Synthesizing the Water Diplomacy Framework and Sustainable Development Goals as a Robust Framework for Transboundary Water Conflict Resolution

Synthesizing the Water Diplomacy Framework and Sustainable Development Goals as a Robust Framework for Transboundary Water Conflict Resolution

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Abstract

When the Grand Ethiopian Renaissance Dam (GERD) is completed, it will join Egypt's High Aswan Dam (HAD) as part of the world's only river basin with two megadams—each with no agreed-upon, coordinated operation and no coordination among the riparian countries through which the transboundary river flows. The GERD, once filled, is a prime area where coordination could prove invaluable, but where divergent interests challenge that prospect. For example, Ethiopia could benefit from a rapid fill of the GERD reservoir, upholding its right to equal access to the shared water resource, while generating electricity and boosting its economy. In contrast, Egypt fears an expedited fill, arguing its right not to be significantly harmed by its neighbor's use of the same river.

I postulate that these opposing interests can be minimized to produce mutual benefit by employing mathematical models and collecting certain data. In order to gauge what impacts different fill rates could have on development in the basin across the water-food-energy nexus, I propose that the United Nations 2030 Agenda for Sustainable Development be used as an analytical lens to assess the intersecting economic, social, and environmental impacts that the GERD might have on each nation. Second, once these impacts are identified, the UN 2030 Agenda's three Sustainable Development Goals (SDGs) that pertain to the water-food-energy nexus can be modeled using a mathematical river basin simulation model to simulate the range of possible outcomes across five fill scenarios: unconstrained, three years, five years, ten years, and no GERD. Finally, I

postulate that the Water Diplomacy Framework (WDF) could then be used to facilitate a mutually agreeable solution by treating these multi-dimensional costs and benefits as fluid currencies within a shared river basin, in contrast to the current zero-sum paradigm over the singular resource of water.

Ultimately, I arrive at three conclusions:

1. The UN 2030 Agenda is a powerful lens through which integration of development priorities can be understood, but national strategy plays an equally important role in customizing those goals.
2. Simulation models can provide a valuable source of objective and testable data to measure potential impacts of the GERD on riparian countries.
3. The WDF can be used to harmonize national priorities between basin-states to enable the GERD’s developmental potential without significant harm downstream that would likely occur in the absence of coordination.

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List of Acronyms

BATNA	Best Alternative To a Negotiated Agreement
bcm	billion cubic meters
FfD	Financing for Development
GERD	Grand Ethiopian Renaissance Dam
HAD	High Aswan Dam
HP	Hydropower
IAEG-SDG	Inter-Agency and Expert Group on Sustainable Development Goals
JFF	Joint Fact Finding
mcm	Million Cubic Meters
MDG	Millennium Development Goals
MW	megawatt
RD	Relative Deficit
SD	Standard Deviation
SDG	Sustainable Development Goals
WDF	Water Diplomacy Framework
ZOPA	Zone of Possible Agreement

Chapter I

Introduction

The Grand Ethiopian Renaissance Dam (GERD) is one of the most contentious infrastructure development projects in the world. Currently under construction, the forthcoming largest hydroelectric dam in Africa promises to revolutionize Ethiopia's energy and economic future.[1] The GERD approaches its estimated 2017 completion despite political resistance by downstream riparian neighbor Egypt as well as ongoing threats of warfare. While Ethiopia expects to gain tremendous benefit from the project, Egypt continuously opposes its progression, fearing significant reductions to its hydrological lifeline stemming primarily from Ethiopia's Blue Nile tributary.[2]

Once the Blue Nile is dammed and its reservoir begins to fill, Egypt will feel the pinch of water scarcity during the filling period in one of the driest regions of the world. Ethiopia downplays this risk and stresses the importance of the project as a tenet of its national sovereignty,[3] a necessity for its rapidly growing economy and population, and a marker of its emerging geopolitical influence on the African continent. In turn, Egypt sees its own national and hydrological security in crisis, its historically Nile-dependent

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[1] William Davidson, "Ethiopia's Largest Hydro Plant to Produce Power This Year," *Bloomberg Business*, March 18, 2015. Available from: <http://www.bloomberg.com/news/articles/2015-03-18/ethiopia-s-largest-hydro-plant-to-produce-electricity-this-year>. Accessed February 21, 2016.

[2] Temesgen T. Deressa, and John Mukum Mbaku, "While Egypt Struggles, Ethiopia Builds over the Blue Nile: Controversies and the Way Forward," Brookings Institution, July 25, 2013. Available from: <http://www.brookings.edu/blogs/up-front/posts/2013/07/23-ethiopia-hydroelectric-power-plant-mbaku>. Accessed February 21, 2016.

[3] Nizar Manek, "Water Politics along the Nile," *Le Monde Diplomatique*, May 2014. Available from: <http://mondediplo.com/2014/05/09egypt>. Accessed February 21, 2016.

economy at risk, and its hard-powered dominance of the world's largest river basin at a pivotal turn toward submission. Sitting between these two countries, intermediary Sudan is caught between historic ties to co-defend its shared claim to riparian dominance with Egypt, and previously unanticipated economic prospects from Ethiopia's dam that could compel its conversion to support it. Despite high-profile gestures by the national leaders of all three countries to defuse heightening tension, the cascading economic, environmental, and social effects coming from the largest infrastructure project in Africa point to historic and lingering potential for conflict in the face of dissent.[4]

For years, the legal dimension of this water "cold war" placed Egypt and Ethiopia at odds over the extent to which Ethiopia could utilize its domestic water resources at the expense of causing downstream harm. While this context is explored more fully in Chapter III on the "History of the Nile," a 2015 agreement between both nations and Sudan agreed on a "Principle Not to Cause Significant Harm."[5] In contrast to causing "no harm," this compromise by Egypt allows Ethiopia to utilize its riparian water resources even if it creates a *degree* of damage downstream. A similar "Declaration of Principles," signed in Khartoum, also speaks to the potential need to alleviate significant harms should they occur, and to compensate harmed parties.[6] With construction of the dam currently underway and the realization that its presence will be felt in some manner

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[4] Hassan Hussein, "Egypt and Ethiopia Spar over the Nile," Aljazeera America, February 6, 2014. <http://america.aljazeera.com/opinions/2014/2/egypt-disputes-ethiopiarenaissancedam.html>. Accessed February 21, 2016.

[5] "Full Text of 'Declaration of Principles' signed by Egypt, Sudan and Ethiopia," Ahram Online, March 23, 2015. Available from: <http://english.ahram.org.eg/News/125941.aspx>. Accessed March 23, 2015.

[6] "Declaration of Principles."

downstream, whether significantly or otherwise, strategies to encourage further cooperation must be thoroughly examined.

Current Challenges

The GERD creates two kinds of challenges for Egypt, Sudan, and Ethiopia. These problems emerge from the unique nature of the water basin: two of the largest mega-dams in the world will be operated by two different countries with no meaningful cooperation in place to administrate their usage.

Challenge One

The first challenge—Ethiopia's aggressive filling of the GERD's reservoir—could limit flow downstream, thereby stressing the water supply for Egypt and Sudan. The amount of time elapsed before Ethiopia could generate maximum energy because the dam is filled to capacity is uncertain; it may be a short to medium challenge or it could take up to 10 years. While Egypt has up to two years' worth of water stored in Lake Nasser behind the High Aswan Dam (HAD), Egypt's concern is that that amount would not be nearly sufficient to cover the time needed to fill the GERD's reservoir. A rapid filling rate, coupled with drier than average years in the Nile River Basin, could lead to dangerous deficits for Egypt that would impact the country's agriculture, food security, hydroelectricity production, and jobs associated with all of the foregoing vulnerabilities. It would adversely affect agricultural jobs first and hardest by restricting crop selection in the face of water shortage, and inadequately distributed safety nets could accentuate inequalities in downstream Egypt and Sudan.

Water must be viewed as one currency of several to resolve problems. For example, water-stressed agricultural unproductivity could create a national food shortage. However, financial resources could go toward importing food to meet demands. This money could come from Egypt's national budget which stands to save on energy costs due to subsidies on Ethiopian hydropower from the GERD once completed, if a transmission line connecting the GERD with the Egyptian grid is constructed. Currently, there are no such plans in development. Thus, while a domestic water shortage is the surface problem, a current inability to optimize resource allocation in the Nile River Basin is the core issue that needs to be resolved. Capitalism has a role to play in appropriating supply to meet demand, but amenable policies are needed to dissolve such hurdles via the gateways of diplomacy and negotiation.

Challenge Two

The second challenge disproportionately hinders Egypt in the medium to long term, and ironically emerges from the same legal context that gave Egypt the lion's share of Nile waters for decades. The 1959 Agreement between Egypt and Sudan for utilization of the Nile waters was a bilateral foreign policy proclamation that allotted to Egypt 55.5 billion cubic meters (bcm) of the river's annual 84 bcm (as measured at Aswan), and 18.5 bcm to Sudan, leaving 10 bcm for anticipated evaporation from Lake Nasser behind the HAD, and none to the other riparian states.[7] Despite Egypt's overwhelming allotment, its

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[7] Mwangi S. Kimenyi, and John Mukum Mbaku, *Governing the Nile River Basin: The Search for a New Legal Regime* (Washington, D.C.: Brookings Institution Press, 2015), 33-45.

allotment has grown to more than 60 bcm.[8] This occurs due to Sudan's lack of a reservoir storage site, which means Sudan can use only 13.5 to 16 bcm[9]—significantly less than was allotted in 1959. The remainder flows downstream and is added to Egypt's share.[10] Egypt also benefitted from the basin's higher-than-average flow in the past century: inflow to Aswan averaged 91 bcm rather than 84.[11]

An upstream hydroelectric dam in Ethiopia, built to constantly generate electricity, would require regular release of its stored water throughout the year rather than the seasonal flow that occurs on the Nile each summer. By receiving water from Ethiopia regularly throughout the year (rather than as a lump amount that cannot be stored and is too large to use at once), Sudan is able to harness its full entitlement of 18.5 bcm of the Nile's annual estimated supply, thereby utilizing the surplus that in the past went to Egypt. The additional supply to Sudan could also help its irrigation and agriculture, and incentivize the country to support Ethiopia's GERD despite Egypt's resistance. In contrast, diminished water supply challenges Egypt in the same ways filling the GERD reservoir would in the short term, only now it would continue indefinitely. Long-term, lower-water supplies cause risks to hydropower generation, agricultural production, and saltwater intrusion into Egypt's delta.

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[8] "The Grand Ethiopian Renaissance Dam: An Opportunity for Collaboration and Shared Benefits in the Eastern Nile Basin: An *Amicus* Brief to the Riparian Nations of Ethiopia, Sudan and Egypt from the International, Non-partisan Eastern Nile Working Group." Available from: <http://jwafs.mit.edu/sites/default/files/documents/GERD_2014_Full_Report.pdf>. Accessed February 22, 2016.

[9] The exact amounts are hard to determine and it has increased in the last decade.

[10] Kevin G. Wheeler, Gamal M. Abdo, Mohammed Basheer, Sami O. Eltoum, Zelalem T. Mekonnen, Azeb Mersha, *et al*., "Cooperative Filling Approaches for the Grand Ethiopian Renaissance Dam," *International Water,* 2016.

[11] "Grand Ethiopian Renaissance Dam: An Opportunity," 9.

These two categories of challenges and their impacts on downstream states have yet been comprehensively contextualized against mutually agreeable parameters to all involved nations. While other specific risks exist and have been studied in considerable depth, their impacts generally fall into the same broad categories I have outlined.

Water shortage in the short or long term affects more than just agriculture; it cascades to other areas of development as well. For example, while Egypt has some of the highest agricultural yields in the world per hectare and per unit of water expended, these accolades come at a cost.[12] Tremendous recycling of water, which is uncommon in less water-scarce countries, is what enables high returns. But the Nile's water quality in Egypt causes a range of health problems, including one of the highest rates of kidney failure anywhere in the world, causing 3% of all deaths and still rising.[13] This speaks to the interdependence of water quantity with water quality, and the impact of both on public health as well as the need for holistic, multi-dimensional solutions.

This is also an example of the reality that Ethiopian decisions that affect Nile administration could have cascading developmental effects downstream, many of which are entirely unintended. Therefore, a river basin administered by multiple countries, each with opposing water interests, needs to look beyond water for the solution to its problems.

Tensions between nations regarding the allocation and utilization of water cause many academics to fear the possibility of wars over water in some parts of the world. The

[12] Lester R. Brown, *Full Planet, Empty Plates: The New Geopolitics of Food Scarcity* (New York: Earth Policy Institute, 2012).

[13] "Egypt: WHO Statistical Profile," World Health Organization. Available from: <http://www.who.int/gho/countries/egy.pdf?ua=1>. Accessed June 16, 2015.

study of solutions to existing and evolving transboundary tensions underscores the urgent need for an approach to negotiation that emphasizes mutual gains rather than zero-sum exchange. To attain that, an agreeable diversification of bartering currency is needed to broaden the scope of impacts and prospects beyond volumetric and energy units.[14]

In the Nile River Basin where two of the largest hydroelectric dams in the world will soon operate without a cooperative agreement or protocol, the absence of harmonized administration could create risks that affect millions of people. During negotiation, involved parties therefore should seek agreement on (a) coordination of both dams' operations, (b) outstanding technical concerns in the GERD's design, (c) sale of the GERD's hydropower, and (d) possible downstream impacts to Egypt and Sudan.[15]

Potential Solutions

Ratification of the UN 2030 Agenda for Sustainable Development is a recent phenomenon in the history of Eastern Nile politics. While developmental intersections were ignored or disagreed upon earlier, they are now enshrined in this international agreement. The 2030 Agenda's negotiation process was exhaustive in creating agreed-upon common ground, and has the added benefit that none of what was adopted is disagreed upon. Therefore, its pre-established consensus, multidimensionality, and intersectionality could position it to dissolve the previous stalemate in regional diplomacy, and simplify the Eastern Nile river basin from a complex watershed to a

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[14] Shafiqul Islam, and Lawrence E. Susskind, *Water Diplomacy: A Negotiated Approach to Managing Complex Water Networks* (New York: RFF Press, 2013).

[15] International Non-Partisan Eastern Nile Working Group, "The Grand Ethiopian Renaissance Dam: An Opportunity for Collaboration and Shared Benefits in Eastern Nile Basin", MIT Abdul Latif Jameel World Water and Food Security Lab, 2014.

"problem shed" whose effective cooperative management may be complicated, yet achievable.

The UN 2030 Agenda—an international agreement that encompasses sustainable development goals (SDGs) as well as the Financing for Development (FfD) initiative that was negotiated in parallel—was ratified by consensus across the international community after an exhaustive and inclusive negotiation process. Thus, it already contains a mutually agreeable framework that identifies where developmental priorities intersect with water. The Agenda approaches development multidimensionally by holistically addressing economic, environmental, and social necessities. Its goals encompass a wide range of developmental objectives, such as increasing the prevalence of renewable energy, and improving access to clean drinking water and sanitation. Its initiatives are as tangible as increasing green spaces in cities and as principled as eliminating practices of gender discrimination.

However, while parts of the Agenda relate more obviously to the construction of a hydroelectric dam than others, each state is ultimately responsible for devising its own national prioritization of goals. The advantage in viewing water flexibly within the context of these SDGs is that the interrelationships and interdependencies of water use are agreed to and thus the applications of water can be more readily negotiated. These applications, such as agricultural yields and energy production, serve as exchangeable currencies. In addition, the UN 2030 Agenda is intersectional in that it encourages policy design while considering those different necessities together, weighing them against national circumstances and priorities and giving a voice to myriad stakeholders from civil society, to the private sector, to various levels of government.[16] Together, these qualities identify the most relevant components within development that could be affected within each country, beyond just water. By diversifying bartering currencies in a way that both countries have already agreed upon, current impediments toward cooperation could be lifted, and mutual gains in related but similarly important areas could be sought and optimized.

The Water Diplomacy Framework (WDF), designed by Shafiqul Islam and Lawrence Susskind, is an approach to transboundary water conflict resolution that addresses water challenges by considering their unique qualities within complex systems and integrating the natural, scientific, and political domains in which they exist. The WDF role in joint fact-finding was to clarify for the parties the information that could be agreed upon, and highlight the reasons for disagreement about certain portions of it.[17]

Propositions

To critically assess the potential of the UN 2030 Agenda and the WDF as they pertain to resolving transboundary water conflicts like those in the Nile river basin, I postulate three propositions. I briefly explain each proposition below, then analyze each one in more detail in the Methods chapter.

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[16] "Transforming Our World: The 2030 Agenda for Sustainable Development," Sustainable Development Knowledge Platform. <https://sustainabledevelopment.un.org/post2015/ transformingourworld>. Accessed February 21, 2016.

[17] Islam and Susskind, *Water Diplomacy*, 200.

Proposition One

I propose that SDGs like those proposed in the UN 2030 Agenda can be used as analytic lenses to help simplify the Eastern Nile basin into a "problem shed" in order to identify mutually recognized economic, social, and environmental challenges and to specify a range of exchangeable currencies to advance cooperative sustainable development.

