

Extreme heat and snow drought preconditioned the August 2026 Nepal rock–ice avalanche flood

WAQAR UI HASSAN

King Abdullah University of Science and Technology <https://orcid.org/0000-0001-5107-9845>

Md Saquib Saharwardi

King Abdullah University of Science and Technology

Hari Prasad Dasari

King Abdullah University of Science and Technology

Vankayalapati Koteswararao

King Abdullah University of Science and Technology

Ibrahim Hoteit

King Abdullah University of Science and Technology

Yasser Abualnaja

yasser.abualnaja@kaust.edu.sa

King Abdullah University of Science and Technology

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Abstract

High-mountain floods can originate from slope failure rather than intense rainfall, yet the environmental states that precede such failures remain poorly resolved. On 26 August 2026, a large rock–ice avalanche from Langtang Lirung generated a destructive flood along Nepal’s Bhote Koshi–Trishuli corridor. Here we show that the failure followed an exceptional, short-lived combination of atmospheric heat and depleted seasonal snow. Precipitation was negligible around the reported failure time despite normal-to-wet antecedent moisture conditions. By contrast, July–August above-freezing thermal accumulation reached approximately the 98th percentile of the 1979–2025 record, while recent snowfall and August snowpack storage were strongly depleted. Regional snowmelt was not exceptionally high, indicating a snow-limited rather than melt-dominated state. The concurrence of exceptional heat and acute snow drought provides evidence of climatic preconditioning of the slope, without identifying the immediate trigger of failure. This antecedent state reveals a pathway to cascading mountain hazards that rainfall metrics or geological analysis alone may not capture, underscoring the need to integrate short-timescale heat and snow diagnostics with direct monitoring of unstable slopes.

Introduction

A mountain collapse can become a flood disaster far from the slope that failed. Rock and ice moving through steep valleys can entrain sediment and water, obstruct rivers and deliver destructive flows to settlements and infrastructure downstream. The 2021 Chamoli disaster demonstrated the reach of such cascade when a rock–ice avalanche transformed into a highly mobile debris-rich flood.¹ Large glacier detachments in Tibet and Alaska likewise show that failure can emerge from interactions among geography, material properties and hydrometeorological conditions rather than from a single recurring trigger.^{2,3} Understanding the state of a mountain system before collapse is therefore relevant not only to slope stability, but also to communities and infrastructure exposed along connected river corridors.⁴

The 26 August 2026 Bhote Koshi–Trishuli disaster in northern Nepal brings this problem into sharp focus. A rapid assessment based on field observations and satellite imagery attributed the event to a rock–ice avalanche from the northern flank of Langtang Lirung, followed by downstream entrainment, interaction with the Lhende River and possible temporary river blockage.⁵ The failure mobilized more than 142 million m³ of ice, rock, sediment and debris, causing severe damage to settlements, bridges, roads, hydropower infrastructure and the Rasuwagadhi border corridor.⁵ Preliminary assessments reported hundreds of fatalities, thousands of people missing and infrastructure losses approaching \$1.5 billion.⁵ Strikingly, unlike conventional rainfall-triggered high-mountain mass-failure floods, the disaster occurred under near-dry meteorological conditions. The flood instead originated from a high-mountain rock–ice slope collapse that entrained glacier ice, rock and debris and rapidly transferred this material downstream. Although the immediate mechanical origin of the disaster is therefore evident, the environmental and geomechanical conditions that preconditioned the slope and favored its failure at this particular time remain unresolved.

The mechanical nature of a rock–ice avalanche describes how a slope fails, but not why failure occurs at a particular time. In high mountains, atmospheric warming can alter the stability of rock–ice systems through coupled thermal and hydrological processes. Sustained warmth and short-lived heat extremes can warm fractured rock, weaken ice-filled joints and ice-cemented material, and promote thawing of fracture ice.^{6–8} The resulting meltwater can penetrate joints and previously frozen pathways, reduce frictional resistance, increase water pressure and modify stress transmission within an already susceptible slope. These processes provide a physical basis for observed links between anomalous warmth, degrading permafrost and high-mountain rockfall or rock–ice failures.^{9,10} Thus, extreme heat may act not as a direct trigger in isolation, but as a preconditioning mechanism that progressively reduces the stability margin before mechanical collapse.

