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FOREWARD

Blue Nile Water Institute is delighted to publish this first issue of the Abbay Journal of Water and Environmental Sciences (AJWES). The journal is named after the famous Abbay River, which is also called Blue Nile River. Abbay contributes about 85% of the water that makes up the Nile River. It is, therefore, a crucial resource for Ethiopia as well as downstream countries like Sudan and Egypt. Covering about 20% of national surface area, the Abbay River basin is home to about 29% of Ethiopia's over 120 million population and contributes about 44% of its total annual renewable freshwater resource of 124 BCM. Moreover, the basin has an estimated hydropower potential of about 78,800 GWh/year, which is roughly 50% the national hydropower potential. The largest freshwater lake in the country, Lake Tana, and the national flagship hydroelectric dam project, the Grand Ethiopian Renaissance Dam (GERD), are both located in this basin. Sustainable development and efficient utilization of land and water resources of the Abbay basin is, therefore, not a choice but a must for Ethiopia to support its economic growth and lift its people in the basin and beyond out of poverty.

However, development of the basin has faced complicated environmental and water use rights related problems. The major environmental problems include severe land degradation and accelerated erosion, siltation of lakes and reservoirs, water pollution and infestation of invasive species, particularly water hyacinth, while the water rights issue mainly arises mainly because of Egypt's intransigence to maintain the Colonial Nile Agreement which deprives Ethiopia of its natural right to use water originating from and flowing through its territory. Although a wide range soil and water conservation related research and development efforts have been made in the past several decades, the environmental problems still persist and are even getting more complicated because of the rapid population growth in the basin. Similarly, a lot of efforts have also been made in the negotiation and public diplomacy arena to ensure Ethiopia's natural right to equitably use of the Abbay River but reaching a binding agreement with Egypt and Sudan still remains a challenge.

The primary purpose of this journal is to promote a new academic discourse towards a sustainable development and equitable utilization of Abbay and the Nile by using the GERD as means of regional cooperation and economic integration. However, the journal is not limited to the Nile Basin. Any research and review papers on a wide range of water related issues such as hydrology and watershed management, irrigation and hydraulics, water supply and sanitation, aquatic and wetland ecosystems and water governance and socioeconomics of water will be accepted.

The papers published in this first issue are selected from those presented at the first *Abbay International Water Conference* which was organized by the Blue Nile Water Institute in September 2022. On behalf of Blue Nile Water Institute and Bahir Dar University, I once again thank all the authors of the papers for presenting their works at our conference and congratulate them to get their papers selected and published in this historical issue of the journal.

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Monitoring Water Withdrawal and Streamflow Data for Effective Water Resources Management in Lake Tana Sub-Basin

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Abstract

The Lake Tana sub-basin is one of Ethiopia's growth corridors with plans that include irrigation expansion. Despite the basin's expanding irrigation activity, there is little information on the rate of irrigation expansion, water withdrawal for irrigation and its impact on the sub-basin's water resources. This study focused on monitoring irrigation water withdrawal from small-scale irrigation schemes and the spatial variation of streamflow in the Gumara River, a major tributary to Lake Tana. For the irrigation water withdrawal monitoring small-scale irrigation schemes from seven districts that use river water diversions were chosen. The command areas of these irrigation schemes range from 20 to 200 ha of land. The monitoring was conducted for two years during the dry season when irrigation activities are dominant. Spot discharge measurements for Gumara River were done at seven locations on the main river at downstream and its tributaries at upstream. The results show that irrigation water withdrawals can range on average from 559 m³ day⁻¹ to 17824 m³ day⁻¹ at different schemes. The amount of water diverted mostly correlates with the size of the irrigated area and the size of the rivers. However, at some locations inefficient use of water was observed as the amount of water diverted was large for a relatively smaller irrigated area. The eastern part of the basin experiences lots of irrigation. The Gumara River at different locations showed water scarcity problem. At the downstream within a few kilometres difference between two locations where spot measurements were taken the discharge dropped by 2.8 m³/s during medium flow season. This suggested that there is substantial irrigation practice along the Gumara River, which was also confirmed through irrigation sites survey. Therefore, this study promotes monitoring irrigation water withdrawals and streamflow data at different locations to better manage the sub-basins water resources and avoid localized water scarcity.

Keywords: Irrigation Withdrawal, Streamflow, Monitoring, Spot Measurement, Lake Tana, Gumara

1. Introduction

The Lake Tana sub-basin is one of Ethiopia's growth corridors with plans that include irrigation expansion. Small-scale community managed irrigation schemes and farmer-led irrigations are becoming common in the sub-basin with surface water irrigation dominant in the uplands and groundwater use in the plains around Lake Tana (Worqlul *et al.*, 2015). Arguably, changes in irrigation use are more recent phenomena especially in the last 10-15 years where irrigation activities

are slowly getting attention and acceptance by farmers. Small-scale irrigation promotion by donors, non-governmental organizations and local governments is substantially supporting irrigation expansion in the sub-basin. Communities are benefiting from the expanding irrigation use with their livelihoods showing improvement (Ayele *et al.*, 2013). However, Kassie and Alemu, (2021) states that there is still work to be done to convert the increased income from irrigation to food security of the households.

In terms of irrigated area, Abera *et al.*, (2020) used remote sensing to show that irrigated area increased from 84,900 ha in 2006 to 121,400 ha in 2016. Although the estimated area coverage requires verification, it shows the undeniable expansion of irrigation in the last decade. Worqlul *et al.*, (2015) estimated about 20% of the Lake Tana sub-basin as suitable for surface irrigation, i.e., 130,508 ha. They indicated that while the average flow of Gilgel Abay and Gumara rivers is sufficient to irrigate the potential irrigable land in the dry season that of Ribb and Megech is not sufficient and can only cover 50% and 35% of potential irrigable area, respectively. With this, Gilgel Abay has the largest potential area for surface irrigation and Megech has the smallest potential area (Worqlul *et al.*, 2015).

Given this large potential, in recent years the use of irrigation during the dry season is increasing. Irrigation by small scale farmers cover more area than the large-scale irrigation schemes at Koga (fully operational) and Megech-Seraba (partially operational). Despite the basin's expanding irrigation activity, there is little information on the rate of irrigation expansion, water withdrawal for irrigation and its impact on the sub-basin's water resources. Taye *et al.*, (2021) showed the use of water for irrigation is causing water scarcity in the Gumara catchment, a major tributary to Lake Tana.

This study extended the information gathered in Taye *et al.*, (2021) on daily irrigation water withdrawn from rivers during dry season on selected sites of the sub-basin. The study also attempted to understand the spatial streamflow amount differences in connection with irrigation water withdrawal in Gumara catchment. This necessitated data collection at multiple spots of the Gumara River and its tributary rivers. The objective of this study is therefore to promote monitoring irrigation water withdrawals and streamflow data at different locations to better manage the sub-basins water resources and avoid local water scarcity issues.

2. Methodology

2.1 Study Area

Lake Tana sub-basin is located at the headwater of the Blue Nile (Abbay) river basin, in the North-western Ethiopia highlands (Figure 1). The sub-basin has area of about 15,321 km² out of which about 3000 km² is covered by the lake. There are four major rivers that feed Lake Tana and they account for 93% of the inflow (Kebede *et al.* 2006). These are Gilgel Abay, Gumara, Ribb and Megech rivers. In

addition to these major rivers, Lake Tana receives runoff from more than 40 small rivers, most of which are concentrated in the western part of the lake with small catchments and intermittent flows (Dessie *et al.* 2015; Rientjes *et al.* 2011). Annual rainfall can be above 2000 mm and on the lower side it can be around 800 mm (Figure 1). The mean annual rainfall is estimated as 1280 mm (Setegn *et al.* 2008). There is one major rainy season from June to September. The rest of the year is dry with small rainfall amount during March to May.

The main livelihood of the sub-basin is agriculture. Consequently, about 67% of the sub-basin area is used by smallholder farmers for rain-fed crop production (Abera *et al.*, 2020). Irrigation occurs during the November to May period in different parts of the sub-basin. This study selected small-scale irrigation schemes from seven districts for daily monitoring of irrigation water withdrawal. The locations of schemes are as shown in Figure 1. The details of the schemes' characteristics are given in Table 1. All these schemes are used by farmers for irrigation using furrow irrigation system. Most of these canals are lined except at two locations (Serja and Zuma, Figure 1 or Table 1).

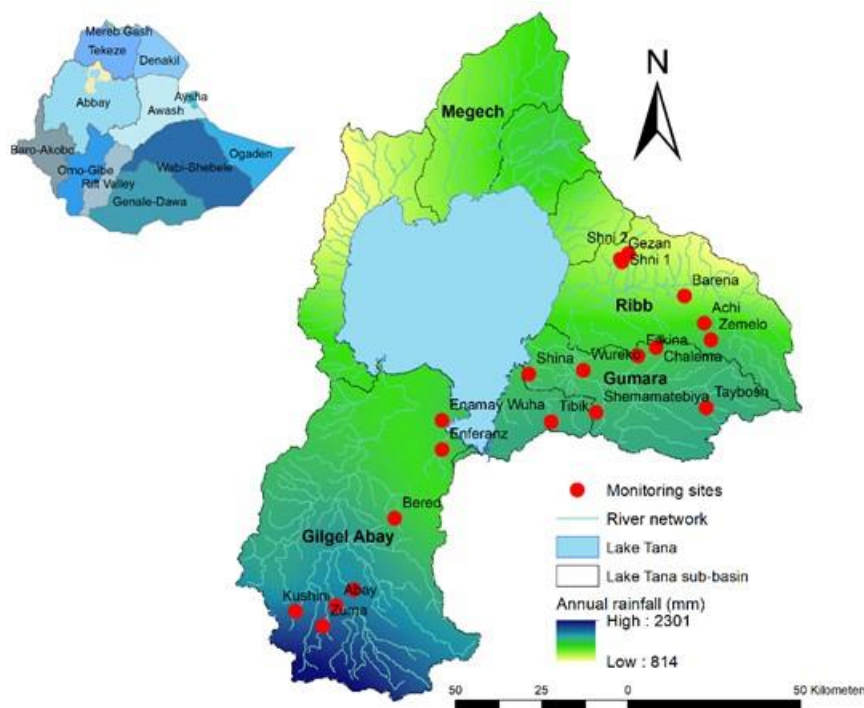


Figure 1. Lake Tana sub-basin and small-scale irrigation schemes used for water withdrawal monitoring

Table 1. Irrigation schemes considered in irrigation water withdrawal monitoring in the dry season of 2020-2022. December 2020 to May 2021, designated as Year 1 and November 2021 to May

No	District	Kebele	River name	Irrigated area (ha)	Monitoring year
1	Dangila	Afesa	Zuma	35	Y1, Y2
2	Dangila	Gayeta	Kuashini	200	Y1, Y2
3	Dangila	Wumbri	Abay	80	Y1
4	Dangila	Zelesa	Asher	25	Y2
5	North Mecha	Enamert	Bered	53	Y1, Y2
6	North Mecha	Dagi	Serja	59	Y1, Y2
7	North Mecha	Goragot	Goguwuha	20	Y1, Y2
8	Fogera	Hageresalam	Silkena	100	Y1, Y2
9	Fogera	Wotemb	Barena	40	Y1, Y2
10	Fogera	Bebeks	Wureko	61	Y1
11	Fogera	Chalema	Wondegri	50	Y2
12	Fareta	Aybaniba	Achi	48	Y1
13	Fareta	M/Tsion	Taybosh	60	Y1
14	Fareta	Terraroch	Zimelo	56	Y1
15	Bahirdar Zuriya	Wogelesa	Enferanz	157	Y1, Y2
16	Bahirdar Zuriya	Selecha	Enferanz	64.5	Y1, Y2
17	Bahirdar Zuriya	Wonjeta	Enamaywuha	48.5	Y1, Y2
18	Dera	Tebabari	Shemamatebiya	146	Y2
19	Dera	Kulala	Tibik	70	Y2
20	Dera	Wagera	Shina	101	Y2
21	Libo kemkem	Addis zemen 04	Shini 1	95	Y2
22	Libo kemkem	Angot	Shini 2	60	Y2
23	Libo kemkem	Gizana	Gezana	115	Y2

2022 as year 2. Y1 refers to year 1 and Y2 refers to year 2

2.2 Irrigation Water Withdrawal Measurement

For the irrigation water withdrawal monitoring small-scale irrigation schemes from seven districts that use river water diversions were chosen. The command areas of these irrigation schemes range from 20

to 200 ha of land (Table 1). In each district three rivers were considered for measurement. The water withdrawal monitoring was conducted by district and *kebele* level experts for two dry season periods. These periods were December 2020 to May 2021, designated as Year 1 and November 2021 to May 2022 designated as Year 2 hereafter.

In Year 1, only 15 schemes were monitored from five districts and in the second year 19 schemes were considered from seven districts. The difference in the number of schemes in the two years occurred because of the difference in the level of support obtained from the district level experts in the two years. Also, there was a security challenge in different districts in either of the years. In Year 2 learning from the previous year experience additional two districts (Dera and Libo kemkem) were considered while one of the districts (Fareta) from the Year 1 was dropped.

Experts were identified from each *kebele* who could measure the canal velocity at daily basis. They were supervised by the district agriculture or irrigation experts. On-site training was given for data observers and supervisors before the start of data collection. The training was mainly focused on how to use float method for velocity measurement and the use of data collection form prepared by this study researchers.

In these schemes, farmers apply water using furrow irrigation method and water is diverted from the rivers for 24 hours. Water withdrawal was monitored using float method. The monitoring was repeated three times for one measurement and the average value was used. This monitoring was conducted during the morning and late afternoon hours. Since the float method provides only surface velocity, we used the commonly adopted correction factor of 85% to obtain average canal velocity of each scheme.

To obtain the volume of water withdrawal data collectors measured the wetted depth of the canal and the canal width (a constant value). The canals in this study were of rectangular shape. These values were multiplied with the canal velocity to estimate the water withdrawal amount. To convert daily measurements to volume per day we used the time factor 24 hrs. This is supported by the information from the farmers on the constant and continuous (day and night) water diversion from the river to the canals.

We used descriptive statistic to summarize the measured water diversion from the rivers. These are daily minimum and maximum discharge to show the range of the variation within the observation period, the dry season, standard deviation, and coefficient of variation were also used to quantify the variability during the irrigation period. The mean value is used to compare the differences between the monitored schemes in the sub-basin.

2.3 Spot Discharge Measurement

During Year 1 the Gumara catchment was found to be facing water scarcity challenges as rivers have gone dry during irrigation season (Taye *et al.*, 2021). Given that the national river gauging site of Gumara River is located at its outlet, it cannot capture the spatial variations of streamflow amount at different locations that can occur due to irrigation water withdrawal. Therefore, to better understand the spatial water availability in the catchment we measured the Gumara River and its tributaries from upstream to downstream location at seven locations (spots). Two measurements were conducted during the medium and low flow seasons where irrigation water withdrawal is common.

Spot discharge measurements were done at seven sites along the Gumara River. Current meter (SEBA mini current meter) was used to measure the river velocity below the water surface at a depth of 0.6 times the flow depth. SEBA mini current meter is capable of flow velocity measurement for streams, rivers, and channels with low water level. Since flow velocity varies laterally across the rivers, the cross-section was divided into multiple segments and the flow velocity and flow depth were measured for each segment. We estimated the discharge of each segment by multiplying the flow velocity by the measured flow depth and segment width. The total discharge at each measurement site was estimated as a sum of the discharge of the segments. River discharge variation from the upstream to the downstream of Gumara was then analysed by comparing the discharges of the seven spot measurement sites.

To understand the extent of irrigation sites in the Gumara catchment, a field survey was conducted at a total of 674 locations. In these locations some have individual pumps and others have a group of pumps (up to 40 pumps in 100 meters distance) in one location to divert river water to farmlands. Also, other structures for water abstraction that are used in this catchment from springs and groundwater sources are explored in the survey.

3. Results and Discussion

3.1 Irrigation Water Withdrawal

Depending on the site, the withdrawal of water diverted from rivers ranged from 559 m³ day⁻¹ to 17824 m³ day⁻¹ on average during Year 1 (Table 2). In Year 2 the withdrawal of water diverted from rivers ranged from 1039 m³ day⁻¹ to 16230 m³ day⁻¹ (Table 3). The daily diversion shows variability during the dry season. At most schemes the variability is less than 50%. In Year 1 two schemes from Bahir Dar zuria district show 60% and above coefficient of variation. In Year 2 two schemes in Fogera district show the highest variability. In all cases water diversions were the highest during the start of the irrigation season and they show decreasing trend until the end of the irrigation season.

The amount of water diverted mostly correlates with the size of the irrigated area and the size of the rivers (Figure 2). However, in some schemes high amount of water is diverted to irrigate only small hectares of land (e.g., at location Enferanz W). This indicates how water is not used efficiently in

these schemes. In other cases, the reported irrigated area is large while the amount of water diverted is relatively low. This might show inaccurate estimation of irrigated area by the local officials. Water abstraction rates for each scheme can be estimated by dividing the volume of diverted water by the irrigated area. The total annual water abstraction in the sub-basin can be estimated using these water abstraction rates multiplied by the total irrigated area data that is annually monitored by each district's agriculture bureaus.

Table 2. Summarized descriptive statistics for daily measured water diversion from five districts representing the daily average (mean), the maximum (max) and minimum (min) daily diverted water, the standard deviation (Std), and coefficient of variation (CV) during the data collection in Year 1

District name	River	Measured flow statistics (m ³ day ⁻¹)				CV
		Mean	Max	Min	Std	
Dangila	Abay	13784	19079	11048	886	6%
	Kuashini	13461	18512	8885	2016	15%
	Zuma	10611	24538	1652	3828	36%
Bahir Dar zuria	Enferanz W	17824	81242	4628	11353	64%
	Enferanz S	9166	61435	4918	5502	60%
	Enamay Wuha	2300	3317	1385	434	19%
Mecha	Bered	3500	6253	1771	1353	39%
	Gogu Wuha	2020	4117	1201	526	26%
	Serja	4009	6249	2289	827	21%
Fogera	Barena	559	1157	311	131	23%
	Wureko	9074	12104	5754	973	11%
	Silkena	1928	4009	713	809	42%
Farta	Achi	1674	3307	501	615	37%
	Taybosh	2062	3800	218	893	43%
	Zemeha	1144	2151	326	393	34%

Table 3. Summarized descriptive statistics for daily measured water diversion from seven districts representing the daily average (mean), the maximum (max) and minimum (min) daily diverted water, the standard deviation (Std), and coefficient of variation (CV) during the data collection in Year 2

District Name	River	Measured flow statistics (m ³ day ⁻¹)				CV
		Mean	Max	Min	Std	
Dangila	Kuashini	16230	27575	11374	2964	18%
	Zuma	4467	9076	2510	1504	34%

District Name	River	Measured flow statistics (m ³ day ⁻¹)				
		Mean	Max	Min	Std	CV
Bahirdar Zuriya	Asher	3991	5508	3219	383	10%
	Enamay Wuha	3047	4722	2404	755	25%
	Enferanz W	13113	26352	13087	4575	35%
	Enferanz S	8916	17,501	7471	1365	15%
	Bered	4,665	7,824	2728	1331	29%
Mecha	Goguwuha	1,767	2,840	1081	453	26%
	Serja	4,110	6,767	2926	737	18%
	Barena	1,140	6381	667	848	73%
Fogera	Wondegri	1,039	1619	869	190	18%
	Silkena	2,966	14263	308	2673	90%
	Shemamatebiya	1699	2037	1654	99	6%
Dera	Tibik	7340	10434	7933	382	5%
	Shina	11682	13133	10344	727	6%
	Shini 1	2431	4077	1137	603	25%
Libokemkem	Shini 2	1808	3756	369	488	27%
	Gezana	2113	4833	1024	820	39%

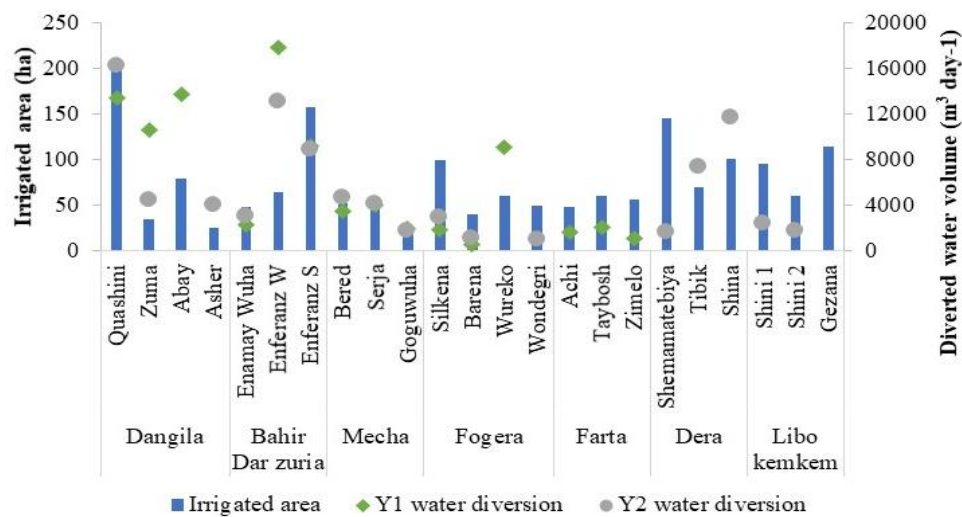


Figure 2. Irrigated area correlation with water withdrawal volume in Year 1 and Year 2 at the irrigation schemes surveyed for this study.

3.2 Spot Discharge Values along Gumara

Based on the spot discharge measurement, there is a decrease in water flow from upstream to downstream along the main Gumara River. For example, the quantity of Gumara discharge at

Wanzaye (Figure 3) is $8.3 \text{ m}^3 \text{ s}^{-1}$ during medium flow season and $0.55 \text{ m}^3 \text{ s}^{-1}$ during low flow season. The Gumara river at downstream of Wanzaye (Figure 3) location is $5.6 \text{ m}^3 \text{ s}^{-1}$ during medium flow season and $0.54 \text{ m}^3/\text{s}$ during low flow season. Within a few kilometres difference between the two locations, the discharge dropped by $2.8 \text{ m}^3 \text{ s}^{-1}$ during medium flow season and $0.01 \text{ m}^3 \text{ s}^{-1}$ during low flow season. This suggested that there is substantial irrigation practice along the Gumara River. This is also evidenced from the irrigation sites' location survey as shown in Figure 4. The area between Wanzaye and the downstream point is crowded with irrigation sites pumping from the river (Figure 4).

At the downstream area, the river has higher amount of water that comes from tributary rivers and back flow of water from the Lake. However, in the middle at different tributary rivers (Sensawuha and Meterey) where irrigation activities are high (Figure 4) and at the upstream of the catchment rivers have low amount of flow (Table 4). These rivers usually experience drying or very low flow during the peak irrigation season (Table 4).

It is therefore important to understand the spatial differences of water availability in the catchment regarding the different activities that occur to devise proper planning of water use. This study demonstrates that such type of flow monitoring is doable and critical for better long-term water management, allocation among different users including upstream-downstream water sharing, and locations that face water scarcity due to high water withdrawal.

Table 4. Measured discharge amount during medium and low flow seasons at the seven spot measurements' locations

No.	Spot locations	Medium flow ($\text{m}^3 \text{ s}^{-1}$)	Low flow ($\text{m}^3 \text{ s}^{-1}$)
1.	Upper Gumara 1	0.06	0.01
2.	Upper Gumara 2	0.35	0.09
3.	Sensawuha	0.91	0.13
4.	Meterey	0.27	0.08
5.	Sebat wodel	0.40	0.03
6.	Wanzaye	8.30	0.55
7.	Downstream of Wanzaye	5.63	0.54

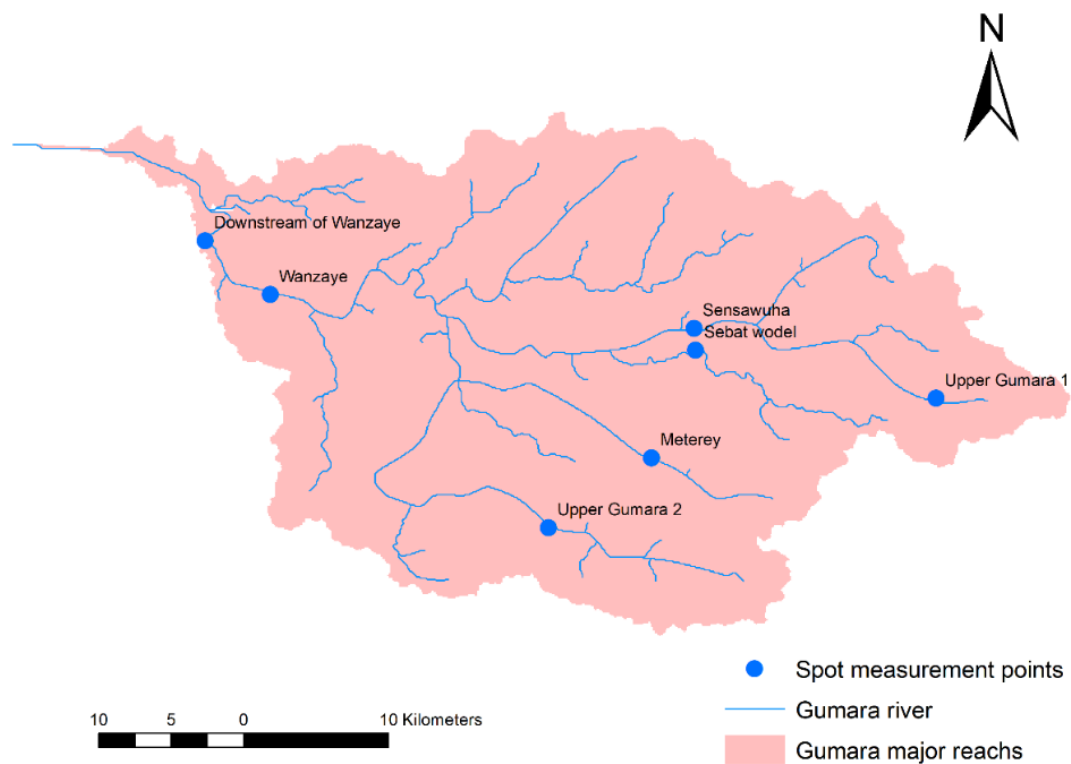


Figure 3. Spot measurement locations in the Gumara catchment

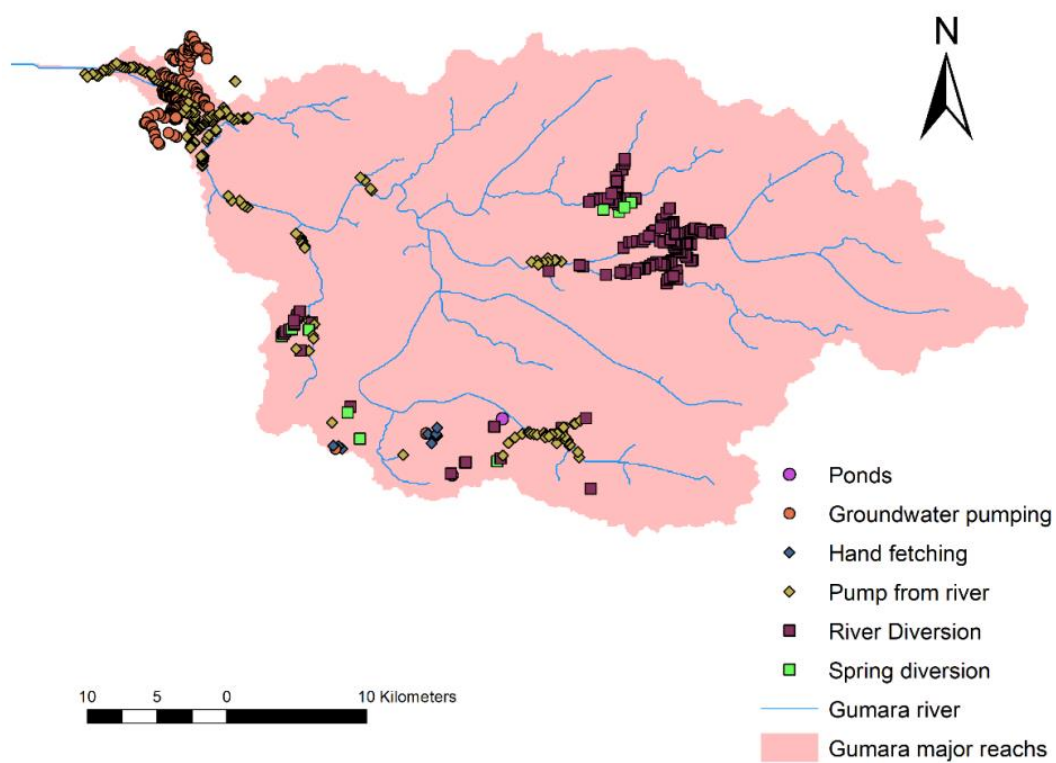


Figure 4. Irrigation sites surveyed in the Gumara catchment

4. Conclusions and Recommendations

Agriculture takes the largest share in the sub-basin's livelihood and irrigation is gaining more attention by farmers. Monitoring water withdrawal used for irrigation and streams amount at different locations will assist in understanding localized water scarcity challenges and finding appropriate solutions. In the Lake Tana sub-basin surface water is the dominant source of water, and it provides about 80% of irrigation withdrawals in the sub-basin (Taye *et al.* 2022). Due to uncontrolled abstraction localized water scarcity is happening in different locations, especially in the eastern part of the sub-basin. In some locations water is diverted in high amount while the irrigated area is not as big. Such conditions show water efficiency problems as water is lost without beneficial use can be very high. This is due to the current types of irrigation methods (mostly furrow irrigation) and available irrigation infrastructure as also discussed in Abera *et al* (2020).

