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Nile River's Basin Dispute: Perspectives of the Grand Ethiopian Renaissance Dam (GERD)

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Abstract- Transboundary river basins are under increasing pressure due to population growth, agricultural and industrial developments, and climate change, as well as river pollution. Water scarcity is on the increase due to the increasing gap between water demands and supply. This will result in more tensions, disputes, conflicts, and deadlocks in negotiations over water distribution, length of time it takes to fill the reservoir, and allocation. Ethiopia is building the Grand Ethiopian Renaissance Dam (GERD) on the Blue Nile River with a hydropower capacity of 6,000 MW. The total estimated cost of the project is US$ 4.8 Billion and will be the largest dam in Africa, which is much larger than the Aswan Dam in Egypt. Regional controversies have risen over the construction of the dam between Ethiopia and the downstream countries (Sudan and Egypt). The Blue Nile River is a source of around 85% of the Nile River water. Egypt claims that GERD will reduce flow of water in the Nile River between 11 and 19 billion m^3(BCM) which will affect 2 million people and will also interrupt electricity supplies 25 to 40%. The real scale of the environmental impacts of GERD, under construction upstream of the Nile River, together with the rising sea levels, due to climate change, leading to saltwater intrusion downstream, are still not clear. But for Ethiopians GERD is empowering development and contribution to their future. With the Nile, no longer Egyptian birthright, and the Nile Delta gradually disappearing into the Mediterranean sea, millions of Egypt's people will inevitably need to look elsewhere for a livable future. The crises, therefore, necessities the adaptation of a more effective institutional arrangement, such as through Rowland-Ostrom Framework, for common pool shared water resource management and cooperative approach to address and resolve present and future problems, including on other common transboundary resources (forest, oil/gas and minerals).The need for expanding traditional integrated water resources management to better include the cultural, social and political complexity of the GERD is the key factor to reconcile the contrasting concepts of "nationalism" and "regional hydro solidarity". Connecting Nile and Congo water system, through diverting water by digging a 600-km canal together with pumping stations and other massive infrastructure to transport water from the Congo Basin to the Nile Basin has been suggested as an alternative way of ensuring Egypt's water security. As part of mitigation measures, Egypt needs to invest in desalinization for fresh water, water-saving drip irrigation, and come up with an Aquifer Storage Recovery (ASR) scheme, artificial recharge and scheduled water extraction, to minimize the cumulative effect of the Grand Ethiopian Renaissance Dam and seawater intrusion downstream along the Mediterranean coast.

Keywords: Ethiopia, Egypt, Sudan, Nile Basin, Millennium Dam, Grand Ethiopian Renaissance Dam (GERD), Hidase Dam, Aswan dam.

I. Introduction

When water quantity or quality degrades, it leads to more competition among water users for meeting the rising water demands (Yihdego and Al-Weshah, 2016). The situation is more destabilizing in the transboundary river basins (the Great Lakes of the United States and Canada; Lake Victoria of Africa, Lake Malawi, Lake Tanganyika, and the rivers: Nile, Amazon, Rhine, Congo, Danube, Mekong, Indus, Jordan, Tigris-Euphrates, and the Brahmaputra, to name a few). Experience has shown that such disputes can be solved through mutual cooperation on sharing water. Legal agreements on water sharing have been negotiated and maintained even as conflicts have persisted over other issues. Thailand, Vietnam, Laos and Cambodia have been able to cooperate since 1957 within the framework of the Mekong River Commission. Hydroelectric dams are increasingly popular in water-rich countries of Sub-Saharan Africa, especially those less endowed with oil. For example, a 250-MW dam wascompleted in 2012 on the Nile in Uganda. A 300-MW dam was also built by China and completed in 2009 on the Tekeze River in Ethiopia. A smaller, 120-MW dam was completed in 2012 on the Wele River in Equatorial Guinea, to mention a few. On the other hand, the Jordan River and its tributes, for example, have been considered as a tension point between the sharing countries of the River, namely: Lebanon, Syria, Jordan, Palestine, and Israel (Salem, 2009). Also, the Grand Ethiopian Renaissance Dam (GERD), which is under construction on the Blue Nile River near the Ethiopian-Sudanese borders might be a trigger point for conflicts among Ethiopia, Sudan, and Egypt. The idea of a dam on the Nile River in Ethiopia, and the threat this would pose for Egypt, have been on the minds of the people of the Nile Basin for centuries. Ethiopia has long claimed a right to use Nile waters, but it was only in 2011 that Meles Zenawi (the former Prime Minister of Ethiopia from 1995 to 2012) announced that Ethiopia would begin construction of a large dam on the Blue Nile River, near its border with Sudan. The advantages of storing

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water in the Blue Nile gorge for hydropower generation and flood control have been recognized for decades. But until recently Ethiopia did not have the political or financial strength to pursue this economic development strategy, without the assistance from the USA and Israel. According to Kenawy (2013), the issue of the Nile water for Egypt is the issue of "life or death", and one of the issues of the conflict that was raised between Egypt and the Nile Basin countries on water resources through the past three decades, as a result of absence of Egypt from Africa during this period. This is in addition to the entry of the USA, Israel, and the World Bank to the Nile Basin's countries and manipulation of the issue of water security, and the launching of new concepts, including water pricing, water privatization, and exchanging of water by these forces. All of these influences may lead to a conflict among those countries in the coming years.

Lake Malawi, also called Lake Nyasa in Tanzania and Lago Niassa in Mozambique, is the lake located between Malawi, Tanzania, and Mozambique, and is ranked 3rd in Africa and 9th in the world in size, and 2nd deepest in Africa (Yihdego and Andrew, 2016). It has the highest number of fish species than any other lake. The partition of the Lake's surface area (29,600 km^2) between Malawi and Tanzania is under dispute. Tanzania claims that the international border runs through the middle of the Lake. On the other hand, Malawi claims the entire surface of this Lake that is not in Mozambique. Both sides cite the Heligol and Treaty of 1890 between Great Britain and Germany concerning the borders. The wrangle in this dispute occurred when the British colonial government, just after they had captured Tanganyika from Germany, placed all of the waters of the Lake under a single jurisdiction, that of the territory of Nyasaland, without a separate administration for the Tanganyikan portion of the surface. Later in colonial times, two jurisdictions were established. The dispute came to a head in 1967 when Tanzania officially protested to Malawi; however, nothing was settled (Chitsulo, 2012). Occasional flare-ups of conflict occurred during the 1990s and in the 21st century. In 2012, Malawi's oil exploration initiative brought the issue to the fore, with Tanzania demanding that exploration cease until the dispute was settled (allAfrica, 2012).

Lake Tanganyika is an African great lake, and is estimated to be the second largest freshwater lake in the world by volume, and the second deepest, in both cases, after only the Lake Baikal in Siberia. It is also the world's longest freshwater lake. The Lake is divided among four countries – Tanzania, Democratic Republic of the Congo (DRC), Burundi (8% of shoreline), and Zambia (6%), with Tanzania (46%) and DRC (40%) possessing the majority of the Lake. The water flows into the Congo River system and ultimately into the Atlantic Ocean. The total Lake's surface area is 32,600 km^2. No disputes have emerged in the Lake Tanganyika yet, but as the borders between the four littoral countries have not be demarcated, potential for disputes exist. The Lake is divided by a median line, but given that Lake levels have dropped considerably in recent years where that line lies needs to be fully established.

The Tigris and Euphrates Rivers: Both rivers are transboundary sources of water among Turkey, Iraq, Syria, Saudi Arabia, and Iran. Although Saudi Arabia and Iran are considered as drainage basin states, they are usually not included in studies of the basins of the two rivers. The Tigris River is approximately 1,840 km long, while the Euphrates is between 2,700 and 3,000 km long, making it the longest river in south-west Asia. Both rivers originate in the mountainous region of southern Anatolia in eastern Turkey. The drainage basin of the Euphrates is located 28% in Turkey, 17% in Syria, 40% in Iraq, and 15% in Saudi Arabia. Meanwhile, the Tigris Basin is stretched into Turkey (12%), Syria (0.2%), Iraq (54%), and Iran (34%). Both rivers merge in their last 190 km, forming the Shatt Al-Arab before flowing into the Arabian (Persian) Gulf. Water flow is roughly estimated at around 32 BCM/yr for the Euphrates River, while it is roughly around 43 BCM for the Tigris River (Kirschner and Tiroch, 2012). With economic growth, population increase, and urbanization, the demand for water and water use have steadily increased in the region. Iraq, for instance, was especially keen to bring more water for irrigation, and, hence, it built several dams on both rivers. The first dam which Turkey built on the Euphrates was the Keban Dam, which was built by the Soviet Union in 1973 to generate hydroelectric power, with a storage capacity of 14.1 km^3 and a total surface area of 674 km^2. The Atatürk Dam on the Euphrates River is located in Bozova in the Sanliurfa Province of the Anatolia region of south-east Turkey. It was built to supply water for irrigation and to generate hydroelectric power. It is the largest dam in Turkey and ranks sixth amongst the largest earth-and-rock fill embankment dams in the world. It was undertaken in the years 1983-1992 with a total cost of US$ 1.25 billion. The central core of the Dam has a crest length of 1,820 m and height of 184 m, and a storage capacity of around 85 MCM, as well as a catchment area of more than 92 km^2, and annual inflow of approximately 27 MCM (Water-Technology Net, 2016).The project of the Turkey's Ataturk Dam has been receiving strong political resentment from Iraq and Syria and other riparian countries as it significantly reduces the flow of Euphrates. In 2009, however, the three countries (Turkey, Iraq, and Syria) initiated talks to establish a water institution to resolve issues related to sharing of the Euphrates and Tigris waters.