The effect of atmospheric heat also depends strongly on the state of seasonal snow. Snow cover regulates surface albedo, insulation and the exchange of energy between the atmosphere and underlying snow, ice and rock.^{14,15} A snow drought, characterized by unusually low snowfall and/or depleted snow-water storage, can therefore amplify the effects of anomalous warmth even when total precipitation is not deficient.¹³ Reduced snow cover can expose darker rock, debris and glacier surfaces earlier in the season, increasing absorbed solar radiation and surface warming, while anomalously warm conditions shift precipitation from snow toward rain and accelerate depletion of the remaining snowpack.^{16,17} Meltwater generated under such conditions can increase runoff and water delivery to glaciers, moraine-dammed lakes and fractured mountain slopes. Heat extremes and snow drought can therefore jointly increase the susceptibility of Himalayan catchments to cascading hazards, including rapid snowmelt floods, glacier-lake outburst floods (GLOFs) and failures of ice-bearing rock slopes. The 2022 South Asian mega-heatwave provides regional evidence that extreme heat and snow drought can act together to destabilize Himalayan cryosphere and increase susceptibility to floods and GLOFs.¹⁸ Assessing atmospheric heat without the contemporaneous snow state may therefore miss an important component of environmental preconditioning.

Here we examine whether the 2026 Nepal avalanche was preceded by exceptional thermal loading and unusually depleted seasonal snow conditions. We combine the reported event chronology and satellite observations with temperature, precipitation and snow diagnostics referenced to 1979–2025. Daily analyses ending before the failure quantify short-term and warm-season thermal accumulation, while monthly indices distinguish snowfall and snow-storage deficits from broader precipitation drought. We use these reanalysis data to assess climatic preconditioning, defined here as antecedent environmental conditions that may increase slope susceptibility without identifying the immediate trigger. We find that the failure followed exceptional late-summer thermal accumulation and pronounced snow scarcity, despite the absence of an intense contemporaneous rainfall pulse or broader precipitation drought. Our analysis therefore characterizes the atmospheric and seasonal snow state surrounding the source region, rather than the mechanical condition of the failed slope.

Results

A large flood without an intense rainfall pulse

The 26 August 2026 Nepal flood propagated through the Lhende–Bhote Koshi valley as a high-magnitude, debris-rich flow, producing a broad downstream inundation footprint (Fig. 1a). A strong seismic signal was recorded at around 08:30 local time, followed by rapid downstream propagation of the flood wave, which reached Rasuwagadhi at 08:44 am and Timure and Syarubesi between 08:50 and 09:00 am. The mapped flood extent reached ~ 300 m at these locations, compared with pre-event active-channel widths of around 30–55 m (Fig. 1b). Across ten selected transects, the inundated width was typically five to six times the pre-event active-channel width. Topography-based estimates indicate maximum flood depths of 100–140 m in the upper reach, followed by a progressive downstream reduction in both flow depth and inundation width (Fig. 1a). Tracing the inundation corridor upstream leads to a large high-elevation slope failure on the northern flank of Langtang Lirung. Post-event imagery delineates an approximately 2 km² scar, extending a maximum of 1.85 km in planform, or 2.12 km along the pre-event topographic surface, and around 1.4 km across its maximum width (Fig. 1d). The source location, scar geometry and downstream trajectory are consistent with the reported rock–ice avalanche associated with the flood.⁵

Despite the magnitude of the event, no intense rainfall pulse accompanied flood onset. ERA5-Land shows only weak precipitation around the event time on 26 August, although intermittent rainfall occurred during the preceding days (Fig. 1c). The broader hydroclimatic background was also not drought-like: August precipitation was near to above normal across much of northern Nepal and the adjoining Tibetan Plateau, while both monthly and three-month standardized precipitation indices were positive (Fig. 2a,b; Fig. 4; Figs. S1–S3). The absence of an intense contemporaneous rainfall pulse therefore separates this immediate slope failure driven flood from a conventional rainfall-driven flood mechanism and motivates examination of whether antecedent thermal and snow anomalies conditioned the slope before failure.