The absence of a database that collects information on actual irrigated area and water withdrawal amount can be something that can be improved by the concerned government organizations. This study suggests that irrigation withdrawal monitoring needs to be adopted by district or kebele level water or agriculture offices. This is important given that irrigation is increasing and the impact on the hydrology will increase in the coming years. As water resources become limited efficient use and water allocation can only be supported if proper monitoring can be conducted regularly.

In already water stressed catchments such as the Gumara River, spot discharge measurements are important to understand the localized differences in water scarcity. This study suggests that other researchers to take lesson from this experiment and continue to conduct similar measurements so that knowledge is built in the area about the relationship between irrigation water withdrawal and the river discharge. This is helpful to understand the temporal changes of withdrawal and rivers amount over the years. Additionally, it will be useful to better understand the upstream and downstream linkage in water use.

Researchers are also encouraged to consider such kind of measurements in their research. From such type of monitoring empirical relationships, change detection, upstream and downstream linkage can be observed. Future studies can explore sustaining the monitoring through community-based approaches and in collaboration with relevant local institutions. Learning from previous research activities conducted by the International Water Management Institute can be scaled up at watershed, catchment, and sub-basin scales.

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Sediment Yield Prediction Using Hydrological Models in Upper Gilgel Abbay and Megech Watersheds, Upper Blue Nile Basin, Ethiopia

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Abstract

Soil erosion, land degradation and loss of agricultural soils are major problems in Upper Blue Nile Basin of Ethiopia. The parameter efficient semi-distributed watershed model (PED-WM), soil and water assessment tool (SWAT) and the generalized watershed loading function (GWLF) are tested for the prediction capability of sediment yield in the Megech and Upper Gilgel Abbay watersheds. Model calibration and validation for the suspended sediment yield for Upper Gilgel Abbay and Megech watersheds was applied from 1997-2007 and 2008-2012; and 2000-2010 and 2011-2014, respectively. NSE, R² and PBIAS were used to evaluate the model performance. The monthly time step model efficiency of PED-W for Upper Gilgel Abbay watershed was found R², NSE and PBIAS (0.89, 0.77, -8.5) and (0.82, 0.81, 5.87) and for Megech watershed (0.85, 0.71, 6.54) and (0.83, 0.72, 12.1) during calibration and validation periods, respectively. On the other hand, the SWAT model efficiency for Upper Gilgel Abbay watershed was (0.84, 0.84, -2.7) and (0.62, 0.62, 3.5) and for Megech watershed (0.64, 0.63, 17.9) and (0.63, 0.60, 27.9) during calibration and validation period respectively. Whereas the efficiency of GWLF model was obtained (0.76, 0.58, -21.24) and (0.76, 0.60, -5.2) for Upper Gilgel Abbay watershed and (0.76, 0.57, 22.42) and (0.73, 0.58, 20.89) were for Megech watershed during calibration and validation period respectively. The result shows that almost all model performance ranges from satisfactory to very good agreement. The overall model performance indicated that PED-WM model was more appropriate model to predict sediment yield than SWAT and GWLF models.

Key words: Hydrological model, Gilgel Abbay, PED-WM, SWAT, GWLF and Megech

1. Introduction

Soil erosion and land degradation are a natural process causing soil loss and generating sediment yield from catchment area even in the absence of human alterations on land cover. Soil erosion by water occurs in two phases, involving the detachment of discrete particle sizes from the soil mass and their transport by erosive agents, and when sufficient energy is no longer offered to transport the particles to the surface, deposition occurs (Morgan *et al.*, 1998). Renard (1997) noted that sediment transport is largely a role of topography and runoff velocity while deposition is a function of runoff velocity and sediment particle sizes. Bai *et al.* (2008) stated that soil erosions by runoff a major environmental

problem, occupying 56% of the world-wide area. Also, the study indicated that soil loss is accelerated by human-induced soil degradation.

Soil erosion by water is particularly a serious problem in the high-rainfall Ethiopian highlands (Zimale *et al.*, 2018). Similarly, as stated by Easton *et al.* (2010) soil erosion is arguably the virtually solid problem in the Blue Nile Basin, as it limits agricultural productivity in Ethiopia, erode benthos in the Nile, and results sedimentation of dams in downstream countries. According to Constable (1985) soil erosion considered to be a major agricultural problem in Ethiopia, particularly in the high lands (above 1500 m a.s.l) which constitute 43% of the total area of the country. The poor land use practice, improper land management and lack of a suitable soil conservation actions have played a major character in land degradation problem in Ethiopia (Setegn *et al.*, 2008). Due to the silting of the reservoir, it is the most challenging problem in the Upper Blue Nile basin (Assfaw, 2019). So that estimation of sediment yields at the outlet of the watershed is necessary in order to establish mitigation measures along the watershed. Knowing the reliable amount of sediment yield collected at the outlet of the watershed is important to establish soil conservation measures at upstream of the watershed outlets. To compute the reliable amount of sediment yield deposited at the watershed outlet, hydrological models are needed.

Hydrological models are essentially a vital instrument in hydrologic response simulating for the utilization such as water resource management efforts, flood regulation and water quality evaluating (Wagener *et al.*, 2010). They define the natural processes controlling the transformation of precipitation to runoff, whereas erosion modeling is focus on understanding the natural laws of processes that happen in the natural landscape (Setegn *et al.*, 2009). Most of hydrological and erosion models are developed to express the hydrology, erosion and sediment yield processes (Oeurng *et al.*, 2011).

These models are useful tools to understand the problems and help to identify acceptable solutions through best management practices (Borah and Bera, 2003). Applying the best management practice is good to soil conservation and land degradation, as well as useful to have information on spatial distribution of runoff (Moges *et al.*, 2017) and sediment (Setegn *et al.*, 2009). Thus, models for estimating sediment yield based on different management scenario are very important for reducing threats of the soil erosion.

The amount of surface erosion in the basin area and the rate of sediment transport in the channel stream contributes sedimentation problem in lakes, reservoirs and downstream areas (Setegn *et al.*, 2009). In the Blue Nile Basin, many water-related projects have been constructed for the purpose of water supply, irrigation, hydroelectric power and etc. However, most of the structures are affected by sediment deposition, and this leads to reduction of reservoir storage capacity and reduce the functionality of structure. The Lake Tana basin is one of the most affected area by soil erosion, soil

transport and land degradation (Setegn *et al.*, 2009). Setegn *et al.* (2009) stated that sediment yield is excess of 30 tons_{ha}-1 for each of the Lake Tana catchment area (18.4% of the watershed) was observed to be high-level erosion potential area.

The Megech watershed faced high sedimentation, and the mean annual sediment yield increased by 33.3% from 1998 land use land cover to 2016 land use land cover (Assfaw, 2020). To minimize sedimentation problem of the watershed, best soil conservation practices should be applied upstream of the watershed. However, to apply soil conservation practice upstream of the watershed, the reliable quantity of sediment yield in the watersheds must be estimated. So, in order to compute the reliable amount of sediment accumulation in Megech and Upper Gilgel Abbay watershed outlets, reliable hydrological models are needed.

One of the critical problems of Megech and Upper Gilgel Abbay watershed knows the best hydrological models for sediment yield prediction of the watershed for planning, designing and implementation of soil and water conservation practice. As a result, it is difficult to manage the sediment problem in proper manner. In addition, mostly Megech and Upper Gilgel Abbay sub basin has no long-time record data to estimate sediment yield, for suitable soil conservation practice.

In this study, the main objective is to evaluate sediment yield predictive capability of hydrological models in selected watersheds and evaluating the sediment yield at the watershed outlet, and the temporal variation of sediment yield in the watershed. Lastly, the hydrological model which performs reliable and best estimation of sediment yield for the selected watersheds will be determined.

2 Materials and Methodology

2.1 Description of the Study Area

Megech, and Upper Gilgel Abbay watersheds, are located in Abbay basin, in the Northern part of the Ethiopia highlands. The Megech River flows in the southern direction into Lake Tana (Assfaw, 2020). The mean annual rainfall of the watershed is around 1,130 mm, with 79% of it occurs between June and September. The total area of this watershed is 507 km².

The Gilgel Abbay River is the longest flow path of all the tributary rivers that drains to Lake Tana. The watershed has an area of 1660 km², like other watersheds of the basin, the main rainy season starts in June and extends to September, which accounts about 70 to 90% of annual rainfall (Kebede *et al.*, 2006, Tarekegn and Tadege, 2006). Figure 1 shows the location of study areas.

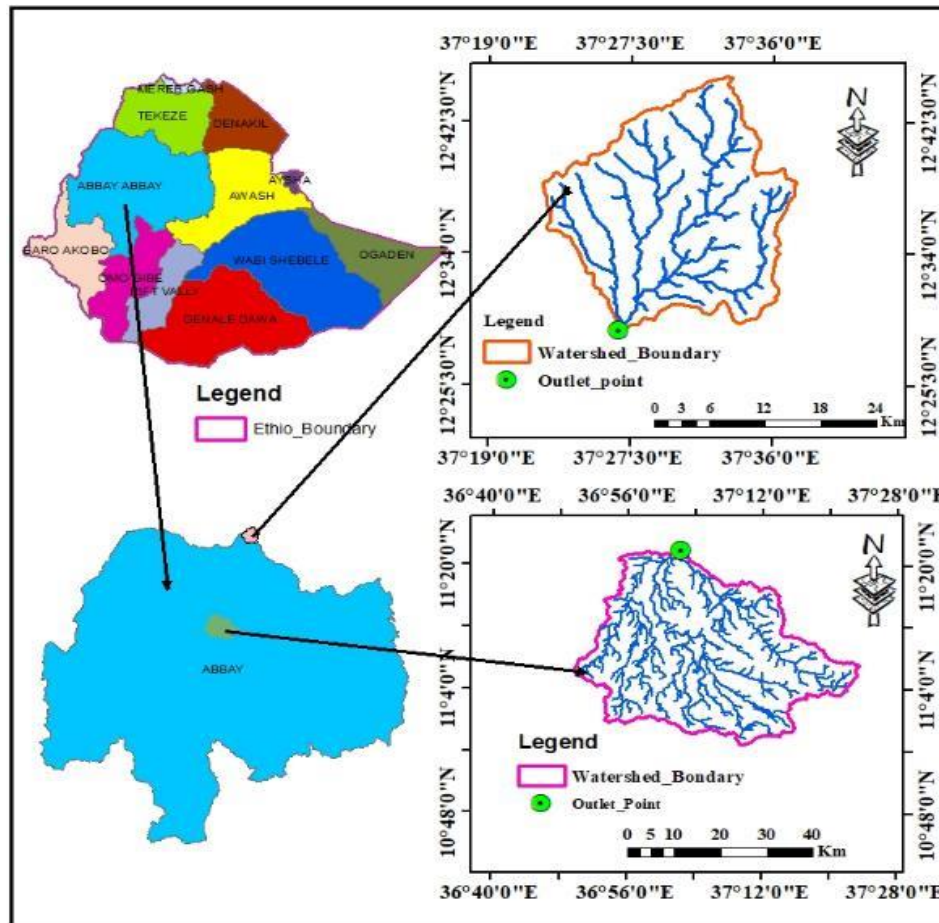


Figure 1. Location of Megech and Upper Gilgel Abbay Watershed

2.2 Data Collection and Analysis

The topography of the selected watersheds is described by using Digital Elevation Model (DEM) which was collected from Ministry of Water and Energy (MoWE). According to Weigel (1986) almost 62.63 percent of Megech watershed slope area lies from steep to very steep slope and 60.99% of Upper Gilgel Abbay watershed area lies from sloping to moderately steep slope.

Table 1. Topographic characteristic of the two watersheds based on slope (source: Weigel (1986)).

Slope (%)	Upper Gilgel Abbay	Megech	Description
	Area Coverage (%)	Area Coverage (%)	
0-2	3.65	6.67	Flat
2-10	44.65	20.68	Sloping
10-15	16.34	15.9	Moderately Steep
15-30	23.94	35.75	Steep
>30	11.5	26.88	Very Steep

Table 2. Land use/ Land cover and Soil type of Megech and Upper Gilgel Abbay watersheds

LULC	Megech	Upper Gilgel Abbay	Soil type	Megech	Upper Gilgel Abbay
	Coverage (%)			Coverage (%)	
Forest Land	1.43	1.24	Eutric Leptosols	0.71	-
Shrubs Cover	1.88	0.4	Humic Nitisols	12.62	-
Grass Land	4.98	1.35	Lithic Leptosols	70.63	-
Crop Land	90	96.7	Eutric Vertisols	13.16	1.85
Built Up Area	1.52	0.2	Haplic Luvisols	2.89	55.94
Open Water	0.13	0.1	Eutric Regosols	-	0.81
			Hapic Alisols	-	40.76
			Haplic Nitisols	-	0.64

2.2.1 Metrological Data Collection and Analysis

Daily precipitation, daily temperature (maximum and minimum), sunshine hour, relative humidity and wind speed were collected from national meteorological agency Bahir Dar branch. Identifying the meteorological station which influences on the watershed are critical points to analysis meteorological data. Therefore, by using Thiessen polygon in ArcGIS 10.5, the nearest station which influenced in the watershed was selected depends on the available climatic variable, length of record period and weight of influence or coverage of the watershed. Therefore, the four meteorological stations which have an influence on the Megech watershed are Ambageorgies, Gonder, Maksegnit and Shembekit meteorological stations and six meteorological data stations which have an influence on Upper Gilgel Abbay watershed are Dangla, Enjibara, Wotet Abbay, Sekela, Kessa and Quarit.

2.2.2 Hydrology and Sediment Data

Both the daily streamflow and sediment data were collected from the Ministry of Water and Energy (MoWE), from 2000 to 2014 at Azezo gauging station for Megech and from 1997 to 2012 at Merawi gauging station for Upper Gilgel Abbay. Unlike streamflow data, sediment data records exhibit several missing. Due to the lack of continuous suspended sediment records, the sediment rating curve was developed for this particular study by using the measured sediment records as a function of the corresponding streamflow values. The sediment rating curve is a widely applicable technique for estimating the suspended sediment load being transported by a river. It signifies a relationship between the stream discharge and sediment concentration or load (Clarke, 1994). The general relationship of suspended sediment rating curve is given by Eq. (1).

$$Q_s = a * Q^b \dots \dots \dots (1)$$

where: Q_s is sediment load in $t\ day^{-1}$, Q is the stream discharge in $m^3\ s^{-1}$ and a & b are regression constants. The measured suspended sediment concentration ($mg\ l^{-1}$) was converted into sediment load ($t\ day^{-1}$) by using the following formula:

$$S = 0.0864 \times Q \times C \dots \dots \dots (2)$$

where: S is sediment load in ($t\ day^{-1}$), Q is streamflow ($m^3\ s^{-1}$), C is sediment concentration ($mg\ l^{-1}$) and 0.0864 is conversion factor. The suspended sediment rating curve equation for Megech and Upper Gilgel Abbay watershed is shown in Figure 2 and Figure 3 respectively.

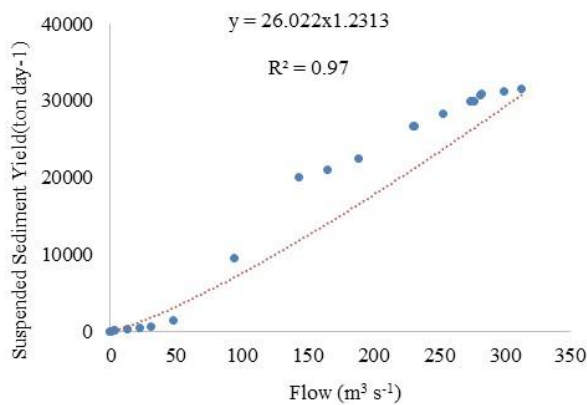


Figure 2. Suspended sediment rating curve for Megech watershed

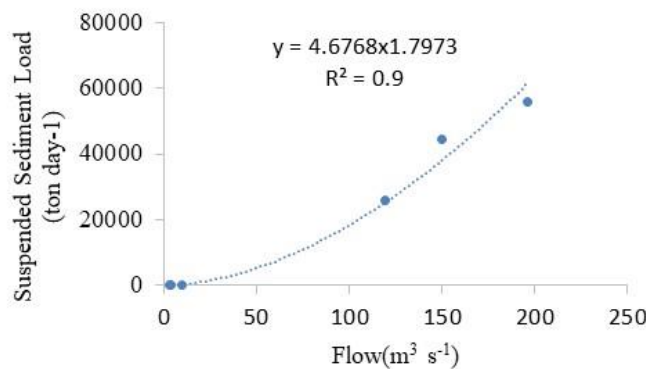


Figure 3. Suspended sediment rating curve for Upper Gilgel Abbay watershed

2.3 Watershed Models Selection

Three watershed models, namely Soil and Water Assessment Tool (SWAT), Parameter Efficient Semi-Distributed Watershed Model (PED), and Generalized Watershed Loading Function model (GWLFL) were used to evaluate the sediment yield prediction capability of Megech and Upper Gilgel Abbay watersheds.

2.3.1 SWAT Model

SWAT is a physically-based continuous model for catchment scale simulations (De Vente *et al.*, 2013, Setegn *et al.*, 2008). The main input data to the SWAT model are: daily climate data, DEM, soil, land use/ land cover, observed discharge and sediment. Model calibration and validation for the

suspended sediment yield for Upper Gilgel Abbay and Megech watersheds was applied from 1997-2007 and 2008-2012; and 2000-2010 and 2011-2014, respectively.

The model was used for discharge and sediment yield simulation by dividing the watershed into sub watershed and the sub watershed also subdivide into small hydrologic response units (HRUs) which have the same soil, land use and slope classes.

SWAT calculates the surface erosion and sediment yield caused by rainfall and runoff within each HRU with the Modified Universal Soil Loss Equation (MUSLE), (Williams, 1975). MUSLE is a modified version of the Universal Soil Loss Equation (USLE) developed by (Wischmeier and Smith, 1978). While the USLE uses rainfall as an indicator of erosive power of energy, MUSLE uses the amount of runoff to simulate erosion and sediment yield. The modified universal soil loss equation is determined by Eq. 3 (Williams, 1995).

$$Sed = 11.8 * (Q_{surf} * q_{peak} * area_{hru})^{0.56} * K_{USLE} * C_{USLE} * P_{USLE} * L_{USLE} * CFRG \dots (3)$$

Where, Sed is sediment yield on a given day (metric tons), Q_{surf} is the surface runoff volume (mm/ha), q_{peak} is the peak runoff rate ($m^3 s^{-1}$), $area_{hru}$ is the area of the HRU (ha), K_{USLE} is the soil erodibility factor (0.013 metric ton m^2 hr (m^3 metric ton cm)), C_{USLE} is the cover and management factor, P_{USLE} is the support practice factor, L_{USLE} is the topographic factor, and CFRG is the coarse fragment factor.

2.3.2 PED-W Model

The PED model represents the local hydrological and erosion processes. It classifies the watershed into two runoff producing areas (periodically saturated areas and degraded hill slopes) and one recharge area (permeable hill slopes) that release the excess precipitation, the base flow and interflow. The two runoff producing areas are assumed to be sources of sediment while the base flow may pick up sediment at low concentrations from the banks. The hydrology model inputs are limited to precipitation, potential evapotranspiration, and nine landscape parameters. The sediment model uses the discharges predicted by the hydrology model and maximum six parameters for the erodibility of the soil at the beginning and end of the rainy phase for each of the three areas.

The model input data requirement for PED model are daily precipitation, evapotranspiration, the areal fraction, maximum storage for each zone and the inter flow and base flow time. Discharge and sediment yield data were used for calibration and validation of the parameter efficient distributed model (PED).

i. Hydrology module

The hydrology module will divide the watershed into three major areas, such as runoff contributing areas, degraded areas and hill slope areas. Runoff contributing areas were in turn divided into two:

bare hardpan or bed rock catchment which produces runoff for little rainfall and the flatter bottom lands which produce runoff after saturation. The discharge Q at the outlet is written as:

$$Q = A_1 Q_1 + A_2 Q_2 + A_3 (Q_B + Q_I) \dots \dots \dots (4)$$

where Q_1 and Q_2 are saturation excess runoff from saturated and degraded areas (mm d^{-1}), Q_B and Q_I are base flow and interflow (mm d^{-1}), A_1 , A_2 and A_3 are area fractions of the saturated, degraded areas and the recharge hillside area, respectively.

Surface runoff generated from the saturated and degraded area was calculated by using Eq. 5 (Moges *et al.*, 2016):

$$Q_{\text{sur2}} = \frac{S_{t-\Delta t} - S_{\text{max}} + (P - \text{PET})\Delta t}{\Delta t} \dots \dots \dots (5)$$

When, $(P - \text{PET})\Delta t > S_{t-\Delta t} - S_{\text{max}}$

The base flow, Q_B and the inter flow, Q_I are then obtained as) (Steenhuis *et al.*, 2009, Tilahun *et al.*, 2013b, Moges *et al.*, 2016).

$$Q_B = BS_t \left(\frac{1 - \exp(-\alpha \Delta t)}{\Delta t} \right) \dots \dots \dots (6) \quad \text{when } BS_t > BS_{\text{max}}$$

$$Q_I = \sum_{\tau=1}^{\tau^*} (2 * P_{\text{erc,I}} (\tau^* - \tau) \left(\frac{1}{\tau^*} - \frac{\tau}{\tau^{*2}} \right), \tau \leq \tau^* \dots \dots \dots (7)$$

where $\alpha = 0.69/t_{1/2}$ and where $t_{1/2}$ is time taken in days to reduce volume of the base flow reservoir by half under no recharge conditions; τ is the day after the rainstorm and $P_{\text{erc,I}}$ is the amount of the percolate that reached the interflow storage and is calculated as the recharge in excess of what can be stored in the base flow reservoir, and τ^* is the duration of interflow after any rainstorm.

ii. The sediment module

In the sediment model, the two runoff source areas, (the saturated and degraded areas), are considered the main sources of sediment. Sediment yield is computed based on the suspended sediment concentration and the discharge of the rivers (Tilahun *et al.*, 2013a). Erosion originates from the runoff producing region.

The concentration of sediment, C (g l^{-1}), in the river is obtained by dividing the sediment yield by the total watershed predicted discharge from the hydrological model.

$$C = \frac{A_1 q_{r1}^{1.4} [\alpha_{s1} + H(\alpha_{t1} - \alpha_{s1})] + A_2 q_{r2}^{1.4} [\alpha_{s2} + H(\alpha_{t2} - \alpha_{s2})]}{A_1 q_{r1} + A_2 q_{r2} + A_3 (Q_B + Q_I)} \dots \dots \dots (8)$$

where the subscript numbers refer to the three areas introduced with Eq. 4, Q is the runoff (mm day⁻¹) calculated with the hydrology model, i.e., Q₁, Q₂ are calculated with Eq. 5, and Q₃ is the sum of Q_B in Eq. 6 and Q₁ in Eq. 7.

2.3.3 GWLF Model

GWLF model has been developed by (Haith and Shoemaker, 1987). The model predicts streamflow and sediment by a water-balance method, based on measurements of daily precipitation and the mean average daily temperature. Erosion and sediment yield are estimated using monthly erosion calculations based on the Universal Soil Loss Equation (USLE) algorithm, which predicts the mean soil erosion, using the component parts of rainfall energy (Wischmeier and Smith, 1978). Erosion from source area k on day t (Mg) is given by:

$$X_{kt} = 0.132 * RE_t * K_k * (LS)_k * C_k * P_k * AR_k \dots \dots \dots (9)$$

in which K_k, (LS)_k, C_k, and P_k are the typical values for soil erodibility, topographic, cover and management and supporting practice factors as specified for the Universal Soil Loss Equation (Wischmeier and Smith, 1978). RE_t is the rainfall erosivity on day t (MJ-mm/ha-h). The constant value 0.132 is a dimensional conversion factor related with the SI units of rainfall erosivity.

The total watershed sediment yield generated in month j (Mg) is

$$SX_j = SDR \sum_{t=1}^{d_j} X_{kt} \dots \dots \dots (10)$$

where SDR is the watershed sediment delivery ratio. The transport of this sediment from the watershed is depends on the transport rate of runoff during that month. A transport factor TR_j is defined as:

$$TR_j = \sum_{t=1}^{d_j} (Q_t)^5 / 3 \dots \dots \dots (11)$$

The sediment supply SX_j is allocated to months j, j + 1, ..., 12 in proportion to the transport rate for each month. The total transport rate for months j, j + 1, ..., 12 is proportional to B_j, where

$$B_j = \sum_{h=j}^{12} TR_h \dots \dots \dots (12)$$

The total monthly yield is the sum of all contributions from preceding months:

$$Y_m = TR_m \sum_{j=1}^m \left(\frac{X_j}{B_j} \right) \dots \dots \dots (13)$$

3. Results and Discussion

3.1 SWAT, PED-W, and GWLF Model Calibration and Validation

All the model parameters were calibrated on a monthly time series from 1997-2007 and 2008-2012; and 2000-2010 and 2011-2014, for Upper Gilgel Abbay and Megech watersheds respectively. The parameters are first determined by maximizing the efficiency criterion of the Nash–Sutcliffe efficiency coefficient (NSE), then the coefficient of determination (R^2), and percent bias (PBias).