Jordan River: The basin of this transboundary river exists in a greatly troubled area in the Middle East, and it is shared by Jordan (40%), Syria (37%), Israel (10%), Palestine (9%), and Lebanon (4%). The basin of the transboundary Jordan River, with a total area of approximately 20,000 km^2 is home to more than 20 million inhabitants that belong to the River Basin's five countries. Due to low average annual precipitation of less than 400 mm/yr and the semi-arid to arid climate conditions throughout most parts of the River's Basin, available freshwater resources are limited (Al-Weshah and Yihdego, 2016). As climate projections indicate further aridification of the region, available freshwater resources will continue to decline in the future while demand on water is dramatically increasing, which is due to the high rates of population growth and the rising standards of living, as well development and urbanization. Therefore, securing adequate access to water resources in the region is considered by decision makers as integral to national security of each of the riparian countries of the Jordan River. The Jordan River's Basin and its water are central issues of both the Arab-Israeli conflict and the Israeli-Palestinian conflict. The Jordan River is more than 360 km in length, but because its course is meandering, the actual distance between its source and the Dead Sea is less than 200 km.Over most of its distance, the Jordan River flows at elevations below sea level. Its waters originate from the high precipitation areas in and near the Lebanon's mountains in the north, and flow through the Tiberias Lake (Sea of Galilee) and the Jordan River Valley, ending in the Dead Sea at an elevation of approximately 400 m below sea level, in the south. The current annual discharge of the Lower Jordan River into the Dead Sea is estimated at 20-200 MCM which is highly polluted, compared to the historic 1,300 MCM of good quality. Further details on the Jordan River can be found in Salem, 1994; Salem and Isaac, 2007; Isaac and Salem, 2007; Salem, 2009; and Salem, 2011.

The *Brahmaputra River* has origin in China and then flows through India and Bangladesh before entering Bay of Bengal. China and India have fought a war over contested territory through which the River flows, and Bangladesh faces human security pressures in the River's Basin that will be magnified by upstream river practices. Controversial dam-building activities and water diversion plans could threaten regional stability; yet, no bilateral or multilateral water management accord exists in the Brahmaputra Basin. The three riparians have taken modest steps at the bilateral level to cooperate in the Brahmaputra Basin, such as limited water data-sharing and government dialogues among technical experts.

The *Tasang Dam* also known as the *Mong Ton Dam*, is a planned multi-purpose dam on the Salween River in the Shan State, Burma. The Tasang Dam's location will be 480 km northeast of Rangoon and 52.8 km west of Mongtong. It will be the first dam on the Salween River and will be the largest hydroelectric dam in Burma and the tallest dam in Southeast Asia if completed. Substantial domestic and international controversy surrounds the Tasang Dam project. Thailand's MDX Group agreed in 2002 to develop the project. Thailand is the main investor in the Dam project and the trade of the Tasang's electricity is expected to help relations between Thailand and Burma. 85% of the hydro-electricity produced is expected to be transmitted to Thailand. The Tasang concrete-faced rockfill dam is designed to be 228 meters tall and house a hydro-power station with a 7,110-MW capacity to produce 35,446 GWh annually. Tasang's 870 km^2reservoir will bisect a large portion of Shan State, precluding serious social and environmental problems.

The Indus River, which has origin in Tebet, flows through India, Pakistan, and finally drains to Arabian Sea. The Indus Waters Treaty is a water-distribution treaty between India and Pakistan, negotiated by the World Bank in 1960. The Indus system of rivers comprises three western rivers — the Indus, the Jhelum, and the Chenab — and three eastern rivers — the Sutlej, the Beas, and the Ravi. According to this agreement, control over the three "eastern" rivers (the Beas, the Ravi, and the Sutlej) was given to India, while control over the three "western" rivers (the Indus, the Chenab, and the Jhelum to Pakistan. More controversial, however, were the provisions on how the waters were to be shared. Since Pakistan's rivers flow through India first, the treaty allowed India to use them for irrigation, transport, and power generation, while laying down precise regulations for Indian building projects along the way. The treaty was a result of Pakistani fear that, since the source rivers of the Indus Basin were in India, it could potentially create droughts and famines in Pakistan, especially at times of war. Now India is building hydropower projects on Indus River to meet its growing energy demands which is elevating tension between the two countries.

The approach followed in this study is mainly to review the recent studies related to the Grand Ethiopian Renaissance Dam (GERD)in relation to the environmental impacts and the shared Nile River resources management.

II. Study Area

According to the UN-Water (UN, 2008), approximately 40% of the world's population lives in river and lake basins that comprise two or more countries, and perhaps even more significantly, over 90% of the world's population lives in countries that share basins. The existing 263 transboundary lake and river basins cover nearly one half of the Earth's land surface and account for an estimated 60% of global freshwater flow. Continued high to very high risk of environmental and human water stresses, due to decrease in renewable freshwater resources and higher water demand from increased population and irrigation, as well as risks resulted from climate change impacts and pollution are

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important factors in increasing risks of hydropolitical tension among countries sharing transboundary river basins, due to political context, disagreement on river's water allocation, etc. These are some examples of transboundary river basins in the Middle East: Orontes, Jordan River, Euphrates and Tigris. The countries significantly affected by these river basins are: Lebanon, Syria, Turkey, Iraq, Palestine, Israel, and Jordan. Regarding the Nile River, which is the subject of this study, it is an international river as its water resources are shared by eleven countries, namely, Tanzania, Uganda, Rwanda, Burundi, Congo-Kinshasa, Kenya, Ethiopia, Eritrea, South Sudan, Sudan, and Egypt. In particular, the Nile is the primary water source for Egypt and Sudan. The Nile River's drainage basin covers 3,254,555 km^2, forming approximately 10% of the total area of the continent of Africa. The Nile Basin is complex, and because of this, the discharge at any given point along the mainstream of the River depends on many factors including weather, diversions, evaporation and evapotranspiration, and groundwater flow (Yihdego and Becht, 2013; Yihdego et al., 2016; Yihdego and Webb, 2016; Yihdego and Webb, 2017; Yihdego et al., 2017a; Yihdego et al., 2017b). The Nile River is 6,853 km long, and, thus, it is considered the longest river in the world. The Nile has two major tributaries, the White Nile and the Blue Nile. The White Nile is considered to be the headwaters and primary stream of the Nile itself. The Blue Nile, however, is the source of most of the water. The White Nile is longer and it rises in the Great Lakes region of central Africa, with the most distant source still undetermined but located in either Rwanda or Burundi. It flows north through Tanzania, Lake Victoria, Uganda, and South Sudan. The Blue Nile begins at Lake Tana in Ethiopia and flows into Sudan from the southeast. The two rivers (White and Blue) meet just north of the Sudanese capital of Khartoum. The northern section of the Nile River flows north almost entirely through the Sudanese desert to Egypt, then ends in a large Delta and empties into the Mediterranean Sea. Egyptian civilization and Sudanese kingdoms have depended on the Nile River since ancient times. Most of the population and cities of Egypt lie along those parts of the Nile Valley north of the city of Aswan (where the Aswan High Dam was built in the 1950s, as it was a key objective of the Egyptian Government following the Egyptian Revolution of 1952), and nearly all the cultural and historical sites of ancient Egypt are found along the banks of the Nile River.

