Nile Water, African "Fertility", & A New Vision for The Way Forward

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Elfatih A B Eltahir,
Ralph M. Parsons Laboratory,
Massachusetts Institute of Technology

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*Antique lithograph of Rhoda Nilometer by David Roberts from the mid-1800s.
This Nilometer was built in the Ninth century to monitor the Nile floods.

Abstract

The conflict over the Nile water has received significant attention in the last few years. A particularly important development was the recent decision by the Ethiopian government to build a large dam on the Blue Nile (the Great Ethiopian Renaissance Dam, or GERD) to produce electricity. Here, I focus on the Eastern Nile basin (Ethiopia, Sudan and Egypt), and propose that the emerging conflict over the Nile water, although appears at the surface to be caused by the introduction of GERD, is rooted in a broader African challenge that I call the African "fertility" challenge shaped by rapid population growth, and poor soil productivity. I also highlight serious deficiencies in the strategies on water resources of the three countries that need to be remedied before a regional resolution of the conflict can be reached. I show how development of a negotiated agreement resolving the apparent conflict on Nile water, in the near future, is consistent with the genuine national interests of each of the three countries. I conclude by offering a new vision for the way forward, proposing five specific elements that should be included for any future agreement to become viable, and remain sustainable.

Introduction

The conflict over the Nile water has received significant attention in the last few years. This attention has been associated with the recent decision by the Ethiopian government to build a large dam on the Blue Nile (the Great Ethiopian Renaissance Dam, or GERD) to produce electricity, mostly for export to neighboring countries. This decision, which was announced suddenly and without prior consultation with neighboring Nile basin countries, is consistent with Ethiopia's long-term plan to utilize its hydropower potential to generate electricity that can be transmitted into neighboring countries in exchange for badly needed hard currency. The dam, currently under construction, is relatively large compared to previous designs for the same location. This caused serious concerns in Egypt, reflecting worries about the security of Egypt's current share in the Nile water in the short- and long-term.

The African Fertility Challenge

Most of the developed world has succeeded in reducing the women fertility rate and stabilizing the population, while improving the fertility of soils and agricultural productivity. In contrast, Africa is "travelling" down the same "fertility" road but in the wrong direction! In general, the fertility rate of African women is the highest, and fertility of African soils is the lowest compared to other continents.

