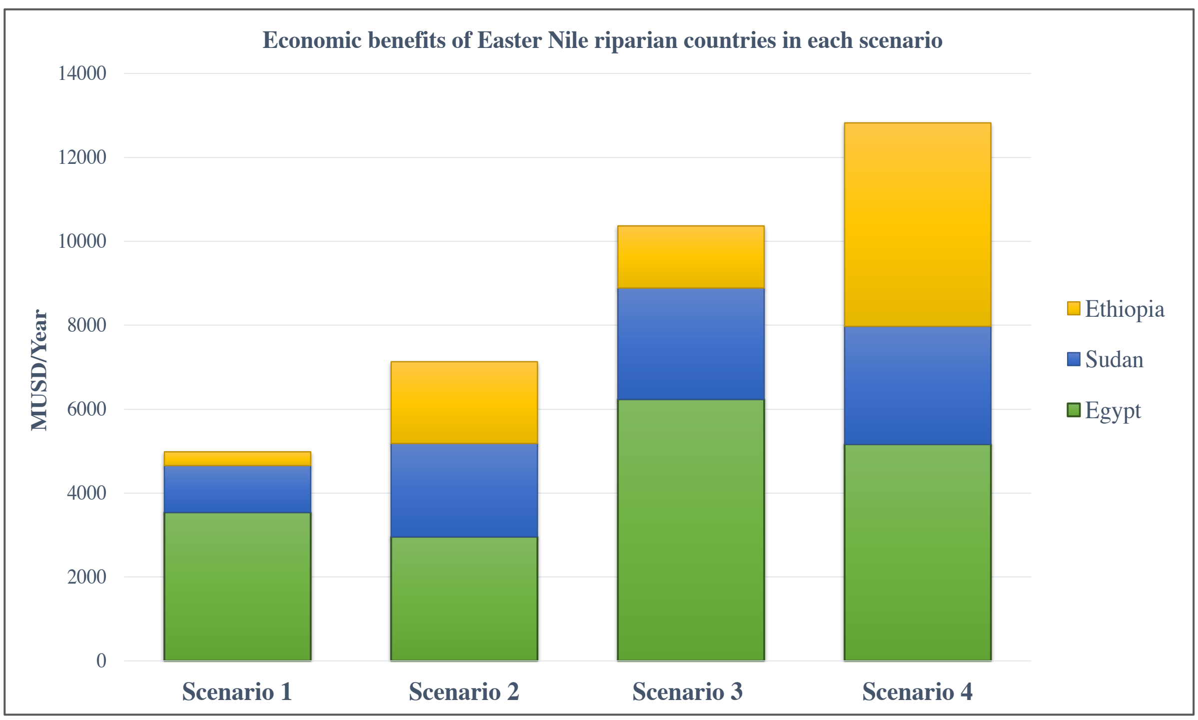

Figure 5-5 Economic gain comparison for Eastern Nile state under each scenario

In Scenario 2, when GERD is operated to boost the net economic benefit from hydropower generation in Ethiopia, the variability of the storage levels at the GERD is reversed. The GERD is not being used to balance downstream flows but only to maximize hydropower output within its capacity. So, while operating, GERD ensures constant yearly power generation and direct economic benefit for Ethiopia and flow regulation for downstream countries. Due to lack of cooperation and sharing arrangements, in Scenario 2, there is no compensation or resource sharing towards downstream countries. The economic benefit of Ethiopia is the greatest, as the result hydropower generation and increased irrigation from GERD in Scenario 2 compared to the other three scenarios. Hydro-electricity produces much lower carbon emissions compared to other energy sources, especially fossil fuels and coal (MoFA, 2013). Many other economic benefits of GERD are not measured in our modeling, which can promote hydropower export to other countries and will have regulated and controlled the supply of water for irrigation.

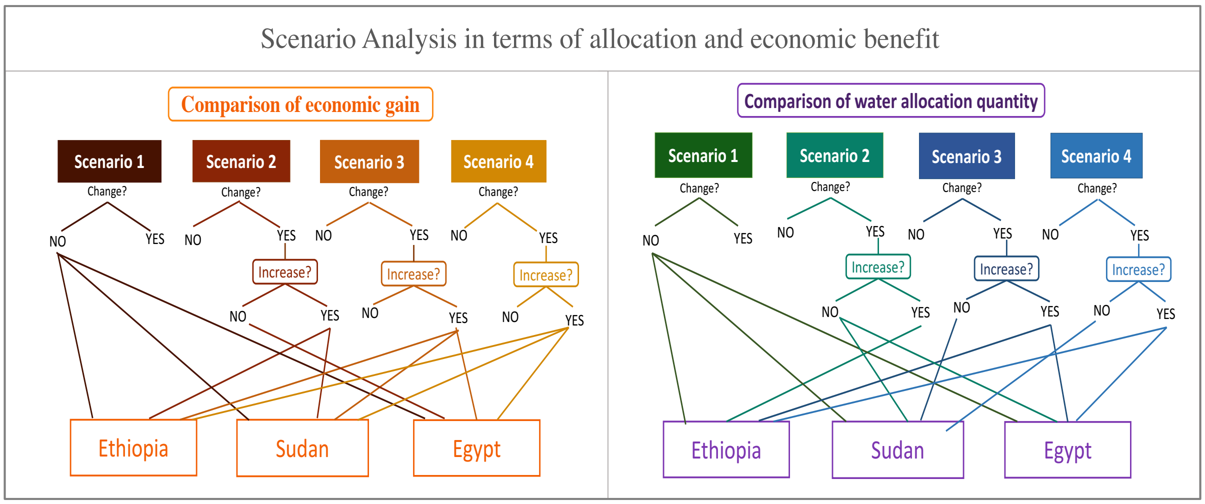

Figure 5-6 Comparing scenarios in allocation quantity and economic benefit for each riparian state

Annual evaporation losses (Table 5-1) in the Eastern Nile, in all scenarios, range from 19.1 to 22.2 MCM annually. The evaporation is much lower evaporation in Ethiopia due to lower average temperatures and higher rainfall that characterizes the headwater region of the Blue Nile and is much more significant in Egypt ranging from 13.4 MCM in scenario 2 to 17.6 MCM in scenario 3 due to natural setting and that cannot be altered in any of the scenarios but can be controlled to some extent. In scenarios 2 and 4, due to the GERD reservoir being operated and less water being stored in Lake Nasser where the rate of water loss to evaporation is the most significant in the entire Eastern Nile Basin. Evaporation losses remain almost constant across all scenarios because, in contrast to Egypt and Ethiopia, the relatively small storage capacity in Sudan does not allow for significant changes in the operation of reservoirs, resulting in little change in losses.

The results of the model demonstrated a significant rise in economic benefit for the Eastern Nile Basin from the operation of GERD under the full cooperation of all riparian countries (Scenario 4) (Figure 5-5). The economic benefit of the whole basin is more significant in both scenarios with cooperation (Scenario 3,4) and the highest in cooperation with GERD (Scenario 4) (Figure 5-6).

A basin-wide energy trade arrangement as an incentive for cooperation, whereby Ethiopia exports part of the massive amount of new hydropower generated from GERD to Egypt would substantially boost Egypt's economy and thereby increase the basin-wide economic value of the dam in a cooperative environment and possibility for joint management of the basin for future development plans. Potential benefits through increased hydropower production from the construction and operation of new hydro-infrastructural facilities depend on the cooperation of all riparian countries to gain mutual benefits rather than aiming at individualistic and opportunistic gains (Yihdego, Rieu-Clarke, & Cascao, 2016).

GERD offers the Eastern Nile Basin's economy significantly higher benefits (Figure 5-5) from increased hydropower generation and possibly increased the availability of water for irrigation in all riparian states, as well as the opportunity for improving water use efficiency as a result of a more regulated flow throughout the year. If these benefits are combined with cooperative joint management of the river, the overall benefit of the basin will exceed beyond economics, contribute to geopolitical stability, security, and sustainability. The recognition of GERD as a profitable undertaking for energy production and trade as well as the potential for sustainable utilization of the water resources brings positive motivation towards broader cooperation and benefit sharing amongst riparian states.

In Scenario 4, the economic benefits of each of the three countries, except for Sudan, are not the highest individually compared to other scenarios, but the whole Eastern Nile Basin benefit is at its peak. The overall benefit of the basin is at maximum in cooperation scenario with GERD; therefore, an equitable satisfaction could be achieved for all riparian.

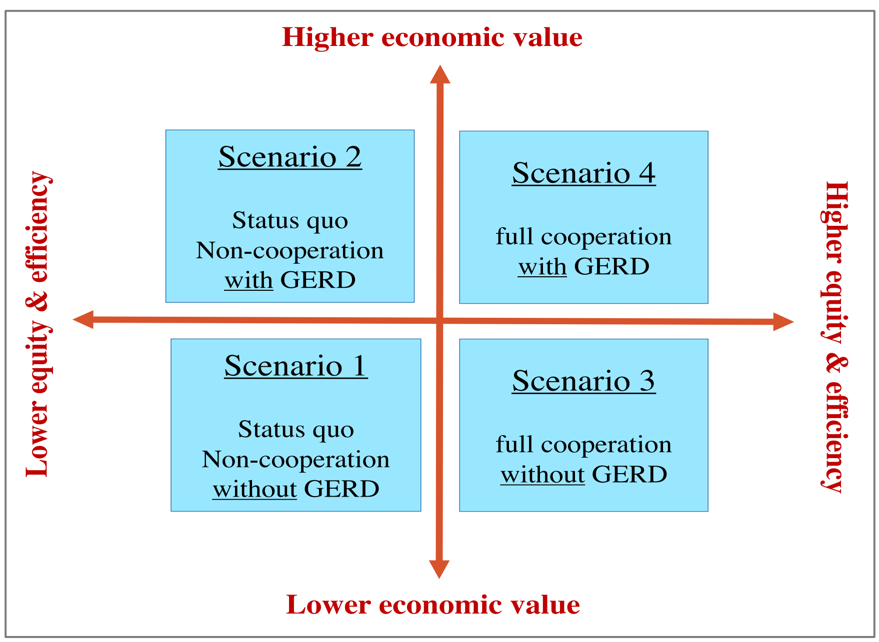

Figure 5–7 Scenario comparison for economic value and efficiency

Although Sudan allocates less water in scenario 2, 3 and four compared to baseline (Figure 5-7) (Figure 5-6), its economic benefit is almost doubled comparatively. It means the economic benefit of cooperation and from other sources than irrigation causes additional gains for Sudan with or without

GERD online. In scenario 4, Sudan gains the greatest benefit compared to others scenarios due to higher water use efficiency and higher agricultural productivity due to the regulated distribution of irrigation water. The detailed results of the model under different scenarios, allow decision makers to perceive water as an economic commodity that has the potential to be allocated where it produces the highest economic gain.

Benefit-sharing among states in a transboundary river basin is based on two fundamental questions: 1) how can the benefits of water allocation be quantified? 2) how to find the most suited benefit sharing option to ensure efficiency and equitability for all? It should be noted that there is no single response to these questions.

This study proposed one approach for distributing the benefits of cooperative management in the Eastern Nile Basin system. This study argues that a successful negotiation for cooperative decision-making can be supported through a well-designed hydro-economic model based on the required components and scale. Such a framework is a tool that provides accuracy, transparency, and flexibility for decision-makers to develop innovative solutions and explore the trade-offs and benefits of different sets of options. Institutionalized cooperation in transboundary settings is assumed to result in benefits for the states involved, as it provides them with information and reduces uncertainty as well as transaction costs. Nonetheless, it can be observed that cooperation on water management between states is a lengthy and complicated process, which requires substantial resources, capacities, and support for it to materialize and be sustained.

5.5 Considerations

Historically, competition for water use among the basin's countries has been recognized and documented. However, in debates over the GERD, it is sometimes forgotten that water allocation tradeoffs between irrigation and hydropower production can be compensated in a cooperative environment. If these compensations and tradeoffs can be identified and used as negotiation tools for cooperation, it has the potential to offset the most obvious of competition over physical water supply. If efficient solutions can be created by states agreeing on cooperative management of the basin, the total level and distribution of economic benefits among the Eastern Nile riparian countries could be expanded with development and operation of the GERD.

When planning a large-scale hydroelectric dam on a major river system such as the Nile, environmental factors need to be considered despite the risk that will impede work or boost upfront costs. Researchers should study how a region's water cycle integrates with biodiversity and local socio-culture, and factor their findings into the proposed design. Producing environmental assessments that follow to international standards can help lessen some of the concerns associated with the projects, such as those relating large displacements, environmental degradation, soil erosion, loss of biodiversity, loss of habitat, etc. Assessments have been carried out for the GERD, while critics say the assessments lacked detail and failed to meet international standards (Dinar & Nigatu, 2015).

According to a broad range of studies, GERD brings both an opportunity and a challenge to the basin. As an opportunity, GERD has the potential to foster cooperation by offering regional socio-economic benefits through coordination, development, and management of infrastructure and institutions in the basin for improved transboundary water management. These improvements, in turn, may significantly assist in addressing the uncertainties that climate change will inevitably cause at the regional level. It can be considered as a tool to build trust, create transparency, promote regional development and strengthen cooperation. Coordination of the operation of GERD may also prove to be a catalyst for additional benefits, such as greater integration of regional markets and energy trade (Sadoff & Grey, 2002).

The model does not include the effects of siltation on the river system and its economic beneficiaries in riparian states. Any dam that controls siltation would affect the economic benefit of the downstream countries by easing dam operation and significantly reducing dredging costs for canals that feed irrigation schemes. At the same time, reduced silt load would increase the need for fertilizer in downstream agricultural lands that currently benefit from natural nutrient-rich silt-laden waters.

Modeling a complex river basin is still in the experimental stage, and there is a need for considerable future development before there is widespread use of such models to support drafting improved policies and strategies. Model structure, simplifying assumptions, and limited data all are some of the constraints that limit accuracy and accountability. The effect of climate change and upstream development, in turn, will be crucial in determining the long-term optimal development of the basin associated with socio-political decision-making.

It should be noted that there are uncertainties associated with projections of the effects of climate change on water quantity and quality in the Nile basin. Some models forecast increased precipitation and runoff, while others forecast reduced rainfall and runoff (Elshamy & Hasan, 2011). The bottom-line for decision makers is that uncertainty has increased and options to adapt to unpredicted future changes become increasingly imperative, and longer delays inversely proportional to higher risks. Cooperation expands the set of useful options for higher security while risks and costs of adoption can be shared among all riparian countries. Unilateral responses by decision makers to the consequences of these growing uncertainties could be both economically inefficient and politically risky.

It is acknowledged that the selected hydrologic method does not reflect future transient climate change conditions; however, the approach is considered sufficiently robust for this analysis as a simple comparison between different game scenarios. The result of the HEM developed in this study is used to design simulation game to facilitate shared learning and explore scenarios to assist with decision-making.

It should be noted; this study did not attempt to compare the results of the model with current water use in the basin. While the presented case study is hypothetical and not consistent with the actual, current situation, yet represents a possible long-term future scenario in the basin, and the results reflect these assumptions. In the best-case scenario, this study assumed basin-wide cooperation with expanded irrigation and hydropower production in the basin and the GERD is online.

This current generic model can be extended and tailored to other specific case studies by incorporating more catchment-specific hydrological models, more elaborate models of price development, and more detailed climate change models. The necessary simplification of the hydrological parameters can be alleviated by combining this model with advanced hydro-informatics models. Such a model will provide more detailed operation scheme where the power plant varies with energy prices, and agriculture production has price elasticity due to changes in market demand.

6 Chapter 6: Laboratory Experiment: Application of trust game

6.1 Introduction

"We are concerned with trust and trustworthiness because they enable us to cooperate for mutual benefit. Cooperation is the prior and central concern. (. . .) Trust is merely one reason for confidence in taking cooperative risks, and trustworthiness is merely one reason such risks can pay off."– Russell Hardin[24]

A large part of any developing nation's economic activities and labor force is unorganized and informal hence voluntary engagement based on mutual trust is the key to cooperation and therefore productivity. Trust as the determinant of fruitful cooperation has been used by economics to understand productivity and, ipso facto economic prospects (Cox , Sadiraj, & Sadiraj, Implications of trust, fear and reciprocity for modeling economic behavior, 2008) (Sobel 2002). Trust is regarded as a central notion for economic, social and political progress; it aids any interaction between two parties with inequitable resources and differing interests. Thus, trust is defined as the "voluntary transfer of a good or favor to the second party with future reciprocation expected but not guaranteed" (Cox, 2004), while Cooperation is correlated to inherent good of strangers and altruistic behaviors.

Cooperation is essential for exchange and to share goods and services, either in a mutual agreement or through legal enforcement. Water conflicts are a product of series of mismanagement and disregard for social and environmental balances accumulated over a period of time; it is the consequence of irregular political decisions on competition and divergence of interconnections among variables and processes in multiple sectors. Water management is crucial for equal and equitable distribution of resources to all stakeholders involved including wildlife and marine life. When water is viewed as a limited resource it lends itself to conflicts over its distribution; however, management based on sound scientifically veritable data can transform a limited water quantity into a flexible resource (Roberts & Finnegen, 2013). A framework to synthesize explicit and tacit water data into tangible, relevant, transparent knowledge ultimately

[24] *Russell Hardin (2002) in the book "Trust and trustworthiness." He was the professor of political science at Stanford University (1940-2017).*

could aid the decision makers to act upon choices based on information rather than speculation (Baird, 2010). Such knowledge replaces the need to rely on the fundamental right and altruistic behavior to build trust with information and transparency, leading to more sincere cooperation (Bhaduri & Barbier, 2008).