The Grand Ethiopian Renaissance Dam (GERD) will impound the Blue Nile River in the Benishangul-Gumuz region (1°12′55″N and 35°05′35″E) of Ethiopia and is about 15 km from the borders of Sudan. It is previously called as the Millennium Dam and occasionally referred to as the Hidase Dam. It is a gravity dam with a reservoir surface area of 1,561 km^2 and storage capacity of 79 BCM (Billion Cubic Meter), making it one of the largest dams in the African continent. The main purpose of the Dam is hydro-electric (hydel) power production and similar dams have been built by the Ethiopian Government (Jembere and Yihdego 2016). Maximum planned installed capacity of the Dam is 6,000 MW making it the Africa's largest hydel power plant and the 11th globally. It is currently under construction and as of October 2014, the Ethiopian Government announced that 40% of the Dam was completed (Al-Ahram, 2014). The construction of the Dam started in April 2011 and is expected to complete in 2017,but unlikely to accomplish as planned. Ethiopia is close to finishing 70% of GERD (Daily News Egypt, 2016). The rendition of the Dam is shown in Figure 1.

The construction of theDam and its potential impacts have led to severe debates in the region. Egypt and Sudan are located downstream and depend heavily on the Nile River for agricultural, industrial, and domestic purposes. The Government of Egypt has demanded from Ethiopia to terminate the project. Egypt has planned a diplomatic initiative to sought support in the region as well as other countries that support the project such as China, Italy and Norway, along with the USA, Israel, and the World Bank (as mentioned earlier). Sudan has accused Egypt of mishandling the dispute. Sudan's shift over the Dam project could be motivated by factors such as: regulation of upstream flow on the Blue Nile will irrigate croplands in Sudan, need of electric power could be alleviated by GERD, and prospects of increased trade with Ethiopia (Sudan Tribune, 2014). Ethiopia has rejected the claims of Egypt and has stated that the project will increase the water flows downstream by decreasing evaporation from the Lake Nasser, covering a total surface area of 5,250 $km^2$and has a storage capacity of some 132 km^3. The Lake was created as a result of the construction of the Aswan High Dam across the waters of the Nile between 1958 and 1970, during the Gamal Abdul-Nasser's presidency, and hence it was called "Lake Nasser". Egypt has demanded an increase in its share of the Nile water from 66% to 90% (Mwakenya & Kalinda, 2016). In May 2011, Ethiopia announced that it will share the blue prints of the Dam with Egypt for examining the downstream impacts. Map of the Nile River along with the location of GERD is shown in Figure 2.

The site for the Dam was identified by the United States Bureau of Reclamation (USBR) between 1956 and 1964 while conducting the Blue Nile survey. Subsequently, the Government of Ethiopia carried out survey at the site in October 2009 and later in August 2010. The design of the Dam was submitted in November 2010. The project was made public on 31 March 2011. The contract for the project was awarded to Salini Costruttori (an Italian construction company) at the cost of US$ 4.8 billion. The finance for the Dam comes from the Government's bonds and private funds. The foundation of the project was laid on 2 April 2011 by the then Prime Minister (Mr. Meles Zenawi) of Ethiopia. The project is owned by the Ethiopian Electric Power Corporation (EEPCO). The planning phase of the project was carried out under the name called Project X, which was later changed to Millennium Dam and finally to the present name (Grand Renaissance Dam, or just Renaissance Dam).

Figure 1: Rendition of the Grand Ethiopian Renaissance Dam (GERD) (Source: Wikipedia)

(Source: Wikimedia Commons/Yale Environment 360)

Figure 2: Map showing the Nile River with its main branches, White and Blue Niles, and the site of the Dam (GERD).

III. Cost and Financing

The total estimated cost of the GERD project, with the characteristics given in Table 1, is US$ 4.8 Billion (as mentioned earlier). The Government of Ethiopia has indicated to self-manage all the costs of the project. For this purpose bonds were issued targeting Ethiopians both inside and abroad. Chinese banks funded the turbines and associated electrical equipment for the hydel power plants at the cost of US$ 1.8 Billion. The remaining US$ 3 Billion will be managed by the Ethiopian Government. The total cost which does not apparently include the cost of power transmission lines is less than 15% of Ethiopia's GDP (Gross Domestic Product), which was US$ 41.906 Billion in 2012.

Table 1: The main characteristics of GERD (Source: Wikipedia)

Type of Dam	Gravity, roller-compacted concrete
Impounds	Blue Nile River
Height	175 m
Length	1,800 m
Elevation at crest	645 m
Spillway Type	Controlled overflow
Spillway Capacity	15,000 m^3/s
Total Reservoir Capacity	79×10^9 m^3(79 BCM)
Turbines	16 x 375 MW Francis turbines
Saddle Dam Height	45 m
Saddle Dam Length	4,800 m

IV. Construction

The Italian company (Salini Costruttori)was awarded the project which has already worked on other projects such as the dams of Gilgel Gibe II, Gilgel Gibe III, and Tana Beles. It is estimated that the project will consume 10 Million metric tons of concrete to be produced locally. Diversion of the Blue Nile River was completed on 28 May 2013. Nearly 32% of the project was completed in April 2013 (Mariam, 2015). The contract for supply of low- and high-voltage cables for the Dam was awarded to the Italian firm - Tratos Cavi SPA - in March 2012 by Salini Costruttori. Alstom (a French multinational company) has providedthe eight 375 MW Francis turbines for the first phase of the project at a cost of €250 Million (approximately US$ 264 Million). Over 9,000 workers (including 400 foreigners) have been working on the construction of the Dam. An overview of the Dam on July 31, 2016 is shown in Figure 3.

Figure 3: Overview of GERD on July 31, 2016 (photo by AL-MONITOR/Ayah Aman)

V. Analysis and Interpretation

a) Benefits

The main benefit from the project is hydel power production which is 6,000 MW (6 GW). The electric power will not only be supplied to domestic consumers but will also be sold to neighboring countries, including Sudan and possibly Egypt. This will require construction of major electricity transmission lines to major consumption areas, such as the Ethiopian capital (Addis Ababa) and the Sudan's capital (Khartoum), both of which are located more than 400 km from the Dam's site. The GERD will improve the electric availability in Ethiopia by 200% with full utilization of the power (Tesfa, 2013). The benefits of the project is not limited with power supply, it can also benefit the downstream countries, mainly Sudan and Egypt, by removing silts and sedimentation, as a result of regulating the water flow (Yildiz et al., 2016).

b) Environmental and social impacts

The GERD is the biggest project in the history of Ethiopia. So far, the Government of Ethiopia has not produced any document about the environmental and social impacts of GERD. Thus, little is known about the impacts of the Dam. Impact of a Dam requires detail assessment of the site and its surroundings (Yihdego 2016a, Yihdego, 2016b). The major concern is that the project will alter the flow of the Blue Nile River which will affect the neighboring countries (Sudan and Egypt), which are located downstream and which rely heavily on the water from the River. The volume of the Dam's reservoir is almost 1.3 times that of the annual discharge of the Blue Nile. The Dam construction has begun without any mutual consultation between Ethiopia and downstream nations (Sudan and Egypt). Critics have asked Ethiopia for more transparency on the impacts of the project. Because of the little information available, the NGO International Rivers hired a local research to conduct a field survey of the Dam's site and adjoining area. A giant dam, such as GERD with a cost of approximately US$ 5 billion, really deserves an environmental and socio-economic impact assessment study with a cost of a few millions of US$. According to Swanson (2014), GERD will reduce sediment loads that travel downstream and interfere with the performance of dams in Sudan and Egypt. Also, silt accumulation in reservoirs and dams can reduce reservoir capacity, lead to power failures, and reduce hydropower output overall. For dams that also serve irrigation purposes, sediment buildup can block irrigation channels and reduce agricultural production. Dredging and maintenance costs to address these challenges can escalate quickly.

