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## **Understanding the water crisis in Africa and the Middle East: How can science inform policy and practice?**

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### **Abstract**

When it comes to conflicts over the allocation of freshwater supply, who bears the burden, at what cost, and at what scale are important questions. While science can contribute to resolution of certain water allocation disputes, more scientific certainty will not resolve most water allocation controversies. Water stress in Africa and in the Middle East—particularly in the Nile Basin—is likely to lead to a range of conflicts, not because there is not enough scientific information to go around, but for other reasons. Water stress is likely to emerge as an increasingly important concern because population growth, current allocation practices, unchecked demand, and underinvestment in infrastructure are not being appropriately addressed. An effective way to resolve water crisis is to reframe conflicting needs and uses of water as opportunities for joint decision-making about this shared resource. The authors use the Nile Basin to illustrate how such informal problem-solving and decision-making can be initiated.

### **Keywords**

complex water problems, drought, flood, Nile Basin, water crisis, water diplomacy, water shortages, water stress

**W**henever there is talk of a crisis regarding freshwater supplies, terms like “water stress,” “water scarcity,” “water access,” and “water risk” are used—often interchangeably. This makes it hard to diagnose the exact problem and determine the appropriate response.

For example, climate change scenarios suggest that almost half of the world’s population will be living in areas of high water stress by 2030 (WWAP, 2012). Water stress is now extreme in Africa and the Middle East, with the most

adversely affected areas in the Gulf nations (Maplecroft, 2013). And water stress in the Middle East is so bad that it has now reached alarming levels with dire consequences for human development (UNDP, 2013).

By 2025, 1.8 billion people will be living in countries or regions with absolute water scarcity (WWAP, 2012).

Meanwhile, 768 million people are said to currently suffer from a lack of water access (UN, Water, 2007).

Exposure to water risks increases with changes in socioeconomic and

environmental factors. While average global flood losses were \$6 billion in 2005, they may increase to more than \$60 billion by 2050 due to increasing populations, economic development, and climate change (Hallegatte et al., 2013).

Beyond their sometimes confusing terminology, such warnings prompt questions regarding water availability in Africa and the Middle East: How much are freshwater levels likely to change in this region? How certain are scientists about their predictions? What can science tell world leaders about the policies they should enact to minimize the adverse effects of both droughts and floods in Africa and the Middle East? More pointedly, can science minimize the likelihood of conflicts sparked by water crises?

Overall, the world is likely to face many water-related crises in the years ahead. But they are probably not going to be caused by nationwide water shortages or a lack of scientific certainty about future water supplies. However minutely the problem is sliced, diced, and labeled, a lack of water is likely to occur because of population growth, misguided practices regarding water allocation, unchecked demand, and underinvestment in new infrastructure.

Fortunately, with some planning, foresight, and investment in technologies that can “create more water,” we can promote changes in agricultural practices, water conservation, and water re-use, *if* the countries of the region—including their civic and corporate players—can reach some joint decisions and collaborations.

But first, some definitions.

### All in a name

Water stress occurs, according to the United Nations Development Programme,

when annual renewable freshwater resources drop below 1,700 cubic meters per person. To get an idea of the size of that volume of water, 1,700 cubic meters is enough to fill a standard Olympic-size swimming pool—which is 50 meters long and 25 meters wide—to a depth of 1.36 meters. That may seem like a huge volume at first, until one considers that this figure contains much more than the basic need to sustain one person for an entire year: the 50 liters per day required for drinking, preparing food, adequate bathing, and sanitation. These basic, day-to-day immediate water needs add up to just a little more than 1 percent (18.25 cubic meters) of all that is needed for modern life. Much more water is consumed by other processes that sustain lives and economies, such as the agricultural production of basic food and cash crops, and by the water needs of industry. In addition, people cannot store and use every drop of water that falls in their region: Some of this water must be reserved to support natural habitats, including those within rivers, lakes, and streams.

Thus, if annual renewable water supply drops below 1,000 cubic meters per person annually (equivalent to 2,740 liters per day—roughly 725 gallons), then *water scarcity* occurs (Watkins, 2006).

Water access, on the other hand, as defined by the World Health Organization (2009), requires that 20 liters of water per person per day be available from a source within one kilometer of where it is needed for essential survival—the minimum amount required for drinking, cooking, and minimal personal hygiene. Looking at the 768 million people without access to potable water in the world, 83 percent live in rural areas, creating the appearance that water access

is predominantly a problem in rural sub-Saharan Africa and Central Asia. However, in urban mega-slums within Khartoum and Cairo, residents must pay exorbitant costs for access to water. And even at these high prices, water is not available on a daily basis.