Exceptional thermal loading before failure

Heat was the clearest atmospheric anomaly. August maximum temperature exceeded its historical mean by more than one standard deviation across extensive parts of the Himalayan arc and by two to three standard deviations in several high-elevation sectors along the Nepal–Tibet border and broader source region (Fig. 2c,d). Maximum, mean and minimum temperatures all showed widespread positive anomalies (Figs. S4–S6), and many high-elevation grid cells, including the failure region ranked August 2026 among their five warmest Augusts during 1979–2026 (Fig. 2e; Fig. S7). Most of the central and eastern Himalayans experienced 6–10 heatwave days, substantially above their historical August occurrence (Fig. 2f; Fig. S8). August positive-degree-day (PDD) anomalies independently show enhanced above-freezing thermal exposure across parts of the high terrain along China–Nepal border (Fig. S9).

The regional temperature evolution shows that this anomaly developed in two distinct episodes. March was exceptionally warm and included an 11-day heatwave, but temperatures moderated in April and were frequently near or below climatology during May and June (Fig. 3a,b,e; Figs. S10, S11). Warm

conditions returned in July and persisted through August, including two three-days heatwaves and a two anomalously hot days shortly before the flood. The state immediately preceding failure was therefore not the continuation of uninterrupted spring warmth, but a renewed late-summer episode following an intervening cool period.

PDD accumulation resolves this timing particularly clearly. From 1 July to 25 August, the regional cumulative PDD anomaly reached + 36. °C day, placing 2026 at approximately the 98th percentile of equivalent periods during 1979–2025 (Fig. 3c). By contrast, the 1 March–25 August anomaly was only about + 10°C day, near the 55th percentile, because cooler conditions during May and June offset much of the earlier excess. Matched historical windows ending on 25 August show the same temporal concentration: maximum and mean temperature, heatwave occurrence and PDD were most exceptional over approximately 7–60 days and became substantially less unusual over 90–120 days (Fig. 3d,f). The reported collapse therefore followed an exceptional short-to-subseasonal period of atmospheric thermal loading.

Acute snow drought under otherwise wet conditions

The seasonal snow state diverged sharply from total precipitation. During the three months ending in August, precipitation remained above normal over the selected region ($SPI-3 = + 0.37$), whereas snowfall was severely deficient ($SFI-3 = - 2.44$; Fig. 4a,b,d). August snow-water equivalent was simultaneously depleted ($SSWEI-1 = - 2.26$; Fig. 4c,d). The spatial fields show the same precipitation–snow contrast across the high-elevation Himalayan belt surrounding the source region.

The monthly and multiscale diagnostics reinforce this separation. August precipitation was above normal ($SPI-1 = + 0.65$), whereas snowfall ($SFI-1 = - 1.73$) and SWE were both deficient (Fig. S2). The stronger three-month snowfall deficit occurred alongside a positive three-month SWE index (+ 0. 85; Fig. S3), showing that the depleted August snow store developed more sharply than the season-integrated SWE signal. At six months, precipitation and snowfall were both positive and SWE was only modestly negative; at twelve months, precipitation remained positive, snowfall was near normal and the SWE deficit was weak (Figs. S12, S13). The corresponding historical series show the same scale dependence (Figs. S14–S16). The anomaly was therefore an acute late-summer snow drought embedded within a non-deficient precipitation regime, rather than a persistent regional water deficit.

Snowmelt provides a further constraint on this state. The August snowmelt index was negative ($SMLTI-1 = - 1.79$), while the three-, six- and twelve-month indices remained comparatively close to climatology (Fig. S17). July and August spatial fields likewise show no broad exceptional positive snowmelt anomaly around the source region (Fig. S18). The long-term regional snow diagnostics show very little water-equivalent seasonal snow remaining during August 2026. Exceptional atmospheric heat therefore coincided with depleted snow storage but not with exceptional regional monthly snowmelt, identifying a snow-limited rather than melt-dominated late-summer state.

Discussion

Compound climatic preconditioning

The conditions preceding the Langtang Lirung failure were unusual not because of a single meteorological extreme, but because several anomalies converged. No intense precipitation pulse in a accompanied the collapse, yet thermal loading over the preceding weeks approached the upper end of the historical distribution while late-summer snowfall and snow-water storage were strongly depleted. The juxtaposition of exceptional heat, acute snow scarcity and non-deficient total precipitation identifies a compound climatic state distinct from the rainfall-dominated conditions commonly associated with Himalayan flood disasters.