Previous studies highlighted some issues that require more attention, which resulted in the following findings:1) At least 5,110 people living downstream will be resettled. Villages located near the Dam (home to 7,380 people) will also be resettled. This estimate is higher than the official presentation of around 800 people to be resettled. Also, the project's planning did not involve participation of the affected people; 2) The high lands of Ethiopia are most sediment-prone and, thus, will pose a big risk for sedimentation of the reservoir and, consequently, will affect the Dam's power generation capacity and life span. Currently no watershed management practices are taken to deal with this problem. Climate change could increase the rates of sediments' flow to the reservoir and the rates of sedimentation; 3) The Benishangul-Gumuz region, where the Dam is located, is one of the few places in Ethiopia that has remnant forest vegetation. The Dam's reservoir will flood 1,680 km^2, which comprise 90% of the forest area. Construction of roads to the Dam's site will also impact the forests, which are a source of livelihood for the local community, and which represents an excellent variety of biodiversity; 4) Studies have indicated at least 150 species of fish in the Ethiopian portion of the Nile River which resulted in high consumption of fish by the local population, implyingthe Dam will impact the natural habitat and the fishery.

c) Impacts on Ethiopia

Ethiopians greatly value the project as it is considered as a sign of modernity, hope, reducing poverty, and of development (Abdelhady et al., 2015; Kahsay et al., 2015; Zhang et al., 2015). The Dam is self-funded by the Ethiopians and they are proud of it as a home-grown project. It has createdup to 12,000 jobs during the construction phase of the project. The Blue Nile River is highly seasonal, so the Dam will reduce flooding downstream. The Dam will be capable of handling a flood of 19,370 m^3/sec (The Brussel Times, 2015). This will help in reduction of damages from floods by protecting the settlements. But contrary to this, if flood recession agriculture is practiced then those fields could be deprived of water availability. The Dam could also be used asa bridge across the Blue Nile, this will complement a bridge upstream under construction in 2009 (Daily Ethiopia, 2009). According to an independent study field report (2013) conducted by a local researcher commissioned by International Rivers, at least 5,110 people will have to be relocated due the project. Another estimate is that 20,000 people are to be resettled (International Rivers, 2014). According to Jennifer (2013), the Ethiopian Government has a solid plan for resettlement of the affected people. The resettled people are happy in their newly built houses and are compensated more than what was expected. Except a few elderly people, all other locals are of the opinion that the Dam is a sign of hope and prosperity for them. The area around the Dam will comprise of a 5 km buffer zone for control of malaria. Similarly, some sediments' control measures have to be taken upstream of the Dam to reduce the flow of sediments into the reservoir. Ethiopia intends to become a regional power hub by damming the Nile. The regulated flow from the Dam will improve agriculture. The impact from evaporation of water from the Dam will be minimal compared to other dams in Ethiopia, which will help in water conservation.

d) Impact on Sudan and Egypt

The Blue Nile River is a source of around 85% of the Nile River water. The Blue Nile starts from the Lake Tana in the north of Ethiopia and then enters into Sudan to join the White Nile in Khartoum then they flow into Egypt as the Nile River. Both Sudan and Egypt have concerns about the construction of GERD, as they say it will affect their share of water use from the Nile River according to the colonial era agreement, which gave them 90% of water share from the Nile River. It is believed that the Dam has already created some geopolitical impacts among the three countries affected by the Dam, which are Ethiopia, Sudan, and Egypt (Conniff, 2017). The Egyptians, in particular, are not satisfied with the Dam project, because the Dam means to them considerable reduction of the amount of water flows to Egypt through the Nile River (Eckstein, 2010; Ashok, 2011; Salman, 2013; Tawfic, 2016; Wheeler et al., 2016; EZEGA, 2017). This means a huge amount of water will be captured and stored behind the Dam. So, the question is: Will the Dam be a trigger in the future for conflicts on water among the three countries (Ethiopia, Sudan, and Egypt)?

The Dam will cut down alluvium in Sudan by 100 MCM (million cubic meter) and also facilitate irrigation of about 500,000 ha of new agricultural lands. In 2016, the population of North Sudan reached more than 41 million and of South Sudan approximately 13 million (Worldometers, 2016). It will also reduce about 40 km of flooding in Sudan upon its completion. GERD will retain sediments which will increase the life of dams located in Sudan, such as the Roseires Dam, the Sennar

Dam, and the Merowe Dam, as well as the Aswan High Dam in Egypt. The reservoir is around 200m deep and is located in the high lands of Ethiopia which will cause a reduction in evaporation of water as compared to Aswan High Dam located on the Lake Nasser that loses 12% of its water due to evaporation.

The exact impact of the Dam (GERD) is not known, but Egypt claims that it will reduce a flow of water in the Nile River during the filling of the reservoir and due to evaporation from the Dam. Egypt, with a population of more than 94 million in 2016 and is forecasted to exceed 151 million in 2050 (Worldometers, 2016), being a dry country, is heavily dependent on the water of the Nile River. And the supply of water from the River could reduce between 11 and 19 billion m^3/yr (BCM/yr), which according to experts, would cause 2 million Egyptians to lose their income (Al Jazeera, 2013). This project will also interrupt Egypt's electricity supply by 25 to 40%, which would leave upper part of Egypt in darkness. The project could also lower permanently the water level in the Lake Nasser, if the flood waters are stored in Ethiopia. This would reduce the evaporation of 10 BCM/yr, but also reduce the ability of Aswan Dam to produce hydropower with a 100 MW loss of generating capacity for a 3 m decrease in the water level (Arab Today, 2015).

The Delta (particularly along the Mediterranean coast) is also subsiding (and becoming less fertile), because it is no longer replenished each year by 100 million tons of flood sediments from the Nile. Instead, those sediments now drop out where the Nile enters the reservoir created by the Aswan High Dam. Other studies have attributed increased seismic activity in the region due to the weight of the Dam and the huge amounts of water stored behind it. In addition to the loss of land area in the Delta, the combination of sea level rise and land subsidence will also increase saltwater intrusion. Egypt is already one of the poorest nations in the world in terms of water availability per capita; it has just 660 m^3 of freshwater a year for each resident. Saltwater intrusion from a one-meter rise in sea level could jeopardize more than a third of the freshwater volume in the Delta (Conniff, 2017).

e) What options are left for Egypt?

While Egypt, Ethiopia, and Sudan are awaiting two studies being conducted by French firms BRL and Artelia on the Dam's impacts, many experts predict that the Dam will operate and start its first filling process in 2017 regardless of the report's recommendations, amid Egyptian concerns about the Ethiopian side, and whether it will be diligent in trying not to harm Egypt's interests and water resources. Hani Sewilam, Managing Director of the UNESCO Chair on Hydrological Changes and Water Resources Management at Germany's RWTH Aachen University, said that *"it does not make sense that we assess the impacts of the Ethiopian Dam after its construction,"* referring to the three countries, especially Egypt, that are waiting for the French firm's reports (HornAffairs, 2016).

The reports, which are expected to take 11 months to complete, were started in February 2016. *"We have never heard of this in the history of engineering. Normally, the country intending to build a dam [Ethiopia] in consultation with downstream countries*[Egypt and Sudan] *carry out all the studies, design scenarios, assess the impacts (economic, social, and environmental) and then select the design scenario with the minimum negative impacts and maximum positive impacts,"* (HornAffairs, 2016). Sewilam said, *"In our current case, by the time the two firms complete the impact studies, the construction process of the dam will be done. What will we [Egypt] do if the studies show significant impacts on the downstream countries? Will we demolish the Dam* [GERD]*? Will we be able to modify the body of an existing Dam* [GERD]*? Or are they* [Ethiopia] *just consuming time because they know that the answer for all these questions is a big NO?"* (HornAffairs, 2016). From a legal perspective, Ayman Salama, Professor of International Law and member of the Egyptian Council for Foreign Affairs (ECFA), articulates that Egypt does not have the right to ask Ethiopia to stop the building process under any conditions (HornAffairs, 2016). Sherine El-Baradei, Assistant Professor in the Department of Construction and Architectural Engineering at the American University in Cairo, said that both Egypt and Ethiopia can try to settle on two main things: the operational process of the Dam and the number of years dedicated to filling it. *"We can make an agreement that when it's the agricultural season for Egypt's peasants, Ethiopia can't close the Dam's gate to generate electricity since we will be in need of the water flow for the inauguration process, especially that 85% of the Nile water that goes towards agriculture and the remaining 15 percent for drinking,"* (HornAffairs, 2016). El-Baradei went on to say that Egypt needs to persuade Ethiopia to increase the years of filling the Dam, which is set to be from 5-7 years. She said that a set period will reduce Egypt's share of water from 12 to 25% while adding more years will minimize the detrimental effects of the Dam. Sewilam (HornAffairs, 2016; King & Block, 2014) listed some facts that Egypt must consider while negotiating with Ethiopia, such as connecting the construction time-plan with the impact assessment time-plan, as the *"construction should go hand-in-hand with the negotiations and assessment, not 10 times faster as is the case right now."* This is in addition to reducing the storage capacity of the Dam, *"because Ethiopia does not need to store 74 BCM (Billion Cubic Meter), which is equivalent to the annual share of the Nile water of Egypt and Sudan combined."* But for Nader Nour El-Din, Professor of Water Resources at Cairo University, Egypt's stance on the Renaissance Dam issue is *"backwards and critical"* (HornAffairs, 2016). *"We are still in the status of negotiating with Ethiopia and the latter started the building process in April 2011, and in March 2015 we signed a Deceleration of Principles which was a carte blanche for Addis Ababa to go build the Dam with its current measurements and storage capacity"* (HornAffairs, 2016). *"In July 2017, Ethiopia will start the first process of generating electricity and by October 2017 the Dam is expected to operate in its full capacity and options and this means that a very large amount of water will be retained behind the Dam"* (HornAffairs, 2016). Nour El-Din argues that Egypt should negotiate with the Ethiopians on reducing the height of the project's smaller side Dam (or Saddle dam), which is currently set at 45m high, and try to reduce it to between 20 ~~to~~and 22m, as the current height would allow the Dam to hold 60 BCM of water. The main Dam, although 145m high, will only retain 14 BCM of water, as it is surrounded by 16 electricity generating turbines. According to HornAffairs(2016), Prime Minster of Egypt Sherif Ismail said that the other regulations and policies Egypt is willing to implement as alternatives to Nile waterare treating sewage water, which can provide 4 BCM, and using new irrigation methods to save water. The Government will resort to linking some canals, providing between 1 and 1.5 BCM of water. Egypt is coordinating with other African countries on a regional project aiming to link the Victoria Lake with the Mediterranean Sea, helping to divert more water to the Nile River. Sewilam asserted that some Egyptian researchers are currently working in different concentrations, such as water treatment, water recycling, increased irrigation efficiency, and desalination. El-Baradei also said (HornAffairs, 2016) that the Government of Egypt needs to consider using groundwater wells as a water resource, but only after treating the saltwater. Sewilam, however, believes that the solution ultimately lies in greater cooperation between the Nile Basin's countries to secure water and other natural resources (HornAffairs, 2016). *"There should be an integrated Water-Energy-Food Nexus plan for all the Nile Basin countries. We should be thinking of self-sufficiency of resources by complementing each other, as for example, we need to identify the countries in the Basin which can generate energy and other countries which can supply water and also the countries that can make use of water and energy to produce enough food for the whole basin"* (HornAffairs, 2016). *"I think the lack of trust, cooperation, and participatory long-term planning between all the Nile Basin's countries are the main reasons for the current situation"* (HornAffairs, 2016). *"The main Dam is allocated for generating electricity while the side Dam is just for water reserves and it won't affect the power generation process of Ethiopia if the amount of the reserved water is reduced"* (HornAffairs, 2016). The GERD's both main and saddle dams are shown in Figure 4.