3.1.1 Calibration and Validation of SWAT Model for the Sediment Yield

Six sensitive parameters were selected for sediment calibration and validation for SWAT model. Linear parameter for computing the maximum quantity of sediment that can be restrained during stream sediment routing (Spcon), channel cover factor (Ch-Cov1 & Ch-Cov2), channel erodibility factor (Ch-Erod), USLE equation support practice factor (USLE-P), exponent parameter for estimating sediment restrained in channel sediment routing (Spexp) and moist soil albedo (SOL-ALB) are sensitive parameters were selected used sediment yield calibration and validation. For this study, auto-calibration or Sequential uncertainty fitting (SUFI-2) algorithms method was applied due to its easy implementation in comparison to other producers and the low number of models runs needed to reach good simulation.

Validation is a process of proving the performance of a model. Based on the available model input data parameters calibration and validation periods of Megech and Upper Gilgel Abbay by SWAT model were tabulated below.

Table 3. Calibrated values of sensitive sediment parameters for Megech and Upper Gilgel Abbay watersheds

Parameter	Range	Fitted value		Megech		G.Abbay		Rank	
		Megech	G.Abbay	p-value	t-value	p-value	t-value	Megech	G.Abbay
CH_COV2	0-1	0.047	0.50	0.21	-1.25	0.65	-0.46	1	2
CH_EROD	0-1	0.48	0.85	0.26	-1.13	0.09	1.68	5	4
SPEXP	1-2	2.0	1.112	0.63	0.49	0.21	1.24	6	6
USLE_P	0-1	-0.50	0.04	0.55	0.6	0.37	-0.89	2	1
SPCON	0.0001-0.01	-	0.0087	-	-	0.41	0.83	-	5
SOL_ALB	±25	0.34	-0.68	0.83	-0.22	0	24.57	3	3
CH_COV1	0-1	0.76	-	0	-8.1	-	-	4	-

In Megech watershed, the objective function of model performance measure of sediment yield NSE value (0.63, 0.60) was less than (Assfaw, 2019) (0.77, 0.81) during calibration and validation period,

respectively, and has similar value of (Lemma *et al.*, 2019) (0.61) during calibration period and less value of (Lemma *et al.*, 2019) (0.7) in validation period in monthly time series. The reason for low NSE value of Megech watershed during calibration and validation may be inaccurate measurement and filling missed rain fall data as well as due to small sample suspended sediment data availability. In Megech watershed, the objective function of model performance measure of sediment yield R^2 value of (0.64, 0.63) had less value than (Assfaw, 2019) (0.82, 0.90) and (Lemma *et al.*, 2019) (0.68, 0.81) during calibration and validation period, respectively, in monthly time series.

3.1.2 Calibration and Validation of the PED Model for the Sediment Yield

According to Moriasi *et al.* (2015) model performance criteria the value of NSE (0.77) and (0.81) good agreement and very good agreement during calibration and validation period respectively for Upper Gilgel Abbay watershed. Also, the sediment concentration R^2 value (0.89) and (0.82) a very good agreement during calibration and validation period respectively, on monthly time series. The model performance criteria the value of NSE (0.71) and (0.72) good agreement during calibration and validation period respectively, for Megech watershed on monthly time series. As shown on (Table 5) the sediment concentration R^2 value of (0.85) and (0.83) very good agreement during calibration and validation period respectively for Megech watershed on monthly time series.

Table 4. PED-W model Sensitivity rank and fitted values

Component	Parameter	Fitted value		Sensitivity rank	
		G.Abbay	Megech	G.Abbay	Megech
Discharge	Area, A_1	0.2	0.1	2	5
	S_{max} , A_1	100	100	9	8
	Area, A_2	0.1	0.05	3	4
	S_{max} , A_2	75	75	8	9
	Area, A_3	0.7	0.75	1	1
	S_{max} , A_3	35	35	5	7
	BS_{max}	150	120	6	2
	$t_{1/2}$	45	30	4	3
	τ^*	40	18	7	6
Sediment	α_t for A_3	0.9	0.5	1	1
	α_s for A_3	1	0.01	2	2

The PED model result shows that the relationship between observed and calculated sediment concentration are very good agreement.

3.1.3 Calibration and Validation of the GWLF Model Sediment Yield

Three sensitive parameters were selected for the calibration and validation of sediment. The selected parameters are sediment delivery ration, Erosivity coefficient, and USLE parameters were used for this study. The fitted values for sediment delivery ration, Erosivity coefficient, and USLE parameter (1.131, 0.343, varies (0-0.05) and (0.153, 0.727, varies (0-0.05) for Megech and Upper Gilgel Abbay, respectively.

The GWLF model efficiency of sediment yield during calibration and validation the value of R^2 had a good agreement both in Megech and Upper Gilgel Abbay watershed on monthly time series. The NSE value had a satisfactory during calibration and validation both in Upper Gilgel Abbay and Megech watershed. The PBIAS value had a satisfactory agreement during calibration and validation in Megech watershed. In the Upper Gilgel Abbay watershed the PBIAS had good agreement during calibration and very good agreement during validation period. Table 5 shows that the performance of the selected model.

Table 5. Summary selected model efficiency criteria for calibration and validation of sediment yield in two watersheds on monthly time series.

Watersheds	Models	Calibration				Validation			
		R^2	NSE	RSR	PBIAS	R^2	NSE	RSR	PBIAS
Upper Gilgel Abbay	SWAT	0.84	0.84	0.48	-2.7	0.62	0.62	0.62	3.5
	PED-W	0.89	0.77	0.47	-8.5	0.82	0.81	0.44	5.87
	GWLF	0.76	0.58	0.65	-21.24	0.76	0.6	0.64	-5.2
Megech	SWAT	0.64	0.63	0.61	17.9	0.63	0.6	0.64	27.9
	PED-W	0.85	0.71	0.54	6.54	0.83	0.72	0.55	12.17
	GWLF	0.76	0.57	0.66	22.42	0.73	0.58	0.65	20.89

4. Conclusions

Three watershed hydrological models were evaluated in simulating sediment yield in the Upper Gilgel Abbay and Megech watersheds in the Upper Blue Nile Basin. At a monthly time, step the sediment yield was simulated using PED- W, SWAT and GWLF models. The predicted sediment for both watersheds each outlet runoff amount and sediment yield were compared with measured data.

PED-WM was relatively better in predicting the sediment at the outlet of Merawi and Azezo gauging station for Upper Gilgel Abbay and Megech watersheds, respectively, followed by SWAT and

GWLF. PED-WM model was also the most preferable to predict sediment yield in scale of watersheds (small to large) when compared to SWAT and GWLF model. This was due to the fact that the PED-WM was saturation excess and scaling up plots, which is the case in the Ethiopian highlands.

The model watershed properties were evaluated using split records of discharge and sediment (68.87% calibration and 31.13% for validation). Optimized parameters were validated after model calibration for watershed models, and the result indicated that a good relation between observed and simulated hydrological variables of the sediment yield.

The calibration and validation of the PED-MW, SWAT and GWLF models for Upper Gilgel Abbay and Megech watersheds can be used to assess the impact of land use change, management practices and soil conservation impact on flow and sediment dynamics in the watershed. Generally, for monsoon climates; the PED-W model is the best for the prediction of discharge and sediment at Upper Gilgel Abbay and Megech watersheds in the Upper Blue Nile basin.

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Review of Soil Erosion and Sediment Transport, and Management Status in the Blue Nile River Basin: The Case of Ethiopia

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Abstract

Soil erosion and sedimentation have a serious effect on the water abstraction structures and sustainable agriculture and that may be managed through appropriate watershed management practices. To make it, information between researchers and government or non-governmental organizations on soil erosion, sediment transport, and watershed management status at the river basin is very important. Therefore, this paper review was conducted to know the updated information about soil erosion potential, sedimentation rate, and status of watershed management practices in the Blue Nile River Basin. Approximately, 22.5% of the Blue Nile basin fell under very high to extreme areas of soil erosion potential and it needs effective watershed management implementation along the basin. The average annual soil loss and sedimentation rates of the Blue Nile river basin were 41.7 and 11.2 tons ha⁻¹ year⁻¹, respectively. The mean annual soil loss in Blue Nile River Basin along the different stations in Ethiopia was 5395.57 ton-km⁻² and it shows a large amount of sediment transported to the Grand Ethiopian Renaissance Dam (GERD) that will reduce dam storage capacity. Aswan high dam and Roseires reservoir received 100 and 30 million tons of sediment per year, respectively from Blue Nile River Basin in Ethiopia and the filling of GERD will raise the life span of Aswan dam from 365 years to 593 years. Around 42% of the Jemma watersheds were covered by terracing and other water management structures up to 2016 and reforestation combined with vegetative strips was the most effective for soil erosion control (87.8% reduction in the case of Jemma watershed). Therefore, cooperative watershed management practice at the basin level is very important to increase the sustainability of GERD and to protect the sedimentation of Sudan and Egypt's water storage structures.

Key Word: Blue Nile Basin, Soil Erosion, Sedimentation, Watershed Management, GERD,

1. INTRODUCTION

Ethiopia is well known for its huge water resources potential and it is considered the water tower of Africa as it is, the source of the Blue Nile and many transboundary rivers (Nigel, 2004) and many

rivers with high annual flow rates. Most of the runoff leaves the country through these transboundary rivers (Awulachew *et al.*, 2005).

Soil erosion and sedimentation have a series of effects on water abstraction structures (Dutta, 2016), and the sustainability of agriculture that may be managed through appropriate watershed management practices (Gebremichael *et al.*, 2005). Soil erosion by water is a major agent of land degradation in Ethiopia and more specifically in the Blue Nile River basin, and it has significant impacts on ecosystem services (Gebrehiwot *et al.*, 2014), crop production (Hurni *et al.*, 2015), downstream flooding (Sultan *et al.*, 2018) and reservoir sedimentation, and economic costs.

In fluvial hydraulics, sedimentation is a significant parameter as it provides a possibility of being used as a capacity-predicting device in all storage zones due to which the life of a reservoir can be predicted; as there is a sole relationship between capacity and life of a reservoir (Chang, 2006). Soil erosion and solid transport in river channels often lead to reservoir siltation (Ayana *et al.*, 2012) and a reduction in the amount of water available for agriculture (Coviello *et al.*, 2015). The adverse impacts of increased sediment deposition can result in increased flooding, property damage, contamination of water supplies, loss of crops, social dislocation, temporary homelessness, and even loss of life (Nigel, 2004).

One-third of the Roseires Reservoir capacity which is constructed on the Blue Nile River in Sudan near the border with Ethiopia has been lost due to sedimentation and lack of insufficient watershed management in the Blue Nile River Basin in the last four decades (Omer *et al.*, 2015)). Khashm el-Girba dam and Roseires dam in Sudan lost 55% and 38% design capacity in 25 and 28 years, respectively (Wolanchu, 2012).

The sedimentation problem of the Aswan high dam reservoir of Egypt is coming from the Abay sub-basin in Ethiopia and the design life of the Aswan high dam reservoir is also estimated to be 265 years, which is only 50% of the reservoir's original design life due to high inflow of sediment from Blue Nile River basin (Wolanchu, 2012). Ethiopia reservoirs like Angereb, Legedadi, Gilgel Gibe I, Tekeze, and others are susceptible to failure by these accelerated sedimentations. Small-scale water diversion structures irrigation in Ethiopia like Gery, Kility, Dana, and Fetam failed due to sedimentation and lack of good watershed management like terracing and soil bunds (Bitew, 2013).

Proper watershed management is the most effective method to increase the life span of hydraulic structures such as dams, weirs, and barrages and to conserve soil, water, and plants. Information flow between researchers and government or non-governmental organizations on soil erosion and sediment transport and watershed management status on the Blue Nile watershed and understanding its major drivers are essential to implement targeted management interventions. This information also minimizes the controversial idea of Sudan and Egypt on the Ethiopian Grand Renaissance Dam. This is because GERD has a positive impact on riparian countries by reducing large amounts of sediment

inflow (Elnashar *et al.*, 2021). Therefore, this paper review will conduct to know the updated information about soil erosion potential, sedimentation rate, and watershed management status in the Blue Nile River Basin and the benefit of the appropriate watershed management practice adopted in the area of Ethiopian Renaissance Grand Dam sustainability and downstream countries such as Sudan and Egypt.

2. Blue Nile River basin

2.1 Location

The Blue Nile Basin and its main tributaries drain an estimated area of 324,000 km², about 250,000 km² on the Ethiopian Plateau (Figure 1). The Blue Nile Basin stretches between 35° 00' 00" E and 40° 0' 00" E longitude, and 8° 00' 00" N and 12° 0' 00" N latitude. The main head of the Blue Nile (Abbey) River is Lake Tana, which is the greatest freshwater lake in the country and it is situated in the north part of the basin (Shobary *et al.*, 2021).

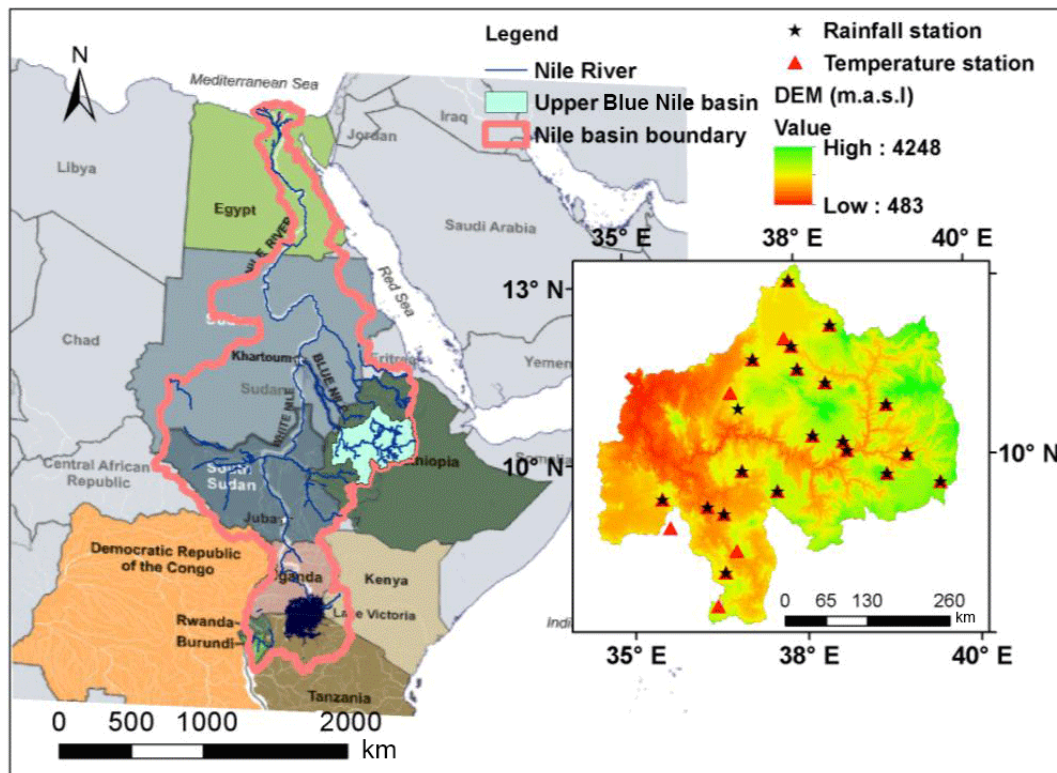


Figure 1: Location of upper Blue River Basin (Chang, 2006)

2.2 Climate

A large amount of rainfall is concentrated in the Ethiopian highlands ranging from 1500 to 2200 mm with peaks in August; on the other hand, the rainfall in the lowlands is less than 1500 mm. The climate of the basin differs from one region to another. The western part possesses the highest temperature, with maximum and minimum ranges of 28°C-38°C and 15°C-20°C, respectively. In the eastern and central parts of the basin's part, a lower temperature is monitored and the maximum temperature ranges from 12°C to 20°C, while the minimum ranges from -1°C to 8°C. In the lowlands,

high temperature and high potential evapotranspiration is ranging between 1800 mm and 2232 mm per year. The lower potential evapotranspiration is observed between 1200 and 1800 mm per year in the eastern and southern parts of the basin. In the highlands, there is the lowest temperature, it has the least potential evapotranspiration below 1200 mm per year (Yilma and Awulachew, 2009).

3. Soil Erosion, Sediment Transport, and Watershed Management

3.1 Soil Erosion Potential

3.1.1 Erosion Potential on Upper Blue Nile River Basin

The soil erosion potential of the watershed in the upper Blue Nile River basin varied with its management system. Abay/upper Blue Nile River Basin has around 14 sub-basins (Figure 2) and the erosion potentials of the basin varied from low to very severe soil erosion severity. The soil erosion potential of each basin depended on soil type, topography, and land use/land cover change of the basin (Organic *et al.*, 2015).

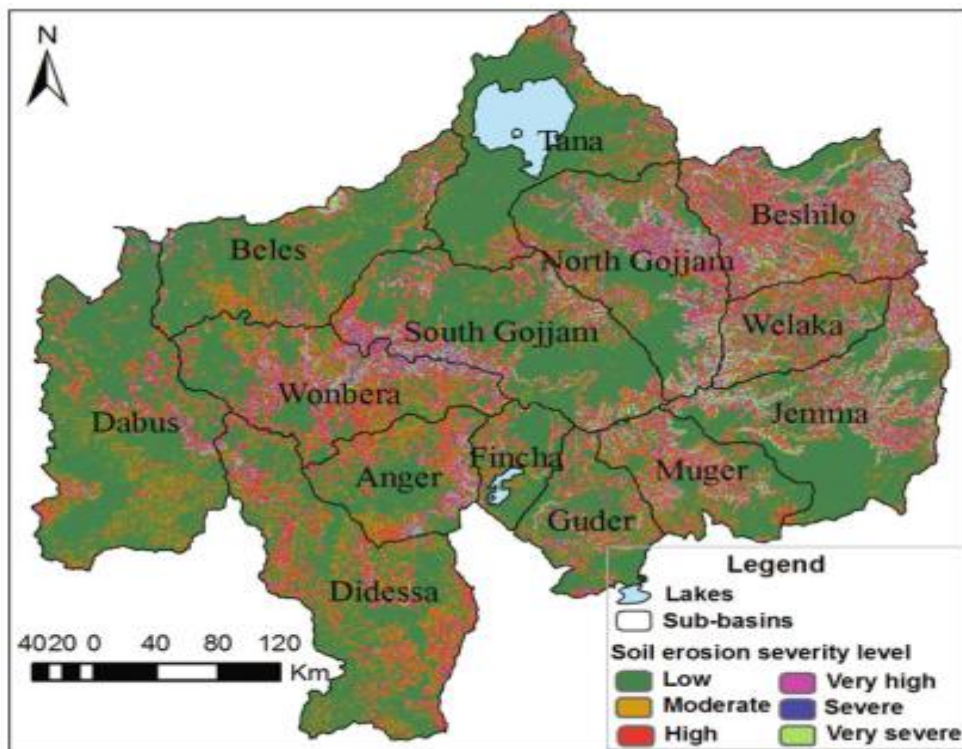


Figure 2: Potential soil erosion hazard in the Upper Blue Nile River Basin (Organic *et al.*, 2015)

The magnitude of soil erosion in the upper Blue Nile Basin is spatially variable and severe to very severe soil erosion was predominantly observed in the northeast, east, and southern parts of the basin including Beshilo, Welaka, North Gojjam, Jemma, and Muger sub- basins (Organic *et al.*, 2015) as seen in Table 1.

Table 1. Soil erosion severity level for sub-basins of Upper Blue Nile River Basin (Organic *et al.*, 2015)

Sub-basins	Area (10 ³ km ²)	Soil loss (t ha ⁻¹ yr ⁻¹)	Severity Level
Tana	15	4.9	Low
Beshilo	13.2	32.7	High
9.9			Low
14.4		23.7	High
Dabus	21	7	Low
South Gojjam	16.8	15.6	Moderate
Jemma	15.8	24	High
Welaka	6.4	27.5	High
Wonbera	13	18.7	Moderate
Fincha	4.1	9.1	Low
Anger	7.9	13.7	Moderate
Muger	8.2	22.1	High
Didessa	19.6	9.2	Low
Guder	7	13.8	Moderate

3.1.2 Erosion Potential Upper Blue Nile River Basin

Amdihun *et. al.* (2014) also reported that a large area of the basin (47%) was characterized by low erosion grade (0-2 t ha⁻¹ yr⁻¹). Nearly 35% of the basin is under moderate to high soil erosion potential. The remaining (18%) areas fall under very high to extreme areas of soil erosion potential. The North East parts of the Abbay Basin (North Wollo, South Wollo, East and West Gojjam, South Gondar, and North Shewa) were identified as areas of high soil erosion belts. On the other hand, the lowland areas of the Western and North Western areas are depicted as low erosion areas (Amdihun *et al.*, 2014). These shows the North parts of the Abbay Basin need more effective integrated watershed management in contrast to the Western and North-western portions of the basin and (Elnashar *et al.*, 2021) also report that 27% of the upper Blue Nile River Basin requires a series of watershed management implementations. Based on above the authors, an average of 22.5% of the Blue Nile River Basin is found under very high to extreme areas of soil erosion potential. This means 56,250 km² area of the basin needs effective watershed management implementations.

3.1.3 Runoff and Soil Loss along Different Stations of Blue Nile River Basin

Maximum soil loss was observed at the Anjeni station in the northern highlands of Ethiopia, Andit tid station in North Shewa, and Maybar station in the Southern Wollo Zone. This shows that amount of soil loss is very high in the central and western parts of Ethiopia. However, the amount of soil loss in

the northern and eastern parties is very low. The average annual soil loss of the Blue Nile River basin from those seven stations was 5395.57 ton km⁻² as shown in Figure 3.

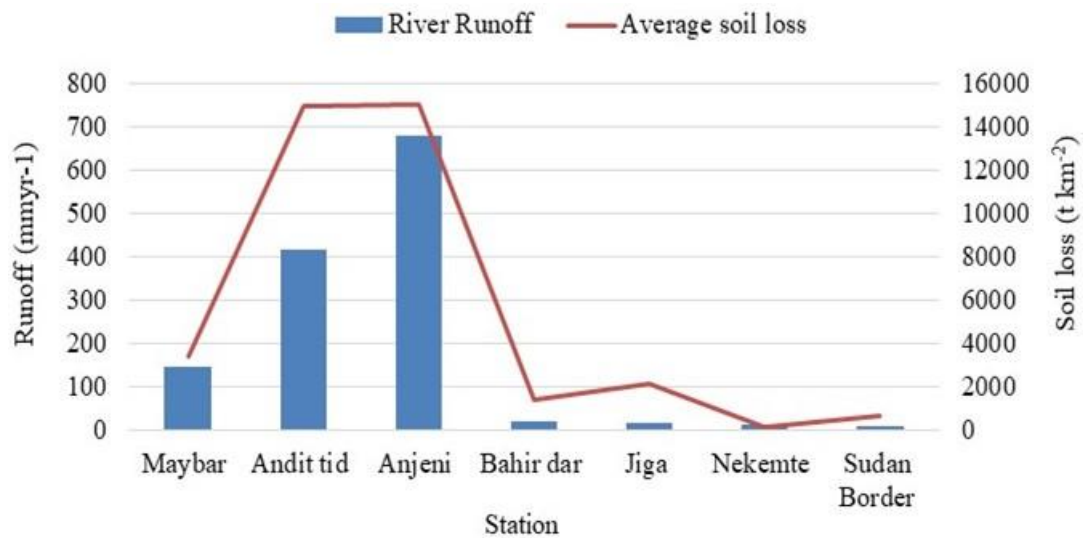


Figure 3. Measured runoff and soil loss at different stations of the Blue Nile River basin (Abdel-Aziz, 2009)

The average rate of soil loss in the upper Blue Nile River Basin varied from 16 to 67.37 ton ha⁻¹ year⁻¹ and it also varied from 8.25 to 100 ton ha⁻¹ year⁻¹ in the sub-basin of the Blue Nile basin (Tesfaye, 2022).

3.2 Sediment Yield

3.2.1 Sediment Yield of Different Watershed

On average, 16 million tons of sediment per year were transported to the Lake Tana sub basin. This load comes that flows from the four River watersheds and it has been shown that prioritizing management practices for reducing the sediment load to Lake Tana is important (Zimale *et al.*, 2018). The four main tributaries of the Lake Tana subbasin are Megech, Gumara, Ribb, and Gilgel Abay watersheds, and the average annual sediment inflow to Lake Tana from such watersheds was 30.4 million tons per year (Zimale *et al.*, 2018).

The Gilgel Abay basin receives the maximum rainfall resulting in the greatest discharge and sediment inflow to Lake Tana. Therefore, the participation of the community, government, and non-governmental organizations is very important to manage lake sedimentation and soil erosion. Soil erosion not only affects Lake Reservoir's capacity but also removes significant soil nutrients from agricultural land and increased soil acidity (Zimale *et al.*, 2018).

Table 2. Sediment yield of the Tana Sub- basin (Zimale *et al.*, 2018)

watershed	Area	Total (Mt yr ⁻¹)	Unit area (t ha ⁻¹ yr ⁻¹)
Megech	500	0.6	12.2

Gumara	1281	6.3	49.4
Ribe	1289	3.2	24.6
G_Abaya	1665	5.9	35.4
Average		4.0	30.4

Toba watershed is a tributary of the Didessa sub-basin in the headwater of the Ethiopian plateau, Upper Blue Nile Basin. The annual sediment yield of this watershed varied from 0.09 t ha⁻¹ yr⁻¹ to 44.8 t ha⁻¹ yr⁻¹ with an average sediment yield of 22.7 t ha⁻¹ yr⁻¹ (Dibaba *et al.*, 2020), and 72.9% of the Toba watershed area, have been identified as critical areas that require implementation of proper measures. The spatial average annual sediment yield distribution through the Guder watershed also ranges from 0.33 to 55.33 ton⁻¹yr⁻¹ with an average value of sediment yield of 27.83 t ha⁻¹ yr⁻¹ (Gonfa and Dereje, 2021). The sediment transport rate in Beshillo and Finchaa watersheds were 35 t ha⁻¹ yr⁻¹ and 36.47 t ha⁻¹ yr⁻¹, respectively (Yesuph & Dagnew, 2019) and (Dibaba *et al.*, 2020).

The variations of the soil loss in different parts of the Blue Nile show that sediment transport rates depended on land use land cover change, topography, and a biophysical environment. That means adapted watershed management practice may vary from one watershed to others.

3.2.2 Sediment Yield on Basin and Watershed Level

Sedimentation rates in Ethiopia at the upper Blue Nile Basin ranged from 4.2 to 18 ton ha⁻¹ year⁻¹, and it varied from 1.1 to 43.34 ton ha⁻¹ year⁻¹ in the sub-basin of the upper Blue Nile River basin. Based on this result, 277.5 million tons of sediment per year will accumulate from the Blue Nile River basin. Hence, it is concluded that high sedimentation rates are serious problems in the basin, and soil and water conservation measures are recommended throughout the basin to reduce both the on-site and off-site effects of soil erosion. It is also highly advised to utilize uniform techniques and a common data source for soil erosion and sedimentation rate estimation at different levels (Tesfaye, 2022).

