Atlantic Council
SCOWCROFT CENTER
FOR STRATEGY AND SECURITY

Ecology Meets Geopolitics

WATER SECURITY IN HIMALAYAN ASIA

by Peter Engelke and David Michel

Atlantic Council

SCOWCROFT CENTER
FOR STRATEGY AND SECURITY

The Scowcroft Center for Strategy and Security works to develop sustainable, nonpartisan strategies to address the most important security challenges facing the United States and the world. The Center honors General Brent Scowcroft's legacy of service and embodies his ethos of nonpartisan commitment to the cause of security, support for US leadership in cooperation with allies and partners, and dedication to the mentorship of the next generation of leaders.

Ecology Meets Geopolitics

WATER SECURITY IN HIMALAYAN ASIA

Cover image: Riccardo Pravettoni/GRID Arendal

This report is written and published in accordance with the Atlantic Council Policy on Intellectual Independence. The authors are solely responsible for its analysis and recommendations. The Atlantic Council, its partners, and funders do not determine, nor do they necessarily endorse or advocate for, any of this report's particular conclusions.

Atlantic Council
1030 15th Street NW, 12th Floor
Washington, DC 20005

ISBN-13: 978-1-61977-583-1

March 2019

by Peter Engelke and David Michel

Contents

Foreword

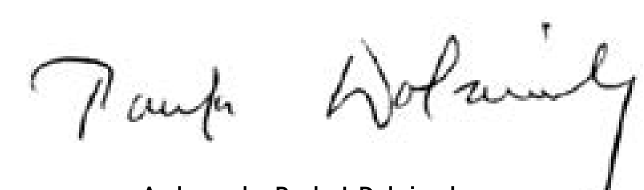
Life is difficult, if not impossible, without consistent access to clean water. Yet unfortunately, too many societies around the world face life without it, a bleak reality that for many threatens to become worse during this century. Swiftly rising global demand for water, increasingly tight supplies of it, and the stresses presented by a rapidly changing planet all are combining to push societies into new and uncomfortable territory. The risk is that water insecurity will lead to violent conflict within societies or across international boundaries. The nightmare scenario, indeed the one we all fear, is that such conflict will involve the world's major powers.

There are few regions in the world where water insecurity has as much consequence as it does in Himalayan Asia, a term delineating the vast swath of the continent dominated by Asia's high mountain ranges and the rivers that flow from them. Those mountains, including the Himalayas, produce much of the fresh water that nourishes billions of people across East, Southeast, South, and Central Asia. Rapid population and economic growth in those regions are placing enormous stresses upon fresh water sources. Himalayan Asia's rivers in turn are experiencing complex hydrological changes arising from both direct and indirect human intervention. Geopolitical competition, including among distrusting nuclear-armed rivals, provides an unsettling backdrop to Himalayan Asia's water challenges.

This study is the culmination of nearly two years' work conducted by the Atlantic Council's Scowcroft Center for Strategy and Security. Through a generous grant from the Smith Richardson Foundation, and in cooperation with the US Water Partnership, the authors of this study embarked on an intensive exploration of the water security challenges in Asia. Their research, which involved travel to the region, expert interviews, and desk study, focuses on the intersection between Himalayan Asia's changing ecology and the dynamic competition for geopolitical leadership among its major powers.

The Scowcroft Center's mission is to develop non-partisan strategies to address the most important security challenges facing the United States and the world. These strategies are informed by the Center's strategic foresight and risks analysis capability, which enables it to produce world-class, forward-looking analyses of global and regional trends. This study is fully in keeping with the Center's mission.

I hope that you find this report to be as rewarding a read as I did, that it will help you better understand this complex topic, and that it will ultimately inspire you to help lead the way in finding solutions to this critical challenge.



Ambassador Paula J. Dobriansky
Former Under Secretary of State for Global Affairs (2001–2009);
Board Director and Member of the Executive Committee, Atlantic Council;
Vice Chairman of the National Executive Committee, US Water Partnership

Executive Summary

Himalayan Asia is a shorthand term referring to the Asian countries that depend on river water from the high mountain ranges of the Tibetan Plateau. As the rivers produced by the Himalayas and other mountain ranges on the Plateau are under increasingly serious pressure, water insecurity threatens much of the continent's peace and security. Himalayan Asia's transboundary water dynamics threaten to erode interstate cooperation, including among the continent's major powers, risk worsening geopolitical competition, and heighten the odds of domestic and interstate conflict. Yet there are viable pathways for avoiding such outcomes, the most important of which treat water as a shared resource to be managed cooperatively.

Himalayan Asia: Water Overview

At the center of Himalayan Asia are the Hindu Kush-Himalayas, Pamir, Karakoram, and Tian Shan mountain ranges. Often collectively referred to as Asia's 'water tower,' these mountain ranges contain the world's largest amount of ice and snow outside of the two poles, and in turn are the source of Asia's most important rivers, including the Mekong, Indus, Amu Darya, Ganges, Brahmaputra, Irrawaddy, Yellow, Yangtze, and Salween rivers. Billions of people living in China, India, Pakistan, and other Asian states depend on them for their fresh water.

Most of the water tower's major rivers traverse multiple countries, several across contested national boundaries. The rivers face stresses arising from both water demand and supply. On the demand side, Asian water use is increasing, owing to rising population, greater agricultural production, increasing urbanization, rising industrial production, intensive dam-building, and much more. Many of the rivers face multiple such factors. The water tower and its rivers also face an uncertain supply-side threat arising from climate change. A warmer climate is melting the water tower's 54,000-plus glaciers that are the source of its rivers. A warmer climate also will shift precipitation patterns. These changes, plus higher temperatures, will have significant impacts on agriculture, settlements, fisheries, energy production, and more across Himalayan Asia.

There are four regions in Himalayan Asia: East Asia, Central Asia, South Asia, and Southeast Asia. Because China controls the Tibetan Plateau, it contains the headwaters of transboundary rivers that stretch across all four regions. These rivers include the Indus, Brahmaputra (known as the Yarlung Tsangpo in China), Mekong (Lancang in China), Salween (Nu in China), Irtysh, and Ili rivers.

Within **East Asia,** China has a limited water supply, a gargantuan water demand, and a severe internal water imbalance between its drier, thirsty north and wetter south. On the demand side, China's booming economy and expanding population have placed its surface and groundwater sources under extreme pressure. On the supply side, China has been one of the world's foremost devotees of gargantuan water projects. Water quality is a serious problem within China.

China, Russia, and Mongolia share the Amur River basin, with much of the river's main channel forming the boundary between Russia and China, a rarity for China in that it is not in a commanding upstream position. China supports more hydroelectric dams and other infrastructure along the Amur's main channel, which Russia has resisted to date.

Central Asia, which includes Kazakhstan, Tajikistan, Kyrgyzstan, Turkmenistan, and Uzbekistan, has a limited and variable water supply. The Syr Darya, Amu Darya, Irtysh, and Ili rivers run through semi-arid landscapes before draining into several internal lakes.

Mountains in the Tian Shan range, Kyrgyzstan. The Tian Shan range is one of several high-altitude mountain ranges within Asia's water tower.

THOMAS DEPPENBUSCH/FLICKR

On the supply side, the region's high mountains are warming faster than the global average, producing greater variability in water supply. On the demand side, Central Asia's ecology has been under threat for decades, extending back to the Soviet Union's decimation of the Aral Sea.

The Central Asian republics live within a competitive energy-versus-water tradeoff that the Soviets created. Diplomatic agreements have not proven strong enough to overcome divergent national interests. There is little interest in tackling the Aral Sea's fundamental problem, which is that the level of cotton production robs the lake of the water necessary to sustain itself.

South Asia faces severe water-related challenges including declining per capita water resources, large and growing populations, a dependence on irrigated agriculture, low water use efficiencies, and poor water management.

South Asia's transboundary water resources consist of two major river systems, the Ganges-Brahmaputra-Meghna and Indus systems, plus large aquifers. These water resources are under increasing stress. Together, the six countries in South Asia (India, Pakistan, Bangladesh, Afghanistan, Nepal, and Bhutan) have a population of 1.8 billion people, many of whom are poor, making food security a massive challenge. Agriculture faces competition from the energy sector and cities. Water pollution is a major problem. Coastal flooding and saltwater intrusion into groundwater sources is a growing challenge, as are changing sedimentation patterns.

South Asia is beset by intense bilateral rivalries between its major powers (India and Pakistan on the one hand, China and India on the other) as well as between the major and minor powers. Unresolved border disputes, longstanding historic grievances, and geopolitical competition have led to the securitization of water.

Southeast Asia is defined as all countries within the two major transboundary river basins, the Salween and Mekong basins, which are the most important sources of surface fresh water in Southeast Asia (aside from the Irrawaddy River, which lies almost entirely in Myanmar).

Southeast Asia's water politics is about electricity versus food. The Mekong and Salween rivers are among the world's most biologically productive. At the same time, both rivers are attractive for hydroelectric development, and several governments are eyeing them for hydroelectric dam construction. The primary controversies involve dams that are planned or under construction from Laos and Myanmar southward. The most controversial of these are in Laos.

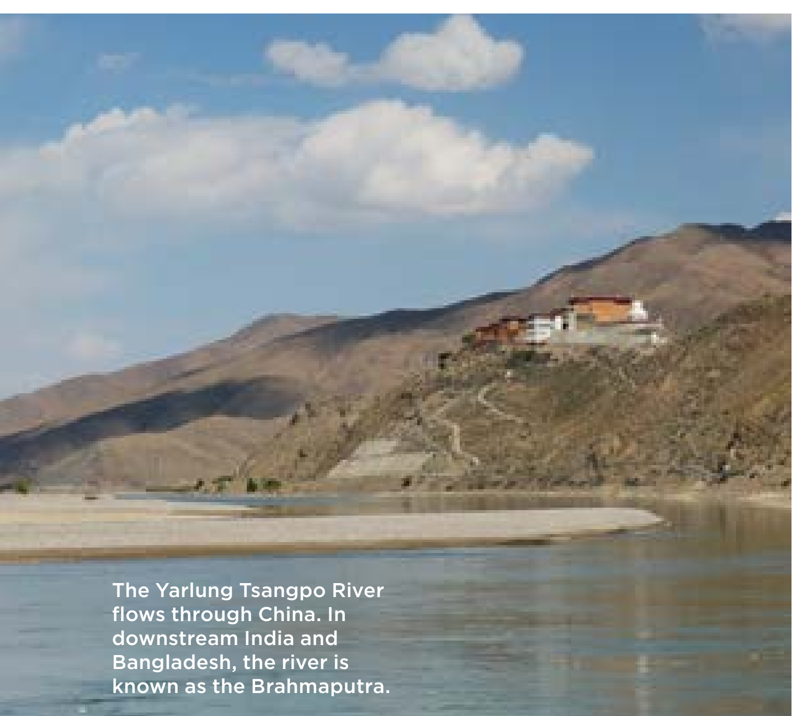
Multilateral instruments to manage transboundary river conflicts have proven largely ineffective. The Mekong River Commission (MRC) has been unable to contain divergent national interests. In keeping with its reluctance to enter multilateral forums not of its own making, China has refused to both become a member of the MRC and negotiate jointly with Myanmar and Thailand concerning the Salween River. In 2016, in what was widely interpreted as an attempt by China to increase its influence across Southeast Asia, it created the Lancang-Mekong Cooperation Mechanism, a regional organization designed to expand cooperation in the region.

Water and Geopolitics in Himalayan Asia

Water contributes to Himalayan Asia's complex geopolitics while being subject to the continent's many geopolitical divisions. Hydrologically, China is upstream of nearly everyone else, giving it a commanding position. Other countries also enjoy upstream positions (India, for example, is upstream of Pakistan and Bangladesh). This hydrological asymmetry is matched by geopolitical asymmetry, with China possessing outsized power.

China's predominant diplomatic inclination is to refuse participation in multilateral forums surrounding transboundary water use, instead preferring bilateral economic diplomacy, much through its Belt and Road Initiative (BRI). Unfortunately, the BRI's overall lack of transparency makes it difficult to divine the role that water investments play in China's plans.

China and India compete indirectly for influence among their South and Southeast Asian neighbors, with transboundary waters occasionally part of the mix. They share one critical river, the Brahmaputra River (the Yarlung Tsangpo in China). India's existential fear is that China will someday divert the river northward. China also views India's intentions through a national security lens, seeing threats in Indian plans to dam the Brahmaputra's tributary rivers in Arunachal Pradesh, a contested territory. India and China have no formal mechanisms for resolving their disagreements over the Brahmaputra/Yarlung Tsangpo.



The Yarlung Tsangpo River flows through China. In downstream India and Bangladesh, the river is known as the Brahmaputra.

ANDREW AND ANNEMARIE/FLICKR

Hydro-diplomacy is central to the bilateral relationship between India and Pakistan. The Indus Waters Treaty (IWT) has survived the many down periods in Indian-Pakistani relations intact. But the IWT falls well short of being comprehensive and malleable enough to deal with novel challenges such as climate-driven changes in Indus water levels. The deep wells of distrust and suspicion within both countries about the other's motivations and behaviors continue to strain relations over the Indus.

In Central Asia, rivers are part of a complex geopolitical landscape consisting of suspicion-fueled rivalries and major power competition for influence. The central disputes involve the region's most important rivers, the Syr Darya and Amu Darya, pitting the three downstream republics (Kazakhstan, Uzbekistan, and Turkmenistan) against their upstream neighbors (Tajikistan and Kyrgyzstan). Of Asia's major powers, Russia and China are currently the most active in influencing Central Asian affairs.

Himalayan Asia's many water disputes are made worse by low trust among riparian states. China, India, and Pakistan all lay claim to overlapping pieces of territory running along the mountainous regions that the three countries share, and that form important portions of their transboundary watersheds. These claims are part of emotionally fraught and historically laden disputes. Overlaid against these worries are perceived threats to their national sovereignty and territorial control. It is easier politically to define water problems as coming from outside national boundaries. Invoking the external threat is a tried-and-true method for politicians to deflect away from domestic criticism, particularly in those parts of Himalayan Asia where such messaging finds ready audiences. These motives are buttressed by utilitarian mindsets that predispose national governments toward unilateral river use and away from joint river management.

Water and Security in Himalayan Asia

Across much of Himalayan Asia, water has become part of a geopolitical chess match, viewed as an asset to be protected against encroachment by one's international rivals and/or as a lever for influencing rival states. Securitization leads states to adopt inflexible, hardline positions vis-à-vis their neighbors while discouraging them from looking inward at their own vulnerabilities. Securitization can play into the hands of politicians who use their domestic constituencies' fears and grievances against constructive solutions, via pointing to their rivals' water-threatening behavior, which is frequently more imagined than real.

Broadly speaking, there are two sets of fears when it comes to water and its relationship to security: the water wars hypothesis and the spillover hypothesis. The water wars hypothesis claims that as states exist in a zero-sum competition for scarce water resources, they are willing to go to war to prevent others from taking their share of transboundary water resources. The water war narrative makes for compelling reading, but there is no evidence of interstate water wars during our own time or in the past, whether in Himalayan Asia or anywhere else.

The spillover hypothesis refers to the risk that increasing water scarcity and/or variability will undermine domestic stability, in turn spilling over into the international arena. The logical pathway is: rising water scarcity and variability in water supply, combined with poor water governance, creates domestic water insecurity, which causes a series of destabilizing effects including rising food insecurity, migration, and rising subnational tensions among different groups up to and including violence among those groups; ultimately, these effects begin to spill over into the international sphere through various pathways, including out-migration. Under the worst-case scenarios, water insecurity contributes to the breakdown of vulnerable societies, resulting in civil conflict and its transmutation to surrounding states.

As domestic water disputes and conflicts are already common in Himalayan Asia, one can forecast scenarios in which water insecurity at the domestic level bleeds into the international one through blame-shifting processes (where politicians blame outsiders, including foreign governments, for water stresses) and grievance politics that brings water issues together with territorial control, ethnic and religious identity, and historical animosity.

Three Big Questions (and Some Recommendations)

1 What are the risks of conflict over transboundary waters in Asia?

Whereas interstate warfare over water is unlikely in the short run, there is more risk of violent conflict over the longer run, given the intense supply-versus-demand squeeze underway. Experts believe there is considerable risk of domestic conflict over water and fear that it will bleed outward into the international arena, in the form of out-migration, blame-shifting of neighbors, and more. Absent hydro-diplomatic breakthroughs, there is a high risk that transboundary water will become an even greater source of tension and competition among geopolitical rivals in Himalayan Asia.

Better governance at both the international and domestic levels is essential. Sharing data and coordinating policy with a neighbor—for example on flood warnings and climate risks—can help manage domestic resources and mitigate one's own risk exposure to transboundary stresses. And better management of domestic resources can help lessen the potential impacts of vulnerabilities to international risks while mitigating the domestic stresses that might generate spillover instability.

Technology alone will not save the day, but new technologies will be critical to help solve Himalayan Asia's water challenges.

Improved data and monitoring can improve tracking and understanding of hydrological conditions. Although water data is often treated as a state secret, that condition is swiftly being eroded given technological changes in remote sensing and other areas. More broadly, civil society can help develop more effective subnational, national, and transboundary water management.

At the international level, Himalayan Asia's transboundary water management regimes need strengthening. Instead of trying to create new comprehensive basin-level treaties from scratch, a better strategy might be to build from the bottom up. Such efforts might focus on negotiating parts of the larger basin puzzle, for example through negotiating a resolution to a controversial dam. Success would serve as a trust-building exercise that then would enable additional negotiations. Expanding hydro-diplomatic engagement through better use of 'Track 1.5,' 'Track 2,' and 'Track 3' approaches has proven effective in building knowledge and trust within the Brahmaputra basin.

2 Will technology save the day?

Technology alone will not save the day, but new technologies will be critical to help solve Himalayan Asia's water challenges.

Desalination is a proven technology that can increase the supply of fresh water in coastal regions.

Although some countries such as Israel have overcome water scarcity through desalination, replicating its experience will be difficult, if not impossible, elsewhere. Despite decreasing costs, desalinated water remains expensive, making it useful for municipal drinking water and commercial and industrial purposes in coastal areas, but not for agriculture. Desalination should be one piece of a comprehensive solution set for Asia's water challenges.

There are promising agricultural technologies in existence, in development, or on the horizon. As Asian agriculture is the most heavily irrigated in the world, making it more water efficient is imperative. Only a small fraction of all irrigated land in Asia is fitted with drip irrigation technologies, as smallholding farmers have proven reluctant to adopt and maintain them. Many water experts are excited by advances in remote sensing technologies, which have enormous power to assist in agricultural production, including the more efficient use of water, down to the farm level and in real time. Agricultural biotechnology also stands at the cusp of breakthrough innovation. Advances in genomics and genetic engineering are allowing scientists to understand plant genetic patterns to improve crop performance yield. There is considerable optimism that seeds that perform well under water scarcity or higher temperatures will be developed over the coming decades.

Regarding the water-energy nexus, decoupling energy production from water use is critical. Scaling renewable energy sources should be a centerpiece of Asian countries' energy strategies. Economic and financial trends are increasingly important in driving the shift to renewables. China is driving much of the downward pressure on renewable energy prices. There is also considerable risk that long-run returns on big hydroelectric dam investments will not pay off. From the climate side, for example, the risk is greater uncertainty on river water levels.

3 What should the United States do?

The United States is the external superpower in the Asian geopolitical context. If the United States plays to its many strengths, it can maintain and even augment its leverage within Himalayan Asia. With an eye toward the big picture, this report offers some recommendations:

→ A. Define water's place within the context of US strategic interests in Asia

The first step is to **create a coherent US government strategy toward Asia incorporating water as a pivotal element.** For the United States, an important part of the strategic challenge is preventing water from contributing to both state fragility (the spillover hypothesis) and international conflict (the water wars hypothesis). Both of those outcomes would undermine every other US strategic objective in Asia.

The US government should deepen its understanding of the linkages between water and its strategic objectives, in Himalayan Asia and elsewhere in the world, and articulate those linkages in its top-level documents. A clear objective should be **the inclusion of water security into the National Security Strategy (NSS) and other strategy documents at the highest levels of governance** (e.g., the Quadrennial Defense Review). A related objective would be **to direct the Office of the Director of National Intelligence (ODNI) to regularly update its Global Water Security assessment** (ODNI cannot do so on its own, it must be directed to conduct such assessments). Doing so would send the clearest signal to United States' partners and allies, and to US government departments and agencies, that water security is treated as a strategic priority at the highest level of the US government. Water security is a non-partisan issue, and easily could become a standard component of future strategic documents, including the NSS, across administrations.

Moving goods on the Mekong River in Vietnam. The Mekong serves as a fishery, transportation artery, irrigation source, and power generator all at once.

OPPOSITE PAGE: DANIEL MENNERICH/FLICKR;
THIS PAGE: DOCUMENTATION CENTER OF CAMBODIA (DC-CAM)/MAKARA OUCH/FLICKR

→ B. Craft a compelling vision around water in Asia

An important task will be to **craft a compelling vision for how the United States can assist Himalayan Asian states in solving their water challenges.** A compelling vision about water, including how the United States can help solve water-related challenges in Himalayan Asia, would provide an opening for the United States to reassert its global water leadership. A starting point would be to **create or commission a high-level report specifying exactly how the US government and its partners should organize its efforts around water to achieve its strategic goals in Asia.** That document should: describe how increased water security contributes to societal resilience; emphasize that water is critical to sustainable development, inclusive prosperity, and cooperation in Himalayan Asia; stress that the United States can help Himalayan Asian states achieve water security through innovation, improved governance, and enhanced cooperation; and articulate how the US government should organize itself to best fulfill America's strategic goals.

With regard to how the US government organizes itself to fulfill its goals, if the United States is to be taken seriously as an honest broker in Himalayan Asia, it needs to show that it can do the hard work of **regional engagement, with a commitment to transparent multilateral diplomacy and building long-term regional dialogues and processes.** In the water context, the US foreign services do not have such a mission. That is one reason why water experts believe that water needs a more permanent and visible presence within the US government's foreign and security policy firmament. For several years, the US Agency for International Development (USAID) has had a global water coordinator and Office of Water, reflective of the dominance of federal spending on water supply, sanitation, and hygiene (WASH) programs. By contrast, funding for the government's hydro-diplomatic activities is woeful. To partially correct this imbalance, **a fully funded and staffed water office and global water coordinator position should be created within the State Department's Bureau of Oceans and International Environmental and**

A Cambodian farmer ploughs his field after flooding subsides.

Scientific Affairs, empowered with a long-range mission and equipped with interagency coordinating powers. Peer positions, focused on global water security, ought to be established within the US Department of Defense and National Security Council.

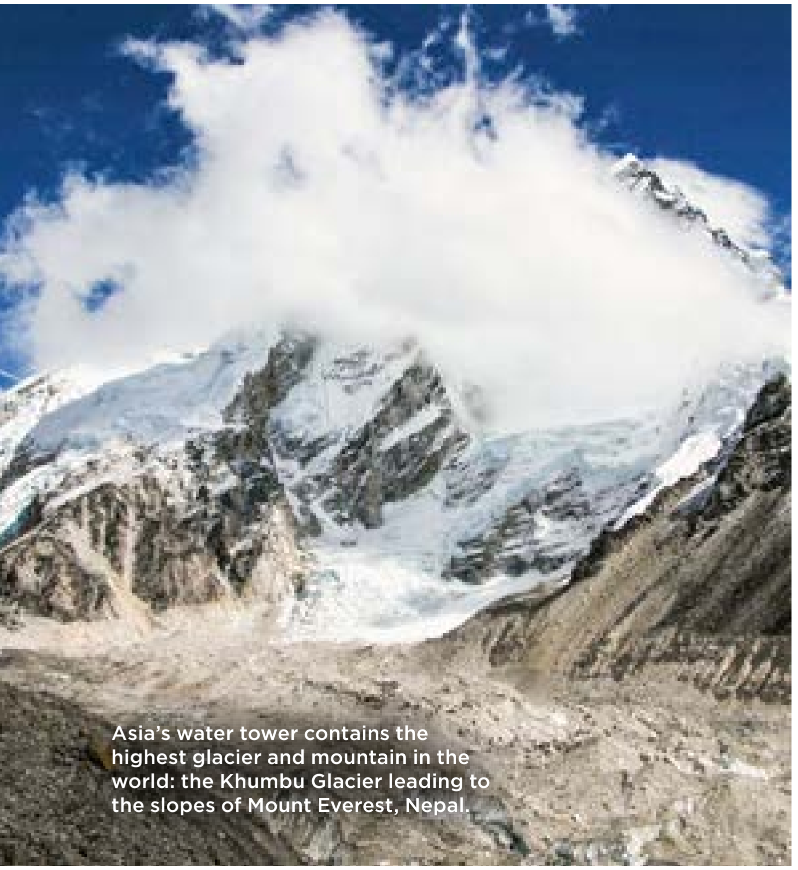
→ C. Work with key allies and partners around the vision

To make the connection between water and US national security, including the risks to US strategic goals in Asia, the **vision will need to be translated into thoughtful, well-articulated, well-planned, and fully fundable plans that can be implemented with allies and partners on the ground.** Ideally, the US government would develop long-range plans that would focus on a mix of policies and processes designed to increase societal resilience to water-related shocks. Capacity building, development of best-practice policies and infrastructural investment strategies, and diplomatic engagement on transboundary water resources would all be included. One key is to expand the definition of who qualifies as a partner. Subnational actors ranging from civil society groups to businesses to provincial governments to local farmers all are key to water-related outcomes. While the US government's foreign affairs departments and agencies engage subnational actors, the engagement is ad hoc. To improve, the US government should **create a fully funded and staffed office for subnational engagement in the State Department** to track interactions with subnational actors, devise strategies for engagement, and coordinate the government's diplomatic outreach.

Another practical step would be to **empower the US government's scientific agencies to: fully engage at the**

international level; ensure the international availability and distribution of their data; and develop partnerships with national and international agencies, the private sector, and civil society in the development of open source data tools that are tailored to end users including non-profits, agricultural extension services, disaster management agencies, and individuals (e.g., farmers). The US government's scientific organizations such as the National Aeronautics and Space Administration (NASA), US Geological Survey (USGS), and National Oceanic and Atmospheric Administration (NOAA) gather among the best and most comprehensive water data in the world. So too do many of its private-sector firms. The challenge is to find ways to have that data be used on the ground by people who make decisions about water use in Asia.

A related and important step would be to create an early warning system focused on predictions of water-related fragility. **The US government should, in coordination with academic analysts and international scientific organizations, develop an early warning of potential water conflict hotspots in Asia and elsewhere in the world.** The models here include the Famine Early Warning Systems Network (FEWSNET), a famine prediction service created in 1985 by USAID, and SERVIR-Himalaya, a Hindu Kush-Himalaya (HKH) satellite monitoring service created by the NASA and USAID in cooperation with International Centre for Integrated Mountain Development (ICIMOD, an intergovernmental organization based in Kathmandu).



Asia's water tower contains the highest glacier and mountain in the world: the Khumbu Glacier leading to the slopes of Mount Everest, Nepal.

WENZEL PROKOSCH/GRID ARENDAL

→ D. Protect Himalayan Asia's water tower

The United States should support the protection of Himalayan Asia's water tower—the HKH ranges, their ecosystems, and the rivers spawned by them. The water tower is the single indispensable feature of Asian geography, one that serves the collective interests of billions of people.

The Arctic Council is the appropriate model. The Arctic Council is an intergovernmental forum whose eight member states work cooperatively on common environmental and scientific challenges facing the Arctic region. Two of these member states are Russia and the United States, which despite being geopolitical adversaries have managed to cooperate on the Arctic.

The United States government should pick up this mantle and **support processes leading to the creation of an intergovernmental forum for the environmental and scientific stewardship of Himalayan Asia's water tower.** Those processes should mirror the processes that led to the creation of the Arctic Council in 1996. A similar permanent, legally established and recognized intergovernmental forum, like the Arctic Council, could be created for Asia's water tower. If the US government were to lead such an effort, its best play is to utilize its diplomatic strengths to **bring other nation-states, multilateral organizations, and civil society into a consensus-building coalition for the creation of precursor institutions and processes.** Those institutions and processes should follow the Arctic Council's template.

Given that the United States is not a riparian state, the US government should **support those multilateral, civil society, and scientific organizations that wish to lead this endeavor.** The purpose of such a forum would be to facilitate collective knowledge building and policy development among the HKH states. In advancing an HKH forum, the United States should **seek diplomatic support from other Arctic Council states that also are active in advancing hydro-diplomatic relations around the world,** including Sweden and Norway, plus Arctic Council observers Germany, the Netherlands, and Switzerland.

One additional and simple recommendation is to **create a special representative for Himalayan affairs** (or similar title) to coordinate the US government's efforts and facilitate the creation of an Arctic Council-like forum for the HKH region. This position should be placed within the Bureau of Oceans and International Environmental and Scientific Affairs, in keeping with the Arctic Council's institutional home at the State Department, and in keeping with the goal to establish an HKH body focused on environmental protection and scientific research.

SECTION I
Introduction

Himalayan Asia is a shorthand term referring to the Asian countries that depend on river water from the high mountain ranges of the Tibetan Plateau. As the rivers produced by the Himalayas and other mountain ranges on the Plateau are under increasingly serious pressure, water insecurity threatens much of the continent's peace and security. Himalayan Asia's transboundary water dynamics threaten to erode interstate cooperation, including among the continent's major powers, risk worsening geopolitical competition, and heighten the odds of domestic and interstate conflict. Yet there are viable pathways for avoiding such an outcome, the most important of which treat water as a shared resource to be managed cooperatively among a variety of actors, public and private, national and subnational. Without such leadership and engagement, there is significant risk of water insecurity becoming a self-fulfilling prophesy, wherein states securitize water and therefore define it in zero-sum geopolitical terms. That scenario has few, if any, positive outcomes.

At the center of Himalayan Asia are the Hindu Kush-Himalayas, Pamir, Karakoram, and Tian Shan mountain ranges. Often collectively referred to as Asia's 'water tower,' these mountain ranges contain the world's largest amount of ice and snow outside of the two poles, and in turn are the source of Asia's most important rivers, including the Mekong, Indus, Amu Darya, Ganges, Brahmaputra, Irrawaddy, Yellow, Yangtze, and Salween rivers. Collectively, these rivers extend across four Asian regions: Central Asia, South Asia, Southeast Asia, and East Asia. Billions of people living in China, India, Pakistan, and a dozen or more other Asian states depend on them for their fresh water, either entirely or in large part (groundwater also is an important source of fresh water in certain regions). Himalayan Asia contains by far the most critical sources of surface fresh water in all of Asia, and arguably the entire world.

Within Himalayan Asia, there are three principal reasons why the linkage between ecology and geopolitics is becoming increasingly important. The first is a rising gap between water supply and its growing demand. On the supply side, surface and groundwater sources are stressed across the continent. Climate change will reduce water supply in some critical sub-regions of the continent and increase the variability in that supply nearly everywhere. Moreover, water supplies are frequently heavily polluted. On the demand side, rising populations, especially in three major powers (China, India, and Pakistan), plus rapid economic growth have translated into rising demand for water for irrigation, industry, energy production, and municipal uses. This demand has led to overuse of the continent's surface water sources (rivers and lakes, primarily) and its groundwater. Absent widespread and significant improvements in water use efficiencies, the demand for water in Asia will continue rising through mid-century.

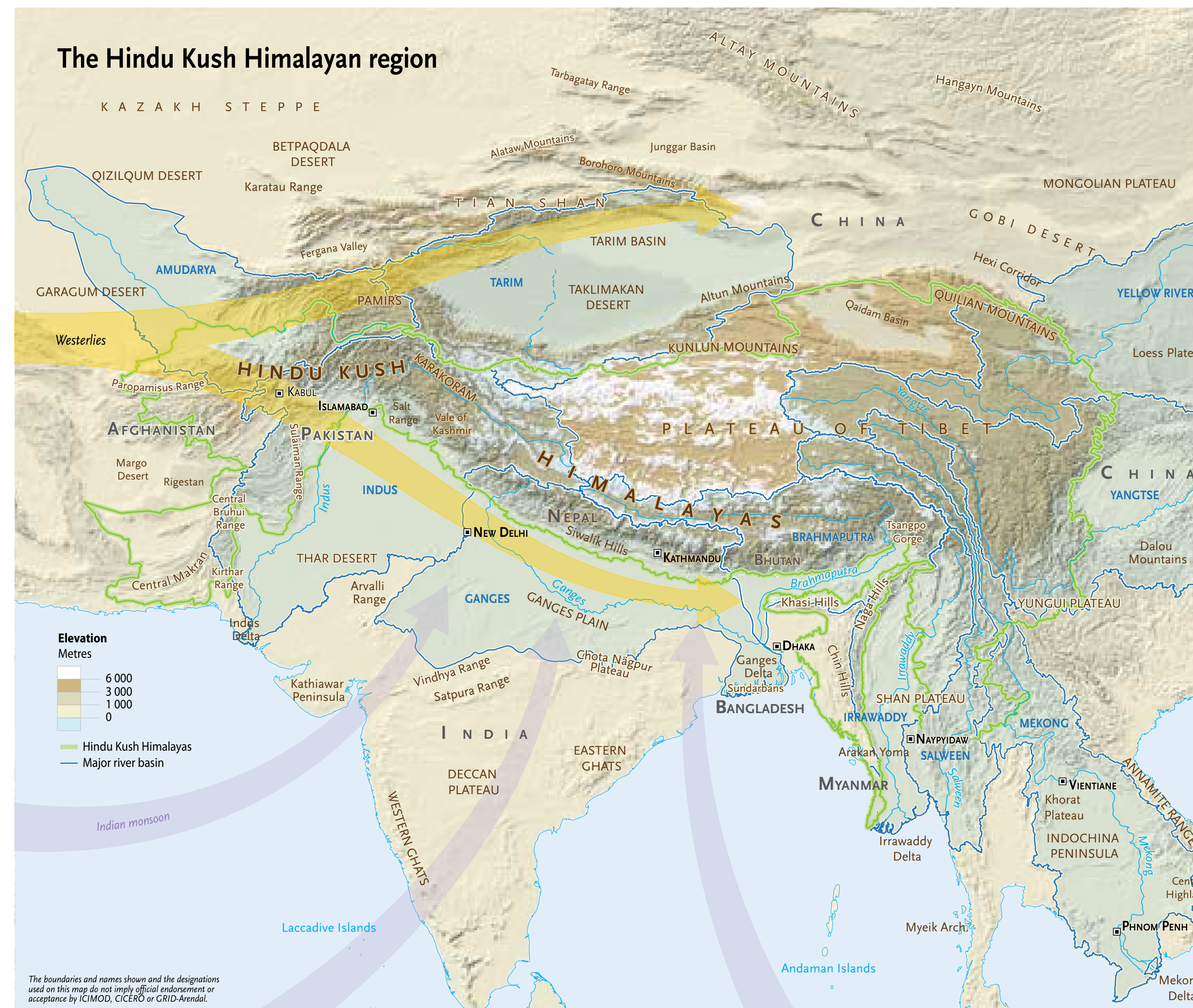
Second, water governance in Himalayan Asia leaves much to be desired. While this is painting with a broad brush—several Asian states, including Singapore, Japan, and South Korea, are generally regarded as highly competent at water governance—most of the countries within Himalayan Asia's major river basins generally face numerous, often severe, water governance challenges. The transboundary governance of water resources is in even worse shape. Himalayan Asia's transboundary rivers are poorly governed at bilateral and multilateral levels, with few robust treaties and institutions governing how transboundary rivers and their basins are used. Its transboundary aquifers are not governed by international agreement in any way, shape, or form.

Finally, Himalayan Asia's geopolitical dynamics intersect with its water dynamics, creating a potentially dangerous nexus of challenges that must be managed through skillful diplomacy. Its geopolitical dynamics have a high potential to both fuel water insecurity across the continent and in turn be fueled by that insecurity, given the clash between water supply and demand plus poor water governance across much of the continent. Himalayan Asia is beset by a series of rivalries among its major continental powers, as well as among and between these powers and the continent's less powerful states. Those rivalries are fueled by historic grievances (e.g., the India-Pakistan dispute), by rapidly rising powers that are upending continental diplomacy (China is the most important of these), by competition for influence (e.g., China and Russia competing in Central Asia, and India and China in South Asia), and by unsettled territorial disputes in some the continent's most important water-producing regions (especially in contested mountainous territories between China, India, and Pakistan). All of these features of Asian geopolitics frequently lead to high levels of mistrust that both complicate the task of creating robust transboundary water management regimes while, conversely and at the same time, raising the odds that transboundary waters will become sources of competition or even conflict among the major powers.

The bottom line is that water is the world's single most precious natural resource, one of a tiny handful of physical goods necessary for every human activity. Although two-thirds of the Earth is covered in water, the vast majority—97.5 percent—is salt water. And only a small fraction of the remaining 2.5 percent of all water is available for human use in the form of surface water and groundwater (much of the world's fresh water is at the Earth's two poles). Therefore, any systemic changes to hydrological cycles threaten to upend complex and often delicate relationships between human and natural systems. This describes reality across most of Asia, where the combination of human interference in these systems plus climate-driven temperature and atmospheric changes are altering the timing and amounts of water that are available to societies, and to the fresh water ecosystems that undergird much human activity, such as fisheries.

Water insecurity is increasingly acknowledged as a threat to peace and prosperity. For years, the World Economic

▼ **The Hindu Kush Himalayan mountain ranges produce many of the rivers spawned by Asia's water tower.**



RICCARDO PRAVETTONI/GRID ARENDAL

Forum's global risks reports have ranked water-related crises to be among the most probable and consequential coming risks. Similarly, a 2012 US Intelligence Community Assessment of Global Water Security, a first for America's intelligence services, hypothesized that water problems will contribute to destabilizing key states around the world. "When combined with poverty, social tensions, environmental degradation, ineffectual leadership and weak political institutions," it argued, water insecurity will "contribute to social disruptions that can result in state failure." Such intelligence community assessments also anticipate that some states might leverage transboundary water resources to gain advantage over their neighbours. Multiple other institutions are focusing on this nexus of issues surrounding water insecurity, peace, and conflict, including the World Bank and United Nations (UN).

Report method and plan

THE FINDINGS IN THIS DOCUMENT RESULTED FROM A COMBINATION of desk research, interviews, and field study. Although the authors consulted hundreds of published documents, their insights were sharpened the most by input from dozens of experts, interviewed in person and by phone over the course of 2017 and 2018. All interviews were conducted off the record. The authors solicited the opinions of experts located in Asia, Europe, and North America, drawn from the public, private, and non-profit sectors, academia, and journalism. In addition, source material for this report also came from villagers living in Jammu and Kashmir state in far northern India. One of the authors had the good fortune to visit the Ladakh region as part of a Himalayan research trip for this report. While there, he interviewed several groups of villagers for their thoughts on local water challenges.

This report is organized into the following sections. Section II examines the water tower's evolving hydrology and its downstream effects, within the context of Asia's changing water dynamics. Section III provides an analysis of water and geopolitics, through an examination of how transboundary water resources intersect with the geopolitical interests and perspectives of major and minor powers in Asia. Section IV segues into a related conversation about the relationships between water and security. Finally, Section V asks three big questions about water and Himalayan Asia's future, providing recommendations for reducing the risk of water conflicts and improving the odds of cooperation over transboundary water resources. One of these questions is about the United States, its strategy, interests, and policies.

Two Special Sections, placed at the end of this report, explore several important topics for those readers interested in more depth. Special Section I explores Asia's water dynamics in greater detail, addressing water stresses across major sectors (agriculture, cities, and energy) and regions (South, Southeast, Central, and East Asia). Special Section II highlights several of Asia's "hot spots and blind spots," including: Asia's hydraulic mission; the Indus River; the Brahmaputra/Yarlung Tsanpo River; the Mekong/Lancang River; and the planned Rogun Dam. Each case illustrates one or more important themes outlined in this report.

NASA EARTH OBSERVATORY

NASA satellite image showing contrast between heavy snow and ice covering the Hindu Kush Himalayan ranges and downstream regions in South Asia, February 2005.

SECTION II
Himalayan Asia's Water Tower

Himalayan Asia's water tower is the most important source of fresh water in Asia, with its major and minor rivers providing water to billions of people north to south and east to west. The tower refers to the high-altitude regions that sit at the center of the continent and collectively act as a kind of water-generating engine for Asia. Because the tower's high mountain ranges contain vast quantities of ice and snow, they produce a long list of rivers, including the Mekong, Ganges, Brahmaputra, Indus, Salween, Amu Darya, Syr Darya, Ili, Irrawaddy, Yellow, and Yangtze rivers. Collectively, those rivers flow into every region of the continent except for West Asia (the region extending from Iran westward) and the Caucasus. Moreover, because these mountain ranges straddle China, India, Pakistan, and other countries with contested borders and regions, the water tower is itself a key part of Asia's geopolitical competition.

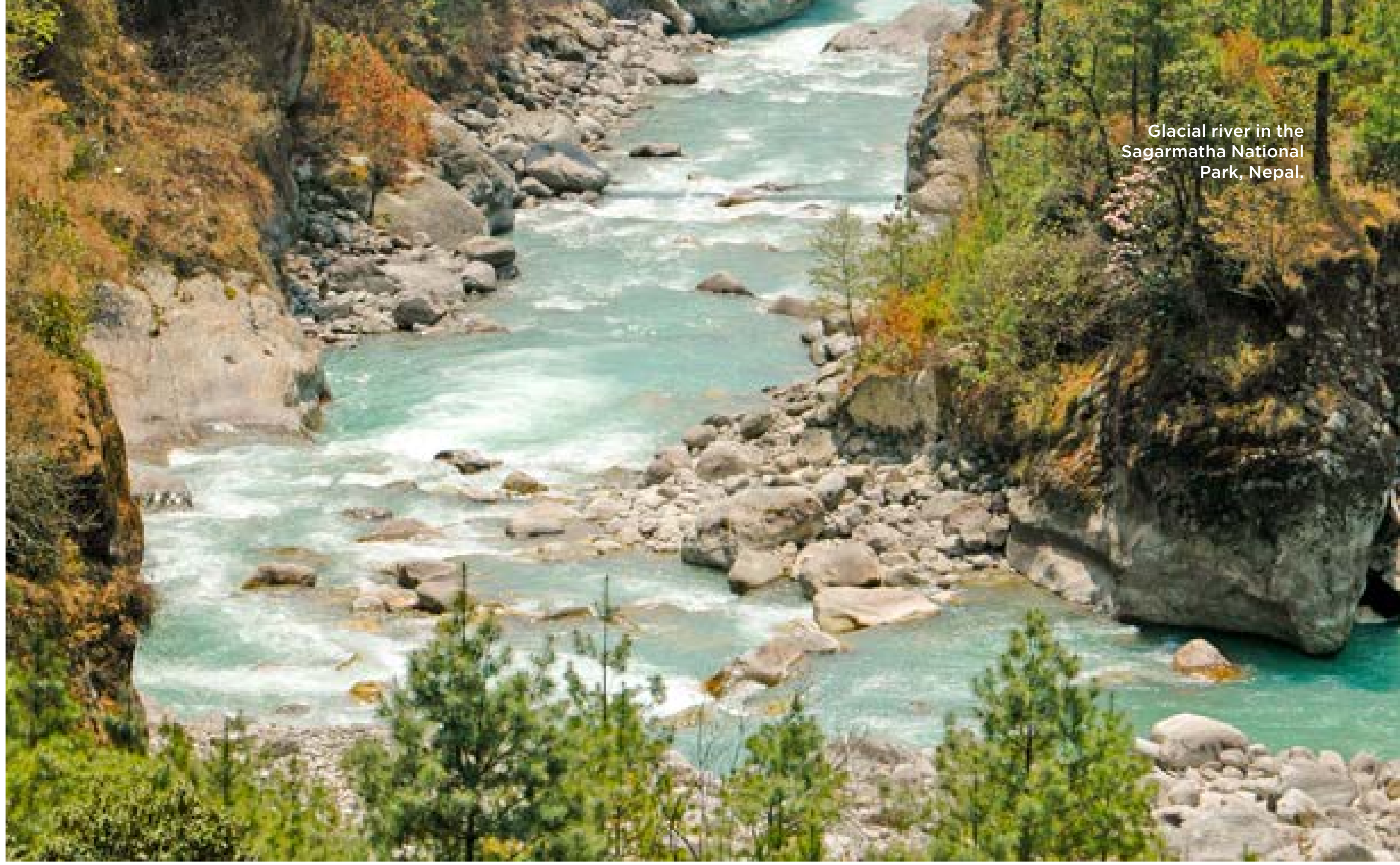
This section summarizes the central features of Himalayan Asia's water tower and the importance of the rivers that flow out of it. It also sketches the dynamics of water use across the continent, with attention paid to the transboundary surface waters produced by the water tower.

Although there is no precise definition of the mountain ranges within the water tower, for purposes of this report it includes the Hindu Kush Himalayas (HKH), Pamir, Karakoram, and Tien Shan ranges. The HKH ranges contain the tallest mountains on Earth, including Mt. Everest, and are the most heavily glaciated. There are more than 54,000 glaciers in the HKH ranges alone, giving them the third greatest concentration of ice on Earth after the two poles. Many of Asia's greatest rivers originate in the HKH mountain ranges, including the Mekong, Ganges, Brahmaputra, Indus, Salween, Amu Darya, Irrawaddy, Yellow, Tarim, and Yangtze rivers. The Tien Shan mountains lie to the north of the HKH ranges and are the source of the Syr Darya and Ili rivers. The only rivers included in this study that do not originate in what might be called the water tower proper are the Irtysh and Amur rivers. The Irtysh originates in the Altai mountains in western Mongolia, and is shared by Mongolia, China, Kazakhstan, and Russia. The Amur River's tributaries originate in Siberia and eastern Mongolia. The Amur is included in this study because the river forms much of the border between two of Asia's major powers, China and Russia.

