

# Receding glaciers in Bolivia leave communities at risk

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Glacier and lake near the villages of Pelechuco and Agua Blanca in the Apolobamba region, northern Bolivia. Credit: Simon Cook

A new study published in *The Cryosphere*, an European Geosciences Union journal, has found that Bolivian glaciers shrunk by 43% between 1986 and 2014, and will continue to diminish if temperatures in the region continue to increase. "On top of that, glacier recession is leaving lakes that could burst and wash away villages or infrastructure downstream," says lead-author Simon Cook, a lecturer at the Manchester Metropolitan University in the UK.

Receding glaciers also put water supply in the region at risk. Glacial meltwater is important for irrigation, drinking water and hydropower, both for mountain villages and large cities such as La Paz and El Alto. Throughout the year, the 2.3 million inhabitants of these two cities receive about 15% of their water supply from glaciers, with this percentage almost doubling during the dry season. Glacier retreat also means less water is available to supply rivers and lakes, such as southern Bolivia's Lake Poopó, which recently dried up.

The new study is one of the first to monitor recent large-scale glacier change in Bolivia, to better understand how receding glaciers could affect communities in the country. "The novelty of our study lies in the bigger picture—measuring glacier change over all main glaciated ranges in Bolivia—and in the identification of potentially dangerous lakes for the first time," Cook says.

The team measured glacier area change from 1986 to 2014 using satellite images from Landsat, the U.S. Geological Survey's and NASA's Earth observation programme. They found that the area of the Bolivian Andes covered by glaciers decreased from about 530 square kilometres in 1986 to only around 300 square kilometres in 2014, a reduction of 43%.

As glaciers recede, they leave behind lakes typically dammed by bedrock or glacial debris. Avalanches, rockfalls or earthquakes can breach these

dams, or cause water to overflow them, resulting in catastrophic floods known as glacial lake outburst floods. The team reports that both the number and size of glacier lakes in the study region increased significantly from 1986 to 2014.

After studying glacier change, the researchers used their 2014 glacial-lake observations to identify the lakes where outburst floods could occur and present a hazard to populations. "We mapped hundreds of lakes," Cook explains. "Some lakes are very small and pose little risk. Others are very large, but there's little or no possibility that they would drain catastrophically. Others are both large enough to create a big flood, and sit beneath steep slopes or steep glaciers, and could be dangerous."

They identified 25 glacial lakes across the Bolivian Andes as potentially dangerous to communities and infrastructure, as they could result in very damaging floods. If the smallest of these 25 lakes was to drain completely, it would yield a flood with a peak discharge of 600 cubic metres per second. The largest could result in a discharge of over 125,000 cubic metres of water, about 50 times the volume of an Olympic swimming pool, in a second.

While measuring glacier area change was a relatively simple task, Cook says "identifying which lakes are dangerous is the million dollar question" as there are various factors to take into account.

"We considered that a lake was dangerous if there were settlements or infrastructure down-valley from the lake, and if the slopes and glaciers around the lake were very steep, meaning that they could shed ice or snow or rock into the lake, which would cause it to overtop and generate a flood - a bit like jumping into a swimming pool, but on a much bigger scale!"

Such catastrophic floods have occurred in the region in the past. Dirk

Hoffmann, a researcher at the Bolivian Mountain Institute and co-author in The Cryosphere study, recently documented a glacial lake outburst flood in the Apolobamba region that happened in 2009 and killed farm animals, destroyed cultivated fields and washed away a road that left a village isolated for months. "As those locations are very remote and far away from the cities, authorities at national level and the wider public are often not even aware of the new dangers that mountain dwellers are facing due to the impacts of climate change, and no appropriate measures are being taken," Hoffmann says.

Cook says these events could be under-reported, suggesting the risk of such floods in the Bolivian Andes has been overlooked. "We heard of other [glacier lake outburst flood] events from villagers when we visited the Apolobamba region in 2015, but there is no mention of these in publications or papers, possibly because many of these communities are relatively remote." Hoffmann adds: "A nation-wide risk assessment of potentially dangerous glacial lakes would be of great interest to local communities in glacier watersheds."

In the study, the team also estimated that glacier area will be severely reduced by the end of the century, to about a tenth of the 1986 values. This would put communities even more at risk from water scarcity, Cook says. "We predicted in our study that most glaciers will be gone or much diminished by the end of the century - so where will the water come from in the dry season? Big cities like La Paz are partially dependent on meltwater from glaciers. But little is known about potential water resource stress in more remote areas. More work needs to be done on this issue."

The team hope the study raises awareness about the rapid glacier loss in Bolivia, how it could change in the future, and how it could affect water supply and cause glacial lake outburst floods. "Ultimately, I hope that our results will be useful to people in Bolivia - governments, agencies,

people living in rural areas and cities," Cook concludes.

**More information:** Simon J. Cook et al, Glacier change and glacial lake outburst flood risk in the Bolivian Andes, *The Cryosphere* (2016).  
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