The latter is an important point. Access to water is not just a function of supply. Key roles are played by the price of water and the ability to distribute water to those who need it. If the price is too high, or if there is a lack of adequate distribution infrastructure, then even if water is present it is effectively not accessible. Therefore access, not supply, is typically at the heart of many water crises.

Meanwhile, water risk refers to the probability and related consequences of a water-related disaster occurring, such as drought, flood, pipeline failure, contamination, or a similar occurrence that affects the availability or quality of water. (Quality is important. After all, water may be available but not drinkable or otherwise suitable for use.) Water stress, scarcity, access, and risk are different problems that affect different groups in different places in different ways, depending on how the water will be used at the end point—something may be good enough for watering plants or washing clothes but not for human consumption. Therefore, it is important to distinguish which of these different kinds of problems characterize a specific water crisis.

Our focus is on water stress—the ratio of water withdrawal to available renewable supply. This incorporates all the domestic, industrial, and agricultural water use per person for any given region (Falkenmark, 1989). Based on this metric, most countries in the Nile River Basin are actually at low risk for water stress—on a scale of 1 to 5, with 5

being the greatest, South Sudan scores a zero, Sudan is 0.90, Ethiopia gets a 0.60, and Egypt a 1.3—as reported by Gassert et al. (2013).

So, if the Nile region is at low risk for water stress, then why is there a frantic discussion about a water crisis in these countries?

### **Nature of freshwater supply**

In any given year, most of Egypt is likely to see between 0 and 80 millimeters of rain. Despite its extremely dry climate and limited arable land (97 percent is unsuitable for cultivation), 86 million people live in Egypt. To accommodate them, Egypt pulls 55.5 billion cubic meters of water each year from the Nile River, which in turn comes from water-rich areas far upstream. This means that to get a handle on its water situation Egypt must consider not only how it uses its own water, but how water is managed up the river by the other 10 countries in the Nile Basin: Burundi, the Democratic Republic of the Congo, Ethiopia, Kenya, Rwanda, South Sudan, Sudan, Tanzania, Uganda, and Eritrea. Being forced to rely on water that originates thousands of kilometers away—Tanzania and Uganda are nearly at the center of the African continent—creates worries for the Egyptians. How much these upstream countries take from the Nile, and any pollutants they may add, is a continual concern.

Adding to these issues, the amount of water in the Nile River is not constant. Precipitation, runoff, and evapotranspiration—the evaporation and water vapor given off by plants during photosynthesis—are natural phenomena that affect any river's flow. These are all quite variable in the Middle East and North Africa. Although the total rainfall in the entire

Nile Basin averages 2,000 billion cubic meters of water a year, less than 5 percent, or 84 billion cubic meters of water, actually makes it to Egypt's Lake Nasser (Awulachew et al., 2012). Some years it has been a lot less, with only 46 billion cubic meters of water arriving in Egypt in 1913; but some times were much more plentiful, with a high of 102 billion cubic meters of water in the river in the 1880s.

In contrast to this variability, the human population in the Nile Basin countries has consistently gone in only one direction: up. In 1960, only about 100 million people lived in these 11 countries. Today, there are 400 million and the population is expected to reach over 700 million in 25 years. And the demand for water in all the Nile Basin countries has gone up with it.

Clearly, the importance of a good year or a bad year in the hydrology of the Nile is dwarfed by this human population growth and the related demands on water. Developing more precise estimates of likely hydrological changes in the Nile flow are not nearly as important for policy making as population growth and the consequent growth in water demand.

### **Water withdrawal and use**

Water demand consists of water withdrawal and use. Generally speaking, evapotranspiration is responsible for the majority of water loss in the Nile Basin, leaving only a small portion of precipitation for groundwater recharge and surface runoff. Sudan and Egypt, primarily desert regions, have a net evaporative loss. A water budget calculation for the Nile Basin suggests that less than 5 percent of total basin-wide rainfall is available (Awulachew et al., 2012).

Yet, most of the discussion among the 11 countries is about who will get how much of that 5 percent, and how each country will allocate its share among the competing sectors within its economy. For example, agricultural use is significant for Egypt and Sudan, but much less so for the other countries.

