How is India preparing against GLOF events? | Explained

How many Glacial Lake Outburst Flood events has Nepal witnessed in recent times? What are the two most prominent types of glacial lakes found in the Indian Himalayan Region? How is the National Disaster Management Authority mitigating risks associated with GLOF events?

Published – July 28, 2025 08:30 am IST

SAFI AHSAN RIZVI

This is the north-end of the Shako Cho lake (5,200 m) in north Sikkim. The north-end shows the glacier that feeds the lake. | Photo Credit: NDMA

The story so far:

On July 8, Nepal experienced a catastrophic Glacial Lake Outburst Floods (GLOF) event which caused a flash flood along the Lende river flowing from Tibet to Nepal, and washed away a China-built friendship bridge. The bridge had serviced the 10-year old inland container port at Rasuwagadhi in

Rasuwa (north of Kathmandu). The catastrophe is also reported to have made four Nepalese hydro-power plants along the Bhote Koshi river unusable, obliterating 8% of the country's power supply. With rising temperatures and subsequent glacial melt, the increased risk of GLOFs is threatening life and property in the higher Himalayas.

Do trans-boundary watersheds diminish possibilities of early warning?

While Chinese authorities have as yet refrained from confirming the cause, most Nepalese scientists and officials confirmed a GLOF event in Tibet, where a supra-glacial lake had burst, diminishing its surface area to 43 hectares from 63 hectares a day before. Nepalese officials were quoted lamenting in local media that neither did the Chinese authorities provide an early warning, nor was there an established system of doing so, despite a recent increase in supra-glacial lakes on the Tibetan side.

Hours later, on the same day, another GLOF event occurred at a moraine-dammed lake in the northern part of the Mustang district in Nepal (north-west of Kathmandu). Two months before, two glacial lakes in the Humla district (far-north corner of Nepal) had witnessed significant GLOF events, while in 2024, a GLOF in the Solukhumbu district had destroyed the Thame village in Nepal, the base camp for Mount Everest climbers. The need for trans-boundary collaborations in setting up early warning protocols seems paramount, given that Nepal has lost many lives and much infrastructure in successive GLOF events.

Similar events have impacted Nepal regularly, including the GLOF in Cirenma Co, a glacial lake, in Tibet in 1981, which released 20 mcm of water raising the Bhote Koshi river by 30 metres. Several decades later the same lake was reported to have rejuvenated and was rated high-risk. Other significant events include the Digi Tsho GLOF event in 1985, and the Tama Pokhari GLOF event in 1998. In response, Nepal has conducted risk mitigation works on the Imja Tsho and Tsho Rolpa lakes by drawing down water levels through artificial channels, a challenging task at heights above 5,000 m, and has further plans to target half a dozen more at-risk glacial lakes.

What is the nature of GLOF risk for India?

As per India's National Remote Sensing Centre, the Indian Himalayan Region (IHR) is home to 11 river basins and 28,000 glacial lakes. There are two prominent types of glacial lakes found in the IHR. The first are supraglacial lakes, formed in depressions on glaciers from meltwater, highly prone to melting in the summer months. The second are moraine-dammed lakes, formed by meltwater at the toe/snout of a glacier, dammed by loose debris or ice-cores, making them prone to sudden failure. Almost two-thirds of GLOF events are triggered by ice avalanches or landslides, and the remaining due to excessive meltwater pressure on weak moraine dams and earthquakes.

With 2023 and 2024 being the hottest years on Earth, extreme temperatures in smaller geographies have been higher, thereby causing more glacial melt in certain pockets, making some glacial lakes highly risky.

This is the south-end of the Shako Cho lake (5,200 m) in north Sikkim. The south-end shows the weak debris that forms its moraine-dam. | Photo Credit: NDMA

In addition to rising heat, is the problem of scale. 7,500 glacial lakes are situated in India, with most above 4,500 metres in height, hence approachable for surveys only during a short window in the summer season. There are almost no weather and water monitoring stations in these regions due to inaccessibility, lack of sustainability and cost, leaving this growing risk largely unmapped.