3.2.3 Sedimentation of the Aswan High Dam Reservoir and Roseires Reservoir

Abay sub-basin within Ethiopia covers about a quarter of the area and its waters provide 57% of the main Nile River flow into the Aswan High Dam reservoir and some 72% of its sediment load. The Tekeze sub-basin within Ethiopia covers a quarter of the area and its water covers 14% of the main Nile River flow into the Aswan high dam reservoir (AHDR) and some 25% of the sediment load. This means that 71% of the main Nile River flow and 97% of the sediment load into AHDR comes from Ethiopia. Generally, 100 and 30 million tons of sediment load into the AHDR and Roseires dam Reservoirs per year comes from Blue Nile River Basin in Ethiopia (Abdel-Aziz, 2009). Therefore, land management in the high land of Ethiopia to control soil erosion and sedimentation of water storage structures that are found in transboundary countries like Ethiopia, Sudan, and Egypt is very important. This watershed management practice must be implemented in cooperation with such a transboundary country.

The 165 million tons per year of sediment inflow into the Aswan High Dam reservoir in Egypt comes from the Ethiopia river basin such as the Blue Nile and Atbara river basins. From this amount, 100 million tons of the sediment comes from the Blue Nile River basin, and 65 million tons of sediment is also from the Atbara River Basin (Tekeze and Angrebe River watershed). The construction of GERD across the Blue Nile River Basin in Ethiopia will have a great benefit for Sudan and Egypt by removing up to 86% of silt and sediment accumulation in reservoirs (El-Nashar & Elyamany, 2018). Therefore, the maximum sediment source for hydraulic structures in transboundary countries is the Blue Nile River basin which shows a common understanding on integrated River management as a core solution to minimize reservoir sedimentation of GERD, and other dams in Sudan and Egypt. The Ethiopian part of the Blue Nile Basin contributes some 62% of the Nile water and is the source of a huge sediment load (122 million tons per year) in the downstream reservoir of Rosaries dam on the Ethio-Sudan border (Amdihun *et al.*, 2014).

3.2.4 Impacts of Nile Sediment Reduction on Lower Nile Countries' reservoirs

Egypt scholars state that the filling of the Grand Ethiopian Renaissance dam will raise the life span of the Aswan high dam reservoir from 365 years to 593 years if the beginning of filling GERD will start by 2016 (Elsharkawy, 2020). Because a large amount of annual sediment inflow to AHDR from the Blue River Nile basin will be protected by the GERD. Reduced sediment load after the construction of GERD results in a longer lifetime of the Roseires, Sennar, Khashm el-Girba, and Merowe dams and reduces the maintenance cost of irrigation canals and water pumping stations in Sudan (Siddig & Basheer, 2021).

3.4 Best watershed Management Practices

The best watershed management practices are filter strip, soil/stone bund, vegetative strip, reforestation, and their combinations and these practices are largely under implementation in the Blue Nile basin. The lowest SY reduction was reported as 36.1% during the implementations of filter strip (FS) whereas the highest reduction was reported as 80.5% by the simulation of the vegetative strip (VS) followed by soil/stone bund (SB). Application of SB on steep slopes and reforestation of the hilly areas reported sediment yield (SY) reduction by 69.3% and 47.5% respectively. However, implementing the combinations of the BMP scenarios improved SY reduction better. The highest reduction in SY was attained by the combination of R and VS followed by SB and VS. The best watershed management practice from the different scenarios is reforestation with the vegetative strip that reduced sediment yield by 87.8% compared with baseline scenarios (Dibaba, 2021) (Figure 4).

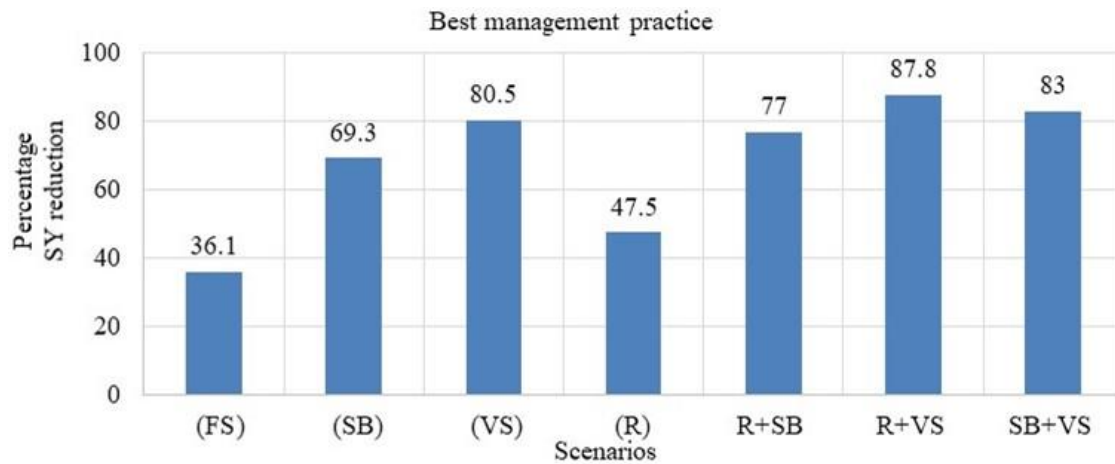


Figure 4. Watershed management scenarios (Dibaba, 2021).

Where: FS, SB, VS, and R stand for filter strip, soil/stone bund, vegetative strip, and Reforestation

The percentage of sediment yield reduction by the stone bund soil conservation structure varies from 72 to 100% with an 86% average value, and the experiment was conducted in Ethiopian and Eritrean highlands (Asmamaw, 2015). Corroborates water harvesting structures and other water management structures like terracing are very fruitful technology to increase the availability of water under different climate conditions in the Jemma watershed of the upper Blue Nile River Basin. However, terrace and other physical soil and water management structures are implemented on about 42% of the watersheds of the Jemma sub-basin up until 2016 (Worku *et al.*, 2020). Currently, existing and prioritized water management structures need to be regularly maintained since there is a study that shows a decrease in the effectiveness of such structures after a certain time. Therefore, management status in the Jemma watershed shows that there are no successful management practices in other watersheds in the Blue Nile River Basin.

The best effective soil and water conservation structures were soil bunds, reforestation with vegetative strips, and water harvesting structures with terracing (Asmamaw, 2015; Worku *et al.*, 2020). Dagnenet *et al.*, (2018) reported that soil trenches also trenches in grazing lands are more effective and it can conserve 55% of runoff due to temporary water storage in the short trenches the experiments were conducted at the Guder watershed in the upper Blue Nile (Sultan *et al.*, 2018). The gully rehabilitation and forestation together would save 828 tons of soil in a year as watershed level per one gully and the experiment was conducted at the Anjeni watershed in the upper Blue Nile River basin (Ashagre, 2014). Effective and sustainable soil erosion management requires not only the prioritization of the erosion hotspots but also the prioritization of the most effective management practices (Dibaba *et al.*, 2020).

The effectiveness of the best watershed management practice depends on the amount of land available, local topographical conditions, and land use/land cover change in the basin, and the

reforestation management practice is more important in steep areas, and filter strips and stone bunds in low slope areas of the catchment (Betrie *et al.*, 2011).

4. Conclusion and Recommendation

Northeast, east, and southern parts of the upper Blue Nile River basin is highly sensitive to soil erosion that leads to sedimentation problem of reservoirs. Lake Tana and different watersheds in Ethiopia like Toba, Bishillo, and Finicha were categorized under sedimentation-prone areas and this high sedimentation yield harmed the Grand Ethiopian Renaissance Dam. This soil erosion and sedimentation problem in the upper Blue Nile River basin showed that watershed management practices were not sufficient. To increase the life span of the Grand Ethiopian renaissances Dam (GERD), the watershed management practice in the Blue Nile River Basin is important for a transboundary country like Sudan and Egypt by minimizing sediment load. Therefore, the construction of GERD has had a positive impact on Roseires Reservoir in Sudan and the Aswan High dam reservoir in Egypt.

Integrated River basin management in the upper Blue Nile among transboundary countries like Ethiopia, Egypt, and Sudan will be used to achieve water security, equitably maximizing economic and social well-being, and maintaining ecosystem sustainability. This also increases good political relationships between the transboundary countries on the Nile River. Governance measures on the upper Blue Nile River basin shall be shared with water resource users, decision and policymakers, transboundary countries, and state agencies to achieve more collaborative and coordinated actions. These upstream-downstream connections and cooperation strategies on watershed management are essential for sustainable water resources management and equitable water sharing among the Nile riparian states.

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Water Productivity and Economic Analysis of Irrigated Upland Rice in the Fogera, Northwest Ethiopia

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Abstract

Irrigation is critical to Ethiopia's national economy in terms of increasing income and achieving food security. A total of 39.35 Mha of potential rice cultivation area is available in Ethiopia, 3.7 Mha of which are irrigable. Despite this potential, the country is importing a huge amount of rice to meet the increasing food demand. This is because, an irrigated rice production and its water productivity was not practiced. Determining the water productivity and economic feasibility of irrigated rice in the Ethiopian context is supremely important to replace the imported rice. Hence, the goal of this study is to determine the water productivity and economic analysis of NERICA-4 variety upland rice under optimal irrigation scheduling in the Fogera plain. Thirty one year climate data from Bahir Dar and Woreta metrological station were used to compute the reference crop evapotranspiration and the crop factors were used to compute the rice crop evapotranspiration. The effective rainfall was determined using CROPWAT model to determine the irrigation water requirement. Five experimental treatments; recommended manageable allowable soil moisture depletion (MAD) of rice as a control (100%), 60%, 80%, 120%, and 140% MAD. The randomized complete block design in four replications were used. The optimum depletion level based on the highest yield (7164 kg ha⁻¹), highest water productivity (1.85 kg m⁻³), and higher economic water productivity (0.87 US\$ m⁻³) was obtained at 80% of MAD. Therefore, based on the highest water productivity and economic water productivity 80% MAD water application was recommended for the Fogera plain and, other similar areas in agro-ecology and soil property areas shows better water and economic water productivity.

Keywords: Irrigated Rice, Rice, Water Productivity, Economic Analysis

1. Introduction

Irrigation development is an essential tool to promote economic growth, rural development, food security, and alleviating poverty (Hagos *et al.* 2009). To assist the irrigation development, adequate irrigation water needs to be distributed efficiently for the crops at the right time. Rice is one of the major staple crops globally and, it is the most rapidly growing food commodity in sub-Saharan Africa (SSA). It is introduced in recent years to Ethiopia. It was first introduced in Gambella (1973–1982), Pawe (1985–1988) and Fogera Plain (early 1980s). However, that rice introduced farming systems, Fogera Plain remained to be the major rice producing area; resulting insignificant changes in agricultural relations and social dynamics associated with the introduction of rice and its subsequent commercialization of crop production (Alemu and Thompson 2020).

In Ethiopia rice is classified as the fourth, “National Food Security Crop” next to wheat, maize, and teff (Kassa 2010). The country has 39.35 Mha of rice potential area under this about 3.7 Mha are believed to be suitable for irrigated rice production; these are distributed around the ten river basins in the country and a wide potential production area lies mostly in the western part of the country (Mustofa and Gondar 2017). Regardless of the huge production potential, the country heavily relies in importing rice from abroad (Tadesse 2020). Following the successful farming transformation with rice in the Fogera Plain, the recent expansion of rice production in different regions demonstrates the agro-ecological suitability of the crop and its future prospect of production and consumption in the country. The National Rice Research and Development Strategy (NRRDS) recognizes seven regional rice research and development hubs, these are; Fogera, Pawi, Abobo, Gura Fereda, Chewaka, Gode, and May Tsebri hubs. From these, the Fogera Hub includes the west central highlands of Amhara Region mainly covering Achefer, Dembia, Fogera, Gonder, Metema, and Takusa districts as main places (Alemu and Thompson 2020). It is also observed that the number of farmers involved in rice production has grown year after year (Negussie and Alemu 2011).

Rice production in the Fogera is mainly rain-fed and the irrigation water productivity and its economic using irrigation water is not well studied. Studying the irrigation water productivity of upland rice in the Fogera plain is essential; to rise the rice production under irrigation. This supports the rice producers to improve food security as well as replacing the imported rice. Therefore, this study aimed to determine the yield and water productivity responses of upland rice under irrigation to identify water productivity with economic benefit.

2. Materials and Methods

2.1 Study Area Description

Fogera district is located in the Amhara National Regional State, which stretches from 11° 40' 30" and 12° 01' 30" north to 37° 30' 00" and 38° 00' 00" east in the northern Ethiopian highlands. Fogera is

one of the ANRS's 106 districts, located in the South Gondar Administrative Zone (Figure 1). Fogera is one of the eight districts bordering Lake Tana and has an estimated water body of 23,354 ha. The total land area of Fogera district is 117,414 ha. Flat land accounts for 76%, mountain and hills 11% and valley bottom 13%. Major crops grown in the district are rice (33.6 %), maize (20.2 %), finger millet (16.07) and teff (13.1 %) and have heavy clay soil (Goshu *et al.* 2003). The seasonal migration of the Intertropical Convergence Zone primarily regulates the temperature of the region. The flood plain experiences yearly rainfall totals between 1100 and 1530 mm. The region's mean monthly temperature is approximately 19 °C, its mean highest monthly temperature is approximately 27.3 °C, and its mean monthly minimum temperature is approximately 11.5 °C. In this region, the wet season lasts from June to September (Enku 2009).

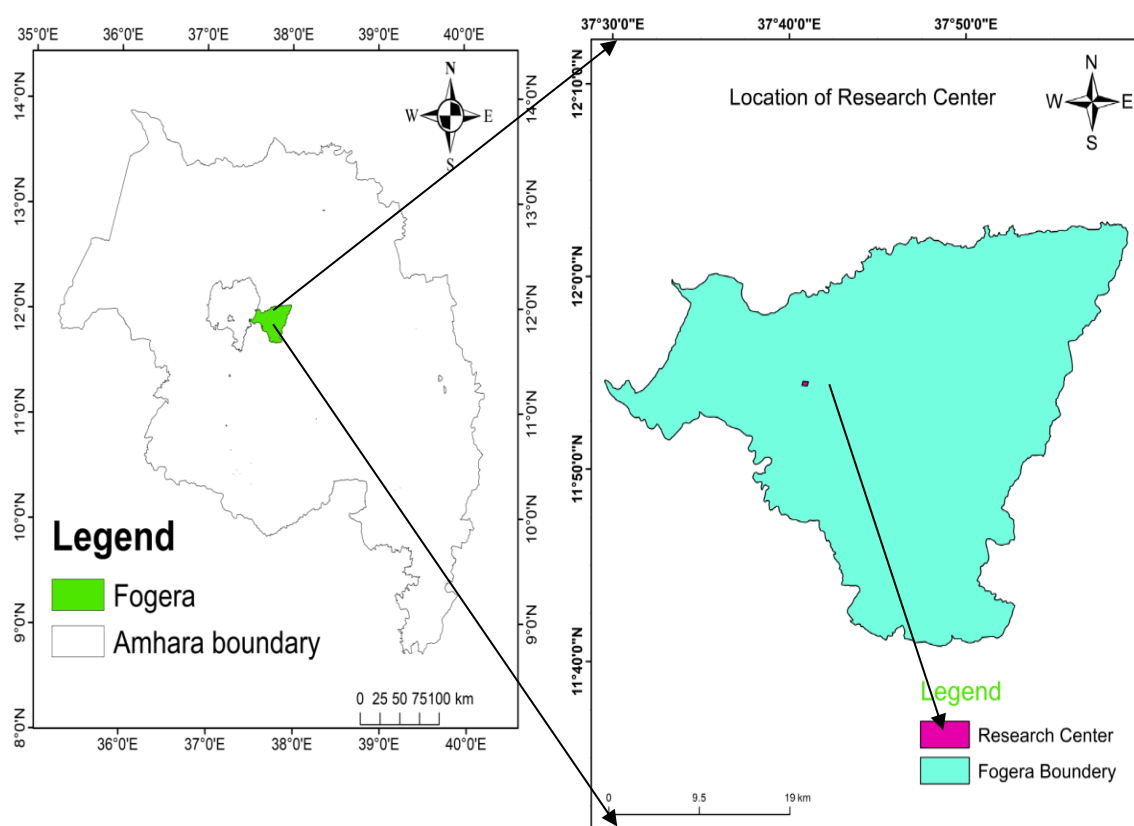


Figure 1. Location of the study area

2.2 Experimental Design

The study was conducted in Fogera National Rice Research and Training Center in 2021. The experimental arrangement was restricted by five treatments of manageable allowable soil moisture depletion (MAD); recommended manageable allowable soil moisture depletion (MAD) of rice as a control (100%), 60%, 80%, 120%, and 140% MAD (Table 1). The experimental design was used randomized complete block design (RCBD) by four replications to increase the degree of freedom at 3*3 m² plot size.

Table 1. Treatment distribution

Treatment	Description
Treatment 1	60% of MAD
Treatment 2	80% of MAD
Treatment 3	100%/Control
Treatment 4	120% of MAD
Treatment 5	140% of MAD

Note: MAD is the maximum allowable soil moisture depletion level of rice

2.2.1 Data Collection and Analysis

Soil data was taken within 30 cm interval up to 120 cm depth from three representative point of the experimental site. Then, the physical and chemical characteristics of the soil such as: soil texture, pH, field capacity (FC), permanent wilting point (PWP), and electrical conductivity (EC) were tested in the Amhara Design and Supervision Works Enterprise (ADSWE) soil laboratory. The soil bulk density (BD) was determined by core sampler at 10 cm intervals from the soil surface up to 60 cm (effective root depth of rice). Then bulk density was estimated based on (Mentges *et al.* 2016).

$$BD = \frac{Wt\ of\ dry\ soil}{V\ of\ core} \dots\dots\dots 1$$

Total Available Water (TAW) which measures the amount of water that a crop can extract from its root zone was controlled by the soil type and rooting depth (Datta *et al.* 2017). It can be determined from FC and PWP as:

$$TAW = (FC - PWP) \times BD \times 10 \dots\dots\dots 2$$

From Bahir Dar and Woreta metrological station, thirty-one-year (1987-2017) climate data: (Max. and Min. Temperature, Rainfall, Humidity, wind speed, sunshine hour) and crop factors the reference crop evapotranspiration and effective rainfall were determined. The ETo was estimated using the FAO Penman-Monteith method and CROPWAT-8.0 (Allen *et al.* 1998a). The USDA-SCS method was used for calculating effective rainfall, using CROPWAT-8.0.

The readily available water (RAW) and gross irrigation requirement (mm) to meet the water consumed through evapotranspiration (ETc) by a disease-free crop growing in large fields under non-restricting soil conditions. Including soil water and fertility, and achieving full production potential under the given growing environment is known as the crop water requirement (Abolpour *et al.* 2017). The RAW is the proportion of TAW that a crop may take from the root zone without suffering from water stress (Domínguez *et al.* 2011).

Depletion (p) is the average fraction of Total Available Soil Water (TAW) that can be depleted from the root zone before moisture stress (reduction in ET) occurs [0-1]. Based on Allen *et al.* (1998b), RAW was calculated as:

$$RAW = TAW \times p \times D_z \dots\dots\dots 3$$

The water application efficiency (E_a) for surface irrigation methods is up to 60% (Haj-Amor *et al.* 2018). So, for this study 60% irrigation application efficiency was used as the recommended surface irrigation.

$$GIWR = \frac{RAW}{E_a} \dots\dots\dots 4$$

Where: GIWR=Gross irrigation water requirement, RAW= readily available water, and E_a = water application efficiency

Water productivity (WP) is defined based on actual evapotranspiration (Hatiye *et al.* 2017), determined by equation 5. Because of actual evapotranspiration measurement material scarcity, crop evapotranspiration was used as it is.

$$WP = \frac{\text{dry biomass}}{ET_c} \dots\dots\dots 5$$

Water use efficiency (WUE) is a measure of how efficient a crop production system is about the amount of irrigation water applied (i.e. the grain yield generated per unit of water consumed by crops) is commonly used to measure (WUE) (De Pascale *et al.* 2011), and it is given as:

$$WUE = \frac{\text{Actual grain yeild}}{ET_c} \dots\dots\dots 6$$

The economic analysis of WP (the economic productivity of water) was calculated using the income (I, ETB) from crop yield and volume of water applied (mm ha^{-1} irrigation plus rainfall) (Tewelde 2019), and it is calculated as:

$$\text{Economic productivity of water} = \frac{I(ETB)}{\text{Water applied (mm-ha)}} \dots\dots\dots 7$$

2.2.2 Analysis

Version 9.4 of the SAS program was used to analyze water productivity, and Analysis of Variance was used (ANOVA). Adapted Duncan's multiple tests were used to compare means at p 0.05 (Duncan 1955).

3. Result and Discussion

3.1 Crop Evapotranspiration

The average reference crop evapotranspiration was 3.46 mm day^{-1} , maximum and minimum were obtained 4.03 mm day^{-1} in April and 3.04 mm day^{-1} in December respectively. The maximum and

minimum crop evapotranspiration were 4.93 mm day⁻¹ in March and 3.36 mm day⁻¹ in January respectively. The crop water requirement of rice was low at the initial stage reaching the value of 3.36 mm day⁻¹ and increased during the development stage reaching the maximum value of 4.93 mm day⁻¹ at the mid-season stage, and there after declined during the late-season stage reaching the value of 4.2 mm day⁻¹. In this research, at the lesser soil moisture stress the grain yield was high. This study was supported by similar studies such as Kumawat *et al.* (2017), who reported the highest levels of water productivity and grain quality when irrigation was scheduled at 0 kPa, i.e., in saturated conditions. Akinbile (2010), also reported that the link between ETc and yield is straightforward. This is similar to this study indicating that boosting irrigation water would result in a higher rice yield. When the soil was left to dry at greater tensions than 20 kpa, both direct seeded rice (DSR) and puddled transplanted rice (PTR) yields decreased, with DSR yields declining more rapidly as tension increased to 40 and 70 kpa (Humphreys *et al.* 2011).

3.2 Water Productivity and Water Use Efficiency

Water Productivity (WP) is the most essential factor in quantifying yield factors that affect crop output and it serves as a helpful standard for agricultural production (Edreira *et al.* 2018). WP was defined as the ratio of actual grain yield to actual evapotranspiration. In this finding, the maximum WP was attained at 80% MAD (1.85 kg m⁻³) and the minimum WP was obtained at 140% MAD (Table 2). The maximum WUE was also observed at the 80% MAD, which was 1.14 kg m⁻³. The minimum WUE was found at 140% MAD level (0.58 kg m⁻³) which might be a high yield loss due to moisture stress (Table 2).

In Iran, Kaur and Mahal (2015), did a research work based on three irrigation management of rice (full irrigation, 5-day, and 8-day irrigation intervals). They found that increasing irrigation interval resulted in a decreased water use while increasing water productivity by 40 and 60% respectively, in a 5 and 8-day irrigation intervals compared to full irrigation with no yield loss. Their result is in line with our finding as the irrigation interval increased the water productivity and the water use efficiency was decreased because of soil moisture stress.

Table 2. Water productivity

Treatments	Grain			Water	Water Use
	Dry Biomass (kg ha ⁻¹)	Yield (kg ha ⁻¹)	Total applied water (m ³ ha ⁻¹)	Productivity (kg m ⁻¹)	Efficiency (kg m ⁻¹)
60%MAD	11560 ^a	7204.9 ^a	6505 ^a	1.78 ^a	1.1 ^a
80%MAD	11600 ^a	7164.3 ^a	6277 ^b	1.85 ^a	1.14 ^a
100%MAD	9160 ^b	5341.9 ^b	5857 ^c	1.56 ^b	0.9 ^b
120%MAD	8720 ^b	4780 ^b	5618 ^d	1.55 ^b	0.88 ^b
140%MAD	8640 ^b	3130.5 ^c	5415 ^c	1.6 ^b	0.58 ^c

Mean	9936	5524.33	5934.48	1.66	0.93
LSD (5%)	733.77	643.97	0	0.15	0.14
CV (%)	3.42	5.40	2	4.12	7.05

Means with the same letter are not significantly different at the $p < 0.05$ level

3.3 Economic Analysis of Water Productivity

Rice price fluctuation was noticeable during the harvesting season (November–January) since many farmers took their grain to market, resulting in a market glut and, as a result, the price fell every year during that time (Gebey *et al.* 2012). As per the market price of seed, fertilizer, fuel, labor cost per day, and all variable costs of each treatment were determined. Based on the results, 60% MAD has taken high cost (161935 ETB ha⁻¹) than the other treatments, and 140% MAD has taken the minimum cost (83099 ETB ha⁻¹). Return benefit and profit are also analyzed, high profit was observed at 80% MAD (160241 ETB ha⁻¹). Economic productivity of water was also higher at 80% MAD (45.38 ETB m⁻³) than the other treatments. 60% MAD also showed higher income per drop of water. The benefit-cost (B: C) ratio registered in each treatment and treatment five showed a high B: C ratio (2.4), and has an insignificant difference with treatments two, three, and four. It was due to less availability of water in decreased irrigation events and produced the highest returns (Table 3).

Economic water productivity of irrigated rice results conform with the report of Sathyamoorthy *et al.* (2019), Rice's many by-products (straw, bran, and husk) have significant economic value and are utilized in animal feed, building, and fuel. Hence, in this research finding, the best economical water productivity was obtained at 80% MAD (0.87 US\$ m⁻³). Irrigation investments were prioritized under Ethiopia's second Growth and Transformation Program, a five-year economic growth plan, and accounted for the largest share (more than one-third) of the Ministry of Agriculture's Agricultural Growth Program's overall budget of US\$582 million (Alemu and Thompson 2020; Awulachew 2019).

Table 3. Economic water productivity

	60%	80%	100%	120%	140%
Treatments	MAD	MAD	MAD	MAD	MAD
Total variable cost (ETB ha ⁻¹)	161935	124592	103845	91397.5	83099
Total Income (ETB ha ⁻¹)	285008	284833	224250	211399	202833
B:C ratio	1.8	2.3	2.2	2.3	2.4
Total profit (ETB ha ⁻¹)	123073	160241	120404	120002	119734
IW (m ³ ha ⁻¹)	6505	6277	5857.4	5618	5415
EWP (ETB m ⁻³)	43.81	45.38	38.28	37.63	37.46

4. Conclusions

Among the treatments, the maximum crop water requirement was obtained at 60% MAD ($6505 \text{ m}^3 \text{ ha}^{-1}$) and the minimum was obtained at 140% MAD ($5415 \text{ m}^3 \text{ ha}^{-1}$). Based on the findings, upland rice variety (NERICA-4) in each treatment showed different growth and yield parameters. Based on these results, 80% MAD has shown high water productivity (1.85 kg m^{-3}) and economic water productivity ($0.87 \text{ US\$ m}^{-3}$) over the other treatments. Consequently, 80% MAD can save about $1090 \text{ m}^3 \text{ ha}^{-1}$ of water as compared with 60% MAD without reducing grain yield, and can increase rice production by cultivating additional land by saved water during the dry season when land is idle but water is an issue. As a general, Irrigation water management of irrigated upland rice was importance to improve irrigated rice in water scarcity area and it improves water productivity as well as economically of the district. Moreover the irrigated rice gives much production to sustain food security of the country. As a conclusion, irrigated rice in different potential area should be widely practiced as a strategic crop to achieve food self-sufficiency of the country.