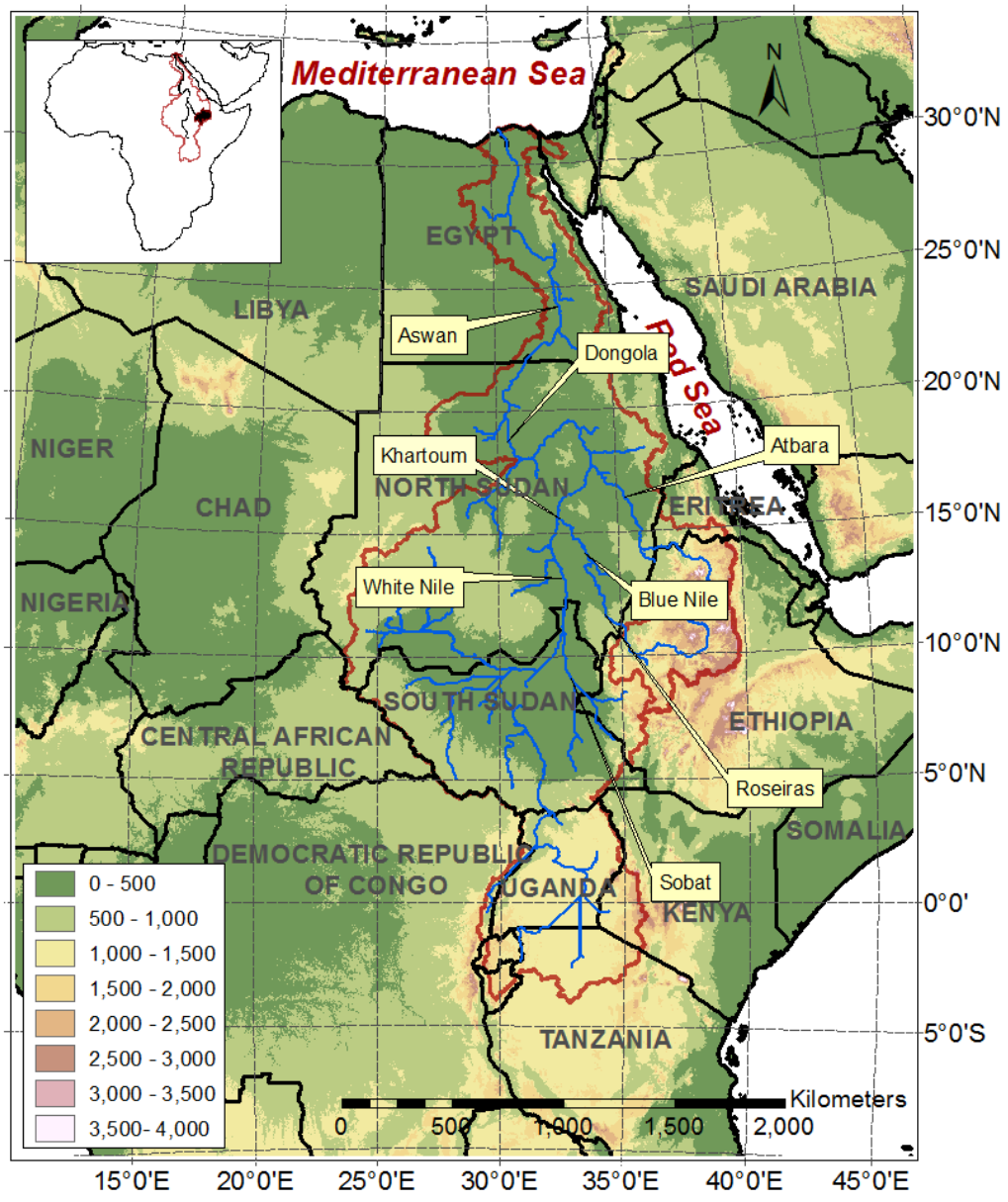

Figure 1: Map of the Nile basin
(Siam and Eltahir, 2015)

The current rate of population growth in Africa should trigger serious global concerns since a continent that is currently hosting 15% of the world population is projected to contribute 50% of the anticipated increase in the world population, by 2050, doubling its population from, roughly, one to two billion, See Figure 2.

At the same time, the rate of application of fertilizers and other agricultural technologies in Africa is the lowest compared to any other continent, and thus the productivity of African soils is the lowest compared to other regions of the world. In fact, some regions of Africa, rather than being fertilized, are being actively depleted of their natural fertility through unsustainable cultivation practices, See Figure 3.

How does use of fertilizers relate to what appears to be a conflict on water? The mass of crop produced per unit volume of water used any where is to a large degree dependent on the rate of application of fertilizers and the type of seeds used (see Figure 3). In order to expand agricultural production in Africa, there are two possible routes: horizontal expansion using more land and more water, or vertical expansion using the same land and water volume but producing more crop aided by fertilizers, better seeds, and more efficient water use technology. The first route leads to water and land conflicts. The second route avoids conflicts.

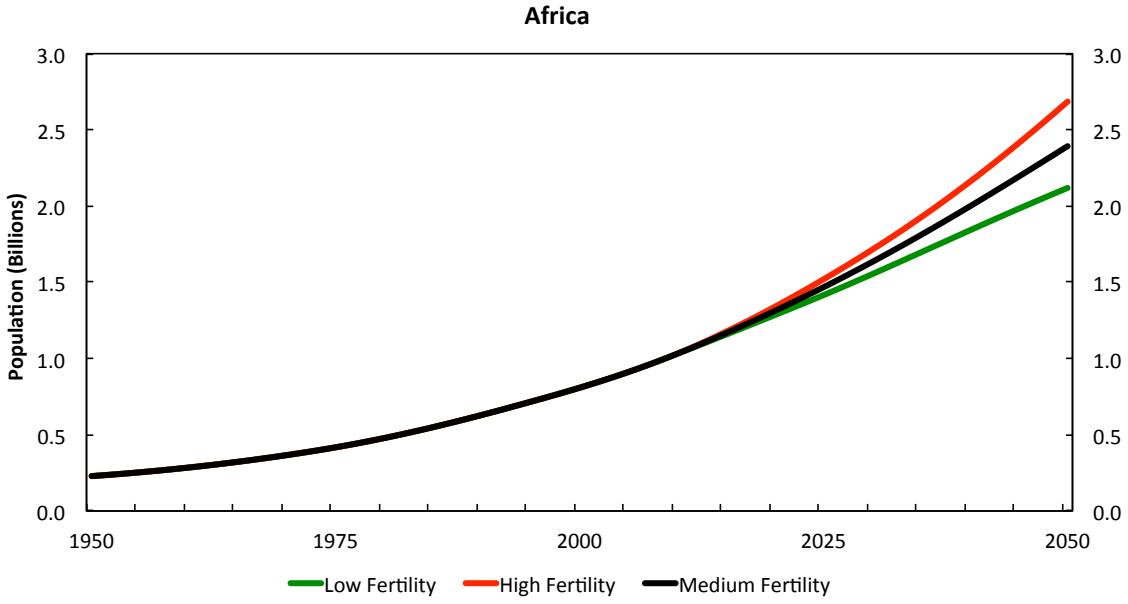

Figure 2: Population of Africa (UN, 2012)