The water tower's mountains themselves also are a significant feature of regional rainfall patterns. As a high altitude wall stretching thousands of kilometers east to west, they impact wind and moisture circulation patterns across much of Asia. By far, most of the rainfall in the Indus River basin and in the Central Asian rivers falls in the high upper basins in the mountains, while the downstream areas are more arid. The mountains therefore effectively 'generate' water not only as snow melt but crucially as rain too. This feature is less important for the monsoon-dominated rivers like the Mekong, where the greatest amount of rain falls well downstream of the mountains. (The HKH ranges play a role in the monsoons: the high mountains create a 'rain shadow,' meaning that they block the monsoons' path into China, confining rains to South and Southeastern Asia.)

Collectively, the water tower's rivers range across thousands of kilometers of Asian territory and dozens if not hundreds of individual ecosystems. While generalizing about the rivers is therefore a difficult proposition, they do share some commonalities. Given the height of the water tower's mountain ranges, nearly all the rivers experience a significant drop in altitude from origin to termination, which in turn means that they are ideal for construction of hydroelectric dams. Indeed, partly for this reason (hydroelectric dams also are built in flatter landscapes), there are more dams already built in Himalayan Asia, or in planning stages, than in any other continent.

Furthermore, as none of the major rivers run through temperate regions from start to finish, they are vulnerable to high fluctuations in river flow. Part of this variability is seasonal, with very wet seasons followed by very dry ones. Spring and summer mountain snow melt gives the rivers their water through the dry seasons. For the rivers that run through South and Southeast Asia, monsoons add to this seasonal variability. The major monsoon season is the June to September/October summer monsoon. (The season has a slightly different onset and departure for South and Southeast Asia.) Since summer is the monsoon season, when precipitation is extreme, snowmelt is less important to river flow in these months. For river levels in South and Southeast Asia, meltwater is most important in the so-called 'shoulder' seasons in spring and fall, before and after the monsoon.



Glacial river in the Sagarmatha National Park, Nepal.

PETER PROKOSCH/GRID ARENDAL

There is also a 'Northeast' monsoon season for South and Southeast Asia, running from October to December (Northeast refers to the origins of prevailing winds). For the HKH ranges, the Northeast monsoon brings much less precipitation, but it is the major source of rainfall for peninsular India. To complicate matters, these seasonal fluxes can be out of sync with water demand, whether for agriculture, hydroelectric power generation, or other uses, depending on river basin and region-specific seasonal weather patterns.

With a few exceptions, the water tower's rivers are transboundary rivers rather than national ones. Unlike the Mississippi River Basin, which lies almost entirely in one country, most of the water tower's rivers straddle multiple countries. Moreover, several of these rivers run across jittery national boundaries, as in the cases of the Brahmaputra/Yarlung Tsangpo (China, India, Bhutan, and Bangladesh), the Indus (China, India, Pakistan, and Afghanistan), the Mekong (China, Lao PDR, Thailand, Myanmar, Cambodia, and Vietnam), the Amur (China, Russia, and Mongolia), or the Amu Darya and Syr Darya (Kyrgyzstan, Tajikistan, Kazakhstan, Uzbekistan, and Turkmenistan), and the Salween/Nu (China, Myanmar, and Thailand). The few purely 'national' rivers that arise within the water tower include the Yangtze and Yellow rivers (China) and the Irrawaddy River (Myanmar).

While power dynamics among riparian countries are not geographically determined (meaning that upstream countries automatically have power over downstream countries), at the same time it is true that upstream countries are in a more advantageous position. Whether that geographic position translates into geopolitical power depends on several other factors, including relative economic, diplomatic, and military power. China, it bears repeating, is the upstream riparian for most of the water tower's rivers. It is the closest thing to an Asian hydro-hegemon because of this geographic position plus its considerable power across numerous other dimensions.

Finally, all of the water tower's major rivers face a difficult combination of stresses arising from both the demand and supply sides of the hydrological equation. On the demand side, the rivers face increasing stresses owing to rising population, greater agricultural production, increasing urbanization, more intensive industrial production, more dam-building, worsening pollution, and much more. Many of the rivers face combinations of several of these factors. A 2012 study in the journal Applied Geography, for example, assessed ten rivers arising in the water tower and concluded that all of them face a range of intense demand-side challenges. The ten rivers ran through regions characterized by high population densities, swift urbanization, ongoing agricultural intensification, high poverty, rapid industrialization, or combinations of these factors. Dense settlement patterns and high populations characterized all the basins. These authors are hardly the first to point out such challenges, with most serious analyses pointing to similar demand-side concerns across much of the continent. These stresses are examined in greater detail in the sub-sections below.

As demand-side pressures are increasing, the water tower and its rivers also face an uncertain and difficult supply-side threat arising from climate change. By now it is well established that the disruptions created by a changing climate will upend hydrological patterns throughout Himalayan Asia and the rest of the world. The questions are how those patterns will change, when they will change, and with what consequences.

For the regions served by the Himalayan Asia water tower, a changing climate introduces several significant challenges. The first and most obvious involves glacial melt, given the tens of thousands of glaciers in the mountain ranges. Temperatures have been rising faster in the water tower's higher elevations than the global average, causing glaciers to shrink across all of the ranges, with few exceptions. Glacial melt is critical for maintaining river flows in the spring and summer months when river water is most needed for crops. Although all of the water tower's rivers depend to some extent on glacial melt, several are more dependent than others. Among the rivers originating in the water tower, the Indus, Ganges, and Brahmaputra are more dependent on glacial melt than the Mekong and Salween, which are more heavily dependent on monsoon rains. Besides accelerating glacial melt, a warmer climate also will shift precipitation patterns, with timing and amounts of precipitation expected to change at high and low elevations. A major problem here is that climate models are inconsistent in their predictions, which in turn means that scientists are reluctant to forecast either greater or lesser precipitation for specific river basins. Greater variability of rainfall is, however, expected everywhere.

Altogether, climate change will have significant consequences for those Asian countries that are dependent on the water tower. Greater variability in river flows and in precipitation patterns, plus higher temperatures, will have significant impacts on agriculture, settlements, fisheries, energy production, and more. Climate change will result in greater glacial melt and changing seasonal snowfall and rain patterns at high and low altitudes (all of which will change river flows), will alter ecosystems at all elevations, and will likely have negative and potentially devastating impacts across human systems (agriculture, settlements, and infrastructure).

ASIA'S WATER TOWER

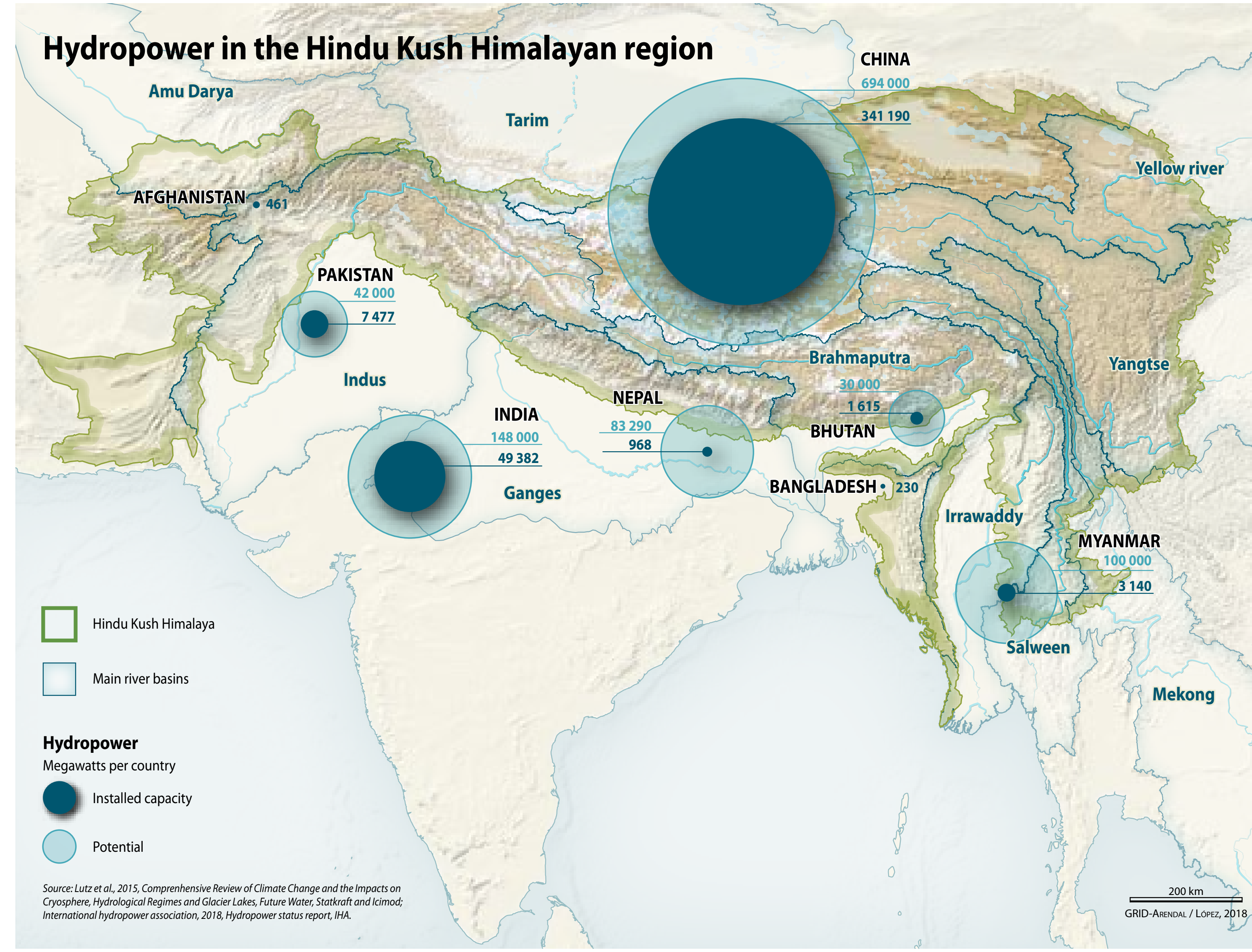
Food, Cities, and Energy

Rising demand for water in Himalayan Asia comes from three broad sources: agriculture (food production plus non-food cash crops), cities (industrial, commercial, and household uses), and energy production. Owing to population and economic growth across the water tower's countries, each of these sources has been increasing its claim to surface and groundwater resources. Agriculture is the largest water user and figures to remain so for a very long time to come, but it is hardly the only sector with rising demand for water. Rapid urbanization and population growth in general have meant the swift growth of hundreds of cities across the continent. That in turn has driven rapid growth of municipal demand for water (from industries, households, businesses, and other entities) and in the production of wastewater. There has been a related and massive growth in energy demand as well, reflecting strong economic growth and urbanization in many countries.

Briefly, experts divide the concept of water use into consumption and withdrawal. Consumption refers to water that is taken from a source (river, lake, groundwater, etc.) but not returned. Withdrawal refers to water that is taken but returned. Globally, agriculture is far and away the largest consumer of water because irrigation water is either absorbed by plant tissue or evaporated into the atmosphere. Water withdrawal is frequently not a neutral exchange because the water taken from a source is often returned to it in a more degraded state.

Agriculture

Asia's large population is the primary reason for its massive agricultural water demand. Feeding 4.4 billion people requires an enormous amount of water, in particular given rising incomes across much of the continent (wealthier people tend to consume both more calories and meat than do poorer people, both of which require more water per person). The challenges involved in feeding China and India's growing and increasingly urbanized populations are primary concerns. Together, the two countries have 2.7 billion people and counting, with both enjoying high economic growth rates. Food security therefore is a dual-sided proposition, involving on the one hand the production of enough food for increasingly wealthy urbanites and on the other finding ways to ensure that poorer populations, which still number in the billions, have sufficient access to food.



NIEVES LÓPEZ IZQUIERDO/GRID ARENDAL

Asian agriculture is the biggest user of water in the world. In 2010, the United Nation's (UN) Food and Agriculture Organization (FAO) estimated that Asia's agricultural sector withdrew 81 percent of all water on the continent and about 75 percent of all water withdrawn for agriculture globally. India (first), China (second), and Pakistan (fourth) are in the top five most prolific agricultural water users in the world.

Asia has by far the most irrigated land in the world, at 41 percent of the continent's cultivated area, with China and India the world's two largest irrigators by a long measure. Several of the world's most intensely irrigated regions are in Asia. The largest of these is the Indo-Gangetic Plain that runs across Pakistan, India, Nepal, and Bangladesh. The Plain is a vast region that is nourished by the water tower's rivers and groundwater. More than a billion people live on the Indo-Gangetic Plain, many of whom are smallholder farmers. Asia also contains intensely irrigated regions in Northern China, Central Asia, and Southeast Asia. Northern China is particularly important for China's food production, although the region is a relatively dry area that requires significant groundwater extraction to support food production.

Climate change likely will have negative impacts on the water cycle and therefore on agriculture. Yield losses from higher temperatures and reduced soil moisture, more frequent and intense flood and drought cycles, increased pest infestations, and loss of farmland in low-lying coastal regions top the list of concerns. Although Asian farmers plant many different types of crops, a few staples dominate. These include the water-intensive cereals of rice, wheat, and maize and a few water-intensive cash crops such as cotton, which is particularly important in Pakistan and Central Asia. Finally, Asian agriculture continues to depend on smallholder farmers, especially in South and Southeast Asia, meaning that climate disruptions will fall hardest upon farmers with the fewest resources to withstand the impact.

Cities

Urbanization is one of the most important demographic, economic, social, and environmental storylines of our era. In 1950, less than one in five (17.5 percent) Asians lived in cities. Today, that number is about one in two. China and India have added around one billion people to cities since 1980, with both set to add several hundred million more in the coming decades. Under forecasted growth rates, Asian cities will have as many as 3.3 billion residents in 2050, more than all other world regions combined.

Urban growth has profound water use implications. As a society becomes wealthier and more urbanized, per capita water use rises, with few exceptions. Rapid urban growth is a key driver of rising demand for water, fueling competition for water and contributing to localized water scarcity. Other consequences include the severe water quality problems created by poorly regulated industrial growth and unchecked residential growth. Reliable estimates indicate that 80–90 percent of all wastewater in the Asia-Pacific region goes untreated. Swift urbanization rates have outstripped the provision of public goods, including adequate housing, modern sewerage, and clean drinking water. Asia has more than half the world's slum population (roughly 530 million people), who both suffer from and contribute to the continent's severe water quality problems.

For a variety of reasons, Asian cities are particularly susceptible to water-related disasters. Deforestation and other land use changes have put downstream cities in many parts of Asia at greater risk of river flooding. Local land use changes, driven by urban expansion, and groundwater depletion often exacerbate river or coastal flooding. Asia's coastal cities, including many of its largest, are at high risk of sea-borne flooding.

Energy

Globally, the energy sector is the world's second largest water user after agriculture, in terms of water withdrawal. Nearly all energy production requires water, at every stage of the energy production process from mining and extraction through power generation and pollution control. Although water requirements are uneven depending on energy source, thermal power plants, which run on fossil fuels (coal, oil, and natural gas) or nuclear materials (uranium), are the most water-dependent forms of power generation.

Over the past decades, fossil fuels have driven Asia's rapid growth. Between 1990 and 2015, the continent's electrical generation grew threefold. Over this period, coal use grew fivefold, to 54.2 percent of total electrical generation power. Asian countries also rapidly expanded electrical production from natural gas and hydroelectric power, although their shares of total electrical power production declined given coal's larger increase. Non-hydroelectric renewables represented a small fraction (3.0 percent) of the total in 2015, but their growth curve by the end of the period was nearly vertical.

Energy production stresses water supplies. Thermal power plants compete for local water supplies with other water users, and under severe water stress can be forced to shut down for lack of coolant water or because the intake water is already too warm to serve as an effective coolant. This is a problem in climate change scenarios where rising air temperatures warm surface water in lakes and rivers. For their part, hydroelectric dams interfere in river ecology, interrupt sediment flows, alter plant and wildlife ecology, and change seasonal water flows. Large hydroelectric dams therefore often create an energy-versus-food tradeoff, which can and frequently does lead to conflict among different users.

Himalayan Asian countries are among the most prolific dam builders on Earth, in part because the water tower's mountain ranges provide enormous hydroelectric potential. The HKH ranges alone have an estimated 500 gigawatts (GW) of hydroelectric power potential, most of which is yet to be developed. As a comparison, the Three Gorges Dam, the world's largest, has a generating capacity of 22.5 GW, less than 5 percent the HKH potential. Multiple countries have ambitious plans to develop the water tower's hydropower potential within their borders. A few, especially China, have begun to realize them.

Given the tradeoffs that are inherent in large dam construction, plans to build them almost always generate controversy. Intense, often transboundary, controversies surrounding proposed hydroelectric dams along the Mekong River and its tributaries (by China, Laos, and Cambodia) and within Central Asia are mainly about the tradeoff between hydroelectric development upstream and agriculture or food production downstream.

Energy has other pathways into water. Cheap energy is an important driver of groundwater depletion in Asia, especially India (as energy is a significant cost of groundwater pumping, India's longstanding practice of subsidizing energy encourages farmers to pump more groundwater than they need). Energy inputs are critical for operating sewer and drinking water systems and water treatment plants. Energy is indispensable to all types of "new" water, by which is meant the production of fresh water from wastewater and salt water. Desalinated fresh water, for example, is expensive because the energy requirements are so high. China and India both have plans to expand their desalination capacities.

Fishing boats sit on what used to be the floor of the Aral Sea. Moynaq, Uzbekistan.

ARIAN ZWEGERS/FLICKR

HIMALAYAN ASIA'S WATER TOWER

Regional Context

The concept of a water tower is valuable because it conveys, in a simple phrase, Himalayan Asia's complex hydrology: water originates in the high mountains of the Tibetan Plateau and then cascades downward, via its rivers, to lowlands across the continent. This sub-section addresses water dynamics in East, Central, South, and Southeast Asia.

East Asia

China is at the center of Himalayan Asia's water dynamics because it is upstream of its neighbors in the majority of the transboundary river basins it shares with other countries. Because China controls the Tibetan Plateau, it contains the headwaters of multiple transboundary rivers, including the Indus, Brahmaputra (known as the Yarlung Tsangpo in China), Mekong (Lancang in China), Salween (Nu in China), Irtysh, and Ili rivers. Those rivers extend into South, Southeast, and Central Asia. China also shares border rivers with Russia and North Korea, the Amur River system with Russia and the Yalu and Tumen Rivers with North Korea. Moreover, there are three large rivers that lie entirely within China, the Yellow, Yangtze, and Pearl Rivers.

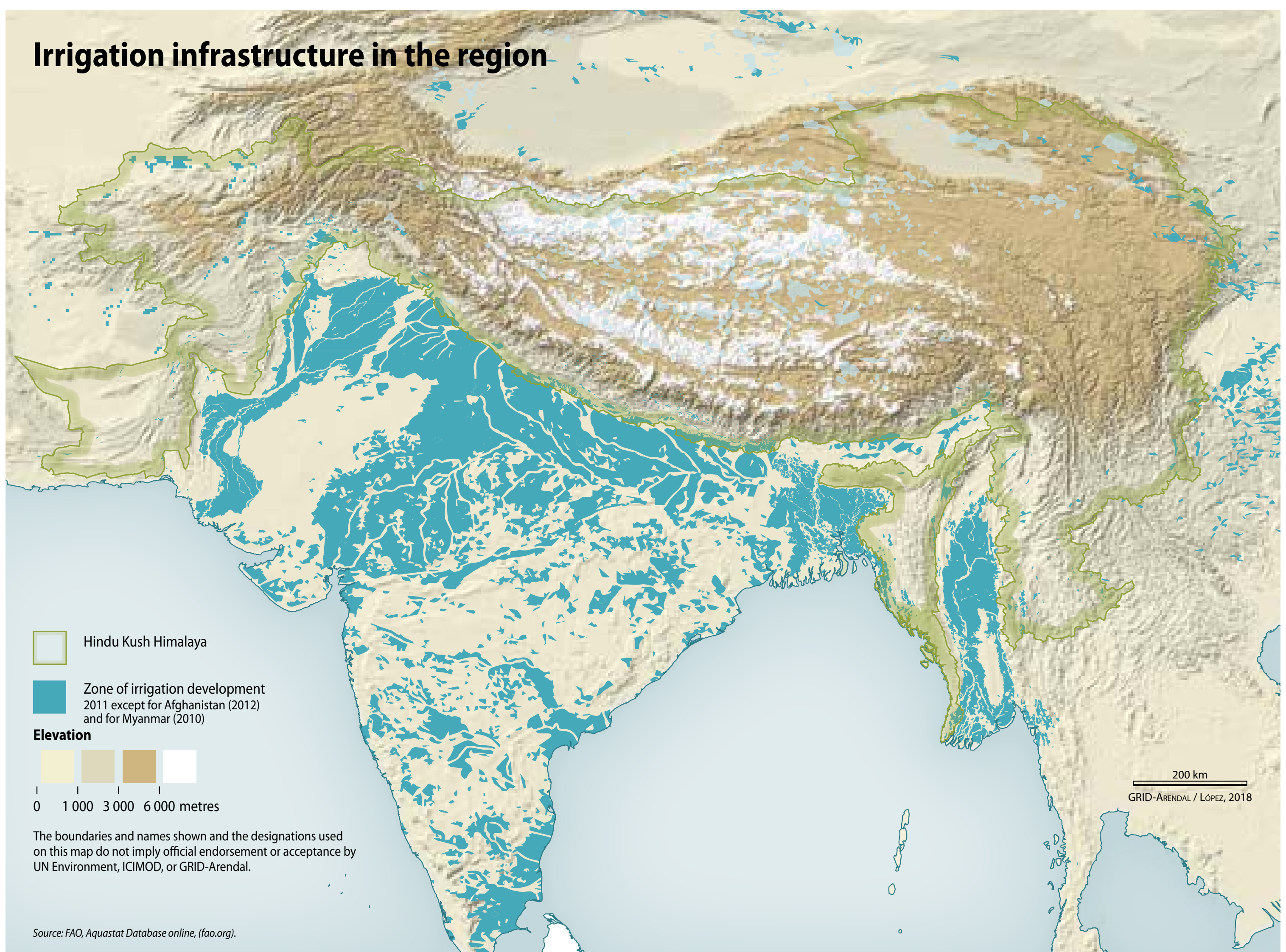
China has a limited water supply and a gargantuan and rising demand. On a per capita basis, in 2014 China's nearly 1.4 billion people each had access to roughly 2,000 cubic meters of water per person per year, a declining per-capita figure that is not far above internationally-defined water stress thresholds. China faces a severe internal water imbalance between its drier, thirsty north and wetter south. This north-south imbalance has been a longstanding concern of China's leadership, and has set into motion massive supply-side infrastructural schemes such as the South-North Water Transfer Project (SNWTP), the world's largest water transfer scheme.

On the demand side, China's booming economy and expanding population have together increased the country's water use more than six fold since 1950. Rising demand for water has placed many of the country's surface and groundwater sources under extreme pressure. Several rivers have had their flow volumes reduced significantly. Water quality is a serious problem within China, with a good portion of China's surface and ground water unsuitable for many uses.

Traditionally, China has been one of the world's foremost devotees of supply-side water infrastructure investment, characterized by a commitment to gargantuan water projects. Yet in recent years China has demonstrated a greater willingness to adopt demand-side water management models. In 2011-2012, it formulated the 'Three Red Lines,' which established ambitious long-term national targets for total water use, water use efficiency, and water pollution. China also has undertaken bureaucratic reform, attempting to create fewer but more effective and responsive water bureaucracies.

In the water context, Russia and Mongolia are China's most important East Asian neighbors. China, Russia, and Mongolia share the Amur River Basin, which is one of the few major rivers in the eastern two-thirds of Asia to not originate in the Himalayan water tower. Much of the Amur's main channel forms the boundary between Russia and China, a rarity for China in that it is not in a commanding upstream position. Although the Amur has not played as central a role in relations between China and Russia as the Brahmaputra has for China and India, or the Indus has for India and Pakistan, there are differences between Russia and China regarding uses and management of the river. China supports more hydroelectric dams and other infrastructure along the Amur's main channel, which Russia has resisted. However, given China's strong interest in expanding infrastructural investment in its own neighborhood, there is reason to suspect that China and Russia may reach agreement in the future about expanding infrastructural investment along the Amur river and into Russia's Far Eastern river systems.

▼ **Asia contains some of the most intensively irrigated agricultural land on Earth, including in South Asia.**



NIEVES LÓPEZ IZQUIERDO/GRID ARENDAL

Central Asia

Central Asia, defined here as Kazakhstan, Tajikistan, Kyrgyzstan, Turkmenistan, and Uzbekistan, contains a fragile set of ecosystems that produce a limited and variable water supply. A few important rivers originate in several high mountain ranges: the Pamir and Tien Shan ranges, plus the western end of the HKH ranges. The Syr Darya, Amu Darya, and Ili rivers flow out of these ranges and run through semi-arid landscapes before draining into two large internal lakes ("endorheic" lakes), the Amu Darya and Syr Darya into the Aral Sea, and the Ili into Lake Balkhash. A fourth major river, the Irtysh, spans China, Kazakhstan, and Russia.

Central Asia's fragile regional hydrology is under threat. On the supply side, the region's high mountains are warming faster than the global average. Climate change is producing more rain instead of snow, shifting seasonal precipitation patterns, increasing glacial melting rates, and decreasing mountain snow cover. On the demand side, Central Asia's ecology has been under threat for decades, extending at least as far back as the Soviet Union's decimation of the Aral Sea. Starting in the 1960s, the Soviets diverted Amu Darya and Syr Darya river water to irrigate cotton, shrinking the lake to the point of collapse. To make this irrigation system work, the Soviets built upstream reservoirs in the republics of Kyrgyzstan and Tajikistan, the water from which irrigated cotton fields during the dry summer months in the downstream republics of Uzbekistan, Kazakhstan, and Turkmenistan. The upstream republics were prevented from generating hydroelectric power during the winter, when it was most needed, in order to preserve water for the summer.

This system worked as long as Moscow could direct an energy-for-water trade between its republics (water sent to the downstream republics in the summer, energy shipped to the upstream republics in the winter). But after the breakup of the Soviet Union, the energy-rich downstream republics began selling energy on the global market while the upstream republics began generating hydroelectric power during the cold winter months.

To this day, the Central Asian republics live with this system, its legacy, and the competitive energy-versus-water tradeoff that it created. The overall scarcity of water in the region, or fear of greater scarcity, has led to clashes at both subnational and international levels. One important case is the Fergana Valley, the most productive agricultural landscape in all of Central Asia and its most populous. There, water has been a frequent source of conflict among multiple ethnic, religious, linguistic, and national groups. Another is the Rogun Dam, a massive hydroelectric project under construction in Tajikistan that has been vehemently opposed by downstream Uzbekistan (the dam is discussed in detail in Special Section II).

Central Asia's ecology has been under threat for decades, extending at least as far back as the Soviet Union's decimation of the Aral Sea.

Since the 1990s, diplomatic agreements have been created to manage Central Asia's water, including the International Fund for Saving the Aral Sea (IFAS), a multilateral forum for joint management of the Amu Darya, Syr Darya, and Aral Sea. Yet neither IFAS nor other multilateral and bilateral agreements and institutions have been strong enough to overcome divergent national interests. There appears to be no interest in tackling the Aral Sea's fundamental problem, which is that the level of cotton production robs the lake of the water necessary to sustain itself.

China and Kazakhstan also share transboundary resources, the most important of which are the Ili and Irtysh rivers. The Ili River basin is endorheic, terminating in Kazakhstan's Lake Balkhash. Kazakhstan is concerned about China's increasing use of river water for its own purposes, fearing a sizable reduction in the Ili's flow and a repeat of the Aral Sea disaster.

South Asia

South Asia faces severe water-related challenges including declining per capita water resources, large and growing populations, a dependence on irrigated agriculture and agricultural employment, low water use efficiencies, and poor water management. Moreover, water has become part of intense international suspicions and disputes. Altogether, these challenges make this region one of the most vulnerable to water-related conflict in Himalayan Asia, if not the entire world.

South Asia's transboundary water resources consist of two major river systems, the Ganges-Brahmaputra-Meghna (GBM) system and the Indus system, plus large aquifers. (The reader is encouraged to consult the Indus and Brahmaputra essays in this report's Special Section II.) These water sources are the central elements of the Indo-Gangetic Plain, lying south of the HKH ranges, that is home to more than one billion people. The plain is one of the most irrigated places on Earth, with surface- and groundwater transmitted to fields via the world's greatest concentration of irrigation canals totaling more than 100,000 kilometers in length.

South Asia's water resources are under increasing stress. Together, the six countries in South Asia (India, Pakistan, Bangladesh, Afghanistan, Nepal, and Bhutan) have a population of 1.8 billion people, many of whom are poor, making food security a massive challenge. Yet agriculture faces rising competition for water resources from other places. Energy challenges abound, with South Asian countries needing to both produce more energy for their cities while overcoming widespread energy poverty in rural areas. Several South Asian countries, including India, have developed plans to build more hydroelectric dams in the HKH ranges. Water pollution is a major problem, resulting from unchecked urban growth, rapid industrial and energy production, and poor farming practices. Finally, coastal flooding and saltwater intrusion into groundwater sources is a growing challenge in South Asia, as are changing sedimentation patterns that might alter food production (e.g., fisheries) and increase flooding risk.

To make South Asia's water context more difficult, the region is beset by intense bilateral rivalries between its major powers (India and Pakistan on the one hand, China and India on the other), as well as between the major and minor powers. These rivalries are fueled by unresolved border disputes, longstanding historic grievances, and old-fashioned geopolitical competition. Unfortunately, transboundary water resources tend to be shoehorned into these preexisting relationships, with water often securitized as part of a zero-sum game. The threat of an upstream rival 'taking' water from a downstream state—India versus Pakistan in the Indus River case, China versus India in the Brahmaputra case, India versus Bangladesh in the Ganges case—reflects this overly narrow, highly securitized, and often binary debate about transboundary resources.

Although the Indus Waters Treaty, signed in 1960, has withstood decades of mutual suspicion between India and Pakistan, disagreement over uses of the Indus River is a perpetual source of mistrust. India, China, Bangladesh, and Bhutan have no treaty concerning uses of the Brahmaputra/Yarlung Tsangpo River. This situation is despite India's longstanding fears that China will divert the river to serve its thirsty northern provinces. Rather, India and China only have two memoranda of understanding regarding data sharing, both of which must be renewed on an annual basis. Several other treaties, the 1954 Kosi Agreement, the 1959 Gandak Agreement, the 1996 Mahakali Treaty, and the 1996 Ganges Water Sharing Treaty, address bilateral relations between India and Nepal, and India and Bangladesh. Although these treaties are meant to placate longstanding suspicions regarding water use between these riparian states, they have not succeeded in eliminating controversy.

Southeast Asia

For purposes of this study, Southeast Asia is defined as all countries within the two major transboundary river basins, the Salween and Mekong basins. Those rivers are the two transboundary rivers and their tributaries are the most important sources of surface fresh water in Southeast Asia, aside from the Irrawaddy River, which lies almost entirely in Myanmar. Southeast Asia also has groundwater aquifers that supplement these surface sources and that are important during the dry season.

The region's water politics is dominated by the use of these rivers, in particular about electrical power generation along rivers that have extraordinarily high levels of biodiversity and contain the world's greatest fresh water fisheries. Southeast Asia's water politics is about electricity versus food.

The Mekong and Salween rivers (called the Lancang and Nu rivers in China, respectively) are among the world's most biologically productive, with multiple niche ecosystems and abundant aquatic life. At the same time, because both rivers drop from several thousand meters in altitude on the Tibetan Plateau, both are attractive for hydroelectric development. For a variety of historical reasons, their long-recognized hydroelectric potential was not tapped. Now, however, both rivers are eyed by several governments for hydroelectric dam construction.

As China already has constructed a cascade of hydroelectric dams on the Mekong River, having refused to consult with its downstream neighbors on their construction, the primary controversies concerning the river's future involve dams that are planned or under construction from Laos southward. The most controversial of these are in Laos, which intends to become Southeast Asia's hydroelectric 'battery' for the entire region.

Although Cambodia and Vietnam have objected strenuously to the Laotian program, with both fearing the repercussions for their fishing, agriculture, and tourism industries, and although both have voiced their objections through bilateral and multilateral channels, Laos has pressed ahead with construction of the first of these dams, the Xayaburi Dam. Opposition to the Xayaburi Dam, as well as other proposed dams on the Mekong and Salween, has also come from increasingly active civil society groups; civil society opposition ranges from local and grassroots groups through international non-profits. The governments of both Cambodia and Vietnam, it needs be said, are on both sides of the issue, criticizing aspects of dams in Laos while also building their own.

Like Central Asia's IFAS, the Mekong River Commission (MRC, founded 1995) was designed as a multilateral instrument to manage transboundary river conflicts. And like IFAS, the MRC has been unable to contain and channel the region's divergent national interests, as best illustrated by the Xayaburi case. Although the MRC has a formal notification and consultation process, it has no real oversight and enforcement power, leading many to question whether the MRC ever will be able to effectively manage transboundary water disputes surrounding the Mekong.

In keeping with its reluctance to enter multilateral forums not of its own making, China has refused to both become a member of the MRC and to negotiate jointly with Myanmar and Thailand concerning the Salween River (it must be noted that both China and Myanmar are 'Dialogue Partners' within the MRC, which allows them to attend and participate in meetings). Yet China maintains a significant presence in Southeast Asian hydro-diplomacy. Indirectly, China's lenders and construction firms are aggressive financiers and builders of water infrastructure. (China is hardly alone as a lender. Other governments finance hydroelectric dam development in the region, several of which at the same time preach cooperative river basin management.) And in 2016, in what was widely interpreted as an attempt by China to increase its influence across Southeast Asia while checking the MRC's influence, it created the Lancang-Mekong Cooperation Mechanism (LMCM), a regional organization designed to expand cooperation across multiple arenas, including water and environment.

The Mekong and Salween river basins

RICCARDO PRAVETTONI/GRID ARENDAL

SECTION III

Water and Geopolitics

As a fluid transboundary resource that is fundamental to every human endeavor, water both contributes to Himalayan Asia's complex geopolitics while at the same time being subject to the continent's many geopolitical divisions. The water tower spawns hundreds of transboundary rivers (if tributaries of the major rivers are included). Partly due to this geographic fact, and partly due to the suspicions and rivalries that infuse the continent's bilateral and multilateral diplomacy, transboundary water disputes roil relationships among all the continent's major powers and more than a few of its minor ones.

Geography is the place to start when discussing Himalayan Asia's hydro-geopolitical nexus. Hydrological imbalances are the prominent feature of the continent's geography, and a fundamental part of this nexus in Asia. The most salient fact is that China is upstream of nearly everyone else. As the Tibetan Plateau is in Chinese-controlled territory, many Himalayan Asia rivers originate in China. China thus has a commanding position regarding surface water resources across much of Asia. China's neighbors, more than aware of this reality, understand that they are vulnerable to China's unilateral water use decisions. Yet this hydrological story is not all about China. Other countries also enjoy upstream positions with respect to some important rivers. India, for example, may be downstream of China, but in the Indus/Sutlej basin it is upstream of Pakistan and in the Ganges-Brahmaputra-Meghna basin it is upstream of Bangladesh.

Himalayan Asia's hydrological asymmetry is matched by an equally important geopolitical asymmetry. It would be one thing if China were a weak upstream country facing a more powerful downstream country, analogous to the Nile River and Ethiopia's historic weakness as the upstream riparian relative to the historically more powerful downstream Egypt. It is another thing entirely that China is Asia's largest economy and most populous country, a nuclear-armed power with a large and technologically advanced military, and has what appears to be an ever-increasing ambition to expand its diplomatic influence in its neighborhood and around the world. China therefore possesses both outsized hydrological and geopolitical forms of power, which could be leveraged for constructive (cooperative) purposes, or not, depending on the government's wishes. Regardless, when it comes to transboundary water resources, China is by far Himalayan Asia's most important state.

China's commanding hydro-geopolitical position in turn intersects with its predominant diplomatic inclination, which consists of a historic reluctance to enter multilateral negotiations and a much stronger preference for bilateral diplomacy. China consistently has refused to participate in multilateral forums surrounding transboundary water use, especially if those forums are not under its leadership. The most public case involves China's refusal to become a member of the Mekong River Commission, which is a regional institution possessing some (albeit weak) capabilities for constraining member states' behavior regarding shared water resources. Rather, China preferred instead to establish the LMCM, a regional body crafted under its own aegis.

Yet while China is reluctant to play the multilateral game, at the same time it has no such qualms about engaging its neighbors through aggressive forms of bilateral economic diplomacy, through infrastructural investment. For decades, China has been a major investor in the water sector abroad, primarily through the financing of hydroelectric dams in Asia and Africa. In 2012, International Rivers, a global non-profit, released a report examining China's foreign hydroelectric dam investments. It found that China, through a state-led investment strategy, was financing some 308 dam-building projects in seventy countries around the world, with more than two-thirds of those investments in Asia. At the time, the Chinese were involved in fifty-five dam-financing projects in Myanmar alone.

Since 2013, China's foreign investment profile has been filtered through its Belt and Road Initiative (BRI), a massive infrastructural investment campaign designed to knit together Eurasia's heretofore poorly connected regions. Although the BRI's numbers are not transparent, it is believed that China is willing to invest hundreds of billions of

Despite the BRI's highly public profile, it unfortunately muddies as much as clarifies China's hydraulic investment agenda.

dollars in dozens of countries across Asia, the Middle East, Africa, and Europe.

Despite the BRI's highly public profile, it unfortunately muddies as much as clarifies China's hydraulic investment agenda. China's leadership, in particular President Xi Jinping, has been at pains to characterize the BRI as an economic cooperation initiative, aimed at enhancing other countries' economies as much as its own. Such win-win assurances are met with skepticism from many quarters both inside and outside of Asia, with critics pointing to a slew of other possible motives behind the BRI. These possible motives range from China's domestic security considerations (how the BRI might help quell dissent in China's western provinces through deepening the provinces' linkages to China's east and the rest of Asia) to China's interest in finding new markets for Chinese exports. Many critics, within Himalayan Asia and well beyond, have concluded that the primary motive behind the BRI is geopolitical, involving China's desire to become the hegemonic power in Eurasia through investments that have geostrategic and even military payoffs in addition to economic ones. Consistent with the BRI's overall lack of transparency, it is difficult to divine the role that water-related investments play in China's plans. Part of the problem stems from the fact that it is not clear which projects, water-related or otherwise, are a formal part of the BRI.

But the larger question is a strategic one: what, exactly, is China trying to accomplish with the BRI? That question, and the many possible answers to it, have led China's neighbors to perceive the BRI with an odd mixture of fear and attraction. China has untold billions to lend under the BRI umbrella for ports, highways, dams, railroads, airports, and more. China's neighbors have been more than willing to accept this financing, seeing in it the funds for badly-needed development projects and a means, for some, to increase governmental legitimacy through partnership with China. Yet at the same time, China's infrastructural funding has triggered pushback in India, Sri Lanka, Malaysia, Pakistan, and Myanmar. This pushback frequently has come from newly-elected governments, the leaders of which discover the onerous financial terms of a BRI investment agreed to by the previous government. The China-Pakistan Economic Corridor (CPEC), a massive $62 billion BRI connectivity scheme between the two countries, is a case in point. Pakistan's newly elected government under Prime Minister Imran Khan has begun a review of CPEC projects that were signed under previous governments, claiming that these projects disproportionately benefit Chinese firms.

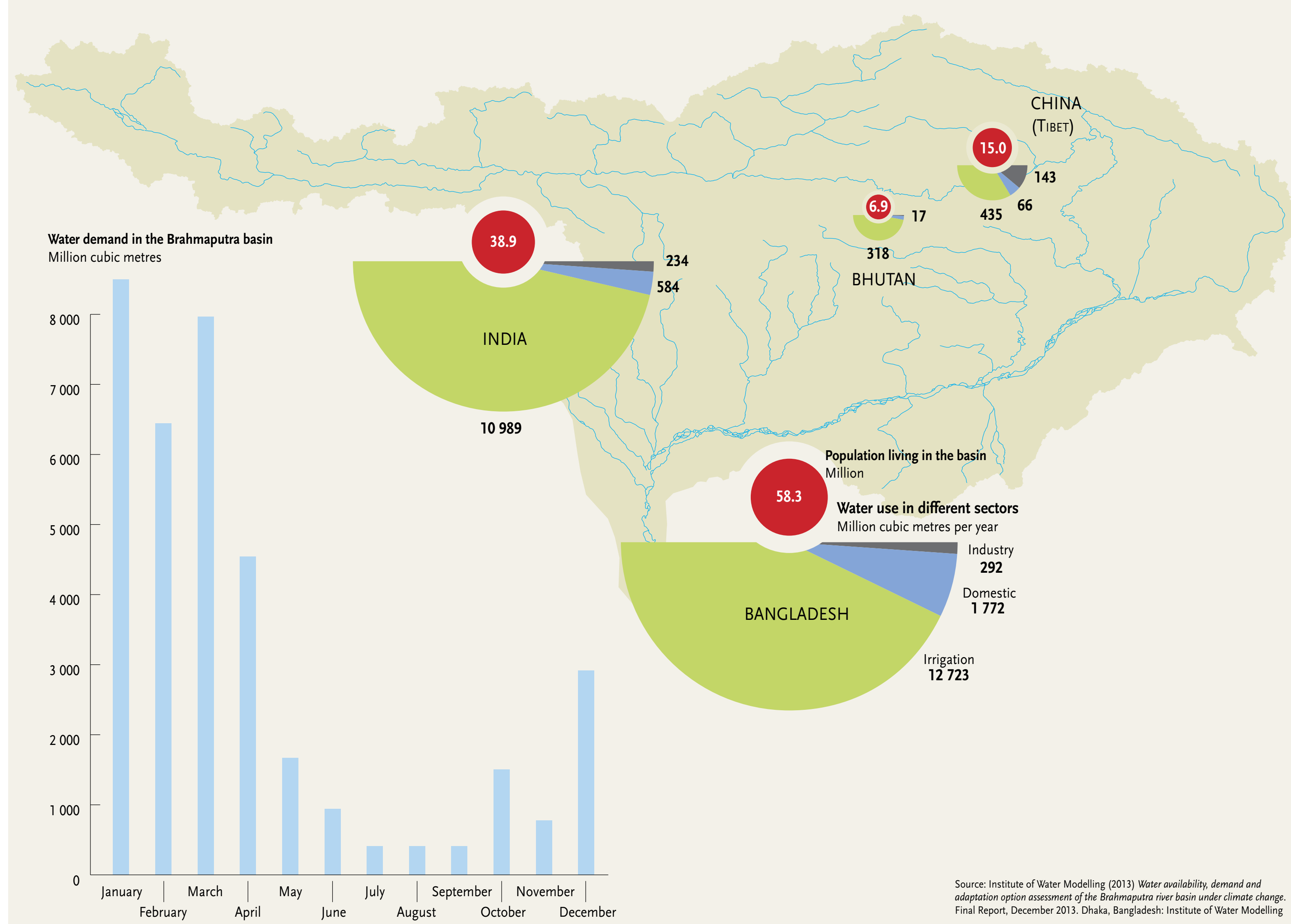
Pushback also has come in the form of popular opinion, with domestic audiences reacting negatively to an array of real or perceived sins committed by Chinese firms operating under the BRI umbrella, for example a preference for hiring Chinese over local workers. China's habit of working exclusively through national governments in the region has come at a price, with its projects often failing to take into account the public's interests. This practice of negotiating directly with other national governments through closed and opaque processes, hence ignoring the views or interests of civil society, has generated resentment in some unlikely places. This resentment has included open opposition even within non-democratic political systems.

In the water context, China has been damaged by the country's deliberate or accidental misreading of public opinion in countries where it has invested, as most famously occurred with Myanmar's Myitsone Dam. Although Chinese backing for the dam was negotiated years before the BRI was announced, the dam's problems highlight the difficulty China has faced in implementing its aggressive infrastructural investment agenda, whether formally under the BRI or not. In 2009, China Power Investment (CPI), a state-owned enterprise, entered into an agreement with Myanmar's military government to build the dam, located in Kachin state in the country's north. Popular protests began not long after the agreement was finalized, spurred by local resistance to plans for forced resettlement, concerns about the dam's potential environmental impacts, and by longstanding Kachin resentment against the Burmese junta. Against all expectations, this protest became strong and sustained enough to force the government's hand, partly due to the fact that Kachin and Shan insurgent groups engaged in open combat with government forces for control of Chinese dam construction sites and access roads. CPI was as shocked as anyone when, in 2011, Myanmar's government bowed to public pressure and announced the suspension of construction. CPI not only had failed to invest the time and resources into understanding the needs of local populations, it had failed to understand that the national government itself lacked legitimacy, in particular in this part of Myanmar.

Nowhere has China's BRI generated more opposition than in India, China's major geopolitical competitor on the continent. India views the BRI with considerable suspicion, seeing in it less of a win-win economic program to better connect poorly connected regions and more of a win-lose geostrategic program designed to enhance China's strategic position—at India's expense—in South Asia, the Bay of Bengal, and the Indian Ocean. The core of India's nervousness lies in CPEC, the BRI program designed to connect China's Xinjiang province to Pakistan's Gwadar port, with elements running through Pakistani-controlled Kashmir. Besides the investment in disputed Kashmir territory, India is concerned that the CPEC-funded upgrading of the Gwadar port, located not far from the Straits of Hormuz, will provide the Chinese navy with the means for interfering in the Middle East oil supply chain to and from India.

