

# AVALANCHE

## GUIDELINES 2026



National Emergency Operations Center (NEOC)  
National Disaster Management Authority (NDMA), Pakistan

## **Executive Summary**

Pakistan's northern mountainous regions are highly vulnerable to avalanche hazards due to steep terrain, heavy winter snowfall, and complex snowpack dynamics. Avalanches typically occur when unstable snow layers accumulate on steep slopes and are triggered by additional loading, temperature fluctuations, wind transport, or rainfall.

The purpose of this guideline is to provide a structured understanding of avalanche hazards in northern Pakistan and to support preparedness, early warning, and mitigation measures. The report integrates terrain analysis, meteorological triggers, seasonal snow monitoring, and remote sensing-based assessment approaches.

The analysis presented in this document highlights the critical role of snowpack stability, Western Disturbance-driven snowfall events, and rapid warming cycles in shaping avalanche risk across the Hindu Kush–Karakoram–Himalaya (HKH) region.

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## **1. Situation Analysis**

Pakistan faces a recurring and significant avalanche hazard in its high mountain regions, particularly within the Hindu Kush, Karakoram, and Himalaya (HKH) ranges. These regions are characterized by steep slopes, heavy winter snowfall, and persistent weak snowpack layers that create ideal conditions for avalanche release.

Avalanches are a natural consequence of unstable snowpack formation in steep terrain. In many cases, avalanche release occurs when a cohesive snow slab overlies a persistent weak layer such as depth hoar, near-surface facets, or buried surface hoar.

In Pakistan, avalanche incidence is highest from February to April when heavy snowfall events are followed by temperature fluctuations, strong winds, and additional snow loading. Such avalanches threaten mountain communities, transportation corridors, strategic installations, tourism zones, and hydropower infrastructure.

For 2026, seasonal forecasts suggest that Western Disturbance-driven precipitation events combined with rapid warming spells may increase snowpack instability. Wind-loaded slopes and terrain traps such as gullies, couloirs, and concave slopes are particularly vulnerable to avalanche release.

The Technical Team of NDMA issued Disaster Early Warning–1 & 2 (DEW-1 & 2) for the first two quarters of 2026, highlighting heightened avalanche vulnerability across high-risk zones of Khyber Pakhtunkhwa (KP), Gilgit-Baltistan (GB), and Azad Jammu & Kashmir (AJK).

In response, a comprehensive avalanche guideline has been developed to support early warning systems, strengthen preparedness measures, enhance risk understanding, and improve proactive mitigation strategies for stakeholders operating in avalanche-prone regions.

## **2. Avalanche Investigation**

Avalanche-prone areas are typically located in high-altitude mountainous terrain where field access and continuous ground monitoring are often difficult. Therefore, remote sensing and GIS-based approaches are essential for effective avalanche hazard assessment.

The integration of Remote Sensing, GIS, and AI-based modelling provides a reliable and spatially consistent approach for regional-scale avalanche susceptibility mapping and disaster risk reduction planning in inaccessible mountain regions.

## 2.1 Avalanche Types

Avalanches can be classified into several major types based on snowpack characteristics, re-lease mechanisms, and movement behavior. Each type develops under specific environmental and snowpack conditions and presents different levels of hazard to people, infrastructure, and mountain transport routes.

### 1. **Loose Snow Avalanches**

Loose snow avalanches typically originate from a single point on the slope and spread outward as they descend. They usually occur in recently fallen, unconsolidated snow and are more common on steep slopes where the snowpack has not yet bonded into cohesive layers. Although they are generally smaller than slab avalanches, loose snow avalanches can still pose significant risks in narrow gullies or terrain traps where snow accumulates rapidly.

### 2. **Gliding Avalanches**

Gliding avalanches occur when the entire snowpack slowly slides over a smooth ground surface such as grass, rock slabs, or glacier ice. These avalanches are usually associated with meltwater at the snow–ground interface, which reduces friction and allows the snowpack to move as a whole mass. Gliding avalanches are difficult to predict and may release suddenly after prolonged periods of slow movement.