Currently, the fill rate of a major hydroelectric dam has inverted incentives for upstream and downstream countries. Filling the GERD too quickly in order to harness its hydropower sooner would benefit Ethiopia but could harm Egypt by forcing the latter to deplete its own water reserves stored in Lake Nasser. This would adversely impact Egypt's agricultural potential and hydroelectric capacity. Filling the GERD too slowly would mitigate the damage to Egypt's resources but only at a financial opportunity cost to Ethiopia. Therefore, if both nations cooperate to fill at a compromised rate, that may enable Ethiopia to capture healthy returns from generating and selling hydropower while giving Egypt the ability to adapt to the river basin's new water regime. However, the losses each incurs by compromising from their "best alternative to a negotiated agreement" (BATNA)—their most desirable outcome if they were to simply choose without negotiating—could be ameliorated by mutual gains in other co-negotiated areas. I will focus on this dimension in greater detail in my third proposition.

The nature of this compromise deserves more attention than just splitting the difference in water availability between each country's BATNA. The WDF stresses the complexity involved in many transboundary water issues, which cannot always be solved by meeting at a nominal midpoint. Water is inherently a critical resource because it rests at the nexus of virtually all other facets of life, society, and sustainable development. It is therefore crucial to view water as spanning a variety of development challenges that will vary regionally, nationally, and locally, rather than as a singular currency.[18] Once the economic, environmental, and social interdependencies of water are recognized as inseparable, so too is the need to consider negotiable solutions that include compromise and exchange among the widest viable range of currencies to achieve an optimal outcome for each party. This is possible because bartering over water is a proxy for what that water is used for. If those needs themselves, spanning the water-food-energy nexus, but also including social demands, could be included in negotiations between Egypt and Ethiopia and exchanged directly, greater opportunity is created for these needs to be creatively fulfilled without relying on water as the only answer.

Proposition Two

I propose that river basin modeling could aid in joint fact-finding of future environmental and policy conditions, thereby informing the design of policies aimed at achieving the SDGs at the water-food-energy nexus. Hydrological modeling is used internationally to simulate segments of the water cycle, and is relied upon among water resource managers in river basins.[19] Hydrological models have helped stakeholders identify the most significant challenges in managing river basins while highlighting

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[18] Islam and Susskind, *Water Diplomacy*.

[19] Robyn Johnston, and Vladimir Smakhtin, "Hydrological Modeling of Large River Basins: How Much Is Enough?", *Water Resources Management* 28, no. 10 (August 2014): 2695-2730. <http://link.springer.com/article/10.1007/s11269-014-0637-8>. Accessed June 5, 2016.

interrelationships and interdependencies within them.[20] Not only have they shown a greater likelihood of recognizing mutually beneficial solutions to water conflicts, but they have been shown to expedite the rates at which such solutions are found.[21]

Proposition Three

The WDF could facilitate an agreement by expanding the conversation from zero-sum water accounting to jointly resolving multiple issues, optimized for each nation according to the priority that each assigns to issues identified among the SDGs and further explored with modeling. This could be achieved by identifying means of administrative cooperation to attain greater distributable benefits across the basin, taking into account each country's BATNA. The goals of such basin-wide efficiency are that Ethiopia could optimize the rate of its hydropower generation while irrigation, hydropower, and water flow could be maximized for Egypt.

[20] H. Assaf, E. van Beek, C. Borden, P. Gijsbers, A. Jolma, S. Kaden, et al., "Generic Simulation Models for Facilitating Stakeholder Involvement in Water Resources Planning and Management: A Comparison, Evaluation, and Identification of Future Needs," Environmental Modeling, Software and Decision Support Developments in Integrated Environmental Assessment 3 (September 11, 2008): 229-246. Accessed June 11, 2016.

[21] Ellen Czaika, and Kenneth Strzepek, "Proposed Model Use in Negotiations about Water Usage on the Blue Nile," United Nations University Wider Institute Draft Paper, December 14, 2015.

Chapter II

Methods

At its core, this study is primarily a qualitative examination of (1) how an international agreement on development could facilitate cooperation, (2) whether hydrological modeling using historic data based on parameters within that agreement could inform policy design, and (3), whether addressing multiple issues together could create better basin-wide outcomes than gains achieved by an uncompromised outcome. While modeling is crucial to this study, I cannot fully test my propositions by relying on quantitative data alone. Therefore, I will begin my investigation with hydrological simulation, followed by qualitative assessments of how findings from the simulation reflect on my three propositions.

My second proposition explores whether modeling with historic climate data could inform riparian administrative decisions as they affect achievement of the SDGs at the water-food-energy nexus. To assess this possibility, I used the Nile Basin Initiative's Nile Basin Simulation Model developed in the Mike Hydro Basin hydrological simulation model created by the Danish Hydraulics Institute.

Since the 2030 Agenda SDGs will be in effect from 2016 until 2030, and the GERD will not complete construction until 2017, this presents two challenges. The first challenge—measuring how Nile administrative strategies could affect Egypt's and Ethiopia's progress toward the SDGs—rests in our inability to predict the future, and later on, the uncertainty of comparing history with the counterfactual. Without a baseline that defines alternative outcomes to the policies that will actually emerge in the basin, the success of these policies could not be determined relative to alternatives. Without knowing how an aggressive fill rate would impact specific indicators within the SDGs compared to more moderate fill rates, the source of eventual success or harm could not be ascertained. Therefore, I propose that by modeling different fill rates with data from both a historic dry decade, and a historic wet decade for comparison, one could forecast how such decisions will impact national development in the areas of water, food, and energy, as captured in the SDGs.

The second challenge is mapping the model's outputs to the adopted SDGs. Fortunately, the 2030 Agenda was designed to include specific targets and indicators to each thematic "goal." Table 1 captures the three SDGs at the water-food-energy nexus, along with their corresponding targets and indicators. While each SDG encompasses an expansive theme, such as "End hunger, achieve food security and improved nutrition and promote sustainable agriculture," its targets are specific, nested objectives that together make each goal comprehensive. The indicators are quantitative measurements that correlate to each target; they inform surveyors of the progress made in each country relative to a nationally determined plan. Together, goals, targets, and indicators make up the SDGs.

To test if progress toward the SDGs could be improved with historic data-driven modeling, it is necessary to map output data from the model to the goals being studied. Table 1 includes the water, food, and energy-focused SDGs, their most pertinent targets and finalized indicators, as well as addendum indicators that I use as region-specific proxy indicators. These proxies will be discussed later in this section.

Table 1. Select SDGs, targets, indicators, and proxy indicators used for this study.

Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture	
Target	**Indicator**
2.1 – By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round	2.1.2 - Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES)
2.3 – By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment	2.3.1 - Volume of production per labour unit by classes of farming/pastoral/forestry enterprise size
2.4 - By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	2.4.2 - Proportion of agricultural area under productive and sustainable agriculture
Goal 2 Proxy Indicator: Relative Irrigation Deficit	
Goal 6. Ensure availability and sustainable management of water and sanitation for all	
Target	**Indicator**
6.1 - By 2030, achieve universal and equitable access to safe and affordable drinking water for all	6.1.1 - Percentage of population using safely managed drinking water services
6.2 - By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	6.2.1 - Percentage of population using safely managed sanitation services, including a hand-washing facility with soap and water
6.4 - By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	6.4.1 - Change in water-use efficiency over time
	6.4.2 - Level of water stress: freshwater withdrawal as a proportion of available freshwater resources
6.5 - By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	6.5.2 - Proportion of transboundary basin area with an operational arrangement for water cooperation
6.6 - By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	6.6.1 - Percentage of change in the extent of water-related ecosystems over time

Target	Indicator
6.a - By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programs, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies	6.a.1 - Amount of water- and sanitation-related official development assistance that is part of a government coordinated plan
6.b - Support and strengthen the participation of local communities in improving water and sanitation management	6.b.1 - Percentage of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management
Goal 6 Proxy Indicator: HAD Release	
Goal 7. Ensure access to affordable, reliable, sustainable, and modern energy for all	
Target	**Indicator**
7.1 - By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.2 - Proportion of population with primary reliance on clean fuels and technology
Goal 7 Proxy Indicator: Hydropower	

Sources: "Transforming Our World: The 2030 Agenda for Sustainable Development," and "Report of the Inter-Agency Group on Sustainable Development Goal Indicators, United Nations."

While the global indicators have already been finalized by the Inter-Agency and Expert Group on Sustainable Development Goal Indicators (IAEG-SDG),[22] the 2030 Agenda leaves room for national and regional addenda.[23] Such additions will be devised by Member States of the UN, and must consider the "global level of ambition but [take] into account national circumstances."[24] Therefore, as a part of follow-up and review of the SDG implementations, nations are asked to develop their own indicators for

[22] Report of the Inter-Agency Group on Sustainable Development Goal Indicators, Economic and Social Council, United Nations, February 19, 2016. Available from: <http://unstats.un.org/unsd/statcom/47th-session/documents/2016-2-SDGs-Rev1-E.pdf>. Accessed June 25, 2016.

[23] "Transforming Our World."

[24] "Transforming Our World."

measuring progress toward targets, complementarily to those universally agreed to within the Agenda.

I modeled for the impact on each of three SDGs with one Nile river basin-specific proxy indicator. Such addenda are intended to address nation- and region-specific challenges. I describe below why each one necessarily complements the global indicators drafted by the IAEG-SDG. Each proxy is also an output from Mike Hydro Basin.

First, Goal 2 aims to achieve food security. To measure it, I use relative irrigation deficit ("relative deficit" or "RD") as my proxy indicator. Relative deficit refers to the difference in availability of irrigation water between supply and demand. It is calculated with the formula:

$$RD = (\text{Total Demand} - \text{Actual Supply}) / \text{Total Demand}.$$

Global indicators for Goal 2 are too detached from the immediacy, and therefore the measurability, of policy decisions on the Nile. While an indicator like "2.3.1 - Volume of production per labor unit by classes of farming/pastoral/forestry enterprise size" may be informative elsewhere, it is not the most efficient correlative measure of the GERD's impact on agriculture or food security. In contrast, the degree of relative deficit directly reflects shortage of irrigation water needed to grow crops, easily mapping from policy to impact on Goal 2.

Second, Goal 6 aims to ensure sustainable water and sanitation for all. I measure this only as an impact on Egypt, since Ethiopia has stated that it will not divert water from the Nile for such purposes, and Sudan is beyond the focus of this study. Therefore, I measure the simulated release of water at the High Aswan Dam ("HAD release") as the proxy indicator for Goal 6.

As described earlier, water quantity already has tremendous impacts on water quality, and Egypt illustrates this relationship well. The more water that flows into Egypt from the HAD, the less will need to be recycled, and the more that can be distributed to achieve this Goal's targets. Hence, like relative deficit, HAD release is a more streamlined metric to map filling strategy to downstream impacts affecting water quantity.

Third, to quantify gains in renewable energy under Goal 7, I used the most pertinent form of renewable energy as my proxy indicator: hydropower generation. Ethiopian hydropower is simulated and measured exclusively for the GERD, while data is collected from Egypt's HAD. While the global indicators are intended to measure proportions of the population with access to electricity (indicator 7.1.1), or with renewable energy in particular (indicator 7.2.1), they effectively bypass the steps in the policy design process where nations decide how to allocate the hydropower they generate in order to create those desired increases in access to energy. For instance, Ethiopia will likely export a large portion of the GERD's electricity to raise capital because the country does not currently have the domestic infrastructure capacity to distribute that electricity locally; by selling it, they are better positioned to spend on such developments.

In contrast to measuring the percentage of its population with electricity, measuring the amount of hydropower is more informative for Ethiopian policymakers who need to decide where to allocate their new source of hydropower, and how to use it to achieve multiple national-specific development priorities. It is for these nation- and region-specific circumstances that the 2030 Agenda left room for Member States to complement the global indicators with their own, to reflect the national realities of their challenges, capabilities, and policy determinations.

In order to simulate a variety of options regarding how quickly the GERD reservoir could be filled, I modeled according to five filling scenarios:

- unconstrained (BATNA for Ethiopia)—simulates completely devoting the Blue Nile tributary to filling the dam, leaving Egypt reliant solely on the White Nile and Atbara tributaries and its reserves in Lake Nasser.
- three-year fill
- five-year fill
- ten-year fill
- no GERD (BATNA for Egypt)—simulates how the proxy indicators would be affected in the complete absence of the GERD.

The three, five, and ten-year fills simulate conditions in the Nile River Basin if Ethiopia fills the GERD reservoir at a rate that will fill it within those respective timeframes. These three scenarios serve as possible midpoints where a fill rate compromise between the parties could be found.

Finally, in order to measure the greatest possible range of climate-based rainfall fluctuation, and thus the impacts they cause for each filling rate, the model simulates impacts on the three proxy indicators by sourcing rainfall data from two historic decades: the wettest decade in the past century (1954-1963), and the driest (1977-1986).[25] By using hydrological models to simulate future outcomes on proxy indicators simulating

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[25] "MIKE Hydro Basin: River Basin Management and Planning." Available from: <https://www.mikepoweredbydhi.com/products/mike-hydro-basin>. Accessed February 22, 2016.

multiple fill rates and using historic climate data, an understanding could be gained of both policy impacts as well as environmental ones.

Burdens

In testing my first Proposition, I look to the outcomes of the simulation to ask if there is evidence to suggest that the debate between riparian states is more “manageable” and therefore more representative of a “problem shed” than a watershed because of its use of the SDGs as a step in preliminary joint fact-finding (JFF). In testing my second Proposition, I examine if there is evidence supporting a better understanding of policy options affecting the SDGs, having simulated ten scenarios (five fill rates and two climate extremes). Lastly, in testing my third Proposition, I question if evidence from the modeling outcomes suggests that greater basin-wide net gains could be achieved or discovered by adhering to the WDF and solving multiple issues simultaneously using water as a flexible currency.

Research Limitations

One of the ways the SDGs may lack agreeability between states for this application is that adjudication by weighing the impacts of its tenets may be too unstructured to be practical. None of the Nile Basin states chose to sign the 1997 Convention on the Law of the Non-Navigational Uses of International Watercourses. Ethiopia listed as one of its reasons that Article 6 presents an array of “factors and circumstances [that] have no given weight, and thus it may be difficult to reach agreement on what combinations of factors constitutes equal utilization."[26] This study does not seek to determine equality in utilization or in policy outcomes. It also avoids recommending any specific policies that each nation has not adopted on its own. In fact, the notion that the riparian states all adopted the 2030 Agenda reflects an appreciation that issue-linking as presented in the SDGs is a step forward in their own paths to development.

Another limitation of the study is the exclusion of Sudan from analysis. While Sudan plays an important role and represents one of three countries directly affected by the GERD, extending this examination to include it was not possible given the time constraints of this writing. However, the methods put forward herein could be replicated in a future study that includes impacts on Sudan as well.

A third limitation is the difficulty of its replication. Mike Hydro Basin and other hydrological models can be inaccessible to many researchers due to pricing as well as a learning curve in understanding how to use them. While Mike Hydro Basin was designed to simplify the modeling experience for non-experts, future products may continue this trend. Also, the designers of this class of software are often well aware of the cost prohibitions they place on researchers, and may be able to offer student, institutional, or other researcher-friendly pricing options. Those should be explored with one's research institutions and software developers directly.

[26] C. M. Carroll, "Past and Future Legal Framework of the Nile River Basin," *Georgetown International Law Review* 12, no. 1 (1999): 269-304.

Chapter III

Geography of the Nile

According to the World Bank, Egypt is among the driest countries in the world, receiving only 5.4 cm of rainfall for all of 2014.[27] In today's turbulent political fluctuations, the country remains as dependent on its prime source of fresh water as it did during pharaonic rule. But for a country that relies so heavily on its river, Egypt has remarkably little control over it.

As the world's longest river (6,853 km / 4,258 mi) (see Figure 1), the Nile travels thousands of kilometers across Africa before Egyptians ever see it. Originating as far south as the springs of Burundi,[28] it collects from tributaries in Lake Victoria, then rushes down the waterfalls of Uganda into South Sudan. It is here where the White Nile (as this portion is called) hits the Sudd—swampland that slows the river's flow so much that half its volume evaporates in the African sun. Now well depleted, it carves a path north through the Sahara Desert, giving life in the areas it touches where life otherwise could not exist. It finally rejuvenates fully in an explosive merger at Khartoum with the Blue Nile, which has made its own journey down the steep canvas of the Ethiopian Highlands into Sudan. From there, it flows north as what is now simply called the Nile River—no

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[27] "Average Precipitation in Depth (mm per Year)," World Bank. Available from: <http://data.worldbank.org/indicator/AG.LND.PRCP.MM?order=wbapi_data_value_2012 wbapi_data_value wbapi_data_value-first&sort=asc>. Accessed February 21, 2016.

[28] Robert O. Collins, *The Nile* (New Haven, CT: Yale University Press, 2002), 6.