The importance of this combination lies in how the snow state modifies the expression of thermal forcing. Despite exceptional warmth, regional snowmelt in August was below normal. Rather than contradicting a role for heat, this indicates that relatively little seasonal snow remained available to melt by late summer. The system was therefore snow limited rather than energy limited: additional atmospheric warmth occurred over an already depleted snow reservoir and consequently need not have produced an anomalously large regional snowmelt flux. This contrasts with the 2022 South Asian mega-heatwave, when a more extensive Himalayan snowpack was exposed to exceptional warmth and rapid snow loss contributed to enhanced melt and hydrological hazard.¹⁸ Together, the two events illustrate that similar thermal extremes can produce different cryospheric responses depending on antecedent snow availability—melt amplification when snow remains abundant, but intense thermal exposure under snow-scarce conditions when the seasonal reservoir is already depleted.

This distinction is important for interpreting the 2026 collapse. Our observations do not identify the process operating on the failure plane, nor do they establish heat or snow drought as the instantaneous trigger. They instead constrain the environmental state in which failure occurred. The exceptional pre-event thermal loading and depleted snow reservoir are consistent with conditions that could have reduced the remaining stability margin of an already susceptible rock–ice slope. In this sense, the climatic signal is best interpreted as preconditioning rather than triggering: it helps explain why the slope may have been unusually susceptible at that time while leaving the final mechanical failure to processes that cannot be resolved from atmospheric and snow observations alone.

Subseasonal memory and cascading hazard

A key feature of this preconditioning is its timescale. Seasonal averages alone would obscure the sequence of exceptional March warmth, cooler conditions during May–June and renewed strong warming through July and August. Conversely, conditions on the day of failure cannot represent the cumulative thermal exposure established during preceding heatwaves. The strongest signal instead emerges over intermediate windows of approximately one week to two months, over which heatwave occurrence and positive-degree-day accumulation became increasingly exceptional before collapse. The snow anomalies show a similar temporal dependence: the pronounced depletion of recent snowfall and late-summer snow storage was not apparent from longer six- and twelve-month precipitation totals,

which remained near normal or positive. The relevant climatic state was therefore produced by the timing and persistence of anomalies, rather than by an annual or seasonal water deficit.

This temporal structure has broader implications for high-mountain hazard assessment. Monitoring systems designed primarily around extreme rainfall may provide little indication of susceptibility when instability develops through accumulated heat and anomalous snow conditions. The Nepal event suggests that short-window thermal loading and snow-storage anomalies can provide information that is complementary, rather than alternative, to rainfall observations. Such diagnostics cannot identify which slope will fail, but they could define periods when susceptible high-elevation terrain is exposed to an unusually adverse climatic background. Their value would be greatest when combined with repeat satellite observations, slope-deformation measurements, seismic records and field evidence capable of resolving the evolving mechanical state of individual slopes.

The downstream consequences make this distinction particularly important. Once the Langtang Lirung mass entered the valley system, a localized slope instability was transformed through entrainment and river interaction into a far-reaching flood cascade. The climatic anomaly was therefore concentrated near the source, whereas its consequences propagated through the connected river network. This separation between the spatial scale of preconditioning and that of impact is characteristic of cascading mountain hazards and means that environmental changes affecting a comparatively small unstable slope can create risk far beyond the source area.

Limitations

Several limitations restrict this causal interpretation. First, ERA5-Land resolves regional atmospheric and snow conditions, not the microclimate or thermal state of the failed slope. Second, positive-degree days provide a proxy for atmospheric thermal forcing but do not resolve subsurface heat transfer, liquid-water routing or the mechanical response of the rock–ice mass. Third, the August 2026 monthly snow diagnostics are estimated by scaling the 1–25 August daily mean to a 31-day month and are therefore used only to characterize the broader late-summer state; the daily pre-event diagnostics provide the more direct evidence for antecedent conditions. We also lack direct observations of the failed slope needed to identify the instantaneous mechanical trigger. Accordingly, our analysis does not attribute the failure to heat or snow drought. It instead establishes that the collapse followed exceptional atmospheric heat and pronounced snow scarcity, while occurring without an intense contemporaneous rainfall pulse. This distinction is central: the results support climatic preconditioning of the slope, but not attribution of the trigger. The Langtang Lirung disaster therefore highlights a form of Himalayan climatic preconditioning that rainfall alone would not reveal and shows why resolving subseasonal combinations of heat and snow scarcity may be important for understanding when local rock–ice instability can develop into a major downstream flood disaster.