For many years, scholars have debated the issues of cooperative vs. non-cooperative solutions to common pool resource allocation. They argued that under certain conditions cooperative solutions to common pool[25] resource allocation produces greater payoff compared to non-cooperation (Agrawal, 2003). An important aspect often neglected by many advocating cooperation in common pool resource allocation problems, is that even if the benefits from joint actions are significant compared to non-cooperation, there are reasons to prefer non-cooperation, e.g. due to lack of trust and confidence (Ostrom, 2008). One explanation for the lack of success is that the extent of potential gains from cooperation is mainly unidentified and the parties have incomplete or even inaccurate knowledge of opportunities of cooperation. Besides, gains from cooperation mean little to different parties unless the benefits are relevant and pertinent to their priorities, and also the required cooperative behavior needs to be incentive-compatible (Sadoff & Grey, 2005). Identifying existing trade-off options allows the experts to develop a platform to share clear, concise and credible data on benefits under different specific conditions, i.e. cooperation or non-cooperation under certain terms and conditions, e.g. GERD, making the decision-making process more encouraged (Islam & Susskind, 2013).

In Chapter 4, the survey results indicated that lack of trust was the most crucial factor impeding data sharing and open negotiation, which in macroscopic view is detrimental for basin-wide cooperation. This chapter focuses on designing and conducting experimental games in a laboratory setting to simulate the negotiation processes for cooperation. The game design is based on results from the HEM, and the expert survey explained in previous chapters. The methodology of this study required that the game be designed as closely as possible to real-world scenarios despite limitations in data. As a comparison approach and a transboundary management tool, game experiment method was applied to explore the role of trust and confidence building for decision-making in transboundary water sharing in the Eastern Nile Basin. In the designed experiment, by conducting trust games, this study aimed to evaluate how effective trust-building is in cooperation in a controlled environment of a laboratory and what condition may promote or damage it.

[25] *Common-pool resources (CPRs) are natural or human-made resources where one person's use subtracts from another's use and where it is often necessary, but challenging and costly, to exclude other users outside the group from using the resource (Agrawal, 2001).*

The trust game explored how cooperative players (decision makers) would choose different options in each round of the game when provided with new sets of information and payoffs. The probability of cooperation in the game is examined by studying the effect of different factors such as the availability of data, transparency, and communication, influencing the negotiation process and the decision-making. The aim of this exercise was to understand the parameters that contribute to successful negotiation processes and the factors that aid decision makers to agree on a binding set of terms and conditions.

The literature review on the conditions and factors that are required for multi-stakeholder collaborations in a transboundary basin context are conducted in the following sections. Furthermore, an analysis is offered through which games are assessed regarding design principles, modes of play, and their potential impact on decision-making for transboundary governance. This chapter concludes with a discussion of the study results and recommendations.

6.2 Literature review

Binding legal cooperative agreements are difficult to enforce, monitor and expensive to obtain; however, rigid or loosely formulated, it also negates mutual trust and compassion among stakeholder since building trust is the key to cooperation (Cox, 2004). Most experimental economists have adopted Coleman's definition of trust described in "Foundations of social theory," published in 1990; trust is an action that involves the voluntary placement of resources at the disposal of a beneficiary with no enforceable commitment from the benefactor. Trust directly proportional to risk, the extent of which is determined by the degree of confidence one has in others[26]. According to goal/expectation theory, "mutual trust is the key to actual cooperation" (Gaechter, Hermann, & Thoeni, 2005) (Warneken & Tomasello, 2009) (Boyd & Richerson, 2009).

After the publication of Berg, Dickhaut & McCabe (1995), economists have used the amount sent in the investment or trust game as a measure of trust, and the amount or proportion returned as a measure of trustworthiness. The basic form of trust game consists of two players, one endowed with money (the trustor) and one without (the trustee). The trustor decides either to keep the money for him/herself or to 'invest' some or all of it by sending it to the trustee. The term invest here loosely refers to a formal or informal arrangement of mutual benefits in exchange for goods

[26] *The interpretation of trust as an action may be somewhat controversial. However, the purpose of this chapter is not to develop a "best definition of trust." With this, we want to see whether widely used behavioral questions about trust can predict actions in trust games that have been widely utilized in the field to measure trust and whether these results are robust to controlling for altruism using the triadic design.*

or services. Any money invested generates a value return (e.g., it is doubled or tripled depending on the design of the game), the trustee after receiving the multiplied money, must decide to either to keep the money and not return anything to the trustor, or to return the initial amount or greater sum (Berg, Dickaut, & McCabe, 1995). In essence, it is a simplified direct investment system where goods and services are exchanged instead of currency and shares. Each player must attempt to win the trust of others by either investing or returning the received investment with interest in kind or benefits so that a mutually beneficial partnership develops which in other words is mutual cooperation. An untrusting trustor would only invest in the trustee if he/she expects the trustee to return a more considerable sum of money compared to what was invested in the first place. Since, without such trust, a selfish trustor would be better off by keeping all the money for him/herself. Therefore, the amount of money sent to the trustee is considered as a measure of trust.

Carlsson et al. (2011), analyzed the role of two kinds of trusting behavior: (a) conditional cooperation, where people may be more willing to cooperate if others do; and (b) unconditional cooperation with the effects of the default alternative, where people may be influenced by the default choice. Their study conducted a field experiment on impacts on household contribution (actual money) for the construction of a communal bridge in rural Vietnam. The analysis reported that both conditional cooperation and default alternative behaviors varied significantly on the size and frequency of donations. One of the observations was that people tended to contribute less compared to others' if contributions are unknown. Also, a zero-default contribution reduced the contribution compared to not mentioning any default value (Carlsson, Johansson, & Nam, 2011). Moreover, households contributed equally or higher when they were made aware of their neighbors' contribution. Thus, the actual contribution has very little correlation to the household's financial capacity but rather was strongly linked to perceived peer-to-peer cooperation, very much on the principles of participatory guarantee system.

Hagen et al. (2007), discussed how useful, different types of games could be in developing trust and empathy amongst stakeholders for the problems faced by other groups. Hagen et al. (2007) indicated that not only a strengthening of relationships between diverse stakeholders by increasing mutual trust and empathy played a significant role in cooperation, but also by improving the understanding of the system and complex issues at play. For example, farmers from villages in conflict over water allocations played simulation games in which the roles were swapped. It was found that the scenario with swapped roles, during which upstream villagers played the role of downstream villagers and vice versa, was very useful in making each agent understand the nature and position of the other. Game simulation platforms provide excellent solutions to test, validate and create new alternatives for transboundary water management and stakeholders' interactions at all scales (Rusca, Heun, & Schwartz, 2012).

Game theory is a widely used tool in transboundary water management, which is designed to solve situations of differing interests among players under conditions of cooperation and competition (Parrachino, Dinar, & Patrone, 2006). The various types of game theory examine how independent and self-interested individuals interact with each other, and how that can help in analyzing the strategy of each stakeholder in any river system (Hui et al., 2015). Madani (2010), studied game theory applications to water resource management and emphasized differences between outcomes predicted by game theory and solutions proposed by optimization methods that inherently assume perfect cooperation among all parties. Complete unconditional cooperation rarely exists in the real-world situation; thus, game theory is a more pragmatic approach to analyzing cooperation among multiple stakeholders for any resources sharing compared to the application of optimization without considering all influencing factors.

“Behavioural game theory" is a recent approach linking game theory to cognitive science by adding cogent details of ‘social utility functions,' principles of limits on iterated thinking which refers to what players guess about other players moves and decisions, and statistical theories of how players learn to influence others (Haug & Huitema, 2009). New directions include the effects of game descriptions on "choice framing," strategic heuristics, and mental representation. Different types of behavioral games as a form of game theory make creative platforms that allow decision makers to share and transfer knowledge, understandings, and perspectives through face-to-face interactions and discussions (Edelenbos, Van Buuren, & Van Schie, 2011). Interactive multi-player game formats that facilitate step-wise, round-based interactions allow participants to develop a greater understanding of different perspectives of upstream and downstream contexts of a river basin (Mahjouri & Ardestani, 2011). In the current dissertation, trust game as of the behavioral game types is applied to the case of Eastern Nile Basin's decision-making model.

This research attempts to simulate the real-world scenarios of current and possible future of Eastern Nile Basin in controlled experimental games in a laboratory setting through the application of role-playing gaming where players represent decision makers. The core of this research involves extensive application of trust game experiments to address issue linkages and benefit sharing among competing players. The advantages of applying game theory to other methods such as traditional quantitative simulation and optimization methods are a) the ability to simulate various aspects of the conflict b) Integrate various characteristics of the conflict and predict possible solutions in the absence of quantitative payoff information (Ambec & Ehlers, 2008).

6.3 Application of cooperative game theory to shared water resource as a complex system

The separate two branches of the game theory according to the classification made by (Harsanyi & Selten, 1988) are:

- o Non-cooperative games, where binding agreements among the players are not possible;
- o Cooperative games, where binding agreements among the players are possible.

The non-cooperative games analyze the situations where the players consider only their strategic objectives, and thus binding agreements among the players are not possible, while the second approach, cooperative games, are purely based on agreements to allocate gains as the product of cooperation among the players (Sechi, Zucca, & Zuddas, 2013).

6.3.1 Game coalition solution

The "suitable conditions" or "incentives to cooperate" are determined by three main factors: 1) the type of the shared resource, 2) the number of "players" (riparian states of shared water). In general, the higher the number of players, the more challenging to achieve cooperative outcomes. 3) heterogeneity or homogeneity of players (Mahjouri & Ardestani, 2011). Correlation among these factors should be considered three other influencing factors as:

(1) Capabilities
(2) Preferences or interests
(3) Beliefs or information

In transboundary basin contexts, capabilities refer to the relative power in the economy, policy and geographic location on the river, i.e. upstream or downstream and related bargaining power of the riparian states. Each riparian's preferences or interests determine the costs and benefits, potential strategies and final outcomes of the game (Dinar A. , Dinar, McCaffrey, & McKinney, 2007). Preferences and interests are the functions of the riparian's perception of current, and future demand calculations, availability of the resource and discount rate of the resource use[27], sense of shared identity, national image, and sovereignty. A riparian's beliefs and the information at its disposal, in addition to its processing of this information, influence its perception of the issue and therefore indirectly affect its interests or preferences (Rogers, 1993). The number of players and their capabilities, preferences, and transparency and availability of information affects the transactions towards cooperation, the ability to communicate, and capacity to make

[27] *Discounting is a mechanism used to compare streams of net benefits generated by alternative allocations of resources over time.*

credible commitments. Changes in any of these variables, then, may alter the incentives of players to cooperate. The key question is how to effect positive change in these variables such that cooperative outcomes are realized (Peleg & Sudhoelter, 2003).

One of the first essential aspects of the methodology is to identify the game's characteristic function. Therefore, N is referred to N = (1,2, ..., n) as a set of players who are participating in the game. Each subset ($S \subseteq N$) is called "coalition," and for (S = N) we have the "Grand Coalition." The players represent real subjects, as agents who share the same water resources. The benefit linked to a coalition S, and the benefit commonly sustained by all of the players that belong to S, is represented as b(S) and consequently, b(N) is the benefit associated with the Grand Coalition. Finally, by convention, the benefit linked to an empty coalition as a no cooperation option corresponds to benefit equals to zero.

If every pair of no coalitions is S' and S", then:

Equation 1: $b(S' \cup S'') \geq b(S') + b(S'')$

In this case, players cooperate to determine a benefit greater than the sum of what they gain individually. The "stand-alone benefit," given as b(i) represents the benefit that is connected to the agent i when the agent is considered autonomous from the other players. As shown below the principle can refer to an individual player or a coalition.

Equation 2: $x_i \geq b(i)$

Equation 3: $\sum x_i \geq b(S) \qquad \forall \; S \subseteq N$

In this equation, x_i is the amount of total game value that is assigned to a given player. According to this principle, no player or group of players that form a coalition would accept a benefit which is lower than the value that it/they would sustain when participating independently, i.e., lesser than its/their initial value.

The cooperative type of game supports the solutions that include all of the players; therefore, the cooperative game theory solution methods can divide the benefit among all of the game participants, despite varied starting points (Bachrach, Meir, & Feldman, 2012). In other words, because of cooperation, each player receives greater benefit compared to x_i as the result of accepting whole range opportunities for compensation schemes that jointly is greater than of non-cooperation. By considering this aspect, a universal solution is defined by a vector called x of components $\{x_1, x_2, \ldots, x_n\}$ such that:

Equation 4: $\sum x_i = b(N)$

Where x_i is the payoff assigned to the i^{th} player. In the game, by concerning each individual's rationality, bringing power and the incentive exchange options, the amount player i gains increases by cooperation rather than unilateral participation. The equation is as: $v_i = b(i) + I_i$. With players rationality, the total gain of the game is:

Equation 5: $v(S) = b(S) + \sum I_i \qquad \forall\ S \subseteq N$

To bring the limits and potential of players in the hydro-economic simulation, the initial amount of water in upstream considered to be exactly the same in all four designed scenarios, and any variation is due to additional water availability along the basin which is measured to be the result of increase in water use efficiency (Madani K. , 2010). If opportunities for placing and rewarding trust are widely available, especially in contexts where the costs of inadequate or lack of trust are initially low, decision makers can build a fabric of good will and confidence that facilitates cooperation, and that is a significant step towards higher economic gains for all (Cox , Sadiraj, & Sadiraj, 2008).

6.3.2 Cooperative games at the basin level

Each riparian may individually exploit the shared resource to its maximum potential. Nonetheless, that is limited to geo-physiology of the system, topography and economical means available to that riparian (Douven, et al., 2014). For example, Sudan and Egypt are primarily flatlands with little elevation differences, although this is useful for irrigation, it is not so suitable for hydropower because of the uniformity of land there isn't enough momentum in the water (force due to gravity) for hydropower generation. However, the Nile flows from highlands of Ethiopia originating at 2000 m above sea level to 300 m at Aswan, so the elevation differences make it the ideal place for construction of multiple hydropower generation dams on the same river in various locations along the gradient (Batisha, 2011).

The collective benefit of cooperation increases the overall utility derived from the shared resource in this case water use for hydropower generation. On the other hand, no cooperation involves economic costs because of the unexploited possibility of taking advantage of efficiency gains (Dinar & Nigatu, 2013). Therefore, the concept is based on the assumption that these cooperation-related gains exceed the costs associated with cooperation. Cooperation necessitates reasonable benefit sharing; explicit and systematized effort to allocate resources among multiple stakeholders in a river basin under intra-country water rights systems or inter-country agreements in order to sustain full economic benefit and equitable disbursement of associated costs and benefits.

6.3.3 Strategic case of Eastern Nile Basin for trust game design

As discussed earlier, a transboundary water cooperation process can deliver increasing benefits over time, as rising levels of trust and cooperation open new opportunities for economic activities in the Eastern Nile Basin.

Eastern Nile River basin is characterized by negotiations between governments of the three countries and lack of mutually agreeable terms and conditions that satisfy cooperation. In order to achieve a stable basin-wide agreement the Nile Basin, riparian countries must develop a favourable environment for negotiation processes (Sechi, Zucca, & Zuddas, 2013). It is imperative that the riparian states examine the interests, preferences, and priorities of each other and exploring mutual gains to come to a sustainable, long-term mutual agreement (Cascão, 2009). Cooperation can manifest itself in a variety of "cooperative institutional arrangements," which means that states – formally or informally – agree to a standard set of rules that govern their interactions' then move towards more binding and lasting agreements for the future development of a basin (Gerlak, 2007).

In short, if the current situation continues, states will seek to maximize their particular individual earnings and will remain indifferent to or in contradiction of the gains achieved by other riparian countries. Therefore, the emergence of cooperation among riparians is possible only when respect and trust among them can be ensured with the help of information access, lower transaction costs, increased transparency, and reduced risks with the presence of water law (Mirumachi & Warner, 2008). By simulating the process of trust building and negotiation in a laboratory setting when players play the role of politicians from the three countries of Eastern Nile, the experimental game developed by this study measured the impact of information sharing and transparency on cooperation among players. The game design in this study considered initial difficulties for cooperative decision-making.

The first obstacle to nurture cooperation is the environment of negotiation: the terms of institutional arrangements that bind the countries or that provide a range of opportunities, which collectively sum up to a higher value as compared to non-cooperation (Cascão, 2009). Therefore, making cooperation more attractive compared to non-cooperative choices in the game creates the opportunity to study how additional benefit due to cooperation promotes or influences players' decision to cooperate.

The second most important concerning problem in transboundary water governance is that effective cooperation among the riparian states is not guaranteed due to inadequate cooperation incentives. One way to deal with the problem is continued negotiations to give decision makers time and opportunity to work together towards confidence building, value creation and joint thinking for solutions by forming different compensation options for cooperation and prevent unilateral decision-making (Islam & Susskind, 2013). So, in this study, players were given time for negotiation in each round of the game with various sets of information and payoff tables. In the role-playing game, decision-makers can learn cooperative behavior in the case of repeated conditions and differing interests by conducting joint fact-finding workshops in a transparent environment.

The sketch upstream-downstream compensation is the economic rationale of the idea of benefit sharing instead of water sharing (Wu & Whittington, 2005). Regarding asymmetrical externalities such as upstream-downstream condition in the Eastern Nile Basin, the distribution of incentives and benefits for cooperation is skewed too. Side payments become a possible option for restructuring incentives for inducing cooperative behaviour. Along with benefit sharing approach, two types of compensation method are applied to the Eastern Nile Basin case study area simulation: a) side payments and b) issue linkages. The side-payment options are a financial condition of each player based on the GDP of the country they represented in the game. Trade-offs among different water allocation plans and counties assigned payoffs for each scenario are the primary basis for issue linkages in the game. In this study, the economic power of each Eastern Nile riparian is considered, to model the differences in capability for incentive strategies of each player who represents these countries.

The following elements are incorporated in the game design as a strategic tool to promote cooperation:

(1) Benefit Sharing: Players have a variety of options from non-cooperation to full cooperation in each round of the game. They have the opportunity to choose the most efficient option and to gain other players trust by paying incentives.

(2) Side payments: A side-payment is either direct monetary payments or units of available resources. In the game, each player was assigned a sum of virtual money that is an equivalent value to his/her geopolitical power within the negotiation platform.