Egypt uses over 65 billion cubic meters of water annually, while 200 billion cubic meters of water is lost from rain-fed crops due to evapotranspiration. Water productivity for crops, or "crop per drop," is similarly low for most of the Nile Basin countries, with crop yields in the range of 1 ton per hectare (about 2.47 acres). This compares to 2.5 to 3 tons per hectare in India and over 4 in the United States for grain crops. These figures show that there is a significant opportunity here to improve crop water productivity and yield in the Nile Basin.

In other countries, such as the Democratic Republic of the Congo, there is a wealth of internal renewable water resources (though most lies outside of the Nile Basin)—in glaring contrast to Egypt's heavy reliance on water from upstream sources. Additionally, differences in economic development and settlement patterns affect how much water is withdrawn per capita, indicating that countries that do not experience water stress at the moment may face challenges in the future as both population and development grow, causing much greater withdrawal for agriculture, industry, and domestic use.

Another concern is the possible effect of climate change: The Earth is warming, glaciers are melting, and precipitation patterns are shifting. In many areas, this will alter the supply and demand balance regarding water. Climate change projections suggest that most of the Middle

East and North Africa will become hotter and drier, exposing an additional 80 to 100 million people to water stress. In the Nile Basin, temperatures are expected to rise, leading to increased evaporation. But to be more precise is difficult, because precipitation models are highly variable across the region, making it hard to establish a clear future pattern for the region (Conway, 2005).

How do the projected impacts of climate change—despite large variations among different climate models, of as much as 30 percent—compare with the likely levels of water stress? If the past is any guide, there may be great changes, and great variability in water supply: There was a 400 percent increase in the human population in the past 50 years, and the Nile has historically fluctuated wildly, from a surplus of 21 percent in the 1880s to a 45 percent drop in 1913. Who will be the 300 million new residents to be added over the next quarter-century in the Nile Basin, and how important will the effects of a changing climate be for them? How will water stress be manifested in their lives? Is climate change the key driver of the water stresses they are likely to face?

These questions suggest that water stress is a problem with two key characteristics: On the one hand there are the competing values, interests, and information that frame the problem; and on the other, the differing views of resolving it—which are related more to uncertainty and the ambiguity of perception than scientific information.

In the public policy world, such problems are formally called “complex problems” (Islam et al., 2010; Rittel and Weber, 1973). Once someone starts unraveling a complex problem for possible solutions, the permutations become nearly infinite.

Debates about what to do are not likely to end, because there are no definitive solutions, due to the endless variations based upon differing values, interests, and perceptions. The only way to effectively address (not solve) complex problems is to try to create a decision making process in which every participant feels involved and listened to, with outcomes that participants feel are politically legitimate and open to change, rather than permanent, one-size-fits-all prescriptions. This implies that concerns about water stress will give rise to debates about “Water for whom?” and “At what cost?” While science can help to inform these debates, technical inputs alone will not solve them.

Therefore, anyone thinking about water crises needs to pay attention to how water stress is defined from the perspectives of the different users; how the science is used or abused in the process, making any policy deliberations over water allocation; and how politically legitimate options regarding the resolution of complex water problems can be developed.

### **Who bears the burden, at what cost, and at what scale?**

The World Resources Institute recently ranked 180 countries, along with the world’s 100 largest river basins and 100 most populous river basins, with regard to the water stress they currently face (Gassert et al., 2013). They used five water risk indicators: the ratio of total water withdrawal to total renewable freshwater per year, the amount of variability from one year to the next, seasonal variability, flood occurrence, and drought severity. The result was that 36 countries face extremely high levels of

“baseline water stress,” including several countries in the Middle East and Africa.

Significant water stress variations exist among countries and river basins. The Nile has a low risk (0.90) while the Tigris-Euphrates (3.50) has a high risk for water stress. Sudan is at a very low risk for water stress. Average annual rainfall varies by sub-region as well: About half of Sudan is desert, receiving less than 25 millimeters of precipitation. Meanwhile, rates of precipitation increase toward the tropical marshlands of the newly independent country of South Sudan, with some areas receiving more than 1,600 mm of precipitation each year.

Whether a person lives in the country or the city also plays a role in water accessibility, as does social position. In general, the cities have better water access than rural areas, and the city elites have better water than those who live in the poorer areas: For residents of Khartoum’s slums, water costs over 12 percent of their monthly income, significantly higher than the rates urban elites with access to municipal water pay (Eltayeb, 2002).

