Troubled Waters

Climate Change, Hydropolitics, and Transboundary Resources

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A Case for Integrating Groundwater and Surface Water Management

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Global water resources are increasingly threatened by overuse, pollution, and climate change. Concern is growing over how to ensure that the planet's endangered freshwater supplies are managed wisely and distributed equitably through space and time. One obstacle is that groundwater and surface water systems are typically viewed as disparate types of resources, and their study and management are often separated into tracks that rarely meet. Policy follows along these lines, with different ministries or departments charged with governance of one or the other. In countries that possess ground and surface water, this creates inefficiencies and makes sustainable use difficult. Groundwater is particularly vulnerable to overpumping, because it is an "invisible" resource and poorly understood.

Groundwater can be renewable or nonrenewable. Renewable aquifers are often connected to surface water systems, such as rivers or lakes, and water is transferred between them. However, the majority of the world's groundwater is confined in fossil water aquifers, which were filled thousands of years ago and are no longer replenished. These often vast natural underground reservoirs of ancient water could be called the last reserves of fresh water on the planet. They are gaining increasing attention as surface water resources become strained beyond capacity. It is of the utmost importance that they be managed carefully, because, as finite resources, they will eventually be tapped to exhaustion. River systems, and other types of surface water, are considered renewable, but they are equally vulnerable to overuse and can suffer seasonal exhaustion. Integrating groundwater and surface water management could enable more sustainable use of both.

Water management and governance are complicated by the fact that water resources often cross state borders and are the focus of competing national claims. This paper compares two cases of transnational water resources—the Nubian Sandstone Aquifer System (NSAS) in North Africa and the Ganges-Brahmaputra Delta in South Asia—to examine the common governance challenges of surface water and groundwater and the dangers of continuing to separate their management. The paper also suggests possible lessons each case holds for the other and their implications for integrating water management on a broader global scale.

Two Cases of Transboundary Water

Water management in the last century mostly consisted of large infrastructure projects such as dams and river diversions. Groundwater was equally exploited, and many countries, including Saudi Arabia and China, are now dealing with severe depletion. What defined the era of the "exploitation paradigm" was the implicit assumption that fresh water was nearly inexhaustible. Now that many countries are experiencing shortages, especially those in the Middle East and North Africa and other water-stressed regions, it is becoming clear that even renewable water resources cannot supply enough water if not managed carefully.

It is necessary to move beyond limiting perceptions of what constitutes "renewable" and "nonrenewable" resources. Equally important is the need to see water resources from a global perspective. Ramaswamy Iyer, former secretary of Water Resources for the government of India, points out that even considering water resources at the basin level is no longer enough, as it creates a "segregation of regions into 'hot spots'" that ignores water systems' global implications.[1] As the discussion of the two very different cases below demonstrates, groundwater and surface water share similar management challenges and goals. A better understanding of these commonalities is needed in order to facilitate their integration under one management scheme and to encourage more sustainable use.

The Nubian Sandstone Aquifer

The NSAS, the largest underground fossil water reservoir in the world, is shared by four states: Chad, Egypt, Libya, and Sudan. It occupies over 2 million square kilometers, underlying almost the whole of Egypt, half of Libya, the northeast corner of Chad, and the northwest portion of Sudan. With an estimated total volume of over 542,000 cubic kilometers (as a comparison, the Caspian Sea, the largest inland surface water body in the world, has a volume of 78,200 cubic kilometers), it has the potential, if tapped on a large scale, to turn an ostensibly water-scarce region into an oasis. In fact, Egypt has tapped the reservoir for decades to make the deserts bloom. Until 1984, when Libya began its ironically titled Man Made River project, a massive engineering feat that pumps the water to the surface and pipes it to the northern coastal cities, most wells that tapped the aquifer were local, village-level enterprises and small-scale projects in planned desert communities such as those in the New Valley, Egypt.[2]

Although scientists know the location of the aquifer underground and its estimated total volume, no one knows how much water is actually recoverable. This depends, among other things, on underground flow patterns, water depth, and the point at which deep wells are no longer economically efficient. With Libya now tapping it on a large scale, and other countries eyeing it as a potential source of copious and thus-far uncontested water, an urgency has been building to develop a better understanding of the aquifer's potential and its limitations. In the last 20 years, several projects have sought both to create more scientific knowledge of the aquifer and to preempt political conflict by forming a commission of the four states that share it. The latest of these, the NSAS project, has the International Atomic Energy Agency (IAEA) as its executing agency and is funded by the Global Environment Facility.

