Drought, Climate Variability & Climate Change: The Blue Nile Case

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Key messages

- Large spatially variable climate conditions between upstream and downstream of river basins needs special attention in mitigation drought risks.
- Great temporal variability in hydrological conditions of transboundary river basins causing droughts and prolonged droughts have to be managed jointly among riparian countries.
- Dams upstream transboundary rivers are human-induced drought risk drivers that can exacerbate drought risks downstream countries and should be designed and managed jointly.
- While Dams may reduce hydrological drought risks downstream river basins, natural renewable Groundwater Aquifers can reduce meteorological drought risks upstream river basins.

Physical & Socio-economic Characteristics

The Blue Nile originates in Ethiopia and flows downstream through Sudan where it joins the White Nile to form the Main Nile which flows downstream through the northern part of Sudan and then Egypt right before it reaches the Mediterranean Sea. The Blue Nile represents the largest tributary to the Main Nile providing an average annual flow of about 50 Billion Cubic Meters (BCM) which is about 60% of the natural average flow of the Main Nile at Aswan in Egypt. Egypt depends on the Nile River waters as its main source of renewable water resources utilizing an annual amount of 55.5 BCM as per the 1959 agreement which also entitles Sudan to 18.5 BCM per year. Ethiopia receives an average of about 936 BCM of rainfall, whereas Sudan receives about 400 BCM of rainfall while Egypt receives about 1.5 BCM of rainfall. This highlights the varied dependency on the Blue Nile River waters showing high dependency of Egypt on the river waters. The impacts of droughts, climate variability and climate change is critical in the case of the Blue Nile. Constructing Dams and hydraulic structures upstream the Blue Nile, if not studied well, can have detrimental effects downstream. The combined effect of Dam filling and operation, together with the effects of droughts, climate variability and climate change on the flows of the Blue Nile needs careful attention to assess vulnerability and resilience in Ethiopia with a population over 100 million people, and the transboundary implications on the downstream countries, Sudan with a population of about 35 million and Egypt with a population over 100 million people.

Ethiopia embarked unilaterally on the construction of the Grand Ethiopian Renaissance Dam (GERD) on the Blue Nile in 2011 with the announced objective of hydropower generation. The GERD's reservoir maximum storage capacity is 74 Billion Cubic Meter (BCM) and is announced to be in full operation by 2023. The transboundary impacts of filling and operation of upstream dams such as GERD on the downstream flows to Sudan and Egypt can be exacerbated by climate variability, especially during years of drought.

Climate change impacts, if proven positive with additional Nile water in this case, may be the only resort that might naturally mitigate for the negative impacts of the GERD on the downstream countries so that they can meet their basic water needs during droughts. Whereas, if climate change impacts proved to be negative, in that case with less rainfall reducing the expected flows of the Nile, the GERD's transboundary negative impacts would be exacerbated. It has to be noted that in order to assess the hydrological, socio-economic and environmental impacts of droughts, climate variability, and climate change impacts on water availability for downstream Sudan and Egypt, the impacts have to be studied upstream, which is outside the national boundaries of Sudan and Egypt. This makes strengthening institutional mechanisms for collaboration, data collection, monitoring and data sharing of an increasing interest. Selecting the appropriate mitigation measures to alleviate the impacts of droughts, climate variability or climate change will be of high importance and may vary from upstream measures to downstream measures.

Droughts are commonly classified as meteorological, agricultural, hydrological, and socio-economic. Meteorological droughts are natural events that result from climatic causes. Agricultural, hydrological, and socio economic droughts, however, place greater emphasis on the human or social aspects of droughts. They highlight the interaction between natural characteristics of meteorological droughts and human activities that depend on precipitation to provide adequate water supplies to meet societal and environmental demands (AWC & Erian, 2015).