To address some of the geographical variations in water stress, another water stress index, prepared by Maplecroft (2013), defines water stress at a much finer scale, calculating the ratio of domestic, industrial, and agricultural water consumption to renewable supplies. One could create a similar water stress index to account for seasonal and inter-annual variations as well, making the estimation of water stress more scientifically certain. But deeper scientific understanding or increasingly sophisticated, fine-grained data will not necessarily make it any easier for policy makers to figure out what to do to minimize water stress or enhance water access for residents in urban slums.

Here, the perfect may be the enemy of the good, and the pursuit of absolute scientific certainty may interfere with making reasonable policy choices. Further fine-tuning of data about likely changes in rainfall or the prospects of floods and drought will not make it any clearer who should get how much water, for what purpose, at what cost. These are political choices that may be aided by scientific understanding but ultimately cannot be resolved by science.

When water is thought of as a limited resource, conflicts immediately emerge over how it should be allocated. Arguments about whose rights and needs are greater lead to tussles over sovereignty and threats of violence—as can be seen in the old adage from the American West that “whiskey is for drinking and water is for fighting.” The Nile Basin is no different. Most debates about water among the countries of the Nile Basin are centered around the allocation of the 84 billion cubic meters of water that flow, on average, every year down the river. (That’s been roughly the average amount of available water over the past several decades.) Egypt wants to preserve its historic rights to the Nile waters on the basis of 1929 and 1959 agreements that gave it 55.5 billion cubic meters of water per year and Sudan 18.5 billion cubic meters of water, assuming the remaining 10 billion would be lost to evapotranspiration. But these agreements all preceded the independence of many of the Nile Basin countries, including the Democratic Republic of the Congo, Rwanda, Uganda, Tanzania, Kenya, Burundi, Eritrea, and Sudan (and now South Sudan). Allocation of the Nile water has been a controversial topic for decades. Recently, this controversy became more heated as the other countries in the Nile

Basin deemed the 1959 allocation agreement invalid.

### **How science can inform policy and practice in an uncertain water future**

One solution may be technological: What if more water could be “created”? The adoption of water conservation and recycling methods combined with improved water use efficiency could be part of the solution for expanding the availability and efficient use of water. At the moment, in any portion of the Nile Basin the largest “user” of water is evapotranspiration, and the greatest portion of water used by humans is for agricultural purposes. Improving agricultural efficiency of water use could include adopting more modern “drip-feed” irrigation techniques, selecting more drought-tolerant crops and livestock, and capturing and reusing the water runoff from irrigated fields. (Some examples can be found in Biagini et al., 2014; Christian-Smith et al., 2012; or Wallace, 2000.) There is also a potential role for desalination, wastewater treatment and reuse, and more sustainable energy sources that power the systems that provide clean water.

However, all this requires coordination and cooperation. Currently, the greatest source of Nile water (upstream precipitation) is far away from the heaviest use of its waters (arid downstream regions). How that water is managed along the way—storage in reservoirs and flow rates in major channels—can affect the amount of water that is lost. Changing water use practices at the farm scale requires communities to be on board with changes in how they choose and manage their crops or

livestock, and how they prioritize, value, and pay for the water they use. Larger projects require ongoing cooperation at the national, international, as well as at the basin scale.

Putting into effect any decision to efficiently and sustainably use water requires much more than just deciding on what technologies to use where and finding someone to pay for it. The values and interests of all those who have a stake in defining and addressing a particular water problem must be addressed (Choudhury and Islam, forthcoming). To do this requires processes of decision making that are not confined to just formal governmental bodies but involve civil society on many different levels. Such decision-making must ensure two guiding principles—integration of water use for competing needs, and equitable distribution of water as a resource—to address the values and interests of stakeholders involved in defining and addressing a particular water crisis problem (Choudhury and Islam, forthcoming).

Unfortunately, water management in the Nile Basin is at a standstill, and the most recent Cooperative Framework Agreement drafted by the Nile Basin countries has not been ratified. In the absence of such an agreement, some countries decided to act unilaterally, which enflamed their relationships with their neighbors. In the absence of a workable agreement, cooperative efforts remain out of reach.

Possible constructive moves include encouraging national political leaders in all Nile Basin countries to formally renounce any unilateral action; reconvening informally to talk about interim steps or possible unofficial experimental measures to “create more water”; and creating joint problem-solving efforts

to monitor how experimental efforts are working and learn from other basin-level efforts worldwide.

### **Pledge not to take unilateral action**

Leaders of the Nile Basin countries could each make a short-term pledge to forestall any further unilateral actions regarding the use of Nile water resources or development that affects the Nile.