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The Rights of Riparians and the Paradox of Negotiations in the Nile Waters: An Effort Escaping from Cooperation to Tripartite Bargain

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Abstract

The Nile is a common natural resource and the longest international river that crosses the boundaries of 11 countries with no binding law allowing its riparian states the right to use its waters. However, among the riparian, Egypt and Sudan have used and established historical rights through the Bilateral Agreements entered in the years 1929 and 1959. Meanwhile, in the early 1980s, other riparian countries have begun to claim a fair distribution of the Nile water as their population and economic demand so desired they challenged unfair utilization by two riparian's and appeared continuously as a counter-hegemonic collective power in the Nile hydro politics agenda claiming and negotiated for a system of shared water resources. In particular, the Nile Cooperative Framework Agreement (CFA), which was drafted in 1999 and was hampered by the Egyptian-Sudanese process, provided a better framework for the Nile water use and management than previous riparian countries' deals. The incidence of the Grand Ethiopian Renaissance Dam (GERD) become another point of discourse that shifted and triggered the Nile water issues as the agenda of the three riparian countries. The basic premise of this article is that disregarding the quest for fair utilization of the Nile River and questions related to the GERD as the only concerns of the three riparian countries violates international water law rules regarding Transboundary Rivers. I argued that such an approach will have a spillover effect and not have a lasting solution to utilize and manage the common water resources and that will continue the tendency to pursue unilateral interests instead of sharing the common resource. Rather than intensifying the riparian joint efforts to have a law that enable them equitable access to shared water, I did not believe that a separate tripartite negotiation on a dam or a project has resulted in a basin-wide legal framework and regional solution to Ethiopia's natural and legal right to use the Nile river resources. Any decisions on the use and administration of the Nile water, including the tripartite negotiations between Egypt Sudan, and Ethiopia which excludes other riparian countries, will inevitably raise questions of legitimacy like the 1929 and 1959 colonial agreements. The tripartite approach downgrades the achievements of the NBI and will bring the Nile water use and management question back from cooperation to a conflict system, and allow the same experience of conflict resolution in the basin to be taken by unilateral action on the shared water.

Keywords: tripartite negotiations, basin-wide legal regime, fair utilization, riparian, cooperation, GERD, international water law

1. Introduction

The quest for equitable and reasonable utilization of international water resources is a fundamental right for sovereign states whose territory is bifurcated by shared water resources. The principle of equitable and reasonable utilization, the obligation not to cause significant harm, principles of cooperation, information exchange, notification, consultation, and peaceful settlement of disputes are widely acknowledged by modern international conventions, agreements, and treaties to some extent in state practice. It is widely understood that the effective implementation of these principles could able to create effective basin-wide water resources utilization and management system involving riparian countries of shared watercourses and hence, maintain stable mutual benefits among riparians. However, the application of these rights and obligations varies from river basin to river basin associated with different hydrologic, history, and peculiar inter-riparian relationships of a given basin under study. Due to the inability to establish a basin-wide legal regime that can ensure the common interests and rights of the riparians, the water issue in some basin areas in the world has become a source of conflict, political conspiracy and foreign intervention, economic, environmental, social unrest, and other an inappropriate relationships. Instances of this can be the Nile basin in Africa, Tigris and Euphrates in the Middle East, the Aral Sea basin in Central Asia, the Parana basin in South America, and the Ganges basin in Asia (Petrella, 2001). Upholding international law principles with the view to create a regulatory basin-wide legal regime that can control and change the state of water tension into transboundary cooperation becomes an unreplaceable solution among the nations (Rahaman and Varis, 2005).

For the last decades, multiple rounds of negotiations have been held between riparian's, and no notable progress has been achieved none of them are agreed upon and become a law to regulate the Nile River basin. The Nile Basin Initiative is the first and most recent regional organ that helped riparian countries to understand that the Nile River is a regional watercourse and its utilization and management must be approached from a regional perspective. It is a remarkable historical incidence, a legal and institutional setup that properly witnessed the first era of counter-hegemony in the Nile basin, and a cause for the preparation of the Nile Cooperative Framework Agreement (CFA). Equally important, the construction of the GERD in March 2011 further fueled and dislocated the issue of the utilization and management of the Nile water from regional perse to tripartite dialogue which created a clear change in the efforts toward a basin-wide legal and institutional riparian deal.

The main purpose of this article is designed to address four main issues as regards the utilization and management of the shared Nile waters. First, the rights and obligations emanating from shared transboundary rivers shall be governed by a legal regime negotiated by all riparians. Secondly, the negotiations, agreements, declarations, and other questions regarding the utilization and governance of shared resources shall be conducted with the full participation of all riparians concerned. Thirdly, any controversy arising from the utilization and management of the shared resource shall be settled

through a basin-wide channel promoting mutual understanding and benefits of all riparians. Hence, claims of any riparian country that wants to invoke the development activities in the Nile River shall be heard within the basin-based system by all riparians even if the problem priorly relates to one or more riparians. Fourthly, unilateral project-oriented negotiation and dialogue cannot be taken as a good practice because it hinders the commitment toward cooperation and is a continuous obstacle to the equitable and reasonable utilization of the Nile waters. Project-based negotiation cannot bring a sustainable solution for the utilization and management of Nile waters in the basin.

The final argument under this paper is that any debate across the Nile water shall be handled in more preference to a human rights-based approach setting aside the political rangling against the human right to development of peoples on their natural resources. Water is a basic component of natural resources, it formulates part of the sovereignty of peoples that entitled them to determine and promote the development of their respective resources. Governments of riparian countries should pursue people's right to natural resources on an integrated approach that ensures the right to equitable and reasonable utilization of the Nile waters for people residing in the basin.

I argued that the claims and negotiations between three riparians Ethiopia, Sudan, and Egypt regarding the GERD are contrary to the principles of international water law and also will have the potential move to shift the previous conflict to cooperation efforts towards cooperation to conflict which in turn promotes individual content of utilizing the shared resource in the absence of basin-wide legal and institutional system.

This article has five sections, section one is about the introduction, section two inter-riparian history, and hydrology of the Nile River basin. Section three is about treaties entered during the colonial regime concerning the utilization of the Nile waters, and its impact on a further cooperative agreement in the basin. Section four focuses on multilateral negotiations by riparian in the Nile basin, and section five is the fundamental part dealing with the tripartite negotiations concerning the GERD and its implication for the principles of international water law and sustainable utilization and management of the Nile waters in general. Finally, a conclusion and recommendation are drawn in an optimistic approach by an understanding of the legal and hydro politics of the Nile water issue raised in this topic. The article used a qualitative research method and analyzes legal instruments and relevant literature to support its argument.

2. Inter-Riparian Relation, History, and Hydrology

2.1 Inter-Riparian Relation

In the past 25 years, many countries have seen their water supplies reduced by half as their populations have doubled and the demands on water supplies have exceeded the amount of water available (David. K; 2010:4). As populations continue to rise, many scholars have argued that competition for this scarce resource could exacerbate the political instability in the region resulting in

a water war (Allan, 2002: 256) Today, 276 international river basins in the world are shared by 145 nations in Which distinct hydro political environment exists in each basin (Council for European Studies, 2018)

As Peter Glerik suggested, international river basins shared by riparian states make water a likely source of conflict based on the reasons: 1). the degree of water scarcity and, 2). the capacity to which the water supply is shared between states, 3). the power exerted by the basin states and 4). the accessibility to alternative freshwater sources. For instance, the Nile and the Jordan River basins, which are shared by 11 and 5 riparians, respectively are already experiencing water scarcity and increased competition for water resources as a result of population growth and increased water demands for economic development (Wolf *et al*, 2006:2)

Accordingly, as water resources become increasingly scarce in the Nile basin, the risk of conflict erupting between competing riparians is expected to intensify. Historically, Egypt has built diversion and storage schemes within its territories to secure the flows of the Nile to meet its growing freshwater demands, often resulting in armed hostilities with its riparian neighbors (Water policy 2008:8). On the other side, riparian states including Ethiopia that contributes 80 percent of the Nile water repeatedly challenged the *status quo* of Egypt and claimed equitable share from the water resource (Water policy 2008:8).

To date, a Cooperative Framework Agreement is formulated by riparian states however; the most beneficial riparian states in the Nile Basin Egypt and Sudan have created an obstacle to the realization of the CFA. Whether we see water conflicts or basin wide cooperation in the future may well depend upon whether these riparian's decide to play in integration or go it alone in their pursuit of reasonable utilization of the Nile water Security. For this reason, one may raise two questions to be answered in the basin scenario.

1. How do riparian stets in the Nile basin achieve equitable water utilization?
2. Due to increasing demand for development, will unilateral action on Nile waters lead to increased conflict between riparian states or will Egypt and Sudan cooperate with other riparian states to conserve and utilize the shared water resources?

The Nile River basin is currently shared by 11 riparian states including Rwanda, Burundi, the Democratic Republic of Congo (DRC), Tanzania, Kenya, Uganda, Eritrea, Ethiopia, Sudan, South Sudan, and Egypt. The total population of the countries that share the basin is almost 300 million with half of this population completely dependent upon the Nile (Swain, 2008:202). All these countries in the Nile basin are facing relatively high population growth. The population of Ethiopia, Sudan, and Egypt alone is expected to be close to 340 million by 2050 (Swain 2008:202), the demand for the Nile's water resources is expected to grow substantially in the coming years while utilizable. Nile

flows are predicted to decrease as a result of increased demand for irrigation, industrialization, urbanization, and water shortages associated with climate change (Alan, N.2011:17)

As Ethiopia overcomes its long history of rebellion, civil war, disintegration, and famines, it faces increased pressure to develop its economy and achieve self-sufficiency in food production by developing its share of water projects on the Nile for irrigation and hydropower. However, any dams that Ethiopia builds (For example the GERD) along the Nile are likely to be seen as a threat to the water security of lower riparian neighbors, as 86 percent of the Nile's flow originates in Ethiopia.

2.2 Hydrological Environment

The Nile is one of the few Rivers that flows from South to North. Starting from its bifurcated sources in humble springs along the Blue and White Nile sub-basins, the Nile traverses a distance of 6825-kilo meters across a vast expanse of land with diverse climatic and natural formations varying from humid mountainous highlands receiving abundant rainfall, semi-arid and arid regions receiving little or no rainfall (Tesfaye. 2001:8) . As D. Grey et.al stated the hydrologic environment of a basin is one of the significant determinants shaping the pattern of inter-riparian relationship and with it the possibility of equitable, cooperative development and utilization of the water resources. The hydrologic environment, i.e. the absolute level of water resource availability, inter-, and intra-annual variability, and its spatial distribution which is a natural legacy that a society inherits (D. Grey and C. Sad off, 2007:545-548) may be easy and hence conducive for equitable utilization.

The hydrologic environment of the Nile though is even worse and rather epitomizes the category of more difficult hydrology where rainfall is markedly seasonal – a short season of torrential rain followed by a long dry season that requires the storage of water or where there is high inter-annual climate variability, where extremes of flood and drought create unpredictable risks to individuals and communities and nations and regions and require over year water storage (water policy 2007 545 - 548). Indeed, the most significant hydrologic challenge in the Nile basin pertains to the river's discharge which is too small to match its reputation as the world's longest river. The fabled Nile shows the lowest specific discharge of comparable large rivers (J. Kerisel, 2001:3) as the relatively meager 84 Billion cubic meters of water it carries downstream annually constitutes only a mere cup (2%) of the Amazon perhaps a glass (15%) of the Mississippi, or at best a pitcher (20%) of the Mekong.

Another challenge pushing forward to the peculiar geographical aspect of the Nile is the unbalance contrast between the riparian state which contributes almost all the water to the Nile but uses almost none (Ethiopia) and that which contributes nothing to the Nile but uses most of its water (Egypt) that established the asymmetric use of water resources. The Nile basin thus constitutes a singularly distinct hydrologic environment where the pattern of utilization of the waters is in stark contrast to flow

contribution. The anomaly is twofold, as the two downstream riparians Sudan and Egypt have consolidated their control over the entire flow of the water resources for decades.

2.3 Historical incidents in the Nile Basin.

Some authorities identify the Nile River Basin as one of the hot spots in an area where violent conflict could break out over the shared water resources because of the various hydro-political intricacies it involves. Mounting demands for more water, alarming population growth, the absence of comprehensive legal and institutional frameworks, and relations among the riparian states that are marred with suspicion (twists and turns) and misunderstanding are among the major factors creating the potential for an extreme conflict in the basin. From the historical perspective, several forces have contributed to molding the issue of water utilization, management, and development in the Nile River basin in the past century. Among the notable factors that shaped the legal regimes over the Nile, are the presence in the basin of British interests during the colonial era and the water security policy pursued by Egypt.

For Egyptians, the water of the Nile is, an issue of national security (David .k 2010:6) and core values and interests defining their foreign policy. In his official statement Jemal Abdul Nasir, on the outcome of the construction of the Aswan High Dam, stated that “Egypt would no longer, after the construction of the Aswan Dam, be the historic hostage of the upper riparian states of the Nile basin” (Daniel Hillel, 1994:123).

A similar statement is found in the speech made by Anwar Sadat, following the Camp David Peace Agreement with Israel, in which he predicted that the only issue which could take Egypt to war was water (water policy 2008:21). He was referring to the water of the Nile and what he was trying to underscore were the Nile water’s special place in Egypt’s life and policy, and the reactions of Egypt if this was tampered with. In 1980, former Egyptian Minister of State for Foreign Affairs (later United Nations Secretary-General) Boutros, Boutros-Ghali commented that the next war in our region (North-East Africa) will be over the water of the Nile, not politics (water policy 2008:21). Generally as described by Zeitoun and Cascao, the national framework of Egypt (as the Nile basin hegemony) has been reflected in its unequal control of the Nile water resources among riparian states and maintains its *status quo* by deploying several strategies unilaterally over the shared resources (Ana Elisa Cascão and Mark Zeitoun 2010: 27).

The bargaining power of Egypt under international diplomacy enabled it to influence riparian states not to utilize the Nile water in particular the water tower of the Nile, Ethiopia has been a victim of Egyptian strategy. For instance, the World Bank Operational Directive 7.50 which allowed objecting to Egypt's every financial loan to Ethiopia is among the diplomatic impositions that Egypt played against the interest of Ethiopia /water policy, 2008:22).

The ambitions of Ethiopia to fully utilize the Nile water remained unsuccessful for decades even if the first comprehensive strategy entitled “Land and water resources of the Blue Nile” a document having 17 volumes was prepared in 1964 in cooperation with the United States of America Bureau of Reclamations.

3. The Nile Water Colonial Agreements and Their Effect on Interstate Relations

Several agreements have been concluded during the era of colonization; however, none of them do have a legal effect within the Nile basin states.

3.1 The 1891 Anglo- Italian Protocol

The protocol was signed on April 1891, between Great Britain representing Egypt and Sudan, and Italy, on behalf of Eritrea. The primary purpose of the protocol is to delimit the colonial boundary of Great Britain and Italy in the Sudan and Eritrea. The Nile issue was addressed under Article III, which states that “the Italian government engages not to construct on the Atbara River, because of irrigation, any work which might sensibly modify its flow into the Nile (Tilahun, 1979: 49). The language used in this article was too vague to provide clear rights to the use of water. In addition, the protocol did not mention the upper riparian states, where a substantial share of Nile water comes from. Thus, it does not bind other riparian states in the fact that the Nile River did not flow in the territory colonized by Italy which was the basis for its claim to its water.

3.2 The 1902 Agreement between Great Britain and Ethiopia.

This agreement was signed on 15 May 1902, between Britain on behalf of Sudan and Ethiopia to delimit the boundary between Ethiopia and Sudan. Even if the purpose of the agreement was to limit boundary, Article III of the agreement imposed an obligation not to construct or allow to be constructed any work across the Blue Nile, Lake Tana, or the Sobat, which would arrest the flow of their waters except in agreement with his Britannic Majesty’s government and the government of Sudan` (Tilahun; 1979:49). The Amharic version, however, gave different meaning and understanding to Ethiopia (Tilahun, 1979:49). The Amharic version restricts Ethiopia not arrest the flow of water. However, Ethiopia did not ratify the agreement and its meaning remained controversial

3.3 The 1906 Tripartite Agreement (British, France, Italy)

The treaty was signed on 13 December 1906 between the three colonizers with the use of the Nile water in Ethiopia’s sub-basin. Article 4(a) of the Agreement states: “To act together----- to safeguard the interests of Great Britain and Egypt in the Nile Basin, more especially as regards the regulation of the waters of Atbara River and its tributaries without prejudice to Italian interests” (Wondimeneh, 2001: 79). This treaty, in effect, denied Ethiopia its sovereign right over the use of its water. Ethiopia rejected the treaty and indicated that no country had the right to stop it from using its waters (Wondimeneh, 2001:79)

3.4 The 1925 Anglo-Italian Exchange of Notes

This agreement was communicated in December 1925 concerning Lake Tana which states “Italy recognizes the prior hydraulic rights of Egypt and Sudan -- not to construct on the headwaters of the Blue Nile and the White Nile and their tributaries and effluents any work which might sensibly modify their flow into the main river “(<https://www.ethiopians/abay/engin.htm1#1925>). Ethiopia opposed the agreement and notified both parties of its objections. When an explanation was required from the British and the Italian Governments by the League of Nations, they denied challenging Ethiopia’s sovereignty over Lake Tana (Tilahun, 1979:90). Notwithstanding, however, there was no explicit mechanism enforcing the agreement

3.5 The 1929 Nile Waters Agreement

The 1929 agreement was concluded between Great Britain (on behalf of Sudan) and Egypt. The agreement aimed to utilize the Nile waters in the proportion of 48 and 4 billion cubic meters of Egypt and Sudan respectively. In effect, this agreement gave Egypt complete control over the Nile during the dry season when water is most needed for agricultural irrigation. It also severely limits the amount of water allotted to Sudan and provides no water to any of the other riparian states including Ethiopia (agreement on 7 May 1929)

3.6 The 1959 Agreement for the Full Utilization of the Water of the Nile

The agreement for the full utilization of the Nile waters was signed in Cairo on 8 November 1959 between Egypt and Sudan, to realize, through joint projects, the full control and utilization of the Nile waters by replacing the 1929 Agreement which did not extend to include complete control of the river waters by the two states (preamble of the 1959 Agreement). This objective to fully control and exclusively utilize the Nile waters has been rightly described as patently anomalous (okidi, 1980: 429). The anomaly lies in the fact that, while it is purely bilateral, it seeks to apportion the entire flow of the Nile to Egypt and Sudan, excluding the interests of any riparians notably Ethiopia (Brunnee and Toope, 2002:125).

The agreement made possible the launching of Nile control projects – the Sudd el Ali and the Reseires dams to be built in Egypt and Sudan respectively which would increase the flow of the Nile (the 1959 Agreement Article 2(1) and (2). It also reaffirmed the acquired rights of the two parties measured in annual volumetric terms at 48 and 4 billion cubic meters respectively (the 1959 Agreement Article 2(1)). This volume of acquired rights was thus deducted from the total annual flow, and the net benefit after a further deduction of 10 billion cubic meters as loss of over-year storage of 22 billion cubic meters to be obtained from the sudd el Ali reservoir was allocated to Egypt and Sudan, which received 7.5 and 14.5 billion cubic meters respectively (the 1959 Agreement Article 2(4)

Though the agreement is concluded between the two countries which created a new era in the history of the Nile Basin, the agreement is, in substance, not much different from previous colonial-era

treaties as its main thrust is to sanction a monopoly on the waters of the Nile by Egypt and Sudan. The viability of this monopoly though is without any legal foundation, as the agreement on which it is anchored in a typical bilateral agreement subject to the *pacta tertiis nec no cent nec prosunt* rule of treaty laws (Vienna convention, 1969: Arts, 24-35), which, therefore, has no binding force on other riparian's.

3.7 The 1993 Framework for General Cooperation between Ethiopia and Egypt

The framework was signed on 1 July 1993 between Egypt and Ethiopia the first bilateral agreement between the two riparians regarding the Nile waters, after the colonial period (kefyalew, 1997:6) It stipulates that future negotiations between Ethiopia and Egypt, concerning the utilization of the water of the Nile, would be based on the rules and principles of international law (Arsano, 2000:52). The framework agreement was only indicative of the base of future negotiation and failed to provide detail working rules. The 'No harm' rule principle was mentioned in it and for this reason, some criticized it as favoring Egypt and compromising Ethiopian's sovereignty over the Nile (T. Tafesse, 2001:80) Even if the 'No harm' rule was part of the framework, it did not mean that it was the sole principle on which shared water allocation would be based since the rules and principles of international law as referred to as the guideline for negotiations in the document itself. For instance, apart from the "No harm" rule, the principle of equitable and reasonable utilization of international Water law principle is a famous principle invoked by lower riparian states all over the world, in particular a principle on which Ethiopia's interest in the Nile water is based. The framework agreement did not in effect as it merely represents the first attempt by the two states to come together and does not have a legal effect on the parties.

All of the agreements signed concerning the Nile Basin water utilization and management are of limited scope in their application. None of them managed to involve more than three states and are concluded mainly to secure the interest of the two lower riparian states. They are, therefore, bilateral and devoid of legal application to the other riparian states. The fact that the treaties are bilateral means that they cannot legitimately be perceived to regulate all of the Nile waters and all the Nile basin states.

One of the legal arguments against colonial treaties concluded in the Nile water is that the colonial circumstances under which the agreements were made have changed so fundamentally that they are not valid anymore. The doctrine of *rebus sic stanti bus* which is recognized in customary international law and the convention of Vienna concerning the law of treaties states that a state has a right to terminate the application of a treaty if a fundamental change of circumstances occurs (Art, 62 of the Vienna Convention on the Law of Treaties 1969). This change of circumstances exists when the changed circumstances are those that make up the essential grounds on which the states consented to

be bound by the agreement and the change affects the remaining obligations of the parties in a radical way (Vienna Convention on the Law of treaties Art 62, 1969).

The position of the upper riparian states was put forward by a statement of the newly independent Tanganyika, (*the Nyerere doctrine or the tabula rasa theory*) and states that ` former colonial countries had no role in the formation and conclusion of treaties done in the colonial era, and therefore they must not be assumed to automatically succeeded to those treaties `(R.O Collins, 2000:257). The upper riparian states have adopted this concept and continuously rejected the colonial agreements regarding the Nile (McCaffrey, 2001:245-246)

Colonial treaties also violate the principle of self – determination and permanent sovereignty over the natural resource of states. The free determination of people’s political status and the ability to freely pursue their economic, social, and cultural development has been a focal issue in the decolonization process and has been recognized as *a jus cogens* principle (Antonio Cassese, 1995:133-40). This argument states that the treaties violate the above principle reason that they freely give away the natural resources of a previously colonized state without its consent or any past or future control over its resources (Vienna Convention on the Law of Treaties, Art 68, 1969).

The 1997 United Nations Convention on the Non-Navigational Uses of International Watercourses in its provisions brought a new paradigm shift that may be favoring the interests of upper riparian states. The convention under Articles 5 and 7 recognized the rights of riparian states to the equitable and reasonable utilization of shared water resources. At the same time, the Convention imposed an obligation not to bring significant harm to other states along the watercourse. In effect, the convention offers a bridge between the divergent water law principles of absolute territorial integrity, which favors the lower riparian states, and the principle of absolute territorial sovereignty (natural rights) which favors the upper riparian states, by offering limited territorial integrity and limited territorial sovereignty to address the common good (David. K.2010:41)

The principle of absolute territorial integrity favors the lower riparian states because it allows them to accuse the upper riparian states of any measures they take whose effect is significant to the lower riparian states' territories. The principle of absolute territorial sovereignty on the other hand is advantageous to the upper riparian states since it holds water bodies as integral parts of a state’s territory. “The prior appropriation” principle, although favoring neither the upper riparian states nor the lower riparian states, protects the rights of use for any state that first utilized the water (FAO-UN, 1998:29-3). In the case of the Nile basin states, Egypt and Sudan defend their position concerning the utilization of the Nile water citing the principle of prior appropriation and absolute territorial integrity (FAO-UN 1998:29-31). Although the upper riparian states could base their rights to Nile water use on the principle of absolute territorial sovereignty, however, they have chosen to pursue cooperative

negotiation for equitable utilization; however, a comprehensive cooperative framework agreement inclusive of all riparian states could not yet come into effect.

The main aspirations of the Nile- related agreements were to prevent upper riparian states from constructing dams and utilizing the waters of the Nile to allow Egypt to maintain undiminished flows to quench its thirst (Brunnce and Toope, 2002:122). However, I cannot argue from this that a zero-sum game will continuously be won by the lower riparian states since the existing legal regime reflects the power politics of colonial times and not that of today. The shift in power politics is reflected by how the upper riparian states have pushed for and signed the Nile CFA Agreement putting Egypt and Sudan in the spotlight.

3.8 Multilateral Negotiations in the Nile River Basin

It has been observed that the problem of achieving effective cooperation between riparian states represents one of the greatest obstacles to ensuring the equitable and reasonable utilization of the Nile waters. The Nile River Basin is a focus in point, combining the greatest strategic and symbolic value for the riparian states. For many decades after independence, the Nile River riparian states have engaged in numerous bilateral and multilateral diplomatic initiatives to resolve the long-standing dispute over the Nile River. These developments, as well as the evolving socio-economic and political needs of the riparian states, have led to harassing lower riparian states, (Egypt and Sudan) to come to agree with a legal regime respecting and adhering to the equitable utilization of the shared resource. In other words, the central objective of the riparian states is to put in place a comprehensive international legal regime that would in many respect conform to international water law principles adopted by the United Nations and provide for equitable utilization of waters in the Nile basin.

Since the 1960s, several attempts have been put in place by the riparian states to establish an acceptable legal regime for the utilization of the Nile waters and its international drainage system. These include, among others, the Hydromet negotiation, Undugu (Swahili for brotherhood), the Technical Cooperation Committee for the Promotion of the Development and Environmental Protection of the Nile Basin (TECCONILE), and The Nile Basin Initiative (NBI). The NBI's basin – Wide cooperative framework aims to realize a shared vision of sustainable socio-economic development through the equitable utilization of and benefit from the common water resources, bringing riparians together and making the Nile one of its central development concerns in recognition of the fact that existing tensions over Nile water use could worsen if countries pursue unilateral projects.

4. The Nile Basin Cooperative Framework Agreement

The Nile CFA is the quintessence of the transformation in Nile riparian cooperation as it, for the first time brought onto the cooperative agenda the fundamental issue of equitable reallocation of the Nile waters. Being such a bold move to transform a basin noted for unilateralism and competition into one

governed by a permanent legal and institutional framework agreed upon by all riparians. The draft Nile Basin CFA was submitted to the Nile Council of Ministers which met in Entebbe, Uganda, in June 2007. Despite extensive discussions, an agreement could not be reached on the question of “water security” introduced by Article 14 of the draft, in respect of which Egypt and Sudan entered reservations calling for the replacement of Article 14(b) thereof by a new sub Article (b) which the other riparian found unacceptable. Nile Basin states agree, in a spirit of cooperation to work together to ensure that all states achieved and sustain water security and do not significantly affect the water security of any other Nile Basin states. However, the two riparian states Egypt and Sudan rejected the proposal and instead provide an amendment that obligates all riparians not to adversely affect the water security and current uses and rights of any other Nile Basin states.

Given the prevalence and importance of CFA in the Nile basin, one may question its long-standing solution for handling future water use conflicts in situations where Nile water is considered a national security issue by lower riparian states, in particular Egypt.

More importantly, if Egypt and Sudan are at odds and refused to engage in a genuine basinwide multilateral negotiation process, would tripartite negotiations relying on an individual project basis bring a viable solution to the utilization and management of the Nile waters and be legitimate within the framework of basinwide scenario and international water law principles.