Methods

Data and study region

We used ERA5-Land hourly and monthly data from 1st January 1979 to 26 August 2026 at 0.1° spatial resolution (~ 9 km).²¹ Hourly variables comprised 2-m air temperature (for full period), total precipitation, snowfall, snow depth, snow depth as snow-water equivalent (SWE) and snowmelt for August 2026. Different temporal aggregations were used according to the analysis. Hourly precipitation and air temperature for August 2026 were retained at their native temporal resolution to characterize conditions around the event. For temperature, heatwave and positive-degree-day analyses, hourly 2-m temperature for 1979–26 August 2026 was aggregated to daily maximum, minimum and mean temperature. Precipitation, snowfall, SWE, and snowmelt were analyzed at monthly resolution for the historical record through July 2026. As the event happened in last week, we used hourly data for 1–25 August for precipitation and snow variables. For accumulated variables (precipitation, snowfall and snowmelt), the mean daily accumulation over 1–25 August was multiplied by 31 to estimate an August-equivalent monthly total. For state variables (SWE and snow depth), the mean over 1–25 August was retained as the representative August 2026 value. These August estimates were used only to characterize the broader late summer hydroclimatic and snow state.

Source-region time series were spatially averaged over 28.1–28.4° N, 85.3–85.6° E, encompassing the reported failure area and surrounding high-elevation terrain (Fig. S19). Event-scale hourly series were converted from UTC to Nepal Standard Time (UTC + 6:00). Topography was derived from the Shuttle Radar Topography Mission (SRTM) digital elevation model obtained through OpenTopography.²² Sentinel-2 imagery provided the pre-event surface reference, whereas Landsat 9 imagery acquired on 26 August 2026 was used to delineate the event-day disturbance and downstream flood corridor.^{23,24} Additional high-resolution imagery used to constrain the failure scar, flood extent and downstream impacts was obtained from the Vantor Open Data archive for the August 2026 Nepal flood, the UN rapid-assessment material and GeoOpera satellite analyses. Event location and chronology were further constrained using the available rapid situation assessments.⁵

Temperature anomalies and heatwaves

Daily temperature anomalies were calculated relative to the corresponding 1979–2025 calendar-day climatology and displayed as 7-day running means for regional timeseries. Monthly absolute anomalies for 1–25 August are departures from the corresponding historical 1–25 August mean; standardized monthly anomalies were calculated as the departure divided by the 1979–2025 August (1–25) standard deviation. Rank maps compare (1–25) August 2026 with August values from 1979–2026, with rank 1 denoting the warmest year.

Heatwaves were identified from Tmax using a calendar-day 90th-percentile threshold (TX90) computed from a centred 15-day window during 1979–2025. A heatwave required at least three consecutive days with Tmax above TX90. The threshold was constrained to be at least 0°C to avoid classifying entirely sub-freezing high-elevation periods as heatwaves. This percentile-duration framework follows established heatwave definitions and its previous application to South Asian Mountain snow conditions.^{18,25,26}

Positive degree days and historical exceptionalness

Positive-degree days (PDD) were calculated from daily mean temperature as $PDD = \max(T_{mean}, 0)$ and expressed in °C day.^{27,28} Daily PDD anomalies were defined relative to the corresponding 1979–2025 calendar-day climatology. These daily anomalies were cumulatively summed from 1 July to 25 August and for a longer 1 March–25 August period, such that the value on each date represents the accumulated excess or deficit in above-freezing thermal exposure since 1 July and 1 March respectively. The same calculation was repeated independently for every year from 1979 to 2025 to derive the historical median and 5th–95th percentile envelope. The longer 1 March–25 August period represents broader seasonal thermal accumulation in 2026 relative to the historical climatology.

Antecedent thermal exceptionalness was quantified over 7-, 15-, 30-, 45-, 60-, 90- and 120-day windows, each ending on 25 August. For every window, T_{max} , T_{mean} , T_{min} , number of heatwave days and cumulative PDD anomaly were calculated for 2026 and for the identical calendar interval in each year from 1979 to 2025. The 2026 value was then ranked against the resulting 47-year historical distribution and expressed as an empirical percentile (Fig. 3d,f). Values approaching the 95th and 100th percentiles therefore indicate conditions near the upper tail or historical maximum of the observational record. These percentiles quantify the exceptionalness of the antecedent thermal state and are not interpreted as return periods or probabilities of slope failure.

