# Benefit of Grand Ethiopian Renaissance Dam Project (GERDP) for Sudan and Egypt

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**Abstract**

This article quantifies the major benefits of the Grand Ethiopian Renaissance Dam Project for Sudan and Egypt based on GERDP technical design and quantitative analysis. Before discussing the benefits, the article will brief the general technical overview of the GERDP. Then, it shows how the GERDP will benefit East Africa by filling the wide gab in electricity power shortage based on the World Bank data. It has answered as how much sedimentation will GERDP remove from Blue Nile River per annum? How much do it cost for Sudan and Egypt to remove this sedimentation from their dam? How the Blue Nile flow looks like after GERDP is working with full capacity? How do Sudan and Egypt will be benefited by having regular water flow throughout the year due to GERDP? How do GERDP will play vital role in conservation of water in Ethiopian highlands? Finally a summary note and a recommendation will be given to indicate the way forward in handling the GERDP for the benefit of the region specifically Ethiopia, Sudan and Egypt.

## 1. Background

In 2011, Ethiopia began building the Grand Ethiopian Renaissance Dam Project (GERDP) on the Blue Nile River in a place called Guba, 60 kilometres from Sudan, which hold 74 billion cubic meters (BCM) storage capacity and about 60 BCM live storage which will produce 6000 MW electric generation.

Figure 1 presents the general facts about Nile River Basin and its flows in the riparian countries. This has become a serious topic of our time both in the North East Africa sub-region and the globe. The issues of GERDP has gained Ethiopian, Egyptian, Sudanese and other African countries as well global experts attention at different degree of depth. For example recently, Paisley and Henshaw [1] have published a review article on the trans-boundary governance of the Nile River Basin which focused on the challenges for the riparian countries in past, present and future. Zeray Yihdego [2] has published in Global water forum about the controversy of Blue Nile in the eyes of international law. Eshetu Girma [3] have discussed in detail the concept of having joint ownerships of the Ethiopian Grand Renaissance Dam at Aigaforum. Recently Tecola Hagos [4] has published on

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Ethiomedia a recommendation paper how the Ethiopia need to deal with other Nile Basin countries specifically with Sudan and Egypt. A Group of professional from Egypt published a recommendation report for their government on the effects of GERDP on Egypt [5].

- Longest river in the World (6,695 Km)
- Location: Africa latitude 40S to 310N
- Total length of the river and its tributaries: 37,205 $Km^2$
- River catchment's area: 2.9 million $Km^2$
- Shared among ten countries: Ethiopia, Burundi, Democratic Republic of Congo, Egypt, Eritrea, Kenya, Rwanda, Sudan, Tanzania and Uganda
- Total population of these countries: about 280 million
- Crosses several climatic regions of Africa: tropical rain forest to desert