The aspiration to have a legal and institutional framework for the utilization and management of Nile water on one side and the struggle to maintain unjust benefits of water on the other curved the initiatives of NBI into a complicated basin scenario. Egypt and Sudan, as they have been doing in the past, hastily introduced an illegal idea (water security) that is not compatible with the principle of international water law, the efforts of NBI, and the fates of CFA aspired to shape the Nile framework from conflict to cooperation remained fruitless.

5. The Paradox of Tripartite Negotiations and the Rights of Riparian’s in the Nile Water

Following the construction of the GERD in March 2011, the tension between the three countries is amplified by and reinforced by larger regional tensions as power dynamics in the northeast continuously challenged and blows up the political atmosphere beyond North-East Africa to the international community. This is a new incidence that occurred while the quest for the basin-wide legal and institutional framework was a recurrent issue at times. The construction of the GERD can be seen in line with Ethiopia’s long-standing claim to equitable and reasonable utilization of the Nile waters. However, the positions of the two lower riparian states cannot be formulated in a consistent way but can be looked at in three main instances.

The first and fundamental issue stems from the non-recognition of Ethiopia’s right to utilize the Nile waters. On the basis of this argument, the two countries, in particular, Egypt has tried their best to stop the construction of the dam. Secondly, while proving that no human power can stop its

construction, their position flows down to the principle of the duty not to bring significant harm. This led to the establishment of the first panel of experts and confirmed in its reports that GERD could not bring significant harm to the lower riparian states. Thirdly, still, Egypt and Sudan did not get trust and confidence in Ethiopia's project and continued to challenge the filling modalities of GERD. Along this trajectory, tripartite negotiations become a permanent forum in the Nile basin setting aside the concerns of all riparians. It is paradox because its process is against international water law principles followed by unformidable results with unsustainable prospects.

The three states signed a framework agreement called the Declaration of Principle (DoP), a platform used to guide their tripartite negotiations. As seen in practice, the negotiations were disorganized and insincere, stemming from the desire to gain diplomatic superiority over each other. This process has turned the common effort that started on the utilization and management of the water resources of the Nile into a tripartite one, which leads to conflict instead of cooperation.

Within the context of shared water resources in the Nile basin, tripartitism and riparianism represent literary individualism and multilateralism/wholism. Tripartitism promotes the claims and interests of the three states. However, multilateralism/wholism equates with the concerns of all riparian states in the Nile basin. These Nile water dilemmas can be easily confirmed by comparing colonial treaties made between the lower riparian states and the existing tripartite negotiations among the three riparian states, Sudan, Egypt, and Ethiopia in one side the formulation of CFA under the auspices of NBI on the other. One of the fundamental criticism against the legitimacy of the colonial treaties is that the two riparian states totally ignored other riparians and make total use of the shared Nile waters for decades. The currency of this behavior is individualism. Let alone sharing the waters of the Nile, other riparian states were intentionally abandoned from participating in the negotiations of the 1929 and 1959 treaties. Because of this, the legal status of colonial treaties has been destroyed while the demand for equitable and reasonable utilization of the shared water is formally shaped by the NBI lead approaches.

However, following the construction of the GERD in March 2011, the Nile water agenda falls at the hotspot between the three riparian states and triggered back earlier efforts. The following section tries to summarize the positions of international law on the rights and obligations of riparian states.

5.1 International law on the rights and duties of riparian states.

Even though, the international community is yet to agree on a uniform mechanism/ convention to manage transboundary water resources (Salman, 2007a, p.638), over the years, some customary and general principles of international law related to water have become the basis of major international conventions, treaties, and agreements for transboundary water resources management. The UN Convention on the Law of the Non-Navigational Uses of International Watercourses which was adopted in 1997 and entered into force in August 2014 can be worth mentioning in this regard. The

Convention embodies a number of principles on equitable and reasonable utilization, including the definition of factors relevant to equitable and reasonable utilization; the obligation not to cause significant harm; the general obligation to cooperate; regular exchange of data and information; the relationship between types of uses; notification and response, among others(<http://sdg.iisd.org/news/un-watercourses-convention-to-enter-into-force-following-35th-ratification/>). Though the Convention can be used as a point of reference in dealing with the utilization and governance of transboundary water resources, it could not have a legal effect against states who are not a party to such a Convention.

The rights and duties of riparians on shared water resources can be seen in line with two international law legal regimes and one theory/ legal doctrine. The theoretical foundation of the principles of international water law related to transboundary water resources management evolves from different theories and doctrines. This includes the theory of absolute territorial sovereignty, the theory of absolute territorial integrity, and the theory of limited territorial sovereignty.

The theory of limited territorial sovereignty is based on the assertion that every state is free to use shared rivers flowing on its territory as long as such utilization does not prejudice the rights and interests of the co-riparians. In this case, sovereignty over shared water is relative and qualified. The co-riparians have reciprocal rights and duties in the utilization of the waters of their international watercourse and each is entitled to an equitable share of its benefits. Principles of equitable and reasonable utilization and obligation not to cause significant harm are the outcome of the theory of limited territorial sovereignty (Schroeder-Wildberg, 2002, p.14). Only this theory has gained wide acceptance and formed the basis of modern international water law (Salman, 2007a, 628).

The first category of international law that recognized the rights and duties of riparians are the Helsinki Rules of 1966 and the UN Water Convention of 1997. The right to equitable and reasonable utilization as the backbone of rights on shared water resources is incorporated under (Article IV of the Helsinki Rules 1966 and Article 5 of the UN Watercourses Convention, 1997). This principle has substantial support in state practice, judicial decisions, and international codifications (Birnie and Boyle, 2002, 302). The International Court of Justice's 1997 decision concerning the Gabčíkovo-Naymaros Project endorsed the theory of equitable and reasonable utilization that was incorporated in Article 5 of the UN Watercourses Convention.

The principle of an obligation not to cause significant harm is also a part of the theory of limited territorial sovereignty (Eckstein, 2002, 82). This principle is widely recognized by international water and environmental law (Khalid, 2004, 11). However, the question remains on the definition or extent of the word 'significant' and how to define 'harm' as 'significant harm'. This principle is incorporated in most modern international water conventions, treaties, and agreements. It is now considered part of customary international law (Eckstein, 2002, 82–83).

The principles of cooperation and information exchange are endorsed by the UN Watercourses Convention of 1997. Article 8(1) advocates the general obligation to cooperate for the optimal utilization and adequate protection of international watercourses. Article 8(2) encourages riparian countries to establish joint mechanisms or commissions to facilitate cooperation. Article 24(1) endorses the idea of a joint management mechanism for the international watercourse. Article 25(1) stipulates, “The Watercourse States shall cooperate, where appropriate, to respond to needs or opportunities for the regulation of the flow of the waters of an international watercourse”.

International human rights law is the second category of international law applicable to the utilization and management of shared water. Three bodies of law are mentioned in this regard, the International Covenant on Civil and Political Rights (ICCPR), the International Covenant on Economic, Social, and Cultural Rights (ICESCR), and the Declaration on the Right to Development (DRTD). Both the ICCPR and ICESCR recognized the rights of each sovereign state to determine the fates of their natural resource. Water is the major component of natural resources and constitutes a fundamental human right. Thus, the right of communities to ‘freely dispose’ of natural resources for their end in a right-based approach confirms the commitments of each riparian agreed to in the above human rights instruments. However, as the Nile water is a shared resource, it poses extraterritorial obligations on states to consider the water needs not only of people within their borders but also people in neighboring states when utilizing transboundary watercourses. Together, these human rights highlight how transboundary watercourse use and management affect the lives and livelihoods of the people and communities in riparian states. Arguably, a human rights-based approach would allow riparians to recognize the need for cooperation and the potential for mutual gains in such cooperation

Instead of adhering to the rules of international water law, the three states prefer to impose their interests one against the other. Whilst an assessment of the continuous untrust negotiation processes, the three countries cannot solve their dispute and their approach reveals to promote self-interest, it offers a range of riparian concerns and participation that may help guide the overall utilization and management of the Nile waters. Unilateral action and separate negotiation scheme in the absence of basin-wide legal regime and institutional setup is against the existing international water law principles and could not bring a sustainable water use system ever. Thus, a preferred way for Ethiopia is better to reunderstand the interests of the international community and the behaviors of the two lower riparian states and push forward to get a legal guarantee through a continuous dialogue within the basin states instead of hunting more effort into the temporal diplomatic bargain. In doing so, Ethiopia proved to show its firm stand towards international law principles i.e the Nile water is a transboundary river, and its use and management require the full participation of all riparian states.

6. Conclusions and Recommendations

6.1 Conclusions

Water can have an overreaching value capable of uniting conflicting interests and promoting consensus-building among countries and societies. The history of the Nile inter-riparian relationship has since been marked as distinctive with twists and turns, super egoistic unilateralism, and misunderstandings. Manifested by infrequent ostentatious displays in an atmosphere of intense inclination to quarrel, the pattern of inter-riparian relationship has long been a tug of war between the lower riparian states, which strive to endlessly perpetuate the *status quo* and the upper riparian states, considered themselves to reach in a state of countering the water hegemony game and replacement by an inclusive, fair and equitable regime.

International Water Law and state practice dictate that a watercourse state cannot be entitled to claim an exclusive right over the shared river and cannot prevent its use by others. Its utilization, management, and development in a sustainable way demand coordination and joint action between all the riparian states. I suggest that unless the riparian states establish a basin-wide legal regime (CFA) on how to utilize their shared water, it is difficult, if not impossible, to resolve conflicts over water and strike a balance between issues of sovereignty related to water in every riparian state. More importantly, the absence of a basin-wide legal framework abounds all riparians for unilateral action against the shared resource. This in turn breaks through the inevitability of conflict over water.

Arguably, neither of the tripartite negotiations currently underway nor the prior appropriation rule may apply as a legal basis for cooperation towards a settled agreement over the issue of the Nile. Still, the existence of a cooperative legal framework inclusive of all riparian states is not questionable to achieve a feeling of sustainable peace in the horn of Africa. The assumption definitely may represent the end of the Nile's hegemonic power against cooperation in the Nile river basin. This scenario will lead the lower riparian states to a choice between backing down and allowing the utilization of the Nile water by other riparian states or pursuing further options which risk an escalated conflict

The other contending issue which worsens the hydro politics of the Nile river basin is the high intensity of commencing unilateral projects in the absence of allocation schemes made in the Nile water. Despite international water allowing riparian states the right of equitable and reasonable utilization of the shared resource, such practice should be conducted with the genuine participation of all riparian states. Participation and cooperation in the use and management of the shared resource are not about "whose claim" but rather a question of standing for principles, justice, and truth with the view to aspire to long-lasting peace in the Nile basin. A basin-wide legal regime prevents the basin states from advancing self-serving claims and tripartite negotiations and arguments. Advancing and a real commitment to the principles of equitable and reasonable utilization and the duty not to bring

significant harm underlining the existence of a basin-wide legal regime negotiated between all riparians should be a precondition to dealing in the Nile today and in the future.

6.2 Recommendation

- Within the framework of weak international and regional settings to resolve disputes of the Nile water, riparian states better sit and understand each other within their basin.
- The Nile basin states should be deeply aware of the increased self-serving claims (project-based negotiations cannot guarantee sustained uses) of Nile waters. The flaws of argument and unilateral action on both sides of the scenario dislocate the legitimate rights of all riparian states. The trends will also pose undesirable consequences and continuous instability in the horn of Africa.
- Avoid interests of foreign powers and instead better work on Democracy and governance problems and improve their respective system that can easily uphold principles of a rights-based approach to development, committed to the common causes of peoples of the basin.
- The basin-wide legal regime as a strategic and unreplaceable tool to have a peaceful claim on Nile water for present and future generations of riparian states in general and in Africa, in particular, shall prevail

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Economic Integration in East African Countries: The Grand Ethiopian Renaissance Dam as an Opportunity

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Abstract

The concept and theory of economic integration has evolved as sub stem of international trade theory, reinforced by globalization that encompasses socio-political, economic and spatial dimension or location theory. Many years ago, worldwide a number of integration arrangements have initiated and practiced to achieve the goal of socio-economic development for the betterment of the integrating countries, where they share both wonders and blenders. In this aspect international waters like Abay/Nile have both integrating and conflicting characters. The integrating nature of international waters is that, through cooperation and agreements, water resources in the form of hydro-electric power have the potential to integrate those countries who are sharing the water resources. The negative impact of that water is the conflicting situation which arises from unfair use of the water resources. Today, Abay/Nile and the GERD have showed such conflicting situation for many years among Egypt, Ethiopia and the Sudan. The positive side of such grand project may be taken as an opportunity to integrate the Abay/Nile sharing riparian countries, if common understanding, collaboration and cooperation are in place. Grand projects such as the GERD can connect East African countries, particularly, the Abay/Nile sharing countries through electrification and water basin managements. This paper analyzed regional economic integration in East African countries arising from the use of the Abay/Nile River, giving special attention to the Grand Ethiopian Renaissance Dam that imposes on regional economic integration. Historical method was used to assess the qualitative and quantitative data obtained from several desktop reviews. From the reviewed literatures and both the qualitative and quantitative analysis, the results revealed that the Abay/Nile has been showed more conflicting situation for many years and continued during the construction of the GERD. But the cooperative agreements on the Abay/Nile are expected to lead to economic integration.

Keywords: Blue-Nile basin, Cooperation, Hegemony, GERD, International water, Riparian

1. Introduction

Globalization is the process of integration of economies across the world through cross-border flow of factors of production, products and information (Francis C., 2011). Today globally, continentally and regionally there is a growing integration of national economies through infrastructure networks that helps the flow of trade, investment, financial flows and movement of labor forces from one continent

to the other and/or from one country to the other. The global and transnational economy is the one which transcends the national borders unhindered by artificial restrictions such as government restrictions on trade and factors movements*. Today, the world society is moving from alienation to integration, from arrogance to tolerance focusing on cooperation and collaboration. For the realization of cooperation and collaboration, the Abay/Nile River as a trans-boundary river could play the role of regional integration among the basin sharing riparian countries.

To remove the obstacles of free flow of goods and services across the national boundaries, regional cooperation, collaboration and then regional economic integration is an important element for socio-economic development, where coordination and cooperation is fully implemented among the integrating counties or regions.

To fully realize the objectives of regional integration, infrastructure net-work, particularly, road and communication net-work play a crucial role. Trans-national road and communication net-work, regional common resources use and other development projects are key elements to strengthen and sustain regional economic integration. Regionalization of transnational roads net-work and communication facilities are at the heart of regional economic integration, where policy issues for integration are very important.

As its objective the paper has assessed the existing economic integration in African countries in general and East African Abay/Nile sharing countries in particular.

The specific objectives of this study were to:

- Explore the importance of economic integration in Africa in general,
- Assess the current opportunities and challenges of regional integration in East African countries,
- Evaluate the importance of GERD for East-African economic integration, and,
- Design some possible ways to realize regional integration in East African countries.

Research questions:

The following questions were addressed in this study:

- What is the importance of economic integration for the integrating countries (regions)?
- What are the opportunities and challenges of regional integration in East African countries?
- Is the GERD an opportunity or a challenge for regional economic integration in East Africa?
- What mechanisms should be in place to enhance regional economic integration in East Africa?

* Ibid, p.83

2. The Importance of Economic Integration for the Integrating Countries

Since the mid of 1950s, the term economic integration has become part of discussion and also vocabulary in international economics. Economic integration is the process of reducing, then step by step elimination of restrictions on international trade, payments, and factor mobility (Robert, C. F., 2006). Economic integration thus, results in the uniting of two or more national economies in regional trading agreements[†]. In regional economic integration, division of labor and specialization fills the gap of uneven distribution of both natural and man-made resources. For example, proponents of regional economic integration have the view that it has an opportunity to create an enlarged productive base for the whole region through a new allocation of productive factors of production that may help to contribute to a larger share.

The success of Europe in forming the European Economic Community (EEC) and then European Union (EU) has motivated many countries, including Africa to design regional or sub-regional economic integration with many ups and downs (Table 1). There are various benefits from regional economic integration: economies of scale, international trade, foreign direct investment, transfer of technology and resources sharing among the integrating countries. Chronologically, regional integration starts from free trade area, and then moves to customs union, common market, economic union and finally political union, which may take a long journey (Dugassa M., 2019).

Free trade area is an agreement between several countries to eliminate internal barriers to trade but maintaining the existing barriers against non-member countries, whereas customs union is an agreement between several countries to eliminate internal barriers to trade and to erect common barriers against non-member countries (Michael, M. and Steven, H., 1995).

One of the major aspects of international trading relations during the post-war period has been the development of regional trading groupings primarily in the form of customs union (Bo Souderton and Geoffrey R., 1994).

Table 1. Levels of regional economic integration (Dugassa M. (2021) Macroeconomics: Theories, Policies and Applications, p.409)

Levels of Integration							
5.	Political Union	Free among member countries	trade	Common external commercial policy	Free factor mobility within the market	Harmonized economic policy	Super-national organizational structure
4.	Economic Union	Free among	trade	Common external	Free factor mobility	Harmonized economic	

[†] Ibid p.266.

	member	commercial	within the policy
	countries	policy	market
3.Common	Free trade	Common	Free factor
Market	among	external	mobility
	member	commercial	within the
	countries	policy	market
2.Customs	Free trade	Common	
Union	among	external	
	member	commercial	
	countries	policy	
1.Free Trade	Free trade		
Area	among		
	members		

To enhance regional economic integration, infrastructure facilities, particularly road net-works and communications system availability play a fundamental role to develop regional integration. Trade is one of the major drivers of global or regional economic integration (Francis C., 2011) given that other logistics and infrastructure facilities are available.

Table 2. Trans-African road network to accelerate regional integration in Africa (Sources: Author's compendium from various sources)

No.	Highway from....	To.....	Distance (KM)
1	Cairo Highway	Dakar Highway	8636
2	Algiers Highway	Lagos Highway	200
3	Tripoli Highway	Cape Town Highway	10808
4	Gaborone Highway	Cape Town Highway	10228
5	Dakar Highway	Ndjamena Highway	4500
6	Ndjamena Highway	Djibouti Highway	4219
7	Dakar Highway	Lagos Highway	4560
8	Lagos Highway	Mombasa Highway	10269
9	Beira Highway	Lobito Highway (Angola)	3523



Figure 1. Trans-African Highway that enhances African net-works for integration (Source: <https://www.webuildvalue.com/en/infrastructure/trans-african-highway-roads-and-railways-to-make-cargo-move.html>)

To realize the objectives of regional economic integration on the African continent, investment in roads, railways, communications and other social infrastructures such as education, health and hydro-power supply can facilitate economic integration and socio-economic development both at regional and continental levels.

As depicted from the Table 2 and Figure 1, the road network (West to East and North to South) the trans-African Highway is a good hope for the African Renaissance and socio-economic development,

if realized and sustained in the long-run perspectives, meanwhile, the GERD has the potential to connect East-African regions through power supply for needy countries.

The benefits of regional economic integration include the following elements, but not limited: increased regional as well as international trade of goods and services, flow of financial capital through foreign direct investment, regional and/or international movement of labor power, transfer of technology and know-how, advancement in transportation to facilitate flow of goods and services, and enhancement of communication among the integrating nations and/or regions.

However, there are critics who stand against economic integration for various reasons. One of such argument is the problem of national sovereignty and cultural issues that may become under jurisdiction of the regional integration. Theoretically, such issues can be resolved under the principles of socio-economic harmonization of the integrating countries at different stages of integration processes.

3. Opportunities and Challenges of Regional Economic Integration in East African Countries

Even though, the region is full of conflicts on the Abay/Nile River for many years, particularly Egypt, Ethiopia and the Sudan, the Abay/Nile sharing East African countries have a good opportunity for integration and co-development, given that co-ordination, cooperation, and peace are in place, there is a vast opportunity for regional cooperation in the region.

In the Nile Basin Initiative (NBI), it has stated that the basin sharing countries agreed to achieve sustainable socio-economic development through equitable utilization of, and benefits from, the common Nile Basin water resources (NBI, 2020), which creates a platform for the regional cooperation and then economic integration.

Table 3. Historical development of the Abay/Nile River agreements & conflicts

Year	Countries (parties)	Agreement	Conflicting issues	Resolved issues
1906	Britain, France & Italy	Tripartite	Nile water use	Ethiopia deprived
1929	Britain [‡] & Sudan	Bilateral [§]	Nile water use	48/4 BCM ²
1954	Egypt & Sudan	Bilateral	Nile water use	Agreement
1959	Egypt & Sudan	Bilateral	Water sharing ^{**}	55.5/18.5 BCM ²
1999	10 Countries	Multilateral	Fair water sharing	NBI Established
2010	10 Countries	Multilateral	Fair water sharing	CFA ^{††}

[‡] Great Britain acting on behalf of its East African colonies

[§] Water share of Egypt 48 billion cubic meter, while Sudan's share was 4 billion cubic meter

^{**} Water share of Egypt and Sudan (55.5 and 18.5 Billion Cubic meters) respectively

2010/13	6 Countries ^{††}	Multilateral	Fair water sharing	Signed the CFA
2015	Egypt, Ethiopia & Sudan	Tripartite	Fair Abay sharing	DOP ^{§§} signed

Source: Author's Compendium from various sources

If the conflicting situation (hydro-politics) among the riparian countries, especially, among Egypt, Ethiopia and the Sudan, peacefully resolved through coordination, cooperation and common understanding, the Abay/Nile and then the GERD will supply hydro-electric power for the needy regions (countries) and enhance regional socio-economic integration among the basin sharing countries. The conflicting situation can be resolved through discussion and common understanding for betterment of all parties. “By coming together to jointly manage their shared water resources, countries can build trust and prevent conflict (Atwan M., 2018).

To solve conflicts and contradictions between two more countries, continuous discussions, dialogues and consensus is very crucial. “The value of consensus, the value of tolerance, the value of hard work, and an emphasis on the communalities among us rather than the divergences^{***}” are noble ideas to achieve regional integration in East African countries in particular, and on the African continent in general.

Table 4. Abay/Nile sharing East African Countries (Source: Source: Author's compilation from www.worldometers.info 2021)

No.	Country	Area (Km ²)	Population
1	Burundi	27,834	12,259,430
2	Congo (D.R)	2.345 million	92,387,839
3	Egypt	1.002 million	104,343,930
4	Ethiopia	1.112 million	117,923,915
5	Eritrea	117,600	5,182,058
6	Kenya	582,646	55,006,704
7	Rwanda	26,338	13,285,989
8	S. Sudan	644,329	14,228,267
9	Sudan	1.886 million	44,913,965
10	Tanzania	945,087	61,501,267
11	Uganda	241,038	47,240,053
Total Population of East African Countries			568,273,417

^{††} Cooperative Framework Agreement

^{††} Burundi, Ethiopia, Kenya, Rwanda, Tanzania and Uganda

^{§§} Principle of Declaration on Fair & equitable use of Abay/Nile River

^{***} Democracy and the Social Questions, p.100.

Source: Source: Author's compilation from www.worldometers.info 2021

As indicated by Table 4, more than half billion of the African population is living around the Abay/Nile basin and this huge population number requires electric power supply from the Abay/Nile, where power supply from GERD can be taken as an opportunity to connect this the basin sharing regions so that there will be a hope for regional connectivity and then regional integration.

Table 5. Regional grouping of African countries to strengthen economic integration (*Source: Dugassa M. (2021) Macroeconomics Theories, Policies & Applications, and P.418*)

No.	Eastern Africa	Western Africa	Central Africa	Northern Africa	Southern Africa
1	Burundi	Benin	Angola	Algeria	Botswana
2	Comoros	Burkina Faso	Cameroon	Egypt	Lesotho
3	Djibouti	Cape Verde	Central African R	Libya	Namibia
4	Eritrea	Cote d, Ivoire	Chad	Morocco	South Africa
5	Ethiopia	Gambia	Congo	Sudan	Swaziland
6	Kenya	Ghana	DR. Congo	Tunisia	
7	Madagascar	Guinea	Equatorial Guinea	Western Sahara	
8	Malawi	Guinea-Bissau	Gabon		
9	Mauritius	Liberia	Sao Tome & Principe		
10	Mozambique	Mali			
11	Reunion	Mauritania			
12	Rwanda	Niger			
13	Seychelles	Nigeria			
14	Somalia	St. Helena			
15	South Sudan	Senegal			
16	Uganda	Sierra Leone			
17	Tanzania	Togo			
18	Zambia				
19	Zimbabwe				

Regional grouping are constantly developed in multiple ways either internally, by adding new dimensions to the existing ones, or by creating new blocs (Michael R.C. *et al.*, 2003). East African region is the largest one among the African regions, where most of them share the Nile basin and this large population number creates a huge demand for electric power supply.

4. Is the GERD an Opportunity or a Threat for Regional Integration in East African Countries?

The primary purpose of the Grand Ethiopian Renaissance Dam is to produce electricity that solves much of the problem of acute energy supply in Ethiopia in the medium range and in the long-run to export electric power to the neighboring East African countries. In addition to electric power supply, the Dam and the Abay River have the potential to create regional cooperation and economic integration among the Abay/Nile sharing East African countries.

Therefore, better cooperation and greater investment in shared water basin is needed (Kinfe A., 2004) by the Abay/Nile sharing countries for equitable and sustainable use of the river.

Inside Ethiopia, both the Dam and the Abay River have the synergy to create and enhance intra-local collaboration and cooperation among the western, south-western and central Ethiopian universities bounding the Abay River and its tributaries. For example, Universities such *Debark, Gondar, Debre-Tabor, Mekedela-Amba, Wollo, Bahir Dar, Debre Markos, Injibara, Debre Berhan, Sellalie, Ambo, Wollega, Assosa, Dembi Dollo, Mettu, Gambella and Mizan-Tepi* are proxy and/or bounding the Abay River or at least its tributaries. These rivers and tributaries feed Abay in the West, Tekezze in the North-West that form the Blue-Nile basin and Baro-Akobo & Alero in the South-West which forms the White-Nile, “River resources of Ethiopia (Bekure W., 2017).



Figure 2. Sources of Blue-Nile and White-Nile from Ethiopia and the GERD (Source: International Rivers 2008)

Therefore, the Dam and the river possess a huge potential for intra-collaboration, cooperation and local or regional integration in Ethiopia too. To keep the Abay basin and its bio-diversity, the above

enumerated universities have the opportunity for collaboration and cooperation to make researches that help river basin management, environmental protection and bio-diversity conservation for sustainable socio-economic development of the country as well as East-African regions.

Socio-economic significance and opportunities of the GERD are electric power supply for Ethiopia and neighboring countries, Creation of artificial lake between Ethiopia and Sudan, inland water transport, natural resources conservation and river basin management, port formation and tourist attraction, and fishery and job creation, and finally economic integration among the Abay/Nile sharing East African countries,

The challenge of the GERD is that the controversial issues on the Abay/Nile River among the riparian countries, particularly, Egypt, Ethiopia and the Sudan for water “Hegemony” by Egypt as imprinted by the colonial legacy of Great Britain.

In order to find the way out of this conflicting situation, the three countries in particular, and all the riparian countries in general, need to design “win-win” solutions that do not cause any harm to the parties involved by looking into various collaboration and cooperation for the betterment of the Abay/Nile river sharing countries.

“Throughout history, human beings have responded to the need to pool their efforts and share resources in the interests of the larger security. Water, in particular, has been one of humanity’s historic learning grounds for community building. We should see it as a potential source, not of conflict, but of agreement....for the transition from culture of war to a culture of Peace (Kinfe A., 2004).