### 3. **Powder Avalanches**

Powder avalanches are highly energetic and fast-moving avalanches composed of fine snow particles suspended in turbulent air. They often occur when large snow masses collapse and generate a dense powder cloud that can travel at very high speeds across long distances. Powder avalanches are particularly dangerous because they can move over terrain obstacles and produce powerful air blasts capable of causing extensive damage.

### 4. **Wet Snow Avalanches**

Wet snow avalanches occur when liquid water weakens the bonds between snow grains within the snowpack. This commonly happens during periods of rapid warming, rainfall on snow, or strong solar radiation. Wet snow avalanches tend to move more slowly than dry avalanches but are extremely dense and destructive due to their high mass and momentum.



Understanding these avalanche types is essential for hazard assessment and early warning operations. Different avalanche mechanisms respond to different meteorological triggers, terrain characteristics, and seasonal snowpack conditions. Recognizing these differences helps disaster management authorities, mountaineers, and local communities adopt appropriate preparedness and risk mitigation measures.

### 3. Methodology

#### 3.1 Contributing Factors in Avalanche Vulnerability

Avalanche vulnerability is controlled by three major categories of factors:

1. **Terrain (Static Factors)** – determine where avalanches can occur.
2. **Snowpack and Meteorological Factors (Dynamic Factors)** – determine when avalanches are likely.
3. **Exposure and Human Factors** – determine who or what is at risk.

#### 3.2 Terrain Factors

**Table 3.1:** Key Terrain Controls for Avalanche Vulnerability

Factor	Critical Range	Regional Interpretation
<b>Slope Angle</b>	30°–45° (peak 35°–40°)	Majority of slab avalanches in HKH initiate in this band; extremely steep slopes (>50°) often slough before slab formation.
<b>Elevation</b>	3000–5500 m	Persistent winter snowpack, strong wind redistribution, and weak layer development dominate above treeline.
<b>Aspect</b>	N, NE, E (winter)	Limited solar radiation preserves persistent weak layers in continental HKH snow climate.
	S, SW (late)	Higher risk of wet avalanches during warming cycles (Feb–

	winter)	March).
<b>Profile Curvature</b>	Convex rollovers	Common fracture initiation points in alpine ridgelines and couloirs.
<b>Plan Curvature</b>	Concave bowls, gullies	Snow accumulation zones due to wind loading; frequent slab development.
<b>Wind Exposure</b>	Leeward slopes of westerlies	Strong Western Disturbances deposit snow on eastern/northeastern aspects → wind slab formation.
<b>Terrain Roughness</b>	Smooth alpine faces	Rock-bound couloirs and open slopes favor slab propagation.
<b>Land Cover</b>	Above treeline (>3000–3500 m)	Sparse vegetation reduces anchoring effect; alpine terrain most susceptible.
<b>Terrain Traps</b>	Narrow valleys, glacial troughs	Increase burial depth and fatality risk, especially along valley settlements and road corridors.

