

Glacial Lake Outburst Floods (GLOFs) in the Nepal Himalayas: Recent events, urgent response, and global actions for cryospheric science

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DOI: <https://doi.org/10.3126/jtha.v7i1.80915>

Abstract

The Nepal Himalayas are experiencing an unprecedented rise in cryosphere-induced hazards, especially Glacial Lake Outburst Floods (GLOFs), as a result of rapid glacial retreat driven by anthropogenic climate change. Between 2024 and 2025, three major GLOF events, the Birendra Lake flood (April 2024), the Thame GLOF (August 2024), and the Limi Valley GLOF (May 2025) demonstrated the escalating frequency and intensity of such disasters. These events pose serious threats not only to vulnerable mountain communities and local biodiversity but also to globally significant mountain ecosystems, including the Sagarmatha National Park, a UNESCO World Heritage Site. This paper provides a comprehensive analysis of these recent events, identifies critical gaps in monitoring, preparedness, and response, and highlights the urgent need for improved integration of cryospheric science with local adaptation and international cooperation. By linking Nepal's experience with global frameworks like the International Year of Glacier Preservation (YIGP-2025) and the UN Decade of Action for Cryospheric Sciences (2025–2034), this study contributes new insights into the pathways for achieving equitable, science-driven, and community-based climate resilience.

Keywords: climate change, cryosphere, disaster risk reduction, GLOFs, glacier preservation

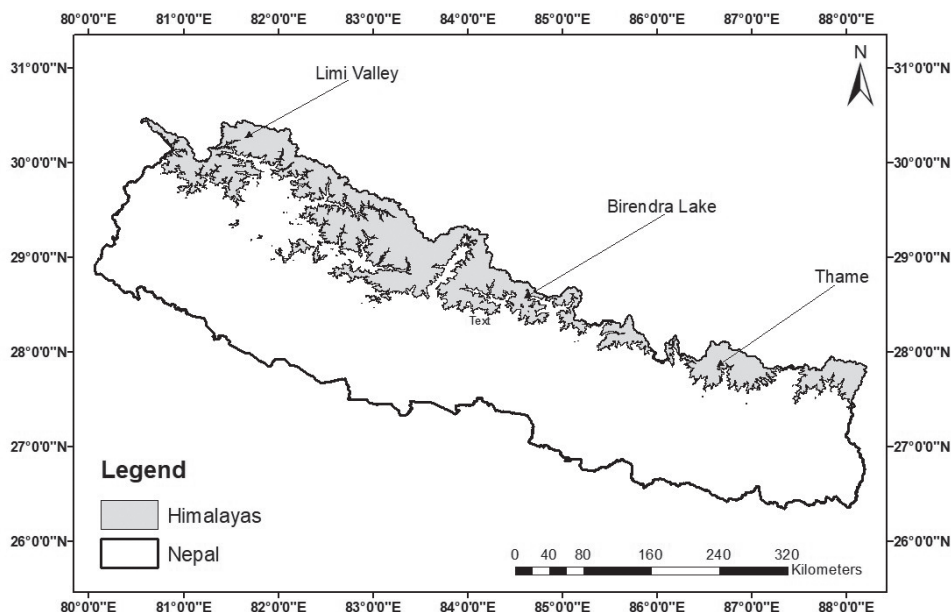
Introduction

The Himalayas, often referred to as the “Third Pole” due to their massive ice reserves, are a vital component of the global hydrological and climate systems. These high-altitude regions store freshwater that sustains the lives of nearly two billion people downstream (Chandrashekhar, 2020; UN-Water & UNESCO, 2025). However, warming rates in the Himalayas have outpaced global averages, resulting in glacial retreat, permafrost degradation, and the rapid expansion of glacial lakes (ICIMOD & UNDP, 2020).

The increasing risk of GLOFs, a sudden discharge of water from glacial lakes, has emerged as a critical concern for disaster risk reduction (DRR) and climate adaptation. Nepal, with over 3,000 glacial lakes (ICIMOD & UNDP, 2020), is particularly vulnerable. This paper examines three recent high-impact events and connects them to broader national and international responses in science, policy, and community-based action. Figure 1 presents a map of Nepal, highlighting the Himalayan region and the specific areas where the three significant cryosphere-induced events occurred.

Figure 1

Map of Nepal showing the Himalayan region and the locations of three recent high-impact GLOF events



Recent cryosphere-induced events in Nepal

Birendra lake flood (April 2024)

Birendra Lake, located in the Manaslu region of Gorkha District, is a moraine-dammed lake fed by the Manaslu Glacier. On 21 April 2024, an avalanche event triggered a partial lake outburst. Within 20 minutes, the Budhi Gandaki River surged by 69 cm at the Ghap hydrological station (Chaulagain et al., 2024, Khadka et al., 2025, Maharjan et al., 2024). Although there were no fatalities, the flood disrupted livelihoods and emphasized the vulnerability of even relatively small glacial lakes.

This event underscored a critical gap in the early warning systems (EWS) for avalanche-induced floods, revealing the urgent need for improved cryospheric hazard modeling and real-time monitoring in high-risk zones.

Thame GLOF (August 2024)

On 16 August 2024, a GLOF originating from the Thame glacial lake caused extensive damage in the upper Khumbu region, within Sagarmatha National Park. Over 200 households were affected, and several trekking routes and biodiversity corridors were severely damaged (Pradhananga, 2024). As the area is part of a UNESCO World Heritage Site, the event raised global concern regarding the impacts of climate change on heritage and conservation areas.

