Students from Nepal's Kathmandu University and their professor, Rijan Kayastha (lower right), take discharge measurements in the Lirung Khola river below the Lirung Glacier in Langtang, Nepal. Photo credit: CHARIS

Taking the Pulse of a Water Lifeline to Hundreds of Millions of People

July 19, 2019

Their summits often soaring to more than 20,000 feet, the great intersecting mountain ranges of Central and South Asia collectively stretch thousands of miles across the continent. Within this vast, often impenetrable, and sparsely inhabited wilderness, snowfields and glaciers store water that has fallen as precipitation and accumulated over the course of years, decades, or in some cases, even centuries. In fact, these ranges — which include the Himalaya, Hindu Kush, Karakoram, Pamir, and Tien Shan — hold so much ice and snow within their mountainous walls that they are often referred to collectively as both High Asia and "The Third Pole."

Perhaps the only thing more staggering than the size of these mountains is the number of people who depend on them and the Tibetan plateau as a water source: One out of every seven people on the planet relies on the rivers draining Asia's great mountain ranges for hydropower and to irrigate crops, support livelihoods, and meet

daily drinking water, cooking, and cleaning needs. Effectively serving as lifelines for much of the continent, these vast river systems deliver snow melt, glacier ice melt, and rainwater to downstream communities, ranging in size from isolated mountain villages to sprawling coastal megacities.

But remote as it may be, High Asia has found itself on the frontlines of climate change in recent years. A recent study has shown that while glaciers across the Himalaya have shed roughly 10 inches of ice every year between 1975 and 2000, that loss rate has increased to an average of 20 inches per year between 2000 and 2016. As warming temperatures and shifting precipitation patterns continue to accelerate the melting of snowpack and glacier ice across the region, the timing and volume of water delivered to communities at lower elevations are already disrupting the rhythms of daily life with intensified cycles of flood and drought. Are the villages, towns, and cities that depend on these waters prepared for the changes and challenges that lie ahead?

Monitoring Hydrological Conditions on the "Third Pole"

A warming world is contributing to snowpack and glacier melt in many areas across High Asia. To predict how future climate conditions will affect glaciers and snow, it is necessary to better understand the current contributions of both glacier ice and snow melt to downstream water supply. The Contribution to High Asia Runoff from Ice and Snow (CHARIS) project has accomplished this task. Since 2012, USAID's CHARIS project, led by the National Snow and Ice Data Center at the University of Colorado, Boulder, has brought researchers and decision-makers together from across High Asia to step up monitoring efforts of the region's snowfields and glaciers and study regional hydrological variability. The ultimate goal is to contribute to sustainable water management decisions in downstream communities so that they may better cope with anticipated future shifts in water availability.

"For the longest time we thought that water [across the region] was forever renewable, and that it would always be there," says Gloria Steele, USAID acting assistant administrator for Asia. "We now know that is not the case, and we need to protect it and manage it effectively."

Prior to CHARIS's conclusion in early 2019, the project spent six years filling knowledge gaps in our understanding of how changes in the climate are affecting water availability in key river basins across Central and South Asia. To achieve this, CHARIS provided support for ongoing water quality sites and glacier monitoring stations across an extensive area stretching from the Kyrgyz Republic to Bhutan. The data gathered at these remote outposts have helped create the most accurate estimates of snowpack and glacier contributions to annual water volume of five major river systems: the Amu Darya and Syr Darya in Central Asia, and the Brahmaputra, Ganges, and Indus in South Asia.

Previous hydrological studies of High Asia have revealed that most glaciers lose mass every year due to rising temperatures. But such studies have not typically included detailed information on how much water is discharged as a result of intensifying seasonal melt cycles. Without these data, water managers in downstream communities have not had the information needed to more accurately forecast future water

availability and shape better water resource management decisions that are aligned to this "new normal."

Thanks to robust data-gathering operations in the field and CHARIS's recent collaborations with partner organizations in eight countries across High Asia, that knowledge gap is starting to be bridged as the region prepares for a more water-variable future.

Change Comes to Asia's "Water Towers"

As far as Central and South Asia's long-term water security is concerned, the strategic importance of High Asia's snowpack and glaciers cannot be overstated. They are considered "water towers," given their ability to effectively store water for long periods of time. For generations, normal seasonal warming periods have caused these snowfields and glaciers to periodically release water in the form of meltwater. Hundreds or even thousands of miles downstream, this meltwater then supplements river flow during dry periods, providing communities with a steady water supply throughout the year.