As executing agency, the IAEA is directly involved with all four member countries and is the principle scientific and technical advisor. The IAEA might at first glance appear a curious choice to lead the project, but isotope hydrology, a technique in which the IAEA specializes, is the primary means of determining the age, origins, and movements of ancient underground water. Other parts of the project include establishing a database of shared information and a legal and institutional framework for joint management, with the ultimate objective of establishing “rational and equitable management of the NSAS for sustainable socioeconomic development and the protection of biodiversity and land resources.”[3]

While an admirable goal, it remains to be seen whether conflict can be avoided if Chad, Egypt, and Sudan follow in Libya’s footsteps and construct their own huge pumping projects. With no international laws or even substantial proposed frameworks for sharing underground water, and no indigenous common practices for doing so on a larger-than-village-level scale, there is the risk of a “race to the pumps”[4] situation if pressure on water resources continues to build. With water considered a national security issue throughout the region, it is unlikely that even with a joint management commission and a common informational database, these countries will readily share their future development plans with each other, much less submit them to joint decision making. Indeed, despite the aquifer’s importance for future socioeconomic development, there is a deafening silence on the part of policymakers—with the exception of first-to-the-plate Libya—as to how it can or will be exploited.

The Ganges-Brahmaputra Delta

Water resources in South Asia, as in North Africa, are often seen as part of national security and are an extremely sensitive political issue. Unlike the case of the NSAS, however, there is already substantial tension between India and Bangladesh over the shared Ganges-Brahmaputra Delta. Bangladesh, the downstream riparian and politically and economically weaker of the two countries, generally feels it gets shortchanged when it comes to allocating the water.[5]

The Ganges and Brahmaputra, which originate in the Tibetan Himalayas, flow through India before entering Bangladesh from the north, and merge near the center of Bangladesh to form one river. This is joined south of Dhaka on its eastern side by the Meghna, which also flows in from India, and drains into the Bay of Bengal. With most of its land mass being either a floodplain or delta, Bangladesh is extremely vulnerable to fluctuations in water supply. Consequently, Bangladeshis have become skilled at coping with moderate seasonal flooding and drought. However, Dhaka claims that modern infrastructure projects in India, such as the Farakka Barrage (dam) over the Ganges some 10 kilometers from the Bangladeshi border, have contributed to making conditions more unpredictable and extreme. India disputes that its dams have contributed to more severe flooding and droughts in its downstream neighbor.

The two countries have signed several treaties and memoranda of understanding over sharing the Ganges River, the most recent in 1996. Flow measurements used to determine each country's share are taken at Farakka,[6] so any water India may divert upstream is not taken into consideration. It is a constant complaint in Bangladesh that India does not share any information about river flow upstream of Farakka,[*] which is taken to be proof that India is diverting much of the water before it reaches the dam, thus "cheating" Bangladesh of its fair share. India, for its part, considered its disputes with Bangladesh to be resolved by the 1996 treaty.[7]

Bangladesh has never formally disputed the treaty, but often points out that India not sharing information about upstream flow conditions for the Ganges and other shared rivers makes it very difficult, if not impossible, for it to have enough advance warning of coming floods. India is mandated to share flow information only when the water level is 1 meter below the "danger" zone,[8] which gives Bangladesh an average lead time of three days at most. More advanced warning would make evacuations and other emergency preparations easier to mobilize in time. The lack of information sharing on the Ganges's and Brahmaputra's flows also occurs between other riparians upstream, and there is no regional mechanism for sharing data.

Perspectives on Groundwater and Surface Water

Internationally and nationally, groundwater and surface water are often separated into silos in the way they are perceived, studied, and managed. The most recent international consensus on the governance of shared water resources, the 1997 UN Convention on the Law of the Non-Navigational Uses of International Watercourses, mentions groundwater almost as an afterthought, and only deals with groundwater that is connected to surface water.[†] Considering the importance of groundwater to domestic water supplies in many countries,

[*] The Institute of Water Modeling, a trust established by the Bangladeshi government to do technical studies of water resources, is working with the Asian Disaster Preparedness Center in Thailand rather than its regional neighbors to develop a South Asian regional river basin model to assist in flood prediction.

[†] Article 2 of the convention is the one instance where groundwater is mentioned; it states: "'Watercourse' means a system of surface waters and groundwater constituting by virtue of their physical relationship a unitary whole and normally flowing into a common terminus."

particularly for irrigation and drinking water in cities,[9] this is an astounding oversight. Groundwater is often taken for granted, and its physical characteristics and flow patterns are not well understood. Consequently, it is still predominantly the domain of scientists and engineers.