The Nile River Basin & the Blue Nile Basin Climate Variability

The Nile basin in Ethiopia receives about 450 BCM of rain per year out of a total of 970 BCM falling on Ethiopian lands. Ethiopia has several aquifers and river basins other than the Blue Nile, Sobat and Atbara basins associated with the Nile basin in Ethiopia. Ethiopia with its largest livestock production in Africa depends on rainfed natural pasture lands for feeding. The geographical climate variability and the distribution of rainfall on the Nile basin countries necessitated Egypt's and Northern Sudan dependency on the river's water and Ethiopia's reliance on direct rainfall, which contributes to vast areas of forests, pasture and rainfed agriculture in Ethiopia, as well as recharging vast reservoirs of renewable groundwater. It is therefore normal that the upstream countries of the Blue Nile such as Ethiopia rely on "rainwater" in the Nile Basin whereas the downstream countries of the Blue Nile such as Egypt and Sudan rely on "running water" in the Nile River itself. Egypt and large areas of Sudan are considered arid and hyper arid areas where there is practically no rainfall. Egypt and Sudan do not represent a large part of the water uses of the Nile Basin waters. Egypt's & Sudan’s shares represents about 4.6% of the total rainfall which is about 1660 BCM per year on average, falling on the Nile basin in the 11 Nile basin countries. The rainfall in the Nile countries, including other basins, reaches about 7000 BCM annually on average. Due to temporal climate variability these rainfall amounts vary from one year to another. The following 2 figures show the distribution of rainfall on the Nile Basin countries within the countries boundaries and within the Basin boundaries. They show a wide range of spatial geographical climate variability.

To understand the Blue Nile countries’ different dependencies on the different types of Nile Basin waters, it is evident that Egypt’s Nile water share of 55.5 BCM/year is not enough to meet its water needs. This shows that Egypt’s dependency is more on “blue water” from the Nile River flows due to the scarcity of rainfall in Egypt. Egypt's imports of agricultural food products in 2015, according to AbuZeid, K. *et al* (2019a), reached more than 48 BCM of the virtual water needed to grow these products. Egypt is the only country in the Nile Basin countries that has also been obliged to reuse wastewater and agricultural drainage to meet its water demand. It has also begun for decades to desalinate seawater to fill the water gap on the coasts of the Red Sea and recently in the cities on the Mediterranean Sea (AbuZeid, K. 2020). On the other hand, Ethiopia’s dependency is more on “green water” from the Nile Basin waters at large. Local food production in Ethiopia uses about 40 BCM/year through mostly rainfed agriculture.

Although Satellite images confirm Ethiopia's use of the Blue Nile basin water in agriculture, industry and urban developments, no data is published showing the exact abstractions or water uses in the Blue Nile Basin in Ethiopia. However, Ethiopia’s agriculture uses are more dependent on rainfed agriculture. Livestock in Ethiopia consumes about 84 BCM/year of “green water” through rainfed pasture land (AbuZeid, K. 2019b).