Subsequently, a rapid response project titled Thame GLOF 2024: A Rapid Response for Biodiversity Conservation of the Sagarmatha National Park was proposed to assess ecological damages and implement mitigation measures (Pradhananga, 2024).

Limi valley GLOF (May 2025)

On 15 May 2025, a catastrophic GLOF struck the Limi Valley of Humla district, one of the most remote regions in northwestern Nepal. The flood displaced dozens of households and caused severe damage to the Tilkhola micro-hydropower project, irrigation canals, residence structures, and even the local monastery (Shahi, 2025). Compounding the crisis, damaged roads and landslides cut off access to the area, delaying the arrival of relief materials by over a week. This event occurred shortly before the Sagarmatha Sambaad, an international dialogue held from 16 to 18 May 2025 in Kathmandu, which brought heightened global attention to the fragility of Himalayan communities (Sagarmatha Sambaad, 2025).

A global fundraising initiative (GoFundMe, 2025) quickly mobilized resources, but the event highlighted systemic issues in regional emergency preparedness and the need for resilient infrastructure in isolated mountain areas. This event underscores the cascading impacts of cryospheric change beyond the snow and ice itself, undermining essential services and forcing communities into unsafe conditions. It emphasizes the urgent need for integrated cryosphere monitoring and early-warning systems in remote Himalayan valleys.

Advances in monitoring and science

The growing urgency of recent GLOFs has sparked a coordinated, multi-stakeholder response involving universities, government bodies, NGOs, and international organizations. Key initiatives include:

- High-resolution hazard mapping using satellite imagery and UAV-based remote sensing,
- Participatory risk assessments are conducted at the community level,
- Enhancement of Early Warning Systems (EWS), and
- Promotion of nature-based solutions, such as afforestation and bioengineering.

These efforts are closely aligned with Nepal's National Adaptation Plan (NAP) and its DRR priorities under the Sendai Framework for Disaster Risk Reduction.

Evidence from Jumla in western Nepal, as featured in the publication "Voices of People" (Gurung et al., 2010), illustrates the stark transformations underway. Once characterized by consistent winter snow cover, the region has witnessed a steady decline in snowfall in recent years, posing serious threats to water availability, agriculture, and rural livelihoods.

Policy engagement and community participation

A key driver of this cross-sectoral effort has been the UNESCO Chair in Mountain Water Sustainability (University of Calgary, 2025), working in partnership with Tribhuvan University, Kathmandu University, ICIMOD, and the Department of Hydrology and Meteorology (DHM). Their collaborative initiatives focus on bridging the science-policy interface while empowering communities to play active roles in adaptation planning.

On 21 March 2025, Nepal marked the first World Day of Glaciers during the National Glacier, Water, and Weather Week (NNGWW-2025). The event featured the launch of the UN World Water Development Report 2025, which underscored the vital role of glaciers as the planet's "water towers" (UN-Water & UNESCO, 2025). Discussions emphasized

inclusive climate action, particularly women's leadership in adaptation, with strong representation from grassroots organizations such as The Small Earth Nepal (2025a).

Looking ahead, upcoming forums like the International Conference on Glacier Preservation (Dushanbe ICGP, 29–31 May 2025) continue to foster international collaboration. One of the authors will present Nepal's experience and lessons learned from the GLOF events, advocating for greater investments in climate-resilient infrastructure in the Hindu Kush Himalaya region

Finally, the People's Forum on Sagarmatha Sambaad jointly convened by several organizations including The Small Earth Nepal (2025b), offered a critical platform for integrating community perspectives into national climate policy discourse. The forum played a key role in shaping Nepal's contributions to global climate frameworks, reinforcing the importance of locally grounded adaptation strategies.

Global significance: IYGP-2025 and the UN decade of action for cryospheric sciences (2025–2034)

In December 2023, the UN General Assembly adopted Resolution, declaring 2025 the International Year of Glacier Preservation (IYGP) (United Nations, 2023). This initiative recognizes the global implications of glacial melt, particularly in the Himalayas, Andes, and polar regions.

Additionally, the launch of the UN Decade of Action for Cryospheric Sciences (2025–2034) calls for long-term investment in glacier monitoring, improved climate models, and stronger linkages between high mountain science and water governance. As global average temperatures approach the 1.5°C threshold, rapid glacial loss will become irreversible in many regions (Yasunari et al., 2010; Gul et al., 2021).

Integrating local initiatives, like the Thame and Limi GLOF responses, into these global frameworks is essential for delivering equitable and actionable climate resilience.

Conclusion

The series of GLOF events in Nepal between 2024 and 2025 underscores the mounting risks posed by accelerating cryospheric change in the Himalayas. With glacial lakes growing rapidly, cryosphere-related hazards are becoming more frequent, devastating local communities, ecosystems, and critical infrastructure. The recent events clearly demonstrate that cryospheric risks are no longer isolated incidents but systemic threats requiring integrated, multi-level responses.

Moving forward, Nepal's experience highlights the need to:

- Scale up real-time monitoring of glaciers and glacial lakes using satellite and drone-based technologies,
- Institutionalize community-based disaster preparedness and local ownership of adaptation strategies,
- Strengthen transboundary and regional cooperation across the Hindu Kush Himalaya,
- Integrate cryospheric science in both national climate strategies and global climate negotiations, and

- Accelerate international collaboration through initiatives such as the IYGP2025 and the UN Decade of Action for Cryospheric Sciences (2025–2034).

As a frontline country in the global cryospheric crisis, Nepal has a critical role to play in advancing scientific knowledge, advocating for vulnerable mountain populations, and contributing to global action for glacier preservation. Protecting the resilience of mountain communities today is essential for safeguarding freshwater resources and human well-being for generations to come.

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