

Rapid Hazard Assessment Report

Location: Dharali, Uttarkashi, Uttarakhand

Country: India

Lat: 30.986058°N - Lon: 78.794640°E - Elevation: 4400 m a.s.l.

Date: 5 August 2025 (potentially still active)

Time: 13:00 IST

Hazard type: Debris flow, landslide

Imagery: (Source: Sentinel-2, Planet)

On the 5th of August 2025 a massive debris flow hit the Dharali settlement, located on an alluvial fan¹, with multiple surges, destroying large parts of the infrastructure, killing at least 6 people with more than 50 presumed missing. At nearly the same time a smaller debris flow hit the adjacent settlement of Harsil, including a helipad (Figure 1). The flood waves from both events travelled downstream and caused further downstream impacts at least for 6 km at Jhalla Bhagirati bridge, where a larger river bed retained material (Figure 2). Initial reporting by the Central Water Commission (Himalayan Ganga Division) suggested the occurrence of two cloudbursts. While rainfall occurred just before the event, intensity in the downstream wasn't particularly high.

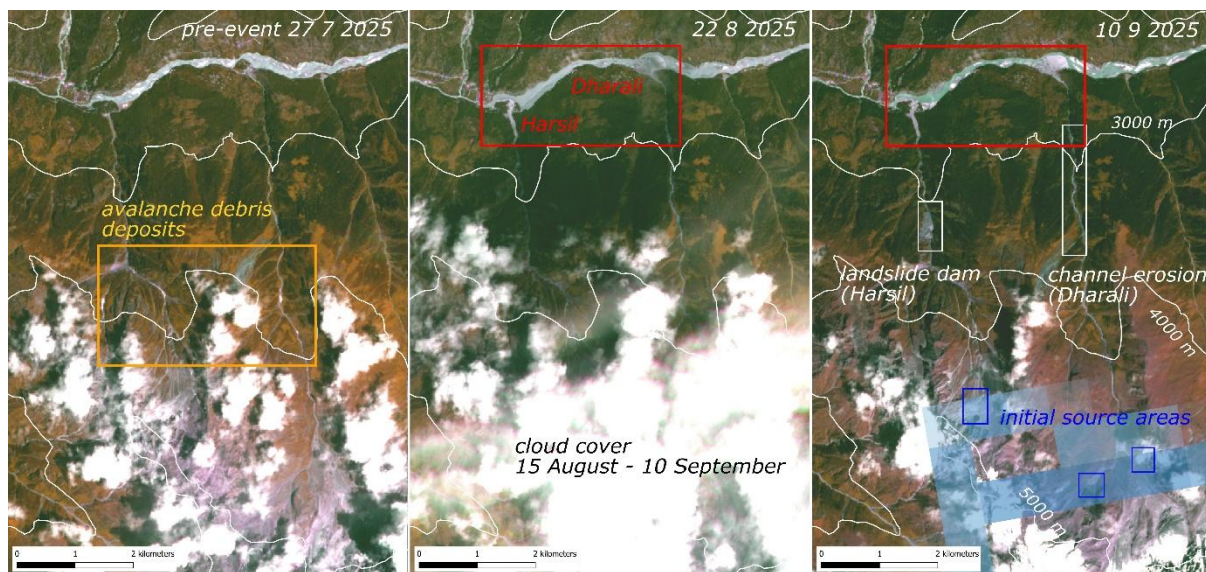


Figure 1: Overview over the debris flow events that happened more or less simultaneously on 5th of August in Harsil and Dharali. Imagery from Sentinel-2 show the area before the event, with snow avalanche debris deposits from the spring season which had been constantly melting for more than a month in these locations, resulting in saturated slopes and what remained were mobilized to increase the volume and velocity of the debris flow (left), 12 days after the event with the source area covered in clouds and no apparent landslide yet in the Thal Gad above Harsil (center) and on 10th of September, when the failures in moraines in the upstream are also visible (right). In shaded blue the area where permafrost was modelled to be probably present (Obu, 2021), also considered as the transition zone where permafrost currently thaws.

Due to cloud covered conditions in the upstream, actual source areas could only be investigated much later. It has since become apparent, that the two debris flows started at similar elevations between 4200 and 4800 m a.s.l. in the permafrost transition zone in proglacial terrain (Figure 3).

¹ <https://www.youtube.com/watch?v=cypkJutut2o>

There were no lakes drainages involved, nor any catastrophic collapse of ice or rock. The initial localized shallow source areas were amplified in both cases by picking up large amounts of older snow avalanche debris deposits, stretching for nearly 1 km just below 4000 m a.s.l. Widening of the two channels (Thal Gad above Harsil and Khera Gad above Dharali) from ca 20 m to nearly 80 m, suggest considerable additional erosion, possibly with some intermittent damming, explaining the large and relatively fluid amounts of debris reaching the settlements in several pulses.

In the Thal Ghad, the debris flow has significantly undercut the channel slope, resulting in a landslide (90 000 m²) that dammed the river along a length of 480 m between the 1st and 9th of September (Figure 4). While so far only small ponding of water is visible, it constitutes a source of material for potential future mass flows.

