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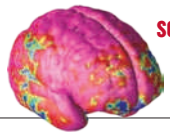

J. BENDIKSEN/MAGNUM PHOTOS

More than a billion people rely on drinking water fed by Himalayan glaciers such as Khumbu in Nepal. This supply could be at risk unless glacial retreat is stopped.

CLIMATE CHANGE

Measuring the meltdown

With global warming hitting the Tibetan plateau hard, scientists gather to plan an international research campaign to understand and mitigate changes at the 'third pole'.

BY JANE QIU IN KATHMANDU, NEPAL

Cold, remote and threatened by global warming: the description applies not only to the North and South Poles, but also to a region of more than five million square kilometres, centred on the Tibetan plateau and the Himalayas, that researchers call the third pole (see *Nature* **454,** 393–396, 2008). After the Arctic and the Antarctic, the region has Earth's largest store of ice, in more than 46,000 glaciers and vast expanses of permafrost. Yet it is much less studied than its high-latitude counterparts, even though many more lives depend on it.

The third pole is also known as Asia's water tower, because its glaciers feed the continent's largest rivers, which sustain 1.5 billion people across ten countries. Those glaciers are melting fast, filling lakes that can overflow and flood valleys. Yet little is known about how climate change is unfolding there. To attempt to rectify this, Third Pole Environment (TPE), an international programme led by the Chinese Academy of Sciences' Institute of Tibetan Plateau Research (ITP) in Beijing, held its second workshop last month in Kathmandu. Researchers in the region laid plans to fill the knowledge gap, and discussed findings that add to the urgency.

"Everyone is doing important work across the region, but it is unclear how they fit together," says Yao Tandong, director of the ITP and chairman of the TPE science committee, which helped to organize the workshop. "The only way forward is for the international community to work together to assess the risks associated with climate change," he says.

As the region's population booms, the top priority of researchers is to understand the status and fate of glaciers that are a vital source of drinking water. Last year, a claim in the 2007 report of the Intergovernmental Panel on Climate Change (IPCC) that Himalayan glaciers could disappear by 2035 turned out to be an error (see *Nature* **463,** 276–277; 2010). But participants at the workshop argued that the IPCC's broader concern about the rapid loss of Himalayan glacier ice was correct. "There is no doubt that many of the glaciers in the region ▶

are retreating fast," says Baldev Raj Arora, former director of the Wadia Institute of Himalayan Geology in Dehradun, India.

But it is not clear exactly how fast, or how this will affect water resources, because there is no glacier inventory for the entire region. Taken alone, satellite studies offer only a rough estimate of glaciated area, and remoteness, high altitudes and harsh weather conditions hamper measurement from the ground.

The evidence that is available is telling. Using a combination of satellite and ground measurements, a team led by Liu Shiyin, a glaciologist at the Chinese Academy of Sciences' Cold and Arid Regions Environmental and Engineering Research Institute in Lanzhou, has just completed the second Chinese national glacier inventory, documenting some 24,300 glaciers and recording characteristics such as their locations, lengths and surface areas. It shows that the total surface area of glaciers has decreased by 17% and that many have disappeared since the last inventory began, roughly 30 years ago.

To get a better estimate of such changes, researchers have also measured the ice volume and mass balance of representative glaciers in various parts of the Himalayas. Such arduous studies, often at altitudes above 5,000 metres, show that "the impact of climate change on some Himalayan glaciers is much worse than previously thought", says Tian Lide, a glaciologist at the ITP. The expansive Kangwure glacier on the northern slope of Mount Xixiabangma in southern Tibet, for instance, has lost nearly half of its ice since the 1970s, and its average thickness has decreased by 7.5 metres.

Most of the glaciers in the Indian Himalayas that have been studied in detail are also losing mass, says Arora. Across the third pole, "regional anomalies exist, but the balance of evidence certainly points towards a trend of fast retreat", agrees Lonnie Thompson, a glaciologist at Ohio State University in Columbus and a co-chairman of the TPE science committee.

CARBON TOLL

One cause of the retreat is the growing amount of sooty 'black carbon' made by fossil-fuel and biomass burning. Xu Baiqing, an environment scientist at the ITP, measured 50 years' worth of black-carbon levels in ice cores from five glaciers in various parts of the Himalayas, and found increased emissions since the 1990s, coinciding with rapid industrial growth in the region. Angela Marinoni, a climate scientist at the Institute of Atmospheric Sciences and Climate in Bologna, Italy, and her colleagues found high concentrations of aerosols, including black carbon, above 5,000 metres in the Nepalese Himalayas, which caused significant atmospheric warming. They calculate that deposition of black carbon could increase snow and ice melting of a typical Himalayan glacier by 12–34%, by reducing its ability to reflect light.

As a consequence, glacial lakes are getting larger and more numerous, causing more floods. A study led by Yongwei Sheng, an ecologist at the University of California, Los Angeles, shows that the area of such lakes on the plateau has increased by 26% since the 1970s, with a devastating effect on surrounding pastures. Outbursts of glacial lakes have caused more than 40 floods in the Himalayas since the 1950s, and more are likely in the coming decades, says Pradeep Mool, a remote-sensing specialist at the International Centre for Integrated Mountain Development (ICIMOD) in Kathmandu. An ICIMOD survey listed more than 20,200 glacial lakes in the region; two hundred are "potentially dangerous" and need close monitoring and an early warning system, says Mool.

So far, scientists trying to forecast the glaciers' future have had little to go on. For one thing, says Thompson, "glaciers respond to climate differently depending on their size, altitude distribution, surface area, debris cover and valley characteristics". And little is known about how climate is changing across the third pole.

Yang Kun, a climate scientist at the ITP, found that many satellite-based measurements of Earth's radiation budget — the balance of incoming solar radiation and outgoing heat — did not work well at the third pole's high elevations, because instruments are typically calibrated and verified against ground-truth data from the lowlands. They can be corrected using field measurements, but across the region, only 16 weather stations lie above 5,000 metres.

Investigators can't rely on climate models, either. Using data from the only weather station at 8,000 metres, on the South Col pass between mounts Everest and Lhotse, Kenichi Ueno, a climate scientist at the University of Tsukuba, Japan, showed that global climate models do not predict moisture and radiation flux well at such high altitude, especially in hot weather or monsoon season. "If you want to know how climate affects glaciers, such details are crucial," he says. "It's extremely important to have more high-altitude observations across the region."

A JOINT ENDEAVOUR

The TPE science committee will soon draft a research programme to document the effects of climate change on glaciers, permafrost, water resources, biodiversity and people. The plan, to be finalized by autumn 2011, will call for joint expeditions to the Himalayas and the Tibetan plateau, and for multidisciplinary research stations across the region, to cover key geological areas and climate regimes as well as important river and lake basins. Once costs have been defined, the committee will seek support from national and international funding agencies.

The most important part of the plan is a common data repository, says Volker Mosbrugger, director of Senckenberg World of Biodiversity, a coalition of research institutes and museums in Frankfurt, Germany, and another co-chairman of the TPE science committee. But national rivalries may stand in the way, especially when the shared data concern water resources. "Whether there can be a central database up and running will determine whether the programme can move beyond its rhetoric," says Gregory Greenwood, director of the Mountain Research Initiative at the University of Bern. "This will be a great challenge."

The committee will draft a policy to be negotiated between countries interested in the programme, letting scientists share information but leave out data deemed politically sensitive. "Without working together and pooling data from across the third pole," says Yao, "comprehensive understanding of climate impact and feedback mechanisms would be impossible." ■

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