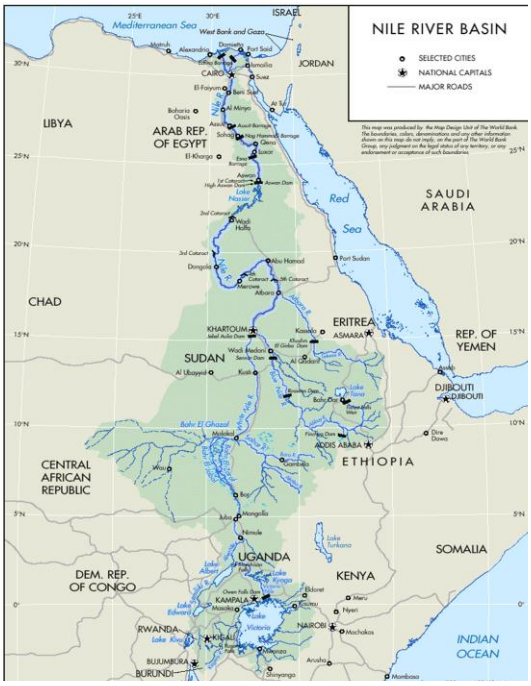


**Figure 1 Facts about Nile River Basin [6]**

Ethiopian National Panel of Experts [7] and Zerihun Ababa [8] on the GERDP responded in detail for issues raised by Egyptian professionals. Ethiopian, Sudanese and Egyptian newspapers have also continued reporting about the GERDP in daylily basis. Most of the articles are focusing on the international law of water sharing, the way of cooperative between Ethiopia, Egypt and Sudan in these volatile issues and some of them focused on the drawback of GERDP (Mostly from Egypt writers). In this article, the major focus will be on the benefit side of GERDP for all Nile basin countries specifically Egypt and Sudan. In most of the articles the benefit of the GERDP is reported in subjective way. This article will quantify major benefits based on the technical detail of the GERDP, extensive review and numerical calculation. Before discussing the benefits, the article will brief the general technical overview of the GERDP. Then, it shows how the GERDP will feel the sever gab in electricity power shortage in East African countries based on the World Bank data. How much sedimentation will GERDP remove from Blue Nile River per annum? How much do it cost for Sudan and Egypt to remove this sedimentation from their dam? How do the Blue Nile flows look like after GERDP is working with full capacity? How do Sudan and Egypt will be benefited by having regular water flow throughout the year due to GERDP? How do GERDP will play vital role in in conservation of water in Ethiopian highlands? Finally a summary note and a recommendation will be given to indicate the way forward in handling the GERDP case for the benefit of the region specifically Ethiopia, Sudan and Egypt.

## 2. Technical Information about GERDP

The GERDP project is located approximately 750 km northwest of Addis Ababa on the Blue Nile River at place called Guba in west of Ethiopia 45Km from Sudan. Guba is geographical coordinates are 11° 16' 0" North, 35° 17' 0" East. The works will mainly consist of a Roller Compacted Concrete (RCC) dam, two powerhouses, a gated spillway and a rock-fill saddle dam. As per information obtained from the National Panel of Experts (NPoE) [10], the main dam which will have a volume of approximately 10MCM, a length of 1780 meters and height of 145 meters, will be a RCC gravity dam, divided in three sections: right bank, central section and left bank. The central section will be used as a stepped spillway. This will create a reservoir that covers, at full supply level, an area of 1,680 sq. km and hold a volume of 74 Billion cubic Meter (BCM) of water. The Schematic representation of GERD is shown in Figure 2.