### 3.3 Meteorological Triggers

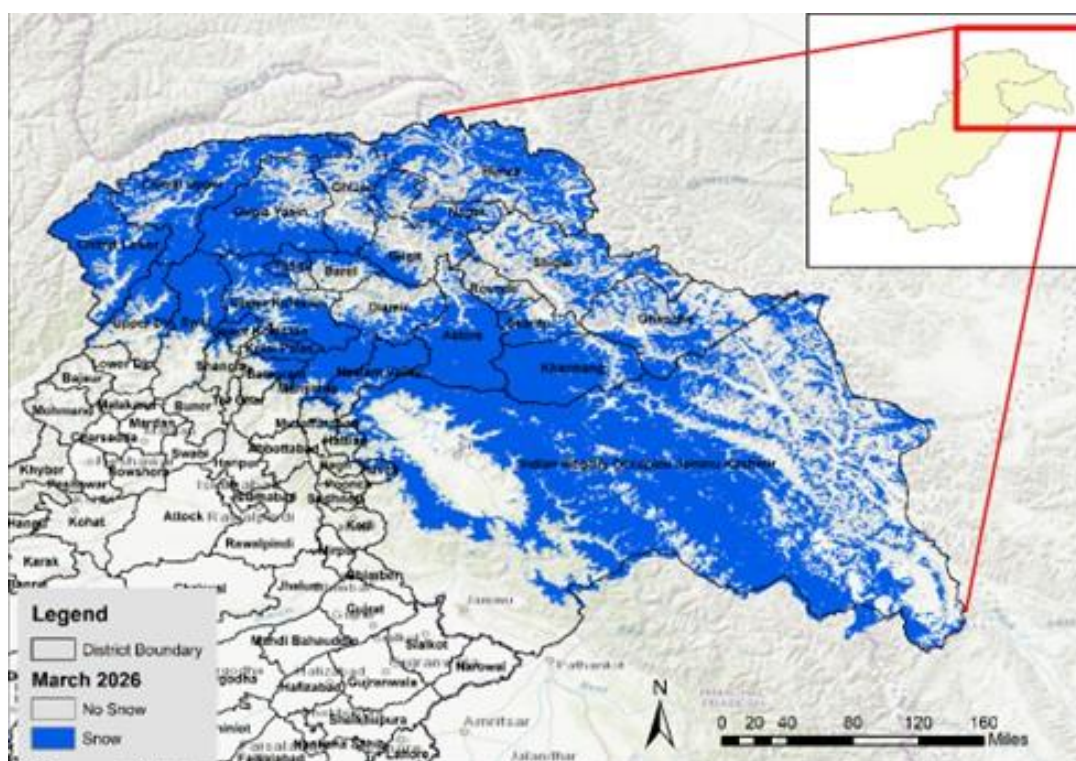
Snowfall Loading Thresholds		
Parameter	Threshold	Risk Interpretation
24-hour snowfall	≥20–30 cm	Elevated instability (rapid loading)
48-hour snowfall	≥30–50 cm	High probability of slab release
Snow Water Equivalent (SWE)	≥10–15% rapid load increase	Shear stress exceeds slab strength
Storm sequence events	Consecutive storms within 72 hrs	Compounding instability
Wind Speed & Snow Transport		
Parameter	Threshold	Risk Interpretation
Wind speed (transport begins)	>5–7 m/s	Snow drift initiation
Wind speed (slab formation)	>10–15 m/s	Wind slab formation likely
Wind direction	Westerlies → E/NE slopes	Leeward loading zones critical
Post-storm wind event	Within 24–48 hrs	High trigger probability
Temperature Gradient & Weak Layer Formation		
Condition	Threshold	Effect on Stability
Temperature gradient	>1°C per 10 cm snow depth	Facet formation (persistent weak layer)
Sustained cold	≤ -10°C	Depth hoar growth at base
Clear cold nights	Strong radiative cooling	Near-surface faceting
Rapid warming	>5°C rise within 24–48 hrs	Wet slab activation
Rain-on-Snow Events		
Condition	Risk Indicator	Impact
Rain above 3000–3500 m	High instability	Slab lubrication
Liquid water percolation	Water reaches weak layer	Wet slab failure likely
Freezing level rise	>400–600 m increase	Rapid destabilization

#### 4. Snow and Avalanche Conditions

During March-April 2026, northern Pakistan is expected to experience a progressive evolution of snow cover and associated avalanche risk, driven by Western Disturbances and seasonal temperature changes.

##### 4.1 March 2026

In March 2026, snow cover remains substantial but shows early signs of spatial fragmentation, particularly at mid-elevations. With this, several snow/rain spells will impact the area. High-altitude zones of central and eastern Gilgit-Baltistan, upper AJK, and the Karakoram Himalayan belt continue to retain deep snowpack, while western and lower-elevation valleys show partial snow loss, likely driven by intermittent warming and rain-on-snow events. The maps suggest continued snow replenishment during active Western Disturbance episodes, especially when enhanced by moisture surges, but with increasing variability. This transition phase heightens the risk of avalanches, landslides, and localized flooding, as accumulated snow becomes more sensitive to temperature fluctuations.