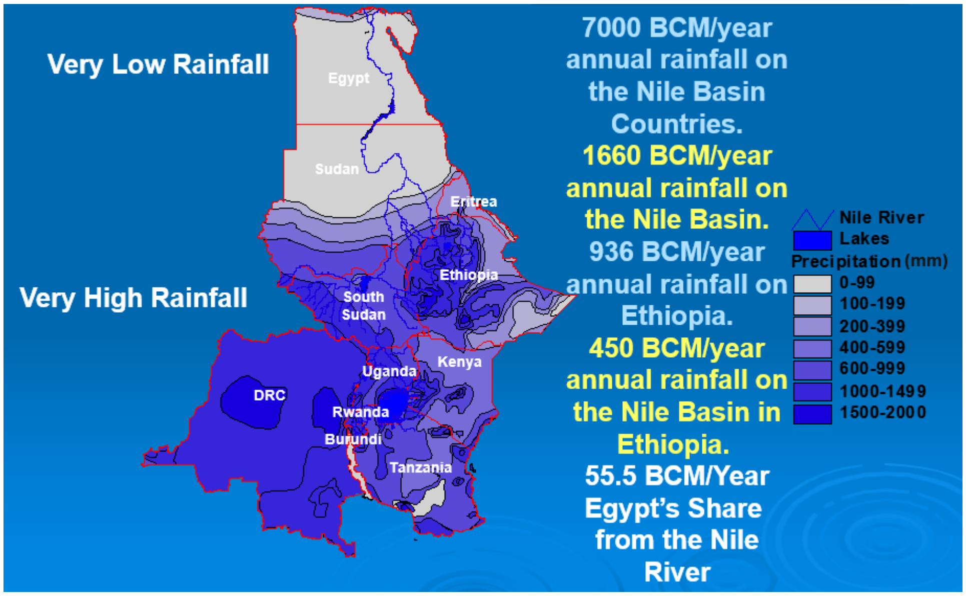

Figure 1: Rainfall within Country Boundaries of the Nile Basin Countries (AbuZeid, K. (2019c))

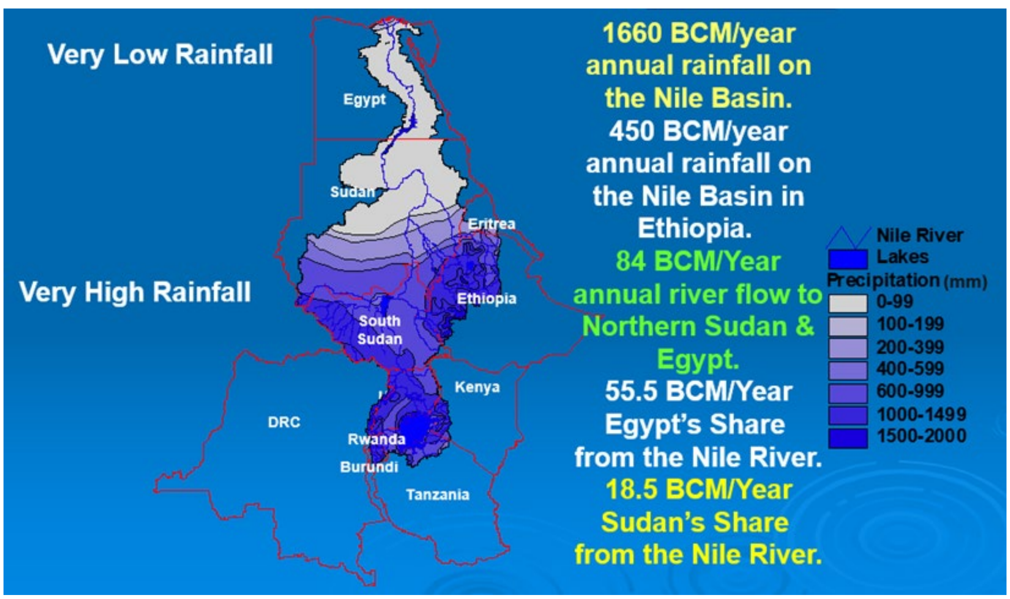

Figure 2: Rainfall within Basin Boundaries of the Nile Basin Countries (AbuZeid, K. (2019c))

Highlights of the Blue Nile drought characteristics

An average of about 300 BCM of rainfall falls on the Blue Nile Basin in Ethiopia. The Blue Nile is the main tributary of the Nile River with the largest flow among all major tributaries discharging about 50 BCM/year on average. The effect of annual climate variability on the Blue Nile flows during the period from year 1911 to 2015 shows a range from 20.69 BCM/y in year 1913 to 69.85 BCM/y in year 1929 as shown in figure 3 below. The Blue Nile originates in Ethiopia, and flows downstream to Khartoum in Sudan where it joins the White Nile into the main Nile which then flows into Egypt.

Studying drought in the Blue Nile basin for 105 years during the period from 1911 to 2015 as per the data shown in the figure 3 below, we see that the driest 10 successive years occurred during the period from 1978 to 1987 where the average Blue Nile flow over the 10 years reached 38 BCM/year. The driest 6 successive years occurred during the period from 1982 to 1987 where the average Blue Nile flow reached 36 BCM/year. It is interesting to note that the driest year, during these 105 years, where the Blue Nile flow reaching as low as 20.69 BCM/year in 1913, did not occur within the lowest successive 10-year Average and also not within the lowest successive 6-year Average. This indicates that droughts could happen in isolated incidents or in a prolonged period having similar effects but with different possible responses depending on the resilience and preparedness of each country for each case.

