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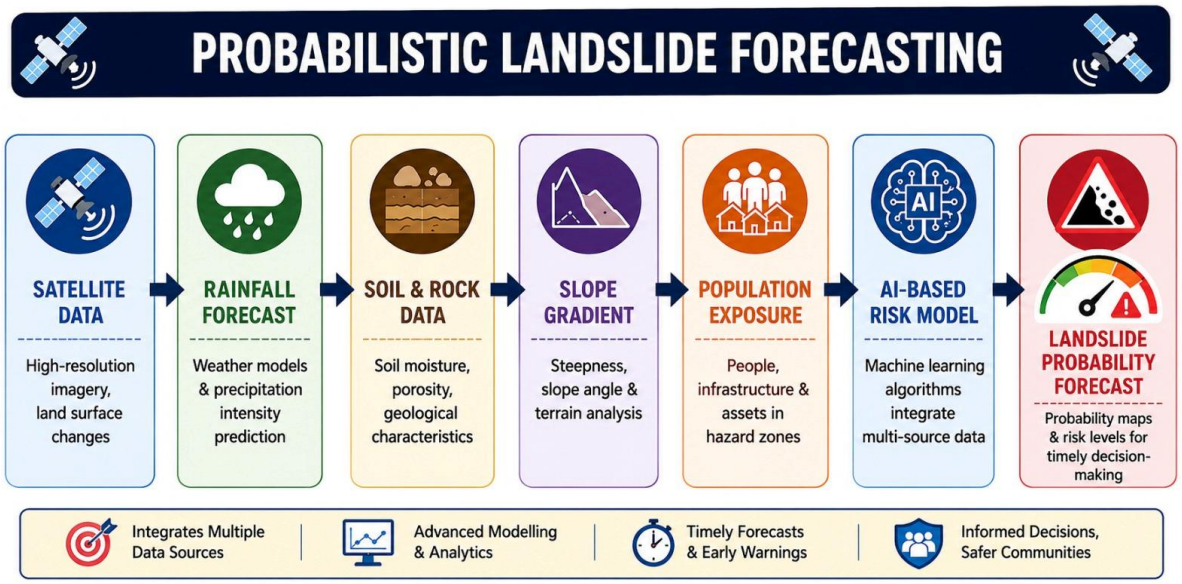
GS Paper III: Disaster Management

1. Landslide Early Warning Systems in India

a. Introduction

Recent landslides in the Western Ghats and other vulnerable regions have renewed attention on the need for Landslide Early Warning Systems (LEWS). These systems aim to minimise the loss of life and property by providing timely warnings that enable evacuation before a landslide occurs.

As climate change increases the frequency of extreme rainfall events, disaster management is increasingly shifting from post-disaster response to risk prediction and preparedness. This has made Landslide Early Warning Systems an essential component of disaster risk reduction.



b. How Landslide Early Warning Systems Work

India is developing two complementary approaches for landslide forecasting.

Sensor-Based Monitoring	Forecast-Based Modelling
Sensors such as tilt meters, pressure gauges and accelerometers continuously monitor slope movement in real time.	Uses satellite observations, rainfall forecasts and terrain characteristics to estimate the probability of landslides.
Warnings are issued when monitored parameters cross predefined safety thresholds.	Generates probabilistic forecasts for landslide-prone regions before extreme rainfall events.
Highly accurate for instrumented slopes.	Covers much larger geographical areas but depends on the accuracy of weather forecasts and modelling techniques.

These complementary approaches combine real-time monitoring with predictive modelling, thereby improving the effectiveness of landslide forecasting across diverse geographical settings.

c. Recent Developments

Recent advances in research and technology have strengthened India's capability to develop effective landslide forecasting systems.

- Amrita Vishwa Vidyapeetham has developed a sensor-based landslide warning system that successfully supported the evacuation of vulnerable communities during the 2024 Munnar landslides, demonstrating the practical value of real-time monitoring.
- Researchers at IIT Mandi have developed a probabilistic forecasting model integrating multiple datasets, including:
    - Satellite records of previous landslides.
    - High-resolution rainfall forecasts.
    - Soil characteristics.
    - Rock stability.
    - Slope gradient.
    - Population exposure.

This integrated approach improves the identification of areas facing the highest landslide risk and supports proactive disaster management.