Figure 4: Main Dam and Saddle Dam of GERD (Source: Hydro World, 2016)

Egypt is exploring ways it might make up the shortfall in its water needs if the US$ 4.8 billion Renaissance Dam is completed. A recent study, conducted by Gamal Al-Qalyoubi, Professor of

Petroleum and Energy at the American University in Cairo (AUC), on connecting the Nile and Congo water systems, suggests one possible way of ensuring water security (Al-Ahram, 2014). The River Congo pours more than 1,000 BCM (one trillion cubic meter) of water each year into the Atlantic. *"Water could be diverted by digging a 600-km canal from the White Nile in southern Sudan to northern Sudan and then to the Lake Nasser,"* said Al-Qalyoubi. The canal, he said, could provide Egypt with an additional 95 BCM annually, almost double its current share (55.5 BCM) of the Nile water. *"Digging the canal would take two years and the entire project, including four pumping stations to transport water from the Congo Basin to the Nile Basin, as well as infrastructure works needed to move the water, would cost US$ 8 billion"* (Al-Ahram, 2014). For such a huge project to succeed, says water expert Diaa Al-Qousy, it must garner international support and guarantees that the hugely expensive infrastructure can be properly secured. *"Both Egypt and Congo should start pushing the project as Egypt's only way out from the current crisis with Ethiopia. They must also begin the process of attracting the necessary funding,"* says Diaa Al-Qousy (Al-Ahram, 2014). Former Minister of Irrigation and Water Resources Nasreddin Allam questions the viability of the canal. The swamps of southern Sudan, he argues, present a major obstacle to digging. He also questions the political costs of the project. *"International treaties prohibit the transfer of river waters outside their basins. Egypt cannot risk violating this international principle, not to mention the very high cost of such a project,"* he warns. *"The Congo and White Nile flow at different altitudes and linking them would require the construction of a huge dam as well as the digging of canals.'* He continues, *"Even if the Government did overcome all the technical and financial obstacles to the project, Egypt would still be in danger of violating international rules,"* says Allam. He continues, *"The Congo's tributaries flow through Cameroon, Guinea, and the Central African Republic, each of which could file a lawsuit in front of the International Court of Justice which they are certain to win. Egypt then will be the only loser."*(Al-Ahram, 2014). Diaa Al-Qousi is unconvinced by Allam's arguments. He insists there is no legal impediment to linking the two rivers (Congo and White Nile). Water experts have reviewed more than 300 river agreements and none of them contain legal deterrents to the project, he says (Al-Ahram, 2014). Cameroon, Guinea, and the Central African Republic could easily be convinced of the mutual benefits that will accrue from the project, says Al-Qalyoubi. And money, he adds, could be forthcoming from oil-rich Arab countries (Al-Ahram, 2014). Congo will welcome the project which will alleviate the flooding of agricultural lands, and such approval will be instrumental in winning the support of the international community and donor nations. *"The River Congo lies on the Equator and is fed by massive rainfalls. The project has any number of benefits for Congo, including the generation of cheap electricity,"* says Al-Qalyoubi (Al-Ahram, 2014). According to a study conducted by the Mineral Resources Authority (Al-Ahram, 2014), linking the White Nile with the Congo River includes three different alternatives that would determine the path of the water. The length of the first proposed canal would be 424 km with a water-level altitude differential of 1,500 m, which would be impossible to implement. The second alternative is to have the canal length 940 km, with an altitude differential of 400 m. Meanwhile, the third alternative would carry the water a distance of 600 km with an altitude differential of 200 m. According to Al-Qousi, the last alternative has the best chances of being implemented, through the use of four consecutive water-pumping stations. *"The project would be capable of generating 300 trillion watts of electricity per hour, enough to satisfy all of Africa's electricity needs,"* claims Diaa Al-Qousi (Al-Ahram, 2014). And according to the feasibility study undertaken by the Mineral Resources Authority (Al-Ahram, 2014), the project will necessitate the construction of a road and rail network that could form the core of a trans-continental transport system, thus promoting trade between Egypt and the rest of Africa.

Reactions: Cooperation and Condemnation

In order to address its concerns over the project, Egypt has requested the Government of Ethiopia for inspection of the project design and other studies related to it. However, the Ethiopian Government has denied the request. After a joint meeting in March 2012 between the ministers for water of Ethiopia, Sudan, and Egypt, the President of Sudan – Omar Bashir - announced that he supported the construction of the Dam (Sudan Tribune, 2012). A Nile treaty was signed by the countries located on the upstream in 2010, however the cooperative network agreement, has not been signed by Sudan and Egypt. They claim that it violates the 1959 treaty which gives Sudan and Egypt exclusive rights to the water of the Nile (Voice of America, 2011). The Nile Basin Initiative (NBI) which was launched in February 2009 serves as a collaboration between the Nile riparian countries that *"seeks to develop the River in a cooperative manner, share substantial socioeconomic benefits, and promote regional peace and security."* To review the study reports of the Dam, an international panel of experts has been established by Ethiopia, Sudan, and Egypt. There are 10 members of the panel with 6 members (2 from each country) and 4 international members expert in the fields of water resources and hydrological modeling, dam engineering, socioeconomics, and the environment. The panel also called tripartite committee, held its fourth meeting in November 2012 in the Ethiopian capital Addis Ababa. The panel visited the Dam's site and reviewed documents related to environmental impacts of the