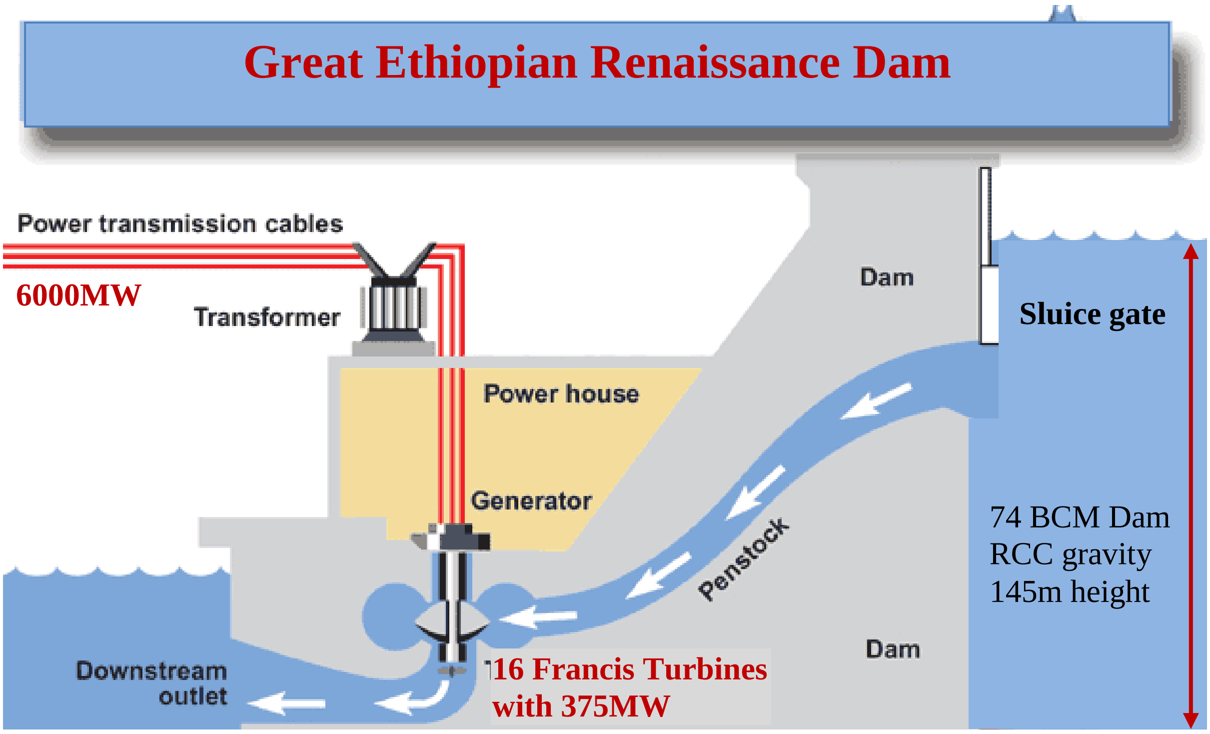


**Figure 2 GERDP lay out (Modified from: Environment Canada)**

The normal and minimum operating water levels will be 640 and 590 meters above sea level respectively, and the reservoir volume at minimum operating level is to be 12 BCM. The two powerhouses will be at the downstream of the main dams: one on the right bank and the other on the left bank. They will accommodate 10 and 5 Francis Turbine Units respectively, with a total installed generating capacity of 6000MW. The reservoir level will be controlled through three spillways, designed to cater for a probable maximum flood (PMF) of 19,370M3/s. The saddle dam, with a maximum height of 60m and approximate volume of 17 MCM will have a curved axis and a length of approximately 5Km.

The cross section will include an impervious asphalt core with the relevant upstream and downstream transition. The dam body is to be made of material obtained from the spillway excavation, whilst selected rip-rap will constitute the slope protection. A wave protection wall will be placed on the 4m wide crest. A 500KV double bus-bar switchyard will be set up about 1.4km downstream of the main dam. The switchyard will include incoming bays from the transformer feeders at the power plant and the outgoing transmission line bays. The first major step in the schedule will be the diversion of the river through diversion culverts. The river will be diverted to enable the construction of the central section of the dam and will be carried out using four culverts constructed in the dam body.

## 3. Benefits of GERDP

The primary objective of GERDP is to generate an electric power of 6000MW, with an annual energy production of 15130GWH/year to cover the power supply demand in the country as well as in the East Africa region. The benefits of GERDP is not limited with power supply, it can also benefit the downstream countries mainly Sudan and Egypt by removing silt and sedimentation,  by regulating the water flow and by conserving water in Ethiopian highlands. In the following section, the benefits of GERDP are described in detail.

## 3.2 Power Hub for East and North Africa

Currently Africa generates 4% of global electricity from which three –quarters of that is used by South Africa, Egypt and other countries along the North Africa littoral [11]. World Bank is also reported only 24 percent of the population of sub-Saharan Africa has access to electricity where as other low income countries have reached with 40 percent coverage. Figure 3 shows the satellite image of Africa, Europa and Asia.

Rosenes and Vennemo [12] have estimated the investment cost of providing electricity to Sub-Saharan Africa over a 10-year period is between 160 and 215 billion U.S. dollars, depending on assumptions for electricity access and the cross-country electricity trade.

**Figure 3 The world at night (Masterresources )[14]**

In rural areas of Malawi, Ethiopia, Niger, Chad and several other countries, less than 2% of the population have access to electricity [10]. Power tariffs in most parts of the developing world fall in the range of US$0.04 to US$0.08 per kilowatt-hour. However, in Sub-Saharan Africa, the average tariff is US$0.13 per kilowatt-hour [13].