(3) Issue linkages create benefits for players with a little gain ipso facto increasing probability of cooperation through peer pressure. In this instance, adding another point or being innovative during the negotiations can redistribute the benefits. This, in turn, allows all participants to experience some gain.

(4) Diplomacy: By applying strategic tools such as creating an opportunity for joint fact-finding in the game session, players were given a chance to work together to find the best option that satisfied all members.

(5) Legality: If trust is too risky of a decision, then policies to promote trust might best focus on creating rules that, for example, improve transparency and encourage peer-to-peer penalty of trust violations as in participatory guarantee systems. In the game payoff structure, each country has certain right towards the shared water. The game was designed according to the International Water Law's principles: 1) Principle of equitable and reasonable utilization, 2) Principles of notification, consultation and negotiation, 3) Obligation not to cause significant harm, 4) Principles of cooperation and information exchange, 5) Peaceful settlement of disputes, as all were discussed in detail in Chapter 3 of this dissertation.

6.4 Framing the laboratory experiment

The game design simulated possible strategic alternatives for negotiation between Egypt, Sudan, and Ethiopia. The three players had an initial set of choices to make a strategic decision that then influences others to make their decisions similarly, and the game moves forward by one round. Then each player makes a strategic counter move until all players reach a mutually agreeable state or win-for-all situation. This is possible because every player is aware that safeguarding his/her starting lump sum amount is a loss and also knows that returning a received investment wins trust and mutual partnership. Thus, every player risks initial investment; the game proceeds round after round based on transparent, available data, decisions are made through negotiations to share, exchange, compensate and eventually had the chance to reach a win-for-all situation.

There are four elements interact in the decision-making in the game according to Beach et al., (2000), which should be determined in any game including the game designed by this research. The four elements are:

(1) Players: playing the role of politician/decision makers from Ethiopia, Sudan, Egypt

(2) Interaction: the choices of one player affect the decisions of the others in the group.

(3) Strategy: each player holds an approach and plan accordingly based on the understanding of the other players' interactions and given game instructions.

(4) Rationality: the players' choices are characterized by rationality – national interests.

In this study, the game was designed in a way to balance the win-for-all situation. The states of winning and losing were critically analyzed through the assigned values, i.e., until the set of games reaches a minimum mutually acceptable option for the satisfaction of all the players continue to play. At the end of a set of games, each player won, i.e. each particular player's interest for cooperation fulfilled.

Although risk and uncertainty appear similar during the game, uncertainty is fundamentally different from risk; the opposite of uncertainty is information, which is formally defined as that which reduces uncertainty depends on its level of accuracy and validity. Decision makers may also be irrationally uncertain: they are unable to make up their minds as to which is the best option, often because the choice is so complex that it was difficult to see through the complexity to the core of the decision (Taghavifard , Khalili Damghani, & Tavakoli, 2009). One of the primary purposes of economic analysis is then to reduce this irrational uncertainty. Thus, eliminating the uncertainties about choices and decisions based on the interests of other players in the group (Liu, 2011). Because each player knows that his/her winnings are equal to every other player with only a marginal difference, other player's payoffs are well known and accepted. At this stage, players knew each other's gains based on the game information system and choices they made in their best interest, so this transparency creates information that then leads to better decision-making.

6.4.1 Rules of the game

Players were randomly allocated to positions A, B, C, where A is an upstream participant, and B the midstream participant and C is downstream. The players keep the same position for the entire duration of the experiment (Figure 6-1). The experiment mimics provision of distribution of water that is available from the upstream, and real-world current allocations.

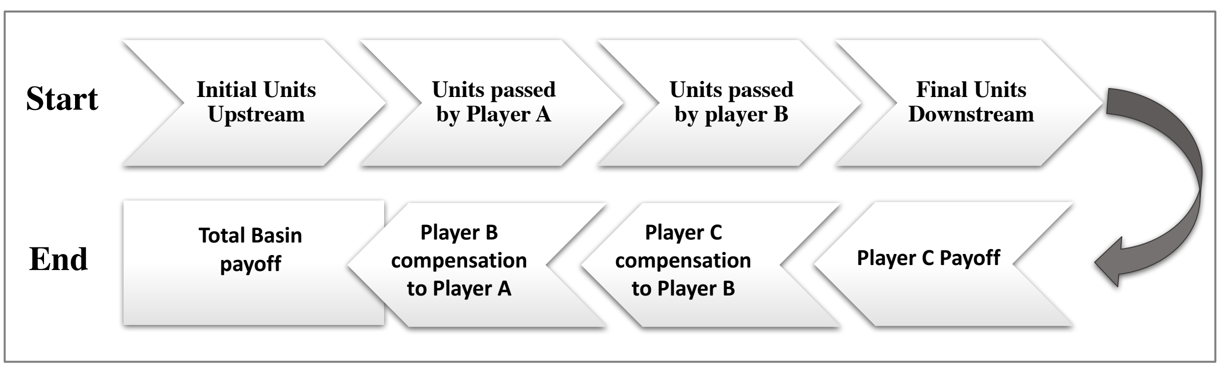

Figure 6–1 Schematic process of Trust Game for three players

As an example, each player has a demand for X quantity of the resource and may receive less (X-1,2.3, etc.) or more (X+1,2,3, etc.). Therefore, in each situation, a new set of opportunities arises for that player. Firstly, his resource needs can be met, which would quantify as 100, any surplus would be 100+1,2,3, and any deficit is 100-1,2,3 and so on. It is also imperative to look at whether a player receives/has more than what he or she can make use of. If a player can only make use of 100 units, from the economic point of view, it makes no sense for him/her to gain more.

Similarly, players who have greater potential and receive fewer units of resource face deficits. A win-for-all situation would be where all players would receive 100% as required, or receive equitable compensation for any deficits in allocation or contributions of surplus. For example, player B has rights to 100 units, but his capacity to use is limited to 50 units so then he/she can trade the other 50 units to either of the players for compensation.

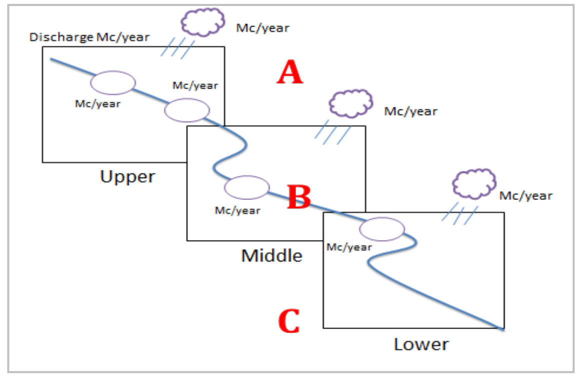

Figure 6–2 Schematic of the basin for the game

This approach is simplified by mainly answering the following questions:

a) who are the players

b) choices of the players

c) what sequence do the players adapt to make decisions

d) what are the uncertainties of each player and

e) what are the payoffs to each player from each possible outcome in the game.

In the game theoretical approach, five core components are:

(1) The players in the Eastern Nile Basin are Ethiopia, Sudan and Egypt as A, B, and C (Figure 6-2).

(2) The initial 2 phases of the methodology, modeled the choices of each player and assigned numerical values for computation, and to create margins of winning scale.

(3) The sequence of decisions was made by Z-tree software.

(4) Uncertainties of players were eliminated through making each player's payoffs apparent to each other and by offering a win-for-all situation in every round of the game.

(5) Payoffs of each player were made explicit to him/herself and others. Thus, strategies based on bargaining power is done away with yet opening up a new spectrum for negotiations on the overlapping choices with best payoffs for each side in multiparty cooperation.

(6) The role of a participant as representing Ethiopia, Sudan, and Egypt did not change throughout the experiment. This setup reflects the repeated-game character of the real situation. In each round of the game, players can choose to defect cooperation.

6.4.2 Payoff structure for the experiment

The game design in this study considers, trust as the willingness to transfer positive units of water ($W_{ij} > 0$) to the other player in the hope of equal reciprocation. The amount of incentive Z_i, about total basin benefit, is an indicator of a player's reciprocal behavior. The higher Z – for a given W_{ij} – shows the higher the degree of reciprocity and willingness to compensate. "Trust" is then calculated as the proportion of willingness to cooperate to achieve higher basin-wide economic benefit and divide it equitably among the players. When all players are at some levels of satisfaction with the share of the water and related benefit they receive, the player can be said to be cooperative, or a win-for-all situation achieved.

The fundamental idea here should be that the resource is a common pool, and all parties are equally entitled. Player A, the trustor, has initial units of water $W^O > 0$ and can decide to use some units and send the rest of the available units of water (W^{AB}) to player B, the trustee. The number of water units that player B receives $0 \leq W^{AB} \leq W^O$.

Now player B becomes the trustor and sends some units of water (W^{BC}) which he/she had as surplus either as excess or either as units beyond exploitation capabilities, to player C in downstream, the trustee at this point with W^{BC} units of water which: $0 \leq W^{BC} \leq W^{AB}$.

Player C gains payoffs out of consuming W^{BC} units of water, he/she had received from player B (Direct benefit of water consumption=G_C) and now can return fair amount in kind or value as an incentive (Z_{CB}) to player B or/and A (Z_{CA}).

In return, player B gains G_B amount of total benefit out of using received units of water from player A plus the incentive he/she had received from player C and player B. Now he/she can return incentives to player A (Z_{BA}) for his/her investment or player C (Z_{BC}) as any amount in kind or cash of G_B or from other sources of income.

The final payoff for player A is benefiting from consuming $W^O - W^{AB}$ units of water (G_A) plus the incentives (Z_{BA}, Z_{CA}) from player B and player C. There is an opportunity for player A to send incentives to B or/and C, as well. Therefore, the total payoff of each player at the end of each round of the game is:

Total payoff of player A (USD): $PO_A = G_A + (Z_{BA} + Z_{CA}) - (Z_{AB} + Z_{AC})$
Total payoff of player B (USD): $PO_B = G_B + (Z_{AB} + Z_{CB}) - (Z_{BA} + Z_{BC})$
Total payoff of player C (USD): $PO_C = G_C + (Z_{AC} + Z_{BC}) - (Z_{CA} + Z_{CB})$

The amount of Z can be used as a measure of the trust in the round of game where players remain anonymous to each other and as well as in the rounds where they are known to each other and negotiate.

The game used tables that list the payoffs obtained by each combination of water releases from Ethiopia to Sudan and from Sudan to Egypt. Payoff tables for each scenario varied due to the range of feasible releases combinations from upstream to downstream. Having defined the payoff functions of the three riparian states the next step is to calculate using real-world data to make the findings more relevant and tangible to decision makers.

6.5 Game procedure

Having formulated the payoff functions, the structure of the game session was developed as the next step of the experiment design. All experiments were conducted under the supervision of Miss Mahsa Motlagh, with help and support of 3 other colleagues from ITT, which are assigned to the role of "Experimenters" for the game session. Experiments with the students were conducted in a computer lab, using pen and paper.

At the beginning of the game, the participants were provided with written instructions and 10 minutes time to read and understand the rules of engagement. A comprehensive description of the use of the experiment sheets was discussed after that. Then the experimenter explained the game to all the participants followed by a brief question and answer session to clarify any doubts. The structure of the session, written instructions and strategy sheet are cataloged in the appendix for this chapter.

Players received specific information related to their individual representative role during the game: (1) Specific factsheet: stating each player's particular interest and strategic preferences and challenges they face as a country (2) Payoff tables for each round (3) Decision-making sheet for each round of the game (4) Virtual money.

Representatives/players could ask questions throughout the experiments. After the players had served all four rounds of the game, they received cash equal to their gain of the entire game. Table (6-1) provides a summarized representation of the experiment stages described. As explained, the game starts with:

(1) Round one: playing anonymously with payoff tables for scenarios without GERD

(2) Round two: playing under Eastern Nile scenario without GERD (same payoff tables as

previous round) - with an introduction to the group members, negotiation time, binding platform and private decision-making

(3) Round four: playing under both Eastern Nile scenario with and without GERD– complete set of payoffs for both situations, negotiation time, binding platform and individual decision-making

(4) Round three: playing under Eastern Nile scenario with GERD – new payoffs - negotiation time, binding platform and private decision-making

Feedback on the actual outcome and evaluation of each participant in the trust game was shared individually at the end of the experiment along with the actual payment.

Table 6-1 Game structure and materials

Round	Material	Stages of the game	Procedure	Time
Introduction	ID Card, Instructor reading Rules of the game explanation General fact sheet of the basin Question time	Hand out ID cards and written instructions	Get familiar with the game rules	10 Min
1	Case study map Instruction of first round Individual fact sheet Payoff table for scenario 1 & 3	Reading the instruction Understand the role and position Individual thinking Decision-making	Playing anonymous from other group members	15 Min
2	Basin fact sheet (Getting familiar with other players' interests and positions) Payoff table for scenario 1 & 3	Introduction to other team members, Data sharing, Casual negotiation Decision-making	Group meeting for negotiation	30 Min
3	Payoff table for scenario 2 & 4	New Data sharing Informal negotiation Decision making	Group meeting for negotiation	30 Min
4	Payoff table for all four scenarios As in round 1 & 2	Casual negotiation Decision-making	Group meeting for negotiation	30 Min
Payment	Players' gains calculation	Real money payment	in private	15 Min

In the introduction stage and game instruction sheets, in which the core rules of the game were explained to the players, the game was framed as that of a "water being passed" from upstream player to the others and players have a role of diplomat/decision maker from the country they were randomly assigned.

The negotiation teams were provided with a basic fact sheet including primary data on their national objectives and interests in the use of the Nile River as described in (Table 6-1). Moreover, each player had a" secret" instructions as the role[s] mission describing additional information and national interests concerning the river (Table 6-2). Each player's goal in the negotiation simulation is to negotiate and draft provisions that are most favorable to the country he/she is representing and its interests according to the given information. They were informed that the goal of the game was to reach a conclusion where the common resource could be optimally used for the benefit of everyone.

Table 6-2 Summary of individual mission fact sheets for each role

Country	Location	Key Characteristics	Key Issues	Interests and Development opportunities	National priority
A	Upstream	Moderate climate, high population growth, high food demand	Lack of agricultural technology and efficiency Huge hydro-electric development potential Low national capital investment opportunity	Hydropower Irrigation Poverty mitigation Watershed management practices Agriculture technology	Water for hydropower
B	Midstream	Dry, Water scarce, high dependency on river, high population growth, high food demand	Low agricultural productivity, high agricultural potential for food production Medium hydroelectric development potential Low national capital investment opportunity	Irrigation Poverty mitigation Flood control Information policy Hydropower Improve agriculture efficiency	Water for agriculture
C	Downstream	Dry, Water scarce, high dependency on River, High population growth, Touristic country, highest economic power in the basin	Medium agricultural productivity with improved technology, largest portion of land under irrigation in the basin No hydropower generation potential crop water consumption	Pollution Control Irrigation Information policy	Water for domestic use / Agriculture

Following the distribution of these materials, each player had time to understand his/her mission prepare for the game before starting the negotiation. Preparation includes studying the fact sheet and secret instructions as mentioned in the (Table 6-2), developing a negotiation strategy that best achieves the country's objectives, considering the points on which each player may be willing to compromise, developing alternative positions, considering alternative solutions that as the negotiator might propose. Each player is expected to negotiate his/her position based on the shared and "secret" mission provided for the game.

According to the rules of the game, players exchange water units in the game based on a designed combination of options in their game sheets, from upstream to downstream and use the virtual money as side payments during the negotiation as compensation alternative.

The sequences of the game adapted aimed to study the process of trust building from entirely unknown until the time players have had the opportunity to meet each other as a team with similar objectives. Step by step, each round gave players more time to build confidence and have a friendly discussion about finding the best solution out of the available options. Meanwhile, the scenario changed from not having GERD to have a fully operational GERD. By having extra benefit in their payoffs due to the GERD compare to previous rounds, this new round could investigate the role of the increase in economic gain in cooperative decision-making.

The game was designed to simulate the asymmetries in power and influence of the Eastern Nile Basin states. Countries' national economic power can be conceived at three levels: (1) resources or capabilities, or power-in-being; (2) how that power is converted through political processes; (3) and power in outcomes, or which state prevails in particular circumstances (OECD, 2009). The main categories of capabilities in the Strategic Assessments Group assessment of power are the gross domestic product (GDP), population, military strength, and a less precise factor capturing innovation in technology.

Table 6–3 Eastern Nile countries' GDP (OECD 2015)

	GDP 2015 (Billion USD)	% Basin Share
Egypt	330.2	69.8
Sudan	81.4	17.2
Ethiopia	61.6	13.0
Eastern Nile Basin	**473.2**	**100.0**

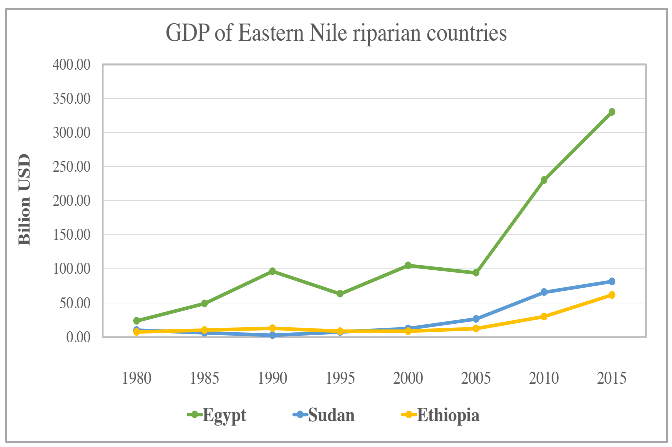

Figure 6–3 Eastern Nile countries' GDP Growth rate

The financial capacity of each player directly corresponded to the economic strength of the country he/she represented. As (Figure 6-3) and (Table 6-3) illustrate, Egypt's economic strength is three times more than Sudan's and slightly more than three times that of Ethiopia's. To simplify the condition, players who played Egypt role got 5000 USD virtual money (player C) in each group, 1500 USD to player B, players who played Sudan's role, 1000 USD to players who played Ethiopia's role (player A).

