



Mains Practice Question

Q. Explain the causes of increasing occurrences of glacial lake outburst floods (GLOFs) in the Himalayas. Suggest strategies for mitigation and early warning systems. **(250 words)**

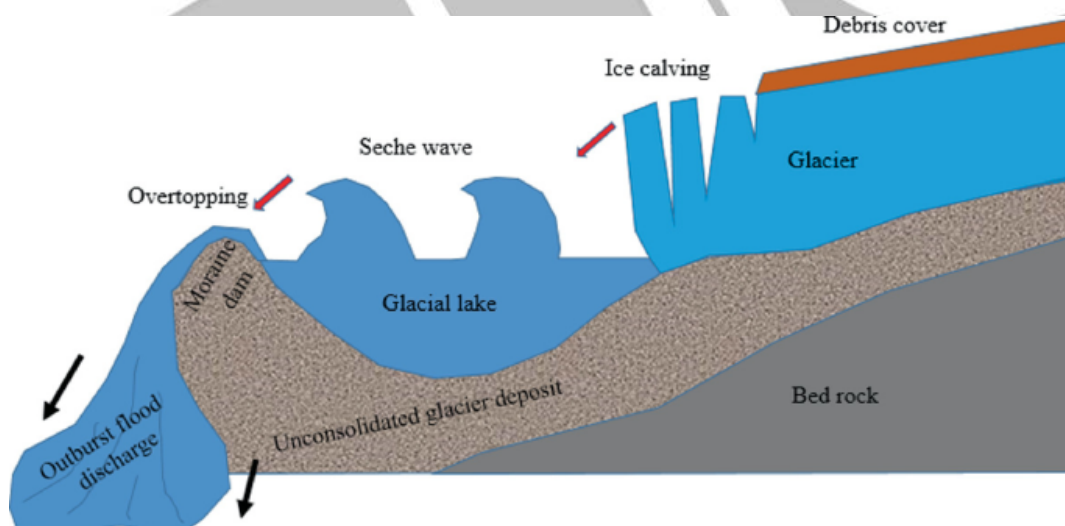
03 Mar, 2025 GS Paper 1 Geography

Approach

- Introduce the answer by briefing about the Glacial Lake Outburst Floods
- Give Causes of Increasing GLOFs in the Himalayas
- Suggest Mitigation Strategies and Early Warning Systems
- Conclude suitably.

Introduction

Glacial Lake Outburst Floods (GLOFs) refer to the **sudden release of meltwater from glacial lakes** due to the failure of natural dams, such as **moraines or ice barriers**. The Himalayan region, home to **thousands of glacial lakes**, is witnessing an increase in GLOFs occurrences due to **climate change, geological instability, and anthropogenic activities**.



Body

Causes of Increasing GLOFs in the Himalayas:

- **Climate Change and Rising Temperatures**
 - Global warming has led to accelerated glacial melting, increasing the number and volume of glacial lakes.
 - The Central Water Commission (CWC) reported a **33.7% increase in glacial lake area in India (2011-2024)**, indicating a higher risk of outbursts.

- **Moraine and Ice Dam Instability**

- Many glacial lakes are dammed by loosely packed moraines, which are inherently unstable.
 - Rising water levels increase hydrostatic pressure, making moraine dams prone to failure.
- **Example: South Lhonak GLOF (2023) in Sikkim**, where moraine dam instability led to catastrophic flooding.