Figure 4 shows the comparison between some of East Africa countries electricity access to electricity supply and Egypt in 2009 and 2010. It can be seen that currently Egypt Electric coverage is 3 times of Sudan, 4.4 times of Ethiopia, 5.5 times of Kenyan, 12 times of Uganda and 7 times of Tanzania.

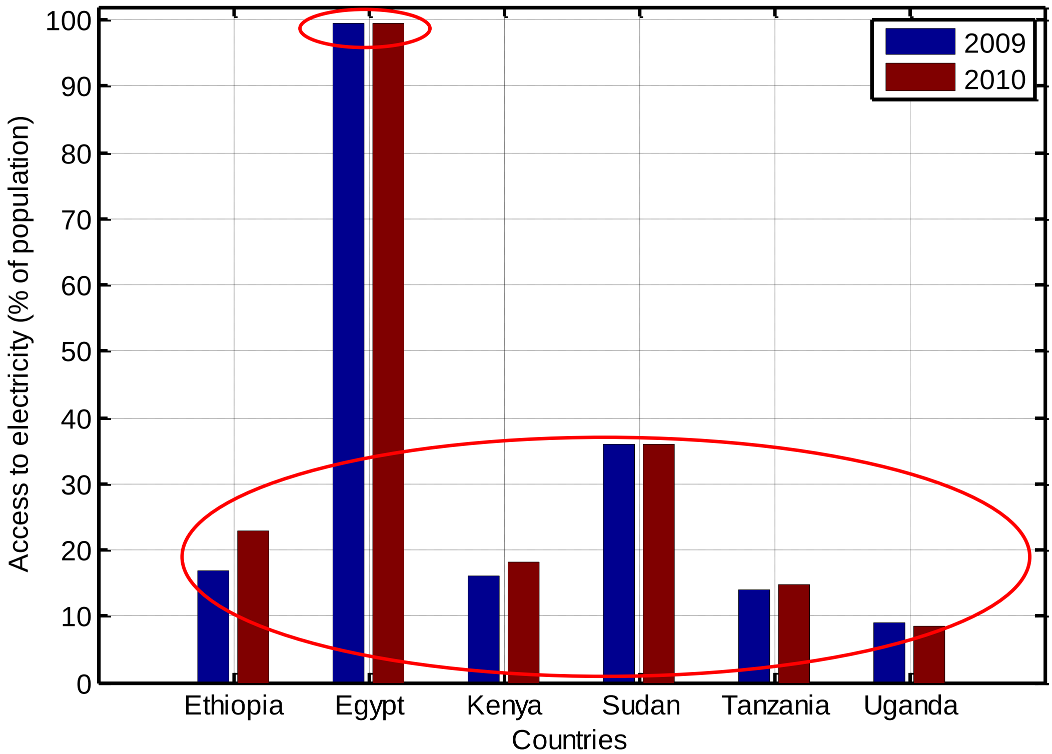

Figure 4 East African and Egypt comparison with population percentage access to electricity in 2009 and 2010

Currently Ethiopia, Sudan and Egypt have generated 894Mw, 1591MW and 2800MW from Nile River [15]. The power demand of Ethiopia has been growing at an average rate of 25 per cent per year during the last five years and the demand forecast for the next five years is estimated to be 32 per cent per annum as per Ethiopian Electric Power Corporation [13]. To alleviate this challenge GERDP will play vital role in East Africa countries as well as Egypt for securing the electric supply. The Ethiopian GERDP will generate electric power with installed capacity of 5,250MW, with an annual energy production of 15,130 GWH/year, and balance the demand/ supply difference that the country has been facing as a result of its expanding development. The GERDP will increase the current Ethiopian Electricity supply by triple [14]. The power will also be exported to other East Africa countries to improve the coverage of the electricity. The GERDP will be the hub for clean and renewable energy supply for Ethiopia and other African countries at cheaper prices. In effects it will be a catalyst for people to people relation as well as the trade between the regions.