It was explained to the participants that the amount of virtual money they had on hand at the end of each round did not count as their final payoff of the game. A number of side payments they exchanged, which caused changes in their financial situation was considered for calculation of their payoffs. For instance, if player C had 3000 USD by paying 1000 USD each side payment to both players A and B; A ended up with 2000 USD plus the gain from the choice he/she made. B would have 2500 plus the benefit from his/her decision for water release, and C would have 3000 USD plus the gain from his/her decision on water allocation option. The final payoff at the end for each round for each player was the total minus the initial amount of virtual money they had in hand. The original sum of virtual money was not topped-up at the beginning of each round. So, players had to think long-term for next rounds of the game and made their decisions accordingly. By doing so, players understood the impact of economic strength in negotiations and effect of asymmetry in power among decision makers. By doing the adjusted calculation for each group of players, economic differences in the real world did not affect the players' monetary earnings from the game.

6.4 Results

The primary focus is the implications of the GERD and the possibility of cooperation. We tested four rounds of role-playing simulation game developed as a form of trust game and used an identical set-up and payoff matrix for each round of the game along with different levels of information sharing. In the session, 24 participants were sorted into groups of three. Therefore, they formed eight groups who played the same role for all four rounds of the game. Each group was located separately in the computer laboratory. The session lasted for about two and half hours (including time spent to read the instructions and payment calculation).

6.4.1 Characteristics of participants

Players were recruited from ITT Master Programs through the email invitation. 24 students (9 female, 15 Male) replied to the invitation email a week earlier than the date of the experiment on 25th May 2016. The participants were from a wide range of disciplines related to water resources management; they were enrolled in one of the three master programs offered by ITT, i.e., Natural Resources, IWRM, and Renewable Energy programs. Therefore, all participants were familiar with and understood the interconnections and dynamics of a river basin. Participants were aged between 21-30 years with the mean age of 27.

At the beginning of the session, students signed a form for confirming the information they sent via email on their age, background, nationality, and field of study. After everyone had been assigned to his or her role, participants were instructed that the experiment explore the cooperation patterns that emerge between people during the so-called trust game. Players were engaged and participated effectively as evidenced by participation levels and acceptance of game mechanics. Based on game observations all players participated realistically and honestly without any outside concerns dominating game play. Ideally, we would have wished to conduct the experiment with participants from Eastern Nile countries. However, few students from that region were enrolled at ITT and participated in the game.

6.4.2 Result of payoff combinations for players

The study analyzed data from the experimental trust games, all with the different payoff structures. At the beginning of every round, participants were presented with a new set of the game card and payoff tables. The payoff tables consist of different options for distributing water units from upstream to downstream with the benefit assigned to it for each player. For making the game transparent, players knew about the advantages other group members might gain from the payoff tables. Clarity in available choices and their value created a sense of trust, transparency, and equitability among the group members.

In each set of payoff tables, the first row is presenting the gains for complete non-cooperation, and the last row in each payoff table is a combination of water releases and assigned benefits in case of full cooperation. The options in between show different degrees of cooperation from full to non-cooperation. The mentioned water release and benefit options are derived from the hydro-economic modeling in Chapter 5. The payoff tables are modified according to the result of HEM of the Eastern Nile Basin.

Participants who played the role of upstream (A) made their decision on passing some water units to the next player. The payoff table they had for the first round was the situation of the basin without GERD (Table 6-4). The reason players played this round anonymously, is to measure and compare the impact of familiarity and association with other group members had on decision-making processes.

Player A had 5 minutes to make his/her decision out of the given options on the payoff sheet of round 1 and wrote the chosen option number on a card. The experimenters collected the cards players' A filled with his/her final decision for the amount of water should be passed to the next player and give the card to player B in his/her group. Players B received some units of water as the result of A’s decision and based on that, made his/her decision on how many units to pass to player C. Since the first round had no time for negotiation, virtual money as provided to players at the beginning of round 2. Players kept the same payoff structure for round 2, but they were provided with new decision cards and virtual money as side payments, which they did not have in round 1. The new set of instructions gave them the required information about the round, their goals in the game, which is increasing their earnings and the instructions for side-payment exchange.

Table 6-4: Payoff table for scenarios without GERD

Unit passed by Play A (BCM)	Unit passed by Play B (BCM)	Player A Payoff (Million US$)	Player B Payoff (Million US$)	Player C Payoff (Million US$)	Total Basin Payoff (Million US$)
88	52	490	1114	3541	5145
87	56	738	1499	3964	6201
86	60	986	1884	4387	7257
85	63	1234	2269	4810	8313
84	67	1480	2652	6235	9367

Table 6-5: Payoff table for scenarios with GERD

Unit passed by Player A (BCM)	Unit passed by Player B (BCM)	Player A Payoff (Million US$)	Player B Payoff (Million US$)	Player C Payoff (Million US$)	Total Basin Payo (Million US$)
75	46	2648	2224	2958	7830
76	51	2531	2445	3652	8628
77	56	2414	2661	4346	9421
78	60	2297	2889	5040	10226
79	64	2180	3110	5734	11024

Table 6-6: Payoff table for scenarios with and without GERD (Sum off Table 6-4 and 6-5)

Unit passed by Pla (BCM)	Unit passed by Pla (BCM)	Player A Payoff (M US$)	Player B Payoff (M US$)	Player C Payoff (M US$)	Total Basin Payo (Million US$)
88	52	490	1114	3541	5145
87	56	738	1499	3964	6201
86	60	986	1884	4387	7257
85	63	1234	2269	4810	8313
84	67	1480	2652	6235	9367
75	46	2648	2224	2958	7830
76	51	2531	2445	3652	8628
77	56	2414	2661	4346	9421
78	60	2297	2889	5040	10226
79	64	2180	3110	5734	11024

After reading the instructions and reviewing their role's purposes and interests, players have been introduced to their team members. They had 10 minutes to talk and communicate to make their minds on the decisions they could take. It was their own decisions on whether to share their private agenda and strategic plans with each other or play differently. They had the chance to convince their team members to partner with them by compensating or incentivizing with virtual money. After 10 minutes, experimenters asked the players to return to their positions and like the last round make their choices on their game cards.

Round 3 started the same as round 2 only with new payoff tables, and different combination of options from the final round (Table 6-5). Players had 5 minutes to read and understand their new options and plan their strategic moves. Players had space and chance to meet with their counterparts and continue their negotiation for 15 minutes. Experimenters observed and took note of conversations each group had during the negotiation time. Same as other rounds of the game, eight parallel negotiations were taking place at the same time. After 15 minutes, players got back to their seats and did the same procedure for making their final decisions in round 3.

Round 4 had the exact procedure as round 3 except for the payoff options (Table 6-6). The payoff tables for the game were the combination of all scenarios, with and without GERD. Players were aware of all possible outcomes and opportunities. By comparing behavior in different rounds of the game, the study was able to examine the effect of negotiation length on trust building among group members as well as choosing options with a higher range of benefit for each player and the whole group considering the exchange of incentives among them.

Player A is the first one in each group who had to make the first move after negotiation time in all rounds of the game. This allows us to test whether players are attempting to condition their cooperation and if they keep their non-binding promises in the actual decision-making stage. According to goal/expectation theory, "mutual trust is the key to actual cooperation, " and as the result of this experiment, we argue that cooperation is assumed to rise if and when all players in a group have a goal of cooperation and an expectation that the other is ready to cooperate. The result shows when players have a chance of negotiation and have a clear perspective of each other's potential benefits out of cooperation and unilateral actions, the possibility of mutual agreement by building some non-binding agreements is higher than the condition with no negotiation opportunity.

The results of the experiment show that the chance of lowering the risk of non-cooperation by building trust is high when players have enough time to get to know each other and negotiate over their shared benefits.

The result also indicated, despite strong cooperation incentives; still, some players make their final decision different from what they promised to their group members during the negotiation time. This leads to untrustworthiness between them for rounds after that. As it is illustrated in Figure (6-4), round 4 had less cooperative decision-making compare to round 3. The reason may be the negative experience from previous rounds and the damaged trust in some cases.

Table 6-7 Result of the game

Role	Group ID	Round 1		Round 2				Round 3				Round 4				Total Payoff	Earning in Euro
		Water Units passed/received	Payoff	Water Units passed/received	Money exchanged		Payoff	Water Units passed/received	Money exchanged		Payoff	Water Units passed/received	Money exchanged		Payoff		
					Paid	Received			Paid	Received			Paid	Received			
A	1	84	1480	84	0	0	1480	75	0	0	2648	77	0	100	2514	8122	22
	2	84	1480	87	0	200	938	76	0	100	2531	75	0	100	2764	7713	19
	3	84	1480	86	0	100	986	79	0	400	2580	76	0	0	2531	7577	17
	4	85	1234	86	0	0	986	79	0	200	2380	75	100	0	2564	7164	16
	5	84	1480	84	200	0	1280	79	0	500	2480	79	0	300	2480	7720	19
	6	85	1234	88	0	300	790	78	0	200	2497	77	0	0	2414	6935	14
	7	86	986	87	0	100	838	75	0	0	2648	76	0	0	2531	7003	15
	8	84	1480	85	100	0	1134	79	0	400	2580	79	0	300	2480	7674	18
B	1	67	2652	67	0	0	2652	64	0	100	3230	64	100	0	3010	11544	22
	2	63	2269	67	100	0	2552	64	0	0	3130	56	0	0	2664	10615	14
	3	67	2652	67	0	0	2652	64	100	0	3030	56	0	0	2661	10995	14
	4	67	2652	63	0	0	2269	64	100	200	3230	64	0	200	3310	11461	20
	5	67	2652	67	0	100	2752	64	0	100	3230	64	100	200	3210	11844	24
	6	63	2269	67	200	100	2752	60	0	300	3430	60	0	0	2889	11340	18
	7	63	2269	67	100	100	2652	64	200	0	3330	60	0	0	2889	11140	16
	8	67	2652	67	0	0	2652	56	100	0	2314	64	100	0	3010	10628	14
C	1	67	6235	67	0	0	6235	64	100	0	5634	64	0	0	5734	23838	23
	2	63	4810	67	100	0	6135	64	100	0	5634	56	100	0	4246	20825	15
	3	67	6235	67	0	100	6335	64	300	0	5434	56	0	0	4346	22350	18
	4	67	6235	63	0	0	6235	64	300	0	5434	64	100	0	5634	23538	22
	5	67	6235	67	100	100	6235	64	600	0	5134	64	200	0	5534	23138	20
	6	63	4810	67	300	0	5935	60	400	0	4640	60	0	0	5040	20425	14
	7	63	4810	67	100	0	6135	64	200	0	5534	60	0	0	5040	21519	16
	8	67	6235	67	100	0	6135	60	300	0	5434	64	200	0	5534	23338	21

These findings are consistent with evidence reported above that most of the players were conditional co-operators who preferred and were prepared to cooperate if and only they believed others would cooperate. Overall, the probability of cooperation was quite high (average 76%) in the laboratory experiment even though decisions were non-binding and non-compulsory without any penalty for non-cooperation and player still cooperate for winning higher economic gains to get higher credits to win the game. Moreover, the experimental results reveal that cooperation is indeed hard to establish in a strategic environment with a sense of uncertainty for the future, but it is still attainable, and its preconditions should be provided. Thus, failure to cooperate should not solely be attributed to the unwillingness or incapability of players. This may partly be due to inadequate compensation and partly because of an uneven split of total profit. Since cooperation is mostly conditional, as long as a set of preconditions are available and particular ranges of incentives are ensured, cooperation continues.

Table 6–8 Result of each round of the game

Group	**Payoff (MUSD)**				**Total payoff each round**
	Round 1	**Round 2**	**Round 3**	**Round 4**	
1	10367	10367	11512	11258	43504
2	8559	9625	11295	9674	39153
3	10367	9973	11044	9538	40922
4	10121	9490	11044	11508	42163
5	10367	10267	10844	11224	42702
6	8313	9477	10567	10343	38700
7	8065	9625	11512	10460	39662
8	10367	9921	10328	11024	41640
Total gain	**76526**	**78745**	**88146**	**85029**	**328446**

A more detailed analysis of the individual behavior of players enabled the investigation to examine alternative strategies and to identify characteristics of cooperative behaviors to some degree. Importantly, results found that optimal decision is sustained by a system of side payments that splits total profits close to equity among players. Thus, perceptions of fairness emerged as a significant determinant of cooperative behavior in this experiment. The study proves that beliefs about the likelihood of being exploited and of the egoism of others were important when one had to make a cooperative move in a situation where there was a risk of being betrayed. Seemingly, these beliefs are much more essential for cooperative behavior to shape players' trust attitudes.

According to the observation during the experiment, if players trusted each other, there was a lower risk of failure or unfaithfulness. However, non-cooperation was a risk-free strategy, led to an outcome, which was not the best, but better than the worst in the absence of trust or the case of betrayal. Therefore, if one player observed signs of cooperation from the other player, he/she would cooperate. However, the players might not have a chance or enough time to repeat the game many times to find if other players are trustworthy, instead, negotiations and clear cooperative signals were helpful for building trust.

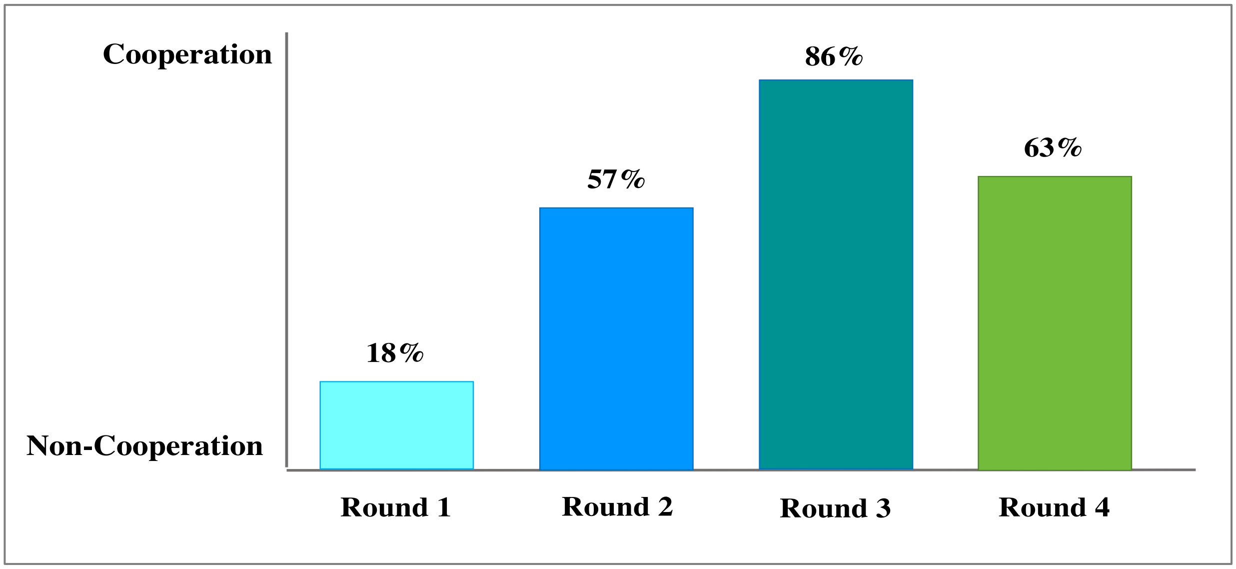

Figure 6–4 Result of the game experiment for total cooperation degree in each round of the game

However attractive the economic gains from cooperation may seem from the perspective of the basin as a whole, in some groups, players could not access to such prospects to reach the higher level of benefit. Achieving and distributing considerable economic benefits required greater attention and a better understanding of the rules of the game. By assuming rationality of the players, this study suggests that they are interested only in the monetary benefits of utilizing water for economic activities. Finally, we found that GERD improved the likelihood of cooperation by bringing higher economic benefit for the basin, which motivated decision makers towards cooperation. If the GERD creates excess benefits compared with the status quo, there is a potential for coalitional arrangements among players due to the increase in the individual and group benefit.

6.4.3 Players' engagement in the game

For any game's result to be justifiable and acceptable, the degree of participants spuriousness and engagement during the game should be proven. One of the measures we used to assess game success is the degree to which players participate, and whether players continue to be interested in the results after the official ending of the game. We had 100% engagement players continued to discuss the game and showed interest in the final results and implication of the design to other basins. They sent suggestions for measuring other factors and have the next sessions longer.

The game is also characterized by interaction. By "interaction," we refer to the degree to which different players and groups work together or communicate. In all rounds of the game, players were motivated and enthusiastically participated in negotiation and dialogue, which is not always the case in real life. The main component of the game is players' engagement and willingness to cooperate. By being "engaged in the game," we mean the degree to which players find the game's purpose, scenario, and understand their roles and mission. There were no objections, and players quickly responded to the scenario and game instruction.

The study did not investigate the effect of gender, nationality and age differences among participants. It was impossible to examine those factors since the participants were all students in an international institute from a wide range of nationalities with different cultures and social norms. The primary concern in this regard was whether players, no matter from which part of the world, was willing to participate fully in the game, given their status, culture, and potential real-world conflicts and concerns among the countries involved.

One of the concerns regarding the participants' selection was that players from different countries would not participate realistically in the game due to a reluctance to replicate real-world political or international behavior. This could be the result of cultural influences, such as a need to check with superiors before making a decision, or real-world concerns, such as not wanting to be seen as realistically aggressive or deceitful because of concerns over image or perception.

Another way to understand the participants' engagement degree in the game was by asking them what they thought of the game after the session finished. Participants' view towards the game was crucial for this study because students represent potential decision makers and have neutral concerns about the Eastern Nile case. Therefore, they could reasonably see if framing the game in a particular context was practically satisfactory or overwhelming. Almost all participants were satisfied, and we received some suggestions for improving the experiment design. Players also remarked that they liked that the game allowed them to take risks, make decisions, and receive feedback at the end plus receiving real cash for their efforts. Since each player was assigned a particular role, they had certain responsibilities to fulfill based on their position and the country's goals and objectives. Besides, players agreed that the game format was more engaging and educating than a typical lecture on the same subject.