Precipitation and snow-drought diagnostics

Hourly precipitation was used to determine whether an intense rainfall pulse coincided with the reported failure, whereas monthly precipitation and snow diagnostics were used to characterize the broader hydroclimatic state preceding the event. Standardized precipitation (SPI), snowfall (SFI), snow-water-equivalent (SSWEI) and snowmelt (SMLTI) indices were calculated over 1-, 3-, 6- and 12-month windows ending in August. SPI followed the probability-based formulation of McKee et al.²⁹ and Guttman³⁰ and the same procedure was applied to snowfall to derive SFI. Because snow-water equivalent and snowmelt do not necessarily conform to the same parametric distribution, SSWEI and SMLTI were derived empirically using the Gringorten plotting position, $p = (r - 0.44)/(n + 0.12)$, where r is the ascending rank and n is the sample size, followed by transformation to a standard normal variate.³¹ Negative index values indicate below-normal conditions and positive values indicate above-normal conditions.

The principal snow-drought assessment combines 3-month SPI and SFI for June–August with 1-month SSWEI for August, thereby distinguishing the antecedent precipitation and snowfall supply from the snow-water storage present immediately before the event. We use snow drought to denote anomalously low snowfall and/or depleted snow-water storage, following Huning and AghaKouchak.¹³ July–August snowmelt and longer-term snow diagnostics were additionally examined to determine whether the late-summer warmth was associated with anomalously high regional melt or instead with limited snow availability.

Because the event occurred on 26 August, August 2026 was represented using observations from 1–25 August. For accumulated variables—precipitation, snowfall and snowmelt—the mean daily accumulation over these 25 days was multiplied by 31 to obtain an August-equivalent monthly total. For state variables, including SWE, the 1–25 August mean was retained without temporal scaling. These August-based diagnostics therefore characterize the late-summer hydroclimatic and snow state preceding the event, rather than the instantaneous conditions or mechanical trigger at the time of failure.

Declarations

Data availability

ERA5-Land hourly and monthly data are available from the Copernicus Climate Change Service (C3S) Climate Data Store (CDS) <https://cds.climate.copernicus.eu/datasets> Shuttle Radar Topography Mission (SRTM) digital elevation data were obtained through OpenTopography <https://portal.opentopography.org/raster>. Pre-event Copernicus Sentinel-2 imagery is available through the Copernicus Data Space Ecosystem <https://browser.dataspace.copernicus.eu> , and post-event Landsat 9 imagery is available through the United States Geological Survey (USGS) EarthExplorer <https://earthexplorer.usgs.gov>. High-resolution satellite imagery used for detailed mapping of the failure area and downstream flood impacts was obtained from the Vantor Open Data Program <https://browser.moregeo.it/external/vantor-opendata.s3.amazonaws.com/events/Nepal-Flooding-Aug-2026> . Additional event information and satellite-based impact assessments were obtained from the United Nations Satellite Centre (UNOSAT) <https://nepal.un.org/en/323255-nepal-rasuwa-floods-2026-situation-reports> and the GeoOpera satellite-analysis platform <https://geopera.com/blog/bhote-koshi-flood-2026-satellite-analysis>. The rapid situation assessment used to constrain the event chronology, source area and downstream impacts is cited as ref. 5.

Code availability

The analysis was performed using Python. Code required to reproduce the diagnostics and figures will be available from the corresponding author for peer review.

Author contributions

W.U.H. conceived and designed the study, performed the analyses and drafted the manuscript. M.S.S. and H.P.D. contributed in interpretation and writing. I.H. and Y.A. contributed to supervision and manuscript revision. All authors reviewed and approved the manuscript.

Competing interests

The authors declare no competing interests.