### 3.2 Water Regulation and Flood Control for Sudan and Egypt

The project will have a major impact on mitigation of drought and on flood management. A number of important studies indicated that semi-arid and arid countries to be more affected by climate change than temperate countries. A recent study commissioned by the Eastern Nile Technical Regional Office, for example, concluded that water infrastructure development, including reservoir construction was one of the five pillars identified to adapt or mitigate extreme hydrological events, including the alteration of droughts and flooding, most likely to be caused by climate change [7]. It is very obvious that the GERDP will allow for regulated and sustainable minimum flow levels in the dry season. The Blue Nile flow trends has been studied by many researchers [16]. For example The Blue Nile River has a minim and maximum flow rate of $200m^3/s$ and $6500m^3/s$ measured at Roseires Dam in Sudan [17], [18].

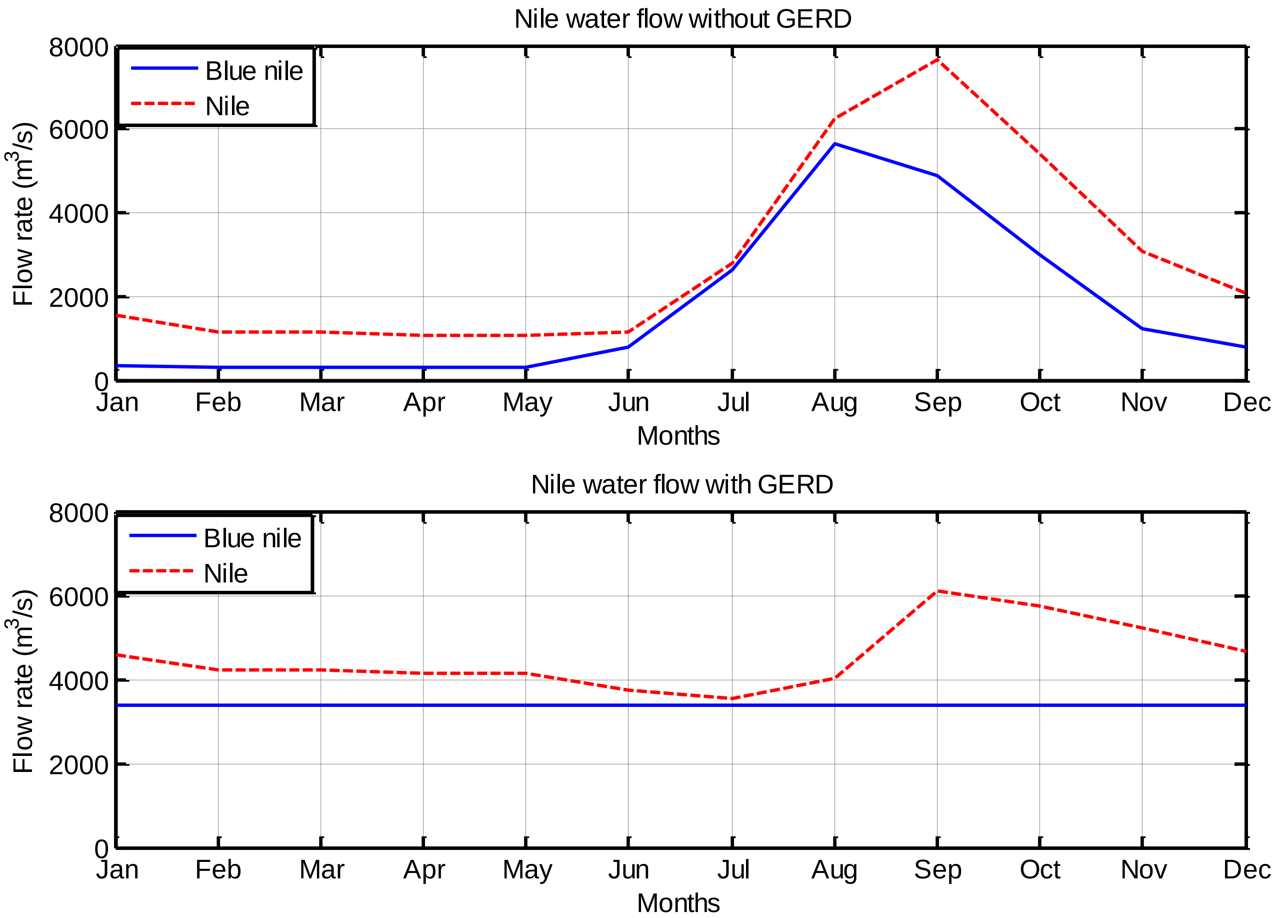


**Figure 5 Blue Nile and Nile River flow pattern before GERDP and after GERDP.**

The new water flow rate has been calculated based on the available information about GERDP (Total power = 6000MW, height of dam= 145m, no of turbines 15 with 350MW capacity, assuming Ethiopia will use the Dam only for Electricity, each turbine will be down for 25 days for maintenance). Once the GERDP is working with full capacity, the water flow in Blue Nile will be in between 3600 - 3800$m^3$/s throughout the year as it is shown in Figure 5.

Sustainable and regulated flow will also allow for increased agricultural production in downstream, ensuring reliable all season supply to downstream irrigation schemes, thus, reducing harvest losses caused by water shortages during critical growing periods. Regarding energy and power production, GERDP will allow underperforming downstream hydropower schemes to perform more effectively as there will be more reliable sediment free, and regular availability of water throughout the year. Indeed, GERDP will benefit Sudan and Egypt immensely by delivering steady water flow throughout the year.

### 3.2 Sedimentation Management in Sudan and Egypt

It is estimated between 157.2 and 207.2 Million Tons of sediment are transported annually from the Ethiopian highlands along the Sobat, Tekeze and Blue Nile, which are the main sub-basins of the Nile [15] (in this article the average of minimum and maximum has been take place). Blue Nile and the Atbara, notwithstanding that these river systems are considered to supply the largest proportions of water (57 and 14%, respectively) and sediment (75 and 21%, respectively) to the Main Nile as per Salah and Shalash report [19] as it was measured in Khartoum. The typical sediment concentrations are ranging from 100 to 6000 mg per litre measured at Khartoum [18].