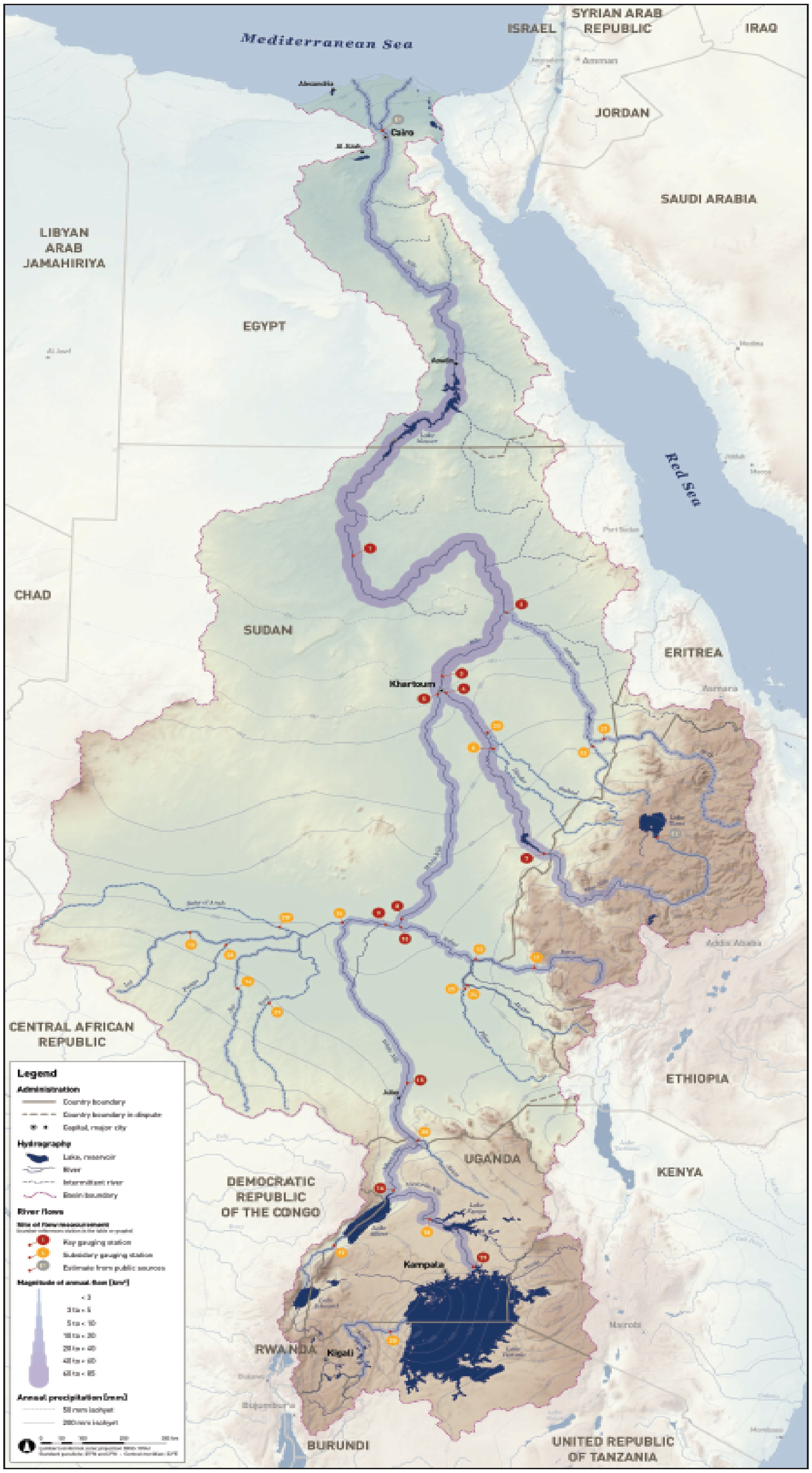

Fig. 1. The Nile River and its riparian neighbors

longer color-tagged like its prominent tributaries. Eventually, it is joined by another Ethiopian tributary called the Atbara River. At that juncture, the Nile turns and flows southwest several hundred miles before turning due north and flowing into Egyptian territory. It is here that its impact as a force of life is most salient, bringing vegetation into an otherwise barren and inhospitable geographic dystopia. Visible from space, the fertile greenery on the Nile riverbank splits the East and West Deserts of Egypt as it moves northward to Cairo, to the delta that is home to the most fertile land in all of Africa before finally emptying into the Mediterranean Sea.

But conflicting national claims to this magnificent river continually fuel regional conflicts between various upstream states where the water originates and militarily dominant downstream Egypt, for which water supply is not a luxury but a passionately defended matter of national security, especially because much of it is spent on agriculture. Less water means less food, and Egypt has no surplus to spare for its hungry, growing population.

Historically, Egypt's population of more than 88 million (as of 2016)[29] has not only survived but thrived economically because of the Nile. It secured rights to 55 bcm of the river's annual 84 bcm through treaties signed with Sudan.[30] But these desert countries are not the only ones positioned to prosper from its gifts. Upstream, Ethiopia has long wanted to build a hydroelectric dam on the Blue Nile, within its own territory, to provide

[29] "The World Factbook: Egypt." Available from: <https://www.cia.gov/library/publications/the-world-factbook/geos/eg.html>. Accessed February 11, 2016.

[30] "United Arab Republic and Sudan Agreement (With Annexes) for the Full Utilization of the Nile Waters." Available from: <http://www.internationalwaterlaw.org/documents/regionaldocs/uar_sudan.html>. Accessed December 13, 2013.

power to its impoverished population, only one-third of whom have electricity.[31] Rwanda and Burundi, whose springs are the Nile's most distant sources, are classified as economically water scarce.[32] They and the rest of the countries in the Nile Basin are barred from diverting or meaningfully extracting any of the Nile's water by colonial-aged treaties that the countries never signed and about which they were ever consulted.[33] Now coping with unsustainable conditions, these countries have begun to contest on principle as well as in action.[34] Egypt has the most at stake should the Nile's waters be redistributed, but militarism is not a sustainable solution. It will need to act diplomatically in dealing with an evolving Africa.

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[31] "Access to Electricity (% of Population)," World Bank. Available from: <http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS/countries/ET?order=wbapi_data_value_2012 wbapi_data_value wbapi_data_value-first&sort=asc&display=default. Accessed February 21, 2016.

[32] "United Nations World Water Development, "Managing Water Under Uncertainty and Risk," Report 4 (Paris: UNESCO Publishing, 2012).

[33] Kimenyi and Mbaku, *Governing the Nile River Basin*.

[34] Kimenyi and Mbaku, *Governing the Nile River Basin*.

Chapter IV

History of the Nile

Finding acceptable common ground upon which to construct and operate the GERD has challenged the riparian nations because their national perspectives describe their own stakes in the political process in starkly contrasting terms. Commonality in determining a path forward is crucial to maintaining the peace and stability needed in the basin, but an understanding of the history leading up to the current divergence is important for putting each nation's intrinsic motivations, claims, and political gestures into context.

British Rule

Conflicting claims over Nile waters are a modern phenomenon, largely because of the Nile's unique history and geography. From the Mediterranean Sea to modern Egypt's southernmost city of Aswan, a continuous stretch of river enabled internal trade within the ancient Egyptian empire, and effective political, economic, and agricultural administration to thrive for millennia. But Aswan was as far as boats could sail because shallow, often rocky portions of the river, reaching as far south as Khartoum, made it difficult or impossible for vessels to travel safely.[35] Hence the empire itself tended to stretch only that far throughout most of its history. Despite ruling over the wealthiest

[35] "The Cataract Nile and the Great Bend," https://www.utdallas.edu/geosciences/remsens/Nile/cataracts.html. Accessed February 21, 2016.

portions of the Nile, the ancient Egyptians did not know where their life source came from, how far it extended, or the diversity of peoples and landscapes it traversed before flooding their crops. Likewise, geography and politics prevented other peoples from traveling both up and downstream to fully grasp the scope of the river. The Nile was always treated as an unlimited but local resource in Egypt, and small populations with small agricultural needs meant this perception posed no problems.[36]

It was not until the 19th century that the British decided to strategically colonize every country along the Nile River (except Ethiopia), thereby enabling the British empire to administer the basin collectively for the first time in history. This step toward efficiency was important because, along with exploitation, the British brought a strong demand for water to produce cash crops like cotton and to sustain the region's growing population.[37] By the end of the century, Britain realized that its local riparian administration was part of the success of its imperial objectives.

Egypt was the crown jewel of Britain's African empire, and feeding the local agriculture with ample water was vital to economic interests.[38] To that end, Britain enacted a series of policies in its upstream colonies to minimize extractions of water from the river so as to maximize Egypt's cotton production. Upstream colonies had no more power to object to Britain's water policies than they did to reject colonization in the first place. Their complacency continued—as did Britain's relentless drive to strengthen Egypt's water security and grow its agriculture.

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[36] Terje Tvedt, *The River Nile in the Post-colonial Age: Conflict and Cooperation among the Nile Basin Countries* (London: Tauris, 2010), 3.

[37] Tvedt, *The River Nile*, 3.

38 Tvedt, *The River Nile*, 4.

In 1902, Britain signed the Anglo-Ethiopian Treaty with Ethiopia, the only riparian state not under its control.[39] The treaty defined Ethiopia's border with Sudan, but also gave the Sudanese and the British veto rights over any project that would decrease the Blue Nile's flow downstream.[40] From that time on, Great Britain hegemonized the Nile's flow from its farthest springs in Burundi and its heftiest tributaries in Ethiopia all the way north to its Mediterranean destination. It must be noted that, in this regard Britain's occupation equally benefited Egypt as much as it did the British. As often happens in occupied countries, however, Egypt became restless under British domination and so fought for its independence and nominally achieved it in the Egyptian Revolution of 1919, although some British troops remained on Egyptian soil.[41]

To ensure their enduring joint economic success, Egypt and Britain signed the first of two Nile River Waters Agreements in 1929.[42] In it, Egypt's historic rights were acknowledged based on prior use. It was agreed that out of an estimated 84 bcm of the Nile's annual flow as measured at Aswan, 48 bcm would be allocated to Egypt and 4 bcm to British-represented Sudan.[43] It also granted Egypt veto power over any upstream

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[39] Edward Ullendorff, "The Anglo-Ethiopian Treaty of 1902," *Bulletin of the School of Oriental and African Studies* 30, no. 03 (1967): 641-654. <http://www.jstor.org.ezp-prod1.hul.harvard.edu/stable/612393?seq=4#page_scan_tab_contents>. Accessed February 21, 2016.

[40] Ullendorff, "Anglo-Ethiopian Treaty of 1902,"

[41] Tvedt, *The River Nile*, 5.

[42] Kimenyi and Mbaku, *Governing the Nile River Basin*, 33-45.

[43] Mwangi S. Kimenyi, and John Mukum Mbaku, "Turbulence in the Nile: Toward a Consensual and Sustainable Allocation of Nile River Waters," Brookings Institution (2010): 4. Available from: <https://www.brookings.edu/research/turbulence-in-the-nile-toward-a-consensual-and-sustainable-allocation-of-the-nile-river-waters/>. Accessed October 12, 2016.

project to divert or decrease its water supply. Because they were still under British control, the basin states were bound by Britain's signing of the treaty.

After Sudan gained independence from Britain in 1956, it consolidated its shared dominance of the Nile with Egypt by signing the 1959 Agreement for the Full Utilization of the Nile Waters.[44] The treaty increased Egypt's share of the Nile to 55 bcm, Sudan's share to 18 bcm, left the remainder to account for evaporation, and gave both states veto power over any upstream water project that could decrease flow. But unlike its predecessor, which bound upstream riparians to their British affiliation, this post-British bilateral agreement meant it was signed neither implicitly nor expressly by any other states. It essentially bound them by proclamation and was enforced by both countries' promise to unite in defense of their claims.

By the 1960s, British influence in Africa had diminished, as had its administration, and although severely skewed in Egypt's favor, the British proved that unilateral management could be highly effective. Moreover, during a period of industrial and agricultural growth, it successfully bolstered Egypt's economic and population growth as well.[45]

As the basin states began gaining independence and exercising it, they regressed to treating the Nile once more as a local resource.[46] Treaties signed during British rule were contested, and there was no authority with oversight to arbitrate disputes. While Egypt and Sudan had long benefitted from the British administration that allowed their

[44] Kimenyi and Mbaku, *Governing the Nile River Basin*, 33-45.

[45] Tvedt, *The River Nile in the Post-Colonial Age*.

[46] Tvedt, *The River Nile in the Post-Colonial Age*.

disproportionate development, other states began to invoke contrasting perspectives on international law and treaty inheritance to unbind themselves from a framework that restricted their growth relative to their downstream riparian counterparts.[47]

Post-Colonial Nile

When the British left Africa, newly formed countries could not simply return to a state of normalcy. For many, there was no concept of a nation-state, which meant that central governments ruling over arbitrarily determined countries that did not exist earlier now had to unify their multi-lingual and multi-ethnic populations based on unrecognizable common national identities. Though this was not a problem for Egypt, where people had long shared a common history. But countries with warring tribes that continued to fight each other as they had for centuries were now deemed at civil war because the hostilities were against countrymen.

Egypt was able to avoid civil war, and it inherited riparian policies largely in its favor, so it continues to grow disproportionately in population and economy relative to the other upstream states. The population growth is accelerating, with a record 2.6 million in 2012 alone, bringing the population to 85 million.[48] Ethiopia's population is accelerating at double the rate of Egypt, making Ethiopia second in size (within Africa) only to Nigeria, which has nearly 94 million.[49]

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[47] Kimenyi and Mbaku, *Governing the Nile River Basin.*

[48] "The World Factbook: Egypt."

[49] "The World Factbook: Ethiopia," CIA, Last Updated: February 11, 2016. <https://www.cia.gov/library/publications/the-world-factbook/geos/et.html>.

In contrast to pre-colonial days, Egypt and Ethiopia with their explosive populations, together with the newly formed nation-states throughout the basin, face different challenges than they did during colonial rule. Today's challenges have a strong impact on their water usage and consumption needs.

Limitations of International Law

Ethiopia advocates that African impoverishment should not continue, especially since the resources needed to ameliorate poverty and to spark economic growth literally flows through its hands. The paradox of great natural resource wealth occurring within the same borders as widespread hunger and underdevelopment suggests mismanagement of those resources. During the reign of the British Empire, blame could perhaps be placed on colonists for usurping African land and what came with it, and misappropriating resources to serve overseas interests.[50] But in a post-colonial Africa, upstream states, where the Nile both originates and passes through, have taken two overlapping approaches to reclaim use of their waters.

Most basin countries share a history of British occupation. When Tanzania became the first nation to invoke the Nyerere Doctrine of State Succession, it was not long before eight other upstream countries followed suit.[51] The doctrine asserts that nations emerging from territory previously under the control of another country are not responsible for treaties signed by the former country on its behalf unless bound by international law. In other words, because the British Empire had interests that often

[50] Tvedt, *The River Nile in the Post-Colonial Age*.

[51] Kimenyi and Mbaku, "Turbulence in the Nile," 5.

conflicted with the interests of its former colonies, it would not be just to hold these newly independent nations accountable as heirs to an agreement signed by their former occupiers. Although Britain effectively administered the Nile holistically, that efficacy had to be measured against the Empire's primary goal of maximizing Egypt's agricultural and economic interests. Tanzania and fellow riparian nations would no longer perpetuate a status quo they considered unjustly imposed upon them by an occupying force now that they were free national entities.

Ethiopia was a sovereign nation during the signing of both the 1929 and 1959 Nile River Water Agreements, so it justifies its rejection of both differently. Its primary objection to the treaties is that Ethiopia was not a signatory and therefore has no responsibility to uphold them. In fact, it was never even consulted on either treaty—both of which dictate how that country should manage billions of cubic meters of water within its own territory.

It was, however, a signatory to the 1902 Anglo-Ethiopian Treaty, which Egypt claims prohibited Ethiopia from constructing dams or similar projects that could decrease water flow to Sudan and Egypt without their approval. In response, Ethiopia claims there was a mistranslation between the Amharic and English language versions of the treaty, saying that the Amharic version does not require Egyptian or Sudanese permission for projects that could affect the river's flow.[52] Ethiopia also claimed that the treaty has no effect because it was never ratified by either consenting party.[53] While Egypt upholds the

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[52] Wuhibegezer Ferede, and Sheferawu Abebe, "The Efficacy of Water Treaties in the Eastern Nile Basin," *Africa Spectrum* 49, no. 1 (2014): 55-67. Available from: <http://aigaforum.com/articles/714-739-1-PB.pdf>, p. 59. Accessed February 21, 2016.

[53] Ferede and Abebe, "The Efficacy of Water Treaties," 60.

legality of all past agreements, Ethiopia and other upstream states have found a variety of reasons to reject them. Ultimately, Egypt and Sudan proclaim that no dams may be constructed that will obstruct the flow of the Nile without their permission—a demand rejected by the rest of the riparian basin.

Proxy Wars and Sabotage

In the case of Egypt, whose greatest national security fear is a diminishing water supply, its government has long expressed unambiguously that armed conflict is an option, if necessary, to defend its national water supply: "Any action that would endanger the waters of the Blue Nile will be faced with a firm reaction on the part of Egypt, even if that action should lead to war," stated Egypt's then-President Anwar Sadat as early as 1972 in a statement directed toward Ethiopia.[54]

Since that time, Ethiopia has continued to pursue its dream of a great dam that would push the impoverished nation out of poverty by providing electricity and storing large sums of water. Other upstream nations have had their own ambitions for similar projects. However, decades have passed with no substantial outcomes despite effectively annulling previous Nile water treaties or failing to recognize their contemporary relevance. Decades have passed without upstream governments undertaking new construction projects that could obstruct the Nile, simply because they could not. Investing in geography-changing infrastructure is extremely costly, and raising the needed investment requires—at the very least—intra-societal cooperation. However, social stability is fiercely challenging to accomplish when weak governments lack the

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[54] Patricia Wright, *Conflict on the Nile: The Fashoda Incident of 1898* (London: Heinemann, 1972), 44.

finances to administer a nation in the first place. Highly competent, daring, and unusually rare leadership is needed to gradually bring countries out of the endless cycle of instability and impoverishment.