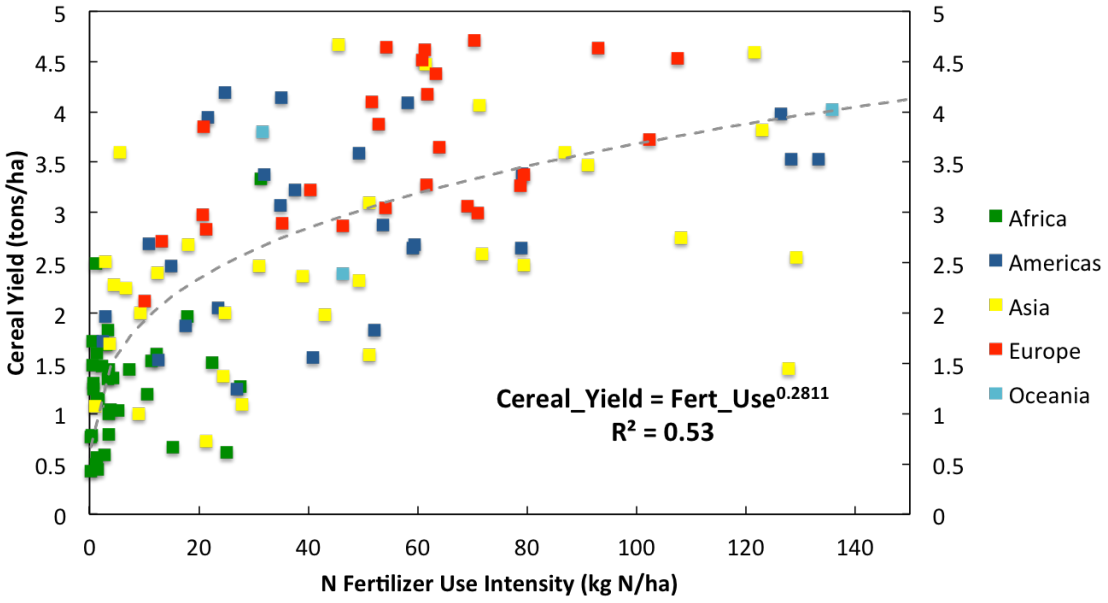

Figure 3: Crop productivity in different countries against fertilizer use intensity. (FAO (2009))

For the sake of real development in Africa, and to achieve improved standards of living, this African "fertility" situation needs to be reversed. The continent needs to take a U-turn and start "driving" in the opposite direction of the "fertility" road! Significant investments are needed in order to control population growth. The most efficient approach to reduce fertility rate of African women is to invest in education of African girls in order to increase female secondary school enrollment levels. Simultaneously, significant investments are needed in order to introduce and enhance agricultural technology in the form of fertilizers and better seeds.

In the Nile basin, the situation of population growth is typical of other sub-Saharan African countries. The combined population of Ethiopia, Sudan, and Egypt more than doubled in the last 30 years or so. The current rates of population growth are very high and range from around 1.5% to 3.0% depending on the country and data source.

As a result, it would be safe to predict that the population of the three countries, which increased from about 100 millions 30 years ago to about 200 millions today, will nearly double by 2050, approaching about 400 millions, See Figure 4. At the same time, the Nile basin suffers from a soil fertility problem. Aside from Egypt where soil fertility is in relatively better shape, the rates of application of fertilizers in Sudan and Ethiopia are among the lowest compared to other countries.