- **Increased Frequency of Avalanches and Landslides**

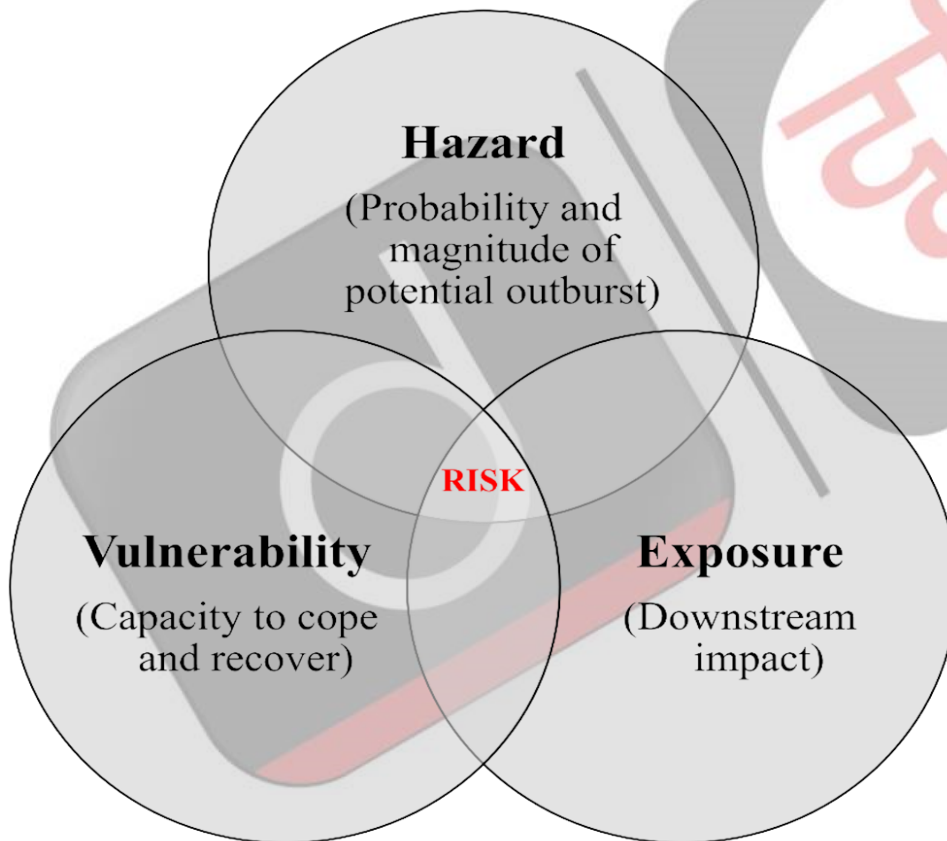
- Melting permafrost and changing precipitation patterns are causing more **rockfalls, ice calving, and landslides**, which can displace large volumes of water, triggering GLOFs.
 - **Example: Dig Tsho Lake GLOF (1985) in Nepal**, where an ice avalanche caused a lake breach, destroying infrastructure.

- **Seismic and Tectonic Activity**

- The Himalayan region is seismically active, and earthquakes can trigger landslides into glacial lakes, causing sudden water displacement.
 - **Example: 2015 Nepal Earthquake**, which increased the risk of glacial lake breaches in the region.

- **Anthropogenic Factors**

- **Unregulated construction** of roads, hydropower projects, and urban settlements increases exposure to GLOFs risks.
- **Deforestation and mining** weaken slope stability, increasing susceptibility to landslides and moraine erosion.
 - **Example: Teesta III Dam destruction (2023) due to a GLOF in Sikkim** highlights the vulnerability of infrastructure.



GLOF risk = Hazard x Exposure x Vulnerability

- **Mitigation Strategies and Early Warning Systems:**

- **Structural Measures**

- **Artificial Drainage of Glacial Lakes**
 - Controlled lowering of lake water levels through **siphoning, spillways, or tunnels** reduces flood risks.
- **Reinforcement of Moraine Dams**

- Strengthening natural dams with **geo-engineering solutions**, such as concrete structures and vegetation, enhances stability.
- **Building GOLF-Resistant Infrastructure**
 - Designing **hydropower plants, bridges, and settlements at safer elevations** and reinforcing embankments can minimize damage.
- **Non-Structural Measures**
 - **Early Warning Systems (EWS)**
 - **Real-time monitoring using remote sensing, satellite imagery, and automated sensors** to detect lake expansion and instability.
 - Installation of **automated sirens and community-based alerts** for downstream populations.
 - **Glacial Lake Hazard Zonation and Risk Mapping**
 - Mapping high-risk lakes using **GIS and remote sensing** to identify vulnerable regions.
 - CWC has identified **67 high-risk lakes in India**, focusing on Ladakh, Uttarakhand, Himachal Pradesh, Sikkim, and Arunachal Pradesh, it is a significant step in the right direction.
 - **Community Awareness and Disaster Preparedness**
 - Training local communities in **evacuation drills, emergency response, and adaptive strategies**.

Conclusion

A multi-pronged approach combining climate adaptation, engineering solutions, and early warning systems building upon UNESCO Climate Change and Mountain Ecosystem Programme is crucial to mitigate risks posed by GLOFs. Strengthening regional cooperation (India, Nepal, Bhutan, China) for data sharing and disaster response will enhance resilience in the region.

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