Ethiopia was never a British colony, but since World War I it experienced a fairly rapid succession of leadership.[55] It first switched between emperor rule and Italian colonization, and back again, before experimenting with communism and at least nominally finding democracy in its 1991 revolution during which Prime Minister Meles Zenawi took power. For decades, as Ethiopia pressed its luck against various forms of government, it battled Somali rebels and Eritrian secessionists until it forced the Somali Islamists back into their own war-torn state but lost control of Eritrea and with it, direct access to a shoreline.

Knowing well the inseparability of geopolitical stability and attraction of investment needed to advance costly and controversial infrastructure like Ethiopia's proposed dam, regional actors have long engaged in indirect means of thwarting such construction. Ethiopia has long accused Egypt of exploiting its dividedness by supporting numerous rebel groups, including the Oromo Liberation Front in the south and Eritrean secessionists against the central government. Overcoming these challenges has been a major challenge to Zenawi's government.[56]

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[55] Terrence Lyons, "Ethiopia: Assessing Risks to Stability," June 2011. <http://csis.org/files/publication/110623_Lyons_Ethiopia_Web.pdf>. Accessed February 21, 2016.

[56] Gregory R. Copley, "Egypt's Instability Triggers a New Proxy War Against Ethiopia and Its Allies," *Oil Price*, June 8, 2013. <http://oilprice.com/Geopolitics/Africa/Egypts-Instability-Triggers-a-New-Proxy-War-Against-Ethiopia-and-its-Allies.html>.

In turn, Ethiopia provided significant aid in opposition to the Jonglei Canal project during the 1970s, seeking to destabilize Sudan.[57] The Jonglei Canal project was first devised by British engineers in 1904 to increase water flow to northern Sudan and Egypt from the White Nile.[58] The 300 kilometer (186 mile) canal, designed to cut through the Sudd region of what is now South Sudan, would have allowed water to pass much faster through a hot and swampy area where its near standstill allows half of the river's flow to evaporate. In effect, 10% more water from the White Nile tributary would reach Egypt, which would help to alleviate the issue of water scarcity.[59]

Because of (mostly) Sudanese disagreements during British rule and after independence, construction only began in 1978, despite strong opposition from South Sudan, which felt it had little to gain from the project.[60] By 1983, civil war broke out which permanently halted construction even though two-thirds of the project had been completed.[61] The canal's construction has not yet restarted (as of 2016), and likely will not, especially since the 2011 referendum which granted independence to South Sudan, thus adding one more piece to an already complicated chess board. These proxy wars

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[57] Jan Hultin, "Source of Life, Source of Conflict: Fear and Expectations along the Nile," in Leif Ohlsson, editor, *Regional Case Studies of Water Conflicts* (Göteborg, Sweden: Padrigu Papers, 1992), 20-45.

[58] J. V. Sutcliffe, and Y. P. Parks, *The Hydrology of the Nile* (Wallingford, England: International Association of Hydrological Sciences, 1999), 5. Available from: <http://www.hydrosciences.fr/sierem/produits/biblio/hydrology%20of%20the%20Nile.pdf>. Accessed October 13, 2016.

[59] Sutcliffe and Parks, *Hydrology*, 87.

[60] "Sub-Saharan Politics: Africa Egypt Builds Downstream Relations with South S," *EIU ViewsWire,* Economist Intelligence Unit, 17 Apr. 2014. Available from: <http://search.proquest.com.ezp-prod1.hul.harvard.edu/docview/1517188520?rfr_id=info:xri/sid:primo>. Accessed February 21, 2016.

[61] Sutcliffe and Parks, *Hydrology*, 172.

between the basin states continue because of no alternative framework for regional conflict resolution.

Despite political turmoil and multilateral military hostilities, newly landlocked Ethiopia still managed to become stable over time under Zenawi's leadership and, after decades of wishful thinking, it gained the foothold needed to attract foreign investment to aid in constructing the GERD. Of the estimated $4.8 billion needed for construction, Zenawi expressed confidence in Ethiopia's ability to raise $3 billion by selling bonds. The remaining $1.8 billion, covering turbines and related equipment or nearly 40% of the project, would be underwritten by China.[62]

However, all this positive activity did not mean that neighboring states were supportive. Under Egypt's then-President Hosni Mubarak, ties with Ethiopia were less than cordial. Egypt maintained its harsh stance, and in documents recently made public by Wikileaks, Egyptian officials not only conspired with Sudanese president Umar Al-Bashir to destroy the GERD, they claimed responsibility for similar sabotage in the past:

> If it comes to a crisis, we will send a jet to bomb the dam and come back in one day, simple as that. Or we can send our special forces in to block/sabotage the dam. But we aren't going for the military option now. This is just contingency planning. Look back to an operation Egypt did in the mid-late 1970s, I think 1976, when Ethiopia was trying to build a large dam. We blew up the equipment while it was traveling by sea to Ethiopia. A useful case study.[63]

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[62] "A Dam Nuisance," *Economist*, April 20, 2011. Available from: < http://www.economist.com/node/18587195>. Accessed December 15, 2013.

[63] "Stratfor sources reveal Egypt, Sudan contingency plans to secure Nile water resources." <http://wikileaks-press.org/stratfor-sources-reveal-egypt-sudan-contingency-plans-to-secure-nile-water-resources/>. Accessed December 17, 2013.

Under President Mohammed Morsi, the Egyptian government remained hostile to Ethiopia's plan to build the GERD, claiming that a drop of water diminished from the Nile's flow to Egypt will be replaced with blood.[64]

Despite earlier hostility, Egyptian regime change led to a more diplomatic approach to the region's tensions. On March 23, 2015, Egypt, Ethiopia, and Sudan signed the Declaration of Principles of the Grand Ethiopian Renaissance Dam in which the co-signors agreed to cooperate in collectively managing the resources of Nile River Basin in light of the project's ongoing construction.[65] This produced a notable step toward agreement on one of the most contentious topics surrounding the dam's construction: the "Principle Not to Cause Significant Harm."[66] While previous international treaties like the 1997 UN Convention on the Law of the Non-Navigational Uses of International Watercourses established a similar "Obligation Not to Cause Significant Harm," that treaty was only ratified by 36 countries—and none of those were Nile Basin nations.[67] The 2015 Declaration was important because it acknowledged that Ethiopia might generate some degree of harm to Egypt and/or Sudan through its use of the river, but it must consult with its riparian neighbors to reduce or eliminate that harm, and discuss

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[64] "Egyptian Warning Over Ethiopia Nile Dam," BBC News, January 10, 2013. <http://www.bbc.com/news/world-africa-22850124>. Accessed July 24, 2016.

[65] Full text of "Declaration of Principles" signed by Egypt, Sudan and Ethiopia. Ahram Online, March 23, 2015. <http://english.ahram.org.eg/News/125941.aspx>. Accessed March 23, 2015.

[66] "Declaration of Principles."

[67] "Convention on the Law of the Non-Navigational Uses of International Watercourses," United Nations Treaty Collection. Available from: <https://treaties.un.org/Pages/ViewDetails.aspx?src=IND&mtdsg_no=XXVII-12&chapter=27&lang=en>. Accessed February 21, 2016.

possible compensation.[68] While it is generally agreed that the GERD will have noticeable effects downstream, the extent to which such effects are felt can now be discussed, along with other Basin-wide issues, for purposes of seeking mutual gains.

68 "Agreement on Declaration of Principles between The Arab Republic of Egypt, The Federal Democratic Republic of Ethiopia And The Republic of the Sudan on the Grand Ethiopian Renaissance Dam Project (GERDP)," International Water Law Project, 2. Available from: <http://www.internationalwaterlaw.org/documents/regionaldocs/Final_Nile_Agreement_23_March_2015.pdf>. Accessed February 21, 2016.

Chapter V

The Water Diplomacy Framework as a System for Cooperation

With the Nile River Basin spanning ten countries, its numerous political boundaries complicate tensions and heighten the political will needed by stakeholders to resolve them. In their book *Water Diplomacy*, Islam and Susskind define transboundary water management problems as "complex," with components that are "not easily knowable, [and] usually unpredictable,"[69] and that arise from the interactions of natural, societal, and political variables[70] (see Figure 2). The complexity of water resources is characterized by a diversity of nations and stakeholders, as well as a range of disciplinary

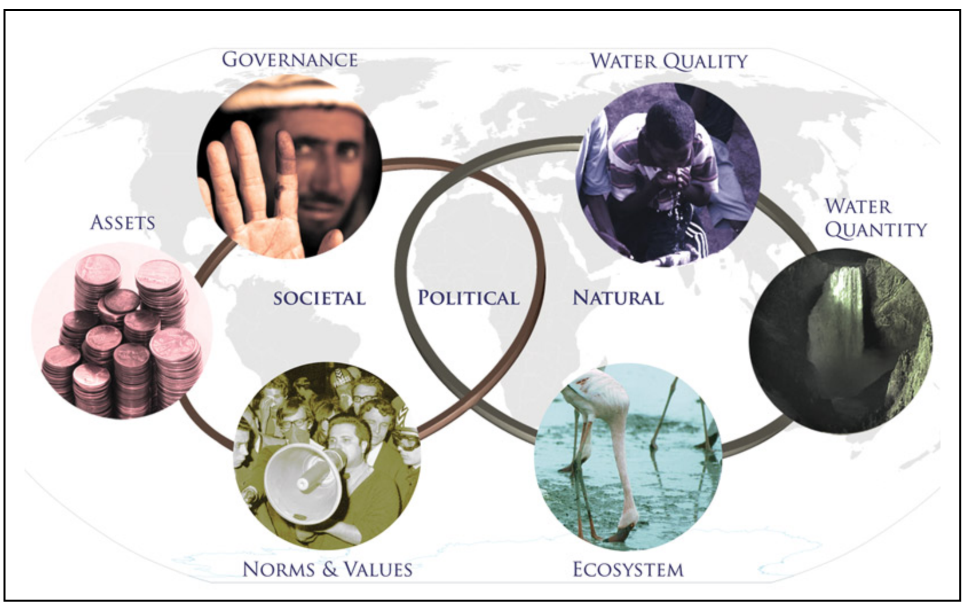

Fig. 2 Players in the complex arena of water management

[69] Islam and Susskind, *Water Diplomacy*.

[70] Islam and Susskind, *Water Diplomacy*, 9.

approaches used to integrate them, from technical engineering analyses to political problem solving spanning the spectrum of diplomacy to militarism.[71]

Islam and Susskind's Water Diplomacy Framework (WDF) (see Figure 3) seeks a "**z**one **o**f **p**ossible **a**greement (ZOPA) wherein opposing parties can identify mutually agreeable solutions that synthesize the natural, societal, and political domains where they once conflicted. This is done by dealing with water as a "flexible" resource[72] whereby its integration with other developmental priorities enables the greatest gains to emerge beyond the limited scope of zero-sum water accounting. The international community has

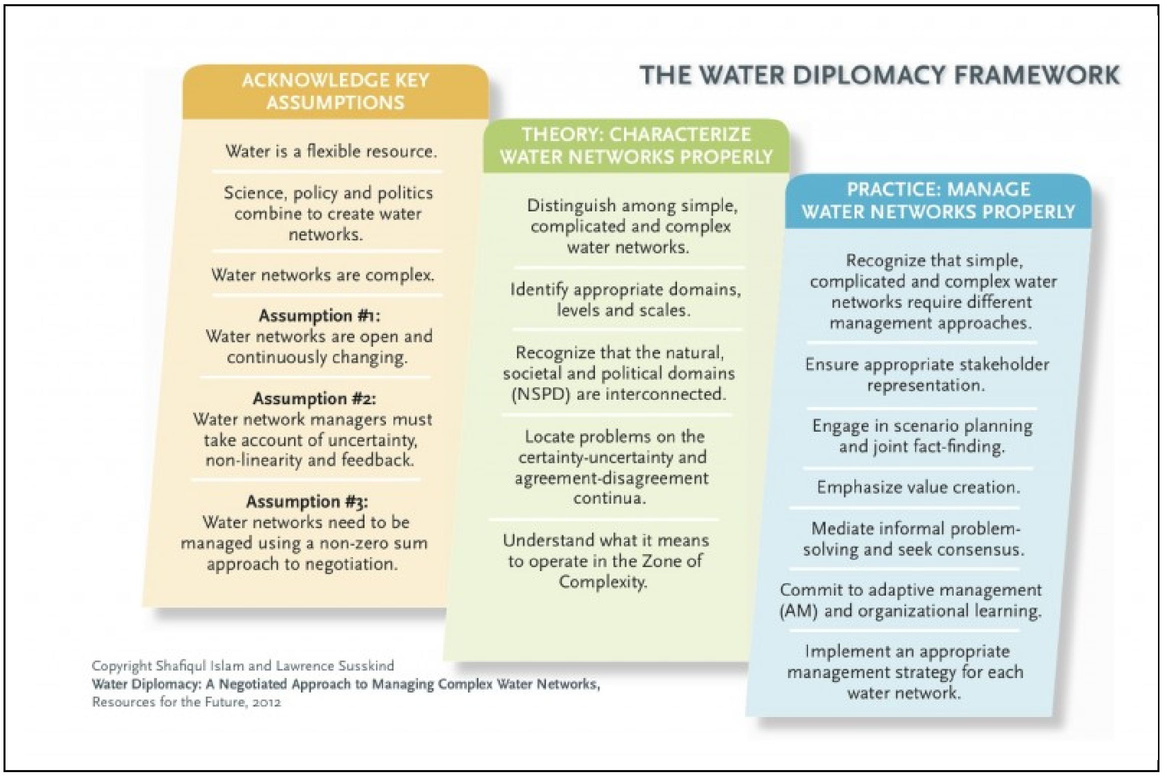

Fig. 3. The Water Diplomacy Framework

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[71] Islam and Susskind, *Water Diplomacy,* 9.

[72] Islam and Susskind, *Water Diplomacy*, 10.

long recognized the water-food-energy nexus as a revolving door of resources: water is used for agriculture and hydroelectricity; food, such as corn, is used for energy; and both energy and water are required in order to produce water and food. In turn, energy is needed to pump, purify, and desalinate water for myriad uses.[73]

Viewing water as a flexible resource whose externalities and resolutions fluidly orbit its nexus with food and energy helps to clarify the constraints of dealing with water scarcity as a policy issue. The WDF makes a distinction between the hydrological unit of a watershed ("an area of land draining into a common body of water such as a lake, river, or ocean"[74]) and a "problem shed"[75] ("a geographic area that is large enough to encompass management issues, but small enough to make implementation possible."[76]) Therefore, in spite of the complexity created by problems involving domains, cooperation between states to manage resources in a shared river basin could help to simplify a complex and politically divided watershed into a better understood and more manageable "problem shed."

Integrating water into the broader nexus of development goals abandons zero-sum negotiating strategies, and instead considers a problem-solving approach that first maximizes collective benefits for the basin before dividing those gains among partners.[77]

[73] "Water, Food and Energy Nexus," UN Water. Available from: <http://www.unwater.org/topics/water-food-and-energy-nexus/en/>. Accessed February 22, 2016.

[74] Islam and Susskind, *Water Diplomacy*, 51.

[75] Islam and Susskind, *Water Diplomacy*, 51.

[76] C. B. Griffin, "Watershed Councils: An Emerging Form of Public Participation in Natural Resource Management," *Journal of the American Water Resources Association*, 35, no. 3 (1999): 505-518.

[77] Roger Fisher, William Ury, and Bruce Patton, *Getting to Yes: Negotiating Agreement without Giving In* (New York: Penguin Books, 1981).

Recognizing the inherent water-food-energy nexus in transboundary river basin negotiation facilitates value creation by enabling exchanges of different kinds of goods or services, rather than just one. Grouping multiple issues and communicating each party's priorities facilitates trades that can result in an ultimately more practical distribution compared to a sequence of zero-sum debates over stand-alone issues wherein each party wishes to maximize its gains even on issues that are not as comparatively important to it.[78]

Together, these principles form the Water Diplomacy Framework, which can be outlined in six steps:

1. adequately identify and represent key stakeholders and interests to capture all possible perspectives and demands
2. synthesize an agreeable view of key variables in the natural and societal processes within a political domain through joint fact-finding
3. maximize collective value across issues—most successfully accomplished with the help of a professional mediator
4. informally engage in problem solving, but link outcomes to formal proposals
5. conduct follow-up efforts to adaptively enhance cooperation
6. upon completion, reflect on ways to improve future capacity building.[79]

In this thesis, I ask if the recently adopted United Nations SDGs and the broader UN 2030 Agenda for Sustainable Development provide an agreeable diversity of currencies by pre-establishing minimal developmental objectives that all of the world's

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[78] Islam and Susskind, *Water Diplomacy*, 137.

[79] Islam and Susskind, *Water Diplomacy*, 197-198.

countries, including Egypt, Sudan, and Ethiopia, agree ought to be achieved by 2030.[80] These objectives cover a spectrum of 17 social, economic, and environmental goals that will be affected by the GERD's construction. Specifying the most pertinent of these impacts, and projecting each nation's vulnerability to their effects using pre-agreed negotiating parameters, could vary the SDGs from a goal-setting and documentary framework to a conflict-resolution device, and could facilitate cooperation toward sustainable development in a region marred by decades of economic and political sabotage, proxy wars, and threats of direct conflict.

[80] "Sustainable Development Goals (SDGs)," UNDP. <http://www.undp.org/content/undp/en/home/sdgoverview/post-2015-development-agenda.html>. Accessed February 21, 2016.

