PLUTUS IAS

CURRENT AFFAIRS

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"UNDERSTANDING THE HIDDEN HAZARDS OF LANDSLIDES"

This article covers "**Daily Current Affairs**" and details the topic of **Landslide**: types: reasons, consequences, government initiatives, and measures.

Syllabus mapping: GS 3: Disaster Management: Various disasters and their management. GS1: Geography: Various geomorphological phenomena.

For Prelims:

What are the types of landslides and the terminology related to it?

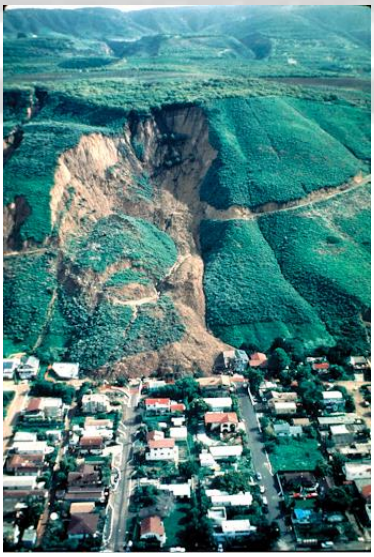
For Mains:

What is a landslide, what are its types, consequences, and initiatives of the government of India, and what measures need to be taken?

Why In News

Wayanad Landslides: Death toll rises to 157; Joint rescue & relief operations underway.

What is a Landslide?



A landslide is a geological phenomenon characterized by the downward movement of a mass of soil, rock, debris, or a combination thereof, along a slope due to the force of gravity. This movement can occur rapidly or gradually and is often triggered by natural and human-induced factors.

Terms and Parts of a Landslide

Head: The uppermost part of the landslide where the failure begins.

Crown: The area at the top of the landslide that is often characterized by a scarp or depression.

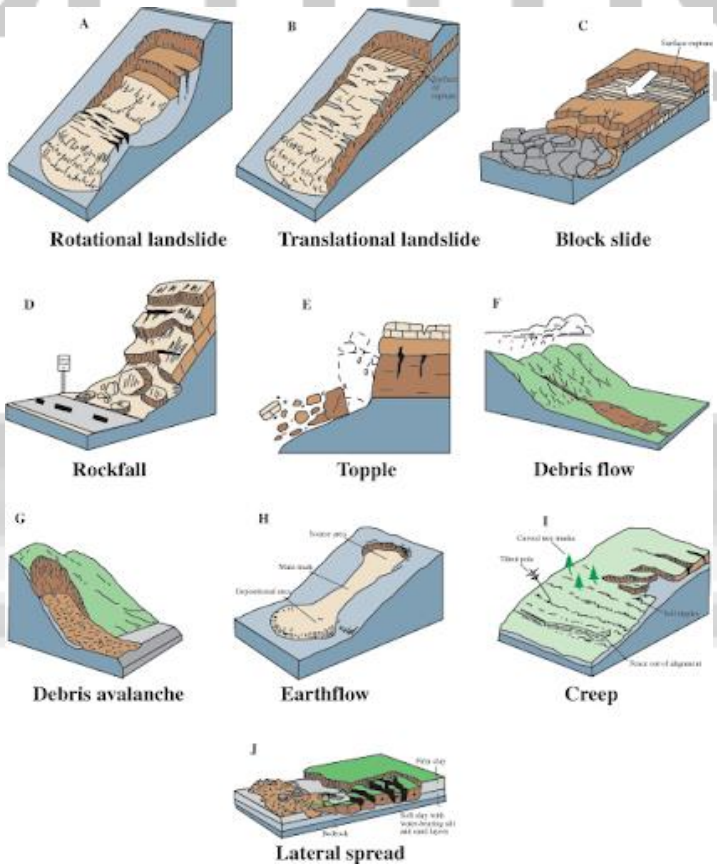
Body: The main mass of moving material that flows or slides down the slope.

Toe: The lowest part of the landslide where the material accumulates.

Scarp: The steep slope or cliff formed at the landslide's head.

Depositional Area: The region where the landslide material accumulates at the bottom.