Because it is not a physical connection, the link between fossil water aquifers and surface water is less obvious than that between renewable aquifers and the surface water that replenishes them, as occurs in India and Bangladesh. In their most recent national water plans, both countries recognized the need to integrate surface and groundwater management,[10] but have yet to put this successfully into practice. Because Egypt and Libya are situated over vast reserves of nonrenewable water, groundwater and surface water policy are completely disconnected. In Egypt, the Groundwater Sector in the Ministry of Water Resources and Irrigation is located within the Irrigation Department, grouped with the Reservoirs and Grand Barrages Sector and other technical/engineering and irrigation-related departments. The Nile Water Sector is located within the "Headquarters," the central department. In Libya, all fossil groundwater is managed by the Great Man Made River Authority, the engineering body that oversaw the Man Made River project.

An argument can be made that the management of groundwater, especially the nonrenewable variety, should be separate from surface water. Indeed, in many ways it is such a special case that it deserves to be separated from surface water in the first instance, if only to encourage more study and understanding of it, as well the creation of an international consensus on its management and governance. The question of how to manage fossil water reserves sustainably is a challenge that will require some creative thinking and a reworking of the traditional "exploitation approach" to natural resources. But it is the very question of sustainability that ties the management of fossil groundwater to that of surface water and constitutes the most important lesson to be learned from examples such as the NSAS. As climate change affects the world's renewable water resources, changing what have come to be seen as their immutable qualities, there will be a need to reexamine the concepts of "renewable" and "nonrenewable."

The Ganges and Brahmaputra Rivers that flow into Bangladesh serve as an example of how water resources can be renewable in supply and yet limited in quantity, and can fall short of fulfilling a country's needs without being exhausted. Most people think of floods when Bangladesh's water challenges are mentioned. But despite being half delta and the final recipient of some of the world's largest river systems, the country is running out of water. Dhaka, which depends on aquifer water that is renewed by the rivers, suffers severe shortages because of declining groundwater tables. The northwest of the country has been experiencing desertification for some years. While drought is a seasonal phenomenon in Bangladesh, it is nonetheless a severe threat to the security of many of its people for much of the year. India is also overpumping its aquifers,[11] and many wells on small-scale farms have dried up completely. Although the aquifers that underlie these two countries are considered renewable because they are nominally replenished by the Ganges and Brahmaputra Rivers, they are clearly as exhaustible as fossil water aquifers.

When the issue of renewable versus nonrenewable water is redefined as one of availability, of ultimately constrained water resources bounded by limited supply and rising demand, the similarities between the governance challenges faced by the NSAS and Ganges-Brahmaputra Delta are more apparent. First, like many large, transboundary water systems, both are shared by states that have considerable distrust and suspicion of each other. Both are in regions where water is considered to be a national security issue. Perhaps the greatest similarity, though, is the lack of information sharing among riparians. This is not always the fault of poor communication. In the case of the NSAS, the main problem is a lack of data.

The NSAS project has created a centralized database for sharing information about water quality, depth, flows, and other relevant data that could help the four riparian countries better understand the aquifer. The usefulness of this database is diminished by the fact that no one knows exactly how much water is there and what kind of future projects might be planned to exploit it. Estimates of how long the aquifer could last run anywhere from 20 to 200 years.[*] Growing demands on water and climate pressures will likely lead all four riparians to want to exploit it to the fullest extent possible, but when or how this will be done, and what kind of political, social, and economic situations will compound any conflicts that may arise, is something that needs more analysis.

In the case of the Ganges-Brahmaputra, where India and Bangladesh are already exploiting the water beyond its renewal capacity, the problems are both the withholding of important information and a lack of basin-level cooperation on data sharing. Bangladesh, as the direct downstream riparian of India, is reliant on its neighbor for information on upstream flow volumes in order to predict flooding and prepare for drought. While the two countries have data-sharing arrangements, these apply only when the water reaches a certain level (1 meter below the danger level). It has been suggested that there should be continual monitoring of water levels, with information transferred to Bangladesh at regular intervals.[12] Even this would not provide sufficiently complete information, because the rivers do not originate in India. A basin-level effort to coordinate monitoring of flow levels from the other riparians—Bhutan, China, and Nepal—would be necessary for this to occur. Currently, no such regional organization exists, and there are no plans to form one.

[*] The Man Made River was built to last of 50 years, a standard lifespan for this kind of infrastructure (Masahiro 1995).

While the lack of complete information and data-sharing cooperation are serious obstacles, the greatest governance challenge in the region is the lack of understanding of the global implications of water resources. A closer look at the NSAS demonstrates the dangers of ignoring the bigger picture.