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Figures

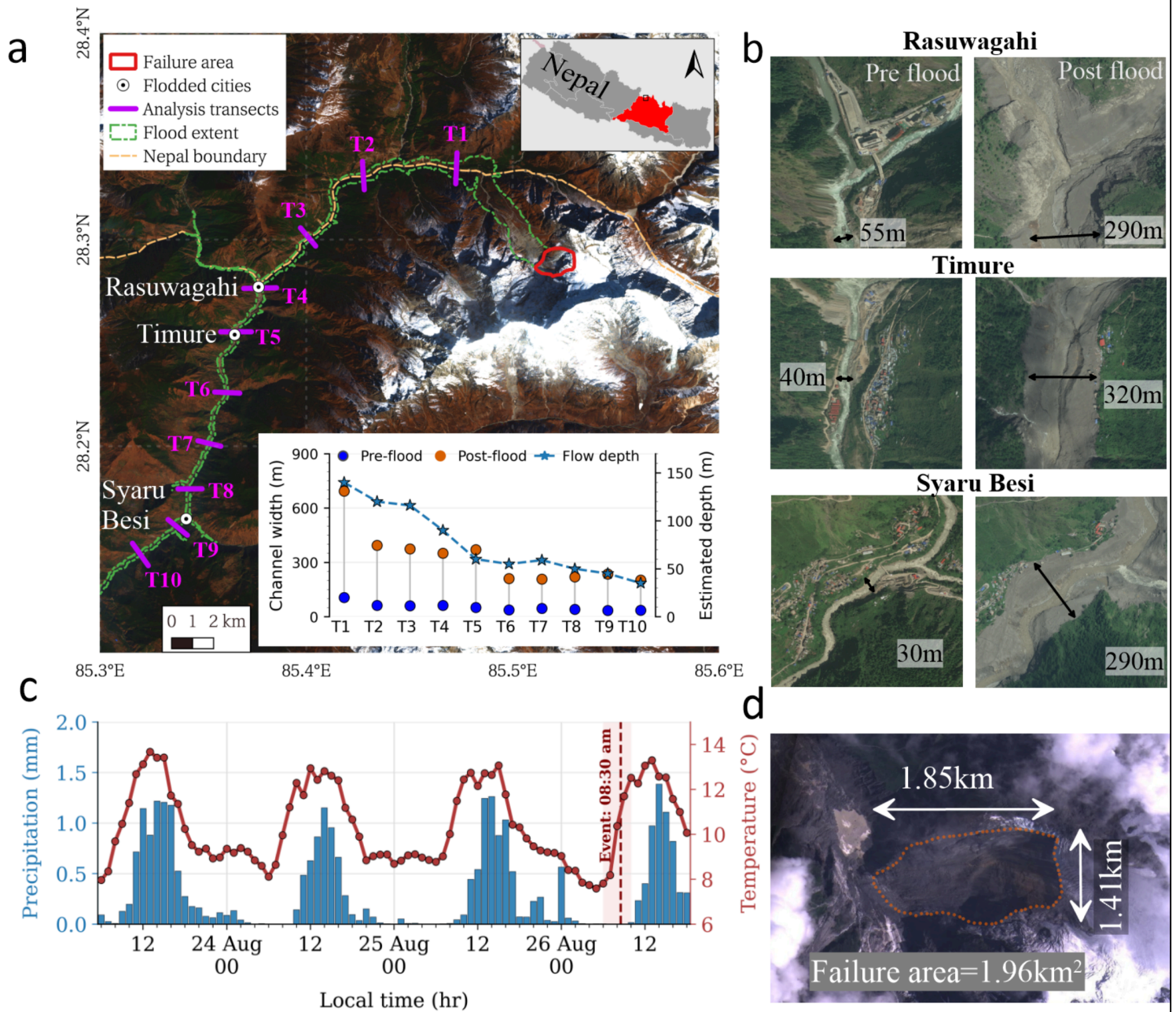


Figure 1

Event setting, flood impacts, and meteorological conditions associated with the 26 August 2026 Bhote Koshi–Trishuli disaster. (a) Sentinel-2 image from 18 February 2026 showing the selected analysis region and highlighting the collapse/failure area, mapped flood extent, and ten cross-channel transects (T1–T10) along the downstream corridor. The inset summarizes pre- and post-flood channel widths and reconstructed flow depths at the transects. (b) Pre- and post-flood imagery at Rasuwagadhi, Timure and Syaru Besi, from the Ventor Open Database illustrating pronounced flood damage with representative river widths annotated. (c) Hourly precipitation and 2-m air temperature during 23–26 August 2026; the dashed line marks the reported failure time (~08:30 local time) and the shaded band indicates the approximate event window. (d) High-resolution SuperView-2 image acquired on 27 September 2026, accessed through Landsat Viewer, showing the mapped failure scar and its dimensions.