Chapter VI

Sustainable Development Goals as an Analytic Approach

The effects of dams on development are vast, diverse, and often unintended. Current data on the ramifications of existing dams on the national implementation of Millennial Development Goals (MDGs) tells an incomplete story, and such a projection to SDGs remains inconclusive. However, SDGs offer the most authoritative, transparent, and exhaustively negotiated metrics the world has ever agreed should be used to define, measure, and track development.[81] Further, they incorporate the broadest possible spectrum of stakeholders in any discussion of development, including those likely to arise from the GERD's construction.

Put in place prior to the SDGs, the MDGs were formed at the United Nations in a 15-year agreement that intended to set a single, cohesive, prioritized global development agenda. The program was largely successful, making significant strides toward eradicating extreme forms of poverty, achieving universal primary education, bridging the gap in gender equity, reducing child mortality, improving maternal health, combatting diseases like HIV, ensuring environmental sustainability, and developing a partnership for global development.[82]

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[81] "Transforming Our World."

[82] "What They Are," UN Millennium Project. Available from: <http://www.unmillenniumproject.org/goals/<. Accessed February 22, 2016.

When the MDGs expired in 2015, the international community extensively negotiated what the Post-2015 Development Agenda would look like, and how the world should prioritize the next 15 years of collaborated development. The result was the series of 17 SDGs, which are boldly universal in their objectives, but designed with flexibility to accommodate varying national circumstances and capacities. The final version of the UN 2030 Agenda, featuring these 17 goals and their 169 nested targets, was officially adopted by the 193 member states of the United Nations at the 70th session of the General Assembly on September 25, 2015 in New York City.[83] The indicators to be used in their measurement were finalized March 2016 by the Inter-Agency and Expert Group on Sustainable Development Goals.

Even as the SDGs were being negotiated, the international community aimed for a highly aspirational agenda. On March 14, 2013, at the first session of the Open Working Group, Egyptian Ambassador and Permanent Representative to the UN Mootaz Khalil stated:

> Sustainable Development Goals have to aim at eradicating poverty. They should be simple enough to relay to the lay man. Yet, they have to integrate economic, social, and environmental aspects of development in order to ensure sustainability . . . . They should focus on . . . quality nutrition, quality education, quality health services, and creating decent jobs . . . .[84]
>
> . . . the Sustainable Development Goals should be applicable to all, while taking into account the different capabilities and circumstances of countries. They should apply to unsustainable modes of consumption, wasting and production in developed countries, without diverting from the international cooperation paradigm based on the principle of common but

[83] "Transforming Our World."

[84] Mootaz Khalil, "Statement by H. E. Ambassador Mootaz Khalil Permanent Representative of Egypt to the United Nations at the First Session of the Open Working Group on Sustainable Development Goals," United Nations, March 14, 2013. Available from: <https://sustainabledevelopment.un.org/content/documents/3453khalil.pdf>. Accessed April 24, 2015.

> differentiated responsibilities between developed and developing countries. They should include agreed indicators that would determine our collective progress in fulfilling our collective responsibilities.[85]

Although Egyptian words, these ideas are echoed by virtually all of the countries as they seek to pave a path toward growth that encompasses economic, environmental, and social prosperity—the three components of sustainable development. Two years later, when the UN 2030 Agenda was adopted, all signatory nations underlined the water-food-energy nexus in a

> supremely ambitious and transformative vision [for a] world where we reaffirm our commitments regarding the human right to safe drinking water and sanitation and where there is improved hygiene; and where food is sufficient, safe, affordable and nutritious. A world where human habits are safe, resilient and sustainable and where there is universal access to affordable, reliable, and sustainable energy.[86]

Like the MDGs before them, each nested target transforms the conceptual and easily communicated language of the goals into specific measurable objectives. Their measurements are indicators that quantify progress toward the targets set by each country according to its own national circumstances and developmental vision. Taking this national ownership into account is what Ambassador Khalil and the final declaration refer to as "common but differentiated responsibilities."[87]

The 2030 Agenda builds bridges between riparian neighbors by devoting "collectively to the pursuit of global development and of 'win-win' cooperation" that is needed to maximize gains in place of zero-sum negotiation.[88] By stressing the need for

[85] Kahlil, "Statement."

[86] "Transforming Our World."

[87] Khalil, "Statement".

[88] "Transforming Our World."

cooperative action on regional and sub-regional issues, the 2030 Agenda makes clear that the universality of its design incorporates transboundary water issues and each country's national stake within the basin:

> We acknowledge also the importance of the regional and sub-regional dimensions, regional economic integration, and interconnectivity in sustainable development. Regional and sub-regional frameworks can facilitate the effective translation of sustainable development policies into concrete action at national level.[89]

This emphasis on national action is further expounded on as a reflection of territorial sovereignty. Although the Agenda stresses the importance of cooperation between states to achieve universal goals for the betterment of humanity, the signatories "reaffirm that every State has, and shall freely exercise, full permanent sovereignty over all its wealth, natural resources and economic activity."[90] The declaration never seeks to create a legally binding accord whereby nations are legally obligated to pursue their developmental objectives in a particular way. In fact, should nations discount the need to adhere to their commitments, the Agenda includes no mechanism for enforcement.[91] This may be seen as a weakness of accountability. However, insofar as it creates commonality and cohesiveness in streamlining the components and connections within development that all nations prioritize, it lays a foundation that can accelerate independent bilateral or multilateral agreements to which signatories may elect to be mutually legally bound. This was the case in the 2015 Khartoum Agreement, which was not legally binding but set the

[89] "Transforming Our World."

[90] "Transforming Our World."

[91] "Transforming Our World."

tone for further tripartite negotiations.[92] In effect, by investing in the SDG negotiation process for three years and emerging with an outcome document, nations have conducted high-order, joint fact-finding characterized by Islam and Susskind as clarifying common information among parties.[93]

The Agenda's capacity to define and quantify mutually agreeable and relevant development indicators positions the SDGs to facilitate conflict resolution by allowing disputing parties to mitigate damages and exchange benefits. For instance, although the GERD may pose a new energy challenge for Egypt, Ethiopia's new supplies could be exported at a subsidized price to offset Egypt's temporarily weakened ability to generate its own energy. Ethiopian revenue from its energy exports to other countries could in part offset economic turbulence in Egypt by creating new markets for Egyptian goods, securing agricultural jobs, and mitigating destabilization.

While this thesis proposes that each country's affirmation of the 2030 Agenda defines agreeable development parameters to negotiate where a vacuum currently exists in dialogue, its practicality can extend further. The 2030 Agenda and its SDGs capitalize on the water-food-energy revolving door of mutual gains that could be maximized in the basin through cooperation to surpass the collective benefits of each country's BATNA.

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[92] "Declaration of Principles."

[93] Islam and Susskind, *Water Diplomacy*, 200.

Chapter VII

The Simulation

This thesis is primarily a qualitative examination of (1) how an international agreement on development could facilitate cooperation, (2) whether or not hydrological modeling with historic data based on parameters within that agreement could inform policy design, and (3) whether or not addressing multiple issues together could create greater basin-wide outcomes than the gains of any uncompromised outcome. To that end, I structured this chapter by first disclosing the quantitative results of the hydrological modeling. Then I synthesized the modeling results with their implications on my three propositions.

Proposition One posits that the SDGs can be used as an analytic lens to help simplify the Eastern Nile Basin into a "problem shed." This would enable the identification of mutually recognized economic, social, and environmental challenges and to specify a range of exchangeable currencies to advance cooperative sustainable development.

In order to test possible negotiable solutions in possible fill rates and rainfall conditions, I used data from the Mike Hydro Basin integrated water resources management analysis tool[94] to model projected outcomes. I used data from historically

[94] MIKE HYDRO Basin is a multipurpose, map-based decision support tool for integrated water resources analysis, planning, and management of river basins. It is designed to analyze water-sharing issues at international, national or local river-basin scale. See: <https://www.mikepoweredbydhi.com/ products/mike-hydro-basin>. Accessed October 13, 2016.

wet and dry decades as benchmarks. To gauge how different fill rates combined with different rainfall conditions could affect the SDG targets and indicators, I used three proxy indicators to correlate to three SDGs along the water-food-energy nexus and their respective proposed indicators (refer back to Table 1).

Proxy Indicator: Relative Deficit

The first proxy indicator I assessed was the relative deficit of irrigation water across regions. This maps to SDG 2: "End hunger, achieve food security and improved nutrition and promote sustainable agriculture and its nested targets and indicators."

Relative deficit (RD) of irrigation supply is measured as:

(total demand – actual supply) / total demand

Therefore, the higher the total RD, the greater the detriment to irrigation and, consequentially, on agriculture in the country. While any irrigation deficit might be compensated for by greater imports to offset a reduction in domestic production, it does not necessarily account for job security within the agricultural sector. Because agriculture composes such a large portion of Egypt's economy, a large RD could have significant cascading effects on Egyptian society that could be measured using a secondary series of SDGs. SDG 8, for example, seeks to "Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all." Should the goods of Egypt's largest economic sector be outsourced, its labor force could face employment insecurity. It should be noted that I did not collect Ethiopian data for this thesis because Ethiopia claims that the GERD's reservoir will not be used to increase its own irrigation.

Upon assessing the RD data across regions, little discrepancy is seen across filling rates. Figure 4 shows: (a) the Egyptian average across regions; (b) Elsalam Canal in the Nile Delta region, which has the greatest RD of all regions assessed in this thesis; (c) Qalyubiyah, the Nile Delta irrigation system with the greatest difference in RD between wet and dry years; and (4) Aswan-Esna, which exhibits no RD, irrespective of any rainfall scenario. Each region's RD is illustrated with all filling scenarios.

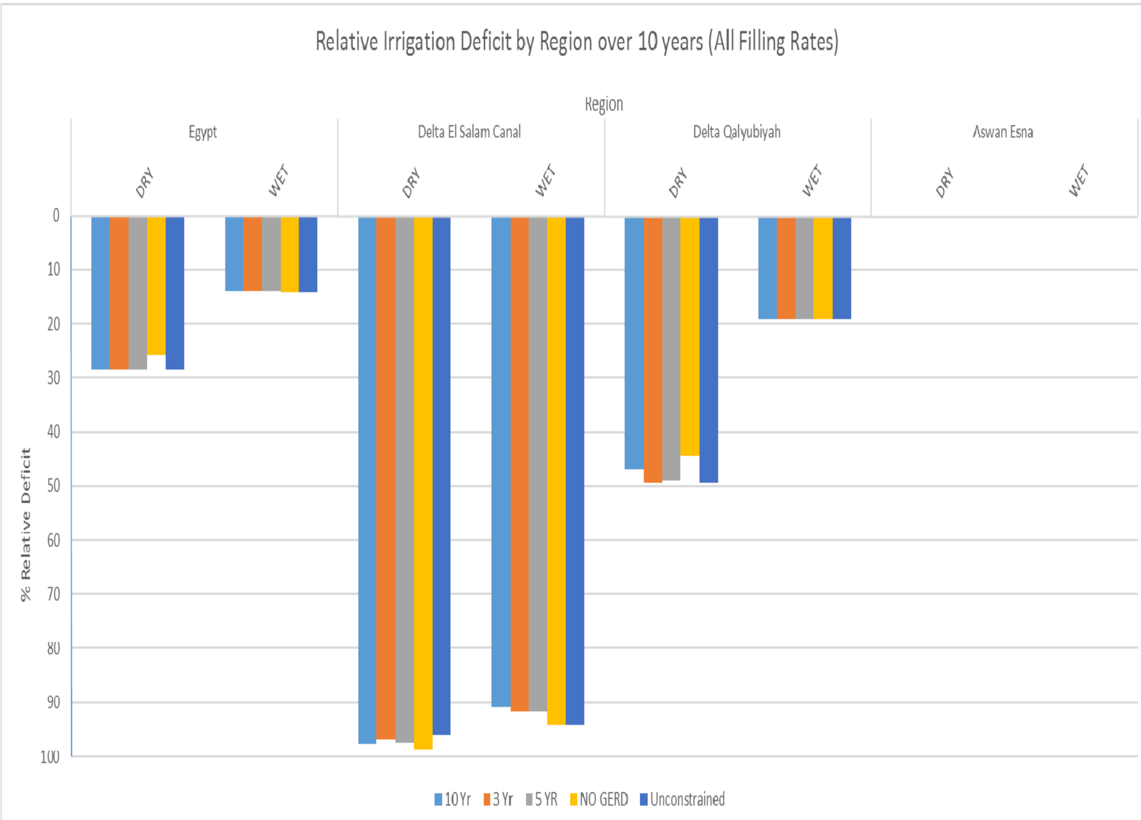

Fig. 4. Relative irrigation deficit by region over 10 years (all filling rates).

Source: thesis author

While a strong contrast can be seen between El Salam Canal and Qalyubiyah, both exhibit a greater sustained RD than Aswan-Esna, which is in upper Egypt where there is higher crop-water demand than the fertile, agriculturally intense Nile delta. This trend, in which the irrigated areas of the Nile delta suffer more intense RD than upper Egyptian areas, is illustrated in Figure 5, which surveys a broader range of regions based on the unconstrained filling rate.

Figure 4 also shows that overall, Egypt's RD across all regions has the potential to more than double between wet and dry years. In other words, regardless of Ethiopia's fill rate, Egypt will suffer nearly identical consequences of irrigation deficit simply due to natural circumstances.

On a positive note, for SDG 1 the proxy indicator projects that Egyptian irrigation supply is insulated from Ethiopia's GERD because RD remains constant even compared to the No GERD scenario. However, its chronic RD points to an underlying need to address its causes, especially given its vulnerability during dry years.

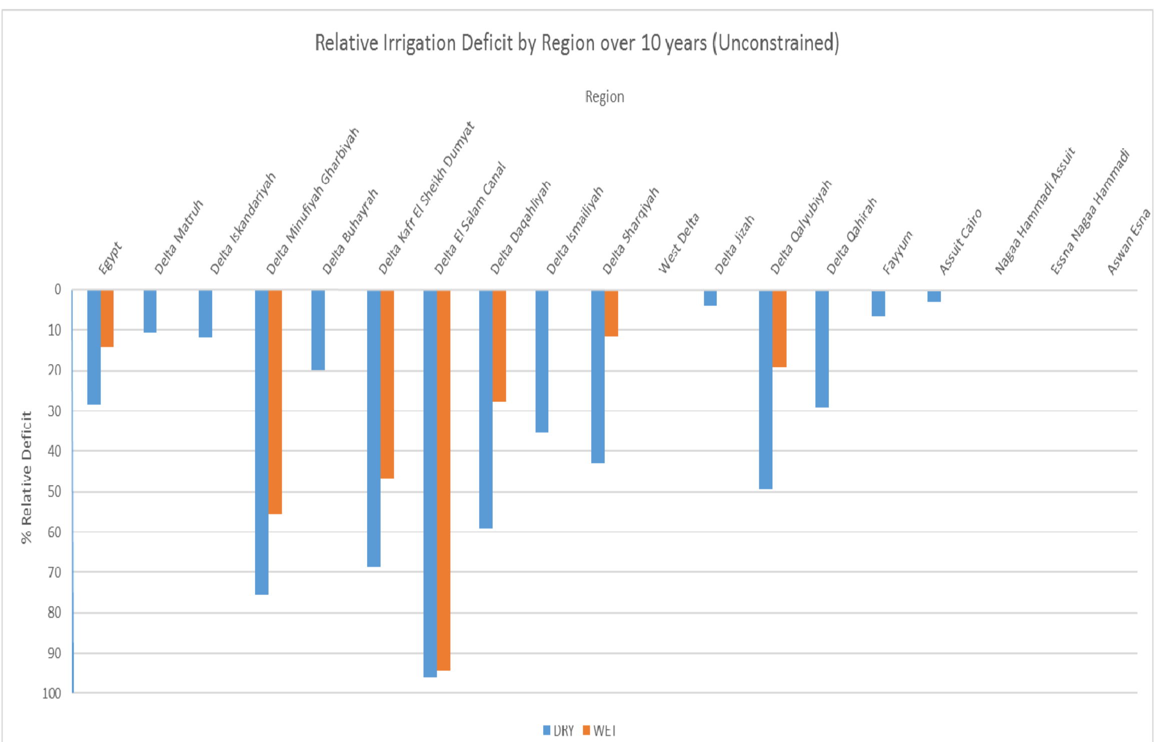

Fig. 5. Relative irrigation deficit by region over 10 years (unconstrained)

Figure 5 illustrates how areas in the Nile delta experience the highest RD in general, but also experience the greatest disparity between wet and dry years. Some upper Egyptian regions like Aswan-Esna never experience a water RD, while others like Fayyum have a slightly higher RD during dry years, but face no such shortage during wet years. Within the delta, however, the shortage is chronic, and the disparity between wet and dry scenarios is greater. Figure 4 shows the Qalyubiyah data as having the most sustained disparity across all five filling rates. However, Figure 5 shows that some irrigation systems can face severe shortages that affect agriculture during dry years (e.g., Buhayrah, 20%; Ismailiyah, 35%) but be unaffected during wet years.

Taken together, the data suggests five conclusions: (1) Egypt has a chronic RD; (2) Nile delta regions are most affected by this RD; (3) dry years worsen the effect of the RD on irrigation systems that already experience it, and (4) create RD where in some regions where it may not even exist during wet years; and (5) filling rate has no significant effect on RD in any part of Egypt.

