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REASONS

The long-range forecast

The Himalayas, roof of the world, are springing a leak. As the climate warms up, melting glaciers are threatening the livelihoods of millions. **David Cyranoski** reports.

The mighty Himalayas straddle many countries and are home to a host of ethnic groups. But all along the mountain range, local communities are finding that they have at least one thing in common: their way of life is being threatened by changes to their environment.

In Nepal, rising temperatures are swelling glacial lakes to bursting point. Across the mountains in Tibet, herdsman are struggling to feed their livestock on an increasingly deteriorating landscape. In recent years, the locals have begun to blame global warming for many of their troubles — and the data now being collected suggest that they may be right.

“Local people do not know much about climate change, but they can very clearly see that there is a change affecting them,” says Lifeng Li, at the China branch of conservation group the WWF.

Billions of people rely on water that ultimately comes from the Himalayas. The range is home to the 14 highest peaks in the world, and the area's snowpack feeds the flow of several major rivers.

Hydrological models¹ suggest that the effects of climate change in the region could be far-reaching. And reports published earlier this year paint a grim picture of vanishing glaciers

and declining water supplies^{2,3}. Future disasters could include floods, droughts, land erosion, biodiversity loss, and changes in rainfall and in the annual monsoon. As a result, scientists and conservation groups are monitoring the region and asking what can be done to help its inhabitants to adapt to the changes.

Swept away

Both sherpa mountain guides in Nepal and cattle herdsman in Tibet stand to benefit from these initiatives. Climate change can have an immediate and disastrous effect on their lives. In 1985, Nawa Jigtar, a senior monk in the village of Ghat in Nepal, heard a loud noise and rushed outside, only to watch helplessly as his cows were carried away by a deluge. “If it had come at night, none of us would have survived,” he told the WWF in a recent documentary, *Meltdown in Nepal*.

That flood occurred when the Dig Tsho glacial lake burst its banks, wiping out more than a dozen bridges as well as a new hydroelectric plant. Studies by the Organisation for Economic Co-operation and Development (OECD) and others have shown that at least 20 such glacial lakes are at risk of bursting in Nepal⁴, with more in Bhutan. The lakes form naturally from the meltwater of glaciers, but as

climate change forces the glaciers into an ever-faster retreat, the excess water floods into the lakes. Fragile moraine dams — piles of rock and debris left by the retreating glacier — are all that stand between the water and the communities downstream, says Shardul Agrawala, a climate-change administrator at the OECD. Earthquakes, landslides or slope instability can trigger the natural dams to collapse.

And the problem seems set to get worse. In March, a WWF team reported on how quickly the Himalayan glaciers are melting², and what consequences that might have for water supply in India, China and Nepal. Temperatures in Nepal have been rising steadily over the past few decades, and climate-change models predict that they will rise a further 1.2 °C by 2050, with a total increase of 3 °C by 2100. As a result, the glacial lakes are growing in both number and size.

“Most glaciers are in retreat, so glacial lakes have to hold more water,” says Ninglian Wang, a glaciologist at the Cold and Arid Regions Environmental and Engineering Research Institute (CAREERI) in Lanzhou, China. Nepal's glaciers are shrinking at a rate of 30 to 60 metres per decade⁴.

On the Tibetan side of the range, 50% of the glaciers were retreating during the period 1950

to 1980 — that rose to 90% in the 1980s and to 95% in the 1990s², according to data gathered by Tandong Yao, head of the Chinese Academy of Sciences' Institute of Tibetan Plateau Research based in Beijing. The runoff from melted glaciers in China is now roughly equal to the annual flow of the Yellow River.

"Melting glaciers are one of the most convincing pieces of evidence for the impact of climate change," says Nigel Arnell, a specialist in climate resources at the University of Southampton, UK. But the picture isn't so clear when it comes to other data, such as the cause of land deterioration in Tibet.