What Is in Store for the Nubian Sandstone Aquifer?

The NSAS is like a shimmering underground oasis that is still relatively untapped and used nowhere near its projected potential. In a time when water scarcity has become an issue of global concern, its value is increasing. However, it does not garner much attention outside the small circles that specifically study groundwater, and very little information is available as to how and when its riparian countries plan to begin exploiting it on a large scale.

Its projected use may be estimated based on current developments in the region. The NSAS underlies four of the most water-challenged countries in the world. The International Water Management Institute estimates that by 2025 Egypt and Libya will suffer from physical water scarcity (when the water used in a country exceeds 60 percent of its usable supplies), and Chad and Sudan will have severe economic water scarcity (when there is enough water, but lack of capacity, infrastructure, and/or governance to deliver it equitably).[13] Two of these countries, Egypt and Sudan, also share the Nile. The original treaty governing the allocation of the Nile, which flows through 10 countries, states that the river belongs to its two most downstream riparians, Egypt and Sudan. For the past decade, the 10 riparian countries have been negotiating the Nile River Basin Cooperative Framework Agreement through the Nile Basin Initiative. These negotiations were recently concluded, but there are still disagreements among the states.[14] Egypt, in particular, is famously insecure about its water rights, to the point of positing its defense of these rights in the language of war.[15] Most famously, then-president Anwar Sadat said in 1979 that the only issue that would cause Egypt to go to war again was water.

While the nine upstream Nile Basin countries do not currently use enough of the river's water to threaten Egypt's downstream flow, fast-growing populations and increasing water scarcity could change this. The already contentious issue of the Nile could well become a source of conflict, even if the cooperative framework agreement proves fairer than the old treaty. Both Egypt and Sudan will most likely look to their copious underground water supplies to relieve some of the pressure of the situation. Chad, with its own growing population and scarce surface water supplies, will not be far behind.

There is another factor that will make the NSAS a very attractive option for its four riparian countries: the goal of agricultural self-sufficiency. Libya, subject to embargoes for decades, has made no secret of the fact that its Man Made River exists to help it grow enough food to eliminate dependence on imports. Choosing to exploit groundwater rather than build desalination plants was also based on a desire for self-sufficiency, as desalination is reliant on foreign technology.[16] While experts in and out of Libya agree that agricultural self-sufficiency is not feasible, even if the Man Made River were run at full capacity, it remains the principle on which the country justifies the US$27 billion spent on an infrastructure project with an estimated lifespan of only 50 years.[17] Agricultural self-sufficiency is more than a matter of national and human security. Having the capacity to feed its citizens is widely perceived as a measure of a developed country. Sudan is currently working toward this still very far-off goal, and, like Libya, plans to make use of the NSAS to do it.[18]

Because no one knows how long the NSAS will last if all four riparian countries begin to exploit it on a large scale, and because of the lack of international consensus on how shared groundwater should be managed and governed, this is an insecure situation at best. However, even if the riparians continue to cooperate through a basin-level organization, there is an additional complicating factor. The NSAS demonstrates that fossil groundwater can be transnational in more than one way. Physically, it is shared by four countries. In terms of its possible uses and who will benefit from its water, it is shared on a global scale among countries that are not physical riparians.

Many countries around the world have given up on agricultural self-sufficiency because they lack either sufficient water or land and are looking to countries rich in both to feed their citizens. Sudan is large and could significantly increase its arable land if it exploited the NSAS.[19] Countries as diverse as Saudi Arabia and South Korea have been courting Sudan with an eye to exploiting its rich land and water resources.[20] Much as foreign companies gain rights to mine in countries with copious minerals, Saudi Arabia and others hope to develop wheat fields abroad and have control over the growing, harvesting, and export/import processes. Naturally, Sudan will benefit from the arrangement, and, for a cash-strapped, conflict-ridden country, the scenario probably has its attractions. Indeed, Sudan advertises opportunities for agricultural investment on its overseas embassy websites.[21]

This challenges the concept that agricultural self-sufficiency refers to food grown inside a state's sovereign boundaries, and brings up a host of legal and governance issues that will mean rethinking how shared water resources are viewed. Who "owns" the water that will be used to irrigate these fields? Does Saudi Arabia have an exclusive use right to the amount of water it needs, even to the detriment of Sudan's own citizens—or those of the other riparian countries? How will Chad, Egypt, and Libya react to Sudan exporting their shared fossil water in this way (crop exports/imports are often called "virtual water"), when there is no current treaty that specifies each country's share? Does the NSAS "belong" to its four riparian countries, or to any entity with the desire and means to exploit it?