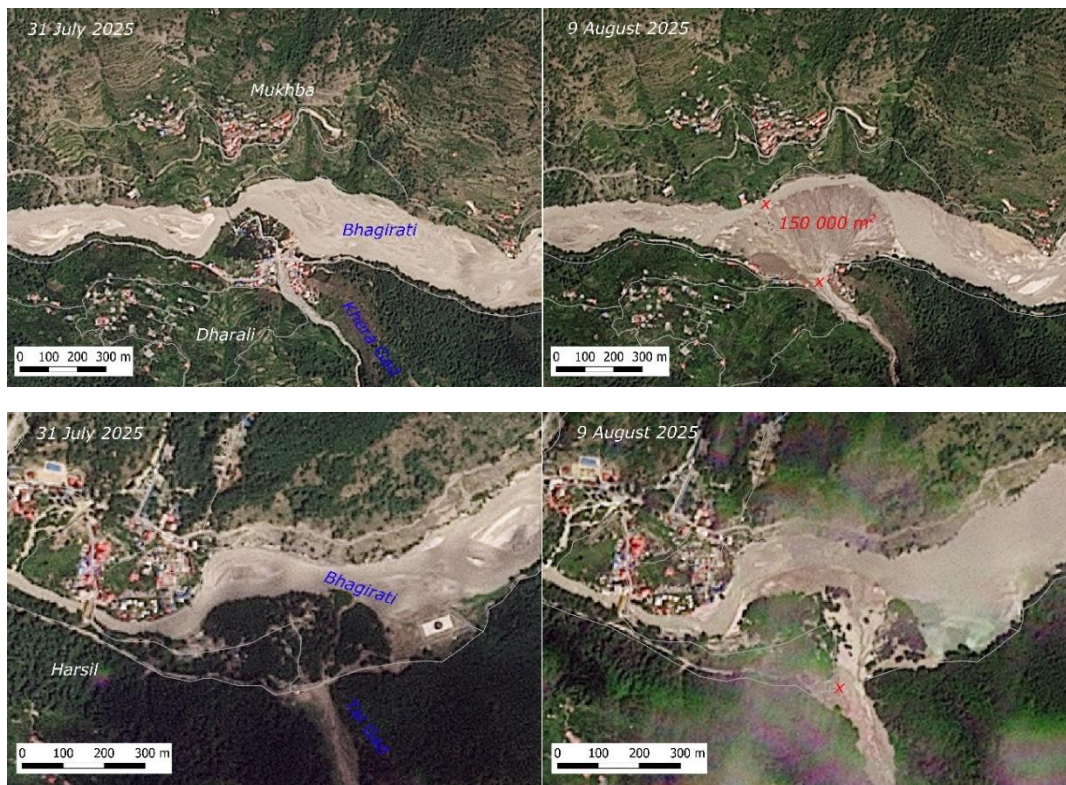


Figure 2: Impact in Dharali (top) and Harsil (bottom), as seen on Planet imagery. Red crosses mark destroyed road connections, the debris deposit in Dharali is roughly 150 000 m² large. In Harsil the helipad is visible before the event. Significant erosion also happened at the opposite river bank. See also²

Preliminary process understanding: While rainfall did occur just before the events, amounts were not especially intense. On the day of the event 6.5 mm were observed in Harsil³, while other reports suggest a much higher rate of 100 mm between the 4th and 5th in the wider area⁴, which however seems unlikely based on video evidence. However, considering the simultaneous activation of two adjacent debris flows of independent sources, and the absence of any earthquake, locally intense precipitation as the final trigger is considered very likely. The source areas of initial limited debris supply are located in proglacial terrain and include failing moraines.

² https://www.isro.gov.in/indian_satellite_data_based_analysis_of_the_dharali_flash_flood.html

³ <https://sandrp.in/2025/08/09/uttarakhands-dharali-disaster-human-causes/>

⁴ <https://timesofindia.indiatimes.com/city/dehradun/1st-aerial-survey-by-scientists-identifies-cloudburst-induced-debris-flow-as-likely-trigger-of-dharali-flood/articleshow/123349265.cms>

The high temperatures leading up to the event as well as the near complete depletion of snow cover over the preceding months (Figure 5), suggest the availability of large amounts of melt water that could have potentially facilitated the failure of the saturated debris material. The large amounts of snow avalanche deposits, that individually covered up to 15 000 m² just one week before the event and in total up to 35 000 m² (with depths possibly larger than 5 m), provide potentially up to 200 000 m³ of water additionally available to drive the debris flow. These deposits were nearly 6 times as large a month earlier, suggesting a lot of melt water that saturated the ground. The undercutting of slopes in Thal Gad has already led to a new landslide forming (Figure 4), which can potentially be the source of future debris flow or provide additional material to debris flows from the upstream. Tension cracks in this landslide zone visible back to at least 2014 suggest the undercutting from the debris flow led to catastrophic failure of an existing slowly evolving instability.