6.5 Conclusion

Based on the results and extensive literature reviews, the main conclusions are:

(1) HEM is a valuable decision-support tool. The use of HEM to derive the payoffs was a crucial step, and it proved to be a decisive factor for trust building among the players. Therefore, decision-makers could use simulation models that project long-term costs, benefits and risks of intervention options.
(2) Trust is fundamentally induced by familiarity and a sense of mutual acceptance. Familiarity is induced through informal and formal introductions, and a sense of acceptance is achieved through joint fact-finding workshops, where each of the stakeholders can empathize on each other's positions.
(3) The application of experimental game methods is particularly useful for the analysis of various scenarios as it quantifies the consequences of each player's options providing information that is indicative of the outcome of the negotiations. Moreover, the equilibrium states of the games, which were formed during the negotiation simulation, can provide the basis for the commencement of the real negotiations between decision makers.
(4) Open and transparent data sharing (payoff tables) is a prerequisite for trust building. Joint institutional structures with exchange platforms where technical experts and specialists will be able to analyze the data and arrive at conclusions on their positions and that of other riparian must precede the negotiation phase.

The result of the experimental game suggests that Egypt must seek to cooperate and induce such cooperation by voluntarily initiating side payments. Otherwise in a state of impasse non-cooperation could lead to conflict and tension in the region, since Ethiopia controls over 65% of Egypt's water resource and source. Similarly, Ethiopia could gain much regarding investments and technical support from Egypt as an incentive for cooperation. This scenario is explicitly clear from the payoff tables. Sudan at this junction had surplus water, so it was sold to Egypt in exchange for incentives and side payments. That eased Egypt's dependence on Ethiopia, plus, Sudan gained a trustworthy ally. Therefore, instituting a basin-wide power trade scheme whereby Ethiopia exports part of the enormous amount of new hydropower generated from GERD to Egypt and Sudan would substantially boost Egypt's economy and thereby increase the basin-wide economic value of the dam while providing regional security.

If instead of side payments in our simulation, resource trade was considered as the primary source of compensation, building GERD can address the interrelation of food, water, and energy security in the basin by exchanging water and energy, based on their productivity and efficiency across the basin countries. The food-water-energy nexus as a package of considerations at the basin level demonstrates the likelihood for cooperation and resource trade within and beyond the basin (Benson, Gain, & Rouillard, 2015). Future work may address these regional trades as an option for decision makers to integrate issue linkages with comparative advantages to provide more insight into regional dialogue in resource management.

Policymakers should consider the power this decision analysis framework presents at a variety of levels:

(1) Facilitating internal decision-making and cooperation about priorities within governments, stakeholders and between institutions
(2) Strengthening negotiation approaches and outcomes
(3) Finding solutions to specific resource management questions from local to international scale

Overall, our analysis suggests that changes in behavior over time in trust games are a result of participants learning how to improve personal income while creating opportunities for better decision-making.

However, there is an increasing range of evidence that individuals do not play games as perfect maximizing machines that they instead exhibit bounded rationality, and can be influenced by a variety of irrelevant factors that do not affect their payoffs positively in the game (Nettle et al., 2013). It is doubtful that decision makers ever have perfect information and the logical starting point is one of uncertainty and how to reach a state where one can say with some confidence that the selected option is to be preferred to all others. To examine the relation between the amount of incentive compensation and the decision behavior of the participants, it would be interesting to repeat the experiment with modified incentive systems and with possible binding contracts for exchanging goods and resources. The designed experiment by this study has been repeated after finalizing the results of this dissertation.

7 Chapter 7: Conclusion and Discussion

7.1 Concluding remarks

Scarcity in essential resources often leads to an expedited competition where the inequitable distribution of shared resources for economic development against survival is frequently sighted as a source of potential conflict between two or more non-consenting parties. Transboundary water basins in developing countries are extremely volatile as each riparian has its own national priority, which may or may not take into consideration fully or partially its neighbors' needs and demands. In such cases each country's action is interlinked to every other country in the network, that is especially true of upstream countries, e.g., their unilateral inconsiderate action could adversely affect all the downstream riparian states, and that is a recipe for conflict "water wars" more so if there is an inherent power asymmetry among the riparian states. Cooperation is increasingly seen as a function of economic factors rather than diplomacy and altruism. Thus, cooperation is often founded on the principles of optimal use of resources to maximize profits, which can be shared among the stakeholders based on mutual agreements. Benefit-sharing approaches emphasize enlarging the scope of potential gains from water cooperation by looking beyond the water resources themselves, which includes the possibility to share economic gains from hydropower, agricultural, trade, etc.

In the case of Eastern Nile, a) there is an inherent and heavily lopsided power asymmetry favoring Egypt due to its vast military and its strategic partnership with the Arab countries and b) the upstream countries have strong national agenda's that are both indiscreet and indelicate. Therefore, more than ever in the history of these countries, it is absolutely necessary and prudent to develop a cooperative framework based on mutually agreed benefit sharing approaches, where Ethiopia and Sudan can successfully engage in their economic development plans, i.e. hydropower and irrigated agriculture, while Egypt can provide technical expertise and investment in return for guaranteed supply of its minimal demand. Joint management and coordination are crucial for the cooperative management of any transboundary water systems.

Fundamentally, cooperative framework formulation takes into consideration all interests and preferences of its parties; however, opposing in nature of every riparian and/or stakeholders within the system or likely to be affected by changes to the system who tries to find a mutually acceptable term for sharing the resources and its benefits in an equitable manner, through which more significant long-term benefits can be realized. These challenges can be overcome through strategic and coordinated action beginning with shared data on relevant information and inclusive dialogue that build knowledge, trust, confidence and moreover, lay the foundation for cooperative transboundary institutions. In order to overcome the transboundary issues and competing claims, all involved riparian states must be willing to engage, commit resources and time in the negotiation processes to develop cooperative arrangements.

The primary purpose of this dissertation was to deconstruct negotiation processes that lead to a cooperative arrangement or otherwise. This study explored the stages of knowledge that lead to a decision-making process. Based on the hypothesis that transparent data sharing and honest exchange of priorities would lead to trust among the participants, this study attempted to map the trust building factors, investigate each riparian priorities and preferences and attempted to replicate the entire process of negotiation and decision-making in a laboratory set up with experimental games. The foundational idea of this study is that making abundantly clear how cooperation can benefit a particular riparian on exactly it is preferred or prioritized agenda, would naturally and inevitably embolden that riparian to cooperation. The shaping of sustainable and equitable transboundary landscapes of interlinked economic, environmental, social and cultural processes is only possible through cooperation between states and reasonable, fair, confidence, transparent and inclusive political decisions.

In order to answer the research questions, the study outlined the significant approaches and focused on the strategic aspects of transboundary cooperation to enhance regional water food and energy security. The study found that key elements to promote international cooperation are the common understanding of the issues in the basin, understanding upstream-downstream impacts as well as sharing a common vision for the future to develop relevant knowledge in support of the policy dialogues. The results of this study intended to give a contribution to the significant studies and literature on cooperation and to show a concrete example of positive synergies contributing toward transboundary cooperation and regional stability in the Eastern Nile Basin.

The results and related assumptions for each part of the methodology used in this dissertation are summarized in Table (7-1).

Table 7-1 Summary of results and assumptions

Method	Results	Assumptions
Expert survey	Basin-wide cooperation is urgently required in the Eastern Nile Basin The likelihood of full transboundary cooperation is high in the region The main obstacle to cooperation is a lack of trust stemming from the lack of transparency due to hard data, policies and political agenda among the three countries Egypt has lower-level of urgency to create a basin-wide agreement compared to Sudan and Ethiopia Sudan is the most cooperative country comparatively Long-term benefits of cooperation are yet not fully understood Construction of GERD has a potential to change transboundary interactions across the Eastern Nile countries Transparency in data sharing, benefit-sharing and open list of priorities increases trust which in turn improves the negotiation process and political willingness to reach an agreement	No cooperation exists in the basin at any level The existence of complete institutional flexibility The result of the survey did not reflect the Eastern Nile countries' situation but used for designing the interactions among them in the experimental game design
Hydro-economic modeling and scenario development	Four scenarios developed with different levels of development of the Nile basin, regarding water usage and alternative strategies as full or no cooperation among the riparian countries Current water allocation and lack of cooperation in the Eastern Nile is the least economically beneficial alternative Construction of GERD brings enormous economic gain to the entire basin Full cooperation with GERD operating on the Nile has the highest economic benefit for riparian countries GERD encourages countries to discuss water issues and perhaps increase the probability of cooperation in the basin Cooperative joint management of the Nile will bring benefits beyond economics, contribute to geopolitical stability, security, and sustainability	The model's results do not represent the exact expected economic gains of the countries due to simplification Water storage and distribution do not limit the maximum use of available water in each country The area under irrigation is fixed in the model in each year Water moves freely between states, ignoring transaction costs and institutional barriers to water transfer The economic value of water and energy is fixed in all scenarios All Nile water goes through hydro plants and capable of generating hydropower ENB countries have limited potential for development due to lack of economic power and limited water availability Water supply and demand are fixed in all scenarios and only distribution and efficiency change
Laboratory trust game experiment	Cooperation increases when all players in a group have a goal of cooperation and an expectation that the other is ready to cooperate	Players are rational and offer full participation Players are motivated by only their material self-interest Players' behavior is consistent Players seek to maximize their economic gains

	Actively engaging in long negotiation processes with a high level of transparency and openness increases the chance of cooperative decision-making	Lab setting captures the crucial characteristics of environments of interest for the game
	Most of the players are self-interested non-cooperative unless there is a motive for cooperation (conditional cooperation)	Insights gained in the lab can be extrapolated to the real world
	Understanding the risks of future uncertainties and identifying the opportunities for transboundary cooperation is one of the primary keys to achieving a basin-wide agreement	Experiment results are generalizable and equally descriptive of the world at large
	Offering transparency, providing diplomatic knowledge and building trust, and confidence among decision makers of riparian states promotes cooperative transboundary establishments	The experimental game does not capture exact feature of interaction among real-world politicians and decision makers
	There is a high chance of cooperation in the experimental setting over sharing the resources and making an exceeded economic gain	

A number of meritorious observations from the results are:

(1) A HEM was used to calculate the amount of water allocation in each of the four scenarios in the experimental laboratory games. These calculations made transparent the benefits and opportunities available to a riparian under a chosen scenario (circumstance). Because it was a computerized model with inputs from the expert survey, the representatives had much faith and trust in the processes of arriving at the calculation and the results. Both are crucial factors for trust building that one must make transparent the entire process of arriving at measurement or a decision, and leave room for critique and suggestions.

(2) In the experimental laboratory games, every player became fully aware of all the opportunities and costs of each other. Thus they had information not only on potential benefits or loses they would suffer but also of others. This lead to a level of negotiations where it was only sensible to minimize one's own risks by compromising on shared benefits rather than attempting to grab the jackpot. High risk was not inversely proportional to high failure/loss. The game in this research gave players the opportunity to negotiate and divide the benefits of their cooperation as demonstrated with the payoffs of each developed scenarios.

(3) Since most states sharing basins have different needs, preferences, and capabilities, it is almost always likely that linking issues opens up value-creating opportunities, compensation options and incentives for cooperation. In the conducted experimental game, the simplified

scenarios, give players a clear picture of synergies and linkages among two components of the game: hydropower and irrigated agriculture. They could make their decisions while they become aware of each other's strategic priorities in using water for specific allocations and the values assigned with each set of decisions. Also, they had the chance to see how their decisions affected their team member's situation for each round of the game.

(4) The methodology of this work may serve as a decision support tool to guide water benefit sharing under different management scenarios and allocation mechanism, which has been demonstrated through the results of the preliminary applications to the Eastern Nile Basin. In establishing an accurate and objective decision basis for the decision makers, in a transboundary context, the decision-support tools must include a provision for undertaking multi-criteria analyses, which process selected information, typically time series of forecast results or measured time series, to compute a set of indicators for a range of possible strategies. If indicators can be derived from the modeling scenarios and compared, they can provide a transparent and objective decision basis. The methodology developed by this study assists the decision makers to assess development scenarios and their impacts while helping them to make more rational decisions based on the best available information, model calculations, and simulations, as well as communication with other parties.

(5) Building the enabling environment, in particular, transparency, knowledge, trust, and confidence among riparian states is the first step in building cooperative transboundary establishments.

(6) Benefit sharing should be considered as phases or time perspectives by anchoring short-term works of strengthening the hitherto existing riparian links, medium-term tracking, and improvement of in-country and international institutional arrangements for resource use and long-term efforts on investment in basin-wide joint development and programs. Therefore, governments of a shared basin must increase the level of communication and transparency by building joint operations institutions with external monitors and due diligence. Between the politicians, governmental authorities and the communities in the basin. Since conflict resolution mechanisms are needed to make sure that participants can resolve differences to ensure transparency, accountability, and continuity through broad participation.

(7) Mutual trust, compensation, and acceptance is the key to cooperation to prevail. Even though the payoff structure of the experimental game in this dissertation was favorable to cooperation and trustful behavior, experimental participants fail to find mutually satisfactory solutions for cooperation in some rounds of the game. It indicated that even within the

controlled circumstances of the experimental laboratory, there are difficulties in applying game solutions to human interactions.

(8) As mentioned in the dissertation, control and management of transboundary water resources unilaterally are costly in the long term, economically and politically. According to the results of the game model, the distribution of the gains and losses among riparian countries is not equitable and is the major obstacle toward the efficient sharing of the Eastern Nile River, in the absence of cooperative management. The risk of future uncertainties imposed by non-cooperation adds to the cost of unilateral actions and development while cooperation promotes economic integration and regional security, beyond the river.

(9) The study findings categorically indicate a willingness to cooperate is the most crucial enabling factor for starting the cooperation process. If decision makers prioritized transboundary water management, through negotiation, all other differences could be ironed out. Strong political will is required in achieving a high level of engagement in confidence building and transparency in decision-making.

(10) Construction of GERD in upstream has the potential for a sharp increase in basin's economic gains, but it requires that the Eastern Nile states can credibly enforce policy conditionality and achieve a binding agreement to prevent conflict on river flow and electricity trade within the basin. Dam construction plans show concern for water management and water access within a nation, but it also impacts the shared resource as a whole. Therefore, it encourages countries to discuss water issues and perhaps increase the probability of cooperation.

(11) Although this study has made every effort to trace the real economic framework as accurately as possible, no experimental model can guarantee that no salient features of the actual situation are lost or distorted when simplifying the economic environment of a basin. Undeniably the laboratory environment adds some artificiality as well. Despite these caveats, the experimental methodology widens the scope for economic case studies and transboundary management of a shared river, when behavioral influences are known to be relevant. As being a tool to support decision options being transparent and highlight benefits and opportunities of cooperative decision-making, experimental games can be applied to conflict resolution approaches at any scale.

(12) Any cooperation process implies the recognition of the different interests of the parties involved. In the end, all parties must be interested in the same goal but for very different reasons and these differences need to be accepted and publicly recognized. Transboundary

water governance is a recursive process: dynamic and contentious information exchange between multi-level institutions and actors.

(13) Inclusive stakeholder participation is essential for the implementation of any policy let alone a regional resource optimization and conservation policy, i.e., all state and "non-state" actors, e.g., NGOs, and networks of scientists and universities, water users, industries play an essential dimension to trust-building efforts.

(14) As we explored, future uncertainties such as population growth and climate change, have a remarkable impact on current decision-making. Understanding the risks and opportunities for transboundary cooperation is one of the main keys to achieving a basin-wide agreement.

(15) The emergence of formal legally binding agreements for the management of water resources is usually presented as a response to the threats associated with the resources, depending on the relative power and preferences of stakeholders. In lack of binding cooperative agreement, changes in political or social structures of a riparian country change any verbal or mutual understanding of the previous government are regarding the arrangements within the region with other riparian states to arrive at the same point. Thus, legally binding agreements which consider flexibilities and re-negotiations in case of any change within the basin, are also a lucrative concept that adds on to the trust-building process to avoid future confusions and long-term grantee cooperation.

7. 2 Recommendations for future studies

Further research about the management of transboundary water resources needs to address several questions that escaped the scope of this research. Practitioners and other actors involved in the daily governance of the resources are in need of means of actionable information on factors that determine both political preferences and the outcome of policy negotiations. Moreover, future assessments should consider the application of the analytical framework suggested for the shared river to other natural resources. Following six points are suggestions for additional research efforts to promote cooperative transboundary approaches:

(1) Additional research is needed related to the economic values used in this experimental game design and application. It may include additional factors, elements, and stakeholders; games can be designed to test various scenarios and distinguish each player's position to value water at different rates which could affect the outcomes of the game.

(2) The compensation scheme used in this study needs to be evaluated to determine water rights, future demands, and the role of new technologies to increase water use efficiency.

(3) Further analysis is required to determine a realistic value for water under different climatic scenarios and hazards such as drought. As scenarios for climate change are developed and implemented in the Eastern Nile planning model, they should be evaluated under the cooperative game analysis to determine their effects on the cooperative and unilateral results. Using climate change scenarios may demonstrate the importance of this type of planning for drought conditions.

(4) Water resource-related challenges change over time. The evolution of a game's arrangement should be considered while studying water resource conflicts in a certain period to incorporate several different sets of variables which can be time capsuled. By understanding a game's evolution, a more realistic interpretation of the stakeholders' behaviors can be provided and being involved within the game design. Providing information about the evolving structure of the problem and the risk of undesirable future outcomes with high costs may help to change behavior and decisions to reduce overall losses by acting non-cooperatively.

(5) As new transboundary water management scenarios are developed, analysis with other players can be conducted. The players in a game are not restricted to the three selected in this dissertation. The flexibility of selecting players to present various groups of stakeholders, NGOs, and international organizations to study the likelihood of cooperative solutions in different scenarios consists of decision makers with a broader range of interests and preferences.