Types of Landslides and Their Classifications:



By Material Type:

Rockfalls: Rapid falls of rock from steep cliffs or slopes.

Debris Flows: Fast-moving mixtures of water, soil, and rock that flow down slopes.

Earth Slides: Movements of soil and other materials that slide along a planar surface.

By Movement Mechanism:

Slides: Movement of a mass of soil or rock down a failure plane. Examples include rotational slides (slumps) and translational slides.

Falls: Free-fall or bouncing of rock or soil from a steep slope.

Flows: Movement of materials that behave like a fluid, such as debris flows and mudflows.

Creeps: Creeps refer to the gradual, slow movement of soil or rock down a slope.

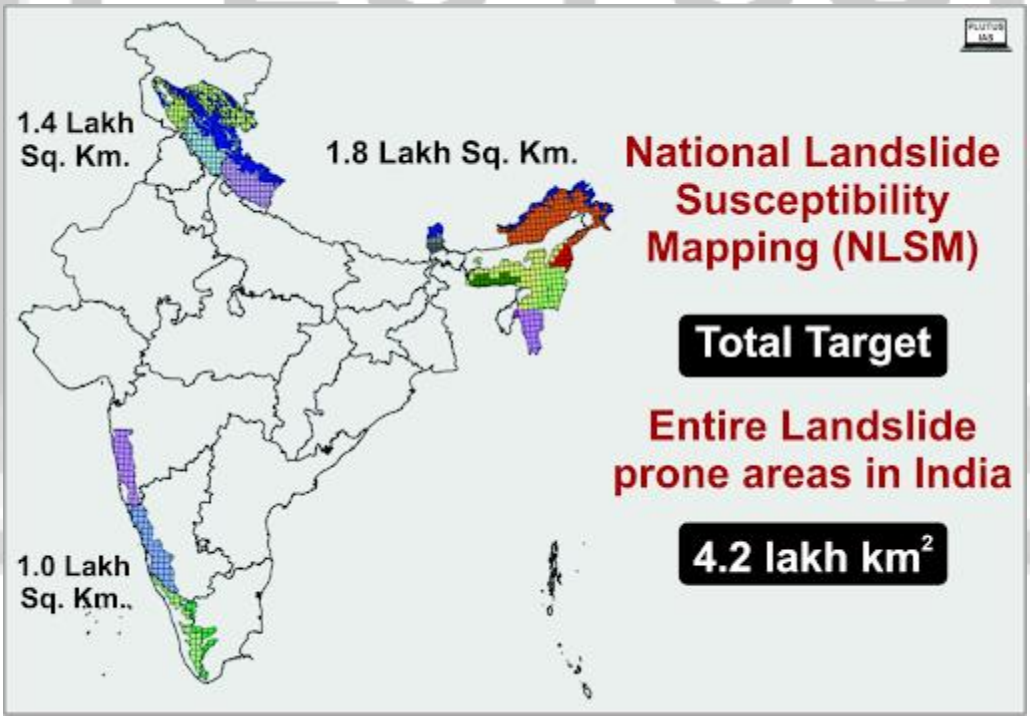
By Failure Type:

Rotational Slides (Slumps): Curved failure surfaces where the material moves downward and outward.

Translational Slides: Movement along a flat or planar surface, often involving a cohesive block of soil or rock.

Complex Landslides: Combinations of different types of landslides, such as a flow following a slide.

Landslide Vulnerability Map of India:



1. **The Himalayan region,** in particular, is highly susceptible to landslides due to its location in earthquake-prone zones (Zones IV and V) where earthquakes with Modified Mercalli intensity VIII to IX can occur.
2. **North East Himalayas** (including Darjeeling and Sikkim) 0.18 million sq. km area.
3. **North West Himalayas** (Uttarakhand, Himachal Pradesh, and Jammu & Kashmir) 0.14 million sq. km area.

4. **Western Ghats and Konkan Hills** (Tamil Nadu, Kerala, Karnataka, Goa, and Maharashtra) 0.09 million sq. km area is vulnerable.

5. **Eastern Ghats** (Araku area in Andhra Pradesh) 0.01 million sq. km is vulnerable to landslides.

