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

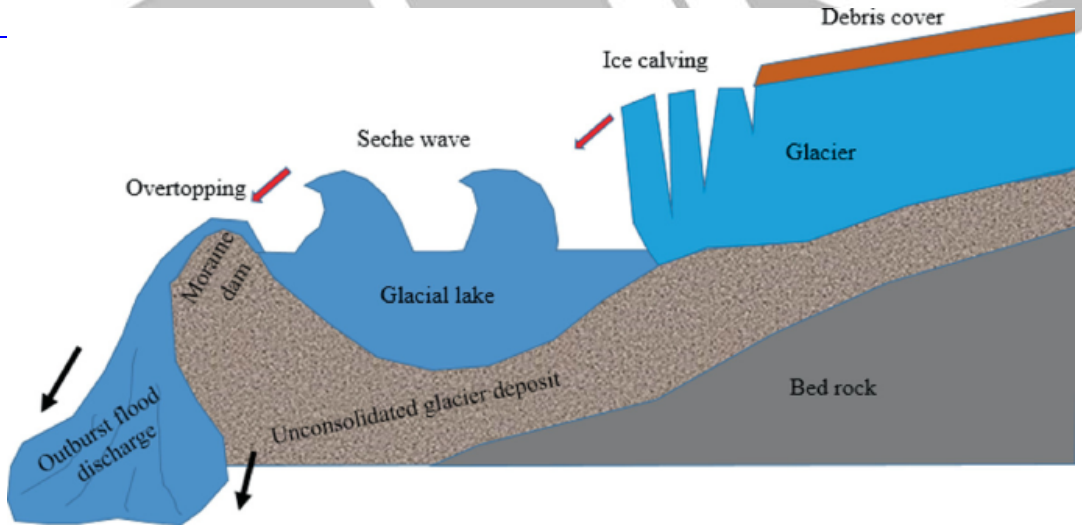
Approach

- 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.**

//



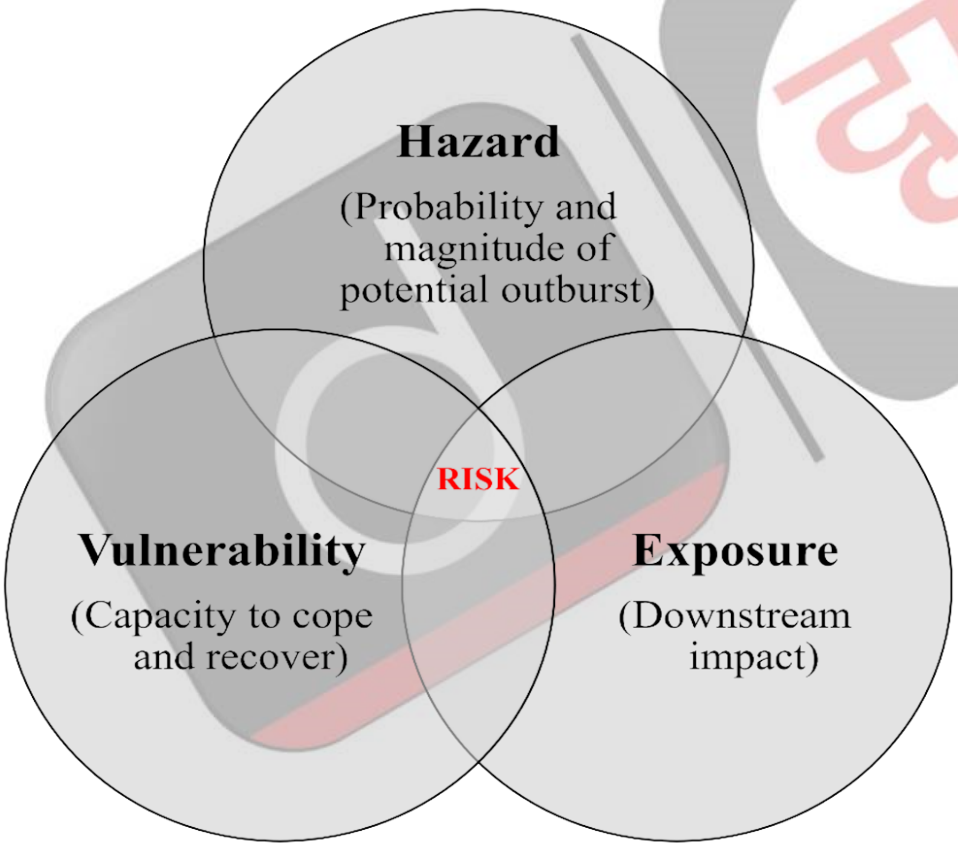
Body

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 r**egional cooperation (India, Nepal, Bhutan, China)** for data sharing and disaster response will enhance resilience in the region.