(6) The experimental game, developed by this study analyzes the monetary benefits from the cooperation but does not demonstrate the additional benefits a player could receive through cooperation. The performance measures highlight the change in water delivery to each player and can be used by the players to determine if their additional benefit. As transboundary management approaches face dynamic multidimensional problems, they require a dynamic multidimensional solution

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Appendices

Survey Questionnaire

Introduction:

Thank you very much for agreeing to take part in this survey. I am sure this study will benefit greatly from your insights. Before we begin with the questions, I would like to provide you with a brief description of this research.

I am Mahsa Motlagh, pursuing my doctoral degree at Bonn University jointly with Institute for Technology and Resources Management (ITT) at Cologne University of Applied Sciences, Germany. The program is financed by the Centers for Natural Resources and Development (CNRD). The present questionnaire-based survey is a part of my Ph.D. study and it aims at achieving a better understanding of Eastern Nile current transboundary water issues and a myriad of future scenarios. It contributes to developing guidelines for stabilizing cooperative activities among the riparian of the Eastern Nile Basin. The study follows a double approach: On the one hand, the study aims to analyze the situation contributing to or hindering international cooperation in the context of transboundary water benefit sharing. On the other hand, it intends to measure the probability of cooperative decision-making in a controlled economic laboratory by designing a set of experimental role-playing games by simplifying the real-world scenario of the Eastern Nile Basin.

The purpose of this survey is to collect information from local actors and decision-makers, policy advisers and academics to create a clear picture of the Eastern Nile basin cooperative perspective at the transboundary level. Please note that the results of this questionnaire will be used only for scientific purposes and will not be revealed to any third parties, without your prior authorization. If you would like to know more about this study, please contact me at mahsa.motlagh@th-koeln.de.

The time to fill in the questionnaire is approximately 30 minutes. As I have mentioned, the current survey is on the transboundary water cooperation and decision-making processes from a socio-economic perspective. I would like to start with some general questions about you:

General Information (Optional)

Name:	
Position:	
Organization:	
Gender:	
Country of Origin:	
Email:	

Would you please start with identifying your professional background and duration of your involvement in Nile-related issues?

	Years					
	1 to 5	5 to 10	10 to 15	15 to 20	20 to 25	More
Policy						
Hydrology						
Economics						
Engineering						
Environment						
Sociology						
Chemistry						

Have you ever been a part of a water-related decision-making team? If yes in which scale? (You may choose more than one option).

International ☐ National ☐ Regional ☐ Sectorial☐ Local ☐

How would you categorize yourself, more as a scientist or policy adviser? If both, which more?

Scientist ☐ Policy adviser ☐ Both ☐

1. On a scale of 0 to 5, 0 being completely disagreed and 5 being strongly agreed, to what extent you think achieving a basin level cooperative agreement is necessary for the Eastern Nile Basin?

0	1	2	3	4	5

B) In your opinion, what factors have been causing difficulties arising in achieving transboundary water cooperation in the case of Eastern Nile basin? Please indicate to what degree you agree with the importance of each mentioned factor, or you disagree (0 means you completely disagree and 5 shows you strongly agree). Please add any other factor, which you think, is missed in the list below.

			0	1	2	3	4	5
1	Lack of political willingness for cooperation:	In Ethiopia						
		In Sudan						
		In Egypt						
2	Political and economic power imbalance among Eastern Nile riparian							
3	Misleading political leadership							
4	Competing claims and perceived national independence essentials							
5	Limited or non-effective exchange of data and information							
6	Miscommunication among scientists and decision makers							
7	Unclear long-term benefits of cooperation							
8	Lack of transparency in data sharing							
9	Lack of trust and transparency in decision-making							
10	Negative past experiences							
11	Non-participation in basin initiatives by some riparian countries							
12	Competition for a finite supply of water							
13	Unknown and unclear prospects of benefit sharing							
14	Cultural differences among decision makers							
15	The high cost of transition and implementation of cooperation							
16	"Only me " attitude in decision-making processes							
17	Historical and geographical legacy							
18	The legal and institutional predicament							

C) Please indicate how much you agree with each of the factors below as milestones in the negotiation phase to achieve a transboundary water agreement in the case of Eastern Nile Basin (0 means you completely disagree and 5 shows you strongly agree). Please add any factor you think should be mentioned in the list.

		0	1	2	3	4	5
1	Providing transparency in all steps of the decision-making process						
2	Recognizing and assessing the benefits of joint actions						
3	Finding a balance between the interests of riparian states through Water Diplomacy						

4	Finding the balance among actual options of each riparian states
5	Covering norms of equity and fairness
6	Resolving disputes between riparian countries
7	Rooting discussions in technical and scientific evidence than emotions or ideology
8	The existence of intergovernmental cooperation
9	Sharing information and conducting joint data assessments with transparency
10	Offering and scaling incentives for cooperation
11	Facilitating access to financial resources
12	Trust building especially in initial stages of the negotiation process
13	Considering the effect of climate change on the future water demand trend in each riparian country
14	Considering the effect of population growth on the future water demand of each riparian countries
15	Considering the costs of no-cooperation for each riparian country
16	Building mutually reinforcing networks and coalitions
17	Good understanding of the basin and future opportunities
18	The role of third parties facilitating the cooperation

D)Please evaluate the importance of each of the below options as a tool to promote basin level cooperation among Eastern Nile riparian countries (0 demonstrates NO importance, and 5 shows the highest importance). If you are not familiar with any of the listed tools or approaches, please tick the "Unfamiliar" box. Also, please add any other option comes to your mind, which should be mentioned.

	Tools:	0	1	2	3	4	5	Un-familiar
1	Cost and benefit sharing mechanisms							
2	Institutional re-arrangements							
3	Developing joint projects to increase collective benefits							
4	All principal stakeholders’ involvement							
5	Improved mediation and dispute resolution mechanisms							
6	Balance flexibility and stability							

7	Incentives for cooperation
8	Transparent information sharing
9	Legal frameworks
10	Scenario analysis approaches
11	Employ political symbols and prestige effects
12	Equitable Investment
13	High-Level Engagement with the Governing Authority
14	Risk assessment tools
15	Considering all actors interests
16	Alternative future problem formulation and assessment
17	Availability of relevant new technologies

F) On a scale of 0 to 5, in which 5 indicates the highest possibility, how would you characterize the possibility of Ethiopia-Egypt chance of cooperation from transboundary water perspective?

0	1	2	3	4	5

G) On a scale of 0 to 5, in which 5 indicates the highest possibility, how would you characterize the possibility of Sudan-Egypt chance of cooperation from transboundary water perspective?

0	1	2	3	4	5

H) On a scale of 0 to 5, in which 5 indicates the highest possibility, how would you characterize the possibility of Sudan-Ethiopia chance of cooperation from transboundary water perspective?

0	1	2	3	4	5

I)On a scale of 0 to 5, in which 5 indicates the highest possibility, how would you characterize the possibility of Sudan-Ethiopia-Egypt chance of cooperation from transboundary water perspective?

0	1	2	3	4	5

J) To what degree does each of the below water usages are prioritized as your country's national priority/interest? (0 shows lowest and 5 indicates the highest importance).

		0	1	2	3	4	5
1	Water for agriculture						
2	Water for hydropower						
3	Water for domestic consumption						
4	Water for industry						
5	Water for the environment						

K) How would construction of GERD positively influence the probability of achieving basin level cooperation in the Eastern Nile from a scale of 0 to 5 (0 indicates minimum, and 5 illustrates the maximum positive impact)

0	1	2	3	4	5

L)To what extent you think the "Declaration of Principles," signed in March 2015, is in favor of achieving a basin-wide agreement? 5 implies the highest impact.

0	1	2	3	4	5

What are your concerns for the "Declaration of Principles of Grand Ethiopian Renaissance Dam (GERD)" in the future of your country's national development agenda?

In your opinion, what are valuable "lessons learned "from past experiences and how would you suggest we improve the future?

Do you have any point to add?

Thank you very much for your time and concern,

Mahsa Motlag

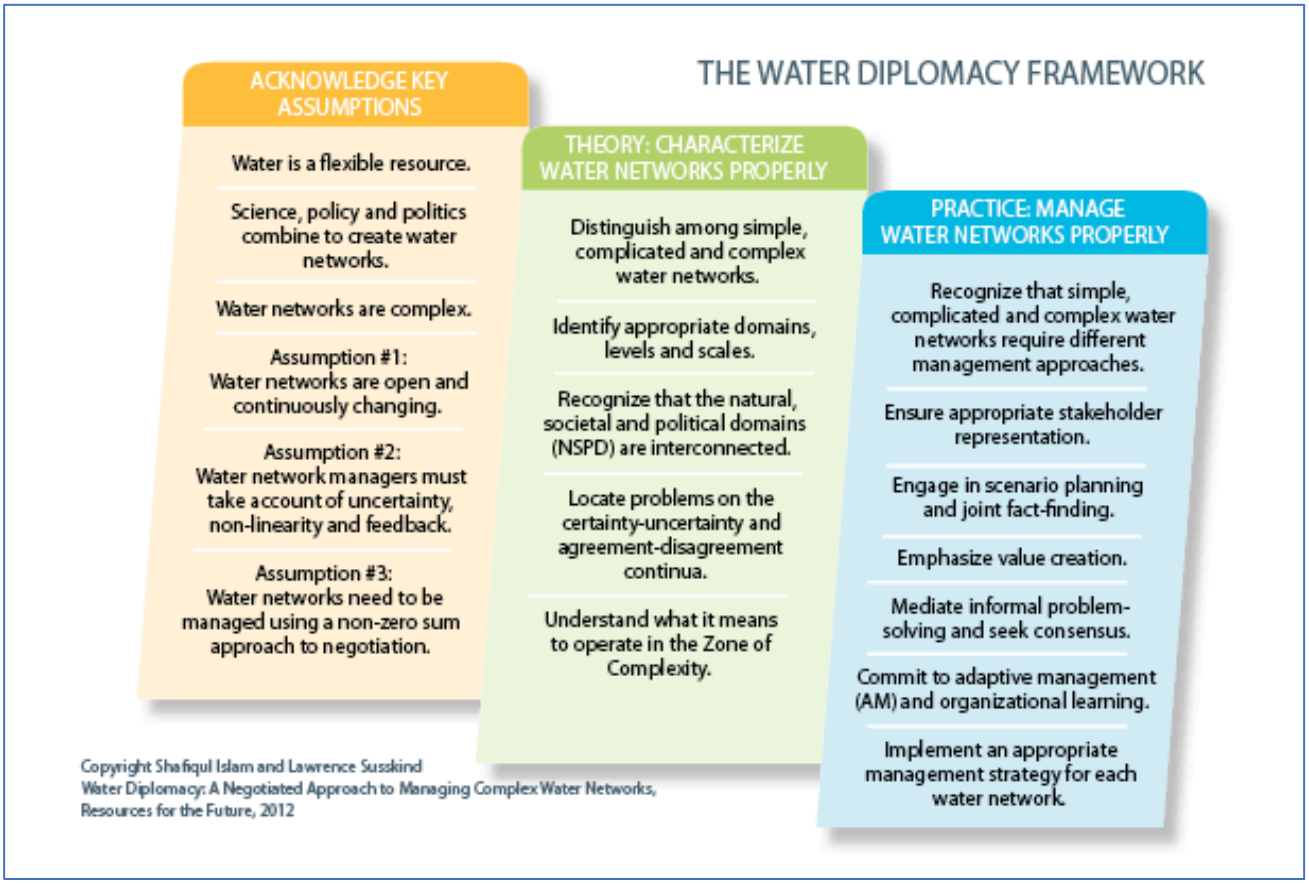
Survey results

A more detailed table illustrates the Eastern Nile riparian countries preferences rank for national water allocation:

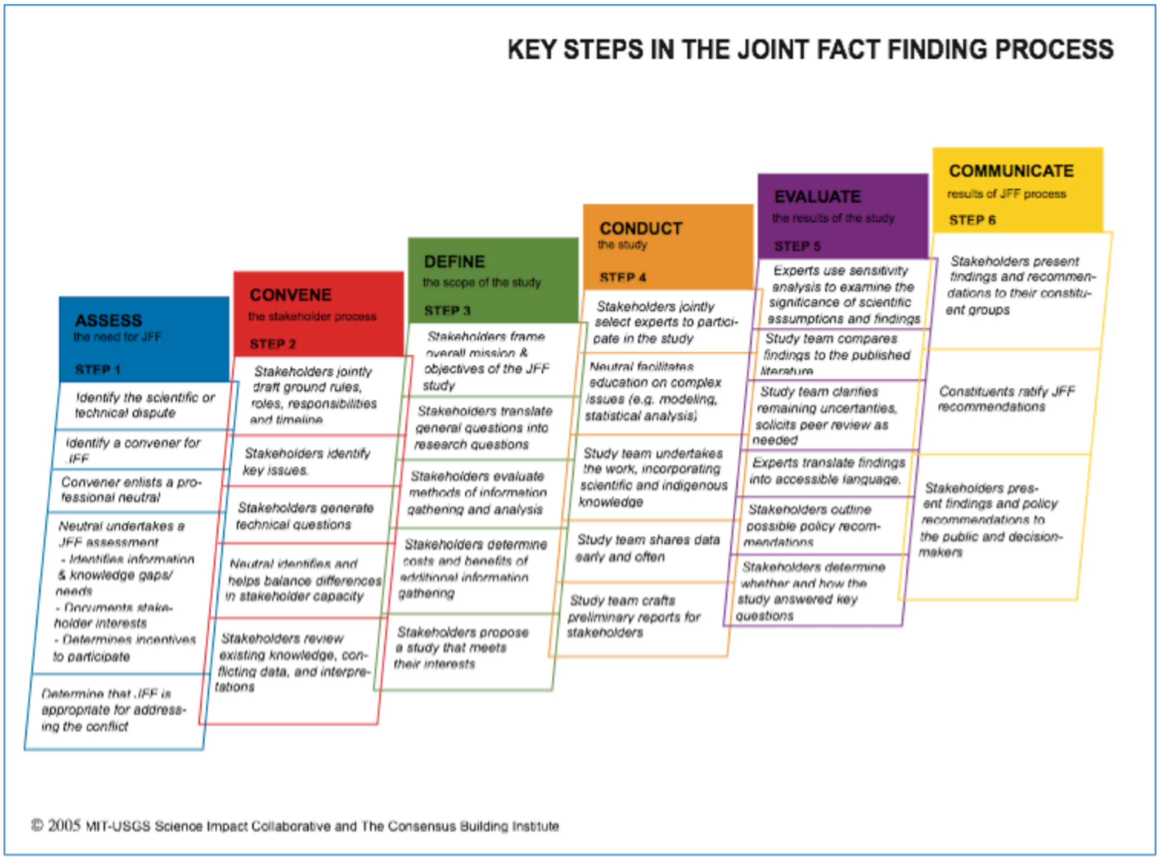
Statistics: national Water Allocation Preferences

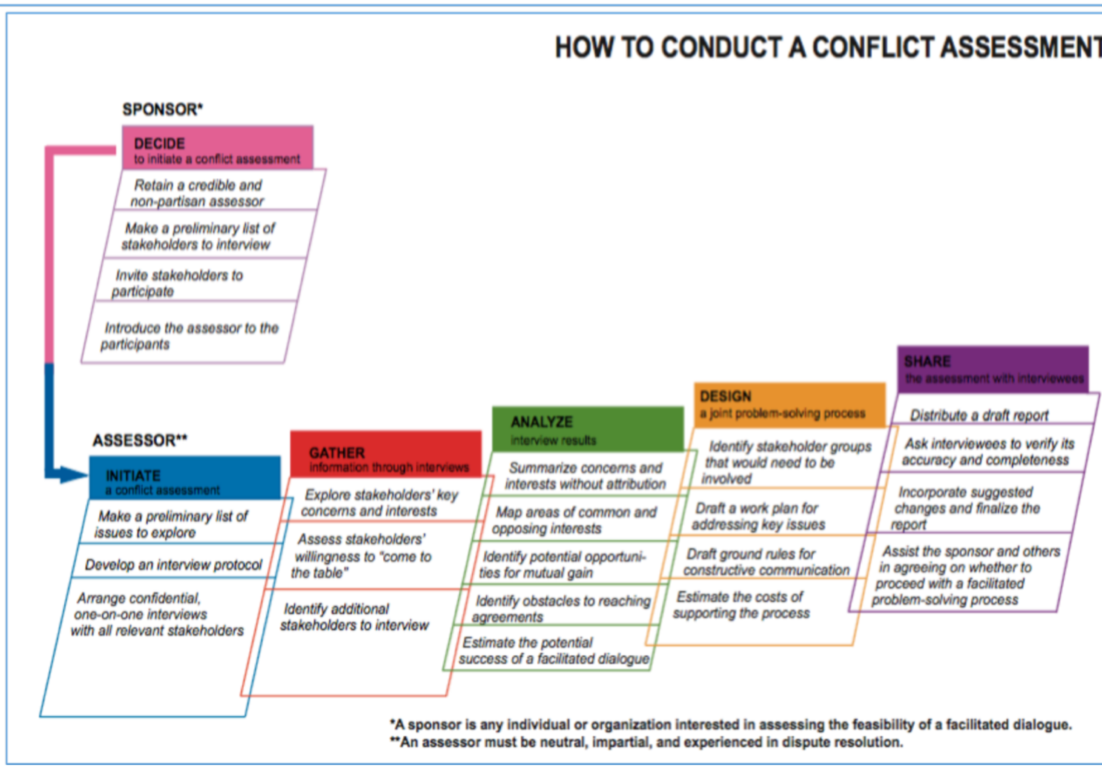
Country			Agriculture	Hydropower	Domestic	Industry	Environment
Ethiopia	N	Valid	25	25	25	25	25
		Missing	0	0	0	0	0
	Mean		4.00	4.80	4.08	3.12	3.16
	Median		4.00	5.00	4.00	3.00	3.00
	Mode		5	5	5	3	3[a]
	Variance		.917	.167	.910	.943	1.973
	Range		3	1	3	3	4
	Minimum		2	4	2	2	1
	Maximum		5	5	5	5	5
	Sum		100	120	102	78	79
	Percentiles	25	3.00	5.00	3.00	2.00	2.00
		50	4.00	5.00	4.00	3.00	3.00
		75	5.00	5.00	5.00	4.00	5.00
Sudan	N	Valid	22	22	22	22	22
		Missing	0	0	0	0	0
	Mean		4.95	3.59	3.95	2.73	2.27
	Median		5.00	3.00	4.00	3.00	2.00
	Mode		5	3	4	3	3
	Variance		.045	.920	.617	.970	1.827
	Range		1	3	2	4	5
	Minimum		4	2	3	1	0
	Maximum		5	5	5	5	5
	Sum		109	79	87	60	50
	Percentiles	25	5.00	3.00	3.00	2.00	1.00
		50	5.00	3.00	4.00	3.00	2.00
		75	5.00	4.25	5.00	3.00	3.00
Egypt	N	Valid	16	16	16	16	16
		Missing	0	0	0	0	0
	Mean		3.88	3.00	4.81	3.75	3.19
	Median		4.50	3.00	5.00	4.00	4.00
	Mode		5	3	5	4[a]	4
	Variance		1.717	1.200	.163	1.267	1.496
	Range		3	4	1	3	4
	Minimum		2	1	4	2	1
	Maximum		5	5	5	5	5
	Sum		62	48	77	60	51
	Percentiles	25	2.25	2.25	5.00	3.00	2.00
		50	4.50	3.00	5.00	4.00	4.00
		75	5.00	4.00	5.00	5.00	4.00

Water Diplomacy Framework



Joint fact-finding and conflict assessment framework





Experimental game: material and handouts

General Information sheet

<u>Introduction:</u>

First of all, a VERY BIG THANK YOU to you all for taking the time to participate in our game session!