The only credible means is measuring growth in surface area via remote sensing over periods of time, a measure which is post-facto and provides little by way of risk assessment or early warning of any sort.

Additionally, vulnerability of the immediate geography is critical to determining the exact nature of risk. This includes damage to homesteads, livelihoods, biodiversity, bridges and hydro-power projects along rivers that relay GLOFs downstream. The South Lhonak GLOF in 2023 in Sikkim wiped out the $2 billion and 1250 MW generating Chungthang dam and also intensified the flash flood causing massive silting downstream. Since then, the Central Water Commission has found that the Teesta riverbed has risen several metres, significantly reducing its carrying capacity and increasing the chances of its banks overflowing.

Besides the Sikkim GLOF, one of the most damaging events in recent times was the Chorabari GLOF in 2013, which turned into a cascading disaster accompanied by cloudbursts and landslides, known as the Kedarnath catastrophe — causing hundreds of casualties and billions in infrastructure damage.

What can India do to mitigate GLOF risk?

The National Disaster Management Authority (NDMA) has markedly accelerated its efforts to manage these increasing risks. With respect to mitigation, it has initiated a proactive shift from mere post-disaster response to risk reduction through its Committee on Disaster Risk Reduction (CoDRR). This national coordination effort brought together related central scientific agencies, academic and research institutions, and States/UTs to study, monitor, warn, and mitigate GLOF risk in India. As a result, the central government finalised its first national programme of $20 million, prioritising 56 at-risk glacial lakes. The list has now been expanded to 195, categorised into four risk levels. Following the expected award of the 16th Finance Commission for the period FY2027 to FY2031, there are plans to scale up this programme, significantly.

Objectives of this programme are five-fold — hazard assessment of each at-risk lake; installing Automated Weather and Water Stations (AWWS); establishing Early Warning Systems (EWS) downstream; mitigating risk by drawing down water levels or building flow through retention structures; and community engagement, an essential element of risk reduction. Under the programme, States where glacial lakes are resident were encouraged to take the lead in sending scientific expeditions to 40 of the highest at-risk lakes in the summer of 2024.

One of the critical parameters in the exercise was to encourage Indian technology, systems and scientific expertise, one of which is the science of SAR interferometry — the art of analysing micro-changes in slope stability (upto a centimetre) using remote sensing satellite imagery as high as 10-metre resolution. The near-absence of usage of this scientific method to predict GLOFs and landslides is an identified gap that needs to be plugged through this programme. Another significant gap is the absence of well-resourced Indian foundations and innovative technology providers in the business of risk reduction in the Himalayan cryosphere.

What is status of mitigation efforts?

Several multi-institutional expeditions returned with success stories, across J&K, Ladakh, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh with a couple of light-hearted tales for their archives. One such expedition lost its way in bad weather, and another had to leave behind an expedition member in the village as security so that the rest of the expedition did not pollute the sacred lake by entering its holy waters. These episodes were evidence of the critical need for community engagement, to integrate the local community in expeditions and the need to convince residents of the credibility and sincerity of the exercise.

The successful expeditions conducted bathymetry to assess the volume of water in the lakes; used Electrical Resistivity Tomography (ERT) to understand the existence of ice-cores under moraine-dams, a key reason for dam breaks; and performed UAV and slope surveys of surrounding land/ice forms. Monitoring stations were installed at two lakes in Sikkim, which relay weather and water data every 10 minutes, with a daily dose of pictures of both ends of the lake and its shoreline. In subsequent summers, States will be installing more such systems, thereby overcoming an oft-repeated data-gap in the IHR cryosphere. In the absence of automated early warning mechanisms, Indo Tibetan Border Police (ITBP) deployments in high reaches have been oriented towards the role of manual early warning. After the monsoon this year, States/UTs are gearing up for another round of expeditions.

Safi Ahsan Rizvi is an IPS officer and adviser to the NDMA.

Published – July 28, 2025 08:30 am IST