Proxy Indicator: High Aswan Dam Release

My second proxy indicator was water release from the High Aswan Dam (HAD). This correlates to SDG 6: "Ensure availability and sustainable management of water and sanitation for all."

Figure 6 shows that during wet years, release is quite consistent across all filling rates, including Egypt's BATNA (No GERD) and Ethiopia's BATNA (unconstrained filling). During the months of summer flooding, a peak is seen each year where conservative releases are at times more likely to happen using unconstrained filling, followed progressively by slower filling rates. These peaks are the only times filling rate affects HAD release during wet months.

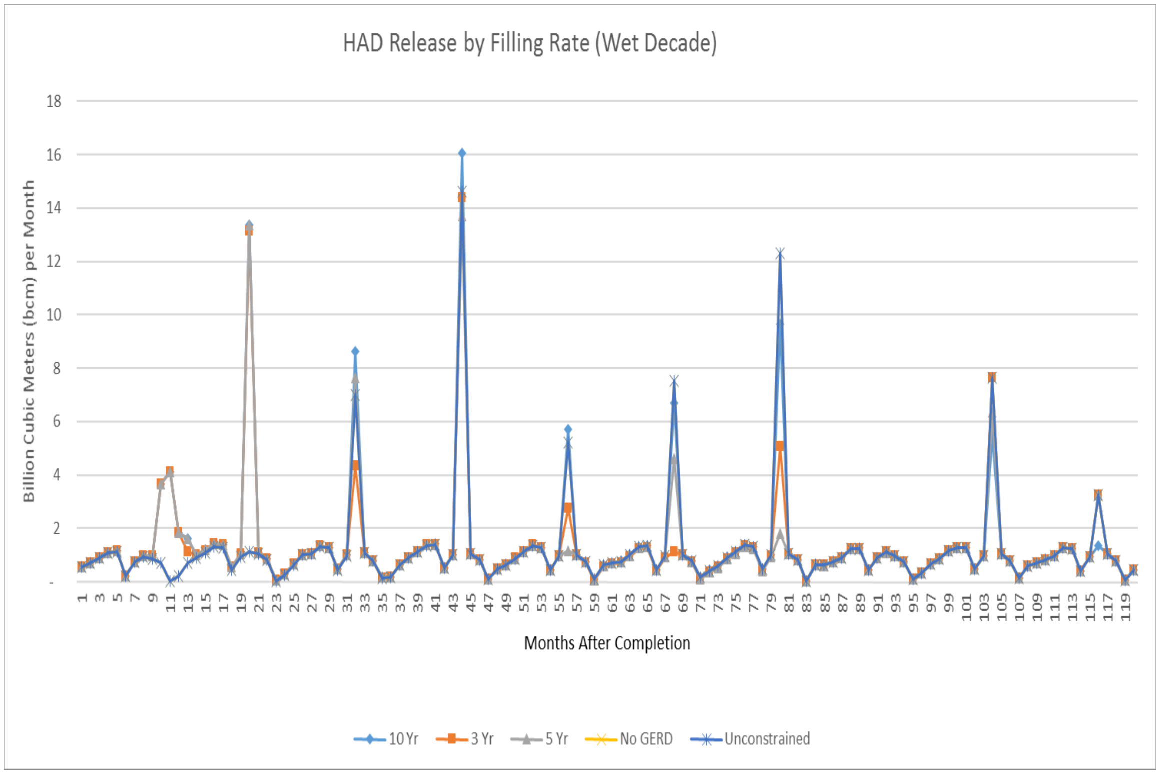

Fig. 6. HAD Release by Filling Rate (Wet Decade)

During the majority of any year, there is no difference in impact on HAD release vis-à-vis Egypt's and Ethiopia's respective BATNAs. However, during the summer months when the basin experiences the most rainfall, the disparity between No GERD and a GERD filled without constraint could be as much as 11 bcm in month 20, while an unconstrained fill rate would only afford Egypt less than 2 bcm to release monthly. A 90% reduction in release could be considered very significant to Egypt's water security, even if it is for just one month of the year. When that one month happens to supply Egypt with the majority of its water for the year, consideration of that impact is especially important.

The dry decade scenario shown in Figure 7 shows a different effect on HAD release. From 89 months onward, all filling scenarios result in virtually identical release; prior to 35 months, the release is nearly the same. In other words, during this time, filling

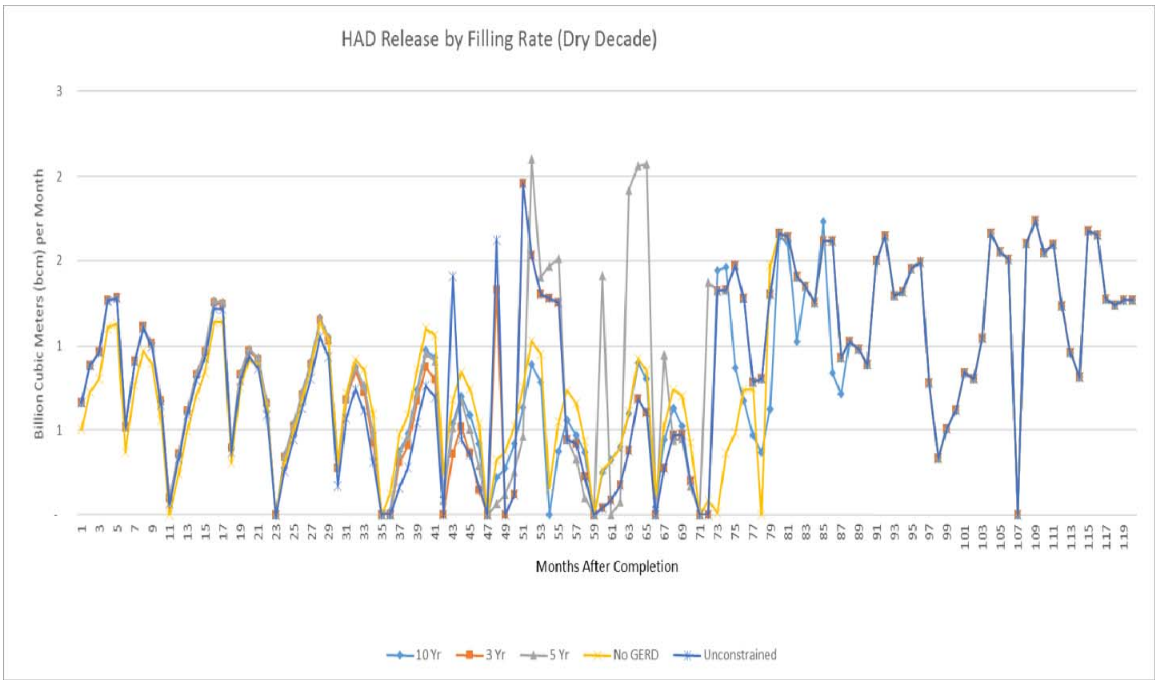

Fig. 7: HAD Release by Filling Rate (Dry Decade)

rate has very little effect on the indicator. However, the time in between shows a drastic disparity in release between filling rates: the difference between 5-year fill and 3-year fill/unconstrained fill reaches nearly 1.4 bcm at 64 months and slightly exceeds that of 10-year fill and no GERD at 72 months. Greater fluctuation suggests that filling strategy has considerable consequence on HAD release and therefore on Egypt's implementation of SDG 6. However, this effect would only be notable for the three central years of this time series.

To further consider the holistic effect of each filling rate on HAD release, Figure 8 consolidates the average monthly release across fill rates, in both wet and dry scenarios.

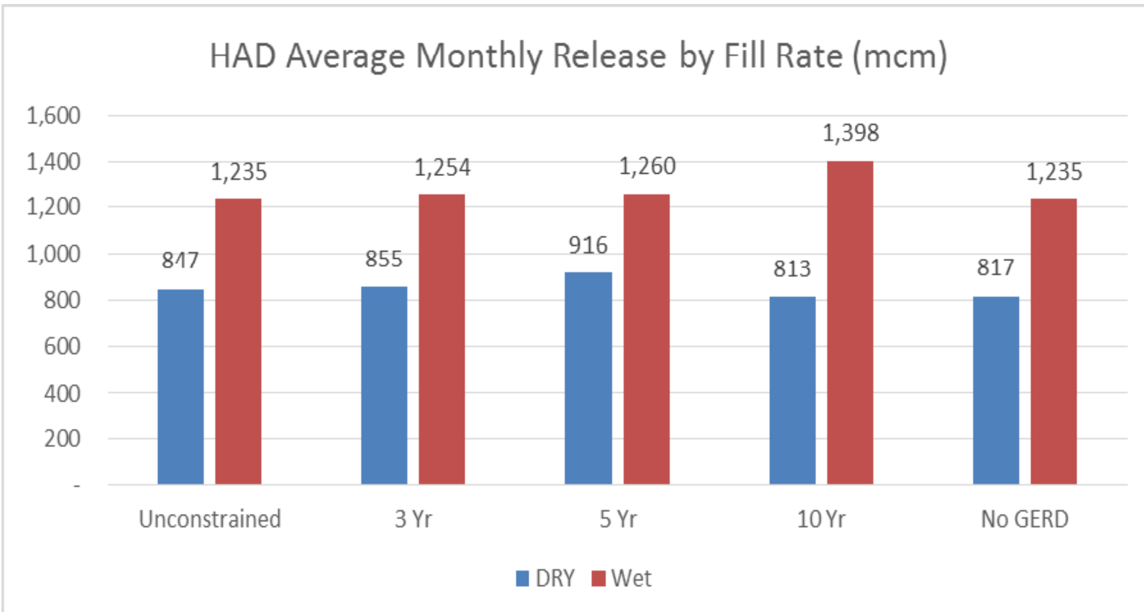

Fig. 8. HAD Average Monthly Release by Filling Rate (mcm)

The average monthly dry release is 849.6 mcm, with a standard deviation (SD) of 37 million cubic meters (mcm). The only fill rate to exceed an SD is the 5 year fill, allowing 916 mcm at an SD of 1.79.

The average monthly wet release is 1,276 mcm, with an SD of 61.56. At an SD of 1.96, the 10-year fill rate is the only strategy that exceeds an SD of 1.0.

Despite the peaks shown in Figure 6, which suggest a great disparity among the filling strategies when investigating HAD release during summer months and an absence of political clarity on how to define significant harm, a statistically significant benefit exists in opting for a 5-year filling strategy during dry years, or a 10-year strategy during wet years in order to enable the greatest release possible to Egypt. This would further support SDG 6 downstream, although its tradeoffs with Ethiopian development must still be considered.

Proxy Indicator: Hydropower

While Ethiopia does not plan to irrigate with water from the GERD's reservoir, and its release will be too far downstream within its own borders to affect its development in the same way the HAD release affects Egypt, hydropower is a factor that does affect both countries. Hydropower (HP) is the proxy indicator that correlates to SDG 7: "Ensure access to affordable, reliable, sustainable, and modern energy for all." More specifically, it points to SDG indicator 7.1.2: "Percentage of population with primary reliance on clean fuels and technology."

When the HAD was first erected, it provided Egypt with nearly half its total energy, although today a smaller proportion of Egyptians rely on the dam's HP for energy. In contrast, Ethiopia could benefit tremendously from a hydroelectric mega dam, since only 12% of its population currently has consistent access to electricity. The GERD could go a long way in raising that percentage.

Despite its theoretical maximum generating capacity of 6,000 MW, Figure 9 shows a different outcome, even in Ethiopia's best-case scenario. Using unconstrained filling during a wet decade, the GERD will quickly produce 1,850 MW of electricity throughout the year, beginning in the first year after completion. However, it will consistently remain at this output, which is less than one-third of what is promised.

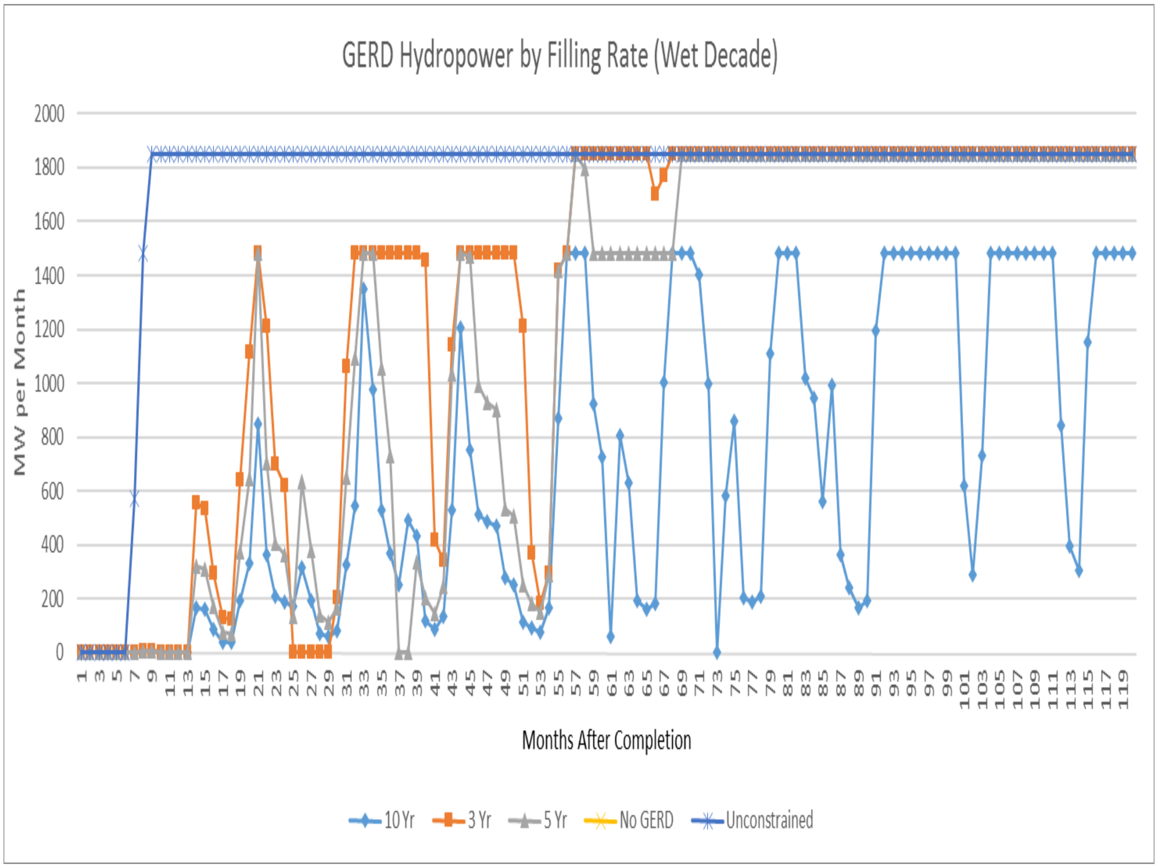

Fig. 9. GERD Hydropower by Filling Rate (Wet Decade)

An unconstrained fill is not the only strategy that could ultimately produce the target maximum. Approximately five years after completion, the 3-year filling strategy would generate maximum hydropower, while the 5-year filling strategy would fulfill that maximum the following year. However, 10-year fill would reach its maximum at 1,480 MW, and would be seasonal, with less hydropower produced in the months before annual summer flooding. Before the other strategies reach their consistent output of 1,850 MW, all but the unconstrained fill max out intermittently at 1,480 MW before rising later. The trend, however, is that the more aggressive the filling strategy, the more HP will be produced for Ethiopia.

During a dry decade, no-fill rate would allow the GERD to produce more than 1,480 MW of power within ten years. Figure 10 shows that an unconstrained fill would allow this level to be reached within the same year, but it would not be produced consistently throughout the year; it would be seasonal based on the Blue Nile's annual flooding.