These technological developments highlight the growing potential of early warning systems to reduce disaster risk. Their significance extends beyond forecasting to strengthening overall disaster resilience.

d. Significance of Landslide Early Warning Systems

- **Reducing Loss of Life:** Early warnings enable the timely evacuation of vulnerable populations, substantially reducing casualties and injuries during landslide events.
- **Promoting Proactive Disaster Management:** Landslide Early Warning Systems shift disaster management from a relief-oriented approach towards prevention, preparedness and risk reduction, making interventions more effective and cost-efficient.
- **Supporting Better Planning:** Accurate forecasts help district administrations identify vulnerable settlements, transport corridors and critical infrastructure, enabling the efficient deployment of emergency resources.
- **Enhancing Climate Resilience:** As extreme rainfall events become more frequent due to climate change, early warning systems strengthen the resilience of landslide-prone regions such as the Himalayas and the Western Ghats.
- **Enabling Risk-Informed Development:** Landslide forecasts support safer land-use planning and infrastructure development by identifying hazard-prone areas before major projects are undertaken.

Despite their transformative potential, developing reliable landslide forecasting systems remains scientifically and institutionally challenging.

e. Challenges

- **Complex Nature of Landslides:** Landslides are highly localised phenomena influenced by geology, rainfall intensity, soil properties, vegetation, slope characteristics and human activities. This complexity makes accurate prediction inherently difficult.
- **Limited Coverage of Sensor Networks:** Sensor-based systems provide highly reliable warnings only for instrumented slopes and require significant investment for installation, maintenance and continuous monitoring.
- **Dependence on Weather Forecasts:** Forecast-based models rely heavily on high-resolution rainfall predictions. Although forecasting capabilities have improved considerably, uncertainties remain, particularly during extreme weather events.
- **Institutional Coordination:** Effective early warning requires seamless coordination among scientific institutions, meteorological agencies and disaster management authorities. Such integration is still evolving across many States.
- **Infrastructure and Capacity Gaps:** Many landslide-prone districts lack adequate monitoring infrastructure, communication systems, trained personnel and community preparedness mechanisms necessary for effective early warning.

Overcoming these challenges requires an integrated national strategy that combines scientific innovation with institutional coordination and community participation.

f. Way Forward

- Establish a National Landslide Early Warning System (NLEWS) integrating the capabilities of the India Meteorological Department (IMD), Geological Survey of India (GSI), Indian Space Research Organisation (ISRO), National Disaster Management Authority (NDMA) and State Disaster Management Authorities (SDMAs).
- Expand high-resolution weather forecasting, satellite observations and real-time geospatial monitoring to improve forecasting accuracy.
- Install sensor-based monitoring systems at identified landslide hotspots, particularly along vulnerable mountain roads, densely populated settlements and critical infrastructure.
- Strengthen community-based early warning mechanisms through regular evacuation drills, awareness campaigns and last-mile communication systems to ensure timely public response.
- Integrate landslide susceptibility mapping and forecasting into district disaster management plans, land-use planning, infrastructure development and environmental impact assessments, ensuring that disaster risk reduction becomes an integral component of sustainable development.
- Encourage research, innovation and the use of Artificial Intelligence, machine learning and geospatial technologies to improve predictive capabilities and reduce forecasting uncertainties.

Conclusion

Landslide Early Warning Systems represent a crucial shift from reactive disaster response to proactive disaster risk reduction. By combining real-time monitoring, advanced forecasting models, institutional coordination and community preparedness, India can substantially reduce the human and economic costs of landslides. Integrating scientific innovation with sustainable development planning will be essential for building resilient mountain ecosystems in an era of increasing climate-induced hazards.

Reader's Note — About This Current Affairs Compilation

Dear Aspirant,

This document is part of the PrepAlpine Current Affairs Series — designed to bring clarity, structure, and precision to your daily UPSC learning.

While every effort has been made to balance depth with brevity, please keep the following in mind:

1. Orientation & Purpose

This compilation is curated primarily from the UPSC Mains perspective — with emphasis on conceptual clarity, analytical depth, and interlinkages across GS papers.

However, the PrepAlpine team is simultaneously developing a dedicated Prelims-focused Current Affairs Series, designed for:

- factual coverage
- data recall
- Prelims-style MCQs
- objective pattern analysis

This Prelims Edition will be released separately as a standalone publication.

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Some sections may feel shorter or longer depending on topic relevance and news density.
To fit your personal preference, you may freely resize or summarize sections using any LLM tool (ChatGPT, Gemini, Claude, etc.) at your convenience.

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The formatting combines:

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- lists
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