For India, CPEC is only part of a disconcerting story. China's BRI-labeled investments in, or plans for, Nepal, Sri Lanka, the Maldives, and Bangladesh have all stirred similar Indian concerns about China's geostrategic intentions in what India considers to be its own backyard. The most notorious case involves China's investment in the Sri Lankan port of Hambantota. Sri Lanka was forced, via debts incurred to China, to lease use of a brand new deep water port on Sri Lanka's southern coast to China Merchants, a state-owned company, for ninety-nine years. As with the Gwadar port, India's concern about Hambantota has extended to the geostrategic realm, a concern that in 2014 was amplified when Chinese submarines docked in Colombo on the same day that Japanese Prime Minister Shinzo Abe made an official visit to Sri Lanka.

Water use: The case of the Brahmaputra river basin



Source: Institute of Water Modelling (2013) *Water availability, demand and adaptation option assessment of the Brahmaputra river basin under climate change.* Final Report, December 2013. Dhaka, Bangladesh: Institute of Water Modelling

RICCARDO PRAVETTONI/GRID ARENDAL

Competition between China and India for South Asian influence has reached Bangladesh and Nepal, two countries long considered to be in India's diplomatic orbit. China's rising trade with Bangladesh, combined with its economic and military investments in that country, have given India much pause. China's increased presence in Bangladesh provides an important context for viewing a longstanding dispute between India and Bangladesh over the Teesta River. The Teesta River is a tributary of the Brahmaputra River, running some 410 kilometers from India's Sikkim region (a disputed territory with China) southward into Bangladesh. For years, India and Bangladesh have flirted with a binding water-sharing agreement regarding the Teesta, but have been unsuccessful in arriving at one largely due to India's domestic politics (India has been building dams along the Teesta's upper reaches). Within Bangladesh, India's hesitancy to reach an agreement has been interpreted by many as an affront by its larger, upstream riparian neighbor. China's recently increased influence in Bangladesh may provide an opening for movement on a Teesta agreement, given India's interests in strengthening what appears to be a diminished hand with Bangladesh. China already has shown that it is willing to engage Bangladesh on water sharing (China provides Brahmaputra water data to Bangladesh free of charge, in contrast to India, which is charged for such data).

While China and India are competing indirectly for influence among their South and Southeast Asian neighbors, with transboundary waters occasionally part of the mix, the two giants do share one critical and highly contested river. The Brahmaputra River (called the Yarlung Tsangpo in China) flows eastward within China for 1,625 kilometers before turning southward at the 'Great Bend' into India and then finally Bangladesh. (For a longer examination of the river and its politics, see Special Section II.) To date, China's primary interest in the Brahmaputra/Yarlung Tsangpo has been about hydroelectric power generation, an interest that is similar to its development of other Tibetan Plateau rivers. China opened the first of a series of planned dams along the Yarlung Tsangpo in 2015. China has demonstrated less interest in the river's water for agriculture, given the largely unsuitable regions (for agriculture) through which its stretch of the river runs.

For India, China's hydroelectric dam building is less threatening than the possibility that China might someday divert the river's flow northward. In contrast to China, the Brahmaputra's water is critically important for agriculture in India and Bangladesh, the two lower riparian states. India's northeast and all of Bangladesh have very high population densities, with irrigated agriculture a central part of the economy in both. India believes it has good reason to fear that China might divert the Brahmaputra's flow. India points to China's massive and growing domestic thirst for water, a thirst that already has led it to eye sources of untapped fresh water, particularly in the country's south, for transmission to its dry north. Here, India points to the 'western route' of China's South-North Water Transfer Program, a route that if realized would transfer water from China's southwest to the north and west. Although there are good reasons to doubt whether China will divert the river in the future, including extremely high economic costs and severe technical obstacles, India sees the mere possibility of Brahmaputra diversion as an existential threat to its national security.

China has its own reasons to doubt the sincerity of India's intentions when it comes to India and the Brahmaputra. Although China is the upstream riparian, and hence should not be concerned about what India does on its stretches of the river, China also views India's intentions through a national security lens. Like China, India long has intended to build hydroelectric dams on the Brahmaputra's Himalayan tributaries—part of a larger set of Indian plans to dam the mountainous rivers across the southern stretches of the HKH ranges. These plans include dam construction in border regions held by India but claimed in whole or part by China, in particular in Arunachal Pradesh. Critics argue that India's dam-building plans have more to do with strengthening its control over Arunachal Pradesh, a disputed territory, than they do with power generation. The Indian state is among the most remote and poorly connected of all Indian states.

India and China have no formal mechanisms for resolving their disagreements over the Brahmaputra/Yarlung Tsangpo. The only bilateral agreements between China and India consist of two memoranda of understanding, wherein China provides seasonal water flow data to India for a fee (recall that China provides such data to Bangladesh for free). Neither country as of yet has been willing to do the hard work of creating robust bilateral agreements such as the Indus Waters Treaty (IWT) nor multilateral institutions that would include all four riparian states (China, India, Bangladesh, and Bhutan).

Hydro-diplomacy is of course central to the major South Asian bilateral relationship between India and Pakistan.

For India, China's hydroelectric dam building is less threatening than the possibility that China might someday divert the Brahmaputra's flow northward.

Gwadar port in Pakistan

MOIGN KHAWAJA/FLICKR

The most well-known bilateral water sharing instrument in Himalayan Asia, and perhaps the world, is the IWT between the two South Asian rivals. The IWT dates to 1960 and apportions water from the Indus and its tributaries between the two countries. The treaty allocates the Indus' three 'western' tributaries to Pakistan (the Indus, Jhelum, and Chenab rivers) and the three 'eastern' rivers to India (the Ravi, Beas, and Sutlej rivers). The IWT attributes the rights to three tributaries to India and three tributaries to Pakistan, with no explicit consideration (outside of certain technical stipulations during a transition period following the treaty's signature) for how much water flows in those tributaries. As the upstream riparian, India is limited in its rights to use water in the western rivers crossing through its territory. (The Indian-Pakistani dispute over the Indus River is examined in more detail in Special Section II.)

The IWT is a good news, bad news story. The good news is that the treaty has survived intact the many down periods in Indian-Pakistani relations, including several wars. In that sense, the IWT is a durable hydro-diplomatic instrument, with its dispute settlement mechanism having proven robust enough to endure multiple rounds of arbitration over Indus water disagreements. And of course, the IWT is one of a vanishingly small number of formal diplomatic instruments that helps smooth the tense relations between these two nuclear-armed neighbors.

But therein lies the bad news as well. The IWT may be robust in some respects, but in others it falls well short of being comprehensive and malleable enough to deal with novel challenges. The treaty has no provisions relating to shared groundwater resources (recall groundwater's critical importance in the Indo-Gangetic Plain), water pollution, or climate-driven changes in Indus water levels that might affect real or perceived (by Pakistan) usage along India's upstream tributaries. Even more important, division of the Indus basin's water is a perpetual source of antagonism on both sides, a fact that complicates the management and improvement of the IWT. The deep wells of distrust and suspicion within both countries about the other's motivations and behaviors have tainted relations over the Indus since before the IWT was signed. As the lower riparian, Pakistan's heavy dependence on irrigated agriculture makes it vulnerable to disruption in Indus water supply, a disruption that it fears that its upstream geopolitical rival would happily impose upon it if given the chance. India chafes at what it sees as the IWT's unfair water allocation formula, at its restricted ability to develop on its own territory, e.g., through dam construction within India, and at what it believes is Pakistan's poor downstream water management. Politicians in both countries use the Indus dispute for their own domestic purposes, hurling charges of incompetence, dishonesty, or bad faith at the other side.

Dynamics at least this complicated also are at work in Central Asia. There, rivers are part of a complex geopolitical landscape consisting of suspicion-fueled rivalries and major power competition for influence. As elsewhere, the central challenges involve limited surface water supplies, rising demand for water, inefficient use of water, and the high probability of climate-driven variability in water supply. Among the five former Soviet republics, the central disputes involve the region's two largest and most important rivers, the Syr Darya and Amu Darya. In contrast to South Asia, however, the geopolitical and hydrological power dynamics involving these transboundary river basins are somewhat different. If power is defined in terms of wealth, population, and ability to bring these attributes to bear on policy goals, then the three downstream republics (Kazakhstan, Uzbekistan, and Turkmenistan) are relatively more powerful than their upstream neighbors (Tajikistan and Kyrgyzstan). Hence, the power dynamic along these rivers is closer to the Egyptian-Ethiopian dynamic regarding the Nile than that along the Brahmaputra/Yarlung Tsangpo or Indus rivers. Within Central Asia, the exceptions to this dynamic are the Irtysh and Ili rivers, where the most powerful riparian (China) also is the upstream riparian.

Of Himalayan Asia's major powers, Russia and China are currently the most active and important in influencing Central Asian affairs. Within the region, Russia is the older and more established external power, China the newer but rapidly rising one. As is true elsewhere, China's increased presence in Central Asia is about infrastructural investment. China sees the region as critical to the BRI's success, in part because Central Asia is itself a connector to other regions, Europe in particular. As in other regions, Central Asia's governments have signed onto BRI-branded infrastructural investments, although there is increasing concern—also true elsewhere—of the increasing indebtedness to China and potential consequences that comes with the investments. Russia, in contrast, has a weaker economic hand to play than China, but a stronger one in terms of soft power and hard security. Since 2015, Russia has tried to forge an economic bloc in the region (the Eurasian Economic Union, or EEU) with the Russian economy at its center, but by all accounts, this European Union (EU)-styled bloc has struggled given the anemic state of the Russian economy. Russia retains its historic advantages in the region and vis-à-vis China, in terms of soft power (shared language, longstanding educational and cultural exchanges, and elite ties, as examples) and in hard security arrangements. Russia has a significant military presence in the Central Asian republics, with multiple military bases spread across them.

Sela Lake in the Indian state of Arunachal Pradesh. The state also is claimed by China.

Caption Tk

PRASHANT RAM/FLICKR

Combined with ongoing or renewed interest in the region from the United States, the European Union, and India, this major power presence in Central Asia is occasionally depicted as a revitalization of the intense nineteenth-century Great Game competition between Great Britain and Russia. With respect to Russia and China at least, it is inaccurate to say that these major powers are (as of yet) engaged in such a showdown. Although China's influence has been increasing rapidly over the past decade, the consensus is that China has managed to prevent its own rise from threatening Russia's core interests in the region. Part of the explanation is due to the fact that China has largely stuck to an economic development script in Central Asia, ceding hard security matters to Russia. Part of it is due to China's attempts to cultivate good relations with Russia, promising for example to find avenues of cooperation between the BRI and EEU. And part of it results from both Russia and China having a shared interest in minimizing the influence of the western powers, especially the United States in Central Asia.

As ascendant as China is within the region, as elsewhere, its ongoing good fortune is hardly assured. Implementation of the vast BRI agenda is facing similar challenges in Central Asia as in other regions. For example, Central Asian states' rising indebtedness to China has translated into increasingly stringent loan agreements, with China often requiring collateral in exchange for loans. And also, as elsewhere, BRI projects frequently utilize more Chinese than indigenous labor, contributing to popular dissatisfaction with Chinese contracts.

Given regional conflicts around water, a scarce transboundary resource, any investor or external power needs to tread carefully in Central Asia. Although China's use of the Ili and Irtysh rivers threatens downstream Kazakhstan's interests, the two countries have a fairly well-developed institutionalized cooperation, including several shared water use agreements dating back to 2001. China's willingness to enter into such agreements is highly unusual, given its disinterest in so doing in South and Southeast Asia. Observers suspect that the reasons for Chinese cooperation include Kazakhstan's status as a hydrocarbon exporter and Kazakhstan's willingness to cooperate on containing Uighur separatism in Xinxiang. Yet neither China nor anyone else can afford to ignore the tensions that are embedded in Central Asia's hydro-geopolitics. The energy-versus-irrigation tradeoff that is at the center of the region's hydro-diplomacy, combined with its chronic water scarcity, mean that infrastructural investments—hydroelectric dams in particular—might be one country's solution but another country's problem.

Himalayan Asia's many disputes surrounding transboundary waters are made far worse by the low levels of trust that exist among riparian nations.

Himalayan Asia's many disputes surrounding transboundary waters are made far worse by the low levels of trust that exist among riparian nations. While some regions suffer more from this problem, the continent's hydro-diplomacy in general labors under broader international tensions with roots extending back decades if not longer. Unlike Europe, which settled nearly all of its territorial disputes decades ago (albeit through warfare), Himalayan Asia still has long-running territorial and border disputes. China, India, and Pakistan, to name only the most obvious cases, all lay claim to overlapping pieces of territory running along the mountainous regions that the three countries share, and that form important portions of their transboundary watersheds. These claims in turn are part and parcel of emotionally fraught and historically laden disputes across multiple domains. The resulting lack of trust becomes a fundamental stumbling block to effective hydro-diplomacy, for it makes finding robust solutions to what should be manageable transboundary water challenges far more difficult than they otherwise would be. Conversely, the same lack of trust heightens the risks of miscalculation and conflict over transboundary resources.

All of this is made worse by the fact that the continent's major powers, in particular China but others as well, directly impact other countries' water resources through their own domestic uses of transboundary rivers. As this section has stressed, upstream behavior (dam building and rising water use, primarily) has helped to drive international tensions over transboundary rivers.

Robust international agreements over transboundary water resources are few and far between in Himalayan Asia. There are few bilateral and multilateral mechanisms that are designed to defuse tensions over these resources. Historically, the scarce number of diplomatic institutions that are designed to address transboundary water disputes have proven too weak to overcome often narrowly-defined national interests. At best, these institutions have managed the status quo without solving the underlying water use and management challenges.

There are some partial success stories. The most important multilateral instruments have included the Mekong River Commission (MRC), created in 1995 (with US backing) to organize and enhance cooperation among Southeast Asian countries regarding use of the Mekong, and the International Fund for Saving the Aral Sea (IFAS), founded in 1992 to organize and enhance cooperation among the newly-independent Central Asian republics regarding transboundary water resources, including the Aral Sea. Although such instruments have been effective under some circumstances some of the time, in general none are considered robust enough to effectively address the full range of transboundary water challenges faced by the participating countries.

Water and geopolitics, from the inside out

Geopolitical analysis focuses on the external behavior of nation-states, on how major powers in particular compete with one another for leverage abroad. This is the Great Game view of geopolitics, one in which states formulate and execute their foreign policy goals in a context of great power competition for influence in the external world. Water, by its nature, complicates this analytical framework and necessitates looking at geopolitical questions as much from the inside out—taking the internal view—as from the external one.

RICCARDO PRAVETTONI/FLICKR

For Himalayan Asia's major and minor powers, water is primarily about the maintenance of domestic stability and the enhancement of domestic economic development. Yet because a country's water resources often are transboundary resources, water cuts across both the domestic and the foreign. Within Himalayan Asia, states are particularly sensitive to the way their neighbors' actions can inhibit their ability to manage their own water-related challenges or compromise their ability to deliver on economic growth and the supply of public goods. Overlaid against these worries are perceived threats to their national sovereignty and territorial control, threats that are made far worse by the continent's unresolved territorial disputes and historical grievances. It is one thing for Germany to worry about whether upstream Switzerland will interfere in the Rhine River's flow into Lake Constance; it is another thing entirely for Pakistan to worry whether upstream India will do the same with the Indus.

Across much of Himalayan Asia, this tangle of issues inhibits productive conversations about effective governance of transboundary water resources, thereby making already difficult water management challenges even more complex and problematic. It is easier politically to define the problem as coming from outside national boundaries. To the Indians, it is the Chinese who create India's problem; to the Pakistanis, it is Indians who create Pakistan's problem; to the Uzbeks, it is the Tajiks; and so on.

These dynamics occur in part from the fact that politicians often benefit from a perceived threat of foreign interference in a country's water resources. Invoking the external threat is a tried-and-true method for politicians to deflect away from domestic criticism, particularly in those parts of Himalayan Asia where such messaging finds audiences that have rarely if ever been asked to think about water as a shared resource. Invoking the external threat is also a way to avoid having a robust and meaningful internal (domestic) conversation about water challenges. Doing so involves making hard decisions, including politically and financially difficult ones. Countries rarely have the collective willpower to go through such searing processes.

In addition, engaging in such robust internal (domestic) conversations amounts to a kind of rhetorical surrender to one's upstream neighbor(s). India demands that China preserve the flow of Brahmaputra water for India's use. For Indians to turn around and engage in a serious conversation about its own water-use inefficiencies would be an implicit admission that the flow of the Brahmaputra's water from China matters less to Indian water security than India's own water management practices, despite years of intense rhetoric from India. As India is both an upstream and downstream country, it plays this game with both China and Pakistan. India accuses Pakistan of wasting water, claiming that if Pakistan got its own water-use house in order it would have far fewer concerns about the Indus. But that position just makes it harder for India to deal with China on the Brahmaputra. South Asia's states are trapped in this exact game. The fear of diversion is also Bangladesh's greatest worry, except it fears that India will divert water from the Ganges-Brahmaputra-Meghna basin as part of India's own massive interbasin transfer plans. In an international context in which states have little cooperative history, with high levels of mistrust across a suite of issues, for any state to claim that their own internal water-use inefficiencies are a problem makes it harder for them to escape this trap.

Domestic considerations also are critical to explaining why states view transboundary river systems as tools for national development rather than as shared resources for joint and cooperative management. The provision of water infrastructure supports an array of domestic agendas: the drive for elites to stay in power; the ideological convictions of technicians sitting in water bureaucracies; the political economy of a national water-industrial complex; and the state fulfilling its perceived role as improving economic development for millions of very poor people. For all of these reasons, within Himalayan Asia, rivers are still viewed as utilitarian instruments to be put to productive use rather than ecological systems to be managed sustainably. Although perceptions are changing, rivers have historically been viewed as resources waiting to be used. The predominant view of rivers has been that any river allowed to flow freely (by now a nearly nonexistent phenomenon on the continent) is in effect a wasted resource. During the early-to-mid twentieth century, a modernist view came to predominate thinking about and policy toward rivers around the world. Reflecting a faith in science, engineering, and the technocratic control of nature, the modern view approached river management in rational, cost-benefit terms, with the presumption that a river was productive only when it was made to serve utilitarian ends.

Although the intellectual bases of this paradigm have eroded around the world, this thinking remains embedded in officialdom. Sometimes called the "hydraulic mission," the paradigm takes a narrowly utilitarian approach to river management via hard infrastructural development. Indeed, such legacy mindsets can remain powerful drivers of policy within water and energy ministries, often bolstered by powerful vested interests from the construction, engineering, and earth-moving industries, among others.

It is fair to claim that the hydraulic mission is fighting a defensive battle, given the powerful inroads that demand-side and ecologically-based water management paradigms have made on the continent. Yet at the same time, it is far from dead. Numerous Himalayan Asian countries are eyeing hundreds of new dams. And the continent's two greatest powers,

Xiaowan Dam on the Lancang (Mekong) River in Yunnan province, China

INTERNATIONAL RIVERS/FLICKR

India and China, have plans to build the largest inter-basin river transfer systems in the world, in essence gigantic national plumbing systems that would upend natural systems entirely.

The hydraulic mission mindset predisposes national governments toward unilateral river use and away from joint river management. If the default view is that building hard infrastructure on a river (dams, etc.) makes the most economic sense for the nation, then it is far easier to swat down arguments that emphasize shared gains, preservation of a river's ecological services, demand-side water management, balance among competing uses, and the need to take other nations' interests into account. Very often in the past, and at least somewhat still true today, the technocratically-minded officials who sit in large national water bureaucracies typically are the ones making such utilitarian arguments. The mission's utilitarianism can lead officialdom to downplay or outright dismiss the negative impacts of proposed dams and other infrastructure on competing uses, interests, and populations. This outcome has happened time and again, involving the planning and construction of large hydroelectric dams in particular.

Demand-side management paradigms, in particular Integrated Water Resources Management (IWRM), arose in large part through a desire to reject the hydraulic mission and its deleterious effects. Even more recent river management approaches that attempt to incorporate river ecology under their paradigmatic umbrellas do as well. Each of these assumes, contrary to a basic premise of the hydraulic mission, that the basin is the appropriate scale for understanding how a river works and, at least in an ideal world, how it should be governed.

But the problem in Himalayan Asia and elsewhere has been that each nation views river flows as their own and wants to appropriate those flows for themselves. Within Himalayan Asia, historically countries have understood rivers in terms of resources for water withdrawal (for irrigation) and for hydroelectric power generation, hence have either failed to see, or at least refused to acknowledge, that the rivers have wider importance. If rivers are conceived as a whole and are jointly managed, then all countries involved should receive higher payoffs, especially over the longer run. But the only way that conception works is if everyone subscribes to the idea that a broader set of benefits are there for the taking. Absent progress in that direction, water will continue to contribute to geopolitical tension rather than help reduce it.

SECTION IV

Water and Security

Across much of Himalayan Asia, and especially among the continent's major powers, transboundary water resources are framed in securitized terms. If securitization is understood as defining an issue primarily in terms of its threat to national security, then national governments across Himalayan Asia are guilty of securitizing debates surrounding transboundary water resources.

Although it bears emphasizing that Asia is a large and diverse continent, many governments have defined transboundary water resources—rivers in particular—through a national security prism. This perspective is a default way for governments to think about water, and one that encourages a zero-sum view of the resource vis-à-vis neighbors and rivals. Largely for this reason, international disputes over transboundary water resources in Himalayan Asia generally focus on the allocation of water quantity from transboundary rivers. In these disputes, the downstream riparian fears a 'taking' of its rightful share of river water by the upstream riparian(s). Any taking of water beyond an explicitly agreed-upon or implicitly understood allotment is defined as not just a material threat to the nation but an insult to national honor and integrity as well. Within Himalayan Asia, transboundary rivers almost entirely lack such explicit agreements. The implicit understandings largely reflect historical usage patterns, long before growing populations and economies began to seriously strain supplies.

This securitization dynamic is both a product of and a contributor to the mutual suspicions that are the fuel for many of the continent's dismal bilateral and regional relations. Himalayan Asia's geopolitical confrontations, whether involving water, territory, or any other dispute, frequently revolve around fixed targets, defined in binary and often rigid terms. Water has become a part of a geopolitical chess match, viewed as an asset to be protected against encroachment by one's international rivals.

There are two tragedies involved in the securitization of transboundary waters. The first tragedy is ironic, in that securitization leads states to adopt positions and policies that detract from actual water security, on the ground, for themselves and their citizens. Securitization leads states to adopt inflexible, hardline positions vis-à-vis their neighbors while discouraging them from looking inward at their own vulnerabilities. Hence securitization hinders the adoption of smart, visionary, and transformative domestic water policies that can in turn insulate countries against external shocks. Securitization inhibits building the societal resilience that will be necessary to combat increased climate- and demand-driven water scarcity and volatility that will occur in the years to come.

The second tragedy is prophetic, in that securitization contributes to realization of the very fears that animated the securitization perspective in the first place. Securitization can play into the hands of politicians who use their domestic constituencies' fears and grievances against constructive solutions, via pointing to their rivals' water-threatening behavior, which is frequently more imagined than real. Articulation of these fears stokes the publics' preexisting resentments about their neighbors and hardens the odds against productive diplomatic progress on transboundary water resources. South Asia is particularly vulnerable to this kind of politics, with leaders in Pakistan, India, and Bangladesh occasionally or even frequently making lurid claims about their neighbors' motives, intentions, and behavior over transboundary water resources. Such messaging works because domestic audiences are primed to believe them. A 2014 Chatham House report, based on surveys of ordinary South Asians, described how "culture[s] of blame" across the region create "sentiments towards other riparians [that] are colored by nationalist standpoints, focusing on past injustice or perceived hostile intentions."

The Sino-Indian dispute over the Brahmaputra/Yarlung Tsangpo provides an apt example of this securitization dynamic. Several experts interviewed for this study believed that India's obsession over China's possible future diversion of the Brahmaputra (at the Great Bend in southern China) has been key to securitizing hydro-diplomatic relations between the two countries, to all basin countries' detriment (recall that the Brahmaputra/Yarlung Tsangpo basin includes China, India, Bhutan, and Bangladesh). If India believes that the single greatest Brahmaputra challenge is Chinese diversion, then India is defining the problem in zero-sum terms. In the diversion scenario, India sees China's security as being enhanced at India's expense. But securitizing the Brahmaputra brings with it costs for India. Securitization means that India reduces any possible future negotiating space with China down to a single issue (water allocation). It also reduces the possible set of actors that could be involved in solving Brahmaputra challenges, down to just the Indian and Chinese central governments. Moreover, the Indian government's reluctance to engage in multilateral conversations about the Brahmaputra mirrors China's reluctance to do the same thing. The end result is that there has not been any serious attempt to build toward an understanding of the river as a regional public good deserving of multilateral approaches to basin-level management.

All of this is unfortunate. Although disputes over transboundary water resources have not resulted in open conflict between riparian states, those disputes are made far more difficult to resolve by the mutual suspicions that permeate interstate relations in Asia. As a result, hydro-diplomacy does not play the productive role that international relations scholars say it can play under the right circumstances. Their contention is that international cooperation around transboundary water resources can help create the reservoirs of goodwill necessary to allow breakthroughs in other diplomatic disputes, up to and including hard security disputes.

PHOTO CREDIT/FLICKR

PHOTO CREDIT/FLICKR

What is the sum of all (water security) fears?

What is the linkage between transboundary water resources and international security? What is it that we fear? For decades, a global network of scholars and practitioners have constructed the field now known as environmental security, which attempts find the linkages between Earth systems and traditional security concerns. The field long has strived to join natural resource challenges, for example oil shortages, with hard security considerations at regional and global levels.

Fresh water challenges have logically become a part of this environmental security conversation. Broadly speaking, there are two sets of fears when it comes to water and its relationship to security: the water wars hypothesis and the spillover hypothesis.

Water wars

The prospect of violent interstate conflict over scarce water resources—the water war—is a specter of our era. The logic is straightforward: the water war hypothesis claims that as states exist in a zero-sum competition for scarce water resources, they seek to control the largest possible share of transboundary water resources, hence are willing to go to war to prevent others from taking their share. The water war narrative makes for compelling reading, given rising water scarcity in many places, including in fragile regions, and where climate change threatens to stress water resources far into the future. Perhaps because the phrase 'water wars' is both simple to understand and frightening in its implications, the media's coverage of global water issues returns to it again and again. A simple Google search for the exact phrase 'water wars,' for example, yields 876,000 results.

Yet the serious empirical work that has been done on the topic offers no evidence of interstate water wars during our own time or in the past. The most comprehensive research on interstate water conflict has been led by Aaron Wolf, a geographer at Oregon State University (OSU). Wolf and colleagues have developed a series of databases that capture interstate interactions over transboundary water resources. Using a coding system along a cooperation-conflict spectrum, their research found no instances of two or more states going to war over water during the modern period, nor any single instance of a water war for the last 4,500 years. Of thirty-seven cases of "acute conflict" after 1948 involving interstate violence over transboundary water resources, thirty were between Israel and its neighbors, with the last occurring in 1970. Within the same post-1948 timeframe, most interstate water events were considered "mild" in nature (mildly cooperative or conflictual). Overall, there have

FIGURE 1. Conflict and cooperation over water in eleven Asian river basins, 1948–2008

Number of events arranged from most conflictual (warfare, coded –7) to most cooperative (+7)

	BASIN AT RISK SCALE														
BASIN	**–7**	**–6**	**–5**	**–4**	**–3**	**–2**	**–1**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Amur	0	0	2	0	0	1	6	1	6	8	7	9	0	2	0
Aral Sea	0	0	2	2	1	1	2	1	21	9	5	13	1	8	0
Ganges-Brahmaputra-Meghna	0	1	2	1	7	21	44	22	87	28	27	31	1	11	0
Helmand	0	0	0	0	1	3	6	0	3	3	5	5	0	0	0
Ili/Kunes He	0	0	0	0	0	0	1	0	1	4	1	3	0	0	0
Indus	0	0	0	0	5	42	68	7	96	20	20	24	0	3	0
Irrawaddy	0	0	0	0	0	0	1	1	2	0	0	1	0	0	0
Mekong	0	0	0	0	0	1	16	5	47	24	24	29	1	3	0
Ob	0	0	0	0	1	0	2	1	7	3	0	1	0	0	0
Salween	0	0	0	0	2	2	10	12	13	2	5	3	0	0	0
Tarim	0	0	0	0	0	0	0	0	1	4	1	0	0	0	0
TOTAL	0	1	6	3	17	71	156	50	284	105	95	119	3	27	0

Source: Oregon State University, Transboundary Freshwater Dispute Database, https://transboundarywaters.science.oregonstate.edu/content/international-water-event-database been more instances of cooperative behavior between states than conflictual behavior.

The data likewise show no interstate warfare within Asia over water during the second half of the twentieth century and the first decade of the twenty-first. As shown in Figure 1, an examination of OSU's International Water Events Database shows no declared warfare over water within eleven Asian river basins over the 1948-2008 period. Only seven out of 937 events (0.8 percent) involved military action of any kind between states, with only one categorized as a "significant war act." Also in keeping with global data, a slight majority of international water events (52 percent) in these eleven Asian basins fell into the "mild" cooperative or conflictual categories (coded -1 to +1 on the fifteen-point scale). Most events (68 percent) were on the cooperative side of the ledger (coded +1 to +7 on the scale), although again it must be emphasized that most of the cooperative events were at the mild end of that scale. It also bears repeating that the OSU data only extends through 2008.

Spillover

The water wars hypothesis does not keep environmental security experts up at night. What does keep them up at night is what we might call the spillover hypothesis, which refers to the risk that increasing water scarcity and/or variability will undermine domestic stability, in turn spilling over into the international arena. The logical pathway is as follows: rising water insecurity occurs within a society, defined by rising water scarcity and variability in water supply, combined with poor water governance; domestic water insecurity causes a series of destabilizing effects, including rising food insecurity, migration, and rising subnational tensions among different groups up to and including violence among those groups; ultimately, these effects begin to spill over into the international sphere through various pathways, including out-migration. Under the worst-case scenarios, water insecurity contributes to the breakdown of vulnerable societies, resulting in civil conflict and its transmutation to surrounding states. The Syrian civil war, which was preceded by a record drought, is the most well-known case study in this vein, although the evidence showing a direct connection to water scarcity is ongoing and nuanced.

Whereas the water wars hypothesis defines water security in classic interstate terms, the spillover hypothesis looks at the problem from the inside out and the bottom up. In many parts of the world the trends are worrisome because of the combination of rising demand and climate-driven impacts on supply. Indeed, across Himalayan Asia rising demand versus more variable supply will be the central water dynamic for years to come.

Domestic water disputes and conflicts already are common in Himalayan Asia. India, for example, has had intense and frequent subnational legal disputes for decades involving shared water resources—over the Krishna, Godavari, Cauvery, and Narmada rivers, to name only a few. Although India has constitutional mechanisms granting the central government powers to intervene in such water disputes between the Indian states, it rarely exercises this power. As Scott Moore, an expert on Asian water security, argues, the reason for the central government's reluctance has to do with the importance of water and its intersection with India's ethno-linguistic cleavages. In other words, the Indian government's reluctance to engage in domestic conflicts involving water is due to the fact that water is too politically toxic for it to handle. "Because irrigated agriculture is so critical to the economy of many Indian regions and because it enjoys commensurate salience as a political issue," Moore writes, "shared rivers have become focal points for ethnolinguistic tensions and cleavages." Politicians at the Indian state level are eager to take advantage of their voters' worst inclinations, shifting blame to neighboring states for water shortages and demanding that their state receive a greater share of water.

Given the lack of robust transboundary water management regimes in Himalayan Asia, plus the mutual suspicions that are characteristic of so many of the continent's bilateral relationships, one can forecast scenarios in which water insecurity at the domestic level bleeds into the international one through similar blame-shifting processes. Under increasing domestic water constraints, politicians, thought leaders, and other elites in downstream riparian states easily could ratchet up their rhetoric against their upstream neighbors, whether from Pakistan to India, India to China, Vietnam and Cambodia to Laos, or Uzbekistan to Tajikistan. Pakistan, for example, has threatened nuclear attacks against India over the Indus, while Indian politicians sometimes threaten to employ water against Pakistan.

Such campaigns are a part of Himalayan Asia's rhetorical landscape, having been employed toward foreign investors in, say, hydroelectric dams and other infrastructure. The campaign against Myanmar's Myitsone Dam, for example, had much to do with how an aggrieved ethnic group in Kachin state perceived that the dam's benefits would be transferred to China (via the export of hydroelectric power). Nor are foreign governments the only possible targets. During a severe 2017 drought in the Indian state of Tamil Nadu, public opinion shifted severely against American soft drink manufacturers Coca-Cola and Pepsi, which were accused of misappropriating increasingly scarce water from the local Thamirabarani River. The drought intensified years-long campaigns against both companies, ultimately resulting in mass and occasionally violent demonstrations.

In such volatile contexts, sub-state actors such as separatist groups, militant groups, and insurgents also play a role. Extremist groups in Pakistan, for example, rally around accusations of India stealing Indus water, employing violent water-or-blood rhetoric to hammer home their point. This is more than blame shifting over water management, rather it is a form of grievance politics that brings water issues together with territorial control, ethnic and religious identity, and historical animosity. This kind of grievance-based politics can become violent under the right circumstances at the subnational level, as was the case with separatist groups in Myanmar. Often, these conflicts are as much about how natural resource decisions are made, and who gets to participate in making them. Political dispossession—being stripped of one's political voice, or never having one at all—appears to matter as much as physical dispossession.


Gangapurna Lake, Nepal

ELMAR BAJORA/FLICKR

What is water security anyway?

It is important to clarify the distinction between water security and the securitization of water. Within the United Nations system and among water scholars and practitioners around the world, water security is defined in broad terms. Whereas securitization emphasizes the national and militarized dimensions of the resource, the broader definitions of water security emphasize shared and sustainable access to a well-managed resource over time.

Although there are many definitions of water security, a couple are worth highlighting. One is the UN's definition, which is broad almost to a flaw. It reads:

> "Water security is the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human wellbeing, and socioeconomic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability."

This definition of water security covers human security, economic development, pollution and disasters, ecosystem protection, peace, and political stability.

Another, slightly more manageable and widely accepted definition, is from a 2007 academic article by David Grey and Claudia Sadoff. For these authors, water security is:

> "The availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems, and production, coupled with an acceptable level of water-related risks to people, environments, and economies."

What such definitions of water security have in common is that all go well beyond the apportionment of water resources. Other important considerations are key to water security. In so doing, these definitions open the aperture, turning away from considerations about absolute water supply and toward issues of access, safety, ecosystem protection, and resilience. Water security is understood as a societal challenge, an iterative task involving multiple stakeholders engaged in a shared endeavor to manage a common set of resources.

This kind of understanding of water security evokes something entirely different from viewing the national security state as the sole actor in the transboundary water space, where the state is engaged in a zero-sum geopolitical competition for access to a strategic resource. While it is important not to discount the significance of national security considerations in transboundary water debates, and to acknowledge that water frequently is framed in such terms by national governments on the continent, a failure to attack the roots of water insecurity as it is broadly defined could lead to the very national security consequences that all fear. Water security should be about cooperating around water and the creation of win-win situations, with mutual trust and mutual gains at their center.

SECTION V

Three Big Questions (and Some Recommendations)

This concluding section asks three big questions about water, security, and geopolitics. Each is geared toward a different dimension of Himalayan Asia's water challenges. The first, about whether water will be a source of conflict, addresses the central theme of this report, namely how transboundary water resources—rivers, in particular—intersect with the continent's geopolitical dynamics. The second, which asks whether technology will be a panacea, addresses a common frame for thinking about environmental challenges, namely that a more promising future will be brought about through breakthrough technologies. The third, which asks what the United States should do, addresses the choices faced by the most powerful non-riparian and non-Asian state. We offer several recommendations while answering this last question.

1. What are the risks of conflict over transboundary waters in Himalayan Asia?

As discussed at some length in Section IV, the answer to this question depends on the type of conflict. Whereas interstate warfare over water is unlikely in the short run, there is more risk of violent conflict over the longer run, given the intense supply-versus-demand squeeze underway. The greater risk involves the spillover effects arising from subnational mismanagement of water and conflicts that might arise as a result. Experts believe there is considerable risk of such conflict and fear that it will bleed outward into the international arena, in the form of out-migration, blame-shifting of neighbors, and more. Even if neither risk materializes in Himalayan Asia (spillover or water wars), absent hydro-diplomatic progress, transboundary water will become an even greater source of tension and competition among geopolitical rivals.

If the risks associated with Himalayan Asia's water challenges are to be reduced in the future, then better governance, at domestic and international levels, is the core solution. At the domestic level, countries across Asia need to implement policies designed to increase societal resilience to water-related shocks and stresses. At the international level, Himalayan Asia's dismal hydro-diplomatic record needs to be improved. Neither proposition has an easy solution. Regarding hydro-diplomacy, Himalayan Asian states often simply do not have the capacity (personnel, budgets, technical capabilities, and so on) to engage in bilateral or multilateral hydro-diplomacy. The same logic extends to the need to deepen transboundary water treaties, which infrequently address complex and increasingly problematic issues such as water quality, groundwater management, and climate change.

At the international level, although building cooperative trust will be difficult, no party can gain by initiating conflict. The costs of an offensive water war would be great and the gains few. Even were a country like Pakistan to successfully attack and destroy Indian dams, for example, this wouldn't give Pakistan any greater control of the river—since its sources would still be upstream—and it would entail collateral damage in relations with India and internationally. For upstream riparians, there is more of a temptation to act unilaterally, but there is little to be gained by deliberately destabilizing a downstream neighbor in the scheme of larger regional relations. For India to intentionally choke off Pakistan (putting aside the technical obstacles to doing so) would not only give extremist reprisals in Kashmir a veneer of legitimacy but also needlessly compromise India's position vis-à-vis China. The cost-benefit calculations of water conflict are bad, such that the greater risk of conflict comes not from deliberate policy choice but from misperception and miscalculation. One role of better international governance is to help defuse misperception and miscalculation by

View of the Ladakh Range, near the city of Leh in far northern India. Glacial melt provides critical fresh water to arid and semi-arid regions across Asia.

PETER ENGELKE

providing information and space for exchange, dialogue, and negotiation.

As asserted, the greater risk is spillover, and it is here that better governance at both the international and domestic levels is essential. Sharing data and coordinating policy with a neighbor—for example on flood warnings and climate risks—can help manage domestic resources and mitigate one's own risk exposure to transboundary stresses. And better management of domestic resources can help lessen the potential impacts of vulnerabilities to international risks while mitigating the domestic stresses that might generate spillover instability.

Although there is no single 'gold standard' metric that is used the world over to measure effective water governance, most states in the water tower can be fairly judged to be falling short. The Asian Development Bank has created a "National Water Security Index" that combines five variables measuring everything from sanitation and wastewater to adequate water supply for sectoral use (agriculture, etc.) to environmental protection to disaster resilience. No Himalayan Asian country scores higher than "capable" (a category at the midpoint of a five-point scale), with the great majority scoring in the two least well-governed categories of "engaged" and "hazardous." All South Asian countries, save Nepal and Bhutan, scored in the lowest "hazardous" category.

The reasons for such low scores are by now familiar. The hydraulic mission ought to be considered a part of the explanation, with its almost singular focus on the development of large-scale water infrastructure to boost supply. As detailed in Section IV and Special Section II, the mission has delivered benefits in the form of increased water for irrigation, ease of navigation along rivers, and increased hydroelectric power. But it just as often has come at a high price, in the form of lost ecosystems and their economic services, such as fisheries, and in the form of the people who are on the losing side of such investment. Even now, the hydraulic mission refuses to die. Together, the countries that share the water tower's ranges have plans to build hundreds of new hydroelectric dams in their stretches of the mountains. Those plans would, if implemented in full, make the Himalayas the most dammed mountain region of the world. Scientists fear the unknown and uncertain ecological consequences; activists fear the more certain human consequences, including the displacement of people that so frequently follows in the wake of dam construction.

The hydraulic mission is hardly the only explanation for poor water governance. Much of the explanation lies with demographic and economic conditions and trends. For decades, rapidly increasing population growth across much of Himalayan Asia, especially in South and East Asia, have made it difficult for policymakers to service swiftly rising demand for water services. Such challenges have been made more difficult given the simultaneous and equally, if not more, rapid urbanization, which has contributed greatly to both rising water demand and increased water pollution.

Politics is never far from the domestic governance storyline either. Water pricing, for example, may be too low nearly everywhere, but as a political matter it is exceedingly difficult for governments to raise water prices. (A more productive approach, now in vogue, might be to focus on water valuation, which places water pricing within a broader framework focusing on the economic, social, and ecological dimensions of water use.) The same is true for the removal of energy subsidies that encourage groundwater extraction, for example in India. Even authoritarian states such as China, which in theory should have less difficulty implementing dramatic water-saving and -protecting measures, have faced difficult political headwinds in reforming their water sectors. When all these conditions are combined with chronically underfunded and under-resourced local and (often) national water ministries, states frequently do not have the capacity to implement sweeping reforms even if they had the political capital to do so.

There is a rising awareness across Himalayan Asia of the importance of water, both domestically and internationally, and of the need to manage it better. Governments are looking for opportunities to improve water governance on national and subnational bases. Despite the hydraulic mission's still-strong legacy, IWRM has made inroads into thinking across Himalayan Asia, with its principles becoming stated norms. Yet it also is worth noting that although the national water policies of all the continent's major countries nominally espouse IWRM, in practice some governments have adopted the IWRM moniker to satisfy external donors' interests, in turn inhibiting rather than advancing actual progress.

Despite the continent's difficult geopolitics, and the securitization of water in general, there are voices within riparian governments and in civil society advocating for greater cooperation with neighbors. Prospects for greater international cooperation over water will depend on internal and external developments. Internally, one could foresee how developments might ease tensions between water users, which in turn might ease pressures on national governments at the domestic level and thus at the international one. An example is improved data and monitoring, which would improve tracking and understanding of hydrological conditions. Although water data is often treated as a state secret, that condition is swiftly being eroded given technological changes in remote sensing and other areas (see question 2 below), which means that technology is evolving independently of state actors. More broadly, civil society can help facilitate these processes and be facilitated by them. Empowered civil society organizations, including multi-national corporations that want to be perceived as good-faith actors on water, academic institutions, activist groups, non-profits, and more, all are engaged in developing more effective subnational, national, and transboundary water management.

Himalayan Asia's transboundary water management regimes need strengthening.

At the international level, Himalayan Asia's transboundary water management regimes need strengthening. The scholars who study such regimes agree that robust institutions based on sound agreements are necessary if the worst effects of future water shocks are to be avoided. Aaron Wolf, for example, argues that the river basins at most risk are those characterized by rapid change (on either the water demand or supply side) and with transboundary institutions that are unable to manage those changes. Conversely, shocks will be managed most effectively through robust yet flexible transboundary water management institutions. In an ideal world, transboundary water treaties would have flexible water allocation criteria (that could be reset based on new scientific evidence), the equitable distribution of benefits, conflict resolution mechanisms, and would contain some capacity for stakeholder engagement from civil society. They would be flexible to allow for shifts in public opinion, climate-driven changes to water regimes, improved technologies and water monitoring systems, and more. Indeed, scholars argue that some ambiguity is helpful in that national governments can frame a treaty (or adjustment to a treaty) in ways that help defuse domestic opposition.

Creating such regimes in the real world is exceedingly difficult, especially where high levels of mistrust exist. Instead of trying to create new comprehensive basin-level treaties from scratch, a better strategy might be to build from the bottom up. Such efforts might focus on negotiating parts of the larger basin puzzle, for example, through negotiating a resolution to a controversial dam. Success would serve as a trust-building exercise that then would enable additional negotiations over other pieces of the basin puzzle. Indeed, some analysts claim that levels of mistrust are so high, and states' geopolitical posturing is so challenging, that formal, comprehensive, and basin-level treaties may never occur in some of Himalayan Asia's most controversial river basins.

Another bottom-up approach is to expand hydro-diplomatic engagement, extending conversations beyond the national governments of major powers. Regarding the Brahmaputra/Yarlung Tsangpo basin, for example, bringing lower riparian countries into a multilateral forum would enable discussion and negotiation over a broader set of issues beyond the allocation of water between China and India (e.g., land use, flooding, siltation, fisheries, irrigation, and more) and among a larger set of state actors. It also could introduce a sorely-needed ecological frame for Brahmaputra/Yarlung Tsangpo river management, providing a counterweight to the dominance of hydraulic engineering perspectives. Although direct talks among the region's governments have not occurred, considerable progress has been made using 'Track 1.5,' 'Track 2,' and 'Track 3' approaches. Under a process known as the Brahmaputra Dialogue, begun in 2013 by non-governmental organizations (NGOs) and research institutions in India and Bangladesh, an increasingly broad set of stakeholders have discussed the river basin's joint management. Since its origins, that process has expanded to include state officials at subnational level and former officials within the basin's national governments. The hope is that the Dialogue will reduce the obstacles to 'Track 1' hydro-diplomacy in the basin.