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Dam(Sudan Tribune, 2012). The preliminary report was submitted to the respective governments in May 2013. Full report has not been made public till reviewed by respective governments. Egypt and Ethiopia have made the details of the report public. According to the Ethiopian Government, *"the design of the Dam follows the international standards and principles"* (HornAffairs, 2013), however, it did not mention them. It also stated that *"the Dam offers high benefits for all the three countries and would not cause significant harm on both the lower riparian countries".* According to the Egyptian Government, the report *"recommended changing and amending the dimensions and size of the Dam"* (HornAffairs, 2013). The political leaders in Egypt in a meeting with former President - Muhammad Morsi - on June 3, 2016 suggested different methods for destruction of the Dam including support for the anti-government rebels (Business Insider, 2012). The meeting was televised live without the knowledge of the participants of the meeting. In response Ethiopia called the Ambassador of Egypt to explain the meeting. The Spokesman of the Egyptian President apologized for the *"unintended embarrassment"* and the cabinet released a statement promoting *"good neighborliness, mutual respect, and pursuit of joint interests without either party harming the other"* (Yalibnan, 2013). The Spokesman for the Ethiopian Government said that Egypt is day dreaming and have tried to destabilize Ethiopia in the past (Yalibnan, 2013). Former President of Egypt – Mohammed Morsi - stressed on engaging Ethiopia rather than forcing them on the issue by issuing a statement on June 10, 2013 that all the options are open implying that he is not calling for a war but Egypt's water security cannot be violated at all (BBC NEWS, 2013). Egypt left negotiations for the Dam in January 2014, accusing Ethiopia of intransigence. The military backed administration in Egypt began to gather international support against the Dam. The campaign aimed to persuade the international community that the construction of the Dam will further destabilize the region, citing that more negotiations with Ethiopia is a waste of time and it directly threatens the Egypt's water security (UPI, 2014). However, the Ethiopian President in February 2014 said that Addis Ababa will not back down on the $4.8 billion GERD, which will be the largest in Africa (Waltainfo, 2014). Egypt also tried to *"target all countries that provide technical assistance for designing and building GERD through private contractors and also the states that likely to fund the construction of the Dam"* (Daily News Egypt, 2014). On February 06, 2014, the Egyptian Minister of Water Resources and Irrigation visited Italy, considered to be Ethiopia's main technical supporter in building the Dam. Egypt sent its Foreign Minister to Tanzania and Democratic Republic of Congo to seek support against the project. The Ethiopians consider the Dam and the other dams they plan to build as a symbol of national pride, as they will produce electricity that will transform the economic prospects not only for their country but also for much of seriously under-developed East Africa as it stands on the cusp of a major oil and gas boom. Egypt, with its 94 million people totally dependent on the Nile River for water, cites the British agreements in 1929 and 1959 that guarantee it the lion's share of the water and a veto over upstream dam construction (Al Jazeera America, 2014). But Ethiopia, along with Tanzania, Rwanda, Kenya, and five other African states with growing populations and mounting demands on agriculture, dismiss these accords as colonial relics. In April 2014, Ethiopia invited Sudan and Egypt for another round of talks over the Dam and the Foreign Minister of Egypt said in May 2014 that Egypt is still open for negotiations. Following an August 2014 Tripartite Ministerial-level meeting, the three nations agreed to set up a Tripartite National Committee (TNC) meeting over the Dam. The first TNC meeting occurred from 20 to 22 September 2014 in Ethiopia (allAfrica, 2014). Experts estimated that already water-starved Egypt could lose as much as 20% of its water in the 3-5 years that it would take to fill the Dam's massive reservoir. It is reported that Ethiopia has asked Egypt to be 50% shareholder in the Dam. The Ethiopian Prime Minister - Hailemariam Desalegn - has already declared in October 2013 that his Government considered the project to be "jointly owned" with Sudan and Egypt (EthioFreedom, 2013). It was the hope of the late Ethiopian former Prime Minister Meles Zenawi that they would finance half of the US$ 4.8 billion construction of the Dam to ensure cheap future electricity. The project is not eligible for funding from the World Bank or other financial concession, due to the fact that multilateral lenders cannot provide support for transnational projects which are unilaterally initiated by one country. Ethiopia has called the project as national sovereignty and has denied the right of any other country in its plans. Lenders are also reluctant because so far no agreement has been signed with neighboring countries for purchase of electricity generated at the Dam. Such agreements are considered essential in the Dam's planning (EthioFreedom, 2013).

Flow is the crucial issue. A draft study which three Oxford Brookes University academics, Emanuele Ferrari, Professor Scott McDonald and Rehab Osman, presented in June 2013 at the 16th Annual Conference on Global Economic Analysis in Shanghai, China, said that the GERD's reservoir capacity is roughly equivalent to the whole annual flow of the Nile River at the Sudanese-Egyptian border (i.e. 65.5 BCM)(Ethio-Freedom, 2013). If all flow at that point were stopped, it would take a year to fill the reservoir. Possibly the most crucial and controversial factor is how long the reservoir would take to fill: if the time is short, shortages are suffered downstream. If it is too long, Ethiopia may not make a return to its power generation. *"This loss to the downstream countries' water share would take place*

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only over the reservoir's filling period," the Oxford Brookes paper states (EthioFreedom, 2013). However, the loss might continue to induce noticeable long-term effects on the downstream countries. Evaporative losses from the Dam's reservoir would permanently reduce the flow of the Blue Nile. The magnitude of these losses is not accurately estimated yet.

An Assistant Professor at the University of Wisconsin, Paul Block, author of a paper on filling the reservoir (EthioFreedom, 2013), says no filling rate has been established. *"It becomes very important from a hydropower generation, economics and livelihood perspective, clearly for Ethiopia but also for Sudan and Egypt,"* he said. If Egypt, Sudan, and Ethiopia decide to fill the reservoir slowly, abstracting *"say 5% of the monthly flow, to minimize downstream effects,"* he says, *"our analysis shows that the reservoir would actually never fill due to evaporation. Hydropower could be generated but never at design capacity."* If Ethiopia were to impound water at a much higher rate, say 25% of the monthly flow, *"certainly the reservoir would fill and they would be generating hydropower at a much sooner time,"* says Block (EthioFreedom, 2013). That, however, would mean lower flows reaching Sudan and Egypt.

Ethiopia wants to earn valuable foreign exchange by exporting electricity all over the region but it could also be used for domestic consumption and would boost the economy. Filling the reservoir fast could be bad for the country, even if it meant generating power sooner. In an earlier research paper, Block (EthioFreedom, 2013) had noted the importance of securing energy contracts before extensive generation. *"Ethiopia may not be ready to immediately absorb all of this new electricity and if they begin generating but don't have a buyer for a few years, this could be financially devastating,"* he says. Energy trade contracts secured prior to the Dam's generation stage, if any, are not publicly available.

Other academicians do not see evaporation as a problem. "It is completely out of the question that the GERD reservoir will not fill due to evaporation. The Dam will fill during a few years," Professor Ånund Killingtveit of the Norwegian University of Science and Technology said (EthioFreedom, 2013). *"The design of GERD seems to be based on good hydrological data and there can be no doubt about the long-term viability of this project."* Killingtveit acknowledges, however, that the devil is in the detail of how long it takes to fill the reservoir. *"There will have to be some reduced flow in the Nile downstream from GERD during the first years after GERD is completed,"* he said, estimating that if filling took 6 years, about 12% less water would reach the Aswan Dam of Egypt over that period of time, meaning less power-generation and less water for irrigation for Egyptians. Yet Killingtveit thinks it is a price well-worth paying because there would be, *"significant long-term benefits for Sudan and Egypt, since the flow in the Blue Nile now will be much more evenly distributed during the year, with reduced floods during the wet season and much higher flow during the dry season from November to June."*(EthioFreedom, 2013). This demonstrates how intensely political the reservoir is, since Egypt will want the minimum disruption to the Aswan Dam.

The Spokesman for Egypt's Ministry of Irrigation and Water Resources, Khaled M. Wassif, appears to agree with Killingtveit. *"We want the end result of the Dam to be achieved but without the side effects,"* he says, noting Egypt's ultimate concern, reductions in flow. *"Farmers sometimes come to us in our headquarters in the Ministry with a dead plant, as a symbol, a proof that a lack of water caused damage to them,"* Wassif said (EthioFreedom, 2013). Water is an extremely emotive issue and any impression of upstream countries *"stealing Egypt's water"* could cause popular unrest and create problems with Ethiopia. Wassif is conciliatory, *"We are not greedy,"* he says. *"We do not want development for just Egypt. We can achieve development in both countries."* (EthioFreedom, 2013).

Sudan's position is different from Egypt's. It has strong concerns about the safety of the Dam because, *"They know if the Dam fails, it will destroy all the cities and villages on the Blue Nile past Khartoum,"* according to Salman Mohamed Ahmed Salman, a Sudanese water lawyer who until December 2009 was lead counsel with the Legal Vice-Presidency of the World Bank and the Bank's Advisor on Water Law (EthioFreedom, 2013). *"They are less concerned about the decrease in the flow of the Nile waters as Sudan uses only 12 BCM of its share of 18.5 BCM under the 1959* [Nile Waters] *treaty with Egypt."* (EthioFreedom, 2013).

The Ethiopian Government estimated the cost of the Dam at US$ 4.8 billion, equivalent to about 11.12% Ethiopia's 2012 economic output ($43.13 billion in 2012, according to World Bank's data).Some engineers believe the 6,000 MWgenerating plant is too big and others doubt the provisional cost estimate. Mamdouh Hamza, a leading Egyptian dam engineer, says his rough calculations put the cost *"in excess of US$ 7 billion"* or 16.2% of Ethiopia's GDP (EthioFreedom, 2013). Without advance electricity agreements, Hamza says the economic viability of the Dam is in question.