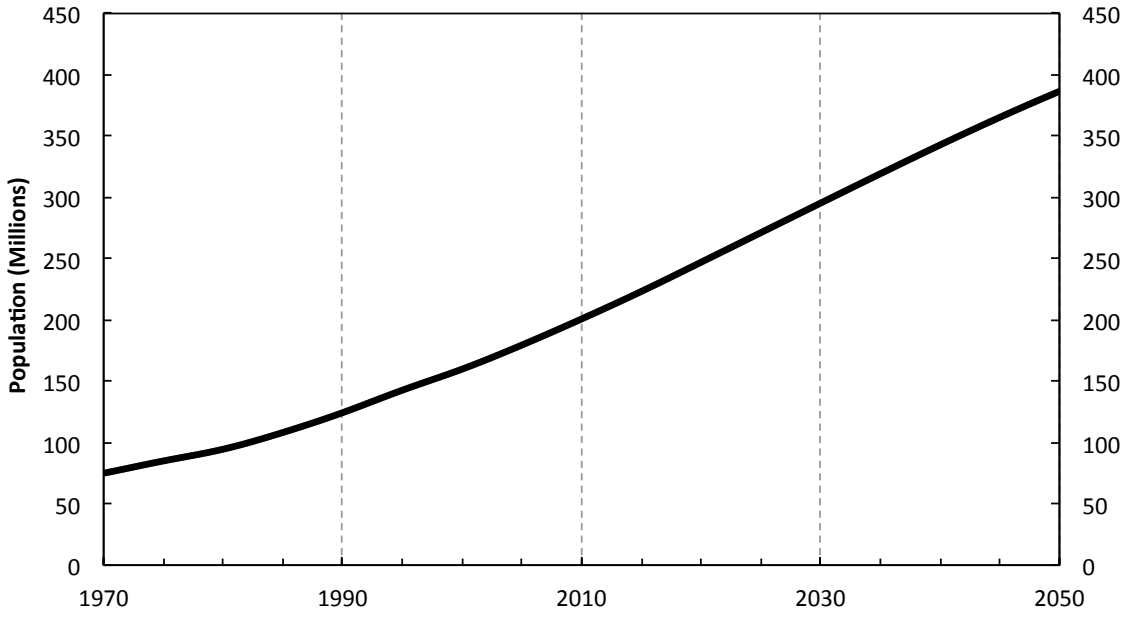

Figure 4: Population of Eastern Nile basin (Egypt, Ethiopia, and Sudan), UN (2012), "Medium Fertility Projection"

In general, if we focus on the entire Eastern Nile basin region including Egypt, Sudan, and Ethiopia, we can express crop production per year, per capita, denoted by C as

$$C = \frac{W \,.\, T}{P} \qquad (1)$$

Where

C : crop production in tons per capita per year

W : total water volume used in cubic kilometers per year

T : agricultural productivity in tons of crops per cubic kilometer of water

P : human population

The rate of change of crop production, with respect to time, contributes directly to the growth rate in gross domestic product (GDP) per capita in the region. We express that rate through simple mathematical manipulation of equation 1, by

$$\frac{\partial \ln(C)}{\partial t} = \frac{\partial \ln(W)}{\partial t} + \frac{\partial \ln(T)}{\partial t} - \frac{\partial \ln(P)}{\partial t} \quad \ldots. \quad (2)$$

Economic Growth	Climate Change	Technology Adoption	Population Growth

This is a beautiful equation that I call the "Equation of Africa's Future"! It explicitly relates long-term growth in crop production, and hence regional economy, to the rates of: climate change, adoption of agricultural technology, and population growth (these three topics are of great interest to me and occupy a significant fraction of my

research activity at MIT!). The above equation expresses clearly that, leaving climate change aside for now, the fractional economic growth attributable to crop production per capita can be enhanced through adoption of agricultural technology such as fertilizers and better seeds, and would significantly be hampered by rapid population growth.

In the Eastern Nile basin countries, the anemic rate of adoption of agricultural technology combined with the rapid growth in population would significantly reduce crop production per capita and the associated GDP per capita. Under such regional conditions, countries would naturally try to achieve more growth through maximization of their share of the limited water resource, at the expense of other countries that share this common resource, hence deepening the apparent conflict over water. Under this hypothesis, the GERD issue is only a symptom of the more serious "disease" that I call the African "fertility" challenge.

Now, coming back to the issue of climate change, we emphasize the high degree of uncertainty about the future climate in the Eastern Nile basin, See Figure 5. The IPCC models, which are the most accurate tools for predicting the future climate, seem to disagree on the sign of the predicted change in rainfall over Ethiopia. As a result our knowledge, at the moment, of the future river flow in the Eastern Nile basin is quite uncertain. However, future climate projections are likely to