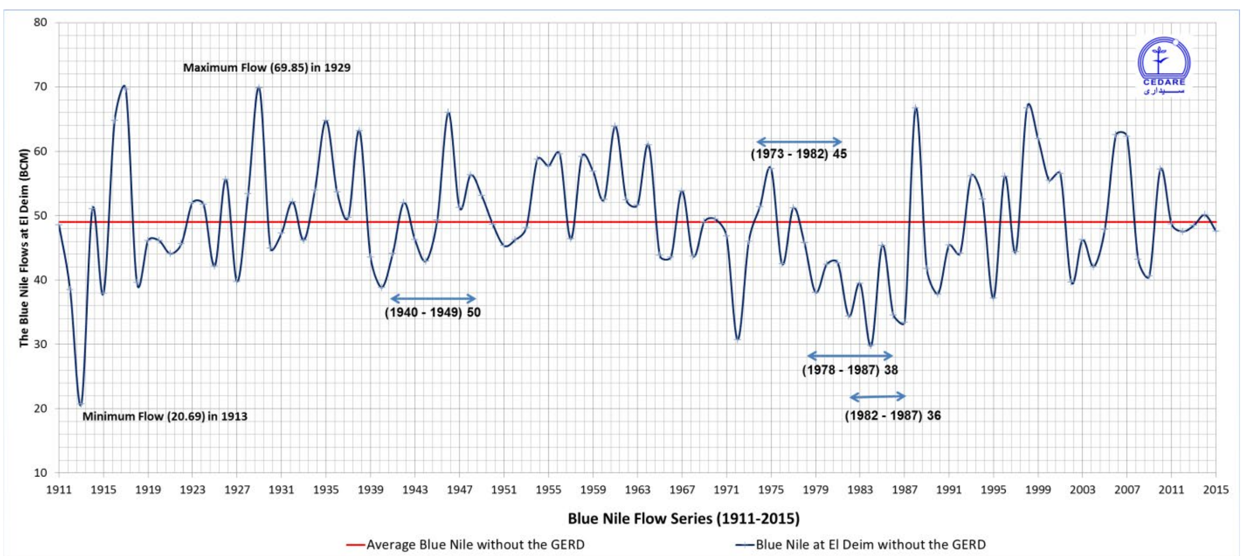

Figure 3: Historical Blue Nile Flows (AbuZeid, K. (2017))

The above analysis and information provided in Figure 3 shows the Frequency and severity of droughts. It is difficult to drive a certain trend especially with the impact of climate change. But definitely climate variability can suggest that future projections should consider frequent droughts with different intensities and durations.

Records for the 1978-1987 successive drought years have shown different impacts from famine in Ethiopia to reduced hydropower generation risks of food shortages and socio-economic impacts in Egypt and Sudan. Had a mitigation plan been in place in Ethiopia to use natural groundwater storage for example during droughts, famine impacts would have been avoided. Similarly alternative solar energy and/or thermal power plants could have been able to reduce potential drought risks in Egypt and Sudan. Now 30 years later, the situation is different and although mitigation measures may be available for some of the Blue Nile countries, however water demand has increased and upstream pressures due to uncoordinated activities and unilateral decisions upstream the transboundary Blue Nile had exacerbated the potential impacts of natural drought risks for downstream countries. It has also created what may be considered as the anthropogenic human-induced drought risk for downstream countries that could develop into an upstream-downstream conflict and civil unrest in downstream affected countries.