The Sennar Dam was constructed on the Blue Nile (Sudan) for irrigation purposes with capacities of 1 billion $m^3$ in 1925. Due to the sediment deposition over a span of 61 years, the reservoir has lost 71% of its original capacity [20]. The Roseires Dam was constructed on the Blue Nile (Sudan) to store water for irrigation as well as hydro power with 3 billion capacities in 1966. It lost 36% of its original capacity in a span of 28 years. Those quantities of sedimentation over the years, made the Roseires and Sennar dams lose their water storage and electric-power generation capacities.

Studies indicate that up to 134 million cubic meters a year end up in the lake Nasaer of Aswan High Dam Reservoir, with 130 million sediment and 6 million passing through the Aswan High Dam to the valley north of Aswan as per Shalash [14], review on different models of sedimentation prediction. The Nile Research Institute estimated more than 6.285 billion tons were accumulated in Asewan High Dam in between 1964 and 2008 [21].

These sediments entail huge costs to Sudan and Egypt –due to reduction in efficiency of hydro power, infrastructure maintenance costs, dredging costs of clogged irrigation channels, etc. That has continued power failures due to the silt accumulation of the turbines at Er Rosaires Dam as announced by the government in official statements [15].

GERDP will have huge impact in sediment management in Sudan and Egypt. Billi and Ali [15] reported during flood seasons, the maximum and minimum discharges at Khartoum were 9754 and 477 $m^3/s$, the mean maximum and minimum suspended load concentrations were 4143 and 28 mg/litre. In this article, the total sedimentation of Blue Nile (75% of 182 million tonnes = 136.5 million tonnes per annum) have been taken. This value is lie in between the sediment yield measured at the Upper Blue Nile outlet (El Diem gauging station), which range from 111 million ton/year to 140 million ton/year [16]. The sedimentation distributions over all the year have been carried out based on the water flow rate in the year as it is depicted in Figure 6. Most of the sediment is occur in three months of heavy rain in Ethiopia during June, July and August. The flow water distribution was taken from data measured at Roseires Dam in Sudan [17], [18].