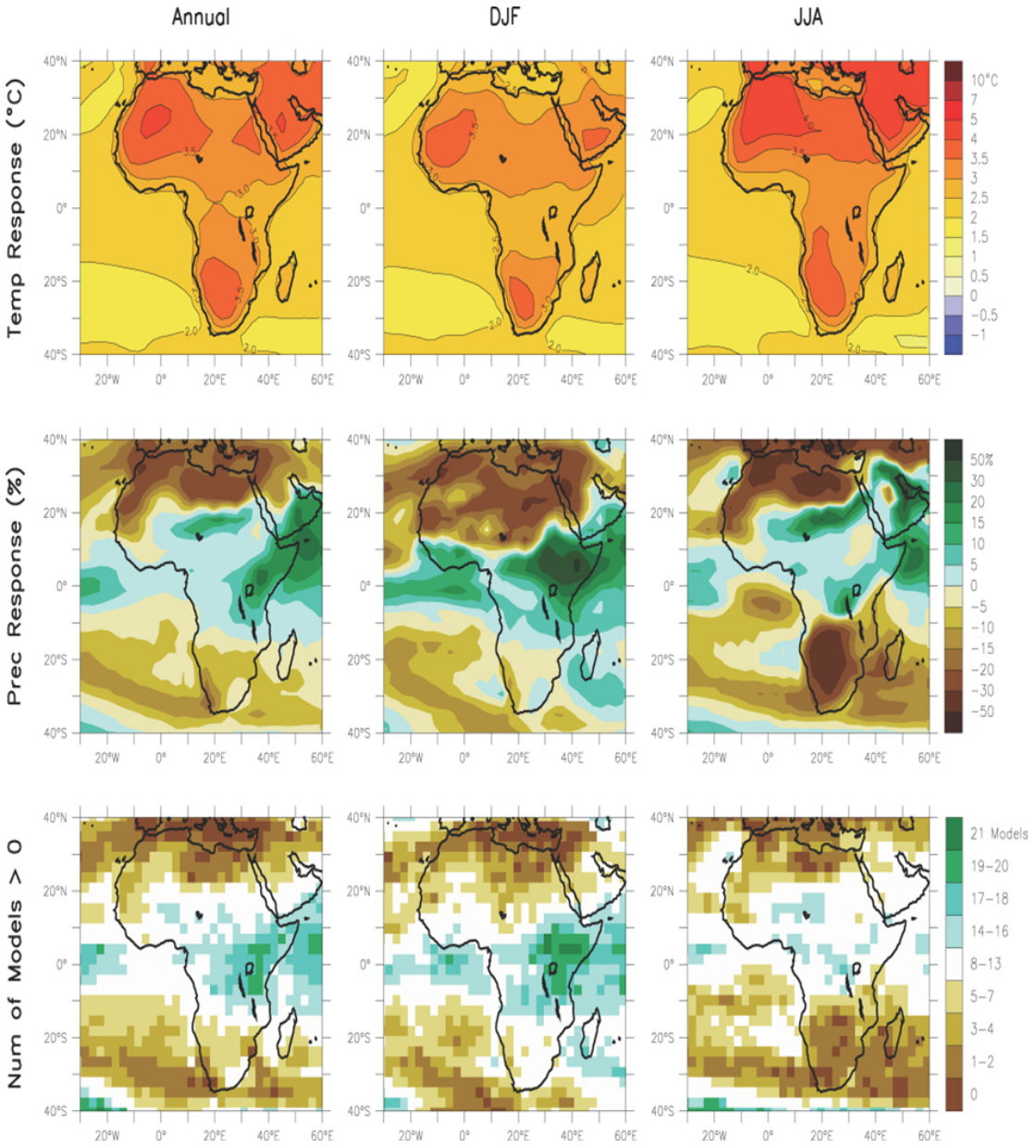

Figure 5: Predictions of Future Climate in the Nile Basin: temperature, precipitation, and number of models that are predicting an increase in rainfall. Over Ethiopia, about 10 to 11 models out of 21 models are predicting an increase, and a similar number are predicting a decrease in rainfall over Ethiopia during (June, July, and August). (From Boko et al. , 2007; IPCC report, The more recent IPCC report shows similar results)

improve with time as the science of regional climate change prediction makes further progress. Hence, water policy in the Nile basin needs to be crafted in a way that can flexibly adapt, as more information about future climate becomes available.

Water Strategies in the Eastern Nile Countries

The strategies guiding planning and management of water resources followed by Egypt, Sudan, and Ethiopia, all seem to suffer from significant deficiencies and may not reflect real national interests. Let us briefly unpack this statement, and discuss it for each of the three countries.

The Egyptian strategy towards the Nile water, though not articulated publicly, seem to most observers as one of preserving the status quo. Under current conditions, Egypt is utilizing the lion share of the Nile river flow volume, See Figure 6. Hence, it would be tempting for Egypt to preserve current conditions and continue to enjoy a disproportionally large share in the Nile water. As explained below, such a strategy is indeed shortsighted, and would not serve the national interests of Egypt in the long-term.