FACTORS RESPONSIBLE FOR LANDSLIDE:

Natural Factors:

The three major natural triggers are **Water, Seismic Activity, and Volcanic Activity.**

Water

1. **Intense Rainfall**: Heavy rainfall increases the amount of water infiltrating the soil, leading to saturation. This reduces soil strength and increases the likelihood of slope failure.

2. **Snowmelt:** The melting of snow can rapidly increase water flow into soils, contributing to saturation and potential landslides.

3. **Ground-Water Level Changes:** Fluctuations in ground-water levels, due to seasonal changes or other factors, can destabilize slopes by altering soil moisture content.

4. **Surface-Water Changes:** Changes in water levels in lakes, reservoirs, canals, and rivers can lead to slope instability. For instance, rising water levels can saturate adjacent slopes or undercut banks.

5. **Flooding:** Flooding can contribute to landslides by eroding stream banks and saturating adjacent slopes. Debris flows and mudflows, often mistaken for floods, frequently occur in steep channels and can happen simultaneously with flooding.

6. **Tsunamis and Seiches**: Landslides occurring in bodies of water can generate tsunamis or seiches (waves in closed-water basins), potentially leading to significant flooding and damage.

Seismic Activity

1. **Earthquakes:** Earthquakes can trigger landslides by shaking the ground and destabilizing slopes. The seismic force can cause immediate slope failures or increase susceptibility to future landslides by weakening the soil structure.

2. **Direct Trigger:** The shaking of the ground during an earthquake can destabilize slopes, causing landslides. The shaking can disrupt the balance of soil and rock on a slope, leading to sudden slope failures.

3. **Loosening of Rock**: Earthquake shaking can loosen rocks and boulders, leading to rockfalls and rock topples. This is particularly common in areas with steep rock faces.

4. **Soil Liquefaction:** In areas with loose, water-saturated sediments, the shaking of an earthquake can cause these sediments to temporarily lose their strength and behave like a liquid. This process, known as liquefaction, can lead to significant ground deformation and landsliding.

5. **Soil Dilation:** The shaking of soil can cause it to expand or dilate, creating voids that allow for rapid infiltration of water. This increased moisture content can further destabilize slopes, leading to landslides.
6. **Lateral Spreading:** An example of a landslide type often associated with earthquakes is lateral spreading, where the ground moves laterally due to seismic forces.

Examples: Kedarnath Landslide (2013), Landslides in Sikkim (2011), Great Alaska Earthquake in 1964.

Volcanic Activity

1. **Volcanic Eruptions:** Volcanic activity can trigger landslides through various mechanisms.
2. **Lava Flows:** Lava flows can destabilize slopes by adding weight and altering terrain.
3. **Volcanic Ash:** Accumulation of volcanic ash can increase soil weight and reduce stability.
4. **Volcanic Debris:** Landslides can be triggered by the collapse of volcanic material, including pyroclastic flows.

Examples : Mount St. Helens, 1980, Krakatoa, Indonesia (1883) volcano caused landslides in Indonesia.

Anthropogenic factors:

Human activities significantly impact slope stability and can either directly or indirectly contribute to landslide occurrences.

Key Human Activities Contributing to Landslides

1. **Urban Development:** Urbanization often involves modifying natural drainage patterns, such as constructing roads, buildings, and other infrastructure. These changes can lead to increased surface runoff and reduced natural drainage, which can saturate slopes and trigger landslides.
2. **Vegetation Removal:** Clearing vegetation for construction reduces the natural reinforcement provided by plant roots, which helps stabilize soil. The removal of vegetation can lead to increased soil erosion and higher susceptibility to landslides.
3. **Oversteepening:** Excavating or grading activities can lead to the oversteepening of slopes. When the angle of a slope is increased beyond its natural stability, it can become prone to failure. Undercutting the base of a slope or adding significant weight to the top can also destabilize slopes.
4. **Loading of Slopes:** Adding structures or materials to the top of a slope increases the load, which may exceed the soil's bearing strength and lead to instability.

5. **Irrigation and Lawn Watering**: Excessive irrigation or lawn watering can increase soil moisture levels, potentially leading to slope saturation and instability. This is particularly problematic on steep slopes where water can quickly lead to landslide conditions.

