Mitigating Flood and Landslide Risks

For Prelims: **Monsoon**, **Himalayas**, **Cloudbursts**, **Moraines**, **Glacial Lake Outburst Floods**.

For Mains: Factors Contributing to Flood and Landslide Vulnerability in Hilly Areas and Measures for Mitigation.

Source: IE

Why in News?

The current **monsoon** has brought unusually **intense rainfall** to **hilly states** such as **Uttarakhand** and **Himachal Pradesh**, exacerbating the incidence of **landslides** and pushing **river systems** to **perilous levels**, thereby heightening risks to both **lives** and **infrastructure**.

What Factors Increase the Vulnerability of Hilly Regions to Floods and Landslides?

- **Steep Slopes and Gravity:** Water flows down **steep slopes** much faster than on flat land, preventing **infiltration**. This causes water to quickly accumulate in **streams and rivers**, leading to **rapid-onset flash floods**.
    - For instance, landslides in **Mandi, Kullu, Dharali, Tharali, and Jammu.**
- **Geology and Soil Type:** Many **young mountain ranges** (like the **Himalayas**) are **geologically active** and made of **fractured, weak, or weathered rocks** that are easily dislodged.
    - **Mountain soils** are often thin and lack **deep root systems**, making them prone to being washed away.
        - Frequent **landslides** in **Darjeeling** and **Sikkim** are due to **weak rock formations** and **fragile soils**.
- **Hydrological Factors:** A **valley** funnels **rainfall** into a narrow **stream or river**, and the **steep gradient** with **high energy flow** gives water strong **erosive power**, which erodes **riverbanks and slopes**, making **floods** worse.
    - For instance, **Alaknanda** and **Mandakini river valleys** in **Uttarakhand** frequently witness **flash floods.**
- **Trigger Factors:** Continuous **rain** or intense **cloudbursts** **saturate soil**, reduce **friction**, and trigger **landslides**, **flash floods**, and **debris flows.**
    - Sudden **temperature rise** or **rain on snow** causes **snowmelt**, releasing large **water volumes**, saturating the ground, and flooding **streams.**
    - E.g., For the season (June-September 2025), the **northwestern region** has **received more than 30% surplus rainfall.**
- **Human-Induced Factors: Road cutting, construction on steep slopes, blocked natural drainage, unsustainable agriculture, and overgrazing destabilize slopes, increasing the risk of landslide.**
    - The **Joshimath land subsidence (2023)**, linked to **unregulated construction**,

highlights **human-induced vulnerability**.

How does Climate Change Increase Flood and Landslide Vulnerability?

- **Increased Extreme Rainfall Events:** A **warmer atmosphere** holds more **moisture (≈7% per 1°C),** causing intense **rainfall** and **cloudbursts**, which trigger **flash floods** as the ground cannot absorb water fast enough, overwhelming **streams and rivers**.
    - **Climate change** disrupts **monsoon patterns**, causing droughts followed by intense **rain**, where dry, hardened **soil** reduces absorption, increasing **runoff**, **flood**, and **erosion** risk.
- **Glacial Lake Outburst Floods (GLOFs):** Rising **temperatures** cause **glacier retreat** and the formation of **unstable lakes** dammed by **moraines**, which can breach in **GLOF events**, releasing massive **water and debris**, leading to **catastrophic flooding** downstream.
    - The **2023 South Lhonak GLOF (Sikkim)** destroyed the **Rs 16,000 crore Chungthang hydropower project**, caused **silting in the Teesta river**, and increased **downstream flood risk.**
- **Permafrost Thaw:** In **high-altitude hilly regions**, rising **temperatures** thaw **permafrost**, causing slope **destabilization**, **rockfalls**, and **landslides**, which add debris to **rivers** and increase **flood risks**.
- **Increased Wildfires: Climate change** makes hilly areas hotter and drier, increasing **wildfires** that destroy **vegetation**, create **water-repellent soil**, and cause **fast-moving debris flows** when **rain** hits.
    - For instance, the **India State of Forest Report (ISFR) 2023** showed that **Uttarakhand** alone recorded **5,351 forest fire incidents** between **November 2022 and June 2023.**