Egypt is located at the mouth of the river, and is relatively the most geographically disadvantaged in the Nile basin. By virtue of its location relative to the two other countries, Egypt receives water that already passed through Ethiopia and Sudan, and hence Egypt's water share is inherently vulnerable to regulation by either of the two countries.

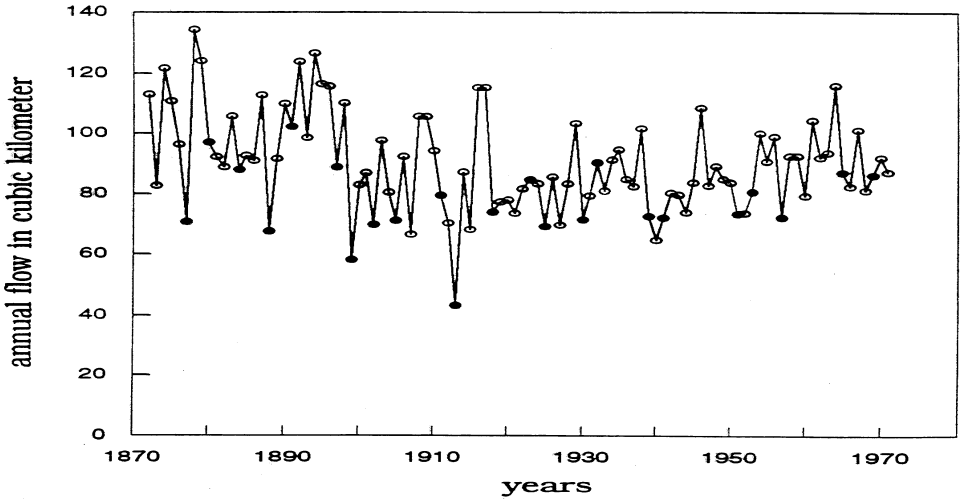

Figure 6: Inter-annual fluctuations in the flow of the Nile river at Aswan (Eltahir, 1996)

This fact explains the desire in Egypt through history to reach binding agreements to secure its share in the Nile water, as was the case in the 1929 agreement between United Kingdom and Egypt, and the 1959 agreement between Sudan and Egypt. Since Ethiopia does not recognize these agreements, the national interest of Egypt seems to lie in a strategy that would seek to arrive at a legally binding agreement with Ethiopia.

As the population in Africa keeps increasing at the current fast pace, and the legitimate aspirations for development of African countries are increasingly recognized worldwide, such an agreement including Ethiopia for the first time needs to be reached *as soon as possible* in order to secure Egypt's share of the Nile water. Time is not on Egypt's side, since what has been achieved in 1959 may not be feasible today and what may be achieved today is not likely to be feasible a decade from now. Interestingly, such consideration for urgency runs diametrically opposite to the apparently adopted strategy by Egypt: preserving the status quo!

The Ethiopian water strategy implicitly revealed through the specific investment plans announced in the last decade or so emphasizes development of the hydropower potential of the country by constructing a series of dams on the rivers originating in Ethiopia. Given the large discharge in these rivers, and the diverse topography of Ethiopia, hydropower development is a natural choice. The purpose of these dams is generation of electricity, mostly for export to surrounding countries. Such a strategy makes economical sense, since Ethiopia needs to secure

significant influx of hard currency into the country, an influx that cannot be achieved otherwise due to the apparent lack of significant oil and mineral resources. However, for such strategy to succeed there have to be viable customers who are capable and willing to pay for Ethiopian electricity. Egypt enjoys a GDP per capita that is roughly double the corresponding GDP for Sudan, and four times that of Ethiopia. Hence, Egypt seems to be the ideal candidate as a customer for the Ethiopian electricity. Significant analysis and studies have been carried, sponsored by the Nile Basin Initiative, which confirm the economic feasibility of transmitting electricity from Ethiopia to Egypt.

Where the Ethiopian water strategy is deficient is in the poor "business" approach taken by Ethiopia in executing the plan for its hydropower development. The Ethiopian approach seems to alienate rather than cultivate a good business relationship with the main potential customer, whose critical role is needed for the success of Ethiopia's business plan for hydropower development. For example, the development and sudden announcement of GERD plans was carried out without prior consultation with the regional partners including Egypt. As the construction of the GERD progresses, and the date for finally producing the electricity gets closer, the critical role of Egypt as the main customer of the produced electricity will become more and more evident.