**Figure 4.1:** Snow Projection – March 2026

## 4.2 April 2026

In April 2026, a clear reduction and retreat of snow cover is evident across much of the region, with snow becoming increasingly confined to higher elevations of Gilgit-Baltistan, eastern AJK, and the upper Karakoram ranges. Mid-altitude districts display significant snow depletion, indicating the onset of seasonal melt under rising temperatures and reduced frequency of Western Disturbances. However, persistent snow cover over the highest terrain suggests continued contribution to spring and early summer meltwater. This evolving pattern points to greater variability in river inflows, increased risk of early snowmelt-driven runoffs, and localized flooding in downstream catchments if late-season precipitation coincides with warming conditions.

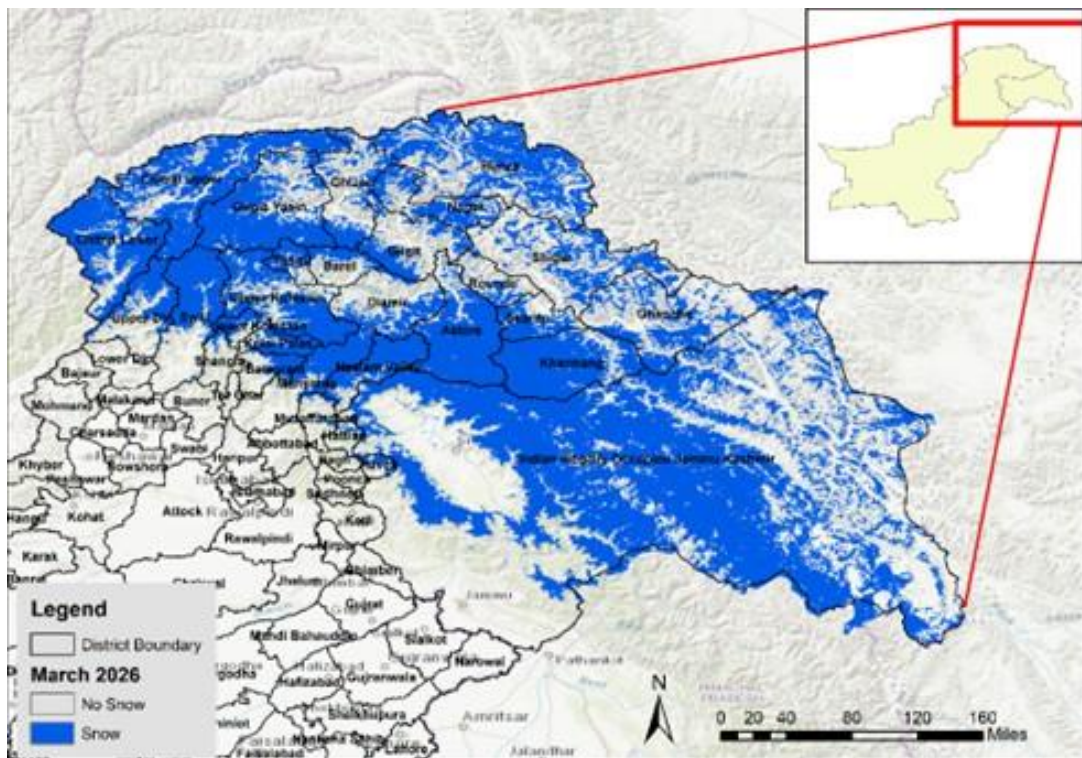
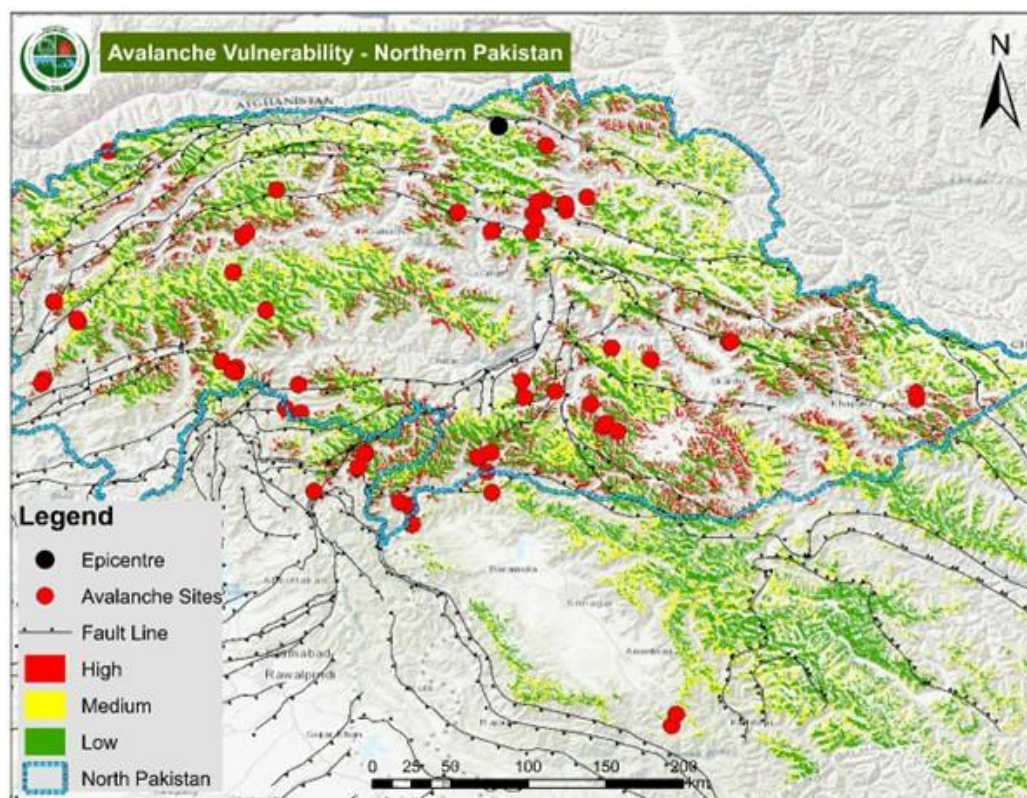