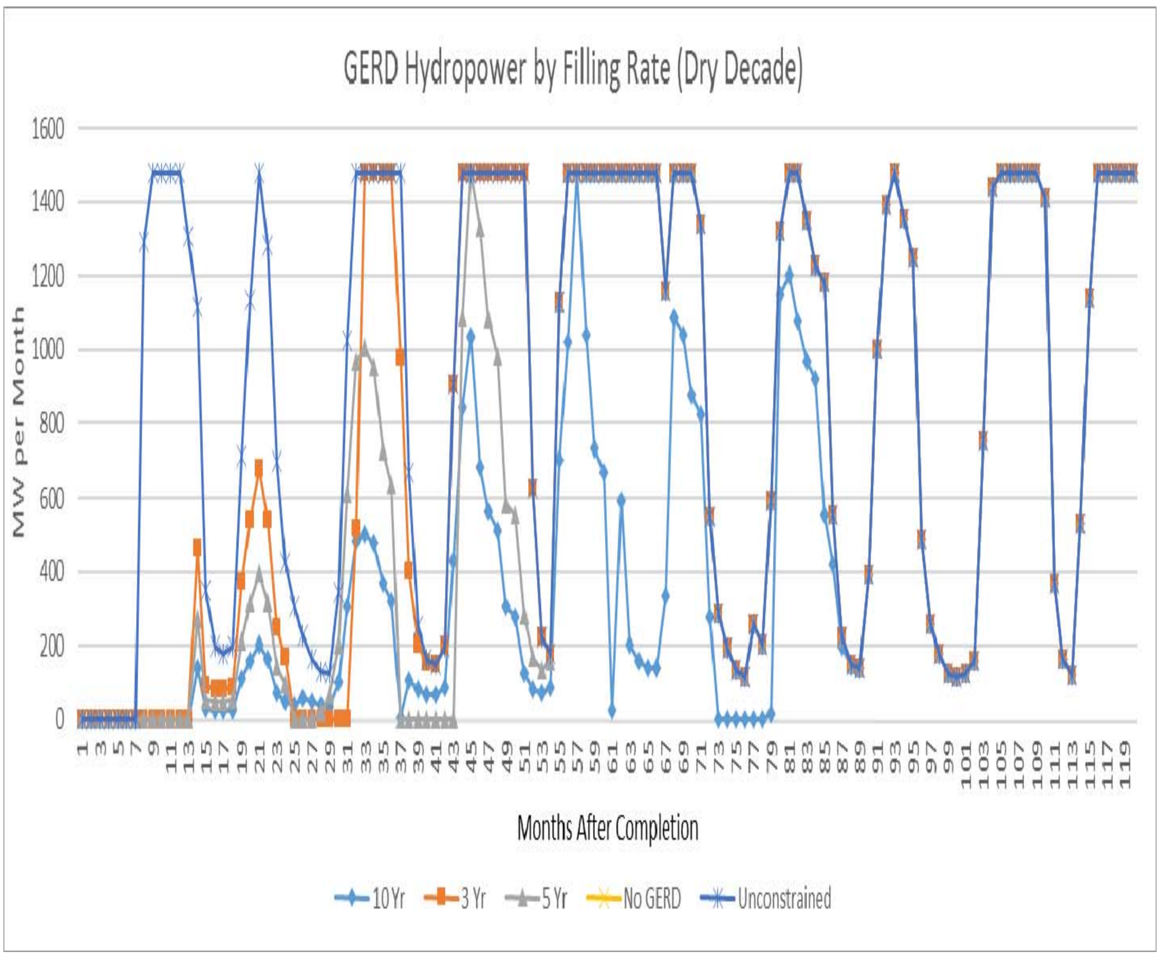

Fig. 10. GERD Hydropower by Filling Rate (Dry Decade)

For the first seven years of filling, all strategies would produce varying HP in correlation with the aggressiveness of each rate. However, when there was a deficit of water, it would restrict the production of all rates compared to a wet decade, and provide economic incentive to Ethiopia to fill its reservoir swiftly. After seven years, HP production synchronizes across fill rates, and no such incentive remains.

Hydropower would also be an important consideration for Egypt, although in a country where its energy supply comes from diverse sources it may not weigh as heavily as in Ethiopia. To calculate Egyptian HP, the sums of production at the HAD, Nagaa, Esna, and Assuit sites were combined into a national total (the overwhelming majority comes from HAD). Figure 11 shows that during wet years, hydropower production in Egypt is essentially unaffected after the first two years of filling, regardless of the fill rate. Even within those temporary two years, the difference between an unconstrained fill and any of this study's alternatives is seasonal, and less than 10%.

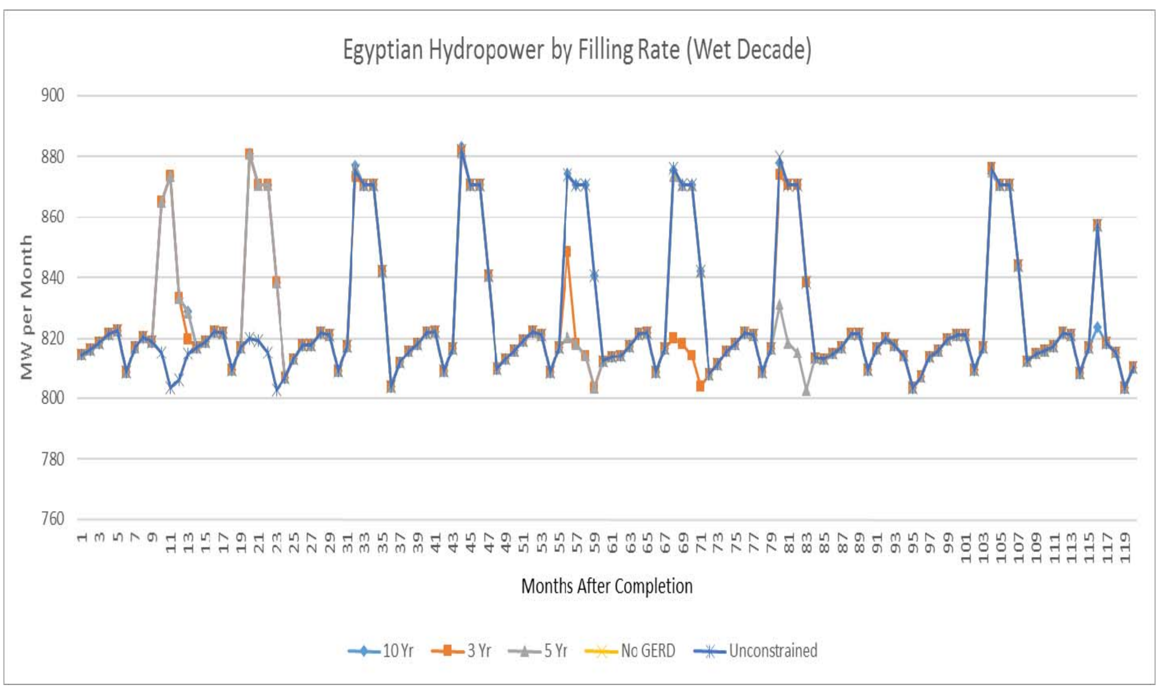

Fig. 11. Egyptian Hydropower by Filling Rate (Wet Decade)

This means the ZOPA is quite clear, in two ways. The compromise for either side is small for reasons just mentioned, and even if Ethiopia chooses the smallest increment among them, it will have virtually identical impacts on Egypt as even the latter's BATNA on this issue. If a small compromise will render similar results as a major one, it is worth considering.

Of the 800+ MW of HP produced in Egypt, Figure 12 shows that during wet years, a consistent 720 MW of it comes from the HAD. This suggests the fluctuation comes from Egypt's other production sites.

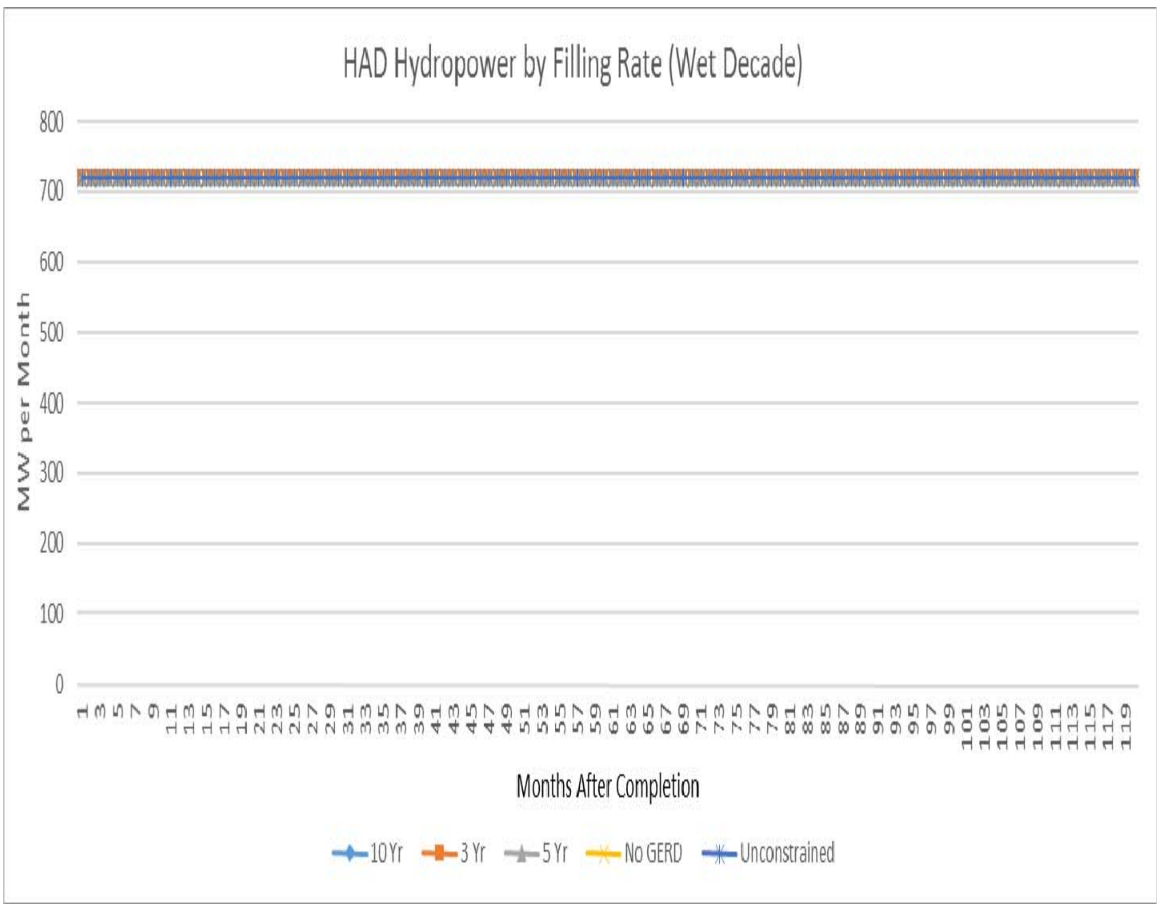

Fig. 12. HAD Hydropower by Filling Rate (Wet Decade)

During dry years, Egyptian HP would be more vulnerable to the GERD's filling strategies. Figure 13 shows that because of an overall water deficit in the region, and even with Egypt's BATNA (no GERD), HP would nearly cease to be produced across the country.

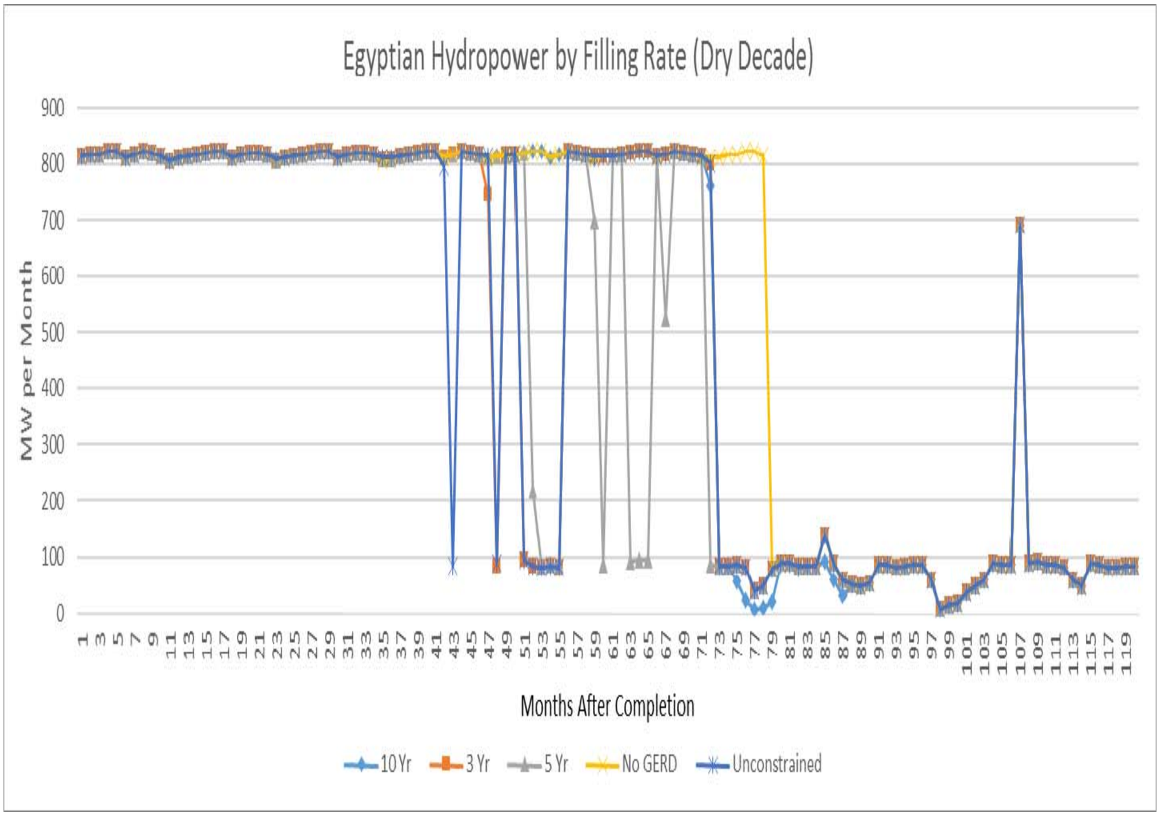

Fig. 13. Egyptian Hydropower by Filling Rate (Dry Decade)

Figure 14 shows that at the HAD, production would shut down entirely. As with national production, the absence of the GERD would only delay this shutdown by six months to month 79, where the other filling rates would all discontinue HP production in Egypt from months 72 and 73 onward. Even with dryness across the decade, Lake

Nasser's reserves will sustain HP production for several years before the lake's depletion midway ultimately discontinues production.

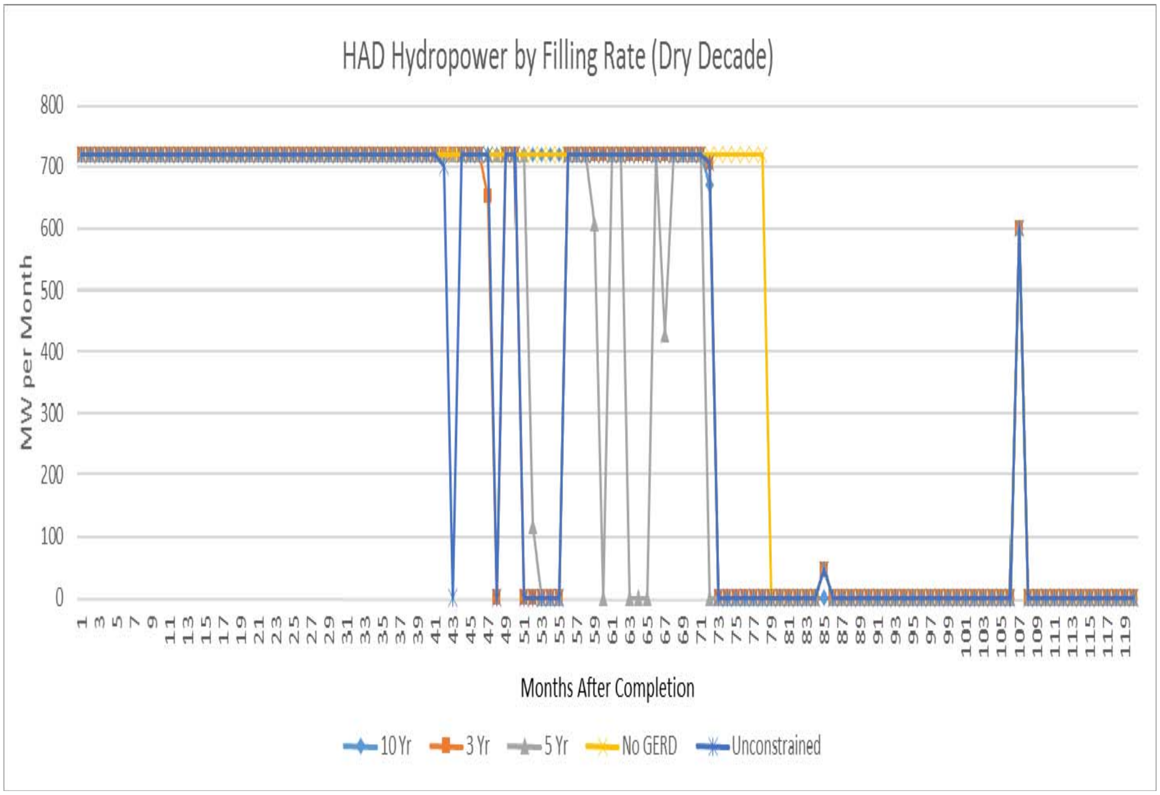

Fig. 14. HAD Hydropower by Filling Rate (Dry Decade)

Prior to 72 months, the Unconstrained, 3-year, and 5-year fill rates allow for brief but complete and repetitive discontinuities of HP production at Aswan, while a 10-year fill maintains a consistent supply of 720 MW at Aswan until 72 months. What this means is that in very dry years, Egypt's HP production will invariably be affected. However, the difference in filling rates during after the GERD's completion will only vary significantly for a span of approximately three years. Although Egypt has a diversified energy economy that relies considerably on fossil fuels, SDG 7 specifies renewable energy, among which HP plays an important role.

The findings of this simulation reflect the advantageous multidimensionality inherent to the 2030 Agenda and its SDGs. With each of the parametric categories of RD, HAD Release, and hydropower generation, both an overlap of impacts between indicators could be seen, as was a multiplicity of impacts for each indicator. RD and HAD release both affect water levels downstream in Egypt that affect agricultural potential, but also affect multiple other areas which could be focused on in further study. With less downstream flow, one could expect heightened difficulty for navigation of the Nile, as well as natural decontamination that comes with greater volumetric flow. Further, less flow from the HAD may be seen to impact downstream hydroelectricity generation, though its impact is minimal for Egypt’s total energy generation. This is an example among many of how indicators overlap, intersect, and collectively work to capture the interwoven workings of a complex water system.