Building robust transboundary institutions is difficult in no small measure because upstream riparian states often are resistant to their creation. In Himalayan Asia, China is the most powerful upstream riparian. Time and again, China has proven unwilling to engage in multilateral transboundary water management forums. But past does not have to be prologue. For its own diplomatic and regional considerations, China is not interested in destabilizing its downstream neighbors through its unilateral water management decisions. And as China has shown with its BRI investments, it is playing a geopolitical game with India, Russia, and others for influence across the continent. China, for example, has shown a strong interest in befriending Bangladesh in part to gain vis-à-vis India. Bangladesh is as interested in the Brahmaputra's flow as India, if not more so. Finally, while China has proven reluctant to become a member of multilateral forums such as the MRC, their existence nonetheless must be considered by China. As the MRC enables Southeast Asian states to negotiate the river's future among themselves, China must take the MRC into consideration when formulating its own plans. Framing the Brahmaputra/Yarlung Tsangpo and other rivers in basin management terms therefore might strengthen the hand of lower riparians when it comes to negotiating with upstream China.

2. Will technology save the day?

The short answer to this question is no, technology alone will not save the day. New technologies will be critical to solving Himalayan Asia's water challenges, but these technologies by themselves will not be enough. The world's water challenges will be solved through improved governance at all levels, from the local to the international. Good governance includes incentivizing the production and scaling of promising breakthrough technologies and coupling that tech-incentive scheme with the right public policies across different sectors (transport, energy, agriculture, etc.). While technology is not a panacea—technologies nearly always have downsides, produce unintended consequences, and/or fail to live up to their initial promise—it is at the same time imperative that promising technologies be identified, promoted, and scaled.

Desalination

Desalination is a proven technology that can increase the supply of fresh water in coastal regions. Globally, desalination is big business and getting bigger by the year. There are nearly 20,000 desalination plants in operation across 150 countries worldwide, generating nearly 100 million cubic meters of fresh water per day.

In his book about Israeli water practices, *Let There Be Water*, Seth Siegel observes that desalination has become a critical piece of Israel's successful national water strategy. Israel is a downstream nation in an arid region (Israel lies downstream of Syria and Lebanon on the Jordan River), a fact that in the past contributed to violent conflict between Israel and its neighbors. Yet Siegel contends that Israel's aggressive desalination program is a major reason why, today, Israel has become the most powerful water broker in the Levant, essentially acting as a hydro-hegemon despite its downstream status. Israel has, essentially, inverted the hydrological power balance between itself and its neighbors. Whereas Israel had been vulnerable to upstream disruption of its water supply, now it is secure in large part because it can produce much of its own supply through desalination.

Desalination enthusiasts point to Israel as an example of how to overcome water scarcity, seeing in its story the promise of independence from natural cycles, freedom from aridity, and even the upending of upstream-downstream power dynamics between unfriendly neighbors. And up to a point, the Israeli experience can be replicated elsewhere. For coastal cities and regions, desalination is a viable option for expanding the amount of available fresh water. Given the hundreds of millions of Asians living in coastal areas, desalination will become a more important part of the water mix in the future. As the largest economy and most populous nation in Asia, China has had an ambitious program to increase the number of desalination plants along its heavily populated coastline, with plans to increase desalination output through the 2020s. Most observers expect other coastal states, including India, to increase their production of desalinated water. There is no reason to expect the desalination trend to slow down or reverse, given increasing water stresses.

Yet Israel also is a unique case that will prove to be difficult if not impossible to replicate in full elsewhere. As water long has been viewed in existential terms in Israel, it has been far easier for the Israeli government to implement comprehensive interventions in the national water supply than could occur just about anywhere else in the world.

With respect to desalination specifically, the first obstacle to replicating the Israeli experience is that despite decreasing costs, desalinated water remains expensive. High capital costs for desalination plants and the large energy inputs required to run them are the primary culprits. As a result, desalination is a viable option for wealthier cities and countries, but not nearly as much for poorer ones. Transporting desalinated water to the interior of a country adds to this expense, which further limits desalination's applicability for large swathes of Himalayan Asia. Because of high costs, desalinated water is consumed mostly as municipal drinking water or for limited commercial and industrial purposes in coastal areas. Desalination is not viable for farming in general, and certainly not for poor farmers, who still constitute most agriculturalists in Himalayan Asia.

Second, the obvious fact is that Israel is a small country of about nine million people. Securing Israel's water supply through desalination is a much easier proposition than doing so for societies that are dozens of times Israel's size in terms of population and land area. Some figures are useful here. Although the world's desalination plants produce 100 million cubic meters of fresh water per day, that total is a tiny fraction of the amount of fresh water produced by natural systems. The Amur River, hardly the largest on the continent, has a daily flow that alone is more than nine times the total amount of water produced by all the world's desalination plants combined. In 2011, after years of expansion, China's desalination plants produced about 640,000 cubic meters of fresh water per day, which is an impressive figure until one considers that it represents about twenty-one seconds of the Yangtze River's flow into the East China Sea.

Rice farming in Bhutan. Surface irrigation remains a dominant irrigation method across much of Asia.

YANNICK BEAUDOIN/GRID ARENDAL

Having said this, desalination should be one piece of a comprehensive solution set for Himalayan Asia's water challenges. Ongoing technical development is reducing desalination's high price while addressing desalination's serious environmental side effects. High prices are due in large part to the huge energy inputs necessary to operate desalination plants. Until recently, desalination plants required the use of fossil fuels (Gulf Cooperation Council states, which together have the most desalination plants in the world, have burned large amounts of their own oil for this purpose). However, renewable energy sources are becoming viable options for powering desalination plants, given reductions in large-scale renewable electricity prices. The desalination industry has embraced a renewable energy-driven future. A few such plants are now in operation, although all admittedly remain in experimental stages. Energy storage limitations (cost-effective industrial-scale batteries) apparently remain the key stumbling block to scaling renewables-powered desalination plants.

In addition, researchers are attempting to create technologies that will limit other environmental impacts of desalination while at the same time expanding the types of water to be cleaned by those technologies. Besides high energy inputs, desalination's environmental impacts include the creation of large amounts of brine. With few if any economic uses, the brine most often is returned to the body from which the seawater was withdrawn, thereby raising that body's salinity levels and harming its ecosystems. Researchers are working on technologies to create more useful byproducts that do not have to be returned to the ocean or sea. They also hold out the hope that improved desalination technologies can be applied to a wider range of water sources, including brackish groundwater and waste water. The hope is that so doing will expand the amount of available fresh water that can be produced through desalination as well as where such production can occur (for example, desalination of brackish groundwater can occur well inland).

Irrigation fields, Yunnan province, China

GLOBAL WATER FORUM/FLICKR

Ag tech

Given the fact that agriculture consumes the most water in the world by a long measure and given that the impacts of climate change will fall heavily on the agricultural sector, it is imperative that food production become more water efficient. With respect to technological development, there is a wide range of breakthrough technologies either in existence, in development, or on the horizon. For several reasons, the scaling of promising new technologies can be a problem within the agricultural sector, as has been true with drip irrigation systems (see discussion below). Farmers, even smallholder farmers in poor countries, will embrace new technology if the right conditions are present. As irrigation patterns show, that process is not automatic (most farmers, even in wealthy countries, do not use the most advanced irrigation technologies available). There are many other factors beyond a technology's existence that weigh into farmers' calculations, including their awareness of a technology's full benefits and costs, their risk calculation, the availability of alternatives, and more.

Irrigation is an important place to start any conversation about water use efficiency in agriculture. As discussed elsewhere in this report, Asian agriculture is the most heavily irrigated in the world, with some 41 percent of the continent's cultivated area being irrigated according to the FAO (versus the Americas at 13 percent, Europe at 9 percent, and Africa at 5 percent). Together, China, India, and Pakistan have by far the most amount of land under irrigation in the world, with both northern China and the Indo-Gangetic Plain being among the most intensively irrigated regions on the planet.

Unfortunately, the dominant irrigation technique used in Himalayan Asia, surface irrigation, also is the least water efficient. Its inefficiency largely is due to evaporation of water from open irrigation canals and the fields themselves. In contrast, only a small fraction of all irrigated land is fitted with the most advanced water-efficient irrigation technologies, specifically drip irrigation technologies. Although there are several variants, as the name implies drip irrigation technologies apply small amounts of water in targeted fashion directly onto the base of a plant. And although its effectiveness varies by type of drip irrigation technology, plant species, soil composition, and other factors, well-run drip irrigation systems can dramatically cut on-farm water consumption while boosting crop yields.

Yet despite their effectiveness at saving water and increasing yields, drip irrigation systems are woefully underutilized. This is not an example of resistance to a new breakthrough technology (drip irrigation technology is several decades old). Rather, it is an example of how difficult it is to scale promising water-saving agricultural technologies even when those technologies have proven benefits for the user. There are several intersecting reasons why farmers, in particular smallholding farmers, do not install and maintain drip irrigation systems. Smallholding farmers tend to be risk averse, in that they resist sudden changes to the farming practices they have been utilizing for years. They are reluctant to invest scarce funds in the high capital costs needed to acquire drip irrigation systems. Given these high initial costs, governments and non-profits occasionally will subsidize the initial purchase of such systems. Unfortunately, evidence from different parts of the world, including from within Himalayan Asia, suggests that farmers often abandon their systems after a few years, largely due to the costs required (in terms of funds plus labor) to maintain them. Where farmers do continue to deploy irrigation technologies, overall water use may actually increase due to so-called "rebound" effects as farmers devote the water saved from more efficient use to expanding the total irrigated area or nourishing more water-intensive crops. None of this is helped by the fact that in many if not most countries, water is not expensive enough relative to other inputs to sufficiently incentivize farmers to adopt costly water-saving technologies. Put plainly, for many farmers, these systems do not pay for themselves.

Despite these hurdles, governments, non-profits, irrigation technology companies, and multilateral institutions continue to hone the mix of policies and incentives necessary for a more rapid expansion of drip irrigation systems. Several experiments in the Indian states of Gujarat and Karnataka have attempted to address the food-water-energy nexus to incentivize farmers to conserve water. Led by Tushaar Shah, one of South Asia's most respected water experts, these experiments innovate around a combination of solar power and drip irrigation. Farmers who install solar panels on their farms to pump groundwater (solar is increasingly common for groundwater pumping in India) are given 'buy-back' guarantees for selling their excess power back to the grid and at the same time are encouraged to invest in drip irrigation systems. This scheme is designed to both discourage the over-pumping of groundwater and encourage the efficient on-farm use of the groundwater that is withdrawn. Shah fears that while solar power has almost unlimited potential to revolutionize subsistence farming in South Asia, it also will allow farmers to pump far more groundwater than they need. The goal is to have farmers sell the excess solar power back to the grid while maximizing on-farm water use efficiency.

Maximization of water-use efficiency at the farm level is one of the reasons why many water experts are excited by advances in remote sensing technologies. These technologies refer to Earth systems data that are captured by satellites and drones and then made available to end users. Although satellite and drone data collection is decades old, in recent years there have been dramatic reductions in the cost of creating and operating such systems and in capturing and transmitting the data. When combined with increased computing power and the ubiquity of handheld mobile devices, a revolution of sorts is in the offing. Remote sensing experts argue that these satellite- and drone-based data collection and distribution systems have almost unlimited power to assist in agricultural production, including the more efficient use of water, down to the farm level and in real time.

Experts interviewed for this study argued that today's remote sensing systems provide several important benefits. The most important involves the data itself. These systems are massively increasing the amount of data, including real-time data, expanding the universe of information that is available to end users, and increasing data precision, for example providing an increasingly fine spatial resolution of land use information. Further, because the data is now either provided by public agencies that are required to release the data to the public (for example, NASA) or collected by private companies who operate their own systems, the data allows analysts and end users, including farmers, to make end runs around national water bureaucracies that historically have treated hydrological data as a state secret. Experts contended that this opening of data collection and dissemination will contribute to greater transparency in the water space and enable easier interstate negotiations regarding water disputes. They also argue that such data can be put in the hands of farmers, to help them understand how they can maximize on-farm crop production while minimizing input inefficiencies, including water-use inefficiencies.

There are, however, several caveats. One is that while several private companies now operate their own remote sensing systems, including satellite systems, that does not mean that the data they collect will be made freely available. Rather, as it remains expensive to both collect the data and analyze it, firms will charge for both services. We might have much more and better data, but it remains a question as to who can pay for it. A second caveat involves trust, in that more data from more sources might lead to an erosion of trust in data, based on a belief in a real or imagined manipulation of

Many water experts are excited by advances in remote sensing technologies.

that data. This argument is analogous to what has happened with news sources in the digital era, wherein the proliferation of internet-based information perversely has eroded the public's trust in news sources rather than enhanced it. Lastly, there are equity issues here as well. Remote sensing technologies may contribute to land ownership disputes, when people farm plots of land that are not legally recognized or recorded, or ownership is contested, as is common. Applied to the water space, this means that it is unclear how remote sensing technologies might assist, say, cropping choices if ownership of a field is unknown or contested.

Finally, a nod must be made to agricultural biotechnology, which like remote sensing is a category of technological research and development that has been ongoing for decades but which also stands at the cusp of breakthrough innovations. Advances in genomics and genetic engineering are allowing scientists to understand plant genetic patterns to improve crop performance yield, including genetic traits that perform well under stressful conditions. As with any promising line of over-the-horizon technologies, no one knows for certain when or how such biotechnologies will impact the world. Yet there is considerable optimism that seeds that perform well under water scarcity or higher temperatures will be developed over the coming decades. Genetic research itself also is becoming cheaper (for example, the cost of plant, animal, and human genome sequencing has plunged), meaning that research funding more easily can be directed toward environmental conditions and toward the crops that Himalayan Asian farmers tend to plant.

While expert opinion supports the general proposition that biotechnological development almost certainly will contribute to higher yields in the future, with some hope that yield increases will occur under more stressful environmental conditions, at the same time experts question the degree to which countries will be able to maximize these advances. As is true of other pieces of the ag-tech equation, the key questions involve where research funding and attention is directed, whether new biotechnologies will be adopted and scaled appropriately, and whether the most promising technological advances will be exploited through supportive policies.

Renewable energy technologies

Decoupling energy production from water use should be an important part of the solution set. Thermal power generation, in particular thermal power generation using fossil fuels, provides the bulk of Asia's electrical power, emits a huge amount of carbon, and uses a great deal of surface water (although the plants return water to the source, they are competitors for often-scarce water sources). National governments and multilateral institutions long have regarded hydroelectric power generation as a low-carbon alternative that consumes little water (even if dams interfere in hydrological cycles). It turns out that neither proposition is true, as dam reservoirs produce large amounts of methane and enhance surface water evaporation. Moreover, in the years ahead, climate change may undermine hydroelectric power generation along rivers affected by more severe and frequent drought. A 1 percent drop in stream flow, for example, can trim hydropower production by 3 percent.

For these reasons and more, including the need to reduce carbon emissions overall, the scaling of renewable energy sources should be a centerpiece of Himalayan Asian countries' energy strategies. This argument is not just an environmental one. Economic and financial trends are increasingly important in driving the shift to renewables, trends that will become more favorable given ongoing technological development surrounding renewables. Given their pricing relative to other energy sources, including hydroelectric dams, renewable energy sources are already cost-competitive in the short term and more than competitive in the longer term. Even without dramatic decreases in battery prices (considered the game-changing technology for the mass scaling of renewable energy sources), the ongoing slide in renewables-generated electricity prices should continue. China is driving much of the downward pressure on renewable energy prices, given its status as the world's leading solar producer.

Grid connectivity is yet another issue. Most of the people in Himalayan Asia who still lack access to electricity are off the grid, with many in rural areas. Providing power to these rural areas from large dams (or thermal plants) requires building out and maintaining the electrical grid to carry power to them. Distributed renewables such as solar, wind, and micro-hydro can supply small communities in decentralized fashion, as they don't require grid connections.

Given the ongoing interest in new hydroelectric dams across the water tower, key questions are whether and when renewable energy sources will become more central to national economic and energy development plans than will hydroelectric sources. There is a real case to be made, and indeed one that has been made for years, that the total negative ecosystem effects of hydroelectric dams outweigh their benefits. But there is an increasingly convincing case to be made that there is considerable risk of the long-run returns on big dam investment. From the climate side, the risk is greater uncertainty on river water levels, especially the possible effects of both more frequent flooding and drought.

Such fears are already coming true in various places around the world. On the Colorado River, for example, water levels on the Hoover Dam's reservoir have dropped to record lows owing to a combination of increased aridity in the basin over the last two decades and rising demand for water from upstream users. The fear there, as elsewhere, is that reservoir water levels will drop below the dam's turbine intakes, rendering it useless for power generation.

Conversely, there will be considerable risk of flooding in mountain regions as well. In the HKH, glacier lake outburst flooding (GLOFs) can destroy dams with catastrophic consequences downstream. Many rivers will see greater sedimentation from more variable and more intense precipitation patterns. Higher sedimentation builds up in reservoirs, lessening storage capacity and damaging turbines.

On the power demand side, an additional challenge facing large hydroelectric dams is regional over capacity. Hydroelectric dam development across much of the HKH is increasingly premised not just on increasing domestic capacity but on selling the excess power to a neighbor. This is Nepal's plan relative to India and for Laos in the Mekong. The challenge for both is finding markets. India has become a net electricity exporter, for example. In other words, even without reference to the falling cost of renewables, the business case for hydroelectric development over much of the HKH is already poor.

3. What should the United States do?

The United States is the external superpower in the Asian geopolitical context, a reality that has negative and positive consequences. On the negative side, despite America's still-significant economic, diplomatic, and geopolitical clout, it does not have a physical presence on the continent and thus cannot wield the full panoply of tools that are possessed by the continent's major powers. Whereas the Chinese or Indians can build dams on their own territory, and hence can affect the flow of Himalayan Asian rivers, the United States cannot. Because the United States is not a riparian anywhere, it cannot affect physical water supply and quality. Because the United States is not part of these basins, it is not part of their shared hydrology, nor part of regional connectivity through river navigation or linked electric grids, nor part of shared ecosystems, nor does it have any populations living in the river basins. The United States has no standing in river basin decision-making and has no 'right' to be part of basin institutions.

It also is an open question whether the United States has as much indirect power in the water space as, say, China. A major part of China's leverage is indirect (through, say, the BRI and water infrastructure financing), but China operates with fewer constraints than does the United States. China has no qualms in sending thousands of construction workers to build the infrastructure that its banks finance, for example. China also is willing to lend with fewer conditionalities than the US and multilateral organizations such as the World Bank. And it hardly needs to be said that China possesses considerable leverage over its neighbors simply because it is in the immediate vicinity.

Yet there are positives and the United States is not destined to second-tier status in shaping water outcomes in Himalayan Asia. If the United States plays to its many strengths, it can maintain and even augment its leverage. Besides the considerable indirect tools that the United States can bring to the table, the United States also can function as a valuable partner in Himalayan Asia because it is not a riparian country, is not a close geographic neighbor, and is not an upstream hydro-hegemon. The last piece is valuable, given the many suspicions among upstream and downstream riparians. America's value as a partner exists in part because it is a powerful state but also a non-Asian one.

For the US government, the relevant questions regarding how to approach water security are as much about defining a strategy and vision as they are about honing policy. A full assessment of how, exactly, the United States government should so engage is beyond the scope of this paper. Nonetheless, with an eye toward the big picture, we offer some starting recommendations:

Define water's place within the context of US strategic interests in Asia

The first step is to **create a coherent US government strategy toward Himalayan Asia incorporating water as a pivotal element.** Although an obvious task, its development and execution is anything but. The principal difficulties involve defining America's strategic goals and then placing water within that context. Neither are straightforward.

Over the past two decades, the US government arguably has had several strategies toward Himalayan Asia (for purposes of this discussion, 'Asia' does not include Western Asia, i.e., Iran westward). These strategies have included a post-September 11, 2001 anti-terror agenda, as embodied in the US government's engagement in Afghanistan and its attempt to enlist neighboring states in that engagement. Other strategies have been oriented around containment of geopolitical foes, for example North Korea, or at the least the checking of its geopolitical rivals, as for example Russia in Eurasia. American strategy toward China has varied over time. Its strategy has included the accommodation of China's economic rise by inducing China to embrace the global trading regime (via the Obama Administration's vision for the role to be played by the Trans-Pacific Partnership).

Lately, American strategy has shifted toward confrontation with China on issues ranging from trade to security, reflecting views that have been gaining currency in Washington's foreign policy circles for years. China's increasingly assertive foreign policies in Asia, its willingness to insert itself into affairs elsewhere in the world, and its unwillingness to accept globally accepted rules and norms (e.g., China did not accept a 2016 decision by the Permanent Court of Arbitration regarding the South China Sea) have contributed to increasingly hardball relations between the United States and China, as over the South China Sea. In December 2017, the current administration's first National Security Strategy (NSS) formally defined China (and Russia) as a "challenger" and "revisionist power" engaged in a "contest for power" against the United States and its partners. It rejected the decades-old premise that China's economic rise would end with its full incorporation into the rules-based international order that was built by the United States and its partners after 1945.

The 2017 NSS also defined the "Indo-Pacific" region as a strategic priority, claiming that a "geopolitical competition between free and repressive regimes" is underway there. Over subsequent months, the administration has attempted to further articulate the contours of what is now known as the Indo-Pacific strategy, a still-amorphous vision with security, diplomatic, economic, technological, and other dimensions. In July 2018, US Secretary of State Mike Pompeo gave a well-publicized speech announcing a $113.5 million Asian infrastructure fund, believed to be a small but important initial step toward a larger Asian infrastructure investment effort organized by the 'Quad' (the United States, Japan, Australia, and India).

The first step is to create a coherent US government strategy toward Himalayan Asia incorporating water as a pivotal element.

Despite this welter of at-times conflicting strategic priorities, including vis-à-vis China, what is clear is that several Asian states are critically important to US foreign policy and strategic interests, whether as friends, competitors, or foes. China, India, Pakistan, and Russia all are atop America's global strategic priorities list. In one way or another, all these are critical actors in Himalayan Asia's water space, whether through their:

- upstream position with respect to rivals (China and India; India and Pakistan);
- downstream vulnerabilities regarding same (India regarding China; Pakistan regarding India);
- investments in water infrastructure in their near abroad (e.g., China through BRI, Russia in Central Asia);
- leverage over smaller downstream states (e.g., China and Southeast Asia); or
- own domestic water-related weaknesses (multiple Asian states).

The transboundary nature of Asia's water resources brings to the fore one of the contradictions embedded in any US strategy that turns any of Asia's major powers, especially China, into a geopolitical foe. As water is a transboundary resource, it is one of the connectors that knits Asian countries together, whether they want to admit it or not. Thus, it is impossible to nationalize water management without increasing the odds of international conflict over the resource. China's upstream position in Asia, combined with the considerable indirect resources it can bring to bear to influence its neighbors' water uses and policies, means that any realistic solution to Asia's serious water challenges must involve China. Hence the need for the United States to find avenues for cooperative engagement with China on transboundary water resources, even if the United States were to increasingly align itself with China's principal Asian competitors (India, Japan, etc.).

For the United States, an important part of the strategic challenge in Asia is preventing water from contributing to both state fragility (the spillover hypothesis) and international conflict (the water wars hypothesis). Both of those outcomes would undermine every other US strategic objective in Asia. Given what we know is likely to occur in the future considering forecasted water supply and demand curves, both outcomes are plausible. Conversely, United States' strategic interests would be best served if it is perceived in Asia as a good-faith actor dedicated to solving the continent's water challenges.

In 2017, the US government released a first-ever Global Water Strategy (GWS). Although the GWS is about neither Himalayan Asia nor geopolitics, it (along with the 2012 Intelligence Community Assessment on water security) is an outstanding step toward articulating how and why the US government should think about water in strategic terms. Among other things, the GWS argues that a "growing global water crisis" may "foster insecurity and state failure" around the world. The US government should advance a "water secure world" through supporting sound water resource governance and promotion of cooperation around transboundary rivers, among other pathways.

The US government should deepen its understanding of the linkages between water and its strategic objectives, in Asia and elsewhere in the world, and articulate those linkages clearly in its top-level documents. A clear objective should be the **inclusion of water security into the National Security Strategy and other strategy documents at the highest levels of governance** (e.g., the Quadrennial Defense Review). A related objective would be to **direct the Office of the Director of National Intelligence to regularly update its Global Water Security assessment** (ODNI cannot do so on its own, it must be directed to conduct such assessments). Doing so would send the clearest signal to United States' partners and allies, and to US government departments and agencies, that water security is treated as a strategic priority at the highest level of the US government. Water security is a non-partisan issue, and easily could become a standard component of future strategic documents, including the NSS, across administrations.

Craft a compelling vision around water in Himalayan Asia

An important task will be to **craft a compelling vision for how the United States can assist Himalayan Asian states in solving their water challenges.** Such a vision should follow in train of an improved understanding of how water fits into the US government's highest strategic goals. A well-crafted vision would do more than align US government departments and agencies around a common water-related agenda on the continent. As valuable as that would be, a well-crafted vision also would be an expression of American soft power, important for motivating institutional partners while providing a positive frame for influencing Himalayan Asian publics through public diplomacy and subnational engagement.

A compelling vision about water, including how the United States can help solve water-related challenges in Himalayan Asia, would provide a helpful alternative to dominant narratives about water and economic development. Those narratives include the hydraulic mission, still alive in too many places, and one that appears to animate China's foreign development strategy, with its almost singular focus on hard infrastructure investment. As this document has emphasized, hard infrastructure investment is only one part of a much larger picture. Increased hard infrastructure investment not only will not solve Himalayan Asia's greatest water challenges, in many ways doing so will make those problems worse. Hard infrastructure investment always creates negatives as well as positives, with costs and benefits unequally distributed across society, most often to the detriment of marginalized populations. Moreover, large infrastructural investments frequently result from opaque decision-making processes that are rife with rent-seeking and corruption.

U.S. NAVY/DUSTIN KNIGHT

US Navy ships patrol the South China Sea, a body of water disputed by the world's two greatest powers

The US government is therefore presented with an opening to reassert its global water leadership, one that it should embrace. A starting point would be to **create or commission a high-level report specifying exactly how the US government and its partners should organize its efforts around water to achieve its strategic goals in Himalayan Asia.** In our opinion, that document should include the following pieces:

First, a vision should emphasize how water security contributes to societal resilience. As outlined in a 2016 Atlantic Council report on global water security, the resilience paradigm stresses the anticipation of future shocks, long-range scenario planning, inclusive and participatory governance, and investment in a diverse portfolio of strategies designed to reduce the risk of shocks and the losses from those shocks should they occur. A resilience paradigm is at once an economic, social, and environmental argument, necessitating that policymakers incorporate multiple perspectives into a balanced view of how the future might unfold.

For example, a resilience paradigm would emphasize caution in large hydroelectric dam investment. Resilience forces policymakers to consider the risk that such long-term investments might not pay off as forecast. Under certain climate scenarios, large dams might become stranded assets, as

Kurpsal Dam along the Naryn River in Kyrgyzstan

NINARA/FLICKR

for instance the Hoover Dam risks becoming in the face of long-range drought in the western United States. Large systems do not adapt well in the face of these kinds of external shocks. Even absent such shocks, new technologies likely will obsolete new hydroelectric dams long before their useful lives are up. The benefits of smaller, greener, more efficient, more distributed, and more adaptable systems are already clear, and will become more apparent over time.

Second, the vision should emphasize that water is critical to sustainable development, inclusive prosperity, and cooperation in Asia. Although at first blush talk of sustainable, inclusive, and cooperative development appears to be nothing more than feel-good language, in the context of Asian water politics it is anything but. A generalized lack of trust surrounds water politics across much of Asia, certainly across national boundaries and frequently within them as well. A vision that emphasizes treating water in positive-sum terms should be an important part of diplomatic messaging, focused on transforming both official and public opinion.

This observation begs the question whether the United States is best positioned to deliver the cooperative message. The sad fact is that, when it comes to environmentally-related global governance, the US has allowed its leadership status to lapse over the past couple decades. If Himalayan Asian states are to take American overtures about innovative and cooperative transnational water management seriously, the US government not only needs to regain its footing as an environmental leader (e.g., through reentering the Paris climate accord or ratifying the UN Conference on the Law of the Sea). It also needs to become more comfortable working toward long-term solutions to difficult regional challenges—exactly the kind of challenges presented by transnational river basins. For myriad reasons, American diplomacy tends to work through bilateral rather than regional relationships. For example, US funding is bilaterally focused, with most diplomatic and development funding going through national governments rather than regional institutions and platforms. Moreover, longstanding diplomatic culture privileges bilateral diplomacy over regional approaches. If the United States is to be taken seriously as an honest broker in Asia, it will need to show that it can do the hard work of regional engagement, with a commitment to transparent multilateral diplomacy and the building of long-term regional dialogues and processes.

Third, a vision statement should emphasize how the United States can help Asian states innovate in the water space. Innovation, like sustainability and resilience, has broad appeal for its positive and forward-looking implications. A stress on innovation plays to one of America's core strengths—the United States remains among the world's most innovative and technically advanced societies—and to foreign publics' views of the United States as the world's preeminent modern society. The vision would lay out how the US government and its non-state partners (tech firms, universities, etc.) could assist in the development and scaling of breakthrough water technologies in energy, food, cities, transport, public health, and more.

Finally, a vision statement should articulate how the US government should organize itself to best fulfill America's strategic goals. Although outlining a reform agenda itself is beyond the scope of this report, it is worth making a couple of basic observations. One is that water experts routinely decry the fragmentation of US government policy and funding in the context of US foreign affairs. Coordinating how water intersects with, say, agriculture, energy production, public health, and urban affairs is no small task for any government. A second is that the US government places great emphasis on water for sanitation and hygiene (WASH) and much less on everything else. There is no question that WASH is critical, given the sanitation deficits around the world. And it is important to note that low WASH provision reflects poorly on governments, which can in turn become another source of grievance against government and therefore contribute to societal destabilization. But Himalayan Asia's water challenges extend far beyond poor sanitation, and its transboundary water disputes have almost nothing to do with sanitation. The US government is not focusing its funding and attention on the most serious problems facing Asia.

Water therefore needs a more permanent and visible presence within the US government's foreign and security policy firmament. For several years, the US Agency for International Development (USAID) has had a global water coordinator and Office of Water, reflective of the dominance of federal spending on WASH. By contrast, funding for the government's hydro-diplomatic activities is woeful. To partially correct this imbalance, **a fully funded and staffed water office and global water coordinator position should be created within the State Department's Bureau of Oceans and International Environmental and Scientific Affairs, empowered with a long-range mission and equipped with interagency coordinating powers. Peer positions, focused on global water security, ought to be established within the US Department of Defense and National Security Council.**

Work with key allies and partners around the vision

To make the connection between water and US national security, including the risks to US strategic goals, the vision will need to be translated into thoughtful, well-articulated, well-planned, and fully fundable plans that can be implemented with allies and partners on the ground. Ideally, the US government would develop long-range plans that would focus on a mix of policies and processes designed to increase societal resilience to water-related shocks. Capacity building, development of best-practice policies and infrastructural investment strategies, and diplomatic engagement on transboundary water resources all would be included.

One key here is to expand the definition of who qualifies as a partner. Subnational actors ranging from civil society groups to businesses to provincial governments to local farmers all are key to water-related outcomes. We live in a polycentric world composed not just of nation-states but of other actors who have their own sources of power. In countries such as India, subnational governments (federal states) possess considerable influence, including within the water space. So too do the world's cities, which in some cases have tens of millions of people living in them. While the US government engages subnational actors, that engagement is ad hoc and uncoordinated. **The State Department should create a fully funded and staffed office for subnational engagement,** the purpose of which is to track interactions with subnational actors, devise strategies for engagement, coordinate the government's diplomatic outreach, and act as the government's point for outreach to subnational actors.

Another practical step would be to **empower the US government's scientific agencies to: fully engage at the international level; ensure the international availability and distribution of their data; and develop partnerships with national and international agencies, the private sector, and civil society in the development of open source data tools that are tailored to end users** including non-profits, agricultural extension services, disaster management agencies, and individuals (e.g., farmers). The US government's scientific organizations such as the National Aeronautics and Space Administration (NASA), US Geological Survey (USGS), and National Oceanic and Atmospheric Administration (NOAA) gather among the best and most comprehensive water data in the world. So too do many of its private-sector firms. The challenge is to find ways to have that data be used on the ground by people who make decisions about water use. Experts interviewed for this report stressed that the US government's scientific agencies do not have a mandate for international distribution of their data, and no programmatic strategy to get the data into the hands of end users around the world.

A related and important step would be to create an early warning system focused on predictions of water-related fragility. **The US government should, in coordination with academic analysts and international scientific organizations, develop an early warning of potential water conflict hotspots in Himalayan Asia and elsewhere in the world.** Such international organizations include the International Centre for Integrated Mountain Development (ICIMOD, an intergovernmental organization based in Kathmandu), the International Institute for Applied Systems Analysis (IIASA, based in Vienna), the World Bank, and UN Water. The models here include FEWSNET (Famine Early Warning Systems Network), a famine prediction service created in 1985 by USAID and SERVIR-Himalaya, an HKH satellite monitoring service created by NASA and USAID in cooperation with ICIMOD. An effort focusing on water conflict would attempt to foresee political tensions and instability related to water stress and poor water governance before these devolve into flashpoints, conflict, and spillover into the international arena. This foreknowledge could then facilitate diplomatic, development, or other capacity building and conflict reduction engagements in the way that FEWSNET enables famine prevention measures like preparing and pre-positioning food stocks and assistance.

Protect the Water Tower

Last but by no means least, the United States should support the protection of Himalayan Asia's water tower—the HKH ranges, their ecosystems, and the rivers spawned by them. The reason is simple: the water tower is the single indispensable feature of the continent's geography, one that nourishes billions of people across the continent. This insight is why the HKH ranges are often referred to as the "Third Pole," a term that instantly conveys the ranges' ecological importance via comparison with the Earth's two natural poles. Like the Earth's two natural poles, cooperative governance of the Third Pole is necessary if countries are to anticipate and manage the shocks that invariably will come in the years ahead.

The idea that ecological boundaries ought to define the boundaries for natural resource governance is not new. With its emphasis on basin-level governance, IWRM has this idea embedded in it. But whereas IWRM is about governing individual basins, protection of the water tower requires governing multiple basins simultaneously. The HKH ranges cannot be protected from climate change one basin at a time. Rather, the water tower presents a complex, multifaceted governance problem. Ideally, solutions will have to be developed that span across the HKH ranges and their multiple river basins.

The United States should support the protection of Himalayan Asia's water tower—the HKH ranges, their ecosystems, and the rivers spawned by them.

The Arctic Council is the appropriate model to emulate. The Arctic Council is an intergovernmental forum whose eight member states work cooperatively on common environmental and scientific challenges facing the Arctic region. Two of these member states are Russia and the United States, which despite being geopolitical adversaries in just about every other sphere somehow have managed to cooperate within the context of Arctic governance. During the 1990s, both countries were instrumental in the creation of the Arctic Council and have cooperated within that body ever since. This Russian-American experience is critical, for it suggests that collective governance of the water tower is possible, even given the border disputes, rivalries, and suspicions that the HKH states share with one another. Indeed, the eight HKH states (India, China, Pakistan, Afghanistan, Nepal, Bhutan, Bangladesh, and Myanmar) already have a precedent for regional cooperation, having founded ICIMOD. Indeed, Asia's two biggest states cooperate in the Arctic as well, with China and India gaining Observer status to the Arctic Council in 2013.

The United States government should pick up this mantle, and **support processes leading to the creation of an intergovernmental forum for the environmental and scientific stewardship of Himalayan Asia's water tower.** Those processes should mirror the processes that led to the creation of the Arctic Council in 1996. Starting in 1989, the Arctic states plus an array of non-state partners began an initiative focusing on Arctic stewardship. Two years later, that process produced the Arctic Environmental Protection Strategy (AEPS), a 1991 agreement signed by eight Arctic states including the US and USSR. The AEPS formalized protection of the Arctic's environment, including protection of its indigenous peoples, and established a cooperative and transparent intergovernmental forum. Five years later, the eight member states issued the Ottawa Declaration, which formally established the Arctic Council. In short, the Arctic Council began as a talking shop, then gained currency through its research and transparent processes to become a highly respected and productive deliberative body.

There is good reason to believe that a permanent, legally established and recognized intergovernmental forum, like the Arctic Council, could be created for the water tower. Given the often-difficult status of diplomatic relations among the water tower's states, an Arctic Council-like outcome will require delicate and lengthy negotiations if it is to be realized. The odds will be maximized if a process can be designed that is like that which created the Arctic Council, based on a commitment to scientific knowledge building, environmental protection, and transparent, collaborative, and consensus-based decision-making.

Protect Asia's water tower: a participant smiles during International Day for Biological Diversity celebrations. ICIMOD headquarters, Kathmandu, Nepal, May 2017.

JITENDRA RAJ BAJRACHARYA/ICIMOD/FLICKR

If the US government were to lead such an effort, its best play is to utilize its diplomatic strengths to **bring other nation-states, multilateral organizations, and civil society into a consensus-building coalition for the creation of precursor institutions and processes.** Those institutions and processes should follow the Arctic Council's template. Given that the United States is not a riparian state, the US government should **support those multilateral, civil society, and scientific organizations that wish to lead this endeavor.**

The purpose of such a forum would not be to 'internationalize' the water tower by granting non-Asian states like the United States the right to participate in decision-making about HKH states' territories and resources. In this respect, an HKH forum would emulate the Arctic Council's experience regarding decisions about the Arctic—no state beyond the eight Arctic Council member states has the right to participate in decision-making. Rather, the purpose would be to facilitate collective knowledge building and policy development among the HKH states. In advancing an HKH forum, **the United States should seek diplomatic support from other Arctic Council states** that also are active in advancing hydro-diplomatic relations around the world, including Sweden and Norway, plus Arctic Council observers Germany, the Netherlands, and Switzerland.

Predictably and logically, the US Department of State has no single bureau with a geographic portfolio spanning the HKH ranges and the rivers that flow from them. Rather, multiple bureaus have jurisdiction over different pieces of this geography. The Bureau of South and Central Asian Affairs has the most expansive geographic portfolio, one that includes the five Central Asian republics and the states running southward from Afghanistan, Pakistan, Nepal, Bhutan, and India. China, the most important upper riparian, and all Southeast Asia is under the Bureau of East Asian and Pacific Affairs. Russian relations fall under the Bureau of European and Eurasian Affairs.

One additional and simple recommendation, therefore, is to **create a special representative for Himalayan affairs** (or similar title), the role of whom would be to coordinate the US government's efforts, and with the primary task of facilitating creation of an Arctic Council-like forum for the HKH region. This position should be placed within the Bureau of Oceans and International Environmental and Scientific Affairs, in keeping with the Arctic Council's institutional home at the State Department, and in keeping with the goal to establish an HKH body focused on environmental protection and scientific research.

SPECIAL SECTION I

Himalayan Asia's Water Dynamics in Depth

Any attempt to generalize about Himalayan Asia's water dynamics carries the risk of reductionism. Indeed, there are significant and important differences in water dynamics across the regions examined in this paper. Yet there are some critical drivers of change on both the supply and demand sides that apply across geographic settings and that are worth discussing at some length.

This Special Section dissects Himalayan Asia's water dynamics across three sectors and four regions. The three sectors—agriculture, cities, and energy—represent the largest sectoral water users in Asia (admittedly, cities can be thought of as a meta-sector that includes residential, commercial, and industrial users). The four regions are Central, South, Southeast, and East Asia.

By sector

While agriculture is Himalayan Asia's largest water consumer and figures to remain so for a long time to come, it is hardly the only sector with a claim on the resource. Indeed, one of its greatest water challenges stems from increasing demand arising from other sectors. Besides agriculture, two sectors stand out. First, rapid urbanization and population growth in general have meant the swift growth of hundreds of cities across the continent, including within Asia's two most populous countries (India and China). That in turn has meant the rapid growth of municipal demand for water (from industries, households, businesses, and other entities) and in the production of wastewater. Second, there has been a related and massive growth in energy demand across much of the continent, reflecting economic growth and urbanization in many regions. The energy-water nexus is critical (energy production is dependent upon water availability).

Agriculture

Globally, agriculture is the greatest user of water, and by a long measure. Agriculture is responsible for around 70 percent of all water withdrawals globally and as much as 90 percent of all water consumed. (Water withdrawal refers to water taken from a source but eventually returned to it, as is the case with a power plant that uses water for cooling; water consumption refers to water taken from a source and never returned, as is the case with irrigation water that is absorbed by a plant.) However, the total amount of water removed from surface and groundwater sources and their respective shares vary considerably by region and country. Asia's agriculture withdraws the most water in the world. In 2010, the UN's Food and Agriculture Organization (FAO) estimated that Asia's agricultural sector withdrew 81 percent of all water on the continent, totaling 2,069 cubic kilometers annually. By contrast, the agricultural sector in the Americas withdrew 415 cubic kilometers per year, representing 48 percent of water withdrawn. European agriculture withdrew eighty-four cubic kilometers per year, at 25 percent sectoral use. To put this agricultural water use in some perspective, Asian agriculture withdrew 75 percent of all water withdrawn for agriculture globally, and half of all water withdrawn in the world.

India, China, and Pakistan all are in the top five most prolific agricultural water users in the world, with India and China ranking first and second, ahead of the United States, with Pakistan fourth. India's agricultural withdrawals alone (688 billion cubic meters annually) are nearly four times that of the United States (175 billion).

There are several reasons why Asian agriculture is the world's largest water user. These can be split into demand- and supply-side explanations. On the demand side, the continent has the world's largest population, at 4.4 billion in 2015 (about 60 percent of the global total), including the two largest countries by population (China and India) plus several of its swiftest-growing economies. Feeding the largest share of the world's people requires the most agricultural production, in particular when population growth is coupled with rising incomes and therefore changing diets. In 2009, the FAO made a splash when it projected that the world would have to produce 70 percent more food by 2050 for 34 percent more people. The FAO forecast a greater rate of food production growth compared with population growth because of rising urbanization and therefore of wealth in developing regions. Wealthier people eat higher-caloric diets, often with greater meat consumption, than poorer people; such diets in turn require more water per capita.

For the past couple of decades, much of the focus has been on China's impacts on food supply chains, given its combination of a massive and growing population plus rapid urbanization and wealth. China's outsized influence has been a focus of global conversation since at least 1995, when Lester Brown's Who Will Feed China? forecast that China's rising wealth and population would overwhelm both

SPECIAL SECTION I
HIMALAYAN ASIA'S WATER DYNAMICS IN DEPTH

its own and the world's food supply. Although there are signs that China has reached saturation and that its food demand growth is leveling off, China is hardly the only large country with a growth spurt. India is urbanizing as fast if not faster than China and has nearly as large a population that is soon to be even larger. And although India is becoming richer, it also contains a massive low-income population, many of whom are subsistence farmers. This fact represents the flip side of food insecurity. Despite rapid growth, billions of people remain either undernourished or at risk of insufficient access to food. South and Southeast Asia contain the largest populations of people so at risk.

On the supply side, Asian agriculture withdraws more water from surface and underground sources because it is less efficient and benefits less from rainfall to boot. Speaking broadly, many practices and policies in Asia are much more wasteful than need be, even in the context of less developed economies, reflecting a lack of high-quality infrastructure, investment, proper incentives, and good information, as well as the impacts of inappropriate policies. On the precipitation side, by way of contrast, Europe lies in a temperate region with year-round rainfall, giving it moist soils that are ideal for farming without irrigation. Although Asia is a vast continent with areas of rain-fed agriculture, large swathes of the continent do not have the luxury of enough year-round rainfall and high-quality moist soils. Much of the continent is arid or semi-arid or has high seasonal variability in rainfall. For example, monsoons drive rainfall patterns across much of South and Southeast Asia, giving those regions very wet but also very dry seasons, meaning that irrigation is required for at least part of the year.

The continent has by far the most irrigated land in the world at 41 percent of the continent's cultivated area, versus 13 percent in the Americas and five percent in Africa. China and India are the world's two largest irrigators, with some 135 million irrigated hectares split evenly between them, versus 26 million hectares for the United States, in third position. Surface irrigation, in general terms the least water-efficient type of irrigation systems, dominates Asian irrigation. After World War II, Asian countries greatly expanded these surface irrigation systems, either building upon existing systems as in South Asia (in Pakistan and India, building on British colonial investment in irrigation) or creating massive new systems as in Central Asia. Although that period of rapid expansion has been at an end for three decades, Asia now maintains a massive set of legacy systems, many of which need modernization.

A quick glance at an irrigation map shows that several of the world's most intensely irrigated regions lie in Asia. Of these, the largest is the Indo-Gangetic Plain, a vast region lying to the south of the HKH ranges across Pakistan, India, Nepal, and Bangladesh. More than a billion people live on the Plain, many of whom are smallholder farmers. There also are smaller but intensely irrigated regions in Northern China, Central Asia, and Southeast Asia. Northern China is particularly important for China's food production, although the region is a relatively dry area that requires both groundwater withdrawals and long-distance surface water transfers. Although Western Asia lies outside the scope of this paper, the Arabian Peninsula contains large and intensively utilized aquifers.

Finally, as elsewhere in the world, climate change very well might become Asian agriculture's greatest future challenge. Although it is possible that climate change will bring some positive changes (e.g., increased glacial melt resulting in more river water over the short and medium terms), few serious experts forecast anything but negative impacts on agriculture. The list of fears is long and indeed worrisome and includes yield losses from higher temperatures, more frequent and intense flood and drought cycles, declining soil moisture and thus productivity, increased pest infestations, and loss of farmland in low-lying coastal regions such as Bangladesh. Agriculture is highly vulnerable to climate-driven disruption, in particular given the large number of subsistence and smallholder farmers in South and Southeast Asia and the importance of water-intensive cereals production. Rice, wheat, and maize varietals are dietary staples across much of the continent; climate change threatens yields for each of these.