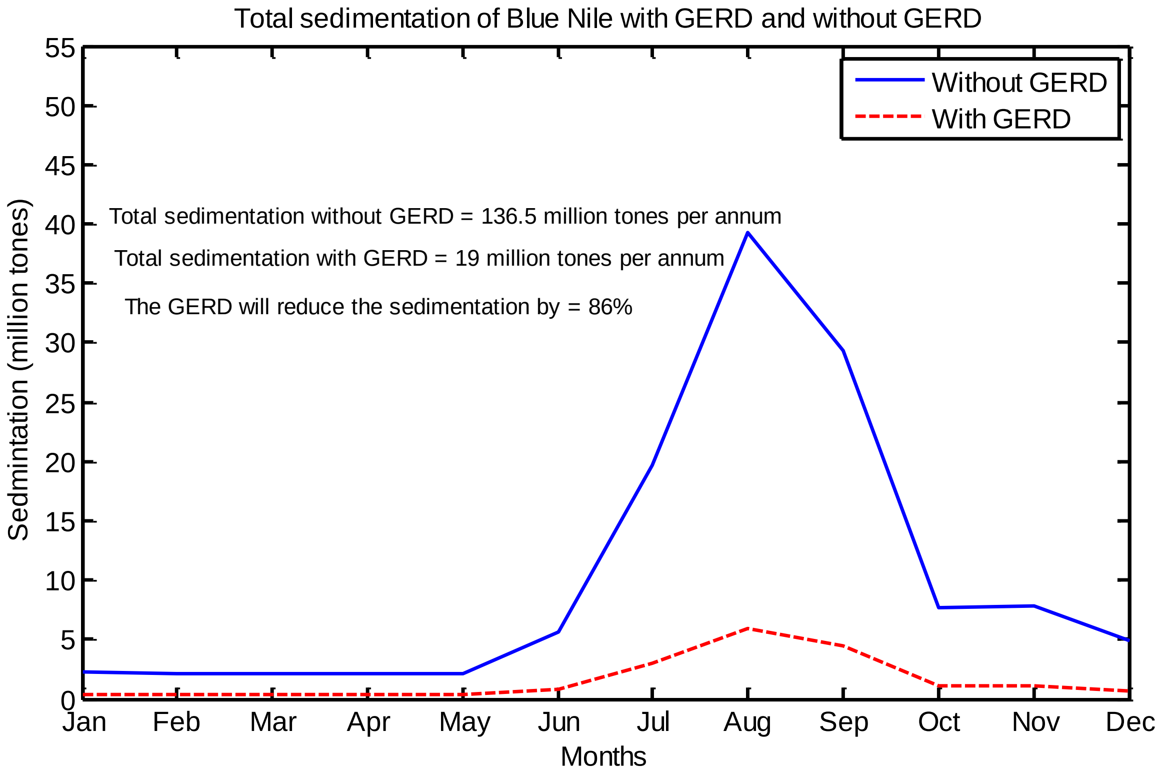


**Figure 6 Effects GERDP on the sedimentation removal of Egypt and Sudan**

The sedimentation in Blue Nile will be reduced by up to 86% when the GERDP is working with its full capacity. Reduction of costs for dredging of canals could save about USD 50 million /year only for Sudan, not to speak of saving in turbine maintenance and replacement costs, ease of gate operation, etc. This may cost Ethiopia to save the dam by taking range of mechanisms to minimize the sedimentation at GERDP []. The major techniques may be by planting trees, using screening and by avoiding deforestation. These need a community mobilization and awareness. Since Ethiopia reduces the sedimentation, Sudan and Egypt need to support the migration methodology for avoiding sedimentation flooding in Ethiopian highlands.