It is believed that discussion; negotiation, recommendation, and then action can change the conflicting situation into an opportunity for the Abay/Nile sharing countries, where all the riparian countries share both the wonders and blenders of the regional “commons” to realize the “possibility of the impossibility”. This is the only avenue to adjourn the long-lasting conflicting agenda among Egypt, Ethiopia and the Sudan.

5. What Mechanisms should be in Place to Enhance Regional Economic Integration in East Africa?

The Abay/Nile belongs to all the riparian countries and no single nation including Egypt can claim “exclusive right and control” over the river and its blessings. “It is an open secret that the major force behind this.....is Egypt, which is trying to thwart Ethiopia’s legitimate right to benefit from the waters of the Blue Nile, the sources of which, as well-known is located in Ethiopia (Teklebirhan G., 2021)” . Whereas, Ethiopia is the net contributor to the water of the Nile (86%), it gets nothing while Egypt, contributing not even a drop of water gets almost everything from the river Nile. But for the past

fifteen years discussions, dialogues and confrontation through the Nile Basin Initiative (NBI) brought about the move from conflict to compromise among Egypt, Ethiopia and the Sudan.

According to Kassa (2015), the Nile Basin Initiative with all its programs and projects has increased the overall level of interdependence among the Nile sharing countries.

The Nile basin has opened opportunities for dialogue, communication and investment, and thus, increase the degree of interdependence among the Nile riparian^{†††}.

To realize the objectives of regional integration the following agreements should be taken in to account:

The main arguments surrounding regional economic integration are based on some economic and political facts of the “No Pain No Gain” principle that is the opportunity cost principle.

A number of arguments surrounding economic integration are: trade creation and diversion, the effects of integration on import prices, competition, economies of scale and factor productivity and the benefits of regionalism versus nationalism (Michael R.C. *et al.*, 2003).

- Egypt and Sudan could support basin management and development projects related to the Abay/Nile river in Ethiopia, since the origin of Abay/Nile is Ethiopia,
- Ethiopia could commit to secure regular water flow to Sudan and Egypt, and the other riparian countries that lead to a win-win situation,
- Ethiopia could aspire to build an alliance with Abay/Nile sharing countries based on benefits sharing of hydro-electric power export and basin management for water and resources sustainability of the Abay/ Nile basin countries,
- Develop strong institutional base for river basin management in the Abay/Nile sharing East African countries,
- The regional groupings in East and Southern Africa such as COMESA, IGAD and SADC should take a better momentum towards trade creation and diversion among the member countries to foster a scrupulous regional economic integration that sustains socio-economic development in the region.

Realization of the above stated ideas needs better understanding of negotiation, collaboration and cooperation that lead to regional economic integration.

6. Conclusion

In modern economy no one country can exist in an autarky system due to the fact that resources are not equally or evenly distributed all over the globe. To reduce scarcity of productive resources, countries or regions are obliged to form associations, made collaborations and/or regional

^{†††} Ibid

integrations. East African region is one of such regions that demands cooperation and regional integrations for socio-economic development.

Regional economic integration through rigorous collaboration, coordination and cooperation creates a good opportunity to enhance socio-economic development of the integrating regions and/or countries. The driving forces to materialize this regional integration are trans-highway road-networks, fast communication networks, agreement on common use of international waters such as Abay/Nile and the GERD in East African countries.

Special attention should be given to discussion, collaboration, commitment and cooperation to realize the GERD project “possibility of the impossibility” for Ethiopia, in which the GERD should connect East African countries through supply of electric-power for needy countries or regions.

Ethiopian universities bounding the Abay and/or its tributaries are advised to collaborate and cooperate to make researches on basin management and conservation (preservation) of bio-diversities of the Abay basin.

In the long-run perspectives, it is advisable to a plan for collaboration and cooperation of Ethiopian universities with Cairo and Khartoum universities on the issues of the Abay/Nile basin management and conservation of its bio-diversities that helps to enhance regional economic integration in East African countries.

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Management of Conflicts over Transboundary Water Resources: Egypt, Ethiopia, and the Blue Nile Basin

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Abstract

How do riparian states manage water conflicts? Why countries in some river basins have been able to effectively manage the conflict whilst the riparians of the Blue Nile Basin failed to do so? These are the main questions this paper dealt with. Most scholars on water conflict disproportionately focused on the possibility of water war or cooperation among the riparians of the transboundary rivers, by adopting narrow theoretical frameworks, which resulted in the scant exploration of low-intensity water conflict. In short, the existing methodology is inadequate in explaining issues about water interactions among the riparians of the transboundary rivers and the dynamics of hydro politics. By applying a ‘richer view of law and politics’, this paper seeks to examine the theories, concepts, and strategies on the management of conflicts arising from the use of transboundary water resources, with a particular emphasis on the Blue Nile Basin. Accordingly, the paper argues that effective management of water conflicts depends, *inter alia*, on the power asymmetry among the Riparian States, the existence of and the extent to which the emerging water use norms are entrenched into the legal framework and state practices, the relative strength of and the mandate bestowed upon institutions regulating the Basin, and the level of convergence (divergence) of state identities and interests of the Riparian States. More particularly, within the Blue Nile Basin, Egypt has been able to establish and maintain an unstable hydro-hegemony in the Blue Nile Basin. To this end, it relied, among others, on colonial treaties, informal institutions, containment strategies such as international financial institutions, the discourse of ‘historic rights’, and the securitization of the river. Over the last three decades, however, the upper riparian countries (mainly Ethiopia) have started challenging the Egyptian hegemony by using various counterhegemonic strategies, mainly through the combination of legal and political mechanisms and noticeably, following the construction of the GERD. It further asserts that the management of conflict between Ethiopia and Egypt has become intractable owing

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to the competing norms, incompatible state identity, and securitization of the Nile, coupled with weak institutions and ineffective conflict management efforts, as evidenced in the protracted negotiation process and the failed US-brokered mediation. It is, therefore, imperative that future Ethiopia-Egypt water conflict management endeavors should take the aforementioned necessary, albeit not sufficient, conditions into account.

Keywords: hydro-hegemony, hydro-harmony, transboundary water resources, water conflict management, securitization.

1. Introduction

Rarely do interstate conflicts; be it a dispute over borders, access to the Sea, economic competition, or conflict over the use of transboundary waters, involve a single issue (Wolf, 2007). It is in the nature of any conflict to encompass elements of competition and cooperation, to varying degrees. This denotes that the main difference between two conflicts lies in their *degree* of cooperation or competition. Consequently, effective management of a conflict depends, *inter alia*, on the underlying causes of the conflict, the issues involved, the identity of the parties, the strategies employed, and the role(s) of third parties in the resolution of such conflict.

In the case of conflicts arising from transboundary water resources (hereinafter water conflicts), interactions among riparian states are characterized by a high level of interdependence or what conflict theorists call “positive linkage” (Coleman 2014, 41). It entails the riparian states either swim or sink together (Tekuya 2020). When it comes to long rivers with many riparian countries, cooperation even becomes more difficult not least because it involves complex interactions, many issues, and competing interests, particularly in the absence of resilient institutions and shared norms. The Nile River is one such transboundary river typified by intractable conflicts and poor cooperation among riparian states.

Even though the Nile is a shared water resource, only Egypt and to a lesser extent, Sudan, have extensively utilized it. This could be *partly* explained by the following reasons. First, Egypt being a downstream country, is highly dependent on the Nile to meet more than 90% of its consumption. The Egyptian civilization is inseparable from the fresh water and fertile soils of the Nile Delta. Second, Egypt being a colony of Great Britain, has been able to safeguard its interests over the Nile through great power politics. Third, even after decolonization, Egypt remained one of the great powers in the region. For these reasons, it should not be surprising that Egypt has been able to establish and sustain *hydro-hegemony* (Warner 2006) over the Nile River.

This hegemonic order over the Nile was built by applying different mechanisms, through the combination of both hard and soft powers. Notably, Egypt relied on the international water law doctrines of prior

appropriation (by building Mega Dams and artificial lakes), invoking the principle of ‘not causing significant harm’ and the claim of ‘historical rights’ (Deng 2007), which were solidified in bilateral treaties. By virtue of these legal norms and existing power asymmetry, the vast majority of the upstream countries were excluded (until very recently) from claiming the fair share of the Nile water (Swain, 1997). Thus, the status quo could not be maintained due to the growing tension between the forces of change and continuity.

That is, the upper riparian states (as spearheaded by Ethiopia) have started challenging Egypt’s hydro-hegemony over the last few decades (Casca˜o 2008). To do so, the upper riparian states have profusely relied on the contemporary international law norms of ‘fair, equitable and sustainable utilization’ of transboundary water resources and sovereignty over the natural resources within the territory of the riparian states as enshrined in various international instruments.

The Nile Basin Initiative (NBI) aimed at ensuring ‘benefit sharing’ (W. Teshome 2009), facilitating dialogues, and laying down the foundation for the subsequent negotiations for a comprehensive agreement. Unfortunately, and to the dismay of many, during the negotiations on the Cooperative Framework Agreement (hereinafter CFA), Egypt has introduced a ‘water security’ clause¹² that would be incorporated into the art. 14(b) of the agreement (Mekonnen 2010) as a tool to safeguard the status quo. It rather ironically, as Salman (Salman 2013) noted, solidified the differences between the upper and lower riparian states.

In the Blue Nile Basin, the water interaction between Ethiopia and Egypt is unique in many ways. Both countries are recognized as one of the oldest civilizations in the world, embodying rich history, culture, mythology, and state identity (Gershoni 2000); those historical interactions are marred with strategic cooperation and confrontations (Jesman 1959); (Erlach 2001) and most significantly, Ethiopia is the main supplier of the Blue Nile whilst Egypt is highly dependent on the continues flow of the river.

These interactions have taken a different form following Ethiopia’s commencement of the construction of the Great Ethiopian Renaissance Dam (GERD) in April 2011. The renaissance dam has as much symbolic value as its economic return for Ethiopia. This means that Ethiopia’s move to reclaim the Nile River has led Egypt to *perceive* it as a unilateral measure to question its hydro-hegemony and significantly escalated the hitherto simmering dispute between the two countries (Mbaku 2020). As a result, in the ensuing years, the process of *securitization* of the Nile (Fischhendler 2015) has intensified, reaching its peak with the lodging of a complaint by Egypt to the UNSC on June 19, 2020, and subsequent complaints

¹² Water security should not be conflated with securitization of the water resources (as Mekonnen did), although a perception of threatened water security may serve as an element of securitization.

2. Theoretical Framework and Research Methodology

Within the general framework of the constructivist paradigm of international relations, this paper approaches water conflicts from a ‘*richer view of law and politics*’ (M. F. Toope 2001). This framework contends that legal norms have constitutive effects on riparian states. It has been argued that “International law can and does result from *belief* and reasoning that compels a response” (Zeitoun 2008, 110), emphasis added). But these beliefs and reasonings are found not only in the commonly identifiable foreground knowledge (treaties, national laws, court judgments, constitutive instruments, formal institutions, etc.), but also as embedded in the repertoire of background knowledge (customary norms, informal institutions, state practices, national discourses, historical narratives, etc.). Indeed, relations among States, including *transboundary water interactions*⁸, are determined by multifaceted interactions at various levels. These complex interactions sustained over time, constitute the identities of the actors and by extension, national interests. It is worth noting that state identity, once formed, would tend to remain stable because of its institutionalization (Zehfuss 2001), subject to evolution through the intersubjective process (Wendt 1999) and *practical* intersubjective interactions and understandings.

Legal norms are one of the mechanisms used to establish *hydro-hegemonic* order. Once established, hydro-hegemony is sustained by entrenching into the common sense of the mass through a discursive practice (Hopf 2013) and through the effective use of power. Indeed, by imposing colonial treaties, institutions, and sanctioned discourses on other riparian states, Egypt has been able to effectively establish and maintain hegemony in the basin (Tekuya, 2018; Cascaño 2008). As to the securitization moves, this research aims at unpacking the discourses of water security and the attendant practices in the basin, in light of the Copenhagen School (Buzan 1998) and its more refined version, the sociological approach ((Balzac(ed) 2011) on the social construction of *security*.

As depicted in table 1, power¹³ lies at the heart of transboundary water interactions. Power is, in the words of Pouliot (2011, 30), “not a capacity but a relation and that it is both material and symbolic.” It is to say that, in addition to being material and symbolic, power is inherently *relational*. How much power is exercised, however, is constrained (or enabled) by other factors: norms, institutions, state identity, and

¹³ Here, power refers to a smart power, which encompasses the combination of the hard power of coercion and the soft power of persuasion and attraction to achieve the desired goal. For a general background on smart power, see Joseph S. Nye, *The Future of Power* (Library of Congress, New York, 2010).

water security. Thus, depending on the interplay between some or all of these factors, the water interactions among the riparian states could be more of hydro-hegemony or hydro-harmony.¹⁴

In short, this paper would seek to problematize state interests and preferences with a view to alleviating the “poverty of neo-realism and neo-institutionalism” (Ashley, 1984).

Table 1. Framework of Hydrohegemony vs. Hydroharmony

Description	Hydro-hegemony	Hydro-harmony	Effects on Conflict Management
Legal Norms	Mostly no comprehensive and basin-wide legal frameworks, norms are rhetorically invoked for instrumental purposes (mainly to sustain hegemonic order), mostly predicated upon the inequitable distribution of water resource, and highly contested until such time it will be replaced by other competing norms.	Commonly there exist comprehensive basin-wide legal frameworks, norms are deeply internalized (taken for granted), they shape the preferences and identity of the actors, ensures equitable utilization of water resource, and tend to endure for a long period but evolves as practice selectively changes.	Divergent interpretations of existing norms (as driven by historical narratives and grounded in background knowledge vs. concordant interpretation (with the possibility of varying practical implementation) and the power of persuasion, resort to costly litigation vs. frequent informal deliberations and the use of alternative dispute resolution (ADR) mechanisms.
State Identity and national interests	No or less common identification between the disputants, a community of practice within the basin is unthinkable and the prevalence of competing, at times mutually exclusive, interests.	Disputants tend to exhibit strong common identification, and a relatively high possibility of forming a basin-wide community of practice and relationship based on shared values and interests.	Characterized by a zero-sum game vs. win-win approach; preservation of relationship vs. winning the battle at any cost.

¹⁴ Hydro-harmony: this is a term coined by the writer of this paper and it refers to a state of affairs whereby the conflicting riparian states move away from hydro-hegemonic order to a mutual and sustainable co-existence with each other and in harmony with the ecological system through an innovative basin-wide water management system. As such, it goes beyond cooperation among riparians to share the water resource, riparian relationships are forged on the basis of common identity and it encompasses ecological harmony. However, a related but conceptually different terminology, *hydro-solidarity*, has been widely used.

Institution	In most cases, there are no institutions, institutions with no or limited mandates, poor cooperation, hostile interactions among riparians, and no or weak dispute settlement mechanisms.	In most cases, strong and resilient institutions, extensive mandates, regular cooperation, positive interactions among riparians, and effective dispute settlement mechanisms.	Delegitimization of institutions (if there are any) vs. strong trust in the institutions, poor management of conflicts vs. effective management of conflicts.
Water Security	Securitization of water resources; unilateral approaches to water utilizations and competition to control of water resources.	Treating water scarcity as common security; integrated resource management and prioritization of efficient use of water resources.	Little room for compromises, hostility, and a threat of war vs. sustained dialogue, pacific resolution of disputes and a negotiated settlement.
The role(s) of power	Power over others: more hard power exerted, and coercive diplomacy used.	Power with others: more soft power exerted, and holistic diplomacy used.	Conflictual relationship and demonstration of power politics vs. acquiescence and common security framework.

Therefore, the central *theme* of this paper is that, in addition to water scarcity, competing interests, lack of resilient institutions¹⁵, and hydro-hegemonic order¹⁶, competing norms and incompatible state identities among riparian states and securitization of water resources significantly contribute to the intractability of water conflict and make its management a complex project to deal with. This is because the bases for building “trusting relationships” (Hoffman 2002), cooperation in good faith, and establishing a strong institutional framework would be unlikely without bridging those differences.

In terms of methodology, this paper has employed an interdisciplinary approach, whereby International Law and International Relations disciplines are synthesized through a normative framework. It relied,

¹⁵ Institutions and regimes play crucial roles in facilitating cooperation and providing for dispute resolution mechanisms. However, institutions are political constructs whose efficacy depends on, among others, common identifications, the normative strength of the constitutive documents, the existence of mutual trust among the members, the existence or lack of regional hegemon, the principal-agent problem, and the level of regional integration and thus, the transformative power of the institutions. In the Blue Nile Basin, for instance, there is the NBI, but its transformative power has been crippled by factors overlooked by conventional explanations. For a detailed discussion on this, see chapter two.

¹⁶ According to the Neo-Gramscian approach, hegemony is generally conceived as consent manifested in the form of broad acceptance of ideas, norms, and ideologies and maintained by material resources and institutions.

extensively, on literature reviews, interviews with some selected government officials and analysts, international treaties, and government websites. In order to further bolster the depth of the analysis, case studies are devised. Even though Sudan is one of the riparian states of the Blue Nile Basin, it was excluded for three main reasons. First of all, Sudan's hegemonic role is less pronounced as compared to Egypt. Secondly, adding Sudan to the mix complicates the causal mechanism, without adding extra value. And lastly, Sudan's position has not been stable over the past few years, as it swings between supporting Ethiopia, serving as a balancing factor, and siding with Egypt.

3. The Role(s) of Institutions¹⁷ and Mediation in the Management of Water Conflicts

It has been pointed out that “building institutional capacity is the strongest method to prevent and resolve water conflicts, despite its imperfections” (Petersen-Perlman 2017, 2). The efficacy of institutions in managing water conflicts is predicated upon the premises that “International water conflicts may happen when there is no institution that delineates each nation's rights and responsibilities with regard to the shared body of water, nor any agreements or implicit cooperative arrangements” (Petersen-Perlman, 7). This is the case because “once cooperative water regimes are established through treaty, they turn out to be resilient over time, even between otherwise hostile riparians and even as conflict is waged over other issues” (J. D. Wolf 2009, 23).

For the most part, it is the resilience of the institutions that help with the management of water conflicts. And of course, as international institutions are born to be mediators, they frequently involve in the conflict mediation process (Touval 1985, 34). Primarily, institutions provide forums for interactions, negotiations of water-sharing schemes, and mechanisms for dispute resolution. As a result, the starting point for conflict resolution is the negotiation between or among the riparians of transboundary rivers. For the process of negotiation is a learning avenue, it may also serve as a potent tool of socialization so that “parties can educate each other in their interests and thus become re-educated in their own interests in the process” (J. D. Wolf 2009, 33) through the process of intersubjective understanding. Then, this sustained dialogue will, to a great extent, help parties to re-examine their previous negotiation positions and modify their interests.

For this process to bear fruits, conflict mediators play important roles by helping parties move from a zero-sum game (position-based negotiation) towards interest-based negotiation strategies. Indeed, if what is hindering the parties from engaging in an integrative negotiation aimed at problem-solving is their irreconcilable positions and mutual distrust, which is very common in international negotiations, it stands

¹⁷ An institution is used in its broader sense, encompassing the rules on conflict resolution and regional and international organizations with the mandate to manage conflicts arising between or among its members.

to reason that a mediator can bring in fresh perspectives (proposals), enhance the legitimacy of the dispute settlement process through confidence building strategies such as informal interactive mechanisms, identifying problems and re-framing the issues (especially where water is subject to securitization).

More specifically, active mediation is more effective than simple facilitations for conflicts characterized by polarizations and involving high politics to break cul-de-sac and bring about constructive dialogue. Furthermore, the success of the mediation process depends on the complexity of the issue(s), the parties have reached a stalemate, the parties' own conflict management procedures have been exhausted and the adversaries show some level of cooperation and are ready to communicate (Bercovitch 1985, 738). It is worth stressing that the overriding goal of mediators in any conflict is to modify the nature and structure of the dispute, thereby altering the behaviors and the mode of interactions between the disputants. A mediator with referent power, that is, "the power to influence one or both sides because the parties to the conflict value the relationship with third party" (Aall 2008), is more suitable to bring about a change of behavior and modify the structure of the conflict.

Contrary to conventional wisdom, the mediator may manipulate the process (Touval 1985, 39), in addition to the roles of facilitating and framing the issues, to achieve a breakthrough. Thus, every strategy devised by the mediator to resolve the conflict should be geared towards achieving this goal; otherwise, there is no need to initiate the mediation process in the first place. The success or failure of the mediation process in water conflicts is contingent upon various factors, inter alia, the nature of the dispute such as issues at stake, duration of the conflict, distribution of power (the existence of hydro-hegemon in the conflict), the identity of the parties, and the legitimacy of and roles entrusted with the mediator.

That is, without the legitimacy of the process and the mutual trust of the mediator by the parties, the entire process is a *fait accompli*. Parties may not need to trust each other (mostly that is why they seek the help of third. In this context, mediation is understood as a continuation of the negotiation process with the involvement of a third party to enhance the parties' effort to reach a negotiated outcome, but the mediator. Equally important, the efficacy of international mediation also depends on the timing of the intervention. It seems that there is a general understanding that, for the mediation process to be more effective, it should follow adversaries' own settlement and not the other way around (J. Bercovitch 1985, 748).

At regional levels, the African Union (AU) is one of the organizations with its own conflict management architecture. It advocates for the norm of "African solutions to African problems", which denotes the capability of the African continent to manage its problems without external intervention (Lobakeng 2017, 2). The origin of this principle can be traced to Arts. III (4) and XIX of the OAU Charter which provided for a procedure of conflict management. According to this norm, member states are obliged to exhaust

African solutions (if available) before resorting to international dispute settlement mechanisms (OAU 1963).

However, the AU appears to have shown a poor track record in managing African conflicts, especially interstate conflicts, though it has been presented with multiple opportunities on different occasions to lead the way. This deficiency partly stems from poor institutionalization of norms, lack of political will and commitment, and the mantle of “non-interference in domestic affairs.” Notably, the very notion of African solidarity hinders African Heads of State from taking initiatives to manage inter-state conflicts. Similarly, as a result of sub-regional competition, “the tension and power politics at play between regional hegemons often prevent them [African States] from coming together and acting with one voice in times of conflict” (Lobakeng 2017, 6), (emphasis added). And AU’s capability to resolve water conflicts remains to be seen.

4. Hydro-hegemony and Conflict Management in the Blue Nile Basin

One of the major factors that hamper cooperation among riparian states in the basin is the existence of a hydro-hegemon. It has been pointed out that hydro-hegemony rests on three main pillars: *power*, riparian geographical *position*, and resource exploitation *potential* of the riparian state (Hanasz 2014, 98). At the core of hydro-hegemony lies the presence of a powerful actor in the basin. The mere presence of a hydro-hegemon within the basin is not problematic *per se* because interactions among riparians range from *benign* to oppressive, depending on the fairness of the outcome for the less powerful riparians and the level of control established over the shared resource by the hegemon (Zeitoun 2008, 112). I argue that hydro-hegemonic order is not stable¹⁸ in the Blue Nile Basin owing to the following reasons: (1) perceptions do change and power configurations are bound to shift, (2) hegemonic order is mainly a social construct, it can be deconstructed, too, particularly by a ‘rival’ riparian, (3) shared resources are not amenable for stable hegemonic order, and (4) hegemony founded on a manifest injustice lacks a legitimacy.

Egypt has been a hydro-hegemon in the Nile basin for a long because it has created and maintained its ‘historically acquired rights’ through a combination of material, structural and discursive powers. To this end, it used its soft power to keep water issues off the regional and international agendas by virtue of

¹⁸ For a general discussion on hegemonic order and its stabilising effects, see Robert O. Keohane, *After Hegemony: Cooperation and Discord in World Political Economy* (Princeton University Press, 1984); Duncan Snidal, “The Limits of Hegemonic Stability Theory,” *International Organization*, Vol. 39, No.4 (1985), pp.570-614 and Michael C. Webb and Stephen D. Krasner, “Hegemonic Stability Theory: An Empirical Assessment,” *Review of International Studies*, Vol.15, No.2 (1983), pp.183-198.

sanctioned discourses and resorting to effective securitization. Fundamentally, Egypt has been able not only to utilize the river but also to prevent the upstream countries from claiming their fair shares (Dessu 2018). Thus, like many downstream countries with a preponderance of power commonly do¹⁹, Egypt has maintained its hegemony through the strategies of resource capture, containment of upper riparians, and integration (Warner 2006). Notwithstanding, the hegemonic order was not benign in nature or has never been regarded *as such* by the upper riparians. What has maintained the status quo is mostly the power asymmetry. If one applies a typology of hegemony (Lustick 2002), it is safe to contend that Egypt's hegemony was highly built on coercive and utilitarian hegemony than normative and ideological hegemony. What is more, given the unfairness of the colonial treaties that ignored the interests of all upper riparian states (Arsano 2007, 89), it is not and should be surprising that other riparians would challenge it, as soon as they get the means and *zeitgeist*.

Even though Egypt's hydro-hegemony had been partially questioned by Sudan as early as 1959, strong challenges have come from Ethiopia, which seeks to change the status quo and replace it with equitable, reasonable, and sustainable utilization of the water. At the end of the cold war, the China factor in the basin and the relative political stability and economic growth in Ethiopia have created a conducive political environment to challenge the status quo. As Casca˜o (2008, 21- 24) pointed out, Ethiopia used four strategies to counter Egyptian hydro-hegemony, which are reactive diplomacy such as the deconstruction of discourses, open protest, refusal to cooperate; proactive diplomacy such as agenda-setting in regional and international organizations, lobbying, garnering support from other riparians; cooperation (through the NBI, CFA negotiations, and bilateral relations) and securing alternative sources of funding. In addition, Ethiopia has also used the strategy of resource capture, notably through the construction of the GERD, public mobilization and diffusion of new norms and counter-narratives. This counter-hegemonic move by Ethiopia, along with other factors, fed into the intractability of the conflict, as will be elaborated further.

5. Water Interactions between Ethiopia and Egypt in the Blue Nile

5.1 Historical Water Interactions: Cooperation and Conquest

Thucydides (Thucydides 1972) described Egypt and Ethiopia as areas encompassing the vast geography spanning from the highlands of present-day Ethiopia through the Nile delta to the Arabian Peninsula. Although trade, cultural exchange, and ancient civilizations have formed part of the historical relationship between the two countries, the Nile served as the main thread connecting the two countries. For centuries, Ethiopia used to receive top religious leaders from Egypt in return for the natural flow of the Nile to

¹⁹ For example, that is what India had been doing on the river Brahmaputra before the rise of China.

Egypt. The Nile and the Cross, as Haggai Erlich argues, has always been inextricably linked from the time when Christianity was introduced to Ethiopia (5th century) until such a relationship severed (the 1950s) (Erlich 2001).

Hence, the Coptic Church had served as a traditional institutional arrangement through which the use of the Nile had been governed for a long.