Cities

Urbanization can be defined as a process wherein an increasing proportion of a national population lives in cities versus in rural areas. Driven largely by economic factors, rapid urbanization has been a hallmark of the industrial era, and has fueled profound social, economic, political, and ecological changes in every country that has experienced it.

Since 1950, urbanization has largely been a story about the global south. Whereas before World War II, urbanization was for the most part concentrated in the rich world (Europe, North America, and parts of East Asia), it slowed considerably after the war, owing mostly to saturation (with urbanization rates reaching 80-plus percent in wealthy countries). In contrast, urbanization since 1950 sped up rapidly in the global south, ultimately involving billions of people. With unprecedented scale and speed, the urbanization of the global south since 1950 is one of the most important demographic phenomena in human history.

Nowhere has the urbanization story been more astonishing than in Asia. In 1950, less than one in five (17.5 percent) Asians lived in cities. Today, that number is around one in two. Rapid population growth combined with swift rural-to-urban migration resulted in an increase from around 250 million Asians living in cities in 1950 to more than two billion people in 2014. The UN estimates that Asian cities are now growing at an average of 138 million people per year, the result of natural growth (children born to people already living in cities) plus ongoing rural-to-urban migration. These increases will mean that by 2050, perhaps 3.3 billion Asians will live in cities, representing a three billion-person increase over a single century (1950 to 2050). To give the reader some sense of scale, in 2050 North America will have around 390 million urbanites, Europe 580 million, Latin America 670 million, and Africa 1.3 billion. In 2050, all world regions together will have fewer people living in cities than will Asia.

Since 1950, the continent's urbanization rates have been among the fastest in the world. Yet speed is less important than scale, given the enormous population. China alone has added nearly 650 million people to its cities since 1980, while India has added 300 million. Although both countries have urbanized rapidly over the past decades, neither is finished. In 2018, roughly 59 percent of China's population and 34 percent of India's is urbanized, which means both countries combined will add hundreds of millions more people to their cities before reaching saturation levels.

The continent's urban growth has produced the largest number of megacities in the world (cities with more than ten million residents), a total of thirteen out of twenty-two such cities globally and twenty such Asian megacities by 2025. Of the world's thirty largest cities in 2015, China had six of these, India four, and Pakistan two.

Urbanization typically translates into greater water demand, owing to the increased wealth that accompanies urban growth. Put simply and crudely, urban residents, as compared with rural villagers, consume more of everything—food, metals, building materials, transportation services, consumer goods, energy, and much more. All that consumption requires more water. As a society becomes wealthier and more urbanized, per capita water consumption rises, with few exceptions. Rapid urban growth is therefore one of the most important drivers of rising demand for water, helping to fuel competition for water with other sectors, including agriculture, and being an important contributor to localized water scarcity.

Beijing provides just one of many possible examples. As is true of countless Chinese cities, Beijing has grown rapidly over the past several decades, from nine million people in 1980 to 21.7 million in 2016. Beijing's population growth has predictably led to rising water consumption. In part because the city is in China's dry north, Beijing's thirst for water has become a major problem affecting the entire country. Beijing's rapid growth has driven it to find water from every source imaginable, including local and long-distance surface water sources (the latter via the SNWTP) and groundwater. Additionally, the city long has had plans to add desalinated water to its mix. Despite the fact that Beijing's rate of water consumption has slowed, based in part on the city implementing various water conservation and recycling measures, the truth remains that Beijing's water demand has outstripped all sources of supply for decades.

The significance of the continent's urbanization story is not just about increasing demand for water. The consequences of urbanization, including poorly regulated industrialization and frequently unchecked residential growth, have produced severe water quality problems across the continent. As has been true around the world, Asia's swift urbanization rate has outstripped the provision of public goods of all kinds, including adequate housing, modern sewerage, and clean drinking water. The number of people living in slums has increased dramatically since 1950, with roughly 530 million people—more than half the world's slum population—now living in such settlements in East, Southeast, and South Asia (the percentage of all urban dwellers living in slums has been declining across the continent, however). Slum dwellers infrequently have access to clean drinking water and modern sewerage, creating serious public health challenges for them while contributing to the production of untreated wastewater for their neighborhoods and their entire city.

Because municipal drinking water supplies are so unreliable, people are often forced to purchase clean drinking water from private vendors. In worst-case but sadly not infrequent scenarios, these vendors are unlicensed, often part of local water 'mafias' that illegally acquire water and sell it at a premium on the black market. Water mafias can have unsavory connections to criminal and even terror enterprises, touching on the spillover hypothesis.

Rapid urban growth has significant consequences for water quality. In 2017, the UN estimated that an astonishing 80–90 percent of all wastewater in the broader Asia-Pacific region goes untreated. It reported that most countries in South and Southeast Asia treat less than 20 percent of their wastewater before discharge and several that treat 10 percent or less. While a combination of swift urban population growth and high poverty levels helps explain this problem in many countries, the wastewater problem is hardly confined to poor places. China provides an important example in this vein. China's water quality is severely compromised, largely the result of the country's breakneck economic growth that has occurred in tandem with the unprecedented speed and scale of its urbanization.

A final piece of the urbanization-water nexus involves disaster risk. For a variety of reasons, Asia's cities are particularly susceptible to water-related disasters. Part of the explanation lies upstream, where deforestation and other land use changes have put downstream cities in many parts of the continent at greater risk of river flooding. But part of the explanation lies with rapidly growing cities themselves. Local land use changes (e.g., removal of coastal mangroves), driven by urban development, often exacerbate river or coastal flooding. So too does local groundwater depletion, which leads to land subsidence. The combination of climate-driven sea level rise, land subsidence, and removal of coastal buffers (such as coastal mangroves) further expose coastal cities, many of which sit on some of the lowest-lying coastlines in the world, to sea-borne flooding risk and storm disasters. A cursory glance at a map shows how many of Asia's largest cities are so exposed, including Shanghai, Dhaka, Kolkata, Ho Chi Minh City, Shenzen, Bangkok, and Guangzhou.

Energy

The energy-water nexus is at least as complex, and as important, as the food-water nexus. In the simplest terms, water is indispensable to energy production, while energy is indispensable to water withdrawal, transmission, use, and treatment. Thus the two resources have a symbiotic relationship, with increased production and use of one generally requiring the same of the other, and vice versa. Given the rising scarcity of water across much of Himalayan Asia, plus the need to reduce carbon emissions from energy production, the trick is to find ways to decouple energy from water, to utilize both resources more efficiently.

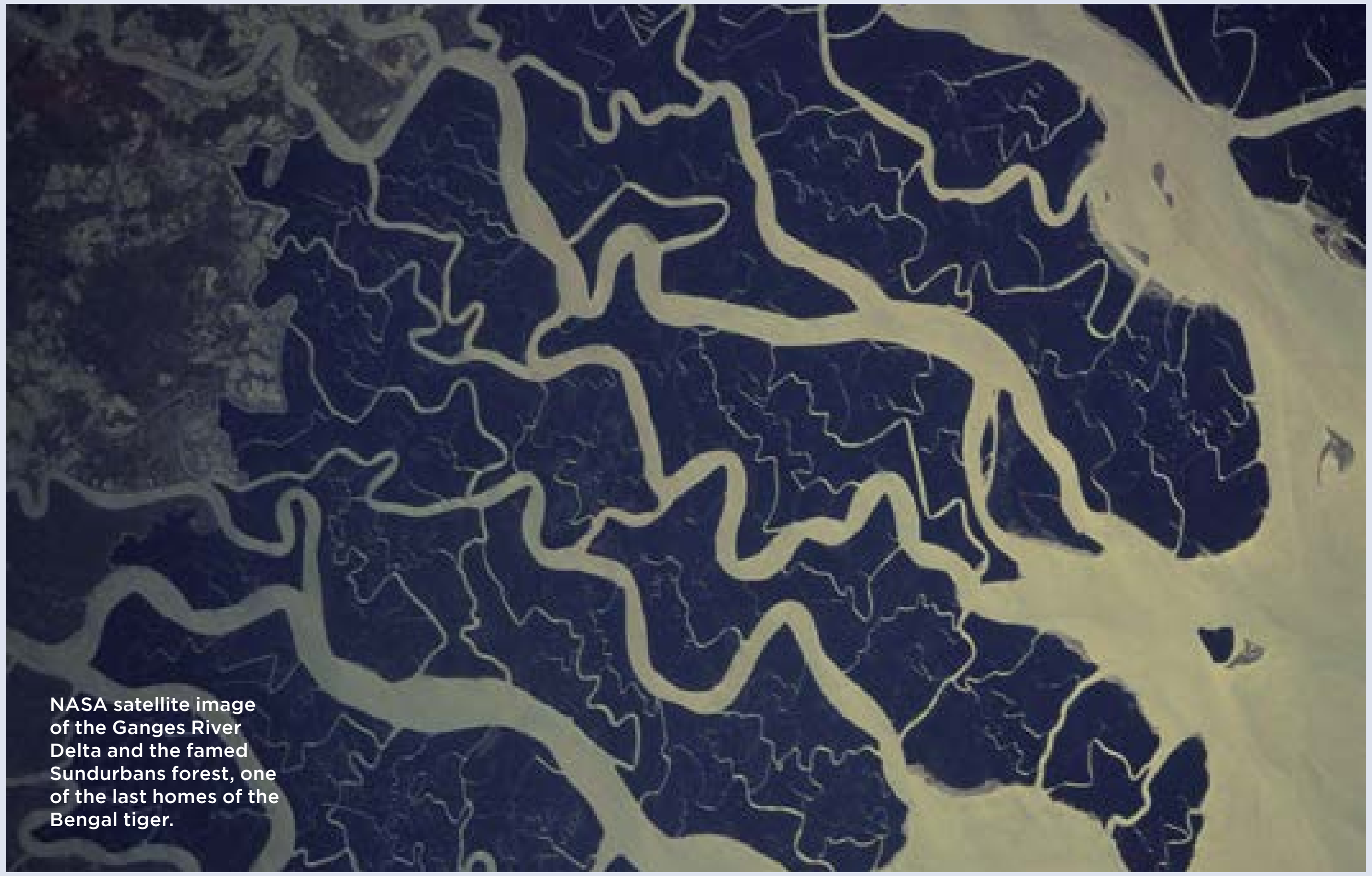
The scale of the global economy's energy needs means that the energy sector has become the world's second largest water user after the agricultural sector. This is because nearly all energy production requires water (in 2016, the World Energy Council estimated that 98 percent of all power production globally required water). Producing energy requires water inputs at every stage, from raw material extraction through power generation to pollution controls.

Water requirements are uneven depending on energy source, however. In simplest terms, fossil fuels require more water than do the (non-hydroelectric) renewable energy sources of solar and wind power. Mining and drilling for fossil fuels require significant quantities of water, as do the refining or processing of these fuels. Hydroelectric power generation, obviously, requires water for production, although water is simply passed through power-generating turbines before release downstream. Hydroelectric power plants therefore, and ironically, consume little water directly through power production, although their indirect consumption of water often is significant. Evaporation from reservoirs created by hydroelectric dams reduces the total amount of river water available downstream.

Thermal power plants are the most water-intensive forms of electrical power generation. Thermal power is a broad category of energy production that includes fossil fuel power plants (coal, oil, and natural gas) and nuclear power plants. To operate, thermal power plants require cooling, with water frequently providing the coolant. Although there are many ways to measure the water requirements for electricity production, studies routinely arrive at the same conclusion, which is that coal-fired thermal power plants are the thirstiest forms of electrical power generation, followed by other types of thermal power plants, then finally by non-hydroelectric renewables, with solar photovoltaics ("solar PV") and wind power the least thirsty of all. One study published in 2014, for example, estimated that coal-fired thermal power production consumed about four times as much water as did other thermal plants (nuclear power plants and those fired by oil and gas) and about ten times as much as non-hydroelectric renewables.

Not all coal-fired plants are alike when it comes to water use. The thirstiest are "once-through" systems that use water once for cooling before discarding it, followed by closed-loop plants that reuse water, and finally by "dry-cooling" systems that use air instead of water. The once-through systems are most common because they use simple and cheap technology. And although the dry-cooling system is far superior in terms of water use, it is a more expensive technology with lower efficiencies, hence requiring more fuel to generate the same amount of power.

Fossil fuels have driven Asia's rapid growth. In 1990, toward the beginning of China's long boom and before India's rapid growth began, all of Asia produced just shy of 4,000 terawatt hours (TWh) of electricity. In 2015, a quarter century later, Asia produced 12,000 TWh, three times as much. Coal provided much of this growth. In 1990, coal provided about a third (31.9 percent) of 4,000 TWh electricity production; by 2015, it generated over half (54.2 percent) of 12,000 TWh. To meet rising demand, Asian countries also rapidly expanded electrical production from natural gas and hydroelectric power, but given coal's even more rapid expansion, their shares of total electrical power production declined (to 18.5 percent and 15.3 percent respectively). In the context of Asia's total electrical generation, non-hydroelectric renewables represented a small fraction (3.0 percent) of the total in 2015. Yet, as elsewhere in the world, renewables are on an exponential growth curve, rising from virtually nothing in 1990 to providing 350,000 gigawatt hours (GWh) of electricity in 2015.



NASA satellite image of the Ganges River Delta and the famed Sundurbans forest, one of the last homes of the Bengal tiger.

NASA

Ongoing urbanization and economic development, driven by the two massive economies of China and India, will require much more energy in the future. All analyses point in this direction. The World Energy Council, for example, forecasts that electrical power generation will more than double between 2015 and 2050, from 12,000 TWh to 28,000 TWh, with a doubling of required water resources from 23 billion to 46 billion cubic meters per year.

Electrical power generation already uses a significant amount of water and therefore has become a major competitor for the resource on the continent. In many places, especially the continent's drier regions, the increasing water needs for electricity generation are running up against ecological constraints and intense competition from other sectors, including agriculture and cities.

The water-for-energy pathway has become more challenging in recent decades largely due to rising electric power generation from thermal power plants and hydroelectric plants, although for different reasons. Regarding thermal plants, the central problem involves electrical power generation in arid regions and during droughts. Because these plants are thirsty—with coal-fired plants, again, being the thirstiest—they can and often do stress local water supplies. Drought can lead to power plants being shut down for lack of coolant water, as occurred during a lengthy drought in India during 2015 and 2016. There, coal-fired power plants were forced to close in several Indian states, some up to months at a time, leading to an estimated $350 million lost in profits for the coal-fired power sector.

In part for water scarcity reasons, new plans to build additional fossil fuel plants have generated sporadic controversy in Himalayan Asia, sparking clashes with local residents in unexpected places. A 2010 Bangladeshi plan to produce 20,000 new megawatts of coal-fired electrical power has met with strident opposition, in particular over a plant located near the village of Rampal, located within the famed Sundurbans mangrove forest and wetland. In that case, water use is one of several reasons for the opposition, along with pollution, ecological damage, and adverse social and economic impacts.

Hydroelectric dams typically are controversial for a wider set of reasons. It is true that new dams siphon river water away from other uses, via the filling of reservoirs during the construction phase and the reservoirs' increased evaporation after filling. But most often their controversy involves tradeoffs between types of uses. Hydroelectric dams interfere in a river's ecology, with several important consequences. Dams interrupt sediment flows, starving downstream river deltas of nutrients and replenishing soil. Deltas generally are the most important food-producing regions of a river. Dams also alter plant and wildlife ecology (migratory fish, for example, often cannot bypass dams). Finally, dams interrupt seasonal water flows, which can be beneficial for flood control but also can harm seasonal irrigation timing.

As water is indispensable to both food and energy production, hydroelectric dams therefore often create an energy-versus-food tradeoff. The controversy over construction of dams along the Mekong River and its tributaries (by China and Laos) is mostly about this tradeoff. Whereas upstream countries such as Laos seek increased electrical production capacity, downstream countries such as Cambodia and Vietnam are much more concerned about food production, especially the integrity of their fisheries (Vietnam's Mekong delta is one of the world's most productive fresh water fisheries). This tradeoff is even clearer in Central Asia. There, upstream countries' need for hydroelectric power is in direct conflict with downstream countries' need for irrigation water. Owing to seasonal imbalances that force a tradeoff between upstream electricity production and downstream agricultural production, the five former Soviet republics of Central Asia have been engaged in bitter disputes surrounding the region's transboundary water resources since the early 1990s.

It is important to note that the water-energy nexus works in the other direction as well, via an energy-for-water pathway. As water is one of the heaviest substances in nature, the pumping of groundwater and the movement of water across level ground or uphill requires enormous amounts of energy.

Cheap energy, via energy subsidies given to farmers, is a driver of groundwater depletion in Himalayan Asia. India is perhaps the most important example, as it is one of the world's largest users of groundwater. Despite severe groundwater depletion within India, generous energy subsidies to farmers continue to incentivize the drilling of tube wells and subsequent groundwater pumping. Groundwater pumping also places enormous demands on energy systems. In Pakistan's Punjab province, for example, agriculture consumes 20 percent of the province's total energy demand, with groundwater pumping accounting for 61 percent of on-farm energy use. Energy inputs are also critical for other aspects of water use, for example operating complex sewer and drinking water systems and water treatment plants. As these systems consume large amounts of energy, total energy consumption will increase as more of the continent's wastewater is treated.

Finally, energy is indispensable to desalination, which has become an increasingly attractive option for fresh water production. Desalination is an expensive way to produce fresh water in large part because the energy requirements are so high, which helps explain why the oil- and cash-rich Gulf Cooperation Council (GCC) nations have become the world's largest producers of desalinated water. But given rising demand for fresh water combined with tight supply, Asian economies are eyeing desalination as an option. Asia has around a quarter of the world's installed desalination capacity (not including GCC countries). China and India have contemplated ambitious plans to build out their desalination capacities. As with wastewater treatment, desalination expansion will require large increases in energy consumption.

By region

East Asia

Although the definition of East Asia normally would include both Koreas and several offshore countries or territories (Japan, Taiwan, and perhaps the Philippines), for purposes of this study East Asia is defined primarily as China plus (to a lesser extent) Mongolia, Russia, and North Korea. This list excludes South Korea, Japan, the Philippines, and Taiwan because they share no transboundary fresh water resources with China.

China is at the center of not just East Asia's water storyline but much of the continent's. There are two primary reasons for its starring role. The first reason concerns geography, in that China has the good fortune of being upstream of its neighbors, at least in the great majority of the transboundary river basins that it shares with other countries. China controls the Tibetan Plateau, the source of the Mekong, Salween, Indus, Sutlej, Brahmaputra, and other rivers. China also contains the headwaters of several other transboundary rivers, including the Irtysh and Ili rivers that extend into Central Asia. Finally, it shares border rivers with Russia and North Korea, the Amur River system with Russia, and the Yalu and Tumen Rivers with North Korea. Moreover, there are three large and critically important rivers lying within China, the Yellow, Yangtze, and Pearl Rivers. Altogether, the rivers originating in China extend into every region covered by this study: East, South, Southeast, and Central Asia.

The second reason concerns economic and demographic power, in that China is by far the most dynamic economy in East Asia and has the largest population. China's outsized economic and demographic weight means that the country's domestic water use has enormous implications for its transboundary rivers and, therefore, its hydro-diplomacy.

When taken together, these two factors mean that China has considerable power to choose whether and how it cooperates—or not—on transboundary water issues with its neighbors in East Asia and in all other regions.

The primary reason why many states are nervous about China's transboundary water politics is because they can see a clash within China between its limited water supply and its gargantuan and rising demand. China is rapidly running out of clean fresh water. One oft-cited statistic is that China has roughly 20 percent of the world's population but only 7 percent of its fresh water. On a per capita basis, in 2014 China's nearly 1.4 billion people each had access to roughly 2,000 cubic meters of water per person per year, compared to the United States' average of some 9,500 cubic meters per year. While not yet meeting the internationally accepted critical water scarcity threshold of 1,000 cubic meters per person per year, China's water availability is trending in that direction.

Moreover, this national picture is complicated by a severe internal water imbalance between China's relatively dry north and relatively wet south. The drier north has both large (and growing) cities and extensive farmland, resulting in chronic water deficits that threaten to curtail economic growth in some of China's most dynamic regions. Returning to the Beijing case, the city's per capita water availability is around 150-200 cubic meters per year, far below the internationally recognized water scarcity line of 1,000 cubic meters. Beijing is hardly an anomaly, as other cities and provinces in China's north face similarly low water availability levels. This north-south water imbalance has been a longstanding concern of China's leaders (in 1952, Mao Zedong famously said that the north should "borrow" water from the south). Fretting about the economic and demographic sustainability of China's northern provinces, they have overseen decades-old plans to realize the South-North Water Transfer Project, the world's largest long-distance water transfer scheme.

In the energy sphere, this geographic imbalance is also at work. Most (85 percent) of China's coal reserves are in the country's arid provinces. And China has had a policy of shifting coal production toward its dry northern and western territories as it has tried to meet the country's burgeoning demand. This in turn means that simply extracting and processing coal is itself a stressor of the country's limited water supplies.

China's water supply difficulties are more than met by challenges on the demand side. China's booming economy and expanding population together have increased the country's water use several fold over the past decades. Whereas in 1950 China consumed an estimated 100 billion cubic meters of water annually, today that figure is six times higher, north of 600 billion cubic meters per year. Agriculture remains the largest single user (around 62 percent of the country's water withdrawals), but industrial and municipal (household, urban, personal) uses have been increasing rapidly over the past decades as China has both urbanized and became much wealthier. Rising demand for water has begun to outstrip supply, especially in the dry north, and has forced cities and provinces to search for the resource anywhere they can find it, often to the detriment of their neighbors. The country's rivers, lakes, and groundwater are under extreme pressure. Several rivers have had their flow volumes reduced significantly (the Yellow River's outflow is roughly 10 percent its original volume), which has contributed to increased groundwater extraction, especially in the country's north.

China's notorious air pollution is perhaps the most visible symbol of China's willingness to trade economic growth for environmental protection. But the country has been willing to make this trade over water as well, with its water quality problem at least as significant as its air quality problem. Pollutants of every kind, from every type of source, have poured into the nation's surface waters and leeched into its groundwater. One recent academic study, hardly an outlier, examined water pollution data and concluded that a good portion of China's water is unsuitable for most human uses. Using the government's own data, the study concluded that in 2013 nearly a third (31.4 percent) of all river water in China was classified as "unfit for potable use or human

SPECIAL SECTION I
HIMALAYAN ASIA'S WATER DYNAMICS IN DEPTH

SPECIAL SECTION I
HIMALAYAN ASIA'S WATER DYNAMICS IN DEPTH


China's Yellow River

LAIKA AC/FLICKR

contact," including 14.9 percent so polluted that the water had a "complete loss of potential for all consumptive uses or human contact." Even worse, 2014 data showed nearly two-thirds (61.5 percent) of China's groundwater classified as unfit for human contact. These aggregate national statistics, as bad as they are, understate the severity of China's problem, as its most severe river water quality is in the country's most populated areas, in particular its north and east.

China's lack of clean water is not just about public health, as important as that topic is. China's massive deficit in clean water also feeds into the country's water quantity problem. Water scarcity is as much about access to clean water as it is about aggregate water availability.

Historically, China's solution to its national water problem was to find ways to increase supply while paying lip service to the water pollution that was a direct by-product of its economic growth. The Three Gorges Dam, the South-North Water Transfer Program (SNWTP), and other massive water infrastructure investments were driven by a leadership that treated the nation's water resources through a hydraulic lens.

However, in recent years China has shown a willingness to change its approaches. In 2011-2012, the central government formulated an ambitious set of long-term water use goals, known as the Three Red Lines. As the name implies, these goals established ambitious national targets for total water use, water use efficiency, and water pollution out to the year 2030. Since then, the central government has put into place detailed regulatory guidance and target requirements for all governance levels. At the same time, China has been engaging in ambitious bureaucratic reform, designed to consolidate the nation's jumbled set of ministries having some responsibility over the water sector. "Nine dragons rule the waters" was the oft-heard and skeptical phrase describing China's confusing welter of bureaucracies having oversight of the environment, including water resources. To address this problem, China implemented a major bureaucratic realignment of ministries having some responsibility over water resources in 2018, consolidating fifteen ministries down to two, the Ministry of Ecological Environment and the Ministry of Natural Resources.

The experts consulted for this study were unanimous in their belief that these policy and bureaucratic changes are more than cosmetic, reflective of Chinese leadership's commitment to both constrain the country's water use and reign in its water pollution. But at the same time, all expressed deep reservations as to whether China will be able to overcome its water challenges given their severity and scale, the relentless pressure placed upon water resources by the country's economic and demographic growth, plus climate change's looming impacts on its water supply. There is healthy skepticism that the tools that have been created to deal with these problems, as ambitious as they are, will be up to the formidable task of turning around a massive set of challenges.

For example, it is hardly a given that the Three Red Lines program will be a success. Among other obstacles, the program requires access to reliable water data at national level across a range of metrics, which experts believe is an exceedingly difficult task even assuming technical advances in water monitoring. Moreover, the program incentivizes misreporting by lower levels of government, given the central government's history of setting ambitious targets that are 'met' because lower-level officials find ways to fudge the numbers.

In the context of water use and sharing, Russia and Mongolia are China's two most important East Asian neighbors. Although Russia is a transcontinental country, given its length east to west, it is also East Asian in the sense that it controls a massive, resource-rich, and thinly populated territory located in the eastern half of the Asian landmass. Russia's water resources are immense. Altogether, Russia has some two million lakes and 120,000 rivers of at least ten kilometers in length. As Russia has a population of only 143 million people (versus China's 1.4 billion), its per capita water resources are massive, at 31,500 cubic meters per person per year (roughly fifteen times that of China's on a per capita basis). Most of this water is in Russia's eastern territories, the most thinly populated portions of the country. Although a high percentage of Mongolia's territory is arid or semi-arid, it too enjoys a high per capita water resource endowment of nearly 11,800 cubic meters a year. However, this number is misleading because Mongolia is one of the most sparsely populated countries on Earth, with a total population just shy of three million people spread over an area twice the size of Pakistan.

The three countries share the Amur River basin, one of Asia's longest at 2,800 kilometers and one of the few major rivers in the eastern two-thirds of Asia to not originate in the water tower. The Amur also is unique in that a significant length of the main channel forms the boundary between Russia and China. Those two countries split the clear majority (91 percent) of the basin's 2.1 million square kilometers of territory. For centuries, the Amur has provided the backdrop and occasional dividing line for a back-and-forth, sometimes-conflictual, sometimes-cooperative relationship between China and Russia.

The Amur is therefore rare for China in that it is one of the few rivers where China is not in a commanding upstream position, rather the river has to be shared with another major power. That reality may be one of the reasons why China, Russia, and Mongolia have signed numerous transboundary water agreements (albeit non-binding), in contrast to China's reluctance to do so with downstream neighbors to its south and southeast. Regardless, China has been the more aggressive party in support of building more water infrastructure in the basin for years, in particular hydroelectric dams and other hard infrastructure along the Amur's main channel. Russia, in contrast, has consistently resisted such a course of action (Russia has, however, been willing to build hydroelectric plants on Amur tributaries in its own territory). This divergence is explained by different economic and demographic profiles on either side of the Amur. China has a far higher population density, hence need for electrical power wherever it can be found. Besides having a lower population density, Russia also has had a robust environmental movement that has been highly critical of plans to dam the Amur's main channel. These groups evidently have had some success in influencing Russian officialdom to oppose Chinese proposals in years past.

Central Asia

With respect to fresh water, Central Asia's key characteristics are its inland geography, unique combination of high mountains and widespread aridity, and unusual political history. The first two of these characteristics have shaped water use patterns across the region for centuries, the last for decades. Looking forward, climate change will have an outsized impact on the region's fragile ecology, hence limited water supply, given temperature rises that are expected to remain above the global average in the decades to come. Demographic shifts also will have important repercussions.

For this study's purposes, Central Asia consists of the five "-stans" (Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan, and Turkmenistan). Together, these five countries comprise a large fraction of the Asian landmass and contain several of the continent's most important rivers and lakes. Politically, their collective significance lies in the complications resulting from the breakup of the former Soviet Union. Although this definition of Central Asia excludes the neighboring states of Russia, China, Afghanistan, and Iran, as with the other regions, these boundary states can and do influence the region's water dynamic.

Water stress in Central Asia is largely a tale of ecology running head-on into politics. On the ecology side, Central Asia contains a fragile set of ecosystems that produce a limited and highly variable water supply. This water supply largely is produced by rivers originating in high mountain ranges located in the southeastern portion of the five-country region. These ranges are the Pamir and Tien Shan ranges, plus the western end of the Hindu Kush Himalayas (HKH), located in Tajikistan, Kyrgyzstan, China, and Afghanistan. These mountain ranges produce three of the region's most important rivers, the Syr Darya, Amu Darya, and Ili Rivers, all of which run through semi-arid landscapes located mostly in the five Central Asian republics. The rivers, in turn, drain into two large internal lakes, the Amu Darya and Syr Darya into the Aral Sea, and the Ili into Lake Balkhash. Historically, the Aral Sea overlapped both Kazakhstan and Uzbekistan. Lake Balkhash lies entirely within Kazakhstan. A fourth major river, the Irtysh, spans China, Kazakhstan, and Russia.

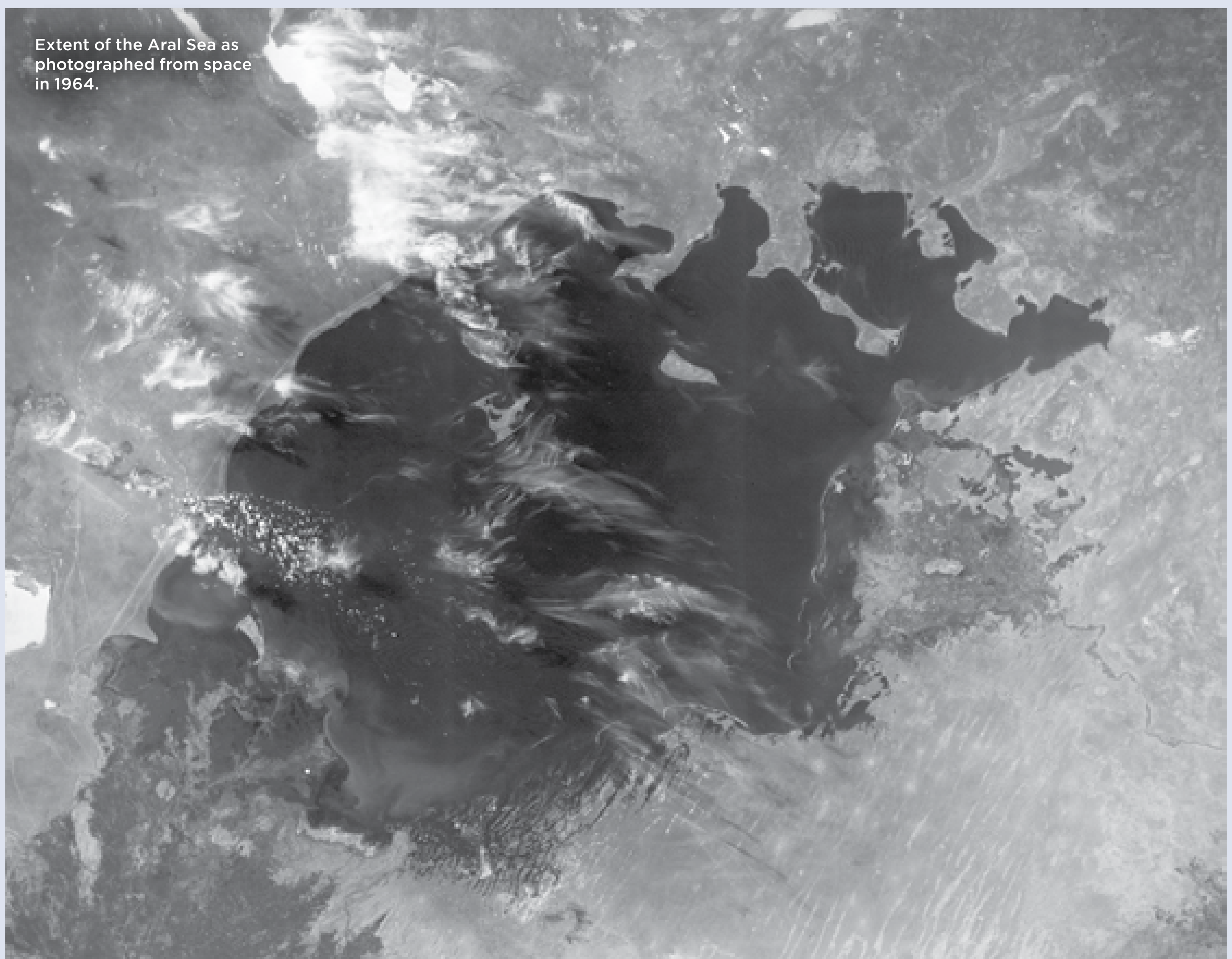
This unique combination of environmental characteristics explains much of why Central Asia suffers from chronic water stress. The region's high mountains that are the source of its rivers also are the most susceptible ecosystems to a changing climate. As is true throughout Himalayan Asia's water tower, Central Asia's mountain ranges are warming at a faster rate than the global average. Rapidly increasing temperatures are changing precipitation patterns, with more rain instead of snow, shifting seasonality of snow accumulation and melting (e.g., timing of the spring melt), increased glacial melt, and likely long-term decreases in summer river flows. Such changes to mountain hydrology are all the more important because Central Asia's rivers run through relatively arid lower elevations, which means that lowland precipitation contributes little to their overall flow. (Climate models cannot forecast reliably whether Central Asia will receive more or less precipitation, nor the intensity of the shift in either direction. Regardless, the region's arid and semi-arid areas will stay that way, the only question is the direction and extent of changes in aridity.) Finally, most of Central Asia's major rivers do not empty to the ocean, rather to internal lakes. These endorheic basins include three of the aforementioned rivers and both lakes (the Amu Darya, Syr Darya, and Ili Rivers, plus the Aral Sea and Lake Balkhash). This ecological oddity is a source of instability. Although endorheic lakes are rich ecosystems in themselves, they are highly vulnerable to disruption from variable water supply and pollution.

Unfortunately, for decades, human activities have assaulted Central Asia's fragile ecology. The primary offense over the past half century, now a well-known and tragic story, involves the decimation of the Aral Sea. Under a Soviet plan created during the 1950s and implemented starting in the 1960s, water from the Amu Darya and Syr Darya that flowed into the Aral Sea was instead siphoned off for cotton irrigation. As Soviet cotton production more than doubled in Central Asia, the Aral Sea shrank to the point of collapse, causing an ecological, social, and economic disaster from which the region surrounding the lake will never fully recover.

To make this irrigation system work, the Soviets built a complex water infrastructure in their Central Asian republics. Among other interventions, they constructed upstream reservoirs on the Amu Darya and Syr Darya and their tributaries in order to increase irrigation during the dry summer months (stored reservoir water would be released downstream for crop irrigation). The downstream republics of Uzbekistan, Kazakhstan, and Turkmenistan therefore benefited from this additional stored water. However, the energy-poor upstream republics of Kyrgyzstan and Tajikistan were prevented from generating hydropower during the winter, when it was most needed, in order to preserve reservoir levels for the growing season. Moscow solved this summer-winter imbalance by directing the energy-rich downstream republics to deliver energy shipments (fossil fuel deliveries plus electricity) during the winter as a form of compensation.

This energy-for-water exchange system worked as long as the Soviet Union existed. However, after the breakup of the Soviet Union and the independence of the Central Asian republics, the system began to break down. Its core feature, the energy-for-water swap, could not be sustained under new economic and political forces that independence brought with it.

To summarize a complex post-independence history in simplest terms, the five republics began divorcing themselves from this system, in the process heightening distrust



Extent of the Aral Sea as photographed from space in 1964.

OPPOSITE PAGE: USGS EROS DATA CENTER; THIS PAGE: NASA EARTH OBSERVATORY

Extent of the Aral Sea as photographed from space in 2018.

SPECIAL SECTION I
HIMALAYAN ASIA'S WATER DYNAMICS IN DEPTH

all around. The downstream republics discovered a lucrative global energy market, to which they began selling at higher prices than could be had from their poor upstream neighbors. For their part, largely because they could no longer count on energy deliveries from their downstream neighbors, the upstream republics of Kyrgyzstan and Tajikistan began generating hydroelectric power during the cold winter months instead of reserving their reservoir water for summer use. The result made everyone unhappy: the disruptions to energy and water supplies required wrenching and at times deadly adjustments on all sides, with each republic racing to fill sudden supply gaps, build new infrastructure to replace lost capacity, and find new markets for selling whatever energy or water surpluses they possessed.

Various bilateral and multilateral agreements were put into place not long after independence to manage this system. Two of the most important multilateral agreements occurred in 1992-1993, the Almaty Agreement and the establishment of the International Fund for Saving the Aral Sea (IFAS). The first informally endorsed a continuation of the Soviet water-for-energy sharing system, while the second was intended to be the forum in which the five republics could hash out their disagreements concerning joint management of the Amu Darya, Syr Darya, and Aral Sea. Since the 1990s, this multilateral architecture has proven too weak to prevent the fragmentation of the Soviet system. Although IFAS continues to this day, and there remains hope that the republics will strengthen the institution, neither it nor various other multilateral and bilateral agreements and institutions have been strong enough to overcome the centrifugal pull of divergent national interests.

Given the transboundary nature of the energy-water linkages and the communities that depend upon them across Central Asia, clashes were bound to occur. Two regional flashpoints are the Rogun Dam and the Fergana Valley. The Rogun Dam, a massive hydroelectric project with planning origins stretching back to the 1970s, is now under construction in Tajikistan, which desires the electricity for itself and for export. The dam has drawn heated opposition from downstream Uzbekistan, which, fearing water shortages, has in the past issued veiled threats of war should it be built (for a longer discussion of the dam, see Special Section II).

The Fergana Valley is the most productive agricultural landscape in all of Central Asia and its most populous as well. The valley also traverses three countries (Kyrgyzstan, Uzbekistan, and Tajikistan), with unsettled boundaries and mutual suspicion among a welter of different ethnic, religious, linguistic, and national groupings. Water, the most precious resource in a region so dependent on agriculture, has been a frequent source of conflict, even more so since the collapse of the Soviet Union and its upstream-downstream energy-for-cotton allocation systems (cotton has been an important cash crop in the Fergana Valley). Episodic outbursts of violence can and do occur in the valley for any number of reasons, including water, and occasionally with lethal effect. The worst occurred in 2010, when clashes around the Uzbek-Kyrgyz border left 2,000 dead and briefly involved an Uzbek military incursion into Kyrgyz territory. Given the pressures from a rising population, with high fertility rates among the valley's peoples, plus climate-induced ecological changes, the Fergana Valley should remain a tinderbox well into the future.

While the water-energy conflict within the Aral Sea basin dominates attention, there are other transboundary water challenges. One of the most important involves transboundary water resources between China and Kazakhstan. The two countries share some twenty rivers between them, with the Ili and Irtysh Rivers being the largest. Both rivers originate in China's Xinjiang region, the Ili in China's portion of the Tien Shan mountain range, the Irtysh in the Altai range located along the Mongolian border, before both flow into Kazakhstan. Since at least the 1990s, Kazakhstan has been nervous about China's increasing use of river water for irrigation and industrial purposes in its dry northwest. Although the Irtysh flows northward into Russia, where it joins the Ob River before flowing into the Arctic Ocean, the Ili basin is endorheic, terminating in Kazakhstan's Lake Balkhash. Kazakh environmentalists fear a repeat of the Aral Sea disaster, in this case due to Chinese diversion of the Ili's water.

South Asia

Of all four regions discussed in this paper, none face the range and severity of water-related challenges as South Asia. Declining per capita water resources, large and growing populations, a dependence on irrigated agriculture and agricultural employment, low water use efficiencies and poor water management, all combined with intense international suspicions and disputes, make this region one of the most vulnerable to water-related conflict. Moreover, South Asia contains two nuclear-armed rivals (India and Pakistan), bordered by a third nuclear power, China, that is upstream of both. Decades-old mutual suspicion hangs over the relationships among all these powers, with transboundary rivers forming an important component of this mistrust.

South Asia's transboundary water resources consist of two major river systems and a set of large aquifers. All of these resources are intensively utilized and are coming under ever-greater pressure. The river systems are the Ganges-Brahmaputra-Meghna (GBM) system and the Indus system. (The reader is encouraged to consult the Indus and Brahmaputra essays in this report's Special Section II.)

As the name indicates, the GBM system consists of three separate rivers and their many tributaries. All three rivers, the Ganges, Brahmaputra, and Meghna, originate in the Himalayas and Tibetan Plateau. The Ganges River originates in far northern India, with a large number of tributaries in Nepal, and runs through the Indo-Gangetic Plain across India before entering Bangladesh and the Bay of Bengal. The Brahmaputra River originates in China's Tibetan Plateau, where it is called the Yarlung Tsangpo, and runs for some 1,600 kilometers west to east across China before heading south and southeast through India and Bangladesh. Several important Brahmaputra tributaries originate in Bhutan. The Meghna is shared by India and Bangladesh. Altogether, the three GBM river basins are home to around 700 million people.

The Indus River system is shared by China, India, Pakistan, and Afghanistan. The system has a complex geography involving two large branches of tributaries. These branches extend across the Hindu Kush-Himalayan ranges spread across all four countries. The farthest reaches of both branches begin in China on the Tibetan Plateau, where they flow across high-altitude terrain before entering India. From there, one branch heads southwestward within India before crossing into Pakistan. The other branch flows westward across far northern India into the disputed territory of Kashmir and then into undisputed Pakistani territory. Both of these branches gather tributaries that in turn have their own origins in the mountain ranges of India, Pakistan, and Afghanistan. For example, the Kabul River originates in Afghanistan's Hindu Kush range and flows southeastward into Pakistan. Within Pakistan, both of these branches finally join together to form the main stem of the Indus River, which heads southwest before ultimately exiting on the Arabian Sea. Altogether, more than 300 million people live within the Indus basin.

Stretching across South Asia, these river systems are the central geographic and ecological elements of the Indo-Gangetic Plain, a vast area south of the HKH ranges that is home to more than one billion people. Although the plain has some of South Asia's largest cities, including Delhi, Kolkata, Dhaka, Lahore, and Karachi, it also is one of the most important agricultural areas in the world. The plain's agricultural production depends on water from the GBM and Indus systems, transmitted to fields via the world's greatest concentration of irrigation canals. Built starting in the nineteenth century under British rule, this canal system extends across much of the plain, totaling more than 100,000 kilometers in length. Surface water sources are complemented by a series of large and critically important transboundary aquifers.

For decades, South Asian countries' high population growth rates have placed these resources under increasing stress. In 1950, the six South Asian countries discussed here (Afghanistan, Pakistan, India, Nepal, Bangladesh, and Bhutan) had a combined population of 468 million people. In 2015, that total was 1.7 billion, nearly four times greater. Over the same 1950-2015 timeframe, India's population increased from 376 million to 1.3 billion people, Pakistan's from 38 million to 208 million, and Bangladesh's from 38 million to 169 million. South Asia's high fertility rates, which although falling remain well above 'replacement' levels, ensure that population increases will occur for decades into the future. Bangladesh, projected to have over 200 million people in 2050, is roughly the same size as the American state of Iowa (also part of an agricultural region but with only three million residents).

Such numbers form the background for South Asia's primary, but certainly not the only, water-related challenge: providing enough food for large and often very poor populations with limited land and water resources. Although urbanization is increasing swiftly across the region, South Asia still is characterized by high agricultural employment, which as a share of total employment ranges from around 40 percent in Bangladesh, India, and Pakistan, up to an astonishing 71.7 percent in Nepal. Most farmers are smallholders, given limited land combined with high populations (the amount of land per citizen ranges from 0.05 hectares in Bangladesh to 0.13 hectares in India). Food insecurity is a major problem, with around 40 percent of the world's poor living in the broader South Asian region, including a third or more of its undernourished.

To make this situation even more critical, South Asia's agriculture is especially water-intensive, involving the production of thirsty crops such as wheat and rice, making the Indo-Gangetic Plain among the most intensely irrigated places on Earth. Water for irrigation is provided by the GBM and Indus systems and increasingly the Plain's aquifers. Farmers here draw roughly a quarter of all groundwater used in the world, utilizing an estimated 15-20 million wells. Although the extent of the Indo-Gangetic Plain's aquifer depletion is debated, no one contests the massive scale of groundwater withdrawal. The stakes are enormous, involving the long-term sustainability of the region's aquifers and

Satellite image showing the Syr Darya River winding its way through Kazakhstan. Irrigated cotton fields are shown to the river's north.

ISS CREW EARTH OBSERVATIONS EXPERIMENT AND IMAGE SCIENCE & ANALYSIS LABORATORY, JOHNSON SPACE CENTER

therefore of its agriculture.