In April, 2013 Ethiopia's Deputy Prime Minister of Economy and Finance - Debretsion Gebremichael - told the press that China Electric Power Equipment and Technology has plans to finance a US$1 billion (EthioFreedom, 2013). A 619-km transmission line that will bring electricity from GERD to the Ethiopian capital; and that funding would come primarily from the Export-Import Bank of China. Plans for a national distribution grid have lagged behind the plans for generation and

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could prove to require a national effort almost as monumental as building the Dam itself.

Kefyalew Mekonen, who studied in the School of Natural and Rural Systems Management at the university of Queensland came up with better ways to harness the flow of the Nile River (UQ News 2005). His Thesis is titled, *"The economics of developing water resource projects in the Ethiopian Nile River Basin, their socio-economic, political, environmental and transboundary implications"*. The Thesis investigates the economics of building small water storages in the upper Nile Basin – the world's longest river which flows from Ethiopia through Sudan and Egypt. Mekonnen said drip irrigation could save up to 48% of the water potentially used to irrigate small areas of cereals, vegetables, and traditional crops on a typical Ethiopian farm, and thus would improve farm productivity, earnings, and family livelihoods. A fairer distribution and use of water in the Nile River Basin could lessen the risk of regional conflict over water resources. The majority of the Nileoriginates in Ethiopia but more than 97% of its annual flow of 84 BCM, is used by downstream countries such as Sudan and Egypt. *"Water resources of the Nile River Basin are not only scarce but also shared among several countries and have the potential to become a major source of conflict." "Egypt is even demanding additional water and there is no unallocated Nile water available to Ethiopia"*. His Thesis detailed the likely costs of building dams, weirs and irrigation, calculated water consumption per crop and analyzed new ways of water harvesting, storage, and delivery to fields. He said new technology, innovative uses of water, distribution and production systems, funding, research, and water trading systems could make better use of the Nile waters, but education and awareness were also important (UQ News, 2005).

Many people are ignorant of the power of the "common pool" approach to resources management sustainability. But there is an emerging acceptance that a common pool resource is an emerging acceptance that a common pool resource is one that is jointly managed with co-owners who act in the best interest of the resources and everyone who uses it. Such common pool resources management is viewed as an effective way to ensure equitable use of shared water resources. The fact demonstrates that the common pool system of resources management is a viable alternative to the strictly 'legal' approaches characterized by the transboundary international law professional or through market-based or state based resources management systems. The Rowland-Ostrom Framework for common pool resources management provides a two-step solution to resource management problems, including transboundary disputes as the case of the Nile River. The first step is identifying the crises that endanger the resource and users of the resources. Crises may include drought, aging or damaged infrastructure, under capacity infrastructure, or over-pumping of water resources. Other crises may involve salt water intrusion, which is typical to the case of the Delta region. The onset of the water resources is detected through the monitoring of critical resources' characteristics, such as dam water level, water table levels, water pressure, salinity, and system efficiency (watermetered for use vs water produced). The most critical and difficult part for people who share a common pool water resources to agree that a crisis situation exists. Self-interest is a mighty counterforce. Relevant lessons can be drawn from the Turkey-Syria relationship on the Euphrates River issues. However, the existence of many long-standing, effective common pool resources' arrangement demonstrates that it is possible to overcome these obstacles. The second step in the Rowland-Ostrom Framework involves transitioning from whatever type of water management system a region is using to a common pool system that follows Ostrom's eight principles. This is a difficult task that requires sacrifice by the users. The means for preventing and resolving transboundary disputes prevails once a common pool resources' management system is in place (Hilhorst 2016; Rowland, 2005).

f) Assumed Oversizing of the Grand Ethiopian Renaissance Dam

The peak flow rate of the Blue Nile River is 5,663 m^3/sec. Data from *Water Balance Assessment of the Roseires Reservoir in South Sudan* (Khartoum, Sudan; Ministry of Irrigation and Water Resources, Sudan) gave a flow rate of the same range: 6,944 m^3/sec in 1985; 5,208 m^3/sec in 1995; and 5,787 m^3/sec in 2005 (Beyene, 2013). The numbers for the Roseires Dam in South Sudan are more reliable since the Dam is close to the Ethiopian-Sudanese borders. The Dam is reported to have 145 mheight. The flow rate and the Dam height fix the maximum possible theoretical power output from the Dam at about 7,250 MW, assuming some 90% efficiency for the Francis turbine. The annual peak flow rate varies, but the above average value 5,663 m^3/sec can be assumed for further analysis. If the Dam were designed to use this peak flow, most of the turbines of the 7,250 MW have to idle when the flow rate drops below 5,663 m^3/sec, and there would be no storage required if not for the required head (elevation). In fact, even after years of initial storage time, the reservoir cannot possibly produce the peak flow rate for extended period of time. The average flow rate of the Blue Nile River is reported to be about 2,350 m^3/sec. This average for the same height of the Dam would provide about 3,000 MW power output. Reverse calculation yields 4,700 m^3/sec flow rate (Figure 5), for the proposed design of 6,000 MW, which is way above the annual average of 2,350m^3/sec. In fact, the 16 turbines with 350 MW each can only produce a total of 5,600 MW, not 6,000 MW. This corrects the design flow rate to

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4,400 m^3/sec, not 4,700 m^3/sec. There are many possible input and design scenarios, which we simplydo not know. One thing is true however. Given the height of the Dam and the flow rate, there is no way the Dam can operate at the level of 5,600 MW output throughout the yeareven if the Dam stores the difference between peak-flow and design-flow rates. If we assume the design engineers factored in two turbines, – 700 MW down time (allowing equivalent water for bypass or storage) for a more realistic 4,900 MW output, the flow rate has to be about 3,800 m^3/sec, which still remains way above the average flow rate (see Figure 5) implying, the peak covers few months to fill the reservoir in the summer when the discharge drops significantly.

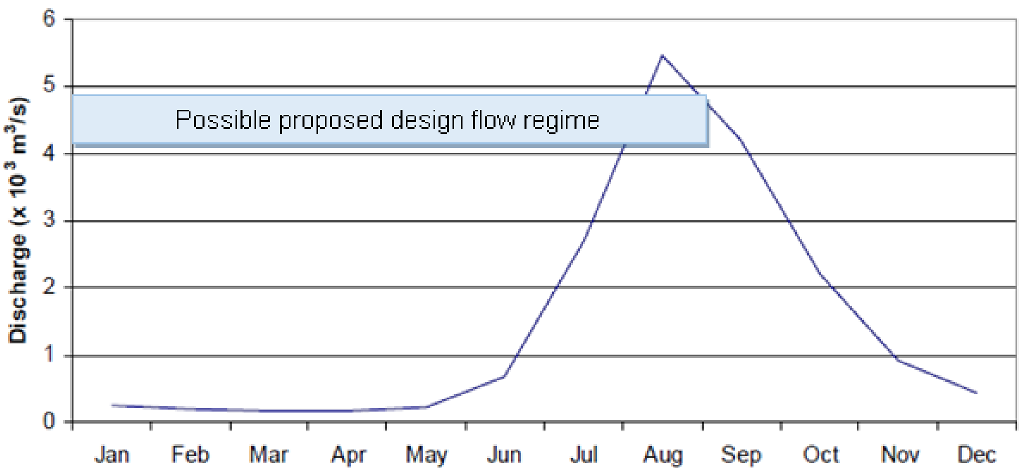

Figure 5: Upper Blue Nile River observed monthly flow based on 1966-2001 *(Source: Nawaz et al., 2010)*

Allowing the average flow rate of 2,830 m^3/sec to pass to downstream countries during peak months will fill the reservoir in about 5 years, but the refill per annum will be too small to sustain annual operation even close to 4,800 MW. The only scenario under which the power supply will be consistent, and the refill can be sustained for summer at about the same power output level is if the hydroelectric dam is designed for a mean flow, which is about 1,456 m^3/sec. This will provide just less than 2,100 MW (say, 7 turbines with 350 MW each). Assuming 700 MW (two turbines for maintenance downtime), the appropriate design target would be 2,800 MW, still larger than the 2,100 MW at the Aswan High Dam – to please those who like to compete. This assures year-round supply of electricity at almost constant level, also requiring a shorter period for initial refill. Such consistency offers high rate on investment. The total price at US$ 800/kW rate will be about US$ 2.3 billion– much less than the $ 4.8 billion for the 6,000 MW (Beyene, 2013). More importantly, Egypt may be happy, making it easy to borrow money for the project.