With the advent of Arab nationalism and the seizing of power by the ultra-nationalist Khedive Ismail, the Egyptian dream of controlling the source of the Nile and uniting the Nile Delta reached its pinnacle. As Jesman succinctly noted, “Just like the Egyptian extremists of today he [Ismail] was inflamed with the idea of the unity of the Nile valley from the great lakes [Lake Tana] to the delta under the green flag of Egypt” (Jesman 1959), 77). This quest to control the entire Nile Delta led the two countries to devastating wars in the 1870s. The notable wars with far-reaching consequences were fought at the Battles of Gura (1875) and Gundet (1876), resulting in the total defeat of the Egyptian forces. Similarly, at the heart of the Ethio-Italian war of 1896 (Jonas 2011)⁹⁴ lay the geopolitical interests of the major powers (Italy, France, and Britain) to control the source of the Blue Nile (H. G. Marcus 1994), 95). This geopolitical competition had emanated from the Anglo-Italian Protocol of 1891 (H. Marcus 1963) which provided for the British mandate to control the Blue Nile on behalf of Egypt and formal recognition of the Italian sphere of influence in the Horn of Africa. Soon after, the second Italian invasion of Ethiopia in 1935 was undergirded by the geopolitical schism between Britain (to safeguard the rights of the two Arab nations over the Blue Nile) and Italy (to control the Lake Tana Project (McCann 1981, 667). Furthermore, all Egyptian Presidents have justified the need to go to war should Ethiopia tamper with ‘Egypt’s water’. In 1979, Anwar Sadat clearly stated: “we are not going to wait to die of thirst in Egypt. We will go to Ethiopia and die there” (New York Times 2020). A decade later, Hosni Mubarak warned: “If Egypt thought about fighting Ethiopia, there will not be one Ethiopian after the war to tell the story” (Deutsche Welle 2013). This rhetoric of water war has been more pronounced following the construction of the GERD (as will be discussed shortly).

Apart from the above-mentioned military confrontations and the constant beating of war drums, Egypt has also actively engaged in sponsoring proxy wars to destabilize Ethiopia. For instance, the government of Egypt openly admitted supporting Somalia’s war of aggression (1977-78) in the eastern part of Ethiopia (Addis Zemen Gazette 1986) and the 2015-2018 mass protests against the Ethiopian government (by supporting political dissidents and Islamic movement factions). It could be argued that this is just a continuation of the water war through a different means. Compounding these historical animosities are the treaties which did not take the interests and rights of Ethiopia into consideration, i.e., all the colonial and the subsequent bilateral treaties have totally removed Ethiopia from the scene of the Blue Nile hydro-

politics. As noted in chapter three, with a view to rectifying the historical injustice, Ethiopia has persistently objected on many occasions against what it calls the 'intolerable' state of affairs. For example, the statement from the government of Ethiopia addressed to Egypt and the UN in protest to Egypt's diversion of the Nile to the Sinai desert partly reads: "...the measures taken by Egypt in regard to the use of the waters of the Nile will in no way affect its legitimate rights to the waters of the Nile..." (Ministry of Foreign Affairs of Ethiopia 1980), para.7). However, apart from denouncing the unequal treaties and inequitable utilization of the Blue Nile, Ethiopia had (until very recently) remained a 'silent partner' (Waterbury 2002). Thus, from the foregoing, it is plausible to argue that the longstanding tensions and historical animosities between the two riparians over the utilization of the Blue Nile have played a significant role in shaping relations dominated by mutual distrust between the two riparians.

5.2 State Identity and Intractable Water Conflict

The most prominent factors that have shaped the identity of the respective states and contributed to the intractability of the conflict are (1) the Nile; (2) the nature of the two regimes: Egypt and Ethiopia; and (3) the discourses of Pan-Africanism vis-à-vis Pan-Arabism.

To begin with, the Blue Nile is not just water traversing boundaries and replenishing the ecosystem. The Nile (Abbaya), beyond its geographical representation, has fundamentally shaped the Egyptian image of Ethiopia and *vice versa*. The Egyptians had considered the people living to the south of their ancient territory as *al-habasha* (Ethiopians in Arabic); who are intent to curtail the flow of the Nile. For Egypt, the people of the Nile Valley included the united Arabs (Egypt and Sudan), whose civilization had flourished based on the riches of the Nile. The best strategy to control the Nile, Egyptian nationalists assert, is to regain its lost historical territory of Sudan (Warburg 2000, 229) and neutralize any threat posed by Ethiopia. The common myth constitutes the identity of Egypt and has continued to inform the foreign policy of Egypt. About a century ago, Gemmill argued that "Egypt is the Nile, and the Nile is Egypt, just as true today as two thousand years ago" (Gemmill 1928, 311). Today, this assertion is equally relevant, if not more. As a result, the Blue Nile has become a nightmare of foreign policy for successive Egyptian Leaders (Rasheedy 2007). Moreover, the myth of Egypt as the Nile was grounded in spiritual practice, which holds that god *Hapi* would be offended if a drop of the Nile water is touched by the upstream countries.

All the same (though not to the same extent), Abbaya occupies a unique place in Ethiopian culture, literature, folklore, history, and national symbols. It is common to hear from the Ethiopian people whereby they personify and (regretfully) call Abbaya a notorious traitor, who endlessly washes the fertile soils from the Ethiopian highlands and constantly feeds the ungrateful Pharaoh and the unruly child of Ethiopia that should be tamed (Gershoni 2000, 9). Hence, it is no wonder that many parents name their

children after the river; *Abbay*, *Abayneh*, and *Abbaynesh* are some of the common Ethiopian names. It has to be noted that Abbay is the symbol of the nation, not necessarily because of its enormous values (as many other smaller rivers have been utilized by far as compared to Abbay in the past), but for its unparalleled symbolic value of national identity (Tafla 2000, 154).

Nonetheless, there is one striking difference between Ethiopia and Egypt in regard to the perceptions of common identity and destiny in the Blue Nile. For Ethiopia, the Nile has always been regarded as a shared resource. This has been pointed out in the letter of the 14th of May 2020 which states: “We [the people in the Nile basin] are ancient civilizations *inseparably* linked by the Nile River” (Ethiopian Ministry of Foreign Affairs 2020, 1), emphasis added). This conception of common identity on the Blue Nile is rarely found in the official discourses of Egypt.

As to the nature of the regime, both Ethiopia and Egypt are dubbed as authoritarian states according to the latest report of the World Democratic Index, ranking 123rd and 138th, respectively. Authoritarian states have, in principle, poor records in regard to embracing the norms of peaceful resolution of disputes, including through third-party mediation. This argument is partly informed by the democratic peace hypothesis discussed in chapter one. Less constrained by democratic deliberations and institutional hurdles, both states have engaged in the securitization of the Dam (as further elaborated in section 4.4) to sway public opinion and consolidate their domestic political power. Moreover, Egypt’s culture of aggressive militarism (Lokesson 2013) and Ethiopia’s social-psychological makeup of constantly defending itself against foreign invaders, appear to have negatively affected the water interactions between the two countries.

Lastly and importantly, the competing discourses of Pan-Africanism (as propounded by Ethiopia) vis-à-vis Pan-Arabism (Egypt acting as its guardian) have noticeably affected the negotiation process over the GERD dispute. In fact, the modern state of Egypt is the assemblage of Ottoman Turks, Western influence, Islamic state, and Arab nationalism (Pratt 2005).

This is discernible from the press release of the Arab League Council on 5 March 2020 where it issued a strong resolution condemning Ethiopia for trying to temper ‘Egypt’s historical right over the Nile water’ and regarded Egypt’s water security as the collective security of the Arab nation. It called upon all the Arab countries to show pan-Arab solidarity towards Egypt and put every possible pressure on Ethiopia (Amin 2020). Similarly, the Congressional Black Caucus issued a press release, wherein it called upon the U.S. government and the international community to respect the sovereignty of Ethiopia, let the disputes between African states be resolved within the AU framework, and stressed that the US government should act impartially and fairly (Congressional Black Caucus 2020). Jesse Jackson, the Chairman of the

Caucus went as far as asserting: “No matter how much I tried, I found it harder to rule out race as a factor in the international play” (Congressional Black Caucus 2020).

In a nutshell, “both a shared sense of identity and power interact with each other when influencing people’s threat perceptions” (Rousseau 2007, 751) and henceforth, contributed to the complex dynamics and intractability of the conflict.

5.3 Competing Norms and the Water Conflict

The water interactions between Ethiopia and Egypt are characterized by contending water use norms and/or irreconcilable narratives. Among others, Ethiopia heavily relies on and ruthlessly advocates for the norms of ‘equitable, reasonable and sustainable use’, of ‘not causing significant harm’ and ‘sovereignty over natural resources and the narratives of ‘win-win solutions and the right to ‘sustainable development’. Egypt, on the other hand, has been constantly invoking the norms of ‘historically acquired rights’, ‘not causing significant harm’ and ‘Egypt’s water’, and the official narratives of ‘water security’ and threat to ‘regional peace and security’. It is interesting to note that both countries recognize the transboundary nature of the river and the duty not to cause significant harm to the environment and interests of other countries. In essence, the difference lies in the mode of assessment of what constitutes significant harm and how to share the common resource. For example, Ethiopia officially proclaimed that the Nile is a shared resource that belongs to all countries in the basin (Ethiopian Ministry of Foreign Affairs 2020, 5), whilst Egypt has refused to sign a basin-wide multilateral treaty (the CFA) that explicitly acknowledges the interests of all the 11 riparian countries in the basin.

In support of its advocacy for equitable, reasonable, and sustainable use of the Blue Nile, Ethiopia has been persistently objecting to unilateral actions taken by Egypt. Ethiopia is of the view that it “did not and still does not have any agreement with downstream countries over water utilization and management of the Nile waters” (Arsano 2007, 90). With a view to persuading Egypt to abandon the colonial norms and come to terms with the new realities, Mr. Meles Zenawi contended that ‘the Egyptians have yet to make up their minds as to whether they want to live in the 21st or the 19th century’ (Malone 2010).

Furthermore, beyond the official discourses, sustainable development has been incorporated into the national constitution of Ethiopia. The relevant provision reads: “All international agreements and relations concluded, established, or conducted by the State shall protect and ensure *Ethiopia's right to sustainable development*” (Federal Negarit Gazetta 1994, Art. 43(3)) (emphasis added).

Gedu Andargachew, the then Minister of Foreign Affairs of Ethiopia boldly stated: “Abbaj used to be a wandering river. Now, we have tamed it such that it will serve both as an international river, which flows naturally and as a lake [referring to the reservoir of the Dam] that we (Ethiopians) will hereinafter be used

for any developmental purposes. Indeed, now we can proudly say that we have reclaimed the Abbaya River” (translated by the author of this article) (Ethiopian Broadcasting Agency 2020).

The narrative of a win-win solution has been serving as the basis for foreign policy instruments as well as informing the negotiation positions of the Ethiopian government. This fact is reiterated by one senior Ethiopian Diplomat who stated a “win-win negotiated outcome has always been our guiding principle and it deeply reflects the official position of the Ethiopian government, because it is concordant with the principle of equitable and reasonable utilization of the Blue Nile” (Yigzaw 2021). And as the GERD discord continues, the narrative of ‘It is My Dam’ has gained more traction.

For its part, Egypt has argued that any utilization of ‘its water’ is tantamount to causing harm to its well-established national interests. More specifically, it asserts that more than 100 million people are entirely dependent on the Nile water for their survival and the GERD poses an existential threat (Foreign Ministry of Egypt 2020, 2). It has become a common practice that whenever negotiation processes falter or when the Egyptian elites believe that domestic pressures are mounting, they frequently revert to their extreme positions of historical and natural rights and the doctrine of territorial integrity by activating what (Senn and Kornprobst 2016) calls ‘background knowledge or ideas’.

Moreover, in tandem with the narrative of Egypt as Nile and Nile as Egypt, Egypt has been frequently linking the Nile issues with broader regional security. In fact, it went as far as regarding any reduction in the flow of the Nile as an assault against the Arab civilization and a plan to exterminate the Egyptian people by denying them the right to life (Egyptian Ministry of Immigration 2020). This has continued despite Ethiopia’s repetitive assurances that the GERD would not cause appreciable damages amid the unprecedented rainfall of the summer of 2020 that coincided with the first filling of the dam.

5.4 The GERD and Securitization of the Blue Nile

The securitization of the Blue Nile has been there for a long from the Egyptian side. What the GERD brought about are the changing dynamics of the Nile hydro-politics and the escalation of the conflict due to mutual securitization processes.

Significantly, following the construction of the GERD, the perception of the downstream countries (especially Egypt), has dramatically worsened, even though it was observed that “contrary to Egyptian and Sudanese perceptions, everyone would benefit from increased regulation of the Blue Nile flood in Ethiopia” (Whittington 2007, 112). If anything, this partly proves the important role perceptions play in foreign policy (Neumann 1996); (Herrmann 2013).

Immediately following the commencement of the GERD in April 2011, Egypt threatened to defend its ‘national security’ by all necessary means, including destroying the dam and waging war. This statement infuriated Ethiopia and consequently, the late Prime Minister of Ethiopia, Meles Zenawi, warned Egypt in the following words: “Nobody who has tried that [going to war with Ethiopia] has lived to tell the story. I don’t think the Egyptians will be any different and I think they know that” (Malone 2010). Then, the coming into power of the Muslim Brotherhood to power further exacerbated the relationship. In 2013, Mohammed Morsi, the then President of Egypt, justified the morality to die while fighting for the Nile in his strong statement. He said: “If the Nile diminished by one drop, then our blood is the alternative” (BBC News 2013). Thus, by treating one drop of the Nile as constituting the corresponding blood of the Egyptian people and in total disregard for the rights of the upper riparian countries to use the shared resource, the Egyptian government had set the stage for the embattled relationship with Ethiopia.

Nevertheless, with the signing of the Declaration of Principles in 2015, the relationship between the two countries has shown some signs of reproaching. This was achieved because of the depoliticization of the GERD, in which more discretion was given to the technical and legal teams. When the tripartite negotiation on the GERD faltered in September 2019, the government of Egypt had fallen back to its default modus operandi; the threat of war. Ostensibly rebuffing Egypt’s discourse of water war, Abiy Ahmed, the Prime Minister of Ethiopia responded forthwith: “No force can stop Ethiopia from building the dam. If there is a need to go to war, we could get millions mobilized. But going to war is in nobody’s best interest” (Aljazeera 2019).

Needless to state, Egypt has been securitizing the Nile through the narrative of ‘Egypt’s water’, as noted earlier, thereby discursively equating the Nile with Egypt. But since securitization does not happen in a vacuum, there have been enabling factors—the prevailing material conditions and the attendant discourses that made it possible. The material condition is related to Egypt’s high dependence on the water which comes from beyond its border (Stetter 2011, 450) which made the discourse of ‘Nile as a matter of survival for Egypt’ easily resonate with the public. At a different point in time, all three elements for effective securitization; context, audience, and power of agency (Thierry 2005, 171), were readily available for the Egyptian government to use. For example, concomitant with the construction of the GERD, there was a global discourse on water security, the domestic audience needed political change (the Arab Spring) and the seizing of power by the military government brought water as a national security into the spotlight of the parliamentary debates, which was mostly used to divert public attention (Maher 2013). All of these culminated in the amendment of the constitution of Egypt, which incorporated the Nile water as one of the overriding national securities (The Constitution of the Arab Republic of Egypt, 2014, Art.44) to be defended by all means.

On the media front, the battle of narratives through what can be called the “politics of blaming” (Qiaoan, 2021) has intensified. It gave a new impetus to the hitherto conventional mechanisms of securitization. Cognizant of this fact, some argued that Ethiopia and Egypt are already at war through different means; a digital war or a war on cyberspace (Mersie 2020). The digital war employed strategies such as the dissemination of facts and figures, sensational stories, inundation of social media platforms with tailored messages, and well-coordinated mis(dis)information campaigns. Among multiple ‘social media warfare’, the campaigns of *ItsMyDam*, *FillTheDam*, *EgyptNileRights*, and *SupportEgyptSaveLives*, have been observed as the prominent tropes. In one of the *ItsMyDam* campaigns, the symbolic value of the GERD was depicted as follows: “The GERD is not just a dam. It is the structure that symbolizes the blood and sweat of millions of Ethiopians. The thrust of *ItsMyDam* campaign is to showcase the symbolic value of the GERD such that the GERD is not just a dam, but the structure that symbolizes the blood and sweat of millions of Ethiopians; it is not a mere water reservoir, rather it is the reservoir of history, survival, and life; it is a symbol of the Ethiopian renaissance. A similar sentiment was reflected in the *EgyptNileRights* campaign which asserted: “We appeal to the world to safeguard Egypt’s Nile rights. Egypt is the gift of the Nile. The GERD will jeopardize our right to survival” (Daily News Egypt 2020).

In addition to social media campaigns, regular debates, documentaries, and commentaries have dominated the major international media. Some of the headlines on the international media outlets read: “Will Egypt attack Ethiopia?”, “Could Ethiopia and Egypt go to war?”, “Egypt and Sudan Are Ganging Up on Ethiopia”, “Egypt and Ethiopia Are Heading to Conflict over the Dam Dispute”, and “Water Conflict between Ethiopia and Egypt Will Destabilize the Entire Region.”²⁰

At the same time, the power of the better argument was demonstrated at regional and international fora, albeit to a lesser degree. By seeking the intervention of the UNSC, Egypt wanted to internationalize the conflict, whereas Ethiopia argued for the doctrine of non-interference in domestic affairs and insisted on the resolution of conflict through the ADR mechanism under the rubric of the AU. On the other hand, the government of Egypt argued before the UNSC that the unilateral filling and operation of the GERD causes significant harm and such an act “constitutes a clear and present danger to Egypt, which could have serious repercussions for that threaten international peace and security” (Foreign Ministry of Egypt

²⁰ For more information, see

<https://www.bing.com/videos/search?q=Will+Egypt+attack+Ethiopia%3f&view=detail&mid=D5C86185AFDF74960A44D5C86185AFDF74960A44&FORM=VIRE..>, <https://www.middleeasteye.net/opinion/egypt-ethiopia-grand-renaissance-dam-war..>, <https://www.bloomberg.com/opinion/articles/2021-03-09/blue-nile-dam-egypt-and-sudan-are-ganging-up-on-ethiopia?leadSource=uverify%20wall..>, <https://www.bbc.com/news/world-africa-50328647>, and <https://arabcenterdc.org/resource/water-conflict-between-egypt-and-ethiopia-a-defining-moment-for-both-countries/>.

2020, 3) and called upon the international community to intervene promptly. In response to this, the Ethiopian government asserted that “The dam is a national project which is designed to help extricate the people from abject poverty and is *by no means a threat to peace and security*, justifying the invocation of the mandate of the Security Council under Article of 35 the Charter” (Ethiopian Ministry of Foreign Affairs 2020, 6) (emphasis added). Therefore, the process of *mutual securitization* has come into play.

5.5 The GERD Dispute and Conflict Management

For more than a decade, various efforts have been made to resolve the dispute over GERD. To this end, political, legal, and technical avenues have been utilized, at different times and to varying degrees.

After many rounds of deliberations, the involvement of technical teams, and the help of AU facilitation, Ethiopia, Egypt, and Sudan were able to craft the DoP, which was hailed as a great leap forward (Zeray Yihdego 2016). The DoP has envisaged dispute resolution mechanisms under Art. 10, with negotiation as the preferred avenue. Indeed, the parties have been negotiating in accordance with this stipulation and they commonly refer to the dispute settlement clause. However, its main achievement has turned out to be one of its major limitations in that the final arbiter of the dispute is the Head of State, the political body as opposed to the quasi-judicial or judicial organ.

The GERD dispute happened following Mr. Putin’s announcement to mediate Al Sisi and Abiy on the 24th of October 2019, which enticed the US’s offer to mediate the parties upon the request of Egypt (VOA News 2019). From the outset, there had been confusion as to the role of the US government; it was not clear whether the US offered active mediation, conciliation, or good office. Ethiopia officially accepted the dispute settlement process, understanding that the role of the US government was merely facilitation or good office. However, during the course of the GERD negotiations, the Trump administration started acting as an active mediator. The U.S. team went as far as preparing a draft agreement and informing the parties to sign it. When the Ethiopian delegate requested further consultations, the other two parties categorically objected to it and the US government accused Ethiopia of refusing to sign the draft agreement. Consequently, on 12 February 2020, the US Secretary of Treasury, Steven Mnuchin, issued a press release critical of Ethiopia and warned that the “final testing and filling of the dam should not take place without an agreement” (VOA News 2020). This was a clear indication of the active mediation role of the Trump administration. After realizing this, the Ethiopian government officially pulled out of the tripartite talks.

A number of issues beg questions here. Why did the US government involve the Department of Treasury when mediation is within the mandate of the State Department? How could a mediator play the manipulator role without defining his/her roles? And even then, how could it be possible to blame one

party openly and selectively while appearing as a neutral mediator? As pointed out in chapter one, it is not a necessary condition that the Mediator or a third-party intervener should act impartially at all times, for the *Insider-Partial Mediator* could be more effective than the impartial one under some circumstances.²¹ Most certainly, the close relationship between the US and Egypt would have greatly enabled the former to extract necessary concessions from the latter because “closeness to one party implies the possibility of “delivering” it, thereby stimulating the other party’s cooperation” (Zartman 2008, 162). Instead, the main problem of the US-brokered mediation is the lack of a common understanding as to the role(s) of the mediator and the conditions attached to the negotiated outcome. For mediation, by its very definition, is a continuation of the negotiation process, the Trump administration must have respected that line unless agreed otherwise. In terms of leverage, which is one of the important elements of effective mediation, the U.S. government has both the carrots and sticks at its disposal to put the necessary pressure on the parties. The involvement of the Department of Treasury in the mediation process was used to attain this very objective.

Nonetheless, economic incentives and manipulative strategies may not work for conflicts where sensitive matters embodying symbolic values, as is the case with GERD, are at stake. This is apparent from the official statement of the Ethiopian government and the public outcry that ensued immediately after the failed mediation (Seyoum 2020). To be more precise, the ‘U.S. factor’ has changed the tone of the official discourse; every Ethiopian citizen across the board started to say “with or without an agreement, we shall fill the dam. It is our dam and we do not need anyone’s approval.” It should be stressed that the primordial role of the mediator is to change the behavior of disputants, but the Trump administration has failed to do so. Rather than bowing to the mounting pressures, the Ethiopian government instead used the opportunity to mobilize the public, rally round-the-flag effect. At any rate, the US-brokered mediation under the Trump administration has not achieved its intended purpose, if not worsened it.

Following the failed mediation process and amid the stumbling negotiations, the GERD dispute was brought to the attention of the UNSC by Egypt in June 2020, to put more political pressure on Ethiopia so that either (1) the parties reach a binding agreement on the filling and operation of the dam or (2) alternatively, the filling of the dam should be delayed until a binding agreement is reached. Concerning the involvement of the UNSC, two issues, namely the tension between the delegitimization of the regional

²¹ From the vantage point of Ethiopia, it is plausible to assert that it accepted the “mediation” offer in order not to risk the U.S. align itself more with Egypt for the obvious fact that all successive U.S. administrations have been by far closer to Egypt than Ethiopia. Of course, that is what can be deduced from U.S. administration’s subsequent actions, notably the harsh chastisement of the Ethiopian delegates and suspension of aids.

conflict management efforts by Egypt and Ethiopia's insistence on the AU-led process and the politicization of the Nile, are worth emphasizing.

While Egypt submitted its complaint to the UNSC before exhausting the regional remedies as enshrined under Arts.33-37 of the UN Charter, Ethiopia advocated for the doctrine of African solutions to African problems and resolution of the outstanding issues through the ADR mechanisms as set out in the DOP and the UN Charter. This can be gleaned from the letter of the

Office of the Prime Minister of Ethiopia, which stated: "the GERD is an affirmation of Ethiopia's commitment for equitable and reasonable utilization of the Abbay River (...) The Prime Minister appreciates the resolve to African Solutions to African Problems undertaken through existing regional mechanisms..." (Office of the Prime Minister 2020). This preference for regional primacy for the resolution of the GERD conflict was further reinforced by the AU Communique in the following words: "The meeting of the Bureau of the Assembly of the AU Heads of State and Government was held in a fraternal spirit guided by the principle of *Pan-African Solidarity* and cooperation and the attendant desire to find an *African solution to an African problem*" (AU Commission 2020), emphasis added). The norm of Pan-African solidarity (Tieku 2013, 7) seems to have profoundly shaped the identity, interests, and dispute resolution preference of the vast majority of the African states, but Egypt has not fully joined the club due to its conflictual identities and since it actively advocates for the greater roles of the non-African actors (Davison 2021). To sum up, the intractability of the conflict between Ethiopia and Egypt over the Blue Nile appears to be rooted in historical animosities, competing norms, and conflictual identities, as compounded by the securitization of the Nile, particularly following the construction of the GERD.

6. Concluding Remarks

This paper has attempted to shed new light on the theoretical framework of conflict and cooperation among riparian states over transboundary water resources and prevailing approaches to water conflict management. It has been shown that, although the existing theoretical frameworks can partly explain the transboundary water interactions, drivers of cooperation and conflict among the riparian states, and mechanisms of managing water conflicts, they suffer from some limitations and remain inadequate. The fundamental limitations of the existing theoretical frameworks and methodology are related to the narrow conceptualization of (water) conflict management; taking norms, the identity and preferences of the riparian states, the discourse of hydro-hegemony and water security as given; and the acute scarcity of interdisciplinary research on water conflict. Consequently, I have argued that the conventional cooperation or conflict approach to the management of water conflict falls short of accounting for multifaceted water interactions among riparian states: in reality, both cooperation and conflict co-exist (Mirumachi 2008, 312). Related to this and more problematic, is the conceptualization of water conflicts

in terms of conventional military confrontation or an all-out war. One could find numerous conflictual situations if water conflict is broadly defined to encompass low-intensity hostility, proxy wars, digital warfare, hegemonic and counter-hegemonic frictions, securitization moves, and protracted legal and political disputes.

In this regard, the illustrative case study (the intractable conflict between Egypt and Ethiopia) has shown that a low-intensity conflict and limited cooperation can, indeed, co-exist. Yet, whether cooperative or conflictual relation prevails across time and space, depends on, among others, whether the water interactions are defined by hydro-hegemony or hydro-harmony, the nature of the conflict itself, and conflict management approaches used. With regard to the norms governing the Blue Nile, though contestation is a common feature of norm evolution and may even enhance the robustness of the emergent norm (Zimmermann 2020, 70), the norm of equitable, reasonable, and sustainable utilization of transboundary rivers could not be institutionalized due to the fact that the contestation is more about the validity of the norm than to its discourse of applicability.

The water interactions in the Blue Nile are highly characterized by hydro-hegemony, which is not benign and unstable in nature; growing water scarcity; lack of constitutive norms and strong institutions, colonial legacies, unilateral utilization of shared water, and incompatible state identities; and poor conflict management practices. Furthermore, as I have tried to show in this paper, in addition to the problems that bedevil the basin, negative historical interactions, competing narratives and norms, and securitization of the GERD, have contributed to the intractability of the conflict, and made it difficult to resolve.

Finally, three caveats are in order. Firstly, while I have analyzed why Egypt and Ethiopia have, thus far, been unable to amicably resolve their differences, comparative case studies are necessary if general inferences are to be made. To this effect, further research projects need to be undertaken. Second, since the conflict is still ongoing (currently characterized by an impasse), a full assessment of the efficacy of the conflict management strategies is impracticable. And third, alternative explanations for some aspects of the conflict are plausible. I would like to suggest two of them here. The reason why the NBI has been paralyzed can be partly explained from the rationalist point of view in the sense that, for Egypt (as a hydro-hegemon and a downstream country), supporting basin-wide governance appears to be irrational, albeit in the short-term. And the rationale behind the mutual securitization of the GERD can be explained through the lens of a diversionary theory of war, in which states use fear-producing and greed-producing targets (Jung 2014) in order to consolidate their own domestic power, which is the case both in Egypt and Ethiopia. Although the diversionary tactics can be subsumed under the securitization moves, as I have tried to point out in this research, in-depth research into this issue is welcome.

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