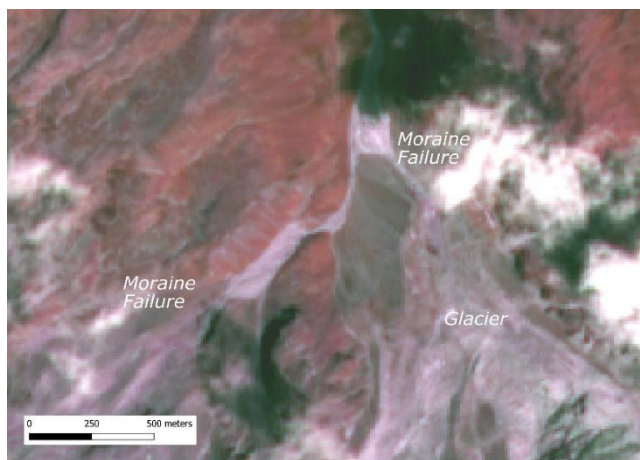


Figure 3: Visible debris source areas in the Khera Ghad above Dharali (Sentinel-2).



Figure 4: The landslide that formed 1 month after the initial debris flow event in the Thal Gad above Harsil, seen on the 22nd of August (left) and the 11th of September (right) on Planet imagery.

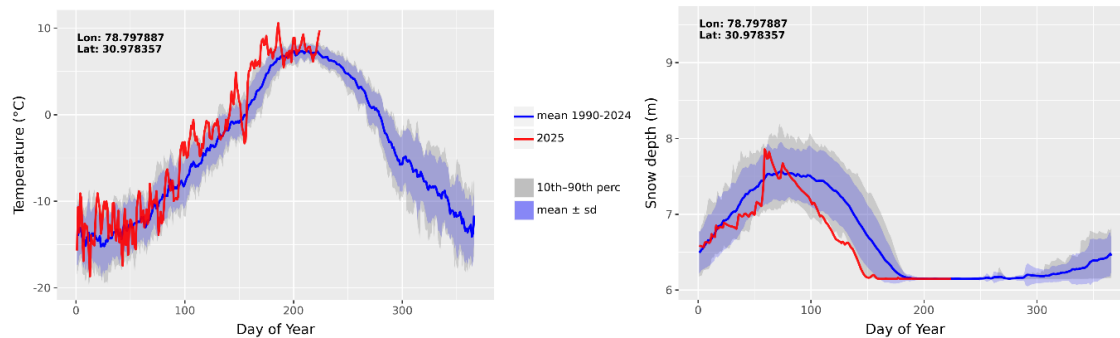


Figure 5: Air temperature (left) and snow depth (right) at the Dharali source area from ERA5-L data.

Impact: Total fatalities are still unclear, but likely are above 50. Nearly 100 houses were reportedly destroyed, including hotels as well as residential houses⁵. Damages to road infrastructure have disconnected large parts of the Gangotri area.

Climate change context: Unclear. Possible thickening of the active layer (uppermost zone of seasonal freezing and thawing) in the moraine sediment owing to long term warming of permafrost. This would have increased the depth with which meltwater and rainfall could penetrate and destabilise the sediment. Higher resolution permafrost monitoring and/or site visits, as well as aerial reconnaissance are needed to determine these conditions.

Socioeconomic risk context: Reports and satellite imagery suggest rapid expansion of housing infrastructure on both alluvial fans in recent years (especially in Dharali) fostered by tourism, increasing exposure and hence risk significantly. Buffer zones and high risk zonation across such fans would be advisable in future.

Early warning: Not in place. Assuming typical debris flow velocities for mountain catchments, warning times in Dharali and Harsil would have been the range of 4 – 24 minutes if monitoring sensors were located in the upper catchments. Identifying high risk gulleys of similar nature, as is being attempted for dangerous glacial lakes is advised.

Potential for recurring events: The combination of unexceptional conditions combining to produce extreme debris flows in Harsil and Dharali is something that could occur repeatedly. Large amounts of debris in proglacial terrain as well as the ongoing permafrost thaw and glacier recession suggest that recurring events are likely. Even steeper accumulations of loose, likely thawing sediment are sitting higher up in the catchments. The repeat deposit of debris material in the channels that can get reactivated increases the chance of large scale events. The developing scenario of the landslide in the Thal Gad that happened more than 3 weeks after the initial event, suggests that the whole system is still active and more immediate recurring events are possible, particularly in the presence of snowmelt and/or heavy rainfall as well as heat waves.

Literature context:

Obu, J. (2021). How Much of the Earth's Surface is Underlain by Permafrost? *Journal of*

Geophysical Research: Earth Surface, 126(5). <https://doi.org/10.1029/2021JF006123>

⁵ <https://www.hindustantimes.com/india-news/uttarkashi-cloudburst-live-updates-uttarakhand-flashflood-dharali-cloud-burst-rescue-harsil-missing-dead-army-101754386714845.html>