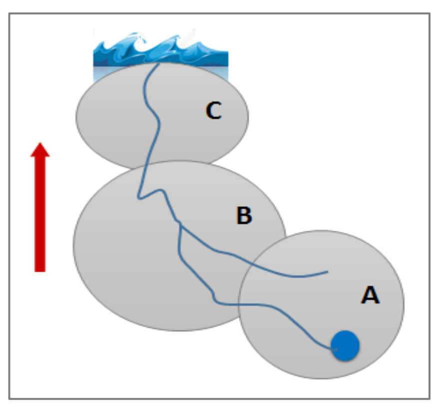
The experimental game you attend today is a part of an ongoing Ph.D. study methodology at ITT (Institute for Technology and Resources Management in the Tropics and Subtropics). This is an experiment in decision-making. CNRD research foundation has provided the funds for conducting this project. Your payoffs (earnings) will depend partly on your decisions and the decisions of other players in your team. Please pay careful attention to the instructions as a considerable amount of money is at stake.

During the session, it is not permitted to talk or communicate with other participants unless the facilitators permit it. If you have a question, please raise your hand, and the moderator will come to your desk to answer it. Throughout the session, you will earn money by making decisions in each round of the game. At the end of the session, your total earning will be sum up according to the decisions you have made during the experiment. You will receive 10 Euros as participation fee for showing up on time and completing the experiment, and you have the chance to increase you're earning up to 25 Euros.

<u>Overview of the Experiment</u>

The experiment consists of 4 rounds with almost similar rules and decision situation which will be explained to you throughout the session.

All participants are divided into three groups of A, B and C. Each group, with three random players, plays completely independently. The composition of the groups' members remains the same all the way through the experiment. You do not know who your team members are, until the end of the first round of the game.



Geography of the Eastern Nile Basin

There are three types of players in this game:
(You are assigned randomly to one of the following groups, which is mentioned on your given ID card):

- Player A, who presents the Upstream country (Ethiopia)
- Player B, who presents Middle stream country (Sudan)
- Player C, who presents Downstream country (Egypt)

All three players are sharing the waters of the Eastern part of the Nile River basin. At the beginning of each round, you will be provided with materials and information based on the role you play.

<u>Payoff Structure:</u>
In each round, the three players must divide a certain amount of water resource. At the end of each round, the players receive a payoff depending on how the resource has been shared. The division of the water takes place as follows:

- Player A, in Upstream, has a certain quantity of water. Player A can pass on some amount of water to player B, by selecting one of the options in the enclosed payoff table. After player B has received a share of the resource, he/she can pass on some quantity of this proportion to player C.

- Player A's payoff from the resource depends on how much of the resource is available and how much of the resource is passed on to player B.

- Player B's payoff depends on the quantity of the resource received from player A minus the amount passed on to player C.

- Player C's payoff depends on the quantity of the resource received from player B.

The payoff of the three players is listed in the enclosed payoff table. The three players' payoff also depends on the payments they make to each other in exchange for the resources received. This is explained in more detail.

You start with an initial capital of US$ virtual money in your hand, which you can see on your desk. Your payoff from each round of the game will be added to this amount. At the end of the session, the total earning you make in US$ will be converted into Euros based on a fixed scale. The minimum payoff is 10 Euros.

If there are no questions, we are ready to begin the experiment!

Fact sheet

Background of the Eastern Nile Basin:

The international community is concerned about growing tension in the region of the Nile basin due to conflicting interests concerning the allocation of Nile waters among three countries of Ethiopia, Sudan and Egypt. All three Eastern Nile riparian countries aspire to the goals of economic development, environmental protection, and poverty alleviation. Ethiopia, Sudan, and Egypt recognize that their economic development is affected by how they manage their shared water resource, the waters of the Nile River. All three countries must ensure that their population and economy have sufficient water supplies for human consumption, food production, industrial growth, and other usages.

The Nile Basin is characterized by high climatic diversity and variability, a low percentage of rainfall reaching the main river and an uneven distribution of water resources. Potential evaporation rates in the Nile region are high, making the basin particularly vulnerable to drought.

Country Profile:

	Country A	Country B	Country C
Total land area (Million km²)	1.10	1.88	1.01
Population (Million)	94.1	37.96	82.06
Population growth rate (%)	2.9 %	2.1%	2.2 %
GDP per capita (US$)	1065	2576	3740
Mean temperature range (°C)	7 °C - 26°C	22 °C - 40°C	20 °C - 36°C
Average precipitation in volume (10^9 m^3/yr)	936	470	51
Agricultural land (% of Total land area)	36.3%	45.8%	3.8 %
Area under irrigation (1000ha)	15	1207	5117
Irrigation efficiency (%)	35%	40%	45%
Dependency ratio on the Nile river (%)	0 %	96 %	97 %
Hydropower share of total electricity generation (%)	99%	70%	9%

Specific documents for Role A

Country Profile A

Country A: Upstream

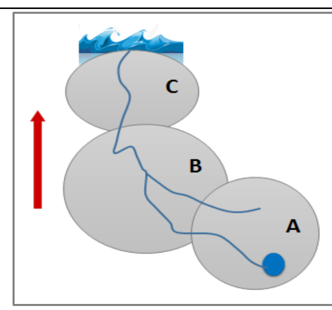
The purpose of this experimental game is to simulate the situation in which you play the role of a political actor, representing Country A (Ethiopia). Even though it seems unfamiliar at first, you should try to play your role as convincingly as possible. Your role requires you to act as a country A's representative in a strategic dialogue.

Information on strategy and behavior during the game:

You are a diplomat representative from Ethiopia, attending in an International Dialogue on "water in Eastern Nile Basin." Your general goal is to reach the possible outcome to maximize your country's economic benefit as well as being concerned for the regional security. During the game, you will be given a chance to negotiate with your team members who represent Sudan and Egypt. You can approach your team members to make progress in decision-making for distributing water.

The national strategic plan towards water security and current challenges your country faces, are summarized for you in the below table. Please keep in mind that you have to try to make the best decision for the people who voted for you and put you in this position. Besides the general information, you were given in the introduction section of Eastern Nile Basin, the following information about the country you present, is given to you as a set of secret information and has not been shared with your other group members yet.

Country A:

Location	Up-stream Country 
Key Characteristics	• Moderate climate • high population growth • high food demand
Key Issues	• Lack of agricultural technology and efficiency • Huge hydropower development potential

	• A low-income country with low national capital investment opportunities • Poor water management
Priorities in water allocation interests and development opportunities	1. Hydropower generation 2. Irrigation expansion 3. Poverty mitigation 4. Watershed management practices 5. Agriculture technology and efficiency improvement
National strategic priority	Water for hydropower

Payoff round 1 Player A

Group A Round No. 1

Player ID Number:

You are playing the role of player A (Up-stream). The initial amount of water in upstream is 100 units (100 Billion Cubic Meters (BCM)). You have five different choices to share the water with your neighboring countries. You can choose how many units of water you allocate for agricultural purposes and hydropower generation, and how many units of water you pass to your neighbor, country B., The economic benefit of each three countries based on different water distribution patterns, are mentioned in the payoff table. These payoffs are calculated based on the real scenarios in the Eastern Nile Basin, considering countries' potentials and efficiencies.

Payoff Table:

Unit passed by Play A (BCM)	Unit passed by Play B (BCM)	Player A Payoff (Million US$)	Player B Payoff (Million US$)	Player C Payoff (Million US$)	Total Basin Payoff (Million US$)
88	52	490	1114	3541	5145
87	56	738	1499	3964	6201
86	60	986	1884	4387	7257
85	63	1234	2269	4810	8313
84	67	1480	2652	6235	9367

Game Decision:

Please mark only one of the below options as your final decision and put the numbers of the unit of water you would like to pass to country B in the blank box.

☐ You pass 87 units of water to player B; your benefit is 1500 Million US$

☐ You pass 87,5 units of water to player B; your benefit is 1480 Million US$

☐ You pass 88 units of water to player B; your benefit is 1450 Million US$

☐ You pass 88,5 units of water to player B; your benefit is 1420 Million US$

☐ You pass 89 units of water to player B; your benefit is 1400 Million US$

<u>Your Total Payoff in Round 1:</u>

How many units of water did you decide to transfer to player B? ☐ Units

Your total earning in round 1 = Vale of water your country receives by the choice you made ☐

Payoff round 2 Player A

Group A Round No. 2

Player ID Number:

You are playing the role of player A (Up-stream). The initial amount of water in upstream is 100 units (100 Billion Cubic Meters (BCM)). You have five different choices to share the water with your neighboring countries. You can choose how many units of water you allocate for agricultural purposes and hydropower generation, and how many units of water you pass to your neighbor, country B., The economic benefit of each three countries based on different water distribution patterns, are mentioned in the payoff table. These payoffs are calculated based on the real scenarios in the Eastern Nile Basin, considering countries' potentials and efficiencies.

<u>Payoff Table:</u>

Unit passed by Play A (BCM)	Unit passed by Play B (BCM)	Player A Payoff (Million US$)	Player B Payoff (Million US$)	Player C Payoff (Million US$)	Total Basin Payoff (Million US$)
88	52	490	1114	3541	5145
87	56	738	1499	3964	6201
86	60	986	1884	4387	7257
85	63	1234	2269	4810	8313
84	67	1480	2652	6235	9367

Game Decision:

Please mark only one of the below options as your final decision and put the numbers of unit you would like to pass to country B in the blank box.

- ☐ You pass 87 units of water to player B, your benefit is 1500 Million US$
- ☐ You pass 87,5 units of water to player B; your benefit is 1480 Million US$
- ☐ You pass 88 units of water to player B, your benefit is 1450 Million US$
- ☐ You pass 88,5 units of water to player B; your benefit is 1420 Million US$
- ☐ You pass 89 units of water to player B, your benefit is 1400 Million US$

Your Total Payoff in Round 2:

How many units of water did you decide to transfer to player B? ☐ Units

Amount of incentive money you have received from player B: ☐ Million US$

Amount of incentive money you have received from player C: ☐ Million US$

Amount of incentive money you have paid to player B: ☐ Million US$

Amount of incentive money you have paid to player B: ☐ Million US$

Your total earning in round 2 = Vale of water your country receives by the choice you made + Money received from player B + Money received from player C - Money paid to player B - Money paid to player C

Total payoff round 2 ☐ = ☐ + ☐ + ☐ - ☐ - ☐

Payoff round 3 Player A

Group A Round No. 4

Player ID Number:

You are playing the role of player A (Up-stream). The initial amount of water in upstream is 100 units (100 Billion Cubic Meters (BCM)). You have ten different choices to share the water with your neighboring countries. You can choose how many units of water you allocate for agricultural purposes and hydropower generation, and how many units of water you pass to your neighbor, country B., The economic benefit of each three countries based on different water distribution patterns, are mentioned in the payoff table. These payoffs are calculated based on the real scenarios in the Eastern Nile Basin, considering countries' potentials and efficiencies.

Payoff Table:

The initial units of water in the beginning in the upstream:100 units

Unit passed by Pla (BCM)	Unit passed by Pla (BCM)	Player A Payoff (M US$)	Player B Payoff (M US$)	Player C Payoff (M US$)	Total Basin Payo (Million US$)
88	52	490	1114	3541	5145
87	56	738	1499	3964	6201
86	60	986	1884	4387	7257
85	63	1234	2269	4810	8313
84	67	1480	2652	6235	9367
75	46	2648	2224	2958	7830
76	51	2531	2445	3652	8628
77	56	2414	2661	4346	9421
78	60	2297	2889	5040	10226
79	64	2180	3110	5734	11024

Game Decision:

Please mark only one of the below options as your final decision and put the numbers of unit you would like to pass to country B in the blank box.

☐ You pass 75 units of water to player B, your benefit is 2600 Million US$

☐ You pass 76 units of water to player B, your benefit is 2550 Million US$

- [ ] You pass 77 units of water to player B, your benefit is 2500 Million US$
- [ ] You pass 78 units of water to player B, your benefit is 2450 Million US$
- [ ] You pass 79 units of water to player B, your benefit is 2400 Million US$
- [ ] You pass 87 units of water to player B, your benefit is 1500 Million US$
- [ ] You pass 87,5 units of water to player B; your benefit is 1480 Million US$
- [ ] You pass 88 units of water to player B, your benefit is 1450 Million US$
- [ ] You pass 88,5 units of water to player B; your benefit is 1420 Million US$
- [ ] You pass 89 units of water to player B, your benefit is 1400 Million US$

Your Total Payoff in Round 4:

How many units of water did you decide to transfer to player B? [ ] Units

Amount of incentive money you have received from player B: [ ] Million US$

Amount of incentive money you have received from player C: [ ] Million US$

Amount of incentive money you have paid to player B: [ ] Million US$

Amount of incentive money you have paid to player B: [ ] Million US$

Your total earning in round 4 = Vale of water your country receives by the choice you made + Money received from player B + Money received from player C - Money paid to player B - Money paid to player C

Total payoff round 4 [ ] = [ ] + [ ] + [ ]

- [ ] - [ ]

Specific documents for Role B

Country Profile A

Country B:

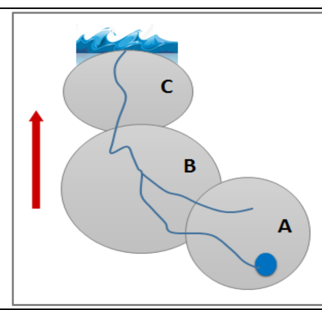
The purpose of this experimental game is to simulate the situation in which you play the role of a political actor, representing <u>Country B (Sudan)</u>. Even though it seems unfamiliar at first, you should try to play your role as convincingly as possible. Your role requires you to act as a country B's representative in a strategic dialogue.

<u>Information on strategy and behavior during the game:</u>

You are a diplomat representative from Sudan, attending in an International Dialogue on "water in Eastern Nile Basin." Your general goal is to reach the possible outcome to maximize your country's economic benefit as well as being concerned for the regional security. During the game, you will be given a chance to negotiate with your team members who represent Ethiopia and Egypt. You can approach your team members to make progress in decision-making for distributing water.

The national strategic plan towards water security and current challenges your country faces, are summarized for you in the below table. Please keep in mind that you have to try to make the best decision for the people who voted for you and put you in this position. Besides the general information you were given in the introduction section of Eastern Nile Basin, the following information about the country you present is given to you as a set of secret information and has not been shared with your other group members yet.

<u>Country B:</u>

Location	Mid-stream Country 
Key Characteristics	• Dry and water scarce • High dependency on Nile River • High population growth • High food demand
Key Issues	• Low agricultural productivity

	• High irrigated and rain-fed agricultural potential • Medium hydroelectric development potential • A low-income country with low national capital investment opportunities • High evaporation rate
Priorities in water allocation interests and development opportunities	1. Irrigation expansion 2. Poverty mitigation 3. Flood control 4. Information policy 5. Hydropower 6. Improve agriculture efficiency
National strategic priority	Water for Agriculture

Payoff round 1 Player B

Group C Round No. 1

Player ID Number:

You are playing the role of player C (Down-stream). The initial amount of water in upstream is 100 units (100 Billion Cubic Meters (BCM)). Your neighbors have five different choices to share the water with you. Your neighbor in Upstream will decide to send country B some units of water. After that, Country B will choose how many units of water to allocate for agricultural purposes and hydropower generation, and how many units of water passes to you. The economic benefit of each three countries based on different water distribution patterns is mentioned in the payoff table. These payoffs are calculated based on the real scenarios in the Eastern Nile Basin, considering countries' potentials and efficiencies.

Payoff Table:

The initial units of water in the beginning in the upstream:100 units

Unit passed by Play A (BCM)	Unit passed by Play B (BCM)	Player A Payoff (Million US$)	Player B Payoff (Million US$)	Player C Payoff (Million US$)	Total Basin Payoff (Million US$)
88	52	490	1114	3541	5145
87	56	738	1499	3964	6201
86	60	986	1884	4387	7257
85	63	1234	2269	4810	8313
84	67	1480	2652	6235	9367

Game Decision:

Please mark only one of the below options as your neighbor final decision about how many numbers of units of water he/she passed to you.