Finally, Sudan's location between Ethiopia and Egypt is a more complex geographical position, and would necessarily dictate a water strategy that is more

complex than the other two countries. In other words, a strategic position where Sudanese interests are presented as perfectly aligned with those of Egypt, or perfectly aligned with those of Ethiopia, is not consistent with the facts of geography.

In some respects, the interests of Sudan align with those of Egypt. Given the large potential of arable land that has not been developed yet, Sudan has an interest in making sure that infrastructure development in Ethiopia is carried out in ways that are structurally safe, and do not significantly impact the flow amount and sediment regime downstream. This is especially true given the fact that Sudan did not yet utilize its full share of the Nile water according to the 1959 agreement. As that important threshold is approached in the coming years, Sudanese worries about water security should come closer to the surface, aligning some of the interests of Sudan closer to those of Egypt.

On the other hand, Sudan and Ethiopia share legitimate aspirations for achieving real economic development. Both countries are located upstream from Egypt, thus enjoy the advantage of being able to regulate the water flow, and are significantly poorer economically by comparison. Upstream water regulation in Ethiopia can potentially improve efficiency of electricity production from hydropower, and enhance the potential for irrigation development in Sudan. These factors taken together would tend to align the interests of Sudan closer to those of Ethiopia, especially in the call for Egypt to consider the needs for equitable utilization of the

Nile water more seriously and to offer serious concessions to the upstream countries.

Contrary to this complex picture, the water strategy for Sudan in the last few decades tends to oscillate between being fully aligned with Egyptian positions and being fully aligned with Ethiopian positions. What would be in the national interest of Sudan is a "triangulation" strategy that would always identify and maintain a distinct set of common interests with both Egypt and Ethiopia, forming a unique set of national interests for Sudan in the Nile water.

A New Vision For The Way Forward

Here, I offer a deeper diagnosis of the apparent conflict on the Nile water. What is often seen at the surface as a water problem and discussed in the context of sharing a common resource is in essence a reflection, or a symptom, of a deeper problem: the African "fertility" challenge that has been described above.

In moving forward, and in order to effectively address the conflict on the Nile water, the key is not to focus on how we fill a reservoir behind a dam here or there, but instead to address the root cause of the problem by reversing the fertility situation: find ways to decrease women' fertility rate, and enhance the soil fertility in the Nile basin. Hence, in any future agreements or declaration about the Nile water, the priority should be given to how and when to take the appropriate measures to address the human population and soil productivity problems.

Education is probably the best approach to address the population problem in the long-term. In particular, a goal of educating all African girls until the secondary school level should be adopted in the Nile basin and beyond, See Figure 7. Educated women would predictably choose to have fewer children. Education of the general public about the population challenge through the official channels of schools and media as well as traditional channels and religion institutions suitable for the African context is likely to be effective in addressing the critical challenge of population in the long term. A few African countries in the north and the south have been successful in controlling their population problems. Lessons and successful approaches identified in these countries can be tried elsewhere in the diverse countries of the African continent.

My proposal to focus on agricultural technology goes beyond the Nile basin and to the whole continent of Africa. I propose that adoption of technologies that improve agricultural productivity in Africa will result in significant desirable outcomes along four dimensions:

A. Accelerate economic development, and achieve food security;
B. Reduce the intensity of emerging conflicts over water between different countries, such as the one in the Nile basin;