Of course, the input values are not known and flow rates also vary from year to year, rendering the calculations here a bit tentative. Regardless, there is little doubt that the system is designed for near-peak flow rate. The question then is, – should one design a system for near-peak flow, i.e., near the theoretical maximum power generation, or for the mean flow rate? This is a common topic in system design, and the question arises whenever input resources or supply demands vary. Hydroelectric dams are best designed to provide maximum kilowatt hour (not kW), which means we target mean flow values. This decision is fairly trivial for the Blue Nile River that has very low flow rate during the dry season. Targeting near peak or peak flow rate makes no economic sense. The remaining question is then, why is it sized for 6,000 MW?

Asfaw Beyene, Professor of Mechanical Engineering and Director of the Center for Renewable Energy and Energy Efficiency at San Diego State University stated that GERD is being oversized (International Rivers, 2013). According to him the consequences of the oversized Dam means that more than half of the turbines will be rarely used. The height of the Dam and flow rate fix the potential of the power generation. The GERD's available power output, based on the mean flow rate (the average of the River's flow throughout the year) and the Dam's height (145 m), is about 2,000 MW. There is little doubt that the system has been designed for near-peak flow rate, but that high flow only happens during the 2-3 months of the rainy season. The planned 17 turbines are in excess of what can be produced given the Dam's height and the River's flow rate. Targeting near peak or peak flow rate makes no economic sense. Engineers use a calculation called "plant load factor" to describe the ratio of a power plant's actual output over a period of time, to its potential output if it were possible for it to operate at full capacity indefinitely. In the case of GERD, the load factor for the Dam designed to produce 6,000 MW would be about 30%. If it were "right-sized" to 2,000 MW, its load factor would be about 90%. The Dam is sized for the peak flow rate of the River, which lasts just a few months. The peak flow rate of the Blue Nile River is under 6,000 m^3/sec, even exceeding 6,500 m^3/sec once in a while. With 145 m of the Dam's height, this peak flow can produce about 7,000 MW. The average flow rate of the Blue Nile River is reported to be much lower. So, given the height of the Dam and the flow rate, there is no way the Dam can produce 6,000 MW for more than 3 months of the year even if the Dam would store the difference between peak-flow and design-flow rates. The only scenario under which the power output will be annually consistent is if the hydroelectric dam is designed for a mean flow, which is about 1,456 m^3/sec. This will provide just less than 2,100 MW. The extra 10 or so turbines will be parked for about 9 months of the year. The size calls for about 7 turbines with 350 MW each. Even if we add one extra turbine for maintenance downtime, the appropriate design target should not exceed 2,800 MW. What does this mean in human terms? According to the World Bank, Ethiopians use on average about 200 kWh of electricity per capita per year. A per capita comparison is, however, less than useful because it shifts with population growth. A better comparison is kilowatt-hours used per household per year, which is about 500 kWh for Sub-Saharan Africa. (For comparison's sake, the global baseline is around 13,000 kWh/year, and the average US household uses 18,000 kWh per year, including natural gas and electric.) If we assume 500 kWh/year per household, the 4,000 MW of "missing power" could have covered more than 70 million households (not including the cost of transmission lines). If we take a South African household average of 5,000 kWh/year, it could affect over7 million households. It has been suggested that the concerned authorities of the project should make the matter transparent, rethink the number of turbines that are to be installed, and resize the hydroelectric power output by reducing the number of turbines (International Rivers, 2013).

VI. Conclusion

In this paper the Authors have tried to explore the different impacts and dimensions of the Grand Ethiopian Renaissance Dam (GERD). This Dam, with a total estimated cost of around US$ 5 billion, is considered by the Ethiopians as a symbol of modernity, development, hope and reducing poverty. The Dam, which is the largest hydropower project in Africa, generating 6,000 MW electricity, will not only meet the country demands but will also be exported to the neighboring countries. For Ethiopians, the Dam is empowering regardless of any ethnicity of political affiliation. It will empower Ethiopia's plan to become middle income country and become carbon emission free by 2025. Entirely financed by the Ethiopian Government, the Dam is said to be source of pride for Ethiopians. According to the Ethiopian Government, the project will equally benefit the downstream countries. The Dam has already affected the dynamics of the region and is a source of controversies between Ethiopia, Sudan, and Egypt. The three countries have so far failed to agree on how to manage the water of the Nile River. Egypt is worried that what impact the Dam will have on its water supplies. On March 23, 2015, the three countries signed an agreement on Declaration of Principles on GERD in Khartoum, Sudan, as a sign of future cooperation. The study's commission by the three governments has not been released yet, and the real scale of the environmental impact is unclear. What certain is that a successful GERD will play an important role in empowering development and will contribute to the future of Ethiopia. Nevertheless, regardless of the importance of GERD to Ethiopia, in particular, the issues of such a Dam should be negotiated and agreed upon, in advance, among the three riparian countries of the Nile River (Ethiopia, Sudan, and Egypt), which will be affected, negatively or positively, by such a mega project, in order to avoid any future conflicts. So, geopolitical agreements, based on strategic plans, should be reached among Ethiopia, Sudan, and Egypt. In addition, environmental, socioeconomic, cultural, legal, etc. impact assessment's studies should be carried out before the beginning of the construction of the Dam, which (studies) unfortunately were not conducted. The filling rate of the reservoir, considered as major point of dispute, has not been established yet. Abebe (2014) argued that the traditional doctrinal approach, one based solely on an examination of international water law, treaties, and customary international law is unlikely to result in a legal conclusion that either state (Egypt and Ethiopia) is likely to respect, because such an approach fails to consider the incentives, material capabilities, and national interests of both countries. Transboundary water conflicts are frequently considered to be international issues resulting from human modifications in the way water moves across the international boundaries. However transboundary problems are more complex than this, and they arise when a decision affecting a resource in one place has an impact on someone in another place. The goal of any water rights system is to achieve equity, efficiency, and certainty. Critical element in any system of water right must define how the water can be used and define relationships that each use has with the other users and uses in the system. Resolution of the Nile River transboundary disputes via Rowland-Ostrom framework for common pool resources arrangement could be among the viable solutions the way transboundary water conflicts are prevented and resolved. The best solution is to answer and see if conflicts can be prevented. The key to preventation is understanding and defining the relationships that exist within the water rights system for the equitable use of shared water resources, including on other common transboundary resources (forest, oil/gas and minerals). Revising a water rights system is never easy, but if transboundary conflicts are to be prevented, this is the starting point. Egypt in any case has little ground for negotiating a favorable deal. It has always asserted its right to the lion's share of the Nile River waters, formalizing that claim in the 1959-Nile Waters Agreements, with little regard to the needs of upstream countries. Hosni Mubarak compounded that slight during his long reign as Egypt's President, taking other Nile Basin's countries for granted and effectively withdrawing from the rest of Africa (Conniff, 2017).

It has been suggested that, the key factor to reconcile the contrasting concept of 'nationalism' and 'regional hydrosolidarity" is to expand traditional integrated water resources management to better include the cultural, social and political complexity of the GERD (Abdelhady et al., 2015).According to Conniff (2017), as Egypt slept, a competent government in Ethiopia has rebuilt its economy, deftly worked with both U.S. and Chinese interests, and launched a hydropolitical offensive to re-order the region, not just in political or theoretical terms, but on the ground, by asserting control over the Nile waters that are the region's lifeblood. The only international agreement that directly addressed transboundary water resources was between France and Switzerland, whereby both countries set aside international law in favor of a simple agreement on a schedule of water extraction and artificial recharge for aquifer management. The case highlights a glaring omission in current international law. International legal principles cover surface water but do not address important specific conditions applicable to groundwater, an important resource depended upon by half of the world's population (Rowland, 2005).In line with this,Egypt needs to invest in desalinization for fresh water, water-saving drip irrigation, and come up with an Aquifer Storage Recovery (ASR) scheme, artificial recharge and scheduled water extraction, in order to minimize the compounded effects of the Grand Ethiopian Renaissance Dam (GERD) and saline sea water intrusion along the Mediterranean coast. With Egypt now also facing a "contraceptive crisis," better government investment in family planning would also help for the longer term. But with the Nile no longer their birthright, and the Nile Delta gradually disappearing into the Mediterranean Sea, millions of Egypt's people will obviously need to look elsewhere for a promising future. Perhaps, a way out from the current crisis with Ethiopia, due to the construction of GERD, could be connecting Nile and Congo water system, through diverting water consideredto be as an alternative way of ensuring Egypt's water security, despite its inevitable engineering challenges being the Congo River and the White Nile River flow at different altitudes, and,thus, linking them would require construction of massive infrastructures (by digging a 600-km canal together with pumping stations and construction of huge dams) to transport water from the Congo Basin to the Nile Basin.

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