However, as changes in the climate become more pronounced, shifting seasonal fluctuations in water availability are placing downstream communities on uneasy footing. In the near- and medium-term, warming temperatures are likely to accelerate glacier ice and snowpack melt, resulting in a higher-than-normal volume of water being delivered downstream — potentially placing communities at heightened flood risk. The opposite may be the case in the longer-term: As High Asia's glaciers and snowfields lose much of their mass due to a warming climate, these "water towers" will no longer store as much water as they once did, leaving downstream communities without enough water to sustain them through dry periods.

Documenting the Origins of a Vital Water Supply

CHARIS's evaluations of water availability in its five target basins revealed that snow melt is by far the dominant contributor of water volume in every basin examined, constituting nearly 75 percent of annual average flow of Central Asia's Syr Darya River, and more than 70 percent in South Asia's Indus and Brahmaputra rivers. The second greatest contributor of water volume in most of the basins studied is rainfall, accounting for roughly a quarter of the annual average flow; one notable exception is the Ganges basin, where more than half of the annual average flow comes from rainfall attributable to South Asia's monsoon.

Meanwhile, glacier ice melt makes up a comparatively small portion of annual river flow in most of the basins examined, typically constituting only 1 or 2 percent of total water volume. But even modest fluctuations in glacier meltwater discharge can have significant implications for downstream communities. In the Indus basin, for example, CHARIS found that glacier ice melt annually supplies roughly 3 percent of the river's volume on average. But with the population of Pakistan — a country of 200 million people wholly reliant on the Indus for its water supply — projected to soar to more than 300 million people within the next 30 years, even a slight decrease in long-term water availability could jeopardize food security and economic growth potential. Furthermore, most glacier meltwater arrives to fields and communities later

in summer (constituting 20 percent of total flow during July and August), when spring and early summer melt from seasonal snow begins to decrease.

Glacier ice melt in other river basins, such as Central Asia's Amu Darya, is similarly important in terms of downstream water availability. Of all the basins CHARIS has documented since 2012, the Amu Darya is the most reliant on glacier meltwater to fortify its annual average flow, making up about 8 percent of the river's total volume. But that figure does not tell the whole story: CHARIS research revealed that in the late summer, the portion of the Amu Darya's flow sourced from glacier meltwater spikes to more than 25 percent. This spike plays a vital role in stabilizing downstream water supply throughout dry periods.

Building Regional Capacity, One Partner Institution at a Time

CHARIS's hydrological data collection has helped shed much-needed light on how water availability in key Asian river systems may fluctuate in response to climate change in the decades ahead. Putting these data into action helps empower research organizations across the region.

Since 2012, CHARIS has helped develop the research capabilities of organizations in partner countries across Asia, including Afghanistan, Bhutan, India, Kazakhstan, the Kyrgyz Republic, Nepal, Pakistan, and Tajikistan. In total, the project fostered 11 partnerships in eight countries, teaming up with universities, research institutes, meteorological services, and water management agencies. CHARIS not only facilitated data sharing among these partners, but also conducted capacity-building training workshops and provided financial support to a glacier monitoring field site in the Kyrgyz Republic and a water chemistry lab in Bhutan. With these collaborations, CHARIS helped boost local resilience to climate change by equipping downstream communities with the knowledge needed to better plan for and respond to water-related disasters, such as flooding or drought, while providing farmers at lower elevations with a better sense of how long-term shifts in water availability may influence the timing and duration of growing seasons in the future.

Leaving a Blueprint for the Future

While much about the future effects of a changing climate in High Asia and elsewhere remain uncertain, CHARIS's research and partnerships have helped build a broader and deeper understanding of where the region's water originates, and how shifting temperature and precipitation patterns might affect water supply. "The CHARIS project has provided us with a very good starting point for understanding the role of glaciers and seasonal snowfall in feeding Asia's major rivers," says Steele. By improving our understanding of the region's hydrology, CHARIS and its partners have positioned the countries that rely on the waters of High Asia to better prepare for a future where significant seasonal shifts in water availability may become the norm. An emerging generation of scientists and policymakers across the region is now taking the baton to better monitor, understand, and prepare for the impacts of climate change in High Asia.

Mary Melnyk, environmental security and resilience team leader at USAID's Asia Bureau, takes pride in CHARIS's many accomplishments. But she is keeping her eyes fixed firmly on the future. "Capacity building, and the ability to leave behind — in research institutions — the tools that they need to continue the work without us is one of the flagstones on the path to self-reliance."

By Russell Sticklor

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Additional Resources:

- USAID Asia Bureau
- National Snow and Ice Data Center: CHARIS

This article appears in Global Waters, Vol. 10, Issue 4; for past issues of the magazine, visit Global Waters' homepage on Globalwaters.org.