Figure 4.2: Snow Projection – April 2026

## 5. Avalanche Vulnerability

During January and February, temperatures in northern mountainous regions of Pakistan remain relatively low, which helps maintain the stability of the snowpack. The cold conditions prevent rapid melting and keep the snow layers compact, reducing the immediate risk of avalanches. With this, several precipitation spells over the Northern areas of Pakistan would result in snowfall. However, as temperatures begin to rise in late winter and early spring, the snowpack becomes increasingly unstable. The melting of lower layers, combined with weak bonding between snow layers, creates conditions that can easily trigger avalanches. This seasonal shift in temperature plays a critical role in avalanche formation, making periods of warming particularly hazardous for communities, infrastructure, and travelers in the high-altitude areas of northern Pakistan. The avalanche vulnerable areas are shown in the avalanche vulnerability map.



**Figure 5.1:** Avalanche Vulnerability in Northern Pakistan

## **6. Conclusion and Recommendations**

Northern Pakistan remains highly vulnerable to avalanches during February–April due to heavy snowfall, temperature fluctuations, and snowpack instability.

Expanding infrastructure, including the Karakoram Highway, hydropower installations, and settlements located in narrow valleys, further increases exposure to avalanche hazards.

Districts such as Chitral, Upper Dir, Ghizer, Hunza, Skardu, Neelum, and Haveli remain particularly vulnerable.

### **6.1 Recommendations**

1. Strengthen avalanche early warning systems.
2. Expand remote sensing monitoring.
3. Monitor Western Disturbances and rapid warming events.
4. Improve coordination between NDMA, PDMA, and local authorities.
5. Increase community awareness and preparedness.