NDMA Guidelines on Flood Management

- **Structural Measures**
    - **Diversion of Flood Water**: Use natural/artificial channels to reduce river water levels.
    - **Catchment Area Treatment/Afforestation**: **Watershed management**, **soil conservation**, **check dams**, **detention basins** to reduce flood peaks
    - **Embankments/Levees/Walls**: Prevent overflow; effective on **Yamuna near Delhi**.
    - **Drainage Improvement**: Restore natural drainage blocked by **roads/canals/railways**.
    - **Channel Improvement/Desilting/Dredging**: Increase discharge capacity, selective desilting at **outfalls/confluences**.
    - **Reservoirs/Dams/Water Storages**: Store excess floodwater.
- **Non-Structural Measures**
    - **Flood Management Plans (FMPs)**: Mandatory for all government departments/agencies.
    - **Flood Forecasting & Warning**: Based on **real-time discharge & rainfall data** from **CWC** and **IMD.**
    - **Flood Proofing**: Raised **platforms**, **utility installations**, **double-storey shelters** for safety.
    - **Integrated Water Resources Management (IWRM)**: Manage water at **basin/watershed scale**.
    - **Flood Plain Zoning**: Regulate land use; map areas as **extremely** or **partially affected zones**.

NDMA Guidelines on Landslides

- **Landslide Hazard Zonation:** Landslide Hazard Zonation maps should be prepared at **macro (1:50,000/25,000)** and **meso (1:10,000)** scales, using advanced tools like **UAVs**, **Terrestrial Laser Scanners**, and **high-resolution EO data**.
- **Early Warning System (LEWS):** An effective LEWS must include **rainfall threshold-based modelling**, **wireless instrumentation**, and **real-time monitoring** for both rainfall- and earthquake-triggered landslides.
- **Capacity Building & Training:** Capacity building requires a **Nationwide Training Need**

Assessment (TNA) in **Landslide Risk Management**, the use of **new technologies in training**, and a focus on **grassroots communities.**

- **Mountain Zone Regulations & Policies:** The strategy recommends **formulating and enforcing land-use policies**, updating **building regulations**, revising **BIS codes**, and including **hazard zoning provisions** in **town and country planning laws** to ensure safety in landslide-prone areas.

What Measures can be Adopted to Mitigate the Vulnerability of Regions to Floods and Landslides?

- **Environmental Measures: Afforestation and Reforestation** with native trees and **Van Panchayats** empower communities to bind **soil**, absorb **rainwater**, and protect **forests**.
    - **Contour trenching**, **terrace farming**, and **check dams** slow **runoff**, allow **infiltration**, trap **sediment**, and reduce **erosive power**.
- **Engineering Measures: Rock bolts, soil nails, retaining walls**, and **debris flow barriers/screens** stabilize slopes and prevent **rocks and debris** from reaching roads or settlements.
    - **Channel improvement, diversion channels**, and **sediment traps** increase river **capacity**, redirect **excess water**, and capture **silt and debris** to reduce **flood risk.**
    - **Urban flood resilience** can be enhanced through **proper drainage**, **sponge city models**, and **rainwater harvesting.**
- **Policy Measures: Enforce carrying capacity studies, stringent** land use planning**, and hazard zone identification to restrict construction on steep slopes, riverbeds, and floodplains, relocate vulnerable settlements, and implement stringent building codes.**
    - Develop robust early warning systems integrating weather forecasts, rainfall data, and river levels, and support them with community sirens and drills to ensure timely evacuation to safe zones.
- **Economic & Financial Measures:** Establish **dedicated disaster risk reduction budgets** for states and districts.
    - Shift to **Parametric Insurance Models** for quick payouts based on **rainfall/flood-level triggers** (avoiding lengthy claims).

Conclusion

Hilly regions are inherently vulnerable due to **steep slopes** and **fragile geology**. However, **human activities** like **unsustainable construction** and **deforestation** have severely amplified this risk. **Effective mitigation** requires an **integrated approach**, aligning with the **Sendai Framework for Disaster Risk Reduction (2015–30)**, by combining **stringent land-use policies**, **ecological restoration**, **engineering solutions**, and **community-based early warning systems.**

Drishti Mains Question:

Q. Critically analyse how geological fragility and human activities contribute to hydrometeorological disasters in Hilly Areas.

UPSC Civil Services Examination, Previous Year Questions (PYQs)

Mains

Q. Differentiate the causes of landslides in the Himalayan region and Western Ghats. (2021)

Q. The Himalayas are highly prone to landslides.” Discuss the causes and suggest suitable measures of mitigation. (2016)