

Glacial Lake Outburst Floods (GLOFs)

Mains: GSIII – Disaster Management

Why in News?

3 years after the 2023 Sikkim GLOF, India has expanded monitoring of glacial lakes, but gaps remain in early-warning systems, last-mile preparedness, risk-sensitive infrastructure and community resilience.

What is a Glacial Lake Outburst Flood (GLOF)?

- **GLOF** – It occurs when a glacial lake suddenly releases a large volume of water.
- It can be triggered by landslides, avalanches, ice falls, earthquakes or failure of moraine dams.
- The sudden water release can cause flash floods, debris flows and landslides downstream.



Why is the GLOF Threat Increasing?

- **Climate Change** – Rising temperatures are causing glacier retreat and expansion of glacial lakes.
- Larger lakes increase the volume of water that can be suddenly released.
- **Fragile Himalayan Geography** – Steep slopes, unstable terrain and seismic activity

increase the vulnerability of Himalayan valleys.

- GLOFs can rapidly transform into landslides, mudflows and debris floods.
- **Increasing Human Intervention** - Hydropower projects, roads, dams and settlements in fragile valleys can increase exposure to GLOF hazards.
- Infrastructure located along river valleys faces particularly high risks.
- **Growing Exposure** - Himalayan communities depend heavily on agriculture, tourism, hydropower and river systems.
- Thus, a GLOF can simultaneously affect lives, livelihoods and critical infrastructure.

Impact of the 2023 Sikkim GLOF

- **Human Impact** - The October 2023 GLOF affected around 80,000 people across 100 villages.
 - It officially resulted in 55 deaths, 74 missing persons and 7,025 displaced people.
- **Infrastructure** - The disaster damaged bridges, roads, buildings, agricultural land and hydropower infrastructure.
 - The Teesta III hydropower dam at Chungthang was severely affected.
- **Economic Impact** - The estimated damage and losses were around ₹1,480 crore across social, agricultural, tourism and infrastructure sectors.
- **Significance** - The Sikkim disaster demonstrated how a high-altitude hazard can generate cascading impacts across downstream regions.

What is the GLOF Risk in the Himalayan Region?

- **Hindu Kush Himalaya (HKH) Vulnerability** -
 - The HKH region covers eight countries and is a major GLOF hotspot.
 - Poverty, dependence on agriculture, rapid population growth and inadequate disaster-management infrastructure increase vulnerability.
 - Limited early-warning coverage leaves millions of people exposed.
- **India's Vulnerability** -
 - India has experienced several GLOF events across the Himalayan region.
 - GLOFs pose risks to Sikkim, Arunachal Pradesh, Himachal Pradesh and Uttarakhand, among other Himalayan areas.
 - Many settlements and infrastructure projects are located in downstream valleys, increasing exposure.

How is India Strengthening GLOF Monitoring?

- **Expansion of Glacial Lake Mapping** - The CWC and NRSC have progressively expanded monitoring of glacial lakes and waterbodies.
 - NRSC's 2023 inventory identified 28,043 glacial lakes larger than 0.25 hectares.
 - By June 2025, CWC was monitoring 2,485 glacial lakes and 358 waterbodies across Indian Himalayan river basins.
- **National Glacial Lake Outburst Flood Risk Mitigation Project (NGRMP)** - The Union government approved ₹150 crore for Arunachal Pradesh, Himachal Pradesh, Sikkim and Uttarakhand under the NGRMP.
- It focuses on
 - Early-warning systems.
 - Real-time remote-sensing monitoring.
 - Controlled drainage of high-risk lakes.

- Strengthening lake boundaries.
- Automatic weather stations.
- GLOF-resilient infrastructure.

What are the Major Challenges in GLOF Management?

- **Early-Warning Gaps** – Many vulnerable locations still lack real-time monitoring and last-mile warning systems.
- **Difficult Himalayan Terrain** – Remote and inaccessible terrain makes installation and maintenance of monitoring infrastructure difficult.
- **Limited Community Preparedness** – Warnings are useful only when communities know when, where and how to evacuate.
- **Infrastructure Vulnerability** – Roads, bridges, dams and settlements in river valleys can become major points of damage during GLOFs.
- **Development-Ecology Conflict** – Hydropower, tourism and road construction can increase exposure when development is not aligned with carrying capacity and hazard assessment.
- **Data and Research Gaps** – Limited long-term data on glacial lakes, past GLOFs, losses and changing risk patterns can weaken policy planning.
- **Transboundary Nature** – Himalayan river systems cross national boundaries, requiring regional cooperation on monitoring, data-sharing and disaster warnings.

What May be the Way Forward?

- **Strengthen Early-Warning Systems** – Expand real-time lake monitoring, automatic weather stations and downstream sensors.
- Establish reliable last-mile warning mechanisms reaching every vulnerable community.
 - Adopt Community-Based Disaster Management
 - Prepare village-level evacuation plans.
 - Conduct regular mock drills and Train disaster-response teams.
 - Use local languages and accessible communication systems.
 - Implement Risk-Sensitive Land-Use Planning
 - Map GLOF hazard zones.
 - Restrict hotels, settlements and critical infrastructure in high-risk areas.
 - Integrate GLOF risk into local development plans.
- **Build Climate-Resilient Infrastructure** – Design bridges, roads, dams and hydropower projects according to GLOF and cascading hazard assessments.
 - Strengthen vulnerable downstream infrastructure.
- **Improve Science and Technology** – Use satellite imagery, remote sensing, AI and predictive modelling for risk assessment.
 - Develop a comprehensive national database covering GLOF frequency, lake characteristics, damage and fatalities.
- **Strengthen Centre-State Coordination** – Ensure coordination among CWC, NRSC, NDMA, State Disaster Management Authorities and district administrations.
 - Combine national monitoring with local preparedness.
- **Promote Regional Cooperation** – Strengthen information-sharing among Himalayan

countries.

- Develop mechanisms for transboundary early warnings and disaster-risk reduction.

What lies ahead?

- GLOFs demonstrate the growing interaction between climate change, fragile ecosystems and infrastructure vulnerability.
- India's response must therefore move from post-disaster relief to anticipatory and community-based resilience.
- A combination of scientific monitoring, early warnings, risk-sensitive development, resilient infrastructure and empowered local communities is essential to protect lives and livelihoods in the Himalayan region.

Reference

[Down To Earth| India's GLOF threat is growing](#)

