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IN THE SIKKIM FLOOD'S WAKE, A TRAIL OF HAZARDS LIE IN WAIT

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Views of South Lhonak Lake before (top) and after it burst its banks on October 3, 2023. | Photo Credit: Maxar/Reuters

The South Lhonak lake in the Himalayan state of Sikkim breached on the night of October 3, resulting in a glacial lake outburst flood (GLOF) that ravaged four districts. At least 42 people died as a result and 77 more are still missing. More than a month after the disaster, the lake remains a potential hazard, say scientists.

The South Lhonak lake is located in North Sikkim, at an altitude of 5,200 m. According to scientists, the current interpretation of the flood – which relies heavily on satellite data – suggests that on October 3 night, a slope failure occurred along the lateral moraine (a mass of debris and rocks) on the lake's left bank. Preliminary research found that some of the landslide material scraped the glacier terminus; most of it hit the lake, creating an impulse wave that moved towards the lake's narrow front end.

An annotated collage explaining the cause of the South Lhonak Lake flood. | Photo Credit: Sentinel Hub (collage and annotation by Ashim Sattar)

It widened the lake's outlet, resulting in a partial breach, said Ashim Sattar, a mountain hazard specialist who is currently studying the GLOF and has authored research articles predicting different GLOF scenarios for the South Lhonak lake. There was also a probable overtopping as water moved over the moraine along the lake's outlet. The result was a GLOF that affected around 88,400 people in Sikkim's Mangan, Gangtok, Pakyong, and Namchi districts.

The lake is one of the largest and fastest growing glacial lakes in Sikkim, and has been a potential hazard for several years now. Dan Shugar, a geomorphologist from the University of Calgary in Canada, who is currently conducting research on the GLOF, noted that before the flood, the lake's area was 1.62 sq. km, and after water being drained out in the GLOF, the area dropped to 1.46 sq. km.

Dr. Sattar said, "While the lake level was lowered due to the flood, it did not drain completely. A lot of water still remains in the lake, making it a potential hazard."

Adding to the existing hazard, weeks after the disaster, there have been continuous landslides along the slope that first failed on October 3, Dr. Shugar added.

When the flood gushed through the valley, it triggered a landslide about 30 km downstream of the South Lhonak lake, which blocked the river, forming a landslide-dammed lake. After reviewing satellite images, Dr. Sattar surmised that the lake had not drained even by November 1.

Considering the risk of sudden release of water downstream, it requires monitoring.

The Sikkim government has been claiming that the GLOF was triggered by a cloudburst. In fact, Sikkim State Disaster Management Authority's daily reports on deaths and damages continue to call the flood "cloudburst induced". The National Disaster Management Authority's October 4 press release also called the event a "likely combination of excess rainfall and a GLOF".

However, according to G.N. Raha, who heads the Meteorological Centre in Gangtok, the possibility of either a cloudburst or extreme rainfall triggering the GLOF is very low. The 10 weather stations across North Sikkim recorded light-to-moderate rainfall for the period of the GLOF, Dr. Raha said.

On the morning of October 4, the station at Lachen, almost 46 km from the South Lhonak lake, recorded only 6.7 mm rainfall for 24 hours, he said. However, scientists continue to analyse meteorological data for accurate information regarding the role of rainfall in the GLOF.

Researchers are also currently checking whether earthquake tremors could have triggered the GLOF.

The disaster downstream of the lake was not caused solely by the GLOF, but by a cascade of several events.

One of the most affected places was Chungthang, a town around 62 km from the lake, where the dam of Sikkim's biggest hydropower project – the 1,200-MW Teesta-III – broke. Water from the damaged reservoir combined with the GLOF, leading to even more destruction downstream of the dam.

While the reservoir's gross storage capacity was 5.08 million cubic metres, the volume of water stored in it at the time of the disaster is currently not known. Further downstream of the Teesta-III dam, two more hydropower projects were damaged: the 510-MW Teesta-V and the 500-MW Teesta-VI that is under construction.

"In the Teesta Basin, where GLOFs are evident, placing mega-dams was a bad decision," said Mayalmit Lepcha, an activist associated with the Affected Citizens of Teesta (ACT), a collective of Sikkim's citizens protesting against harmful dams on the Teesta river for more than a decade and a half. The lack of early warning also proved to be detrimental, she said.

Maximillian Van Wyk de Vries, an assistant professor of physical geography at the University of Nottingham, U.K., said that at the South Lhonak lake, a large section of the lateral moraine was "moving for many years preceding the collapse, at a rate of several metres per year".

Prior analysis of a possible landslide, which can be inferred using satellite imagery, would have guided glacial lake management efforts and infrastructure planning in the Teesta Basin, he said.

On October 13, the Indian Space Research Organisation's (ISRO) National Remote Sensing Centre published satellite images showing a large deposit of sediments and several landslides along the path of the flood, especially in and around the Chungthang dam. The loose sediment may pose a threat to downstream areas in future, said Kalachand Sain, Director of the Dehradun-based Wadia Institute of Himalayan Geology.

In view of the many hydropower-related dams in the Teesta Basin, the large amount of loose sediment that can easily be eroded by heavy water flow may imply a shorter lifespan for dams and lower efficiency for hydropower projects, scientists said.

In the South Lhonak glacier, the signs of climate change emerged decades ago and became stronger as the rate at which the glacier melted increased, resulting in a rapidly growing lake that was bound to breach – as several research studies stated. In 1990, the South Lhonak glacier was 6.4 km long. A research article published in 2021 found that, by 2019, it had reduced by about 1.3 km and that its area had declined by about 0.96 sq. km.

In 1976, the South Lhonak lake area was a mere 0.20 sq. km, according to a research article published in 2018. As the glacier shrank, the lake grew larger. By 2019, the lake was covering 1.35 sq. km, per the 2021 article.

South Lhonak lake has been rapidly growing in size | Photo Credit: Kavita Upadhyay and research articles

GLOFs are natural, but the rapid increase in the lake's size as a result of the glacier's accelerated melting tied closely to anthropogenic climate warming, said Dr. VWDV (as he prefers his last name) of the University of Nottingham.

Anil V. Kulkarni, Distinguished Scientist at the Bengaluru-based Indian Institute of Science's Divecha Centre for Climate Change, said, "The lake's rapid expansion might have weakened the permafrost that was holding the moraines, which would have been one of the important reasons behind slope failure on October 3."

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