### 3.4 Water Conservation for Sudan and Egypt in Ethiopia Highlands

Water conservation is the other benefits which will be yearning from GERDP. The GERDP will minimize the evaporation loss from dams located in less favourable downstream desert settings. It is estimated 14.3 billion cubic meters(BCM) [22] [23] and 4.7 BCM of water evaporator from the Aswan High Dam and other dams in Sudan annually respectively. Evaporation at the Jebel Aulia dam in Sudan amounts to 2.11BCM annually in 2001 from

2.54 BCM storage capacity (originally designed for 3.22BCM, the siltation reduced its capacity) [24]. By contrast evaporation loss from the full development of the GERDP is likely to be no more than 0.4 BCM. In fact, the development of GERDP will encourage the decommissioning of wasteful dams like Jebel Aulia and reduce the operating level of the Aswan High Dam, and other dams in Sudan. The best way for ‘Egypt and Sudan is to ‘store’ Nile water in Ethiopian highlands by making more reservoirs, where evaporation rates would be far lower than they are in Lake Nasser behind the Aswan High Dam., in the middle of the desert, which loses 2 meters every year to the sun [25]. With GERDP operating upstream, average annual High Aswan Dam losses will be reduced to 9.5 BCM/year from about 10.8 BCM/year in case of High Aswan Dam alone [7]. This is due to the topography of the GERDP location and the fact that the reservoir is to be built in a deep gorge on the Abbay/Blue Nile River which will help in minimizing the water’s direct exposure to sunlight (smaller surface/volume ratio). Even the water evaporates in Ethiopian highlands; it forms the cloud and feed Nile back in the normal water cycle. But the 14.3 billion cubic meters water evaporates at Aswan dam disappears in the Sahara desert.

## 4. Conclusion and Recommendation

### 4.1 Conclusion

The primary objective of GERDP is to generate an electric power of 6000MW, with an annual energy production of 15130GWH/year to cover the power supply demand in Ethiopia as well as in the East Africa region. The GERDP will improve the electric availability in Ethiopia by 200% with full utilization of the power. The benefits of GERDP is not limited with power supply, it can benefit the downstream countries mainly Sudan and Egypt by removing up to 86% of silt and sedimentation. It will regulate the steady water flow throughout the year and it will avoid un-expected flooding to downstream countries. GERDP will also conserve the water in Ethiopian highlands by having lower evaporation and water recycling mechanisms.

### 4.2 Recommendation

GERDP have multi-fold application in East Africa region. The success of the dam will be symbol for integration of the region. To the success of the project, this article recommends the following direction:

1. Egypt should trust Ethiopia and Sudan on the discussion of the dam:- recently the Ethiopian Sudanese and Egyptian, ministers of water resources met in the Sudanese

capital Khartoum on Sunday, Nov. 4, to begin the first round of negotiating sessions set to deal with the Renaissance Dam, as well as to consult with each other on the mechanisms needed to complete it, and how to implement the recommendations of an international committee of technical experts. However, still Egyptians are in dilemma regarding GERDP dam. As it is discussed above the dam has multi-fold benefit for Egyptians, the discussion should be evidence based analysis. The Egyptian professional can confirm the leaders the GERDP benefits based on full cone and prone analysis of the dam.

2. One of the recommendations which forwarded by international experts was to undertake further analysis on the environmental impacts of the GERDP on Sudan and Egypt. The three countries experts need to come together to address the issues with their available data on the historical data of Nile water consumption, rain fall, evaporation rate etc. To undertake these, the three countries can establish a separate professional team from the three countries to undertake further investigation and recommend the mitigation mechanisms.

3. In coming meeting the three countries (Ethiopia, Sudan and Egypt) must use their time to discuss on the technical issues of how to optimize the on-going construction of the GERDP for the benefit of the three countries instead of arguing in trivial issues. They need to develop systems which help working together based on agreed principles by the three riparian states. The GERDP can be the central point for integrating the regional development in East and North Africa.

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