6. **Reservoir Management:** The creation, draining, or mismanagement of reservoirs can affect slope stability. Rapid changes in water levels or the removal of water from reservoirs can alter the hydrostatic pressure on slopes, making them more prone to failure.

Examples: 1989 San Francisco-Oakland Earthquake, 2005 Leyte Landslide, Philippines, 2018 Montecito Mudslides, California:

EFFECTS AND CONSEQUENCES OF LANDSLIDES:

Effects of Landslides on the Built Environment

1. **Damage to Foundations and Utilities:** Landslides can destabilize or destroy the foundations of residential buildings, leading to partial or complete structural failure. Utility lines (sewer, water, electrical) may also be damaged, affecting the functionality and safety of the property.

2. **Business Disruption:** Landslides impacting commercial buildings can lead to significant economic losses, especially if the business is critical to the community, such as a grocery store or medical facility.

3. **Infrastructure Impact:** Like residential areas, commercial areas can experience damage to foundations, utilities, and access routes.

4. **Road and Rail Blockages**: Landslides often block roads and railways, disrupting transportation and causing delays in the movement of goods and people.

5. **Maintenance and Repairs:** Rockfalls and landslides can cause significant damage to roadways and railways, leading to expensive repairs and ongoing maintenance issues. **Disruption of Services:** Landslides can damage critical infrastructure such as water, sewage, and electrical lines, leading to service outages and potential public health risks.

Effects of Landslides on the Natural Environment

1. **Habitat Destruction:** Landslides can destroy natural habitats, leading to loss of vegetation and wildlife. The removal of plant cover can exacerbate erosion and further destabilize slopes.

2. **River and Stream Blockages:** Landslides can block rivers and streams, leading to flooding upstream and the formation of temporary or permanent dams. If these natural dams fail, they can release large volumes of water downstream, causing catastrophic flooding.

3. **Tsunamis:** Landslides into oceans or large lakes can displace significant volumes of water, generating tsunamis. These waves can travel great distances and cause damage to coastal areas far from the landslide site.

4. **Altered Landforms**: Landslides can reshape landscapes, creating new landforms and altering drainage patterns.

5. **Mountain and Valley Systems:** Landslides can drastically alter the morphology of mountain and valley systems. The movement of large landslide masses can reshape mountains, valleys, and coastal areas. For instance, landslides can create new landforms such as ridges or depressions, and change the course of rivers.

6. **Aquatic Life:** Landslides affecting riverbanks and coastal areas can lead to sedimentation, which can impact fish and other aquatic organisms. Increased sediment load can affect water quality and disrupt breeding grounds.

Examples: 1994 Northridge Earthquake (USA), 2004 Indian Ocean Tsunami, 2010 Haiti Earthquake and 2018 Montecito Mudslides (USA).

KEY GOVERNMENT INITIATIVES AND POLICIES WITH REGARD TO LANDSLIDES IN INDIA

- **National Landslide Risk Management Strategy (NLRMS):** To provide risk assessment, monitoring, early warning systems, and community preparedness.
- **Landslide Hazard Zonation Mapping:** Conducted by the Geological Survey of India (GSI) and the National Remote Sensing Centre (NRSC), among others. This helps in planning and implementing preventive measures and land-use planning.
- **National Disaster Management Plan (NDMP):** The NDMP outlines strategies for disaster risk reduction and includes provisions for landslide management.
- **Early Warning Systems:** The Geological Survey of India (GSI), Ministry of Mines in collaboration with the British Geological Survey (BGS) under the National Environmental Research Council (NERC), UK-funded, multi-consortium LANDSLIP project has developed a prototype regional Landslide Early Warning System (LEWS) for India**.**
- **Infrastructure Development:** Projects under the Hill Area Development Program (HADP) focus on infrastructure improvements in hilly and landslide-prone areas.
- **International Collaboration:** India is a member of the **Sendai Framework** on disaster management which focuses on landslide hazards.

KEY STRATEGIES FOR LANDSLIDE PREVENTION AND MITIGATION

1. **Avoidance:** The most straightforward approach is to avoid construction on steep slopes and known landslide areas. While ideal, this is not always feasible in practice.