Three additional water-related challenges are at work across South Asia. One is rising competition for water resources to meet demand from non-agricultural sectors, including the energy, industrial, and urban (municipal) sectors. Across the region, these sectors are increasing in importance given ongoing urbanization and increasing, albeit unequal, wealth production. Energy challenges abound, with countries in the region facing the need to both produce more energy for their swiftly-growing cities and, at the same time, to overcome widespread energy poverty. The trouble is that water is required for most forms of energy production. Indian states, for example, have occasional blackouts in part because of chronic water shortages, which can become severe enough during drought conditions to reduce thermal power generation. Partly for this reason, and ironically, India and other South Asian countries have developed plans to build more hydroelectric dams in the Himalayas, solutions that if realized will exacerbate rather than lessen tensions over transboundary water resources. Water pollution is a second and related problem. The region's surface and groundwater sources are under threat from a combination of increasing urbanization (e.g., untreated municipal wastewater), industrial and energy production, and poor farming practices. Arsenic leaching into groundwater is especially problematic on the Indo-Gangetic Plain. And although the numbers have been improving, South Asian populations have low access to good sanitation facilities, affecting hundreds of millions of people in the region. Finally, coastal flooding and saltwater intrusion into groundwater sources is a growing challenge, the result of low-lying coastlines, especially in the Bay of Bengal, climate-driven sea level rises and more powerful storms, and increasing aquifer withdrawals.

Given South Asia's multiple water-related challenges and the enormous number of (often poor) people who are reliant on the region's transboundary water resources, one would hope that the region's countries would be willing to cooperate around these increasingly scarce resources. Unfortunately, this is not the case in South Asia, which is beset by a series of geopolitical rivalries extending back decades if not much longer and that constrain productive basin-level hydro-diplomacy. The well-known and intense bilateral rivalries between India and Pakistan and China and India are fueled by border disputes, historic grievances, and geopolitical competition. The same is true regarding relations between South Asia's larger and smaller powers, in particular India, Nepal, and Bangladesh. The threat of an upstream rival 'taking' water from a downstream state reflects the overly narrow, highly securitized, and often binary terms within which water is defined in South Asia. Although the Indus Waters Treaty, signed in 1960, has proven resilient enough to withstand decades of hot-and-cold war between India and Pakistan, the utilization of the Indus River and its tributaries always forms part of the two countries' antagonism toward one another. Politicians in South Asia have repeatedly characterized other governments as acting in bad faith over transboundary rivers, providing examples of how domestic audiences' preexisting negative views toward other countries in the region can be manipulated through hyping disagreements over transboundary water resources. Indeed, public opinion data in South Asia shows that when it comes to water, people hold generally negative and distrusting views toward the region's governments at all levels, subnational, national, and foreign.

Making this situation worse is the lack of accessible water data. South Asian countries have limited data collection and management capacities, the result of limited infrastructure and human resources, fragmented bureaucratic coordination, and official disinterest in public disclosure. The latter speaks to a problem that besets water bureaucracies, and that is especially problematic in South Asia, concerning a lack of transparency in providing the public with timely and accurate data. Although there are multiple reasons why bureaucracies in general want to retain data in house, in South Asia this desire for secrecy is amplified by the nationalist lens through which water is viewed. A 2015 Asia Foundation report concluded that because water in South Asia remains a "politically charged and nationalistic issue," water data has been "zealously securitized."

Southeast Asia

For purposes of this study, Southeast Asia is defined as all countries within the two major transboundary river basins, the Salween and Mekong basins. The list therefore includes China, Myanmar, Thailand, Vietnam, Laos, and Cambodia, but excludes Malaysia, Singapore, and island states such as Indonesia. The two transboundary rivers and their tributaries are the most important sources of surface fresh water in Southeast Asia, aside from the Irrawaddy River, which lies almost entirely in Myanmar. Southeast Asia also has groundwater aquifers that supplement these surface sources and that are important in different parts of the region, especially during the dry season.

Most of the controversy regarding the region's water resources involves use of the two major transboundary rivers plus the Irrawaddy. The region's water politics—domestic, transboundary, and interstate—surrounding these rivers is characterized by an increasingly zero-sum debate concerning the tradeoffs between types of water uses, energy versus food in particular. There are clear parallels here to the water-versus-agriculture tradeoff that dominates Central Asia's water controversies. But whereas Central Asia is largely a debate involving electricity power generation for upstream users and irrigation water for cotton production downstream, Southeast Asia's controversies are about electrical power generation along rivers that have extraordinarily high levels of biodiversity and contain the world's greatest fresh water fisheries. In essence, Southeast Asia's water politics is about electricity versus food.

Both the Mekong and Salween, called the Lancang and Nu rivers respectively in China, originate in the Tibetan Plateau before entering Yunnan Province, where they run parallel to the Yangtze River through a series of deep gorges. This area, now a UN Educational, Scientific, and Cultural Organization (UNESCO) World Heritage Site called the Three Parallel Rivers National Park, constitutes one of the world's greatest natural formations and one of Asia's richest in terms of biodiversity. From there the Mekong runs southeast, either bordering or running through all of the countries on the above list, while the Salween runs due south into Myanmar and Thailand. While not a transboundary river, the Irrawaddy, which runs roughly parallel to the lower Salween, is a critical source of fresh water and food for Myanmar.

The Mekong River is the most important river in Southeast Asia, given its length and elevation drop, the number of countries it runs through, its extraordinarily rich fisheries, and the number of people who depend on it. Running nearly 5,000 kilometers in length, the Mekong/Lancang originates in China's Tibetan Plateau, makes a huge drop in elevation while coursing through Yunnan Province, then into Laos, Thailand, Cambodia, and finally Vietnam. The river's drop in elevation within China and in the downstream countries is the reason why the river is attractive for hydroelectric development. But at the same time the river is one of the world's most biologically productive. A combination of extreme seasonal variability in river levels due to the region's monsoons, high sediment flows, and warm temperatures year round (in the lower reaches) produce a vast and unique set of riverine ecosystems and an abundance of aquatic life, including important migratory species of fish

SPECIAL SECTION I
HIMALAYAN ASIA'S WATER DYNAMICS IN DEPTH

such as the giant catfish. The river's unusual and biologically productive ecosystems include Cambodia's Tonle Sap lake and Vietnam's delta region, both of which depend on the combination of highly variable seasonal flows and rich sediment loading.

Whereas most attention is on the Mekong, given its importance to the region, similar challenges face the other major transboundary river, the Salween, which is shared by China, Myanmar, and Thailand. The Salween originates in the Tibetan Plateau and flows southward through China into Myanmar and Thailand, before exiting to the Andaman Sea. China and Myanmar have the greatest combined share (95 percent) of the basin. As is characteristic of rivers in the water tower, the upper reaches of China's Salween (Nu) River are at high altitude (4,000 meters above sea level), which in turn means that the river drops a significant vertical elevation over its 2,400-kilometer length. The Salween's drop means that it, like the Mekong and all other rivers originating in the water tower, possesses enormous hydroelectric potential. Although engineering studies have identified this potential since the 1950s, the Salween is one of the last major rivers in Himalayan Asia without a large dam along its main channel. As the Salween runs through a similar set of ecosystems as the Mekong and at roughly the same latitude, it too is subject to high monsoon-driven seasonal variability in its lower reaches. The Salween basin therefore contains high biodiversity and rich fisheries, like the Mekong basin providing critical sources of food and employment for millions of people living on or near the main river and its tributaries.

As is true elsewhere, groundwater is both an important transboundary source of fresh water in Southeast Asia and yet (paradoxically) not a highly controversial subject within the region's hydro-diplomatic context. This apparent contradiction is due entirely to the nature of groundwater, which as a subsurface resource is both imperfectly quantified and largely invisible. Moreover, as subsurface aquifers are not complex living ecosystems, they do not have the same usage trade-offs as rivers, for example between electrical power generation and fisheries. Southeast Asia has eleven formally identified transboundary aquifers across the region. Increasingly over the past few decades, these aquifers have helped meet rising demand for water, particularly in the region's dry season. Unsurprisingly, a number of the region's aquifers are showing evidence of strain from overuse. One of these aquifers, lying beneath the Mekong River delta, is heavily utilized to meet irrigation and municipal uses in this densely populated and critically important rice-producing sub-region. Since the 1990s, groundwater levels have declined as much as twenty meters in some parts of the delta.

Southeast Asia's electricity-versus-fish dynamic is the result of rising demand for energy within the region, in turn the result of swift economic growth, including within the industrial sector, and population increases. The Asian Development Bank (ADB) forecasts rapid regional energy growth, including a rise in electricity demand across the region "requiring extensive expansion of the [electrical] power system." Much of the region's increasing electrical demand comes from Thailand, which struggles to meet its domestic demand through its own sources. The ADB forecasts a near tripling of future electrical generation capacity in the region by the year 2025, including more than twice the number of large dams.

Like the neighboring Salween and Irrawaddy rivers, there are grand plans to develop the Mekong River's vast hydropower potential. Unlike the Salween and Irrawaddy, several of these plans have been realized. China already has constructed a cascade of seven hydroelectric dams on its section of the river, having refused to consult with its downstream neighbors on their construction. As China's dams are a fait accompli, the primary controversies concerning the Mekong's future involve dams that are planned or under construction for the river's lower reaches, from Laos southward. The most controversial of these are in Laos, which intends to become the region's 'battery' (electrical power generation for export) through an aggressive hydroelectric dam-building program, and in Cambodia.

Cambodia and Vietnam have objected strenuously to the Laotian program, with both fearing the repercussions for their fishing, agriculture, and tourism industries. Both have voiced their objections through bilateral and multilateral channels, the latter through the Mekong River Commission (MRC). Like Central Asia's IFAS, the two-plus decades old MRC was designed as a multilateral instrument to manage conflicts over use of the Mekong. And like IFAS, the MRC has come face to face with the region's divergent national interests. Although the MRC has a formal notification and consultation process, through which Laos has submitted its plans for the first dams on its territory, and although it has issued technical reports criticizing these plans, the MRC itself has no real oversight and enforcement power, nor do downstream countries have a veto right within the MRC. These factors have led to widespread criticism of the MRC as a viable multilateral instrument for effective transboundary water diplomacy within the region.

A loose but vibrant and vocal coalition of civil society groups have undertaken visible, loud, and at times confrontational campaigns against dam building within the lower Mekong region. These groups represent local peoples within all of the lower Mekong region states, including from Laos, Thailand, and Myanmar in addition to Vietnam and Cambodia. They are joined by objections from the international community, including global non-governmental organizations. The official dam-building plans, and on occasion the actual dam construction sites, have been their targets, with limited success at suspending or stopping the construction of individual dams. Much of their focus has been on the first large hydroelectric dams planned for the main stems of the Salween and lower Mekong rivers, the Myitsone Dam on the Salween in Myanmar and the Xayaburi and Don Sahong dams on the Laotian stretch of the Mekong.

The regional diplomatic context in Southeast Asia clearly is about more than China against its downstream neighbors. Usage of the lower Mekong and Salween rivers is controversial among the downstream countries and between those countries and a robust civil society. The lower Mekong states have their own divergent agendas, with Laos thus far the most willing to forego its neighbors' wishes and in some key respects those of its own citizens.

Yet China remains the most important riparian country in Southeast Asia. China is upstream of its Southeast Asian neighbors and has had extensive plans (some already realized) to build a series of hydroelectric dams on these rivers. In keeping with China's reluctance to enter into multilateral arrangements, it has refused to become a member of the MRC and has not negotiated jointly with Myanmar and Thailand concerning the Salween River's future. China never has sat still, however, with respect to its regional neighbors. Chinese lenders and construction firms such as Sinohydro long have been important players in the financing and construction of the region's water infrastructure, in particular the financing and construction of large dams. And in 2016, in what was widely interpreted as an attempt by China to increase its influence across Southeast Asia, it created the Lancang-Mekong Cooperation Mechanism (LMCM), a regional organization designed to expand cooperation across multiple arenas, including water and environment.

Thai fishers protest construction of Laos' Xayaburi Dam, August 2012.

INTERNATIONAL RIVERS/FLICKR

SPECIAL SECTION II

Hot Spots and Blind Spots

The Hydraulic Mission

The 'hydraulic mission' describes approaches to water management that first emerged during the twentieth century and are still operative around the world. Coined within the last decade, the phrase refers to both a rational-scientific mindset to understanding and controlling natural aquatic systems and to the powerful bureaucratic-institutional apparatus that countries around the world have created in order to turn this mindset into reality. During the twentieth century, the United States, Soviet Union, communist China, and pre- and post-independence India/Pakistan all were in thrall of the hydraulic mission. Within Himalayan Asia, despite significant challenges to the paradigm, the mission survives in still-powerful water bureaucracies to this day.

Although states have been attempting to control and channel water systems for millennia, the technical tools necessary to transform entire natural systems only arose during the nineteenth and (especially) twentieth centuries. Those tools included new materials such as concrete and steel and more powerful construction equipment such as bulldozers, steam- or diesel-powered cranes, and motorized trucks. Operating under the prevailing scientific and technical paradigms of the time, engineers envisioned using these tools to rework natural water systems to fulfill a set of instrumental ends such as increased food or electricity production. Delivering these ends required transforming natural water systems to make them both more reliable (to deliver water on a more constant basis) and controllable (to prevent floods or enable river navigation). Natural bodies of water—rivers, lakes, estuaries, and so on—were treated as little more than functional components of a larger system, each with a purpose, akin to the pipes and valves and pumps and holding tanks that comprise a fully artificial water system.

The hydraulic mission's central goal is to make the entire aquatic system and all of its components more predictable so as to consistently deliver water to specific users. Engineers aimed to transform the unique, particular oddities of each individual natural body of water so as to conform with a standard (hence predictable) template. Rivers become canals, their sharp curves straightened, fluctuating depths made constant, boulders and snags removed, seasonal water levels controlled. Over the past century in particular, engineers applied this template to rivers around the world, to the point where there are now few left anywhere that remain untouched. Massive hydroelectric dams, only made possible by construction tools and materials created in the twentieth century, became key functional components of this process.

To accomplish such ends, governments the world over began creating large water bureaucracies starting in the early twentieth century. Although the first of these focused mostly on the creation or expansion of large irrigation systems, by mid-century the most powerful water bureaucracies were focused on construction of massive hydroelectric dams. The United States became a global leader, through the Bureau of Reclamation, the Tennessee Valley Authority (TVA), US Army Corps of Engineers, and other water bureaucracies. So too did the Soviet Union, with both Lenin and Stalin enthusiastically endorsing the hydraulic mission, as well as Mao's China. Taking cues from both the United States and Soviet Union during the Cold War, newly independent countries in Africa and Asia also pursued this agenda, often with money supplied by either side. In newly independent India, for example, Prime Minister Jawaharlal Nehru famously called hydroelectric dams the "temples of modern India."

The premise of the hydraulic mission is that human welfare can be increased through deliverance of more reliable and controllable flows of water. Measured by these narrow goals, the mission has delivered tangible benefits to societies around the world.

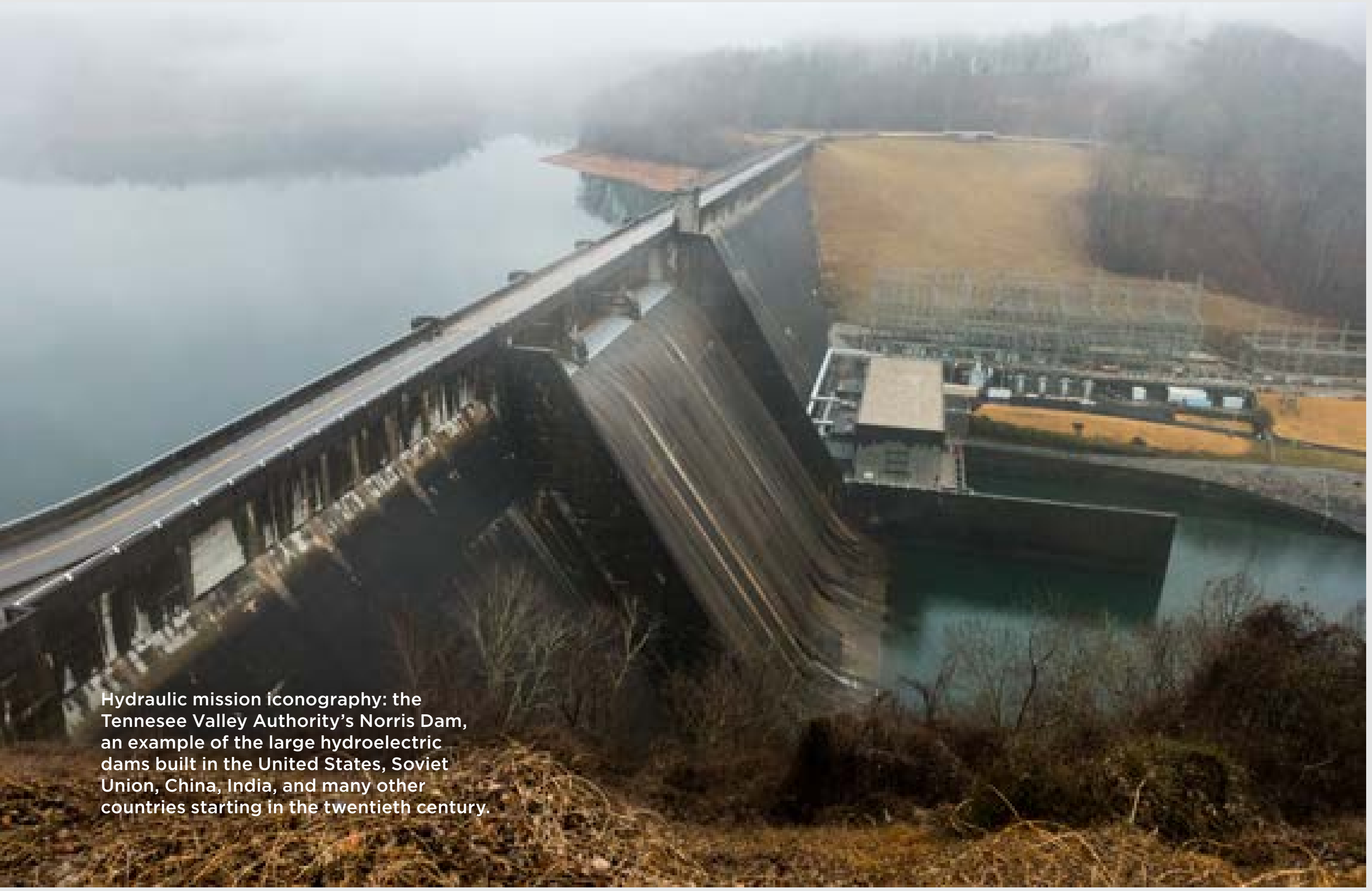
But the model also has three critical and, in our opinion, mortal weaknesses. The first is that the hydraulic mission prioritizes water supply over demand. Within water bureaucracies, water managers have placed less emphasis on development of tools to manage demand, for example water efficiency tools. A bias toward construction of new water infrastructure that will increase fresh water supply is therefore baked into the model.

Second, the hydraulic mission is reductionist, treating nature as a hydraulic engineering problem rather than as a set of diverse and complex ecosystems to be managed and husbanded. Because the model prioritizes energy production, irrigation for agriculture, and transport for river navigation, it fails to consider or simply downplays the significant negative impacts that the creation of water infrastructure has on natural systems and on the services that those systems provide, such as habitat for fresh water fisheries. The model is strictly utilitarian, in that it gives no consideration whatsoever to the protection of nature for its own sake.

Third, the hydraulic mission is exclusionary in that it places greatest power in the hands of a small number of people within water-industrial complexes, while giving little or none to those on the outside. These water-industrial complexes consist of government bureaucracies plus those industries that benefit commercially from creation of water infrastructure (construction, earth moving, energy, etc.). Input from other interests and communities, for example fresh water fishermen, local villagers, environmentalists, and independent scientists, is frequently ignored or marginalized.

These weaknesses repeatedly have led to local and regional conflict over water infrastructure around the world, as well as to the occasional disaster. The collapse of the Aral Sea is the best-known and most tragic case. The destruction of the Aral Sea was an expected one: Soviet planners knew they were trading increased cotton production for the lake's destruction, a calculus they justified on narrow cost-benefit lines (the economic value of increased cotton production versus lost fisheries). Although the Aral Sea disaster was unprecedented, its contours were broadly similar to hydraulic engineering schemes found the world over. Because these schemes often brought social, fiscal, and environmental problems with them, the hydraulic mission's appeal began to erode. By the end of the twentieth century, a loose coalition of experts and policymakers inside multilateral organizations such as the World Bank and UN, several national governments, and academia had articulated a new paradigm that came to be called Integrated Water Resource Management (IWRM). This model turned the hydraulic mission on its head, emphasizing demand management, ecosystem protection, and inclusive decision-making, among other priorities, and conceiving of the river basin as the appropriate unit of analysis.

IWRM since has become the default way to think about water management around the world. Yet, at the same time, the hydraulic mission not only survives but lives on. This is unsurprising given the legacy of the institutional power and thinking that arose along with the hydraulic mission, the water-industrial complex that continues to exist and benefits from new water infrastructure, and the ongoing appeal of water infrastructure as a simplified solution to complex water problems for national governments and even multilateral institutions.



Hydraulic mission iconography: the Tennesee Valley Authority's Norris Dam, an example of the large hydroelectric dams built in the United States, Soviet Union, China, India, and many other countries starting in the twentieth century.

JACOB IAN WALL/FLICKR

For these reasons, it is an open question as to whether Himalayan Asia's largest and most powerful states, as well as many of its smaller ones, remain in the hydraulic mission's grip. India, for example, is proceeding with decades-old, on-again, off-again plans to construct a massive water transfer and control scheme that would link some sixty rivers into a single system. This river-linking scheme is being pushed ahead by Prime Minister Modi's government against vociferous opposition by numerous Indian non-governmental organizations (NGOs) and activists as well as many water experts. One Indian historian, Rohan D'Souza, has criticized the river transfer scheme as a type of legacy thinking, a holdover from the country's long history of modernist "supply-side hydrology" that ignores the considerable environmental and social costs created by large-scale water infrastructure. His article, published in 2003, could well be reprinted today with just as much relevance.

And although China is aggressively implementing demand management approaches to solving its water challenges, as exemplified by the Three Red Lines, at the very same time Chinese leadership has continued to invest heavily in large-scale supply-side water infrastructure. The massive Three Gorges Dam is a powerful symbol of China's commitment to gigantism in water development. So too is the breathtakingly ambitious SNWTP, the world's biggest water transfer scheme designed to move nearly 15 billion cubic meters of water annually from the well-resourced south to the dry north. The SNWTP's critics argue that the project follows the flawed logic of the hydraulic mission, which prioritizes investment in supply-side, often gargantuan, water infrastructure as a technical solution for problems that are far better and more cheaply solved through demand-side approaches. China has one of the most advanced and formidable water-industrial complexes in the world, responsible not only for massive projects such as Three Gorges and SNWTP but for tens of thousands of dams built within the country since the 1949 revolution. Moreover, China has consistently offered its engineering expertise and funding for the planning and construction of large-scale water infrastructure elsewhere in Himalayan Asia and around the world.

The hydraulic mission has enormous significance for transboundary water disputes. The main reason is that the mission encourages the view that a country's water resources are to be used for a narrow set of national purposes, in contrast to IWRM's sensitivity to multiple water-use purposes for diverse stakeholders at the subnational, national, and basin levels. The recent history of the Mekong River Commission provides an illustration of this problem. Over the past decade, the main dispute over the use of the Mekong has involved Laos' desire to become the "battery" of Southeast Asia, via construction of a series of hydroelectric dams on its stretches of the Mekong and tributaries. Laos has begun construction of the first of these dams, over the sustained and strenuous objections of downstream Vietnam and Cambodia and much of the international community as well. Laos has done so despite numerous studies (including the MRC's) showing that the power generation benefits would be outweighed by the dams' negative impacts on food production and other river uses. As is often true in transboundary river disputes, Laos' pursuit of a unilateral dam-construction agenda over the objections of its downstream neighbors shows how it perceives rivers as economic engines to be exploited for its own narrow (hydroelectric power) purposes.

The Indus River

The Indus River represents one of the most important water systems in Himalayan Asia, vital to the livelihoods and welfare of 270 million people inhabiting the basin. India itself derives its name from the Indus via the Sanskrit word Sindhu, the river's historical appellation. Crucially, the Indus nourishes the agricultural breadbaskets of the subcontinent. Agriculture accounts for 93 percent of all water withdrawn from the river. In Pakistan, the Indus waters the world's largest contiguous irrigation system, producing of over four-fifths of the country's food grains. In India, the river generates one quarter of total cereal harvests, ensuring much of the national buffer stocks that offset deficits elsewhere in the country. The basin also holds considerable hydropower potential, estimated at 100,000 megawatts (MW), in a region where hundreds of millions of people lack access to electricity. Yet growing economies and populations are driving increasing water demand, even as supplies are strained by environmental stressors and unsustainable consumption practices. Left unaddressed, these forces could sharpen competition over scarce water resources and fuel regional tensions.

The Indus rises from Lake Ngangla Rinco on China's Tibetan Plateau, flowing 3,180 km across northern India and down the length of Pakistan to empty into the Arabian Sea near Karachi. While the Indus River system encompasses twenty-seven major tributaries, the six most important branches—the Beas, Chenab, Jhelum, Ravi, Sutlej, and the Indus main stem—run westward through India before crossing into Pakistan. A seventh significant tributary, the Kabul River, begins in Afghanistan and flows east into Pakistan. Altogether, the Indus Basin extends over 1.12 million square kilometers equal in size to France, Germany, and Great Britain combined. Some 47 percent of the basin lies in Pakistan, 39 percent in India, 8 percent in China, and 6 percent in Afghanistan. In turn, 65 percent of the total territory of Pakistan falls within the basin, as does 14 percent of India's land mass, 11 percent of Afghanistan, and 1 percent of China.

The fraught hydro-relations dividing the Indus riparians date from the very creation of modern India and Pakistan. The international boundary that partitioned former British India and set the two nations apart at independence in 1947 also set them at odds over water. The new frontier bisected the six main tributaries of the Indus system and the canal networks feeding the region's agriculture. As the downstream neighbour, now reliant for three quarters of its water on sources originating beyond its borders, Pakistan feared that Indian withdrawals or diversions from the Indus could deprive it of critical water supplies, posing an existential threat to its economy and food security. As the upstream riparian, India asserted its sovereign right to develop the rivers on its own territory. Mounting tensions between the two states drew the World Bank to mediate their dispute, resulting after eight years of negotiations in the 1960 Indus Waters Treaty (IWT). Though today often characterized as a 'divorce settlement' rather than a mutually cooperative agreement, at the time of its signature then World Bank President Eugene Black deemed the accord managed to resolve clashing interests that otherwise could have plunged the two riparians into war.

Unlike other transboundary water treaties that typically distribute water allowances among the parties, either as absolute volumetric entitlements or as percentages of the river flow, the IWT physically divides the fan of six major tributaries that comprise the Indus system. The treaty allocates full use of the three principal western tributaries—the Indus main stem, Jhelum, and Chenab—to Pakistan. India must allow these rivers to flow through its territory unhindered, except for restricted purposes and specifically defined amounts related to domestic and agricultural needs and limited hydropower generation. India in turn receives full rights to the three main eastern branches—the Ravi, Sutlej, and Beas. Pakistan must refrain from impeding the flow of any tributaries to the Ravi and Sutlej that traverse its territory before joining these rivers in India (the Beas lies entirely within India, prior to merging with the Sutlej). When the eastern rivers ultimately exit India, they become available for Pakistan's use.

Since 1960, the IWT has held unbroken through two wars, in 1965 and 1971, and withstood the 1999 Kargil conflict, as well as numerous lesser clashes. Despite its historical success stabilizing water relations between India and Pakistan, however, the Indus Treaty offers little response to many emerging risks to their shared water supplies. Yearly water withdrawals in Pakistan have jumped by 20 percent since the mid-1970s, while total annual withdrawals in India have doubled. As the riparians' resource requirements have grown, water extractions from the Indus are outpacing natural rates of replenishment. Many users have increasingly turned to groundwater to supplement or supplant scarce surface water sources, rapidly depleting the region's underground aquifers. Across the Indus, yearly water demand now regularly bumps against the limits of renewable water supplies. Considering both surface and groundwater together, long-term renewable water resources in the Indus Basin average 287 cubic kilometers per year. Against these available supplies, estimated total annual water demand ranges from 257-299 cubic kilometers.

Continuing demographic and economic growth will further stress the basin's finite water resources. Studies conducted by ICIMOD and the International Water Management Institute project that both municipal and industrial water use on the Indian side of the Indus will double from 2001 levels by 2025, while combined municipal and industrial demand in Pakistan will surge more than two-and-a-half times over current use. Likewise, experts anticipate that irrigation withdrawals on the Indian stretches of the Indus will climb 12 percent in the coming decade. Pakistan alone will need 250 cubic kilometers of water for irrigation and to feed its ballooning population in 2025. Consequently, a growing number of analyses foresee alarming water scarcities afflicting the Indus Basin. According to one recent assessment, assuming that current policy regimes persist and existing water efficiency levels continue, renewable water supplies will fall some 40 percent short of annual demand in Pakistan in 2030, while the Indian portion of the Indus will suffer more than a 50 percent gap between projected water needs and available resources.

Climate change will impose additional pressures on the Indus. Climate change will disrupt regional precipitation patterns, upsetting the distribution of rain and snowfalls. Half of the annual rainfall nourishing the Indus, for example, occurs during the June-September monsoon. Much of this rain falls in sudden downpours. Climate change will alter the drivers of the monsoons, for example the moisture content of the atmosphere and the temperature difference between the ocean and land. Monsoons themselves may change as a result, generating stronger floods and deeper droughts and dry spells. By the same token, the Indus depends on snow and ice melt more than other major river basins, especially

before and after the summer monsoon rains. Glaciers in the upper basin are massive fresh water repositories, releasing meltwater during warmer months. That water contributes a calculated 35–50 percent or more of the river's total flow. Rising global temperatures have been shrinking most of the Hindu Kush-Himalayan glaciers. Initially, increasing glacier melt could increase river flows. But as deglaciation continues, meltwaters will subsequently diminish and decrease water supplies downstream.

In the face of these challenges, the IWT furnishes few solutions. The agreement contains no provisions concerning the basin's groundwater aquifers that both India and Pakistan unsustainably exploit. Nor does it address environmental protections or water quality—beyond hortatory expression of intent to prevent pollution where practicable—though deteriorating water quality effectively reduces available water quantities as some sources become too degraded for many uses. Negotiated when inklings of potential global warming were unrecognized outside a tiny scientific circle, the treaty includes no mechanism for the parties to manage variations in water flow that climate change could engender. Finally, beyond neglecting particular issues, the IWT also omits particular parties, the river's other riparians, Afghanistan and China. Though continuing political turbulence in Afghanistan and remote and rugged geography in China have so far largely hindered river development, water demands in both countries continue to rise.

At the same time, significant dissatisfaction—and mutual mistrust—surrounds the IWT in both Pakistan and India. Pakistani critics maintain that, although individual Indian infrastructure developments on the Western tributaries may observe the letter of the agreement, multiple dams on these rivers will increasingly generate damaging cumulative impacts downstream. Moreover, many in Pakistan fear that each additional project augments India's potential capacity to disrupt vital flows down river, enhancing its leverage to throttle Pakistan's agriculture-dependent economy in the event of conflict. India counters that its dam projects consist mostly in "run-of-the-river" structures, meaning that they do not in fact feature the technical capacity to impound significant volumes of water. Substantial Indian opinion thus regards persistent Pakistani objections to planned installations on the Indus' western branches as unfairly stalling India's legitimate development programs. Nevertheless, India has often fuelled Pakistani threat perceptions by opting to begin dam construction unilaterally and delaying or delivering incomplete data on engineering specifications or the timing and volume of operational water releases.

For both India and Pakistan, water governance on the Indus intertwines with the bitter legacy of Partition and the security politics of territorial sovereignty. The basin's three western tributaries, the Indus main stem, the Jhelum, and Chenab, as well part of the Ravi forming the border with Himachal Pradesh, flow through the contested region of Jammu and Kashmir. Pakistani militant groups opposed to Indian control of much of the majority Muslim former princely state, such as Lashkar-e-Taiba, accuse India of either withholding river water from Pakistan or of worsening flooding in Pakistan (via release of water from dammed reservoirs), often overtly threatening violent reprisals. Indeed, former Pakistani President Asif Ali Zardari has asserted that failure to resolve certain Indus disputes fuels the discontent behind terrorism. Some Indian analysts and policymakers, in turn, advocate that Delhi should condition its own ongoing compliance with the IWT in order to compel Islamabad to deal with its extremists.

The fraught hydro-relations dividing the Indus riparians date from the very creation of modern India and Pakistan.

Quarrels over control of the Indus similarly roil both regional geopolitics and subnational governance. Within Jammu and Kashmir, many Kashmiris consider that by allotting use of the western rivers to Pakistan, the IWT shackles their economic development and thwarts their political autonomy, illegitimately removing resources decision-making from local control and rendering water management an issue in separatist debates for Kashmiri independence. In 2002, the state legislature passed a nearly unanimous resolution calling for annulment of the Indus Treaty. At the international level, Chinese funding of Pakistani hydropower projects on the upper Indus under the One Belt, One Road Initiative draws Delhi's suspicion of an anti-Indian alignment. By the same token, Delhi's assistance to Afghanistan's development of a dozen prospective dams on the Kabul River feeds Pakistani apprehensions of encirclement by its Indian adversary.

Water security in the Indus basin is increasingly endangered. Yet the basin countries can take a number of steps to reduce risks and increase benefits to ensure a sustainable water future. Cooperative research plus better data sharing would enable otherwise nationally based information to be more widely shared, in turn contributing to policy formation. The riparian countries could collaboratively identify best practices for improved management of water infrastructure and conduct joint observation of their operations. Similarly, the basin states could conduct and release joint studies of environmental and socioeconomic impacts of such infrastructure, leading to internationally standardized environmental impact assessments.

Despite its flaws, the IWT provides a foundation upon which improved cooperation might be built. As it mandates the regular exchange of river flow and water utilization information, the IWT provides an example of how reciprocal data sharing and policy coordination could be enhanced between the riparian states, including China and Afghanistan. The IWT has no mechanisms for adding new parties, but memoranda of understanding (MoU) could be created for this purpose (China and India have an MoU for Sutlej data sharing). Such common institutional frameworks for exchanging data and coordinating policy can expand policy options and best practices. Notably, all riparian countries' national water policies explicitly call for these forms of cooperation. Policymakers must enact them.

The Brahmaputra (Yarlung Tsangpo) River

Just as the Indus River system has become the hydro-diplomatic flashpoint between upstream India and downstream Pakistan, so too has the Brahmaputra River (called the Yarlung Tsangpo in China) fulfilled this role for relations between upstream China and downstream India. Like the Indus, the Brahmaputra's singular value as a transboundary water resource crystallizes hydro-diplomatic relations between Himalayan Asia's two greatest powers. Indeed, it is precisely because the Brahmaputra carries such outsized importance for both countries, including as a signifier of national power and interest, that episodic controversies surrounding it have the power to derail diplomatic relations between China and India. Conversely, for this reason as well, any future diplomatic breakthroughs surrounding the joint management of the Brahmaputra likely would open the space for broader cooperation elsewhere.

The Brahmaputra's main stem and its tributaries actually flow through four countries: China, India, Bangladesh, and Bhutan. As is true of so many transboundary rivers originating in the water tower, the source of the Brahmaputra/Yarlung Tsangpo lies in Chinese-controlled Tibet, making China the upstream riparian. The river flows due eastward within China for 1,625 kilometers before it meets the Great Bend, taking a ninety-degree turn southward. From there it crosses into India through the disputed (by China) state of Arunachal Pradesh, after which the river flows southwest through Indian territory (including the tea-growing region in Assam state) before entering Bangladesh and finally the Bay of Bengal. The river's total length is 2,880 kilometers. Although the main stem does not pass through Bhutan, several tributaries flow into India from Bhutan. Together, China and India possess the greatest share (86 percent) of the Brahmaputra basin's territory. Yet because the Brahmaputra passes through a largely arid and sparsely populated region within China and far wetter and more heavily populated regions within India and Bangladesh, the two lowest riparians are much more reliant on the river's water. In 2013, India had 39 million people living in the basin and Bangladesh 58 million, compared with 16 million in China and 700,000 in Bhutan. Reflective of the importance of agriculture, irrigation accounted for 86 percent of Bangladesh's use of Brahmaputra water and 93 percent of northeastern India's.

Like other major rivers in the world, including the Indus, Nile, Tigris, Euphrates, and Mekong, in the Brahmaputra/Yarlung Tsangpo case the central controversy revolves around competing visions of appropriate levels and types of water use by upstream and downstream states. As the lowest riparian, Bangladesh faces the biggest risks resulting from upstream states' uses of the river's water, but as it and Bhutan are the smallest and weakest basin states, they factor less into the basin's hydro-diplomatic dynamics than do China and India.

The overwhelming point of dispute between India and China concerns both countries' intentions—real or imagined—for appropriating the river. Both countries have ambitious plans, largely unrealized, to build large numbers of hydroelectric dams on either the main stream or its tributaries.

As is true on China's other transboundary rivers, for example the Mekong, China has eyed the Brahmaputra as a source of much-needed electrical power. In 2015, it opened the first of a series of large dams planned for its stretches of the Yarlung Tsangpo and tributaries. Called the Zangmu Hydropower Station, the dam was slated to generate 2.5 billion kilowatt hours of electricity per year. India consistently has objected to China's agenda, arguing that the Zangmu and other slated dams would interfere with the river's hydrology and ecology. This interference would increase the possibility of worse flooding (a chronic problem on the downstream reaches of the Brahmaputra) or, alternatively, lower river flows during the dry season.

Beyond the dams, however, the scenario that most terrifies India is the possibility that China someday might divert a large part of the river's flow in order to satisfy China's enormous water demand. Indian officials and observers have pointed to China's long-planned "western route" of the South-North Water Transfer Program, which as the name suggests would transfer water from the south and southwest of the country, including Tibet, to its parched north and west. From India's standpoint, fear of the Brahmaputra's diversion has become the most contentious aspect of hydro-diplomatic relations between the two countries.

None of the experts interviewed for this study could forecast China's intentions with confidence, given the opacity of Chinese decision-making and planning at the highest levels. While several were concerned that Brahmaputra diversion is a real possibility that ought to be taken seriously, more were skeptical that China will divert the river in the future.

China's defenders point to several reasons why they see river diversion as unlikely. One argument is that a proposed diversion of the Brahmaputra has never been a part of the

RICCARDO PRAVETTONI/FLICKR

SPECIAL SECTION II
HOT SPOTS AND BLIND SPOTS

SNWTP, rather part of unofficial proposals. The most notorious, the Great Western Water Diversion Plan (GWWDP), was authored by a retired engineer, Guo Kai. Although the GWWDP has attracted some informal support from members of the Chinese military, it has never been formally endorsed by the government and, moreover, has been savaged by China's scientific community as unfeasible. In any case, the western route of the SNWTP has been suspended for over a decade on cost-benefit, technical, and environmental grounds. Another argument is that Chinese leadership is supposedly far more aware now of both the environmental and economic costs of large-scale hydraulic engineering of the kind that would be required to divert the Brahmaputra northward as well as the diplomatic costs of engaging in such radical behavior vis-à-vis its neighbors, India and Bangladesh included. There are good reasons to remain skeptical of the latter claims, not the least of which is that one should not assume that China is a unitary actor when it comes to transboundary rivers. Like India and other countries, China's foreign policies in this space are as much driven by domestic considerations as they are by its foreign policy priorities.

Although China is upstream of India, hence should be little concerned about India's behavior on the Brahmaputra, China has its own reservations about India's intentions. Like China, India has an aggressive dam-building agenda along its stretches of the Brahmaputra and tributaries. Much of this agenda is focused on construction of numerous proposed dams in Arunachal Pradesh, India's farthest northeastern state and a territory that China claims as its own. To some critics inside and outside of China, India's hydraulic engineering plans are hypocritical because India is planning to do on its stretches of the river what it is accusing China of doing farther upstream. Even more importantly, critics argue, India's plans are really intended to strengthen the country's control over a disputed region that both it and China claim. The argument is that investments in dams and other hydraulic infrastructure will help tie the otherwise remote and poorly connected state of Arunachal Pradesh more closely to the rest of India. India's objections to Chinese dam building, so this argument goes, are a way to deflect attention away from its own behavior. This criticism mirrors that often levied against China regarding Tibet, wherein China's infrastructural investments are accused of being secondary to their real purpose, which is to cement Beijing's control over a contested region.

Expert opinion on international conflict over the Brahmaputra/Yarlung Tsangpo can be boiled down to two large categories of concern. The first centers on the lack of formal transboundary river management institutions and agreements in the Brahmaputra/Yarlung Tsangpo basin. Unlike the Indus, Mekong, and the Amu Darya/Syr Darya basins, there are no bilateral or multilateral institutions that act as forums for smoothing out disagreements among riparians. A multilateral trade and investment forum called the Bangladesh–China–India–Myanmar Forum for Regional Cooperation (BCIM Forum) does exist, which some scholars suggest could become a platform for negotiating Brahmaputra water management issues. Yet the same scholars point out the serious difficulties in so doing, largely because of India's unwillingness. Without the vigorous participation of China and India, it is very difficult to envision the creation of a credible multilateral institution. There also is a lack of strong bilateral mechanisms regarding the Brahmaputra, and for similar reasons. The only bilateral agreements between China and India are two memoranda of understanding, wherein China agrees to provide seasonal water flow data to India. These agreements are not treaties, and India is required to pay China for the data.

The two countries' disinterest in creation of strong transboundary institutions speaks to a second category of expert concern, regarding the risks of over-securitization of the river. Several experts interviewed for this study believed that India's (near-) singular obsession over China's possible diversion of the Brahmaputra has effectively securitized hydro-diplomacy between the two countries, to all basin countries' detriment. Defining the Brahmaputra's management solely in terms of diversion means that the Indian government has (a) reduced the possible negotiating space down to a single issue, (b) reduced the possible set of actors that could be involved in negotiations down to just the Indian and Chinese central governments, and (c) defined the problem in zero-sum terms (China's security is enhanced at India's expense, and vice-versa)—a classic securitization outcome.

A possible solution for breaking this bilateral impasse, therefore, is to broaden the aperture for hydro-diplomatic engagement. Bringing lower riparian countries into a multilateral forum would provide such a platform, enabling discussion and negotiation over a broader set of issues (e.g., land use, flooding, siltation, fisheries, irrigation, and more) among a larger set of state actors. It also could introduce a sorely-needed ecological frame for Brahmaputra/Yarlung Tsangpo river management, providing a counterweight to the dominance of hydraulic engineering perspectives. At the same time, lower riparian states could initiate multi-level platforms for hydro-diplomacy, as ways to build trust across national boundaries, identify a wider range of issues and solutions, and broaden stakeholder buy-in to negotiations at

PHOTO CREDIT/FLICKR

SPECIAL SECTION II
HOT SPOTS AND BLIND SPOTS

PHOTO CREDIT/FLICKR

interstate level. Such efforts could build upon the momentum established by the Brahmaputra Dialogue (discussed in Section V above) and its Track 1.5, 2, and 3 approaches. This amounts to a de-securitization agenda, focused on trust-building measures, transnational approaches, multilateralism, and awareness of multiple and competing trade-offs when it comes to river management.

While China has proven reluctant to so engage along its transboundary rivers, its participation in any such initiatives ought to be encouraged. Although China is not a member within the MRC, the existence of the MRC provides Southeast Asian states with a visible forum for negotiating the river's future among themselves, one that China has to take into consideration when formulating its plans. Framing the Brahmaputra in basin terms therefore might strengthen the hand of lower riparians when it comes to negotiating with upstream China.

The Mekong (Lancang) River

Although all of the rivers originating in the water tower are critically important for the regions through which they flow, few are more important than the Mekong River. Coursing from the Tibetan Plateau in China, where it is called the Lancang River, through or along Myanmar, Laos, Thailand, Cambodia, and Vietnam, the Mekong is the most critical natural resource in Southeast Asia. Shrouded in both myth and history, the river long has provided an abundance of food and a vital transportation artery for the region. In recent decades, the Mekong also has become an increasingly important source of hydroelectric power, eyed by several national governments for its vast power-generating potential. Extensive hydroelectric dam-building plans in the lower Mekong basin (to the south of China and Myanmar), most of which are yet to be realized, have created the central flashpoint over the Mekong. It is not hyperbole to say that the river's future and the fates of its rich ecosystems, innumerable species, and diverse peoples living along it hang in the balance.

The source of the Mekong lies in the Tibetan Plateau of China, at an elevation greater than 5,000 meters above sea level. In China's Yunnan Province, the Mekong/Lancang runs parallel to the Salween and Yangtze rivers for some 500 kilometers through the Three Parallel Rivers National Park, characterized by its massive gorges, some over 2,500 meters deep. After leaving China, long stretches of the Mekong form the borders between Laos and Myanmar or Laos and Thailand, before the river courses through Cambodia and finally into Vietnam. The river runs through highlands in Laos and Thailand, with frequent changes in direction, creating numerous niche ecosystems. The river's lowermost stretches are exceptional for their unique settings and extraordinary biodiversity. Cambodia's Tonle Sap Great Lake, the region's largest, is one of the world's most unusual due to its extensive growth and contraction over the wet and dry seasons. During the wet monsoon season, the force of the Mekong's river water is so enormous that water pushes from the main channel upriver, via the short Tonle Sap River tributary, expanding the lake to six times its dry season area and forty to fifty times its dry season volume. Farther downstream, the Mekong Delta, located largely in Vietnam, is a large, rich alluvial plain that drains the river into the South China Sea.

The scenario that most terrifies India is the possibility that China someday might divert the Brahmaputra northward.

The Mekong River is a case study of the contradictions that are inherent in the use of surface bodies of fresh water. In the Mekong's case, the primary contradiction involves energy and food. Because the lower Mekong flows through a diverse set of tropical and sub-tropical ecosystems, it contains the richest fresh water fisheries in the world, valued at some $17 billion annually and delivering half or more of all animal protein to the basin's peoples. In addition, the Mekong's water provides for a wide variety of crops grown throughout the basin, including many planted by villagers on the river's edge itself.