The case of the Grand Ethiopian Renaissance Dam (GERD) being constructed on the Blue Nile provides a unique case of transboundary water-energy-food nexus, where Ethiopia aims at using the waters of Blue Nile upstream for the generation of energy. This will eventually impact the availability of water downstream the Nile, water which is already being used for the generation of energy, production of food, and providing for domestic and industrial water needs. Reaching an agreement on the filling and operation of the GERD could provide for a positive water-food-energy nexus solution.

However, without an agreement between the three countries of Egypt, Ethiopia, and Sudan on the filling and operation of the GERD, the case could lead to a water-food-energy nexus conflict instead. Although a dam such as GERD which is announced to be used only for hydropower generation, is supposedly thought to have no impact on water flows downstream , however the downstream impacts can be detrimental due to the exacerbated drought impacts during normal drought periods due to the accumulative evaporation and seepage losses from the huge potential 74 BCM reservoir behind the dam, and due to the uncertainties associated with the filling and operation rules of the dam, and the uncertainties around other potential uses of the GERD Blue Nile waters by Ethiopia.

Although a huge amount of "green water" is available for consumptive use in Ethiopia, however the political drivers in Ethiopia are pushing towards unstainable water use of transboundary "blue water", exacerbating drought impacts downstream.

Potential management/mitigation and adaptation options

As of now there are no drought management policies or plans or agreed legislations between the three countries sharing the Blue Nile. There are ongoing negotiations among the three countries to address among others how to deal with drought conditions in the context of the filling and operation of the Grand Ethiopian Renaissance (GERD). Agreement has not been reached yet and is facing some challenges although some steps have been taken in 2015 when the Declaration of Principles on the GERD has been signed by the three countries to set the objective of reaching an agreement on the rules for filling and operating the GERD which should supposedly consider the cases of droughts and prolonged droughts as they have been mentioned in the recent negotiations and proposed agreements among the three countries.

There are possible options to increase the resilience and minimize the risk from droughts and their hydrological impacts in the case of the Blue Nile especially at the current stage of construction of the GERD. The current stage of construction allows for less than 7% of anticipated full storage capacity of the exaggerated size of the GERD dam. Reducing the storage capacity can reduce the drought risk on downstream countries due to the reduction of evaporation and seepage losses from the Dam reservoir (AbuZeid, K., 2017). The dam is the largest on the Blue Nile with a capacity of 74 BCM being more than 1.5 times the size of the annual average flow of the Blue Nile. With the objective of hydropower generation, if the dam is operated at low annual average levels, the water surface area in the Dam reservoir will be less and the evaporation and seepage losses will be less.

This will result in less impact on the Blue Nile flows downstream especially during drought years. This could be achieved by releasing all of the annual flow throughout the year without carrying over water storage from one year to the next and by basically lower the reservoir water levels to the minimum operating levels right above the dead storage by the end of each hydrological year (AbuZeid, K. 2019c). It may result in a slightly less hydropower generation from the GERD than originally designed by Ethiopia, but it would significantly reduce the impacts of droughts and prolonged droughts on Egypt and Sudan downstream. These mitigation measures of drought risks are critical and need to be agreed in a binding agreement among the three countries.

Information technology, information systems, rainfall forecasting, climate and hydrological modeling, multi-objective planning with the water-energy-food nexus approach can play an important role in the efficient management and mitigation of drought risks and its hydrological impacts in the Blue Nile.

Political stances can stand as barriers to the adoption of a proactive drought risk management on the Blue Nile and especially to implement a resilience-based approach to possible mitigation alternatives. Ethiopia which enjoys about 936 BCM of average annual rainfall, sees that Egypt and Sudan has no right to their meager historical and existing uses of a combined amount of 74 BCM from the whole Nile River waters, and that it has a free hand in constructing, filling and operating dams on rivers originating in its territories, while Egypt and Sudan see that the 74 BCM capacity GERD dam that Ethiopia is building on the Blue Nile river (the major tributary of Nile River), should abide by the Ethiopia-signed agreement in 1902 prohibiting Ethiopia from constructing dams in the Nile Basin without agreement with downstream countries, and should be managed by a binding agreement among the three countries with agreed filling and operation rules.

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