This summer, a team from CAREERI sponsored by Greenpeace documented shrinking glaciers and lakes in the source region for the Yellow River³, which rises on the Tibetan plateau and is a crucial water resource for millions of Chinese. The group found that the region is experiencing vegetation loss of 3–10% each year. If the trend of rising temperatures continues, the team predicts a decrease in water availability of 20–40% over the next 50–100 years, and a fall in total agricultural output including wheat, rice and corn crops of 10% by 2030–50.

Down to earth

But the question of land use — particularly overgrazing — is complicating the picture. The locals tend to reject the idea that they are partly to blame for the deterioration. For instance, Tibetan herdsmen near the source of the Yangtze River, who were interviewed by WWF researchers, were adamant that global warming had ruined the amount and quality of their grasslands, as well as increased the spread of disease from animals such as rats. And one of the main findings of the subsequent report³ put together by members of the Chinese Academy of Sciences, was to correct the notion that overgrazing had destroyed the ecosystem.

Most scientists, however, believe that overgrazing is playing a major role in the vegetation loss — the question is how much. The issue highlights one of the major problems in assessing the changes caused by global warming. Anecdotal surveys form the bulk of the data for these regions, and experts warn against relying too heavily on this kind of evidence. The regional studies are often not rigorous, notes Martin Parry, a senior research fellow at Britain's Met Office. "Even if you can estimate the climate change, you can look at what the impact would be on agriculture today, but agriculture in the future will be different," he says. "You need to take into account social, economic and political change."

Occasionally, local governments have taken the initiative to try to mitigate the effects of climate change. In February, the Chinese government allotted 7.5 billion renminbi (US\$930 million) for conservation projects in the source regions of the Yangtze and Yellow rivers. To solve the problem of land degradation, officials are talking about relocating many of the



Researchers interview Tibetan herdsmen (above) and measure glaciers in a bid to assess the effects of climate change on the Himalayas.



Tibetan herdsmen, says Li. He argues that such an approach would be too costly, both financially and in terms of its cultural impact. "We should try to improve productivity of the land rather than move people," Li says — perhaps by selecting more robust species of grass and improving irrigation in the region.

Peak practice

Dealing with the threat of glacial lakes is a little more straightforward — if there is money available. Beginning in 1998, the Netherlands spent US\$3 million to drain Tsho Rolpa, one of Nepal's most dangerous glacier lakes. The project lowered the water level by 3 metres, but the respite is only temporary, warns Agrawala. Meltwater is likely to fill it up again shortly, he notes.

A new book from the OECD that examines the situation in Nepal⁴ suggests other measures, such as early warning systems for floods to reduce the risk to local communities. It also proposes using smaller hydroelectric plants

spread out on several rivers, rather than relying on one major plant that could be wiped out in a single lake burst, as happened in 1985.

Such solutions are just one approach to a multifaceted problem. Regional policy-makers must juggle social and economic needs while worrying about how to adapt in the face of global warming. "There is a lot of talk of climate change, but how do you tell national planners to take it into account?" asks Agrawala.

One possible solution could be a new adaptation fund, to be considered when member states of the United Nations Framework Convention on Climate Change meet in Montreal starting on 28 November. The framework would provide funding, insurance and technology transfer to developing countries whose geography puts them at risk from climate change — such as countries prone to drought, and those with mountainous ecosystems.

Regardless of what aid it could get in the future, China may already be getting a taste of things to come. In Qumalai County, near the headwaters of the Yangtze, wells have recently gone dry and smaller rivers have vanished completely. If climatologists are correct, these water shortages may be a harbinger of the future along the Himalayas. ■

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3. Ding, Y., Liu, S., Xie, C., Zhang, Y. & Wang, J. *Yellow River at Risk: An Assessment of the Impacts of Climate Change on the Yellow River Source Region* (Greenpeace, 2005); available at http://activism.greenpeace.org/yellowriver/yrs-english_web.pdf.
4. Agrawala, S. (ed.) *Bridge Over Troubled Waters: Linking Climate Change and Development* (OECD, Paris, 2005).

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