These are only some of the questions in need of further exploration. They challenge deeply rooted conceptions of water resources that states are only beginning to examine through practices such as integrated water resource management. Such practices go against the traditional water management paradigm that posits natural resources as a matter of sovereignty. However, the future of the NSAS itself is easy to predict. Eventually the water will run out. And long before that happens, dropping water levels will likely make mining it prohibitively expensive. Saudi Arabia, one of the countries now looking to exploit it, ironically offers the best example of how fossil water can disappear, and over a relatively short period of time. In the 1970s, Saudi Arabia also had a goal of wheat self-sufficiency, and mined its nonrenewable groundwater to create oases in the desert. By 1984 it had achieved its goal and was using groundwater to meet 75 percent of its water needs. In fact, for a while, it was one of the world's top wheat exporters.[22] Not 30 years later, much of its groundwater is gone or has become so polluted and salty from overpumping that it is no longer suitable for irrigation.[23] Now Saudi Arabia is looking beyond its boundaries for water, and is joined by a growing company of similarly land- and water-scarce states.

Toward an Integrated Understanding of Water Resources

The underlying themes of all water resource discussions, especially now that climate change is an accepted phenomenon, are scarcity and sustainability. As examined earlier, even so-called "renewable" water resources, such as the Ganges and Brahmaputra that flow into Bangladesh, are limited and do not always supply what is needed. It is necessary to begin considering all water as if it were nonrenewable and to adjust management strategies to encompass a more holistic view of water resources.

This will require integrating what are currently seen as separate types of water resources—surface and ground—under one water management scheme. Here India's and Bangladesh's national water plans, which stress the interconnectedness of the Ganges and Brahmaputra to underlying aquifers, are a good place to start. However, countries that have confined groundwater that is not physically connected to its surface water resources, such as Egypt and Sudan, also need to understand that these resources have interdependent uses. Although fossil water can never be used sustainably—even with careful management, it will not last forever—its life can be extended if used in tandem with surface water resources.

It is also necessary to recognize that water is no longer just a national or regional issue. As Saudi Arabia's and other countries' interest in the NSAS demonstrates, freshwater resources are of global interest, and should also be of global concern. This is the case for the Ganges-Brahmaputra Delta, whose headwaters are in Tibet. China, like Saudi Arabia, has overexploited its fossil water reserves, particularly the deep aquifer under the North China Plain. Pumps in the area must now drill down over half a mile to access water, a process that is too expensive for most farmers.[24] China is considering diverting water from the Brahmaputra River in the south to irrigate its northern farms.[25] If this plan is carried out, India's and Bangladesh's water supplies will be profoundly affected. Recognizing linkages between water resources separated by thousands of miles and several sovereign borders—and particularly between fossil groundwater and surface water systems—is necessary to truly commit to sustainable practices.

Conclusion

Without understanding that groundwater is an integral part of the global water supply, there is a risk it will be exploited on a scale similar to rivers in the last century. The era of large, ecologically indifferent infrastructure to "push rivers around"[26] is indeed still alive and well in many parts of the world. Fossil groundwater, invisible, not well understood, and finite, is especially vulnerable to this exploitative paradigm.

Much research has been devoted to the concept of using water management as a way of encouraging cooperation among states. Indeed, it has been argued that states are much more likely to cooperate than fight over shared water resources.[27] While collaboration is encouraging, it is not enough to simply cooperate. The goal of sustainable use must define water management in the coming decades. It has been shown that sustainability can function as a framework within which cooperation is possible.[28] However, without moving beyond dichotomous concepts such as renewable versus nonrenewable, and surface water versus groundwater, managing for sustainability will be similarly constrained.

To an end user, it matters little whether the water comes from a surface source or from underground; the main concern is that it be plentiful and clean. All types of water in a given system, such as a country or region, form a totality of that system's water resources and should be managed together to ensure that use is equitable, ecologically responsible, and sustainable. Equally important is acknowledging the links among seemingly unconnected water resources. Recognizing the wide-ranging global implications of water use is the next step in creating wise governance of the planet's freshwater reserves.

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25. R. Hodum, "Conflict over the Brahmaputra River between China and India," American University ICE Case Studies, No. 205 (Washington, DC: American University, 2007).

26. K. Conca, *Governing Water: Contentious Transnational Politics and Global Institution Building* (Cambridge, MA: MIT Press, 2006), p. 18.

27. In particular, A. Wolf at Oregon State University has extensively researched this topic. Also see I. van der Molen and A. Hildering, "Water: Cause for Conflict or Co-operation?," *Journal on Science and World Affairs* 1(2) (2005): 133–43.

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