But as Southeast Asia is a vibrant region with several dynamic economies, its increasing wealth, industrialization, and urbanization has led to rapidly rising demand for electricity. At the same time, the region also has widespread

SPECIAL SECTION II
HOT SPOTS AND BLIND SPOTS

energy poverty, in particular in rural areas in Laos, Myanmar, and elsewhere that have either no electricity access or only have access to unreliable sources at high prices. With these factors uppermost in mind, several of the region's governments arrived at the conclusion that they need to meet this rising demand through hydroelectric power development, which government officials have perceived as being a free resource given the vast hydroelectric potential of the Mekong and its tributaries (the lower Mekong alone has an estimated 30,000 megawatts hydroelectric potential).

China, which has rejected participation in multilateral institutions not of its own creation, has planned and built seven large hydroelectric dams already on the Lancang. There are two primary worries about these dams, one concerning the volume of river water that China can retain behind them, the other their interference in the river's natural flow of sediment (critical for downstream ecosystems). As China's dams were planned and constructed without formal consultation with the downstream countries, their existence is now a fait accompli.

Yet because the river still has roughly half its original elevation to drop between when it reaches the Laotian/Myanmar border and the sea, the downstream countries also have developed hydroelectric plans of their own. While all of the lower Mekong countries have built dams on the river's tributaries, until recently the main stem, hydrologically and ecologically the most significant part of the basin, has been left alone.

Over the past decade, this situation has changed dramatically, with lower Mekong states planning as many as eleven dams on the main stem. Most of these dams, eight in total, are to be built in Laos, part of a larger agenda including the construction of dozens of dams on tributary rivers. Laos's goal is to become the 'battery' of Southeast Asia, providing electricity to itself and for export, for example to energy-hungry Thailand. Laos's plans for hydroelectric dam development on the lower Mekong are by far the most controversial within the region, owing to the number and size of the proposed dams but also the concrete steps it has taken to build the first two, the Xayaburi and Don Sahong dams.

To summarize a complex history involving the Laotian dams, in 2007 the Laotian government contracted with a Thai developer to conduct feasibility study for the first of its planned dams, the Xayaburi Dam in northern Laos. Because it is a member of the Mekong Regional Commission (MRC), the primary multilateral hydro-diplomatic institution in Southeast Asia, Laos was required under the MRC's regulations to submit its plans for review and consultation.

Boatmen on the Brahmaputra River, Assam, India

MICHAEL FOLEY/FLICKR

This process, known as the Procedures for Notification, Prior Consultation and Agreement (PNPCA), swiftly became a political one. Over a several-year timeframe, Laos's downstream neighbors, Cambodia and Vietnam, accused Laos of providing incomplete or misleading information about the dam and of not following PNPCA protocols. These governments were joined by coalitions of non-governmental organizations and citizens' groups from within and beyond the region. Nonetheless, the Laotian government pressed ahead over these objections, moving to build the dam. It is nearing completion.

The Xayaburi case, and later the Don Sahong case, exposed the MRC's institutional shortcomings and lack of power. While the PNPCA requires countries to submit their plans for review by the other basin states, the MRC has no means for denying any project to which its member states object. Laos's behavior showed not only that it was unwilling to stop construction of its dams, it also came under severe criticism for balking at the procedural details of the PNPCA itself. The states with the greatest objections to the Laotian plans, Vietnam and Cambodia, even had to resort to bilateral pressure to ensure that Laos went through the PNPCA process at a later time regarding the Don Sahong dam. Indeed, the MRC's toothless oversight and management capabilities led member states, especially Vietnam, to pursue bilateral avenues in order to garner influence within the Laotian government. The Vietnamese government also played a part in encouraging civil society's strenuous objections to the dams, again as a way to influence the Laotian government.

Some regional experts caveat their conclusions regarding the MRC's weaknesses, arguing that the PNPCA process that Laos went through, together with the emergence of robust civil society activism across the region (including the politics surrounding the Mekong, Salween, and Irrawaddy rivers), did have some positive results. Among other things, the PNCPA process and civil society pressure together induced Laos and its development partners to undertake extensive additional research, resulting in time delays, increased costs, and modifications to the dams' original designs (for example, improving fish passageways). These changes have added to a perception that appears to be growing among investors in the region regarding the rising political and financial risks of large hydroelectric dam investments. At the same time, falling renewable energy costs have eroded the power of the financial and energy security arguments normally used to buttress the case for large dam investments. Southeast Asian countries utilize a relatively low mix of non-hydropower renewable energy sources, despite significant potential, of solar power in particular.

As if to take advantage of the MRC's weakened position, China began its own Mekong basin initiative in 2016. Called the Lancang-Mekong Cooperation Mechanism (LMCM), the initiative has a broad remit across economic, development, security, and cultural issues. The LMCM is a mechanism by which China hopes to extend its influence within the region through application of its considerable financial and economic power. According to experts, China may be using the LMCM to extend its Belt and Road Initiative into Southeast Asia through greater investment in regional infrastructure, including hydroelectric dams, expand its commercial trade in the region, and assist China in navigating diplomatic disputes with its neighbors, such as disagreements over the South China Sea, among other priorities. As is true elsewhere, Chinese investors, including its state-owned enterprises, are important in financial backing of the region's dams (although Japan remains the largest backer of regional infrastructure).

The Rogun Dam

The long-planned but not-yet constructed Rogun Dam in Tajikistan is one of Central Asia's most contested pieces of water infrastructure. A legacy of the Soviet Union's hydraulic planning for its Central Asian republics, the dam has become a flashpoint for conflict since the republics' independence, principally between upstream Tajikistan and downstream Uzbekistan. In keeping with general Amu Darya/Syr Darya management controversies in Central Asia, the Rogun Dam's primary controversy involves energy-poor Tajikistan's desire to increase its electrical generation capacity for both domestic consumption and foreign export and water-poor Uzbekistan's desire to maintain the flow of the Amu Darya for crop irrigation, particularly during the dry summer months. The Rogun Dam therefore is a crystallization of Central Asia's primary water conflict in a single infrastructural project.

The Rogun Dam is a proposed hydroelectric dam on the Vakhsh River, a main tributary of the Amu Darya, in Tajikistan. If constructed, the dam would be the world's tallest at 335 meters (1,100 feet) in height and would generate some 13.1 billion kilowatt hours (kWh) of electricity annually. The dam's origins extend back to 1976, when Soviet planners envisaged the Rogun to complement power output provided by the Nurek Dam, another massive dam (eventually completed and currently operational) further downstream on the Vakhsh. The Rogun's long and difficult history since 1976 remains an incomplete one, consisting of decades' worth of fits and starts owing to the dam's high cost (currently estimated at around $2.2 billion to build) and related problems acquiring financing, its technical challenges, international objections, and disruptions brought about by Tajikistan's independence. However, construction began anew in 2016, with the Italian contractor in charge of construction, Salini Impregilo, claiming that the first turbine would become operational by the end of 2018.

The Rogun Dam and the international controversy surrounding it sits at the delicate intersection of Central Asia's agriculture-water-energy nexus. The primary dynamic stems from the breakdown of the Soviet Union in 1991 and the emergence of Central Asia's five independent republics. Before the Soviet collapse, Moscow had put into place a regional water-for-energy scheme wherein the water-rich/energy-poor upstream republics provided sufficient river water to meet downstream irrigation needs (especially in summer) and the water-poor/energy-rich downstream republics provided energy to meet the upstream republics' needs (especially in winter). This situation worked as long as a central government could manage the system. After independence, however, the political and economic underpinnings of this scheme collapsed. To simplify the problem, the downstream republics wanted water during the summer for their agricultural production (cotton, largely) while the upstream republics wanted it during the winter for their electricity generation.

The Rogun Dam and the international controversy surrounding it sits at the delicate intersection of Central Asia's agriculture-water-energy nexus.

The Rogun Dam is critical to fulfilling Tajikistan's long-running dream of vastly increasing its electricity production. Because Tajikistan is a poor country lacking in fossil fuels, it has had meager electrical generation capacity. Tajikistan has had to suffer the occasional widespread power blackout, particularly in the winter months, due to its inability to acquire enough electricity from an oft-unreliable regional power grid. During the unusually cold winter of 2007-2008, Tajikistan could neither generate enough electricity nor acquire enough from abroad, necessitating severe electricity restrictions throughout the country. Two years later, Tajikistan temporarily crashed the aging regional electricity grid when it drew more than its allotted share. The Rogun Dam would solve Tajikistan's seasonal problem, but only if it releases turbine-spinning water from its reservoir during the winter months. The dam's massive size also will allow it to generate enough power to meet Tajikistan's entire domestic needs plus export surplus power to its neighbors. The dam would be critical to Tajikistan's electricity generation output within the goals of the CASA-1000 (Central Asia-South Asia) plan, a project endorsed by the World Bank that is designed to transmit surplus power generated in Tajikistan and Kyrgyzstan to Afghanistan and Pakistan.

Uzbekistan, in contrast, is rich in energy resources but poor in water resources (in 2011, the country had barely 1,760 cubic meters of water per capita per year, compared with Tajikistan's 3,140 cubic meters). Water for irrigated agriculture, cotton in particular, is critical to Uzbekistan's economy. And Uzbekistan needs water during the summer's dry growing season, which means it needs upstream Tajikistan to withhold reservoir water during the winter so as to have enough to release during the summer.

Uzbekistan therefore objected to the Rogun Dam for precisely the opposite reasons that Tajikistan has used to support building it. Perceiving that his country had much to lose and little to gain, former Uzbek president Islam Karimov stridently opposed construction of the dam, even obliquely threatening war in 2012. In 2013, Uzbekistan cut off gas supplies to Tajikistan, worsening the latter's already precarious energy situation and forcing it to look for alternatives even harder. The following year, Uzbekistan's deputy prime minister issued a statement saying that Uzbekistan would "never, and under no circumstances" support construction. Although there was some softening of Uzbekistan's policy toward the dam in the last year of Karimov's rule, the two countries had been at loggerheads over the dam for the entire period since the republics became independent.

However, relations began to improve after Karimov's death in 2016, with Uzbekistan's government under new President Shavkat Mirziyoyev sending out more conciliatory signals to both Tajikistan and the other republics about both regional water sharing and the dam itself. In March 2018, Miziyoyev traveled to Dushanbe to meet with his counterpart, Emomali Rahmon, the first official visit of an Uzbek president since 2000. While there, Mirziyoyev announced that Uzbekistan would no longer object to Rogun's construction, while Rahmon indicated that Tajikistan would not withhold water from Uzbekistan upon the dam's completion. Uzbekistan's new strategy appears to be to find ways to secure water from upstream through a combination of a good-neighbor policy plus direct purchase, in the hopes that so doing would open doors for other benefits, for example in expanded bilateral trade and via counter-terror security initiatives.

A young Tajik shepherd tends his flock near the Tajik-Uzbek border.

RONAN SHENHAV/FLICKR

These recent developments portend a breakthrough in the longstanding Uzbek-Tajik dispute over the Rogun Dam. There is much at stake for both countries, with a good deal to gain from cooperation and much to lose from lack thereof. Coordinated strategies regarding energy production and the timing of seasonal water flow from the dam will have far greater positive impacts than will go-it-alone strategies. One academic modeling exercise conducted in 2015, for example, concluded that coordinated water releases from the Rogun Dam would increase hydropower electricity generation by 93 percent while decreasing downstream irrigation losses to less than 1 percent. Go-it-alone strategies, in contrast, would see downstream irrigation losses of 31 percent. Uzbekistan also could undertake much-needed agricultural sector reforms to deal with decreased water flow. Raising irrigation efficiency should be chief among those reforms.

While climate models cannot reliably forecast the long-term changes in regional precipitation, increasing temperatures in Tajikistan's mountainous regions are melting the region's glaciers. Experts fear that Central Asia has a limited time to resolve its delicate hydro-diplomatic conflicts. Over the short and medium terms, they argue, the odds are that the region's rivers will receive more water due to increased glacial melt. Over the long term, however, the odds are much higher that water flow will be significantly reduced because many of the glaciers certainly will have melted away and the region very well might receive less rain on a year-to-year basis. Under such a scenario, water becomes far more scarce than it is now and use of the Rogun Dam's water easily could become a renewed flashpoint for conflict.

Authors' Bios

Dr. Peter Engelke is a senior fellow within the Atlantic Council's Scowcroft Center on Strategy and Security. His diverse work portfolio at the Center's Foresight, Strategy, and Risks Initiative spans geopolitics, climate change and natural resources, global and regional futures, innovation and technological disruption, and urbanization among other topics. Dr. Engelke has managed numerous projects on these subjects, resulting in a lengthy list of Atlantic Council publications. His work has appeared in the Washington Post, Los Angeles Times, The Hill, The National Interest, Citiscope, Meeting of the Minds, the World Economic Forum's Agenda platform, and other outlets. His professional experience includes stints at think tanks and foundations in Europe and the United States, including as an executive-in-residence at the Geneva Centre for Security Policy, a Bosch fellow with the Robert Bosch Foundation in Stuttgart, Germany, and a visiting fellow at the Stimson Center in Washington, DC. His most recent co-authored book, *The Great Acceleration*, is a global environmental history from 1945 to 2016. His first, *Health and Community Design*, was penned while he was on the research faculty at Georgia Tech and is a study of public health and urban form. Dr. Engelke holds a Ph.D. in history from Georgetown University and has master's degrees from Georgetown's Walsh School of Foreign Service, the University of Maryland, and Indiana University. He currently is adjunct faculty at Georgetown's School of Continuing Studies.

David Michel is a senior manager with the Transboundary Water Management Department at the Stockholm International Water Institute (SIWI) in Sweden. He is responsible for conducting political economy analyses to identify conflict risks and collaborative opportunities in transboundary river basins, developing multi-stakeholder policy dialogues, and designing water diplomacy training and other capacity building initiatives to advance international cooperation. He has written widely on transboundary water governance, natural resources management, and the emerging policy challenges and potential security risks posed by global environmental change. He has advised the National Intelligence Council and the Departments of Defense, Energy, and State on water, food security, and climate policy issues, and frequently lectures on environmental conflict and cooperation at institutions in the US and abroad. Prior to joining SIWI in 2017, he was director of the Environmental Security Program at the Stimson Center in Washington, DC. He previously served as an executive-in-residence at the Geneva Centre for Security Policy and as a senior associate at the Center for Transatlantic Relations. He was educated at Yale University, the École des Hautes Études en Sciences Sociales and the École Normale Supérieure in Paris, and The Johns Hopkins University School of Advanced International Studies.

Acknowledgments and Disclaimer

The Atlantic Council would like to thank the Smith Richardson Foundation for its generous funding of this project.

Numerous people contributed to this study in one form or another. Dozens of experts consented to interviews in person or by phone; their insights proved indispensable in putting this report together. Interviewees literally spanned the globe—from Asia, Europe, and the United States—and represented every kind of institution: public, private, non-profit, intergovernmental, academic, and otherwise. A smaller list of people acted as external reviewers, providing input to the first draft of this document. Their recommendations proved enormously valuable in improving the final product. As all interviews and reviews were conducted off the record, no individuals are listed here. The authors thank every person who gave generously of their time and who offered their critical insights into the range of topics discussed in these pages. The authors are responsible for all errors and omissions.

David Michel contributed to this report in his personal capacity. The views expressed are his own and do not necessarily represent the views or positions of the Stockholm International Water Institute, its funders or partners, nor any other agency or organization with which he is or has been affiliated.

Endnotes

1 World Economic Forum, *Global Risks Report 2019*, January 2019, http://www3.weforum.org/docs/WEF_Global_Risks_Report_2019.pdf. For a summary of water within previous World Economic Forum global risks reports, see Brett Walton, "World Economic Forum sees big risks in water and climate," Circle of Blue, January 17, 2018, https://www.circleofblue.org/2018/water-management/world-economic-forum-sees-big-risks.

2 Office of the Director of National Intelligence, *Global Water Security. Intelligence Community Assessment ICA 2012-08* (Washington: ODNI, February 2, 2012), https://www.dni.gov/files/documents/Special%20Report_ICA%20Global%20Water%20Security.pdf, iii.

3 On the World Bank, see, e.g., Claudia W. Sadoff, Edoardo Borgomeo, and Dominick de Waal, *Turbulent Waters: Pursuing Water Security in Fragile Contexts* (Washington: World Bank, 2017). In January 2018, the Global High Level Panel on Water and Peace, a body formed in Geneva and closely aligned with the United Nations, issued a major report on water and transboundary insecurity titled *A Matter of Survival*: https://www.genevawaterhub.org/resource/matter-survival.

4 For the reader who is interested in a more detailed discussion of these themes and topics, see Special Section I.

5 The HKH ranges have 54,252 glaciers with an estimated volume of 6,127 cubic kilometers of ice. See Aditi Mukherji et al., "Megatrends in Hindu Kush Himalaya: Climate Change, Urbanisation and Migration and Their Implications for Water, Energy and Food" in *Assessing Global Water Megatrends*, ed. Asit K. Biswas, Cecilia Tortajada, and Philippe Rohner (Singapore: Springer, 2018), 127; Tobias Bolch et al., "Status and Change of the Cryosphere in the Extended Hindu Kush Himalaya Region" in *The Hindu Kush Himalaya Assessment: Mountains, Climate Change, Sustainability, and People*, ed. Philippus Wester et al. (Kathmandu: International Centre for Integrated Mountain Development, 2019), 221.

6 International Commission on Large Dams, *World Register of Dams* (Paris: ICOLD, 2018), https://www.icold-cigb.org/GB/world_register/general_synthesis.asp; Christiane Zarfl et al., "A global boom in hydropower dam construction," *Aquatic Sciences* 77 (2014), 161-170.

7 Olli Varis, Matti Kummu, and Aura Salmivaara, "Ten major rivers in monsoon Asia-Pacific: An assessment of vulnerability," *Applied Geography* 32 (2012), 441-454.

8 See, e.g., Rene Reijer Wijngaard et al., "Climate change versus socio-economic development: Understanding the future South Asian water gap," *Hydrology and Earth System Sciences* 22 (2018), 6297-6321; Charles Fant et al., "Projections of water stress based on an ensemble of socioeconomic growth and climate change scenarios: A case study in Asia," *PLOS One* (March 30, 2016), 1-33; Yusuke Satoh et al., "Multi-model and multi-scenario assessments of Asian water futures: The Water Futures and Solutions (WFaS) initiative," *Earth's Future* 5 (2017), 823-852.

9 Regarding HKH glacial melt, the eastern Himalayas have seen faster glacial mass loss than western glaciers. An interesting and "puzzling" exception is the so-called Karakoram anomaly, referring to how a few glaciers in the highest sections of the Karakoram range have grown, bucking the overall trend. See AB Shrestha et al., eds., *The Himalayan Climate and Water Atlas: Impact of climate change on water resources in five of Asia's major river basins* (Kathmandu: ICIMOD, GRID-Arendal and CICERO, 2015), 18-21, 36-40. On Tien Shan glaciers, see Daniel Farinotti et al., "Substantial glacial melt in the Tien Shan over the past 50 years," *Nature Geoscience* 8 (2015), 716-722. On glacial melt versus monsoon dependence across the HKH rivers, see Arun B. Shrestha et al., "Regional water cooperation in the Hindu Kush Himalayan region" in *Free Flow: Reaching Water Security Through Cooperation*, ed. UNESCO Publishing (Paris: United Nations Educational, Scientific and Cultural Organization, 2013), 66 and Map 10.

10 See, e.g., Shrestha et al., *Atlas*, 8; Walter W. Immerzeel, Ludovicus P.H. van Beek, and Marc F.P. Bierkens, "Climate change will affect the Asian water towers," *Science* 328 (June 11, 2010), 1384-1385; Mukherji et al., "Megatrends," 129.

11 Wester et al., eds., *Assessment*.

12 Susanne M. Scheierling and David O. Treguer, *Beyond Crop per Drop: Assessing Agricultural Water Productivity and Efficiency in a Maturing Water Economy* (Washington: World Bank, 2018), 13-14 and Table 2.1.

13 Data from Food and Agriculture Organization of the United Nations, Table "Water withdrawal by sector, around 2010," Undated, http://www.fao.org/nr/water/aquastat/tables/WorldData-Withdrawal_eng.pdf.

14 Scheierling and Treguer, *Beyond*, 15, Table 2.2.

15 *Area Equipped for Irrigation*, Food and Agriculture Organization of the United Nations (2014), http://www.fao.org/nr/water/aquastat/infographics/Irrigation_eng.pdf.

16 This list is derived from Asian Development Bank, *A Region at Risk: The Human Dimensions of Climate Change in Asia and the Pacific* (Manila: Asian Development Bank, 2017), 55. See also Food and Agriculture Organization of the United Nations, *The State of Food and Agriculture 2016: Climate Change, Agriculture and Food Security* (Rome: Food and Agriculture Organization of the United Nations, 2016), 24-25, Table 2.

17 United Nations Department of Economic and Social Affairs, Population Division, *World Urbanization Prospects: The 2014 Revision* (2015), 38-40, Tables II.8-II.10; United Nations Department of Economic and Social Affairs, Population Division, *World Urbanization Prospects: The 2018 Revision* (2018), Data Files 19 and 21, available at https://esa.un.org/unpd/wup/.

18 These arguments are advanced in detail in Peter Engelke, *The Security of Cities: Ecology and Conflict on an Urbanizing Planet*, November 2013, http://www.atlanticcouncil.org/publications/reports/the-security-of-cities-ecology-and-conflict-on-an-urbanizing-planet.

19 United Nations World Water Assessment Programme, *Wastewater, The Untapped Resource. The United Nations World Water Development Report 2017* (Perugia, Italy: UNESCO Division of Water Sciences, Programme Office for Global Water Assessment, 2017), 97-98, Table 11.1.

20 United Nations Human Settlement Programme (UN-Habitat), *World Cities Report 2016: Urbanization and Development. Emerging Futures* (Nairobi: UN-Habitat), 57-58.

21 Gilles Erkens et al., "Sinking coastal cities," *Geophysical Research Abstracts* 16 (2014); Robert Brears, "Opinion: Achieving urban water security in Asia-Pacific through demand management," *Johns Hopkins Water Magazine*, May 5, 2014, http://water.jhu.edu/index.php/magazine/achieving-urban-water-security-in-asia-pacific-through-demand-management/; Michael Kimmelman, "Rising waters threaten China's rising cities," *New York Times*, April 7, 2017 https://www.nytimes.com/interactive/2017/04/07/world/asia/climate-change-china.html.

22 World Energy Council, *World Energy Perspectives 2016: The Road to Resilience—Managing the Risks of the Energy-Water-Food Nexus*, 2016, 2, https://www.worldenergy.org/wp-content/uploads/2016/03/The-road-to-resilience-managing-the-risks-of-the-energy-water-food-nexus_-early-findings-report.pdf.

23 Data from the Asia Pacific Energy Portal, https://asiapacificenergy.org.

24 Michelle T.H. van Vliet et al., "Power-generation system vulnerability and adaptation to changes in climate and water resources," *Nature Climate Change* 6 (2016), 375-380.

25 On the 500 GW figure, see Shrestha et al., "Cooperation," 67-68. On the Three Gorges Dam figure, see "Three Gorges Dam: the world's largest hydroelectric plant," *US Geological Survey*, Undated, https://water.usgs.gov/edu/hybiggest.html.

26 Miguel Angel Sanz, "2018 Trends in Desalination and Water Reuse," Presentation at Singapore Water Week, July 10, 2018, slide 6, https://www.siww.com.sg/docs/default-source/default-document-library/mr-miguel-sanz.pdf?sfvrsn=2. On China, see Xiang Zheng et. al, "Seawater desalination in China: Retrospect and prospect," *Chemical Engineering Journal* 242 (2014), 404-413; Yiting Sun, "Sustainable energy: China's massive effort to purify seawater is drying up," *MIT Technology Review*, July 11, 2016, https://www.technologyreview.com/s/601861/chinas-massive-effort-to-purify-seawater-is-drying-up/. On India, see S.C. Lahiry, "Is desalination worth its salt?," *India Water Portal*, October 6, 2017, http://www.indiawaterportal.org/articles/desalination-worth-its-salt; "A sea of opportunities: Desalination to help achieve water supply stability," *Indian Infrastructure*, March 2017, https://indianinfrastructure.com/2017/03/04/a-sea-of-opportunities/; Keith Schneider, "In water-scarce regions desalination plants are risky investments," *Circle of Blue*, November 22, 2016, https://www.circleofblue.org/2016/asia/water-scarce-regions-desalination-plants-risky-investments/.

27 Two of the Pearl River's outer tributaries run through Vietnam for short stretches.

28 Food and Agriculture Organization of the United Nations, Aquastat Global Water Information System, China and the United States fact sheets, http://www.fao.org/nr/water/aquastat/countries_regions/index.stm.

29 Global Water Partnership, *Technical Focus Paper: China's water resources management challenge: The 'three red lines'*, 2015, 9, https://www.gwp.org/globalassets/global/toolbox/publications/technical-focus-papers/tfpchina_2015.pdf; Charlie Parton, *China's Looming Water Crisis*, April 2018, 8, https://www.chinadialogue.net/reports/10608-China-s-looming-water-crisis/en; Jesper Svensson, "Q&A: China's growing water scarcity challenge," *Global Water Forum*, June 20, 2017, http://www.globalwaterforum.org/2017/06/19/qa-chinas-growing-water-scarcity-challenge-2/.

30 Michael Webber, "Tackling China's water pollution," *Global Water Forum*, October 9, 2017, http://www.globalwaterforum.org/2017/10/09/tackling-chinas-water-pollution/.

31 For a summary, see Ma Tianjie and Liu Qin, "China reshapes ministries to better protect environment," *China Dialogue*, March 14, 2018, https://www.chinadialogue.net/article/show/single/en/10502-China-reshapes-ministries-to-better-protect-environment.

32 This history is outlined in Kristopher D. White, "Nature-society linkages in the Aral Sea region," *Journal of Eurasian Studies* 4 (2013), 21-22, https://www.sciencedirect.com/science/article/pii/S187936651200022X.

33 Benjamin Pohl et al., *Rethinking Water in Central Asia: The costs of inaction and benefits of water cooperation* (Adelphi and CAREC, 2017), IV-V, 7-10. A partial list of agreements can be found in Aibek Zhupankhan, Kamshat Tussupova, and Ronny Berndtsson, "Could changing power relationships lead to better water sharing in Central Asia?," *Water* 9, 139 (2017), Table 3, 8, http://www.mdpi.com/journal/water.

34 The 100,000 kilometers figure is in A.M. MacDonald et al., "Groundwater quality and depletion in the Indo-Gangetic Basin mapped from in situ observations," *Nature Geoscience* (August 29, 2016), 1.

35 R. Edward Grumbine and Maharaj K. Pandit, "Threats from India's Himalaya dams," *Science* 339 (January 4, 2013), 36-37.

36 Insights from expert interview conducted May 31, 2018. See also Nilanthi Samaranayake, Satu Limaye, and Joel Wuthnow, *Water Resource Competition in the Brahmaputra River Basin: China, India, and Bangladesh*, May 2016, https://www.cna.org/CNA_files/PDF/CNA-Brahmaputra-Study-2016.pdf; Strategic Foresight Group, *The Himalayan Challenge: Water Security in Emerging Asia* (Mumbai: Strategic Foresight Group, 2010), 3; Barbara Neumann et al., "Future coastal population growth and exposure to sea-level rise and coastal flooding – A global assessment," *PLoS One* 10, 3 (2015), https://doi.org/10.1371/journal.pone.0118571.

37 As mentioned in Samaranayake, Limaye, and Wuthnow, *Competition*, 5-6.

38 The Ganges and Mahakali treaties are discussed in Sheila Rai and Sanghamitra Patnaik, "Water Disputes in South Asia" in *Water Resource Conflicts and International Security: A Global Perspective*, ed. Dhirendra Vajpeyi (Lanham: Lexington Books, 2012), 106-114, 127-131.

39 The Irrawaddy's headwaters are of some controversy, with its tributaries' sources lying in contested territory along the Myanmar-China border. Regardless of the legal status of these headwaters, there is no dispute that either the entirety or near entirety of the Irrawaddy lies within Myanmar. See, e.g., Zarni Mann, "Environmentalists reject Irrawaddy River as 'International' waterway," *The Irrawaddy*, May 17, 2014, https://www.irrawaddy.com/news/burma/environmentalists-reject-irrawaddy-river-international-waterway.html.

40 Arjun Thapan, "A Perfect Storm in the Greater Mekong Subregion:

Climate Change Impacts on Food, Water, and Energy" in *Water, Security and US Foreign Policy*, ed. David Reed (New York: Routledge, 2016), 281-282.

41 Nguyen Dinh Sach, "The Lancang-Mekong Cooperation Mechanism (LMCM) and its implications for the Mekong sub-region," CSIS Pacific Forum *Issues & Insights Working Paper* 18, 1 (January 2018).

42 International Rivers, *The New Great Walls: A Guide to China's Overseas Dam Industry*, November 26, 2012, 4-6, https://www.internationalrivers.org/resources/the-new-great-walls-a-guide-to-china's-overseas-dam-industry-396.

43 Julan Du and Yifei Zhang, "Does One Belt One Road initiative promote Chinese overseas direct investment?" *China Economic Review* 47 (2018), 189-205; "China's Belt and Road Initiative is falling short," *Financial Times*, July 29, 2018, https://www.ft.com/content/47d63fec-9185-11e8-b639-7680cedcc421.

44 For a summary of the BRI and an assessment of how to interpret China's goals, see Stephen Aris, *One Belt, One Road: China's Vision of 'Connectivity,'* CSS Analyses in Security Policy 195 (Zurich: ETH-Zurich, Center for Security Studies, September 2016), http://www.css.ethz.ch/content/dam/ethz/special-interest/gess/cis/center-for-securities-studies/pdfs/CSSAnalyse195-EN.pdf. See also Tom Mitchell, "Beijing insists BRI is no Marshall Plan," *Financial Times*, September 25, 2018, https://www.ft.com/content/48f21df8-9c9b-11e8-88de-49c908b1f264. On the relationship between the BRI and Chinese geostrategic aims, including military aims, see Maria Abi-Habib, "China's 'Belt and Road' plan in Pakistan takes a military turn," *The New York Times*, December 19, 2018, https://www.nytimes.com/2018/12/19/world/asia/pakistan-china-belt-road-military.html.

45 CSIS, the American think tank, houses an Asian infrastructure investment database at https://reconnectingasia.csis.org/database/.

46 Jamil Anderlini, Henny Sender, and Farhan Bokhari, "Pakistan rethinks its role in Xi's Belt and Road plan," *Financial Times*, September 9, 2018, https://www.ft.com/content/d4a3e7f8-b282-11e8-99ca-68cf89602132?kbc=017a36cd-82e2-4f8d-ac0f-a8c7a3eb97d7.

47 Gatra Priyandita and Trissia Wijaya, "Winning hearts on China's belt and road," *The Diplomat*, May 4, 2018, https://thediplomat.com/2018/05/winning-hearts-on-chinas-belt-and-road/.

48 This history is detailed in: Andrew Higgins, "Chinese-funded hydropower project sparks anger in Burma," *The Washington Post*, November 7, 2011, https://www.washingtonpost.com/world/asia_pacific/chinese-funded-hydropower-project-sparks-anger-in-burma/2011/10/17/gIQAGYFfxM_story.html?noredirect=on&utm_term=.47b79aa1dc3e; Julian Kirchherr, Katrina J. Charles, and Matthew J. Walton, "The interplay of activists and dam developers: The case of Myanmar's mega-dams," *International Journal of Water Resources Development* 33, 1 (2017), 111-131.

49 On India's view of the BRI in strategic terms, see Bharath Gopalaswamy and Robert A. Manning, The Sino-India Clash and the New Geopolitics of the Indo-Pacific, November 2017, 4, http://www.atlanticcouncil.org/publications/reports/the-sino-indian-clash-and-the-new-geopolitics-of-the-indo-pacific.

50 Harsh V. Pant, "India challenges China's Intentions on One Belt, One Road Initiative," *Yale Global Online*, June 22, 2017, https://yaleglobal.yale.edu/content/india-challenges-chinas-intentions-one-belt-one-road-initiative; Pramit Pal Chaudhuri, "Why India sees China's Belt Road as a geopolitical threat," *Aspenia Online*, November 17, 2017, https://www.aspeninstitute.it/aspenia-online/article/why-india-sees-china's-belt-road-geopolitical-threat.

51 Maria Abi-Habib, "How China got Sri Lanka to cough up a port," *The New York Times*, June 25, 2018, https://www.nytimes.com/2018/06/25/world/asia/china-sri-lanka-port.html.

52 Ishrat Hossain, "Bangladesh balances between big brothers China and India," *East Asia Forum*, June 6, 2018, http://www.eastasiaforum.org/2018/06/06/bangladesh-balances-between-big-brothers-china-and-india/; Gauri Noolkar-Oak, "Xi Jinping threat looms over river Teesta: Time for India to engage in water diplomacy, counter China's advances," *First Post*, March 7, 2018, https://www.firstpost.com/india/xi-jinping-threat-looms-over-river-teesta-time-for-india-to-engage-in-water-diplomacy-counter-chinas-advances-4380187.html; Rupak Bhattacharjee, "Why the Teesta matters," *Himal South Asian Magazine*, January 14, 2015, https://m.himalmag.com/teesta-matters/.

53 Pia Malhotra-Arora, "Sino-Indian Water Wars?" in *Water Resource Conflicts and International Security: A Global Perspective*, ed. Dhirendra Vajpeyi (Lanham: Lexington Books, 2012), 146-149; Sudha Ramachandran, "Water wars: China, India and the great dam rush," *The Diplomat*, April 03, 2015, http://thediplomat.com/2015/04/water-wars-china-india-and-the-great-dam-rush/; Avalok Langer, "Swimming with the enemy," *Tehelka* 14, 9 (April 7, 2012), http://www.tehelka.com/2012/04/swimming-with-the-enemy/.

54 Institute for Defence Studies and Analysis, *Water Security for India: The External Dynamics*, 2010, https://idsa.in/book/WaterSecurityforIndia.

55 Joel Wuthnow, "Water war: This river could sink China-India relations," *The National Interest*, April 19, 2016, http://nationalinterest.org/feature/water-war-river-could-sink-china-india-relations-15829; Hongzhou Zhang, "Sino-Indian water disputes: The coming water wars?," *WIREs Water* 3 (2016), 157-158; Mirza Zulfiqur Rahman, "China and India's race to dam the Brahmaputra river puts the Himalayas at risk," *The Conversation*, September 26, 2016, http://theconversation.com/china-and-indias-race-to-dam-the-brahmaputra-river-puts-the-himalayas-at-risk-65496.

56 Neda Zawahri and David Michel, "Assessing the Indus Waters Treaty from a comparative perspective," *Water International* 43, 5 (2018), https://www.tandfonline.com/doi/abs/10.1080/02508060.2018.1498994?journalCode=rwin20.

57 Ali Hasnan Sayed, Chelsea N. Spangler, and Muhammad Faizan Usman, "The Perils of Denial: Challenges for a Water-Secure Pakistan" in *Water, Security and US Foreign Policy*, ed. David Reed (New York: Routledge, 2016), 229; Shah Meer Baloch, "Water crisis: Why is Pakistan running dry?," *Deutsche Welle*, June 7, 2018, https://www.dw.com/en/water-crisis-why-is-pakistan-running-dry/a-44110280; Amit Ranjan, "Disputed waters: India, Pakistan and the transboundary rivers," *Studies in Indian Politics* 4, 2 (2016), 198.

58 Gennady Rudkevich, "Central Asia is at the mercy of Russia and China," *East Asia Forum*, October 26, 2018, http://www.eastasiaforum.org/2018/10/26/central-asia-at-the-mercy-of-russia-and-china/.

59 Balihar Sanghera and Elmira Satybaldieva, "Central Asia is the new economic battleground for the US, China and Russia," *The Conversation*, June 29, 2018, https://theconversation.com/central-asia-is-the-new-economic-battleground-for-the-us-china-and-russia-98263; Paul Stronski, "China and Russia's uneasy partnership in Central Asia," *East Asia Forum*, March 29, 2018, http://www.eastasiaforum.org/2018/03/29/china-and-russias-uneasy-partnership-in-central-asia/.

60 "Russia's military bases in Central Asia," *Nazarbayev University Political Science Review*, January 11, 2017, https://nupsreview.wordpress.com/2017/01/11/russias-military-bases-in-central-asia/.

61 For a classic review of the Great Game, see David Fromkin, "The Great Game in Asia," *Foreign Affairs*, Spring 1980, https://www.foreignaffairs.com/articles/south-asia/1980-03-01/great-game-asia. On India's recently revitalized interests in the region in particular, see Dipanjan Roy Chaudhury, "India and China new players in Central Asia's 'Great Game'," *The Economic Times*, July 12, 2018, https://economictimes.indiatimes.com/news/defence/india-china-new-players-in-central-asias-great-game/articleshow/60905273.cms.

62 Paul Stronski and Nicole Ng, *Cooperation and Competition: Russia and China in Central Asia, the Russian Far East, and the Arctic,* 2018, 8-15, https://carnegieendowment.org/2018/02/28/cooperation-and-competition-russia-and-china-in-central-asia-russian-far-east-and-arctic-pub-75673; Morena Skalamera, "Russia's lasting influence in Central Asia," *Survival*, November 19, 2017, https://www.belfercenter.org/publication/russias-lasting-influence-central-asia.

63 Rudkevich, "Central Asia".

64 Selina Ho, "Why is China cooperative on water issues with Kazakhstan?," *WaterPolicy.online*, December 12, 2017, http://waterpolicy.online/why-is-china-cooperative-on-water-issues-with-kazakhstan/. See also Zhang Hongzhou, "Can China solve Central Asia's impending water crisis?," *East Asia Forum,* February 2, 2017, http://www.eastasiaforum.org/2017/02/02/can-china-solve-central-asias-impending-water-crisis/.

65 Nishtha Chugh, "Will Central Asia water wars derail China's silk road?," *The Diplomat*, March 24, 2017, https://thediplomat.com/2017/03/will-central-asia-water-wars-derail-chinas-silk-road/.

66 United Nations Environment Programme, *Transboundary River Basins: Status and Trends* (Nairobi: United Nations Environment Programme, 2016).

67 For evidence from South Asia, see Gareth Price et al., *Attitudes to Water in South Asia*, June 27, 2014, viii-xii, https://www.chathamhouse.org/publication/attitudes-water-south-asia#.

68 Organisation for Economic Cooperation and Development, *Meeting the Water Reform Challenge* (Paris: OECD, 2012).

69 Tushaar Shah and Upali A. Amarasinghe, "River Linking Project: A Solution or Problem to India's Water Woes?" in *Indian Water Policy at the Crossroads: Resources, Technology and Reforms*, ed. V. Narain and A. Narayanamoorthy (Cham, Switzerland: Springer, 2016).

70 For an insightful example of modernist approaches to river management in the United States and Soviet Union, with an emphasis on what has come to be called "high modernism," see Dorothy Zeisler-Vralsted, "The Cultural and Hydrological Development of the Mississippi and Volga Rivers" in *Rivers in History: Perspectives on Waterways in Europe and North America*, ed. Christof Mauch and Tom Zeller (Pittsburgh: University of Pittsburgh Press, 2008), 63-77. For a generic articulation of high modernism plus a forceful critique of its connection to large-scale centralized planning, including dam-building, see James C. Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed* (New Haven: Yale University Press, 1999).

71 An initial definition of the term was provided by Philippus Wester, "Capturing the waters: The hydraulic mission in the Lerma–Chapala Basin, Mexico (1876–1976)," *Water History* (2009), 2.

72 This argument was made by Claudia Sadoff and David Grey, "Beyond the river: The benefits of cooperation on international rivers," *Water Policy* 4 (2002), 389-403.

73 For an overview of securitization as an idea in the international relations field, see Michael C. Williams, "Words, images, enemies: Securitization and international politics," *International Studies Quarterly* 47 (2003), 512-515. On securitization in the water sector, see Itay Fischendler, ed., "Special Issue: The securitization of water discourse," *International Environmental Agreements: Politics, Law, and Economics* 15, 3 (2015).

74 These two points are distilled from multiple expert interviews conducted over 2017-2018.

75 Price et al., *Attitudes*, ix.

76 A summary of this history can be found in Rita Floyd and Richard A. Matthew, "Environmental Security Studies: An Overview" in *Environmental Security: Approaches and Issues*, ed. Rita Floyd and Richard A. Matthew (New York: Routledge, 2015), 1-20. Key early essays in environmental security include Lester R. Brown, *Worldwatch Paper #14: Redefining National Security* (Washington: Worldwatch Institute, October 1977); Richard H. Ullman, "Redefining security," *International Security* 8, 1 (Summer 1983), 129-153; Jessica T. Mathews, "Redefining security," *Foreign Affairs* 68, 2 (1989); Thomas F. Homer-Dixon, "On the threshold: Environmental changes as causes of acute conflict," *International Security* 16, 2 (Fall 1991), 76-116.

77 The seminal paper, still cited in the literature, is Aaron Wolf and Mark Giordano, "International waters: Identifying basins at risk," *Water Policy* (February 2003), 29-60 (see pages 38-41 for research findings). Luca De Stefano et al., *Updating the International Water Events Database* (Paris: UN World Water Assessment Programme, 2009) updates the analysis.

78 Data from Oregon State University, College of Earth, Oceans, and Atmospheric Sciences, Program in Water Conflict Management and Transformation, International Water Events Database, https://transboundarywaters.science.oregonstate.edu/content/international-water-event-database. The database contains coded events from the years 1948 through 2008; Oregon State researchers are updating the database to include events after 2008.

79 For a lengthy assessment of how water insecurity contributes to societal fragility and breakdown, see CNA, *The Role of Water Stress in Instability and Conflict*, December 2017, https://www.cna.org/CNA_files/pdf/CRM-2017-U-016532-Final.pdf.

80 See Brad Plumer, "Drought helped cause Syria's civil war. Will climate change bring more like it?," *The Washington Post* (September 10, 2013), https://www.washingtonpost.com/news/wonk/wp/2013/09/10/drought-helped-caused-syrias-war-will-climate-change-bring-more-like-it/?utm_term=.db40a79f1148. The Syrian case remains the subject of ongoing debate. See Francesca de Chatel, "The role of drought and climate change in the Syrian uprising: Untangling the triggers of the revolution," *Middle Eastern Studies* 50, 4 (2014); Jan Selby et al., "Climate change and the Syrian civil war revisited," *Political Geography* 60 (2017), 232-244; Guy Abel et al., "Climate, conflict, and forced migration," *Global Environmental Change* 54 (2019), 239-249.

On the use of water as a weapon during Syria's civil war, see Marcus D. King and Julia Burnell, "The Weaponization of Water in a Changing Climate" in *Epicenters of Climate and Security: The New Geostrategic Landscape of the Anthropocene*, ed. Caitlin E. Werrell and Francesco Femia (Washington: Center for Climate and Security, June 2017), 67-73.

81 A history of these disputes is traced in K. Deepalakshmi, "After Cauvery: A look at other inter-state water tussles," *The Hindu*, February 21, 2018, https://www.thehindu.com/news/national/after-cauvery-a-look-at-other-inter-state-water-tussles/article22813510.ece.

82 Scott M. Moore, *Sub-national Hydropolitics, Conflict, Cooperation, and Institution-Building in Shared River Basins* (Oxford: Oxford University Press, 2018), 113.

83 Moore, *Sub-national Hydropolitics*, 112-114.

84 Uttam Kumar Sinha, "India and Pakistan: Introspecting the Indus Treaty," *Strategic Analysis* 32, 6 (November 2008), 965; "India should end Indus Waters Treaty with Pakistan: Yashwant Sinha," *Financial Express Online*, September 27, 2016, https://www.financialexpress.com/india-news/india-should-end-indus-waters-treaty-with-pakistan-yashwant-sinha/393781/; "Blood and water cannot flow together: PM Modi at Indus Water Treaty meeting," *The Indian Express*, December 17, 2018, https://indianexpress.com/article/india/india-news-india/indus-water-treaty-blood-and-water-cant-flow-together-pm-modi-pakistan-uri-attack/.

85 Keith Schneider, "The right to life and water: Drought and turmoil for Coke and Pepsi in Tamil Nadu," *Circle of Blue*, May 24, 2017, https://www.circleofblue.org/2017/world/right-life-water-drought-turmoil-coke-pepsi-tamil-nadu/.

86 "South Asia's water: Unquenchable thirst," *The Economist*, November 19, 2011, https://www.economist.com/briefing/2011/11/19/unquenchable-thirst.

87 This point is made in David Michel, *Water Security, Conflict and Cooperation. Strategic Security Analysis* No. 13, November 2016, https://www.gcsp.ch/News-Knowledge/Publications/Water-Security-Conflict-and-Cooperation.

88 For a review of water security definitions, see Mark Giordano, "Water Security" in *International Encyclopedia of Geography: People, the Earth, Environment and Technology*, ed. Douglas Richardson (Washington: American Association of Geographers, March 6, 2017), 1-9.

89 "What is water security? Infographic," *UN Water*, May 8, 2013, http://www.unwater.org/publications/water-security-infographic/.

90 David Grey and Claudia W. Sadoff, "Sink or swim? Water security for growth and development," *Water Policy* 9 (2007), 547-548. Both this definition and UN-Water's definition are provided in Eelco van Beek and Wouter Lincklaen Arriens, *Water Security: Putting the Concept into Practice. TEC background papers* No. 20, 2016, 18-19, http://www.cawater-info.net/bk/iwrm/pdf/tec_20_e.pdf.