There has been a rush of such projects lately: Ethiopia announced the beginning of the construction of its Grand Ethiopian Renaissance Dam, intended to generate 6,000 megawatts of hydropower on the Blue Nile—a major Nile tributary that provides the majority of water that reaches Egypt. Similarly, Uganda proceeded with its Bujagali Dam; Rwanda, Burundi, and Tanzania jointly formed the Rusumo Falls hydropower project; and the Sudan proceeded with the extension of the Roseires Dam and the construction of the Merowe Dam. These developments pose short-term challenges to a long-term agreement.

Therefore, any break helps in the frantic tit-for-tat staking of claims to the Nile's water before your neighbor does. To show that they are serious, these countries might pledge to hold off on any new developments for some specific time period (say, a year), creating pressure on neighboring countries to resume stalled negotiations and develop a more comprehensive Nile Basin water management agreement. The rationale for such a pledge is that it would be in the self-interest of each country, because there is no way for any one country to respond to water stress on its own.

### **Focus on “creating more water”**

The absence of a formal basin-wide agreement need not prohibit informal agreements. For example, the Nile Basin Initiative was established by countries bordering the river as a transitional institution in 1999 to achieve sustainable social and economic development through the equitable use of a shared resource: the basin's water. The initiative has made significant achievements in understanding the science of the river, including the development of an agreed-upon, common, state-of-the-art decision analytic tool. In June 2010, six upstream countries signed the Cooperative Framework Agreement regarding the river's use. (The two downstream countries of Egypt and Sudan objected to the signing and froze participation in NBI activities.)

And in February 2014, more than 60 water professionals, decision makers, diplomats, and other nongovernmental players from Egypt, Ethiopia, Sudan, and South Sudan participated in an informal problem-solving effort, which included a cross-boundary water negotiation simulation called “Indopotamia,” complete with professional mediators from substantial technical backgrounds (Islam and Susskind, 2013).

Because they are unofficial, such problem-solving forums are not bound by any procedural rules, which increases their flexibility. Because these are ad hoc, they can be initiated at any time by any interested parties. While they are no substitute for formal discussions about comprehensive basin-wide agreements, they help to re-establish trust and build working relationships. (In this regard, it is worthwhile to note that in June 2014 Sudan officially ended its



boycott of cooperation with the Nile Basin Initiative and called on Egypt to ratify the Cooperative Framework Agreement.)

### **Collaborate in joint fact-finding**

Even as negotiations continue as to how to arrive at a more comprehensive basin-wide agreement, it is helpful for all Nile Basin countries to jointly design experimental efforts to capture and retain more water. For example, the operators of Egypt's Aswan Dam and the likely operators of the Grand Ethiopian Renaissance Dam could talk about joint management of the Blue Nile when Ethiopia's dam is finished. Elsewhere in the world, large dams on the same river have joint operating agreements; Egypt and Ethiopia could benefit from doing the same. Whether or not Egypt wants Ethiopia to complete the Grand Ethiopian Renaissance Dam, it makes sense to explore possible joint agreements that can maximize water flows for Egypt, Ethiopia, Sudan, and South Sudan under the various possible circumstances. In addition, a joint monitoring body, appointed by the leaders of all the Nile Basin countries, could host periodic meetings with officials and managers from other parts of the world. Continued interaction with basin managers from other transboundary rivers of the world would surely stimulate helpful ideas and approaches that could be applied in the Nile basin.

### **Reframing the complex problem in the Nile Basin**

First, water crisis related to water stress is likely to be a problem in Africa and in

the Middle East, but not because there is not enough scientific information to determine the likely impacts of climate change or to know exactly how hydrological variations are likely to evolve. Rather, water stress is likely to emerge as a problem because of population growth, current allocation practices, unchecked demand, and underinvestment in new infrastructure and technology—neglected tools that have the potential to “create more water” by promoting changes in agricultural practices, water conservation, and water reuse, and improvements in water infrastructures.

Second, water stress is what policy makers call a “complex problem” in which the questions of who bears the burden, at what cost, and at what scale become all-important parameters to defining the problem. Science can help inform these debates but can't provide definitive solutions. The only way to address complex problems is to reframe them as joint decision-making tasks that can generate politically legitimate policies with widespread regional support.

Third, in the Nile Basin, a helpful next step could be to put aside the negotiations on how to divvy up the existing pie (a zero-sum problem) and instead concentrate on how to create a bigger pie and “create more water” (a positive-sum problem). New collaborations, involving not just government officials but civil society and corporate actors, can help to build trust and working relationships that may, over time, make it easier to reach broader agreements.

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