2. **Regulation:** Implementing land use regulations to ensure that construction activities do not compromise slope stability is essential. This requires the use of landslide maps and a clear definition of hazardous areas to guide development and prevent exacerbating existing hazards.

3. **Monitoring and Warning Systems:** These systems can provide early warnings and enable temporary evacuation when there is a high probability of landslide activity, helping to protect lives and property.
4. **Soil Slope Stabilization:** Stabilizing slopes involves various techniques aimed at maintaining or improving slope stability:
5. **Directing Surface Water:** Channeling surface water away from the landslide area to prevent additional erosion or saturation.
6. **Groundwater Drainage:** Installing drainage systems to lower the groundwater table and reduce pore water pressure that can destabilize the slope.
7. Impermeable Membranes: Covering the landslide with an impermeable layer to prevent water infiltration.
8. **Retaining Structures:** These are used to support and stabilize soil masses. Types include timber crib walls, steel bin walls, pile walls, cantilever walls, sheet pile walls, plastic mesh, and reinforced earth walls. Each type has specific applications depending on factors like soil type, slope angle, and cost considerations.
9. **Planting Vegetation:** Encouraging natural growth or planting vegetation can help stabilize slopes by binding the soil with root systems and reducing surface erosion. This is discussed in more detail in the section on biotechnical mitigation methods.
10. **Bioengineering:** Techniques such as bioengineering involve combining biological and engineering methods to stabilize slopes. Examples include combining live stakes (cuttings of live plants) with traditional engineering structures.

BEST PRACTICES OF LANDSLIDE MANAGEMENT

Best practices from India:

1. **Sikkim:** The Sikkim State Disaster Management Authority (SSDMA) has implemented vegetative stabilization programs and retaining walls along critical roadways and vulnerable slopes.
2. **Uttarakhand:** The Uttarakhand State Disaster Management Authority (USDMA) has integrated early warning systems using remote sensing and GIS technologies for real-time monitoring of landslide-prone areas
3. **Kerala:** The Kerala State Land Use Board has implemented watershed management projects that include reforestation and soil conservation measures to stabilize landslide-prone areas.
4. **Maharashtra:** Mumbai Metropolitan Region Development Authority (MMRDA) has applied zoning regulations and risk assessments to prevent development in known landslide-prone areas.

5. **West Bengal:** The West Bengal State Disaster Management Authority has implemented retaining walls and drainage improvements in vulnerable areas to control erosion and prevent landslides.

Best practices across the world:

1. Japan used the strategy of Slope Stabilization and Vegetation
2. Switzerland introduced the Rockfall Protection Systems
3. The California Landslide Early Warning System (CLEWS) provides real-time alerts and detailed monitoring data to manage landslide risks effectively.
4. The Retaining Wall Systems and Soil Nailing Techniques are used on the Amalfi Coast to stabilize steep slopes and protect infrastructure in Italy.

CONCLUSION:

India, with its diverse topography and climatic variations, faces significant challenges from landslides, particularly in its hilly and mountainous regions. The increasing frequency and intensity of landslides in recent years underscore the urgent need for effective management and mitigation strategies.

PRELIMS QUESTION:

Q. Consider the following statements:

Statement-I:

The Himalayas are formed by the ongoing collision of the Indian and Eurasian tectonic plates and experience frequent seismic activity due to this tectonic movement.

Statement-II:

The Western Ghats, while also hotspots for geological activity, are more prone to landslide hazards compared to the Himalayas.

Which one of the following is correct in respect of the above statements?

(a) Both Statement-I and Statement-II are correct and Statement-II is the correct explanation for Statement-I

(b) Both Statement-I and Statement-II are correct and Statement-II is not the correct explanation for Statement-I

(c) Statement-I is correct but Statement-II is incorrect

(d) Statement-I is incorrect but Statement-II is correct

Answer: c

MAINS QUESTION

Analyze the various anthropogenic and natural factors responsible for landslides in India, and what specific measures should be implemented to effectively reduce and prevent the landslides in India?

(250 words, 15 marks)

Munde Dhananjay Navnath