☐ You receive 51 units of water; your benefit is 4500 Million US$

☐ You receive 56 units of water; your benefit is 4830 Million US$

☐ You receive 61 units of water; your benefit is 5150 Million US$

☐ You receive 66 units of water; your benefit is 5470 Million US$

☐ You receive 71 units of water; your benefit is 5800 Million US$

Your Total Payoff in Round 1:

How many units of water did you decide to transfer to player C? ☐ Units

Your total earning in round 1 = Vale of water your country receives by the choice you made ☐

Payoff round 2 Player B

Group B Round No. 2

Player ID Number:

You are playing the role of player B (Mid-stream). The initial amount of water in upstream is 100 units (100 Billion Cubic Meters (BCM)). You have five different choices to share the water with your neighboring countries. Your neighbor in Upstream will decide to send you some units of water. After that, you can choose how many units of water you allocate for agricultural purposes and hydropower generation, and how many units of water you pass to your neighbor, country C., The economic benefit of each three countries based on different water distribution patterns, are mentioned in the payoff table. These payoffs are calculated based on the real scenarios in the Eastern Nile Basin, considering countries' potentials and efficiencies.

Payoff Table:

The initial units of water in the beginning in the upstream: 100 units

Unit passed by Play A (BCM)	Unit passed by Play B (BCM)	Player A Payoff (Million US$)	Player B Payoff (Million US$)	Player C Payoff (Million US$)	Total Basin Payoff (Million US$)
88	52	490	1114	3541	5145
87	56	738	1499	3964	6201
86	60	986	1884	4387	7257
85	63	1234	2269	4810	8313
84	67	1480	2652	6235	9367

Game Decision:

Please mark only one of the bellow options as your final decision and put the numbers of unit you would like to pass to country C in the blank box.

☐ You pass 51 units of water to player C, your benefit is 3100 Million US$

☐ You pass 56 units of water to player C, your benefit is 2980 Million US$

☐ You pass 61 units of water to player C, your benefit is 2850 Million US$

☐ You pass 66 units of water to player C, your benefit is 2720 Million US$

☐ You pass 71units of water to player C, your benefit is 2600 Million US$

Your Total Payoff in Round 2:

How many units of water did you decide to transfer to player C? [ ] Units
Amount of incentive money you have received from player A: [ ] Million US$
Amount of incentive money you have received from player C: [ ] Million US$
Amount of incentive money you have paid to player A: [ ] Million US$
Amount of incentive money you have paid to player C: [ ] Million US$

Your total earning in round 2 = Vale of water your country receives by the choice you made + Money received from player A + Money received from player C - Money paid to player A - Money paid to player C

Total payoff round 2 [ ] = [ ] + [ ] + [ ] - [ ] - [ ]

Payoff round 3 Player B

Group B Round No. 3
Player ID Number:

You are playing the role of player B (Mid-stream). The initial amount of water in upstream is 100 units (100 Billion Cubic Meters (BCM)). You have five different choices to share the water with your neighboring countries. Your neighbor in Upstream will decide to send you some units of water. After that, you can choose how many units of water you allocate for agricultural purposes and hydropower generation, and how many units of water you pass to your neighbor, country C., The economic benefit of each three countries based on different water distribution patterns, are mentioned in the payoff table. These payoffs are calculated based on the real scenarios in the Eastern Nile Basin, considering countries' potentials and efficiencies.

In this round, we face a new scenario. Country A (Ethiopia) has constructed a new large dam in Upstream which affects the payoffs of other countries as below:

Payoff Table:

The initial units of water in the beginning in the upstream:100 units

Unit passed by Player A (BCM)	Unit passed by Player B (BCM)	Player A Payoff (Million US$)	Player B Payoff (Million US$)	Player C Payoff (Million US$)	Total Basin Payo (Million US$)
75	46	2648	2224	2958	7830
76	51	2531	2445	3652	8628
77	56	2414	2661	4346	9421
78	60	2297	2889	5040	10226
79	64	2180	3110	5734	11024

Game Decision:

Please mark only one of the below options as your final decision and put the numbers of unit you would like to pass to country C in the blank box.

☐ You pass 46 units of water to player C, your benefit is 2900 Million US$

☐ You pass 50 units of water to player C, your benefit is 2800 Million US$

☐ You pass 55 units of water to player C, your benefit is 2700 Million US$

☐ You pass 60 units of water to player C, your benefit is 2600 Million US$

☐ You pass 64 units of water to player C, your benefit is 2500 Million US$

Your Total Payoff in Round 3:

How many units of water did you decide to transfer to player C? ☐ Units

Amount of incentive money you have received from player A: ☐ Million US$

Amount of incentive money you have received from player C: ☐ Million US$

Amount of incentive money you have paid to player A: ☐ Million US$

Amount of incentive money you have paid to player C: ☐ Million US$

Your total earning in round 3 = Vale of water your country receives by the choice you made + Money received from player A + Money received from player C - Money paid to player A - Money paid to player C

Total payoff round 3 [ ] = [ ] + [ ] + [ ] - [ ] - [ ]

Payoff round 4 Player B

Group B Round No. 4

Player ID Number:

You are playing the role of player B (Mid-stream). The initial amount of water in upstream is 100 units (100 Billion Cubic Meters (BCM)). You have five different choices to share the water with your neighboring countries. Your neighbor in Upstream will decide to send you some units of water. After that, you can choose how many units of water you allocate for agricultural purposes and hydropower generation, and how many units of water you pass to your neighbor, country C., The economic benefit of each three countries based on different water distribution patterns, are mentioned in the payoff table. These payoffs are calculated based on the real scenarios in the Eastern Nile Basin, considering countries' potentials and efficiencies.

Payoff Table:

The initial units of water in the beginning in the upstream:100 units

Unit passed by Pla (BCM)	Unit passed by Pla (BCM)	Player A Payoff (M US$)	Player B Payoff (M US$)	Player C Payoff (M US$)	Total Basin Payo (Million US$)
88	52	490	1114	3541	5145
87	56	738	1499	3964	6201
86	60	986	1884	4387	7257
85	63	1234	2269	4810	8313
84	67	1480	2652	6235	9367
75	46	2648	2224	2958	7830
76	51	2531	2445	3652	8628
77	56	2414	2661	4346	9421
78	60	2297	2889	5040	10226
79	64	2180	3110	5734	11024

Game Decision:

Please mark only one of the below options as your final decision and put the numbers of unit you would like to pass to country C in the blank box.

☐ You pass 46 units of water to player C, your benefit is 2900 Million US$

☐ You pass 50 units of water to player C, your benefit is 2800 Million US$

☐ You pass 55 units of water to player C, your benefit is 2700 Million US$

☐ You pass 60 units of water to player C, your benefit is 2600 Million US$

☐ You pass 64 units of water to player C, your benefit is 2500 Million US$

☐ You pass 51 units of water to player C, your benefit is 3100 Million US$

☐ You pass 56 units of water to player C, your benefit is 2980 Million US$

☐ You pass 61 units of water to player C, your benefit is 2850 Million US$

☐ You pass 66 units of water to player C, your benefit is 2720 Million US$

☐ You pass 71units of water to player C, your benefit is 2600 Million US$

Your Total Payoff in Round 4:

How many units of water did you decide to transfer to player C? [ ] Units
Amount of incentive money you have received from player A: [ ] Million US$
Amount of incentive money you have received from player C: [ ] Million US$
Amount of incentive money you have paid to player A: [ ] Million US$
Amount of incentive money you have paid to player C: [ ] Million US$

Your total earning in round 4 = Vale of water your country receives by the choice you made + Money received from player A + Money received from player C - Money paid to player A - Money paid to player C

Total payoff round 4 [ ] = [ ] + [ ] + [ ] - [ ] - [ ]

Specific documents for Role C

Country Profile A

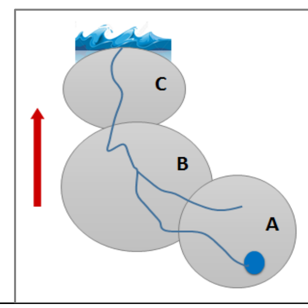
Country C:

The purpose of this experimental game is to simulate the situation in which you play the role of a political actor, representing Country C (Egypt). Even though it seems unfamiliar at first, you should try to play your role as convincingly as possible. Your role requires you to act as a country C's representative in a strategic dialogue.

Information on strategy and behavior during the game:

You are a diplomat representative from Egypt, attending in an International Dialogue on "water in Eastern Nile Basin." Your general goal is to reach the possible outcome to maximize your country's economic benefit as well as being concerned for the regional security. During the game, you will be given a chance to negotiate with your team members who represent Sudan and Ethiopia. You can approach your team members to make progress in decision-making for distributing water. The national strategic plan towards water security and current challenges your country faces, are summarized for you in the below table. Please keep in mind that you have to try to make the best decision for the people who voted for you and put you in this position. Besides the general information, you were given in the introduction section of Eastern Nile Basin, the following information about the country you present, is given to you as a set of secret information and has not been shared with your other group members yet.

<u>Country C:</u>

Location	Down-stream 
Key Characteristics	• Dry and water scarce • High dependency on Nile River • High population growth • Touristic country • Medium-income, greatest economic power in the basin
Key Issues	• Medium agricultural productivity with improved technology • Largest portion of land under irrigation in the basin • Very limited hydropower generation potential • High crop water consumption • High evaporation rate
Priorities in water allocation interests and development opportunities	1. Water pollution control 2. Irrigation expansion 3. Finding new sources to import energy
National strategic priority	<u>Water for Domestic use</u>

Payoff round 1 Player C

Group C Round No. 1

Player ID Number:

You are playing the role of player C (Down-stream). The initial amount of water in upstream is 100 units (100 Billion Cubic Meters (BCM)). Your neighbours have five different choices to share the water with you. Your neighbour in Upstream will make a decision to send country B some units of water. After that, Country B will choose how many units of water to allocate for agricultural purposes and hydropower generation, and how many units of water passes to you. The economic benefit of each three countries based on different water distribution patterns is mentioned in the payoff table. These payoffs are calculated based on the real scenarios in the Eastern Nile Basin, considering countries' potentials and efficiencies.

Payoff Table:

The initial units of water in the beginning in the upstream:100 units

Unit passed by Play A (BCM)	Unit passed by Play B (BCM)	Player A Payoff (Million US$)	Player B Payoff (Million US$)	Player C Payoff (Million US$)	Total Basin Payoff (Million US$)
88	52	490	1114	3541	5145
87	56	738	1499	3964	6201
86	60	986	1884	4387	7257
85	63	1234	2269	4810	8313
84	67	1480	2652	6235	9367

Game Decision:

Please mark only one of the bellow options as your neighbour final decision about how many numbers of units of water he/she passed to you.

- ☐ You received 51 units of water; your benefit is 4500 Million US$
- ☐ You received 56 units of water; your benefit is 4830 Million US$
- ☐ You received 61 units of water; your benefit is 5150 Million US$
- ☐ You received 66 units of water; your benefit is 5470 Million US$
- ☐ You received 71 units of water; your benefit is 5800 Million US$

Your Total Payoff in Round 1:

How many units of water did you receive? [ ] Units

Your total earning in round 1 = Vale of water your country received [ ]

Payoff round 2 Player C

Group C Round No. 2

Player ID Number:

You are playing the role of player C (Down-stream). The initial amount of water in upstream is 100 units (100 Billion Cubic Meters (BCM)). Your neighbours have five different choices to share the water with you. Your neighbour in Upstream will make a decision to send country B some units of water. After that, Country B will choose how many units of water to allocate for agricultural purposes and hydropower generation, and how many units of water passes to you. The economic benefit of each three countries based on different water distribution patterns is mentioned in the payoff table. These payoffs are calculated based on the real scenarios in the Eastern Nile Basin, considering countries' potentials and efficiencies.

Payoff Table:

The initial units of water in the beginning in the upstream:100 units

Unit passed by Play A (BCM)	Unit passed by Play B (BCM)	Player A Payoff (Million US$)	Player B Payoff (Million US$)	Player C Payoff (Million US$)	Total Basin Payoff (Million US$)
88	52	490	1114	3541	5145
87	56	738	1499	3964	6201
86	60	986	1884	4387	7257
85	63	1234	2269	4810	8313
84	67	1480	2652	6235	9367

Game Decision:

Please mark only one of the bellow options as your neighbour final decision about how many numbers of units of water he/she passed to you.

☐ You received 51 units of water; your benefit is 4500 Million US$

☐ You received 56 units of water; your benefit is 4830 Million US$

☐ You received 61 units of water; your benefit is 5150 Million US$

☐ You received 66 units of water; your benefit is 5470 Million US$

☐ You received 71 units of water; your benefit is 5800 Million US$

Your Total Payoff in Round 2:

How many units of water did you receive from player B? ☐ Units

Amount of incentive money you have received from player A: ☐ Million US$

Amount of incentive money you have received from player B: ☐ Million US$

Amount of incentive money you have paid to player A: ☐ Million US$

Amount of incentive money you have paid to player B: ☐ Million US$

Your total earning in round 2 = Vale of water your country receives by the choice you made + Money received from player A + Money received from player B - Money paid to player A - Money paid to player B

Total payoff round 2 ☐ = ☐ + ☐ + ☐ - ☐ - ☐

Payoff round 3 Player C

Group C Round No. 3

Player ID Number:

You are playing the role of player C (Down-stream). The initial amount of water in upstream is 100 units (100 Billion Cubic Meters (BCM)). Your neighbours have five different choices to share the water with you. Your neighbour in Upstream will make a decision to send country B some units of water. After that, Country B will choose how many units of water to allocate for agricultural purposes and hydropower generation, and how many units of water passes to you. The economic benefit of each three countries based on different water distribution patterns is mentioned in the payoff table. These payoffs are calculated based on the real scenarios in the Eastern Nile Basin, considering countries' potentials and efficiencies.

In this round, we face a new scenario. Country A (Ethiopia) has constructed a new large dam in Upstream which affects the payoffs of other countries as below:

Payoff Table:

The initial units of water in the beginning in the upstream:100 units

Unit passed by Player A (BCM)	Unit passed by Player B (BCM)	Player A Payoff (Million US$)	Player B Payoff (Million US$)	Player C Payoff (Million US$)	Total Basin Payo (Million US$)
75	46	2648	2224	2958	7830
76	51	2531	2445	3652	8628
77	56	2414	2661	4346	9421
78	60	2297	2889	5040	10226
79	64	2180	3110	5734	11024

Game Decision:

Please mark only one of the bellow options as your neighbour final decision about how many numbers of units of water he/she passed to you.

☐ You received 46 units of water; your benefit is 4200 Million US$

☐ You received 50 units of water; your benefit is 4470 Million US$

☐ You received 55 units of water; your benefit is 4750 Million US$

☐ You received 60 units of water; your benefit is 5000 Million US$

☐ You received 64 units of water; your benefit is 5300 Million US$

Your Total Payoff in Round 3:

How many units of water did you receive from player B? [ ] Units

Amount of incentive money you have received from player A: [ ] Million US$

Amount of incentive money you have received from player B: [ ] Million US$

Amount of incentive money you have paid to player A: [ ] Million US$

Amount of incentive money you have paid to player B: [ ] Million US$

Your total earning in round 3 = Vale of water your country receives by the choice you made + Money received from player A + Money received from player B - Money paid to player A - Money paid to player B

Total payoff round 3 [ ] = [ ] + [ ] + [ ] - [ ] - [ ]

Payoff round 4 Player C

Group C Round No. 4

Player ID Number:

You are playing the role of player C (Down-stream). The initial amount of water in upstream is 100 units (100 Billion Cubic Meters (BCM)). Your neighbours have ten different choices to share the water with you. Your neighbour in Upstream will make a decision to send country B some units of water. After that, Country B will choose how many units of water to allocate for agricultural purposes and hydropower generation, and how many units of water passes to you. The economic benefit of each three countries based on different water distribution patterns is mentioned in the payoff table. These payoffs are calculated based on the real scenarios in the Eastern Nile Basin, considering countries' potentials and efficiencies.

Payoff Table:

The initial units of water in the beginning in the upstream:100 units

Unit passed by Pla (BCM)	Unit passed by Pla (BCM)	Player A Payoff (M US$)	Player B Payoff (M US$)	Player C Payoff (M US$)	Total Basin Payo (Million US$)
88	52	490	1114	3541	5145
87	56	738	1499	3964	6201
86	60	986	1884	4387	7257
85	63	1234	2269	4810	8313
84	67	1480	2652	6235	9367
75	46	2648	2224	2958	7830
76	51	2531	2445	3652	8628
77	56	2414	2661	4346	9421
78	60	2297	2889	5040	10226
79	64	2180	3110	5734	11024

Game Decision:

Please mark only one of the bellow options as your neighbour final decision about how many numbers of units of water he/she passed to you.

☐ You received 46 units of water; your benefit is 4200 Million US$

☐ You received 50 units of water; your benefit is 4470 Million US$

☐ You received 55 units of water; your benefit is 4750 Million US$

☐ You received 60 units of water; your benefit is 5000 Million US$

☐ You received 64 units of water; your benefit is 5300 Million US$

☐ You received 51 units of water; your benefit is 4500 Million US$

☐ You received 56 units of water; your benefit is 4830 Million US$

☐ You received 61 units of water; your benefit is 5150 Million US$

☐ You received 66 units of water; your benefit is 5470 Million US$

☐ You received 71 units of water; your benefit is 5800 Million US$

Your Total Payoff in Round 4:

How many units of water did you receive from player B? [ ] Units

Amount of incentive money you have received from player A: [ ] Million US$

Amount of incentive money you have received from player B: [ ] Million US$

Amount of incentive money you have paid to player A: [ ] Million US$

Amount of incentive money you have paid to player B: [ ] Million US$

Your total earning in round 4 = Vale of water your country receives by the choice you made + Money received from player A + Money received from player B - Money paid to player A - Money paid to player B

Total payoff round 4 [ ] = [ ] + [ ] + [ ]

- [ ] - [ ]