Chapter VIII

Synthesis of SDG and WDF Illustrated Through the Simulation

This thesis examined three propositions. I will discuss each one in turn in this chapter.

Findings Regarding Proposition One

The first Proposition is: SDGs can be used as an analytic lens to help simplify the Eastern Nile Basin into a "problem shed" in order to identify mutually recognized economic, social, and environmental challenges and to specify a range of exchangeable currencies in order to advance cooperative sustainable development. I conclude that the SDGs proved highly valuable in that regard.

An important complication inhibiting agreement between the riparian states on the Nile is the lack of agreement among them as to which issues matter. This is illustrated by the absence of any bilateral or multilateral agreement that specifies particular benefits and harms to be advanced, preserved, or compensated in the case of harm.

The SDGs can help to resolve this problem and simplify ambiguities by defining a broad range of development goals and nested targets that all signatory parties can agree are benefits and whose detriment suggests harm. Because the SDGs emerged through consensus-driven facilitation, all involved Nile states inherently agree that these are harms, even if inadvertent, with respect to their specific application to transboundary water concerns.

Another way the SDGs help to simplify complexities involving the Nile River Basin is by means of their multidimensionality. The SDGs cover a spectrum of issues that encompasses economic, social, environmental, and political concerns. By broadening the scope of discussion to include virtually all relevant factors contributing to the basin's management, the "tunnel vision" that might occur by viewing water as a single issue and therefore zero-sum conversation has the potential to be ameliorated, and due justice can be given to all pertinent factors.

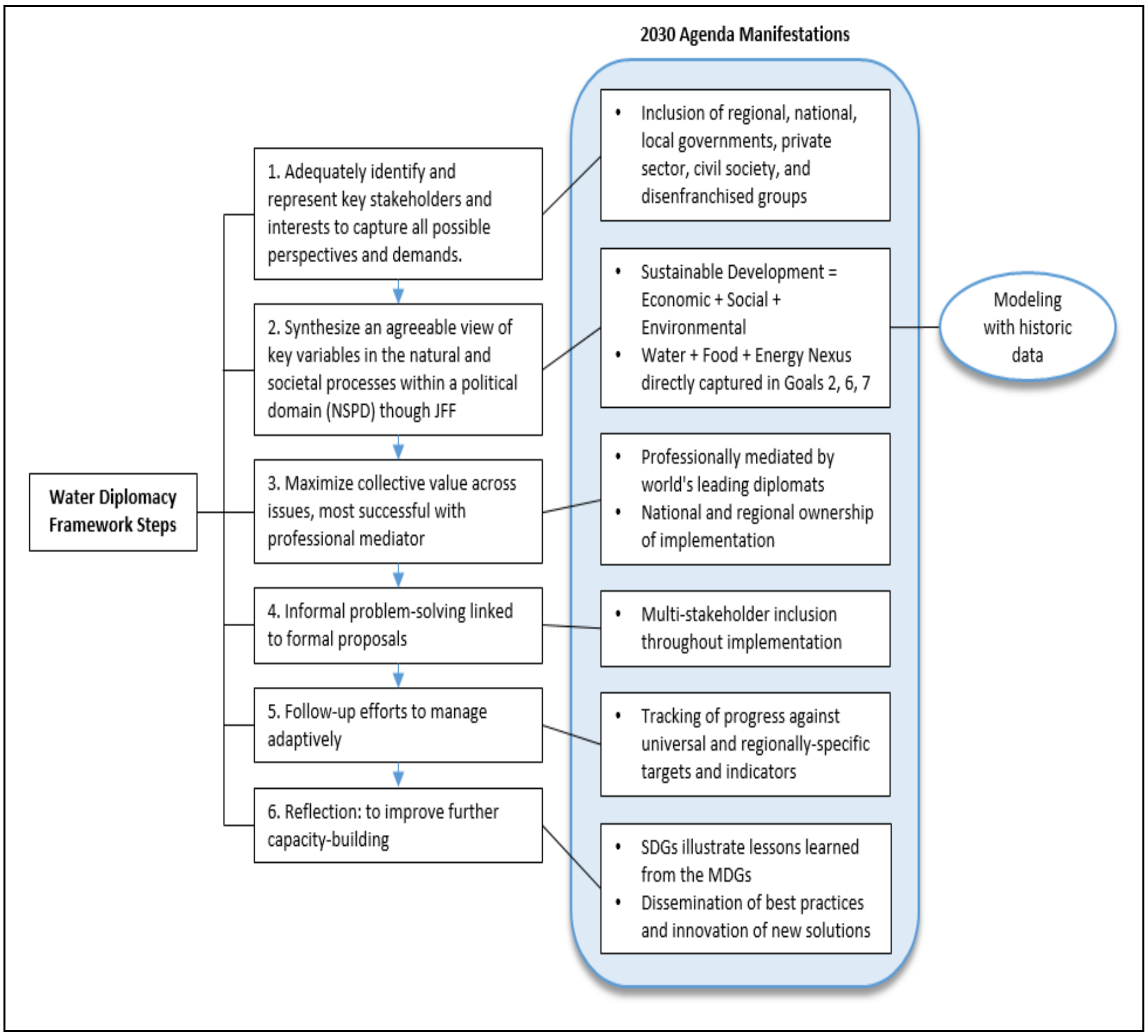

Fig. 15. Steps of the WDF Manifested in the UN 2030 Agenda.

Source: thesis author

There are three implications of this multidimensional approach. The first is that such an approach enables parties to barter together over multiple issues, and thus concentrate their diplomatic efforts on issues most consequential to them. By negotiating multiple issues simultaneously rather than individually, parties can afford to loosen their grip on less significant matters and create the good will needed to attain their interests in matters that are of greater comparative importance.

The second implication is the achievement of joint fact-finding. The comprehensiveness of the SDGs reflects an exhaustive assessment of relevant concerns from multiple groups of stakeholders. In the process of negotiating and refining the SDGs, voices from civil society, as well as NGOs, multiple levels of government, and myriad disenfranchised groups were granted a podium from which they could express their development requirements for the 15 applicable years of the 2030 Agenda. The inclusion of these concerns is reflected in the multidimensionality, and suggests a progressive move away from traditionally myopic approaches toward state-driven negotiation processes.

The third implication of this multidimensionality is the regional and sub-regional flexibility afforded to parties to create their own indicators for quantifying progress toward goals in their domains. It is reflected in this thesis by allowing me to choose three proxy indicators that were not included by the United Nations Statistics Division. These indicators were useful, allowing me to use forecasts from the Mike Hydro Model to correspond to the three goals chosen from among the SDGs across the water-food-energy nexus, and thus furthered the two propositions.

The third way SDGs simplify the complex Nile River Basin and facilitate cooperative management is through their intersectionality. This quality allows multiple issues to be grouped together and then considers their combined impact(s) as potentially more than the sum of their parts. Intersectionality is valuable because it helps to bridge the SDGs with the WDF. Intersectionality aids in viewing complex water systems as open and dynamically changing, which the WDF considers an essential for understanding and managing them. It also helps in the second WDF assumption, namely, that feedback, nonlinearity, and uncertainty characterize these water networks. In other words, impacts on part of a system may have ramifications elsewhere in it, in greater or lesser magnitudes, and these impacts are not always predictable. While models and historic data can suggest how these interactions may manifest, the open and dynamic nature of transboundary river basins suggest that uncertainty will still remain, even if these tools assist in managing the network more effectively.

The third assumption of the WDF—that water networks should be managed without resorting to zero-sum paradigms—quintessentially captures the point of intersectionality: if water is moved from one part of a system to another part, that need not mean that the party losing the physical resource is shorted of its benefits. By defining interchangeable currencies, such as agricultural output or energy, water can be allowed to shift across a network while its derivatives can replace it, allowing for more efficient allocation rather than loss. As data is collected on the evolving interactions across a system, managing parties gain the ability to adaptively manage it by responding to unforeseen circumstances.

Findings Regarding Proposition Two

The second Proposition I examined was whether modeling using historic data from the river basin generates a better understanding of policy options affecting the region's progress with SDGs as reflections of benefits and harms across the simulated scenarios. I found that the modeling produced a thoroughly informative understanding, challenging my initial expectations and alerting me to recalibrate my attention to the region's concerns. I address this here by discussing each SDG and respective proxy indicator individually.

The first SDG I assessed was SDG 2: "End hunger, achieve food security and improved nutrition and promote sustainable agriculture." To measure it, I invoked relative deficit (RD) of hydrological resources in Egypt as a proxy indicator. Greater RD caused by the GERD's filling would indicate greater harm to the agricultural sector in the Egyptian economy. I predicted that more aggressive fill rates compared to less aggressive ones would produce the most significant effects on RD for Egypt, but regardless of the fill rate, the impact was seen to be minimally effective. What actually produced the greater impact was comparing the RD during a wet decade with that of a dry one. Rainfall fluctuation caused dramatic impacts on RD, suggesting that policy makers in Egypt should be more concerned with preparing for dry years in the Basin than be concerned with a more aggressive GERD fill rate.

The second SDG that I assessed was SDG 6: "Ensure availability and sustainable management of water and sanitation for all." This was measured by using HAD release as a proxy indicator. I predicted that a more aggressive fill rate would significantly affect HAD release downstream by preventing water from reaching Egypt and forcing that downstream state to either voluntarily budget its release from the HAD or simply run its Lake Nasser reservoir dry. Figure 8 summarized that the overall HAD release over ten years would be greatest under the 10-year fill scenario, although the greater impact on the metric does not come from fill rate but from which rainfall scenario is being considered. Again, I found that a dry decade has a much more devastating impact on HAD release and, therefore, to Egypt's progress toward achieving SDG 6 than did the impact of any fill rate considered within each rainfall abundance scenario.

Third, I assessed SDG 7: "Ensure access to affordable, reliable, sustainable, and modern energy for all, as measured by hydropower generation." Because the GERD affects HP in both Ethiopia and Egypt, its impacts in both countries were considered. I held the same prediction: that fill rate would significantly affect GERD production. I learned that a fill-rate compromise between Ethiopia's and Egypt's BATNA would be helpful during a wet rainfall decade, and necessary during a dry decade. While this finding affirmed the significance of my indicator on the SDG, it also pointed to the climate-dependent comparative significance that its successful compromise would have.

In all, the findings from my modeling experiment confirmed my second proposition. By defying my own predictions on the significance that a policy choice like fill rate would have on the region, and alerting me to the greater comparative impact that rainfall would have in affecting developmental progress across the water-food-energy nexus, I drew an important conclusion. This conclusion was that prioritizing the risk of low rainfall volumes in the basin would more consequently prepare Egypt than solely advocating for a worst-case scenario should Ethiopia prove unwilling to compromise in its choice of fill rate. Additionally, Ethiopia could protect itself from the need to compensate Egypt for downstream harms by showing great willingness to slow its fill rate, particularly during a dry scenario.

Findings Regarding Proposition Three

In my third Proposition, I proposed that pairing the SDGs with the Water Diplomacy Framework could facilitate agreement through joint problem solving. I concluded that this pairing aids in developing the understanding needed to create agreement. My first Proposition showed that the SDGs outlined a range of economic, social, and environmental development goals for nations to prioritize as appropriate for their national circumstances. These prioritized objectives were shown in the discussion of my second Proposition to be data-driven by means of direct historic comparison, and by means of incorporating historic data into models simulating current or future conditions in the water network. As a product of national ownership of the development process, and the corresponding agency inherent in sovereignty to barter the material outcomes of their policy determinations such as the prioritization of SDGs, various issues can more easily be addressed collectively, which provides a number of benefits.

Among the benefits of joint problem solving is the ability of the parties comprising a water network, such as the Nile River Basin, to expand the pool of benefits that are common to the region. When the British Empire collectively administered the full Nile River Basin except Ethiopia, it was not equitable to all of its constituents, but it had the ability to choose any number of goals and maximize value across those goals throughout the Basin as it saw appropriate. For an empire driven by profit and exploitation, Egyptian cotton happened to be an overwhelmingly unitary focus of the

Crown, and most territories in the basin were deprived of developmental attention as were their people. Had the British Empire been more concerned with the holistic and equitable development of the ten modern states whose territories then constituted their administration, it could be argued that a single managing entity would be more effective at efficiently allocating resources to the diversity of constituencies and objectives across the basin. However, no single such entity exists today to govern the entire Nile River Basin, and the prospect of any single administrator is null.

Instead, the WDF parallels the efficiency that a single administrator could affect across a complex water network. While preserving state autonomy, the WDF recreates some of the benefits that unilateral decision making could have in efficiently allocating resources across a water network by recreating them through multilateral consensus. First, insofar as efficiency emerges from knowledge, the WDF requires a liberal exchange of information between parties and encourages validation and consensual understanding through the joint fact-finding process. Second, while part of joint fact finding is the communication of intentions, joint priorities, and individual priorities, the WDF allows the aforementioned mutually agreed understanding of the basin to inform negotiating parties as well as any professional mediators involved as to how best the basin's collective priorities could be weighed against the individual priorities of each party. Further, it informs to how the latter could be sub-prioritized such that an even more refined understanding could be achieved regarding which lower priorities are most appropriately compromised for greater basin-wide gains, such as cases when the achievement of one is mutually exclusive to the other.

By maximizing knowledge and good will through communication, a harmonized and cooperative management of water system challenges could be achieved. The pool of basin-wide resources could be maximized by efficient allocation and consequential growth, as the individual resources of each negotiating party could be optimized and selected for compromise when necessary. This is a product of the successful integration of the SDGs acting as a catalogue of quantifiable options, while the WDF guides the cooperative administration and exchange of their underlying resources.

Chapter IX

Discussion and Conclusion

This analysis proved valuable for supporting the use of SDGs as a device in conflict resolution. Although designed for general, indeed ambitious, direction of sustainable development, nowhere in the UN 2030 Agenda document does it detail how to use the SDGs as a tool to resolve conflict between nations where the source of that conflict originates from the same measures of development that the Goals encompass. To suggest that the most exhaustive, inclusive, and aspirational agenda to develop the planet for today's and future generations is also a key to resolving conflict between people is a positive implication for a significant diplomatic process: the 2030 Agenda, which deserves greater attention for the further potential it could unlock.

Among the explained potential of the 2030 Agenda is its use in transboundary water networks. While the WDF already provides a structured methodology toward consensus-based negotiated solutions to maximize collective value across a water network, synthesizing it with the SDGs takes it even further. This synthesis not only achieves many of the requisites for the WDF to be successful, such as indicators for joint fact-finding, but preliminarily achieves an inclusive, mutually agreed, detail-rich characterization of the natural, social, and political systems factored into the WDF.

Further, the multidimensionality and intersectionality of the catalogue of assessments afforded by the SDGs allow for clarified articulation and prioritization of the parameters or objectives addressed in water networks to be quantified and ultimately administered through the negotiating processes of the WDF. In the case of the Eastern Nile River Basin, this step could be instrumental, as Egypt and Ethiopia have yet to define between themselves which developmental parameters deserve to be acknowledged as important and subsequently negotiated in their goal of "No significant effect on RD in any part of Egypt" in the filling and long-term operation of the GERD. It is my assessment that the SDGs help to fill that void, and position the nations to build on this agreement by proceeding with the next steps of the WDF.

However, despite the observed theoretical synthesis between the SDGs and the WDF, challenges exist with respect to the adoption of these findings by stakeholders. Despite ratifying the SDGs, the document itself is non-binding. Therefore, countries can choose to ignore their signatures, and thereby neglect the valuable consensus forged as its product. This effective withdrawal violates no international law, and could be sought by nations convinced that their BATNA is more deserving of pursuit than a negotiated outcome to a transboundary water challenge.

Similarly, nations like those in the Nile River Basin could refuse to accept that the SDGs could be applied for this purpose, and demand that an isolated agreement be drawn without acknowledging the gains afforded by such existing diplomatic breakthroughs. This would unfortunately restrain progress, but as it stands, it is the political reality of both the Nile River Basin and the rest of the world. It is for this purpose that greater academic attention should be invested into exploring how the SDGs can help to resolve conflict.

More generally, the SDGs are not only shown to synthesize well with the Water Diplomacy Framework, but this synchrony suggests that modifications to the WDF or pairing the SDGs with alternative conflict resolution frameworks could help to address different kinds of development challenges beyond those specifically involving complex water systems, as the WDF was designed for. The complexity of these systems and their characteristics stemming from the unique properties of water may complicate the application of a similar approach if applied to different kinds of development or infrastructure challenges beyond the immediate scope of the water-food-energy nexus.

Should social equity be addressed, such as the consideration of Goals surrounding gender equality, access to education or healthcare, and the improvement of governance, among others, be the topics of a multilateral negotiation, I anticipate that the SDGs would be helpful in articulating the agreeably defined priorities of each party. But I predict that other conflict-resolution frameworks have been or are being developed to cater more specifically to these forms of developmental challenges.

Finally, by viewing water as an exchangeable currency, as the SDGs support within the water-food-energy nexus, the geopolitical tensions that arise in water conflict could much more easily and economically be ameliorated through intra- and extra-network trade than by resorting to warfare. War is the most destructive and uneconomical answer to resource scarcity that humanity is capable of. Viewing water as a currency that can be exchanged for energy, agricultural products, or manufactured goods provides a practical and often profitable way to supplant the need for physical water in a water network, and instead expand the pool of collective resources by recognizing the interchangeability of its derivatives. Water wars are irrational so long as water is viewed flexibly, and the political will exists to break out of traditional zero-sum accounting.

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