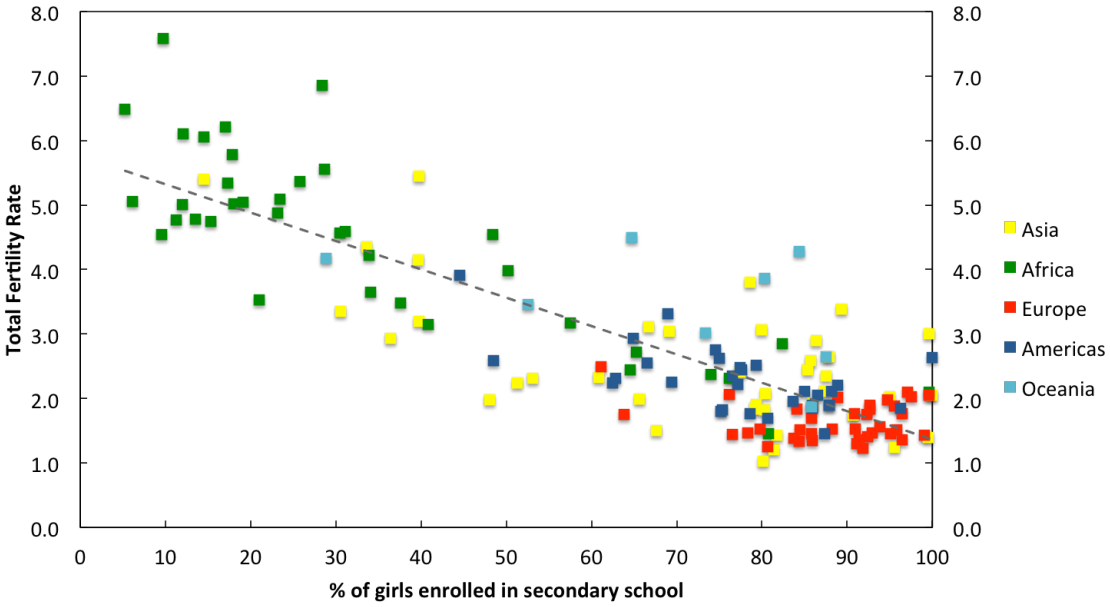

Figure 7: Women fertility rate versus percent of girls enrolled in secondary school, for different countries (Earth Policy Institute (2015))

C. Resolve apparent conflict over land between needs for horizontal agricultural expansion and needs for environmental conservation; and,
D. Enhance capacity of African societies to deal with the challenges of climate change

A negotiated agreement on sharing the water resources of the Blue Nile between Sudan, Egypt, and Ethiopia seems necessary and urgent in order to ensure security and stability in the Eastern Nile basin. As argued above, Egypt needs to reach an agreement as soon as possible in order to secure its share of the Nile water for future generations. Similarly, Ethiopia needs to recognize the critical role of Egypt as the main potential customer of the electricity produced in the Blue Nile, and cultivate a better "business"-like relationship. Hence, finding a negotiated resolution of the apparent conflict on the Nile water, in the near future, may not be as antithetical to the genuine interests of the Eastern Nile countries, as it may seem at the surface.

If Ethiopia, Sudan, and Egypt were regions of the same united country, national planners would be wise to recommend a national strategy of utilizing the potential for rain-fed agriculture in the Ethiopian region, use most of the river flow for irrigated agriculture in the Sudanese and Egyptian regions, as well as extensive development of the hydropower potential in the Ethiopian and Sudanese regions to generate electricity that can be transmitted and sold in the downstream regions.

However, the national government under this hypothetical situation would also see urgency in integrating the markets across the regions of this country so that some of the wealth generated in the relatively richer downstream regions is invested upstream to help in developing the Ethiopian region, eliminating any significant gradient in standards of living. This simple thought experiment should inform any future framework that may be crafted for a negotiated resolution of the conflict in the Nile basin.

Here, I propose five elements that are necessary to include in order to strike a balance, and achieve a sustainable agreement between Ethiopia, Egypt, and Sudan:

1. The first priority is to reach an agreement between the three countries on curtailing the rate of population growth! A target population growth rate of about 1% in each of the three countries, reached within a period of about 10 years seems feasible and sufficient to bring the population "crisis" under control, before further more stringent measures are taken.
2. A commitment from the three countries to invest in new agricultural technologies such as better seeds, more use of fertilizers, and efficient water use technology including more efficient use of water in irrigation is necessary. All international partners with interest in the stability of this region should try and help bring about a significant level of adoption of agricultural technology in order to enhance development and economic growth, while reducing the intensity of conflict over water.

3. Given the natural topography of Ethiopia and the associated hydropower potential, Egypt and Sudan should welcome and support the Ethiopian plan for developing its hydropower potential. Hydropower conversion is a non-consumptive use of water. Instead of obstructing the efforts for building the GERD, the two downstream countries and especially Egypt should commit to playing the role of a reliable customer for Ethiopian electricity, sold at fair market price. This should insure a sustained flux of hard currency from Egypt to Ethiopia, which would finance badly needed development plans and help to sustain the Ethiopian economy.
4. Given the natural disparity in the distribution of rainfall between Ethiopia and Egypt, Ethiopia should concentrate on rain-fed agriculture instead of irrigated agriculture, and should commit to securing a sustainable annual flux of water downstream, close to the current rate of flow into Sudan, to be divided in a separate agreement between Sudan and Egypt.
5. The countries of the Eastern Nile Basin should develop a common regional approach to incorporate the future impacts of climate change on rainfall and river flow in any negotiated agreement. Climate change will modify the hydrology of the Nile, offering new opportunities and presenting new challenges that can only be addressed through cooperation between the three countries.

Acknowledgement

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