91 On the evolution of international water agreements at global level, see Mark Giordano et al., "A review of the evolution and state of transboundary freshwater treaties," *International Environmental Agreements* (February 25, 2013).

92 Zawahri and Michel, "Assessing".

93 Asian Development Bank, *Asian water development outlook 2016: Strengthening water security in Asia and the Pacific* (Mandaluyong City, Philippines: Asian Development Bank, 2016), 15-28.

94 Sunil S. Amrith, "The race to dam the Himalayas," *New York Times*, December 1, 2018, https://www.nytimes.com/2018/12/01/opinion/himalayas-mountains-dams.html?action=click&module=Opinion&pgtype=Homepage; John Vidal, "China and India 'water grab' dams put ecology of Himalayas in danger," *The Guardian*, August 10, 2013, https://www.theguardian.com/global-development/2013/aug/10/china-india-water-grab-dams-himalayas-danger; Marcus W. Beck et al., "Environmental and livelihood impacts of dams: Common lessons across development gradients that challenge sustainability," *International Journal of River Basin Management* 10, 1 (2012), http://www.consbio.umn.edu/download/Beck_et_al2012.pdf; Atif Ansar et al., "Should we build more large dams? The actual costs of hydropower megaproject development," *Energy Policy* 69, 43 (2014).

95 In 2016-2017, the United Nations and World Bank convened a series of consultations on water valuation, culminating in a declaration of principles and final outcome document. For background and documentation, see the Global Water Partnership's dedicated page at https://www.gwp.org/en/we-act/campaigns/high-level-panel-on-water-valuing-water-initiative/.

96 On this point, see Mark Giordano and Tushaar Shah, "From IWRM back to integrated water resources management," *International Journal of Water Resources Management* 30, 3 (2014), 364-376.

97 Aaron T. Wolf, "A long term view of water and international security," *Journal of Contemporary Water Research & Education* 142 (August 2009), 69.

98 L. De Stefano et al., "Assessment of transboundary river basins for potential hydro-political tensions," *Global Environmental Change* 45 (2017), 37; Jacob D. Petersen-Perlman, Jennifer C. Veilleux, and Aaron T. Wolf, "International water conflict and cooperation: Challenges and opportunities," *Water International* (2017), 6-7.

99 These insights developed from expert interview conducted in January 2019.

100 This argument is advanced in Anamika Barua and Sumit Vij, "Treaties can be a non-starter: A multi-track and multilateral dialogue approach in Brahmaputra River Basin management," *Water Policy* 20, 5 (July 2018).

101 Barua and Vij, "Non-starter"; Yumiko Yasuda et al., "Multi-track water diplomacy: Current and potential future cooperation over the Brahmaputra River Basin," *Water International* (2018), 1-19.

102 This summary is distilled from multiple expert interviews conducted over 2017-2018. Several of the arguments also are presented in Nimmi Kurian, "Policy Brief. Flows and flaws: Diverting the debate on water with China," *Centre for Policy Research*, January 2016, http://www.cprindia.org/sites/default/files/policy-briefs/Flows%20and%20Flaws%20Diverting%20the%20Debate%20on%20Water%20with%20China%20_%20Revised.pdf.

103 Figures from the International Desalination Association at https://idadesal.org.

104 Seth M. Siegel, *Let There Be Water: Israel's Solution for a Water-Starved World* (New York: St. Martin's Press, 2015), chapter 6.

105 Aaron Wolf, for example, suggests that desalination could revolutionize upstream-downstream relations under some conditions. See Wolf, "A long term view," 72-73.

106 Zheng et al., "Seawater desalination in China"; Sun, "Sustainable energy".

107 Lahiry, "Desalination".

108 Russell Sticklor, "Riding the wave of the future with solar-powered desalination," *thrive*, June 23, 2014, https://wle.cgiar.org/thrive/2014/06/23/riding-wave-future-solar-powered-desalination.

109 The Amur River's flow is roughly 10,900 cubic meters per second or nearly 950 million cubic meters per day. River flow data from Yoshihiro Tachibana, Kazuhiro Oshima, and Masayo Ogi, "Seasonal and interannual variations of Amur River discharge and their relationships to large-scale atmospheric patterns and moisture fluxes," *JGR Atmospheres* 113, D16 (August 17, 2008), https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2007JD009555.

110 Desalination data from Louisa Mitchell, "Desal in China: Trends and opportunities," *China Water Risk*, November 10, 2011, http://www.chinawaterrisk.org/resources/analysis-reviews/desal-in-china-trends-opportunities/. Yangtze flow data from Traci Pedersen, "Yangtze River: Longest river in Asia," *Live Science*, February 17, 2017, https://www.livescience.com/57905-yangtze-river-facts.html.

111 For a summary of Gulf Cooperation Council desalination trends, see R. Al Hashemi et al., "A review of desalination trends in the Gulf Cooperation Council countries," *Journal of International Interdisciplinary Research* 1, 2 (November 2014), 72-96, https://www.iijsr.org/data/frontImages/gallery/Vol._1_No._2/6.pdf.

112 A summary is Tom Freyberg, "Desalination + Renewables: A long engagement without the wedding?," *Water and Wastewater International*, March 1, 2018, https://www.waterworld.com/articles/wwi/print/volume-33/issue-2/technology-case-studies/desalination-renewables-a-long-engagement-without-the-wedding.html. See also Kate Zerrenner, "The importance of clean power desalination," *Water Online*, July 10, 2017, https://www.wateronline.com/doc/the-importance-of-clean-power-desalination-0001.

113 A bit dated but still useful overview is Cheryl Katz, "New desalination technologies spur growth in recycling water," *Yale Environment* 360, June 3, 2014, https://e360.yale.edu/features/new_desalination_technologies_spur_growth_in_recycling_water. On the overall cost trajectory of desalination, see Nikolay Voutchkov, "Desalination—past, present and future," *International Water Association*, August 17, 2016, http://www.iwa-network.org/desalination-past-present-future/.

114 Food and Agriculture Organization of the United Nations, *Area Equipped for Irrigation*.

115 Jennifer Chu, "Watering the world," *MIT News*, April 19, 2017, http://news.mit.edu/2017/design-cuts-costs-energy-drip-irrigation-0420.

116 Haoyang Li and Jinhua Zhao, "Rebound effects of new irrigation technologies: The role of water rights," *American Journal of Agricultural Economics* 100, 3 (2018).

117 Expert interview conducted April 23, 2018; Dr. Jonas Wanvoeke, "The dubious 'success' of micro drip irrigation kits," *Global Water Forum*, August 16, 2016, http://www.globalwaterforum.org/2016/08/16/the-dubious-success-of-micro-drip-irrigation-kits/; Yasmin Siddiqi, "Blog poll: Is technology the answer to growing more food with less water?," *Asian Development Blog*, February 4, 2016, https://blogs.adb.org/blog/blog-poll-technology-answer-growing-more-food-less-water.

118 Tushaar Shah et al., "Solar pumps and South Asia's energy-groundwater nexus: Exploring implications and reimagining its future," *Environmental Research Letters* 13 (2018), 115003; Tushaar Shah, Shilp Verma, and Neha Durga, "Karnataka's smart, new solar pump policy for irrigation," *Economic and Political Weekly* 49, 48 (November 29, 2014), 10-14.

119 Unless otherwise cited, this discussion is based on expert interviews conducted on May 24, 2018, May 31, 2018, July 25, 2018, and August 24, 2018. For an overview, see Dennis P. Lettenmaier et al., "Inroads of remote sensing into hydrologic science during the WRR era," *Water Resources Research* 31 (2015), 7309-7342.

120 The last argument is derived from Rina Chandran, "Hi-tech mapping threatens land rights across the 'digital divide': experts," *Reuters*, November 26, 2018, https://www.reuters.com/article/us-philippines-myanmar-landrights/hi-tech-mapping-threatens-land-rights-across-the-digital-divide-experts-idUSKCN1NV0WH.

121 Unless otherwise cited, this discussion is based on an expert interview conducted May 22, 2018.

122 Jaswinder Singh, Simerjeet Kaur, and Haritika Majithia, "Emerging Genetic Technologies for Improving the Security of Food Crops" in *Emerging Technologies for Promoting Food Security: Overcoming the World Food Crisis*, ed. Chandra Madramootoo (New York: Woodhead Publishing, 2016), 32.

123 On plant sequencing cost trends, see Luigi Faino and Bart P.H.J. Thomma, "Get your high-quality low-cost genome sequence," *Trends in Plant Science* 19, 5 (May 2014), 288-291.

124 On methane production, see Warren Cornwall, "Hundreds of new dams could mean trouble for our climate," *Science*, September 28, 2016, https://www.sciencemag.org/news/2016/09/hundreds-new-dams-could-mean-trouble-our-climate.

125 Javaid R. Laghari, "Melting glaciers bring energy uncertainty," *Nature* 502, 617 (2013), http://www.nature.com/polopoly_fs/1.14031!/menu/main/topColumns/topLeftColumn/pdf/502617a.pdf.

126 Unless otherwise cited, the discussion in this sub-section is based on expert interviews conducted on May 22, 2018, May 30, 2018, and August 6, 2018.

127 *Associated Press*, "Water levels continue to drop at Lake Mead, Lake Powell," The Denver Post, September 3, 2018, https://www.denverpost.com/2018/09/03/lake-mead-lake-powell-drought-colorado-river/.

128 As an example, on China and the United States in the context of Southeast Asian diplomacy, see Priyandita and Wijaya, "Winning hearts".

129 This section is developed in part from multiple expert interviews conducted in 2017 and 2018.

130 On the South China Sea arbitration, see Jane Perlez, "Tribunal rejects Beijing's claims in South China Sea," *The New York Times*, July 12, 2016, https://www.nytimes.com/2016/07/13/world/asia/south-china-sea-hague-ruling-philippines.html.

131 The White House, *National Security Strategy of the United States of America*, December 2017, https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf, 25.

132 The White House, *National Security Strategy,* 45-47 (quotation on 45).

133 Ankit Panda, "Pompeo's Indo-Pacific speech: Geoeconomics on a shoestring," *The Diplomat*, July 31, 2018, https://thediplomat.com/2018/07/pompeos-indo-pacific-speech-geoeconomics-on-a-shoestring/. On the Indo-Pacific strategy more broadly, see Alyssa Ayres, "The US Indo-Pacific strategy needs more Indian Ocean," May 25, 2018, https://www.cfr.org/expert-brief/us-indo-pacific-strategy-needs-more-indian-ocean.

134 An analogue to this argument is made by Robert A. Manning, "US Indo-Pacific strategy: Myths and realities," *Russia in Global Affairs*, September 21, 2018, https://eng.globalaffairs.ru/valday/US-Indo-Pacific-Strategy-Myths-and-Reality-19763.

135 Office of the Director of National Intelligence, *Global Water Security*.

136 US Department of State and US Agency for International Development, *US Government Global Water Strategy* (Washington: US Department of State and US Agency for International Development, November 15, 2017), https://www.state.gov/r/pa/prs/ps/2017/11/275611.htm.

137 Peter Engelke and David Michel, *Toward Global Water Security: US Strategy for a Twenty-First-Century Challenge*, August 2016, https://www.atlanticcouncil.org/publications/reports/toward-global-water-security.

138 FEWS NET's website is http://fews.net; NASA-SERVIR's website, including links to its Himalayas and Mekong River initiatives, is https://www.nasa.gov/mission_pages/servir/overview.html.

139 For a summary of US-Russian cooperation in the Arctic, including within the Arctic Council, see Mike Sfraga and Lawson Brigham, "US, Russia look north to the Arctic to find common ground," *The Hill*, July 17, 2018, https://thehill.com/opinion/international/397472-us-russia-can-look-north-to-the-arctic-to-find-common-ground.

140 ICIMOD's website is http://www.icimod.org.

141 "Observers," *Arctic Council*, May 7, 2015, https://arctic-council.org/index.php/en/about-us/arctic-council/observers.

142 This history is briefly outlined at the Arctic Council's website: https://arctic-council.org/index.php/en/about-us/arctic-council. See also "Arctic Environmental Protection Strategy," *Climate Policy Watcher*, May 30, 2016, https://www.climate-policy-watcher.org/canadian-arctic/arctic-environmental-protection-strategy.html.

143 Helen Fyles and Chandra Madramootoo, "Water Management" in *Emerging Technologies for Promoting Food Security: Overcoming the World Food Crisis*, ed. Chandra Madramootoo (New York: Woodhead Publishing, 2016), 117.

144 Data from Food and Agriculture Organization of the United Nations, Table "Water withdrawal by sector, around 2010," *Undated*, http://www.fao.org/nr/water/aquastat/tables/WorldData-Withdrawal_eng.pdf.

145 Scheierling and Treguer, *Beyond*, 15, Table 2.2.

146 Food and Agriculture Organization of the United Nations, *How to Feed the World in 2050* (Rome: Food and Agriculture Organization of the United Nations, 2009), http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf.

147 Lester R. Brown, *Who Will Feed China? Wake-Up Call for a Small Planet* (New York: W.W. Norton, 1995). On China's slowing food demand, see Kai Cui and Sharon P. Shoemaker, "A look at food security in China," *Science of Food* 2, 4 (2018), https://www.nature.com/articles/s41538-018-0012-x.pdf.

148 According to the International Food Policy Research Institute (IFPRI), Asia's most food-insecure populations live in Afghanistan, Pakistan, and India, followed by Bangladesh, Lao PDR, Cambodia, Nepal, and Myanmar. See IFPRI's Global Hunger Index site, at https://www.globalhungerindex.org.

149 Food and Agriculture Organization of the United Nations, *Area Equipped for Irrigation*. Nearly 95% of all irrigated hectares in South and Southeast Asia are surface irrigation systems. See Siddiqi, "Blog poll".

150 Aditi Mukherji et al., *Trends and transitions in Asian irrigation: What are the prospects for the future? Issue paper prepared by IWMI for discussion at the IWMI-FAO workshop on Asian Irrigation,* International Water Management Institute, January 7, 2009, 5-7; Ranjan, "Disputed waters," 192-196; Colin Chartres, "Is water scarcity a constraint to feeding Asia's growing population?," *International Journal of Water Resources Development* 30, 1 (2014), 33.

151 This list is derived from Asian Development Bank, *Region at Risk*, 55. See also Food and Agriculture Organization of the United Nations, *State of Food*, 24-25.

152 For example, 39 percent of China's, 32 percent of India's, 70 percent of Bangladesh's, and 46 percent of Vietnam's agricultural production is devoted to rice, wheat, and maize. Data compiled through the FAO's FAOSTAT database at http://www.fao.org/faostat/en/#data.

153 United Nations Department of Economic and Social Affairs, Population Division, *World Urbanization Prospects, The 2014 Revision*, 38-40, Tables II.8-II.10.

154 United Nations Department of Economic and Social Affairs, Population Division, *World Urbanization Prospects: The 2018 Revision*, Data Files 19 and 21.

155 Asian Development Bank, *Asian water development outlook 2016*, 7.

156 United Nations Department of Economic and Social Affairs, Population Division 2018, Data File 11a.

157 These arguments are advanced in Engelke, *Security*..

158 Beijing Municipal Bureau of Statistics, "Resident Population (1978-2016)," http://www.bjstats.gov.cn/tjsj/cysj/201511/t20151109_311727.html.

159 On desalination and Beijing, see Yiting Sun, "Sustainable energy: China's massive effort to purify seawater is drying up," *MIT Technology Review*, July 11, 2016, https://www.technologyreview.com/s/601861/chinas-massive-effort-to-purify-seawater-is-drying-up/.

160 Global Water Partnership, *Technical Focus Paper*, 2015, 30-36; Feng Hao, "'Irreversible' subsidence is causing Beijing to sink," China Dialogue, August 30, 2016, https://www.chinadialogue.net/article/show/single/en/9219--Irreversible-subsidence-is-causing-Beijing-to-sink-; Nadya Ivanova, "Off the deep end—Beijing's water demand outpaces supply despite conservation, recycling, and imports," *Circle of Blue*, May 3, 2011, https://www.circleofblue.org/2011/world/off-the-deep-end-beijings-water-demand-outnumbers-supply-despite-conservation-recycling-and-imports/. A more optimistic take on Beijing is provided by Sarah Rogers, "Opinion: Water won't constrain China's development," *The Third Pole*, May 16, 2018, https://www.thethirdpole.net/en/2018/05/16/opinion-water-wont-constrain-chinas-development/.

161 UN-Habitat, *World Cities*, 57-58.

162 Aman Sethi, "At the mercy of the water mafia," *Foreign Policy*, July 17, 2015,https://foreignpolicy.com/2015/07/17/at-the-mercy-of-the-water-mafia-india-delhi-tanker-gang-scarcity/; Sabrina Toppa, "Dry dams, leaky pipes and tanker mafias – Karachi's water crisis," *The Guardian*, 28 June 2016, https://www.theguardian.com/global-development-professionals-network/2016/jun/28/karachi-pakistan-water-crisis.

163 United Nations World Water Assessment Programme, *Wastewater*, 97-98, Table 11.1.

164 Webber, "Tackling". On China's urban water pollution, see, e.g., Deng Tingting, "In China, the water you drink is as dangerous as the air you breathe," *The Guardian*, June 2, 2017, https://www.theguardian.com/global-development-professionals-network/2017/jun/02/china-water-dangerous-pollution-greenpeace.

165 Erkens et al., "Sinking"; Brears, "Opinion"; Kimmelman, "Rising waters".

166 World Energy Council, *Perspectives*, 2.

167 "How it works: water for electricity," *Union of Concerned Scientists*, November 9, 2017, https://www.ucsusa.org/clean-energy/energy-water-use/water-energy-electricity-overview#.W5ls_GbMx0s.

168 For a lengthy discussion of reservoirs' water balance, including evaporation, see Rick J. Hogeboom, Luuk Knook, and Arjen Y. Hoekstra, "The blue water footprint of the world's artificial reservoirs for hydroelectricity, irrigation, residential and industrial water supply, flood protection, fishing and recreation," *Advances in Water Resources* 113 (2018), 285-294.

169 E.S. Spang et al., "The water consumption of energy production: an international comparison," *Environmental Research Letters* 9 (2014), 8, Figure 4. Not all renewables are equally thrifty in terms of water consumption. While wind and solar PV require almost no water for power generation, 'solar thermal' power generation can require significant quantities under some conditions (as the name implies, solar thermal uses heat to generate electricity). For a summary, see Chris Clarke, "Fact check: how much water does solar power really use?," *KCET*, May 6, 2014, https://www.kcet.org/redefine/fact-check-how-much-water-does-solar-power-really-use.

170 "How it works: water for power plant cooling," *Union of Concerned Scientists*, Undated, https://www.ucsusa.org/clean-energy/energy-and-water-use/water-energy-electricity-cooling-power-plant#.W5IETmbMzUp.

171 Data from the Asia Pacific Energy Portal, https://asiapacificenergy.org.

172 World Energy Council, *Water for Energy*, 2010, https://www.worldenergy.org/wp-content/uploads/2012/10/PUB_Water_For_Energy_2010_WEC.pdf, 25-29 and Figure 10. Note that WEC forecasts a decline in water requirements within Asia for all energy production (including electricity production), owing to the decline in "traditional biomass" production as Asians shift to fossil fuels, hydroelectric power, and renewables.

173 Sonal Patel, "Indian water crisis shuts down multiple power plants," *Power Magazine*, August 1, 2016, https://www.powermag.com/indian-water-crisis-shuts-multiple-power-plants/.

174 Keith Schneider, "Protests over water safety, bank financing rock Bangladesh coal plants," *Circle of Blue*, November 1, 2016, https://www.circleofblue.org/2016/world/protests-water-safety-bank-financing-rock-bangladesh-coal-plants/.

175 Several interviewees stressed the importance of this subsidy-groundwater connection, especially within India. For an overview of the groundwater depletion issue, including the link to energy subsidies, in Punjab, one of India's most important agricultural regions, see Athar Parvaiz, "As India's 'granary' exhausts groundwater, farmers eye new crops," *Reuters*, October 17, 2016, https://www.reuters.com/article/us-india-water-agriculture-idUSKBN12H0I1.

176 Afreen Siddiqi and James Wescoat, "Energy use in large-scale irrigated agriculture in the Punjab province of Pakistan," *Water International* 38, 5 (September 2013), 1-17.

177 A reliable summary of the energy requirements for wastewater treatment, if in the US context, is provided by Claudia Copeland and Nicole T. Carter, *Energy-Water Nexus: The Water Sector's Energy Use* (Washington: Congressional Research Service), January 24, 2017, https://fas.org/sgp/crs/misc/R43200.pdf.

178 Sanz, "2018 Trends".

179 Zheng et al., "Seawater desalination"; Sun, "Sustainable energy"; Lahiry, "Desalination"; Schneider, "Water-scarce regions".

180 Two outer tributaries of the Pearl River extend into Vietnam.

181 Food and Agriculture Organization of the United Nations, Aquastat Global Water Information System, China and the United States fact sheets, available at http://www.fao.org/nr/water/aquastat/countries_regions/index.stm.

182 Although there are different indicators of water scarcity, the most commonly used and well known is the Falkenmark Indicator, which has three levels of scarcity: below 1700 cubic meters per person annually, a society suffers "water stress"; below 1000 cubic meters a society suffers "water scarcity"; below 500 cubic meters a society suffers absolute scarcity. See Chris White, "Understanding water scarcity: Definitions and measurements," *Global Water Forum*, May 7, 2012, http://www.iwmi.cgiar.org/News_Room/pdf/Understanding_water_scarcity.pdf.

183 Mao's statement is referenced frequently in the literature. See, e.g., Lily Kuo, "China is moving more than a River Thames of water across the country to deal with water scarcity," *Quartz*, March 6, 2014, https://qz.com/158815/chinas-so-bad-at-water-conservation-that-it-had-to-launch-the-most-impressive-water-pipeline-project-ever-built/.

184 Parton, Looming, 8. For a discussion of China's policy of shifting coal production to the country's north and west, see Max D. Woodworth, "China's coal production goes west: Assessing recent geographical restructuring and industrial transformation," *The Professional Geographer* 67, 4 (2015), 630-640.

185 Global Water Partnership, *Technical Focus Paper*, 9; Parton, *Looming*, 8; Svensson, "Q&A".

186 Dongmei Han, Matthew J. Currell, and Guoliang Cao, "Deep challenges for China's war on water pollution," *Environmental Pollution* 218 (2016), 1223.

187 Han, Currell, and Cao, "Challenges," 1223-1225 and Fig. 1.

188 The Three Red Lines program is discussed in exhaustive detail in Global Water Partnership, *Technical Focus Paper*.

189 Tianjie and Qin, "China reshapes".

190 James E. Nickum, Jia Shaofeng, and Scott Moore, "The Three Red Lines and China's Water Resources Policy in the Twenty-First Century" in *Routledge Handbook of Environmental Policy in China*, ed. Eva Sternfeld (New York: Routledge, 2017), 74-80.

191 Food and Agriculture Organization of the United Nations, Aquastat Global Water Information System, Russia profile, available at http://www.fao.org/nr/water/aquastat/countries_regions/RUS/index.stm.

192 Food and Agriculture Organization of the United Nations, Aquastat Global Water Information System, Mongolia profile, available at http://www.fao.org/nr/water/aquastat/countries_regions/MNG/index.stm.

193 River data from Eugene Simonov & Eugene Egidarev, "Transboundary cooperation on the Amur River Basin in recent decades" in *China and Transboundary Water Politics in Asia*, ed. Hongzhou Zhang and Mingjiang Li (New York: Routledge, 2018), chapter 5. The two countries' history with respect to the Amur is briefly reviewed in "Competing interests on the mighty Amur River," *Stratfor*, August 10, 2016, https://worldview.stratfor.com/article/competing-interests-mighty-amur-river.

194 Daniel Karthe et al., "Water in Central Asia: An integrated assessment for science-based management," *Environmental Earth Sciences* 76 (2017), 690-705, https://doi.org/10.1007/s12665-017-6994-x.

195 White, "Nature-society," 21-22.

196 David Trilling, "Water wars in Central Asia," *Foreign Affairs*, August 24, 2016, https://www.foreignaffairs.com/gallerys/2016-08-24/water-wars-central-asia; Isabel Post, "Water and politics in Central Asia," *McGill International Review*, January 9, 2018, https://www.mironline.ca/water-politics-central-asia/; Konstantin Parshin, "Tajikistan: Citizens ponder bleak future amid harsh winter," *Eurasianet*, January 23, 2008, https://eurasianet.org/node/61697.

197 Pohl et al., *Rethinking*, IV-V, 7-10; Zhupankhan, Tussupova, and Berndtsson, "Changing power relationships," 8, Table 3.

198 Christine Bichsel, "Liquid challenges: Contested water in Central Asia," *Sustainable Development Law & Policy* 12, 1 (2011), 25-27; "Central Asia: The complexities of the Fergana Valley," *Stratfor*, October 7, 2013, https://worldview.stratfor.com/article/central-asia-complexities-fergana-valley; "Central Asia: Tensions grow in the Fergana Valley," *Stratfor*, October 8, 2013, https://worldview.stratfor.com/article/central-asia-tensions-grow-fergana-valley;

199 Sebastian Biba, "Desecuritization in China's behavior towards its

transboundary rivers: The Mekong River, the Brahmaputra River, and the Irtysh and Ili Rivers," *Journal of Contemporary China* 23, 85 (2014), 39-41; Zhupankhan, Tussupova, and Berndtsson, "Changing power relationships," 7; Hongzhou, "Can China solve".

200 Golam Rasul, "Why Eastern Himalayan countries should cooperate in transboundary resource management," *Water Policy* 16 (2014), 19-20.

201 Food and Agriculture Organization of the United Nations, Aquastat Global Water Information System, *Indus River Basin*, Undated, http://www.fao.org/nr/Water/aquastat/basins/indus/indus-CP_eng.pdf.

202 MacDonald et al., "Groundwater," 1.

203 Figures from *World Population Prospects: The 2017 Revision*, United Nations, Department of Economic and Social Affairs, Population Division (2017), custom data acquired via website at https://population.un.org/wpp/.

204 Data from International Labor Organization, ILOSTAT database, at https://www.ilo.org/ilostat.

205 Golam Rasul, "Food, water, and energy security in South Asia: A nexus perspective from the Hindu Kush Himalayan region," *Environmental Science and Policy* 39 (2014), 36-40.

206 An early paper using NASA's GRACE (Gravity Recovery and Satellite Experiment) satellite data and showing massive groundwater loss in the Indian portion of the Plain is V.M. Tiwari, J. Wahr, and S. Swenson, "Dwindling groundwater resources in northern India, from satellite gravity observations," *Geophysical Research Letters* 36, L18401 (2009), https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2009GL039401. A largely technical paper addressing the shortcomings of GRACE satellite data in the context of northern Indian aquifers is provided in Di Long et al., "Have GRACE satellites overestimated groundwater depletion in the northwest India aquifer?," *Scientific Reports* 6, 24398 (April 14, 2016), https://www.nature.com/articles/srep24398. A nuanced view of aquifer depletion across the Plain is provided in MacDonald et al., "Groundwater," 762-766.

207 For an assessment of the energy-water nexus in India, see Paul Faeth et al., *A Clash of Competing Necessities: Water Adequacy and Electric Reliability in China, India, France, and Texas*, July 2014, 28-31, https://www.cna.org/cna_files/pdf/IRM-2014-U-007191.pdf.

208 Grumbine and Pandit, "Himalaya dams," 36-37.

209 Eunhee Lee et al., "Assessment of transboundary aquifer resources in Asia: Status and progress toward sustainable groundwater management," *Journal of Hydrology: Regional Studies* (2018); Sayed, Spangler, and Usman, "Perils," 227.

210 In terms of numbers of people affected, India is the most significant case in South Asia, with only about 40 percent of the population as of 2015 having access to "improved sanitation facilities" such as covered pit latrines or flush toilets. Data from Land Portal, https://landportal.org/food-security.

211 Insights from expert interview conducted May 31, 2018. See also Strategic Foresight Group, *The Himalayan Challenge*, 3; Neumann et al., "Future coastal".

212 For an overview of South Asian hydro-diplomacy, see Rai and Patnaik, "Water Disputes," 103-138. On the Indus dispute, see: Ranjan, "Disputed waters"; Sayed, Spangler, and Usman, "Perils," 222-236. On public opinion in South Asia, see Price et al., *Attitudes*.

213 M. Surie and S. Prasai, *Strengthening Transparency and Access to Information on Transboundary Rivers in South Asia* (New Delhi: The Asia Foundation, 2015), 1-4 (quotation on page 2).

214 While the Irrawaddy's headwaters are of some controversy, the entirety or near entirety of the Irrawaddy lies within Myanmar. See Mann, "Environmentalists".

215 "Three Parallel Rivers of Yunnan Protected Areas," *UNESCO World Heritage Convention*, Undated, https://whc.unesco.org/en/list/1083.

216 Food and Agriculture Organization of the United Nations, Aquastat Global Water Information System, *Mekong River Basin*, Water Report 37, 2011, http://www.fao.org/nr/water/aquastat/basins/mekong/index.stm.

217 Food and Agriculture Organization of the United Nations, Aquastat Global Water Information System, *Salween River Basin*, Water Report 37, 2011, http://www.fao.org/nr/water/aquastat/basins/salween/index.stm.

218 Lee et al., "Assessment".

219 Asian Development Bank, *Greater Mekong Subregion: Energy sector assessment, strategy, and road map*, 2016, (Manila: Asian Development Bank), 4.

220 Asian Development Bank, *Greater Mekong Subregion*, 5, Tables 5 and 6.

221 Thapan, "Perfect Storm," 281-282.

222 Civil society's opposition to the Xayaburi dam is reviewed in Kenneth R. Olson and Lois Wright Morton, "Water rights and fights: Lao dams on the Mekong River," *Journal of Soil and Water Conservation* 73, 2 (2018), 35A-41A. On opposition to the Myitsone Dam within Myanmar, see Kirchherr, Charles, and Walton, "Interplay," 111-117.

223 Sach, "Lancang-Mekong".

224 While river transformations through human intervention long predated the twentieth century, it was only during the twentieth century that they could be massively scaled owing to the power that the new tools provided. For an example of a river's transformation during the nineteenth and twentieth centuries, see Mark Cioc, *The Rhine: An Eco-Biography*, 1815-2000 (Seattle: University of Washington Press, 2002).

225 The "hydraulic mission" idea, including its contours and the history of projects and institutions ostensibly falling under its umbrella, is outlined in Francois Molle, Peter P. Mollinga, and Philippus Wester, "Hydraulic bureaucracies and the hydraulic mission: Flows of water, flows of power," *Water Alternatives* 2, 3 (2009), 328-349. For an outstanding read on Chairman Mao's approach to nature and society, see Judith Shapiro, *Mao's War against Nature: Politics and Environment in Revolutionary China* (New York: Cambridge University Press, 2001).

226 White, "Nature-society," 21-22.

227 For a summary of the making of IWRM as a paradigm at global level, see Jeremy Allouche, "The birth and spread of IWRM—A case study of global policy diffusion and translation," *Water Alternatives* 9, 3 (2016), 412-433.

228 India's history of modernist approaches to water management, including a critique of the river interlinking project, is provided in Rohan D'Souza, "Supply-side hydrology in India: The last gasp," *Economic and Political Weekly*, September 6, 2003, 3785-3790. On contemporary developments and critiques of the project, see "PM Modi pitches for river interlinking," *The Times of India*, March 30, 2018, https://timesofindia.indiatimes.com/india/pm-modi-pitches-for-river-interlinking/articleshow/63550325.cms; Mayank Bhardwaj, "Modi's $87 billion river-linking gamble set to take off as floods hit India," Reuters, August 31, 2017, https://www.reuters.com/article/us-india-rivers/modis-87-billion-river-linking-gamble-set-to-take-off-as-floods-hit-india-idUSKCN1BC3HD; Manu Balachandran, "Why India's $168 billion river-linking project is a disaster-in-waiting," *Quartz India*, September 18, 2015, https://qz.com/india/504127/why-indias-168-billion-river-linking-project-is-a-disaster-in-waiting/.

229 This argument is made in Britt Crow-Miller, Michael Webber, and Sarah Rogers, "The techno-politics of big infrastructure and the Chinese water machine," *Water Alternatives* 10, 2 (2017), 233-249.

230 From expert interview conducted August 8, 2018. A good if somewhat dated summary of this dispute can be found in Joshua Zaffos, "Life on Mekong faces threats as major dams begin to rise," *Yale Environment* 360, February 20, 2014, https://e360.yale.edu/features/life_on_mekong_faces_threats_as_major_dams_begin_to_rise. For a detailed summary of the Laos dam dispute within the context of the MRC's dispute resolution process, see Rémy Kinna, "An alternate past/future for Mekong River dams under the UN Watercourses Convention: Part 2," *Global Water Forum*, April 18, 2016, http://www.globalwaterforum.org/2016/04/18/an-alternate-pastfuture-for-mekong-river-dams-under-the-un-watercourses-convention-part-2/.

231 Indus Basin Working Group, *Connecting the drops: An Indus basin roadmap for crossborder water research, data sharing, and policy coordination*, 2013, https://www.stimson.org/content/connecting-drops-indus-basin-roadmap-cross-border-water-research-and-policy-coordination-0; Shrestha et al., *Atlas*; ICIMOD, "The Indus Basin Initiative," http://www.icimod.org/indus.

232 Food and Agriculture Organization of the United Nations, Aquastat Global Water Information System, *Indus Basin*, 2011, http://www.fao.org/nr/water/aquastat/basins/indus/index.stm.

233 Eugene Black, "The Indus: A Moral for Nations," *The New York Times*, December 11, 1960.

234 Indus Basin Working Group, *Connecting*.

235 Indus Basin Working Group, *Connecting*.

236 2030 Water Resources Group, *Charting our water future: Economic frameworks to inform decision-making*, 2009, https://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/sustainability/pdfs/charting%20our%20water%20future/charting_our_water_future_full_report_.ashx.

237 David Michel, "Managing the Indus in a warming world: The potential for transboundary cooperation in coping with climate change" in *Imagining Industan: Overcoming water insecurity in the Indus Basin*, ed. Z. Adeel & R.G. Wirsing (Switzerland: Springer International, 2017), https://link.springer.com/chapter/10.1007/978-3-319-32845-4_6.

238 Zawahri and Michel, "Assessing".

239 Asif Ali Zardari, "Partnering with Pakistan," *The Washington Post*, January 28, 2009, http://www.washingtonpost.com/wp-dyn/content/article/2009/01/27/AR2009012702675.html.

240 Zawahri and Michel, "Assessing".

241 Ashok Swain, "Water Insecurity in the Indus Basin: The Costs of Noncooperation" in *Imagining Industan*.

242 Indus Basin Working Group, *Connecting*; Michel, "Managing".

243 Michel, "Managing".

244 Michel, "Managing".

245 Shrestha et al., *Atlas*, 25. Basin data from Food and Agriculture Organization of the United Nations, Aquastat Global Water Information System, *Ganges-Brahmaputra-Meghna* river basin (2011), Table 1, http://www.fao.org/nr/water/aquastat/basins/gbm/gbm-CP_eng.pdf. A summary description of the river can be found in Ramachandran, "Great dam rush".

246 On Bangladesh, see Samaranayake, Limaye, and Wuthnow, *Competition*, 65-88.

247 Malhotra-Arora, "Sino-Indian," 146-49; Ramachandran, "Great dam rush"; Langer, "Swimming".

248 A summary of the GWWDP can be found in Zhou Wei, "Divided waters in China," *China Dialogue*, September 20, 2011, https://www.chinadialogue.net/article/4539-Divided-waters-in-China.

249 These arguments are fleshed out in Zhang, "Water wars?".

250 Insights from expert interview conducted in August 2018. See also Satu Limaye, Joel Wuthnow, and Nilanthi Samaranayake, "China and India's slow-moving path to 'water wars'," *China and the World Program*, November 1, 2016, https://cwp.princeton.edu/news/china-and-indias-slow-moving-path-water-wars.

251 Wuthnow, "Water war"; Zhang, "Water wars?", 157-158; Rahman, "Race".

252 Nilanthi Samaranayake, Satu Limaye, and Joel Wuthnow, *Raging Waters: China, India, Bangladesh, and Brahmaputra River Politics* (Quantico: CNA and Marine Corps University Press, 2018), 68-70.

253 Such a scenario, involving Bangladesh and the BCIM Forum, is developed by Samaranayake, Limaye, and Wuthnow, *Raging Waters*, 94-99.

254 This summary is distilled from expert interviews conducted over 2017-2018 and Kurian, "Policy Brief".

255 "Physiographic regions," *Mekong River Commission*, Undated, http://www.mrcmekong.org/mekong-basin/physiography/physiographic-regions/.

256 Thapan, "Perfect Storm," 272.

257 The 30,000-megawatt figure is reported in Mekong River Commission, *State of the Basin Report 2010* (2010), 27.

258 For overviews of Southeast Asia's hydropower controversies, see: Stefan Lovgren, "Southeast Asia may be building too many dams too fast," *National Geographic*, August 23, 2018, https://www.nationalgeographic.com/environment/2018/08/news-southeast-asia-building-dams-floods-climate-change/?user.testname=none; Zaffos, "Life on Mekong".

259 The history of the Xayaburi within the context of the PNPCA is examined in three lengthy pieces by Rémy Kinna, "An alternate past/future for Mekong River dams under the UN Watercourses Convention," *Global Water Forum*, April 4 and 18, 2016, and May 2, 2016. Part 1: http://www.globalwaterforum.org/2016/04/04/an-alternate-pastfuture-for-mekong-river-dams-under-the-un-watercourses-convention-part-1/; Part 2: http://www.globalwaterforum.org/2016/04/18/an-alternate-pastfuture-for-mekong-river-dams-under-the-un-watercourses-convention-part-2/; Part 3: http://www.globalwaterforum.org/2016/05/02/an-alternate-pastfuture-for-mekong-river-dams-under-the-un-watercourses-convention-part-3/.

260 Richard Cronin and Courtney Weatherby, *Letters from the Mekong: Time for a New Narrative on Mekong Hydropower*, 2015, 10-11, https://www.stimson.org/content/letters-mekong-time-new-narrative-mekong-hydropower; Thapan, "Perfect Storm," 281-282. On civil society and the Mekong, see: Olson and Morton, "Water rights"; Richard P. Cronin, "Laos' Xayaburi dam project: Transboundary game changer," *Global Water Forum*, April 30, 2012, http://www.globalwaterforum.org/2012/04/30/laos-xayaburi-dam-project-transboundary-game-changer/. On civil society and the Salween, see Kirchherr, Charles, and Walton, "Interplay".

261 Cronin and Weatherby, *Letters*, 21-23. Several insights also drawn from expert interview conducted August 6, 2018. On Vietnam's solar energy trajectory, see: Lars Blume, "A late start: Renewable energy development in Vietnam," *CleanTechnica*, August 21, 2018, https://cleantechnica.com/2018/08/21/a-late-start-renewable-energy-development-in-vietnam/; Keith Schneider, "One by one big hydropower dams disrupt Mekong River's free flow," *Circle of Blue*, August 2, 2017, https://www.circleofblue.org/2017/world/one-one-big-hydropower-dams-disrupt-mekong-rivers-free-flow/.

262 Sach, "Lancang-Mekong"; Yanjun Guo, "The evolution of China's water diplomacy in the Lancang-Mekong River Basin" in *China and Transboundary Water Politics in Asia* (New York: Routledge, 2018), 72-88, ed. Hongzhou Zhang and Mingjiang Li. On Chinese financial investments in dams overseas, including in Southeast Asia, see Frauke Urban, Giuseppina Siciliano, and Johan Nordensvard, "Transboundary river management in Southeast Asia" in *China and Transboundary Water Politics in Asia*, 43-70.

263 Catherine Putz, "Dam deja-vu: Construction begins at Rogun," *The Diplomat*, November 1, 2016, https://thediplomat.com/2016/11/dam-deja-vu-construction-begins-at-rogun/; "Nurek: Tajikistan's aging king of dams," *Eurasianet*, June 25, 2018, https://eurasianet.org/nurek-tajikistans-aging-king-of-dams; "Tajikistan says $4bn dam to open in November," phys.org, February 1, 2018, https://phys.org/news/2018-02-tajikistan-4bn-november.html.

264 "Tajikistan dreams of regional electricity grid rebirth," *Eurasianet*, June 27, 2017, https://eurasianet.org/node/84136; Shahzadi Tooba Hussain Syed, "CASA-1000: An energetic challenge," *Foreign Policy News*, May 22, 2016, http://foreignpolicynews.org/2016/05/22/casa-1000-energetic-challenge/; Catherine Putz, "CASA-1000 creeps toward construction bridging Central and South Asia," *The Diplomat*, February 8, 2018, https://thediplomat.com/2018/02/casa-1000-creeps-toward-construction-bridging-central-and-south-asia/. For a rosy assessment of the dam's benefits, including output projections, see Kh.S. Karimov et al., "Rogun hydropower plant project of Tajikistan: Expected benefits for neighboring countries," *World Applied Sciences Journal* 26, 2 (2013), 239-243.

265 Food and Agriculture Organization of the United Nations, Aquastat Global Water Information System, Uzbekistan and Tajikistan fact sheets, available at http://www.fao.org/nr/water/aquastat/countries_regions/index.stm.

266 Catherine Putz, "Uzbekistan's Changing Rogun Tone," The Diplomat, July 10, 2017, https://thediplomat.com/2017/07/uzbekistans-changing-rogun-tone/.

267 Petr Bologov, "The Rogun Dam: A source of division in Central Asia," *Carnegie Moscow Center*, December 2, 2016, https://carnegie.ru/commentary/66334.

268 Joseph Hammond, "Uzbekistan and Tajikistan: No more dam problems?," *The Defense Post*, July 30, 2018, https://thedefensepost.com/2018/07/30/uzbekistan-tajikistan-no-more-rogun-dam-problems/; "Uzbekistan drops objections to giant Tajik hydro project," *Reuters*, March 9, 2018, https://uk.reuters.com/article/tajikistan-uzbekistan-hydro/uzbekistan-drops-objections-to-giant-tajik-hydro-project-idUKL5N1QR4CD; Putz, "Changing"; Casey Michel, "Why Uzbekistan's shifts on water politics matter," *The Diplomat*, April 18, 2017, https://thediplomat.com/2017/04/why-uzbekistans-shifts-on-water-politics-matter/.

269 Maksud Bekchanov, Claudia Ringler, Anik Bhaduri, and Marc Jeuland, "How would the Rogun Dam affect water and energy scarcity in Central Asia?," *Water International* 40, 5-6 (2015), 867-870.

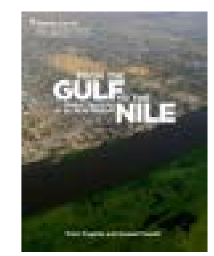
270 Shokhrukh-Mirzo Jalilov, Thomas M. DeSutter, and Jay A. Leitch, "Impact of Rogun Dam on downstream Uzbekistan agriculture," *International Journal of Water Resources and Environmental Engineering* 3, 8 (August 2011), 161-166.

271 Insight from expert interview conducted August 24, 2018.

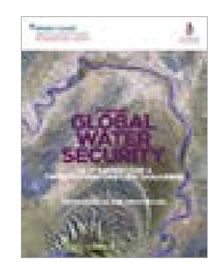
RELATED PUBLICATIONS

"The Global Innovation Sweepstakes" (June 2018)
This publication examines how emerging technologies will remake the global order and explores strategies for how the United States can retain its innovative edge. Tech-based innovation—in fields such as artificial intelligence, robotics, green energy, and biotechnology—will reshape the future of human civilization. Those nations that can create and adapt to cutting-edge technologies will realize enormous economic and geostrategic benefits in the decades to come.

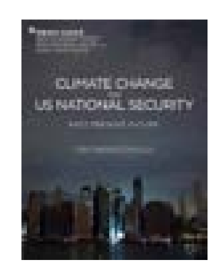
"Asian Water Security: A Present and Future Test" (November 2017)
An insecure supply of clean water raises the dangers of economic disruption, social tension, and even conflict over water resources at both the domestic and international levels. This paper examines water security risk in Asia, where water challenges affect several of the world's most populous and powerful states, and many smaller ones as well.



"From the Gulf to the Nile: Water Security in an Arid Region" (March 2017)
Current trends on both the supply and demand sides strongly suggest that clean freshwater availability will become more challenging in more places. As a result, water will become even more important than it currently is in contributing to the degradation of social, political, and economic systems. Nowhere are these dynamics more evident or more important than in the Middle East and North Africa. This publication draws greater and more focused attention to this region and this rising problem.



"Toward Global Water Security" (August 2016)
While numerous American public, private, philanthropic, scientific, and academic organizations are addressing water challenges the world over, there is no explicit strategy binding their diverse activities together into a coherent whole. After assessing how the United States government and other stakeholders engage on water issues abroad, this report asserts that the United States needs a water grand strategy and outlines a process for forging a stakeholder-driven, "Whole of America" approach.



"Climate Change and US National Security: Past, Present, Future" (March 2016)
The publication examines the past, present, and future of climate security in the United States. Under a climate security framework, US policymakers could use national security grounds to justify both mitigation and adaptation strategies: mitigation strategies to reduce the threat of a changing climate, and adaptation strategies to increase American society's resilience in the face of that threat.

Atlantic Council Board of Directors

1030 15th Street, NW, 12th Floor, Washington, DC 20005

(202) 778-4952, www.AtlanticCouncil.org