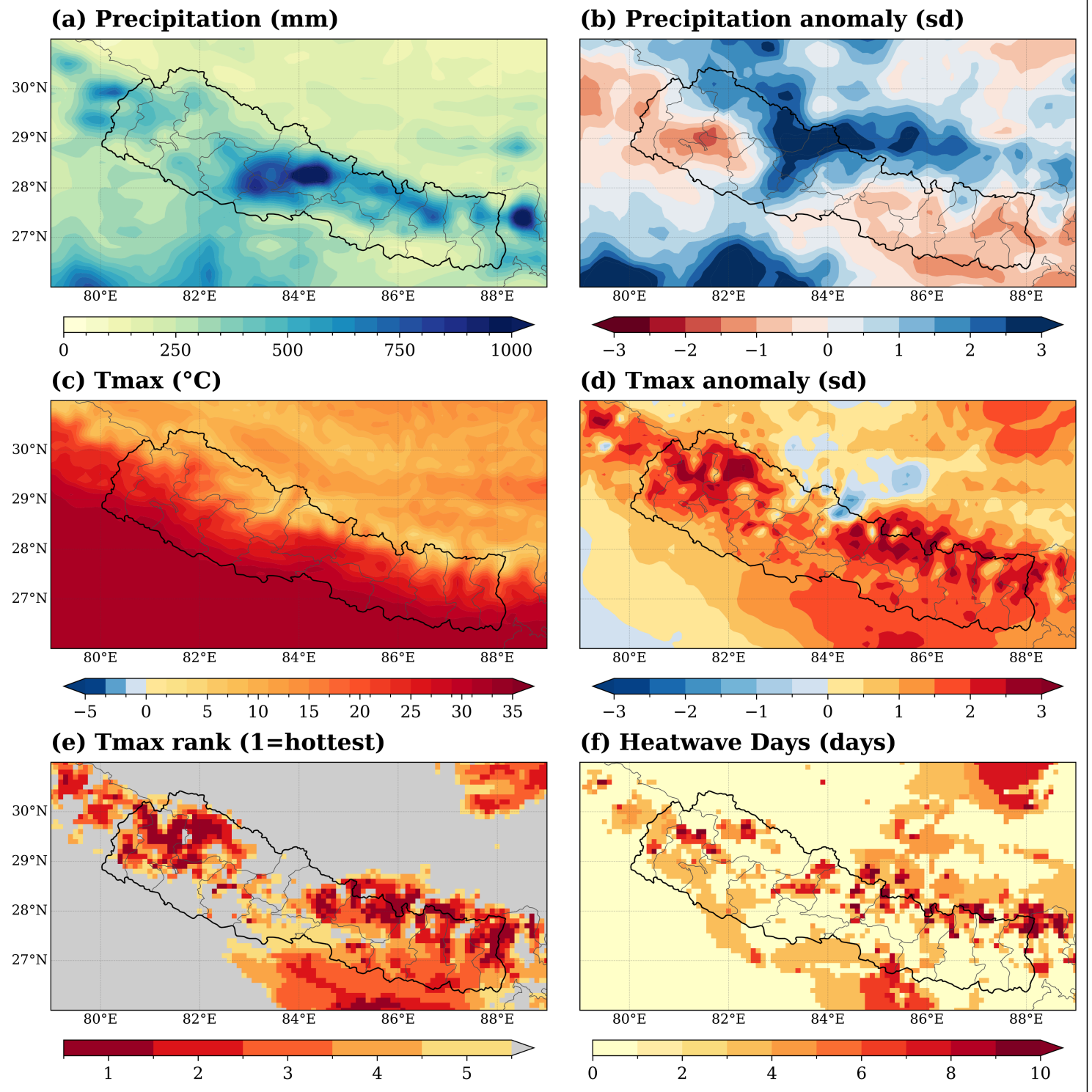


Figure 2

Regional precipitation and temperature context during August 2026. (a) 1–25th August precipitation and (b) its standardized anomaly relative to 1979–2025. (c) August-mean daily maximum temperature and (d) its standardized anomaly. (e) Historical rank of August maximum temperature during 1979–2026 (rank 1 is warmest). (f) Heatwave days identified using the TX90 criterion.

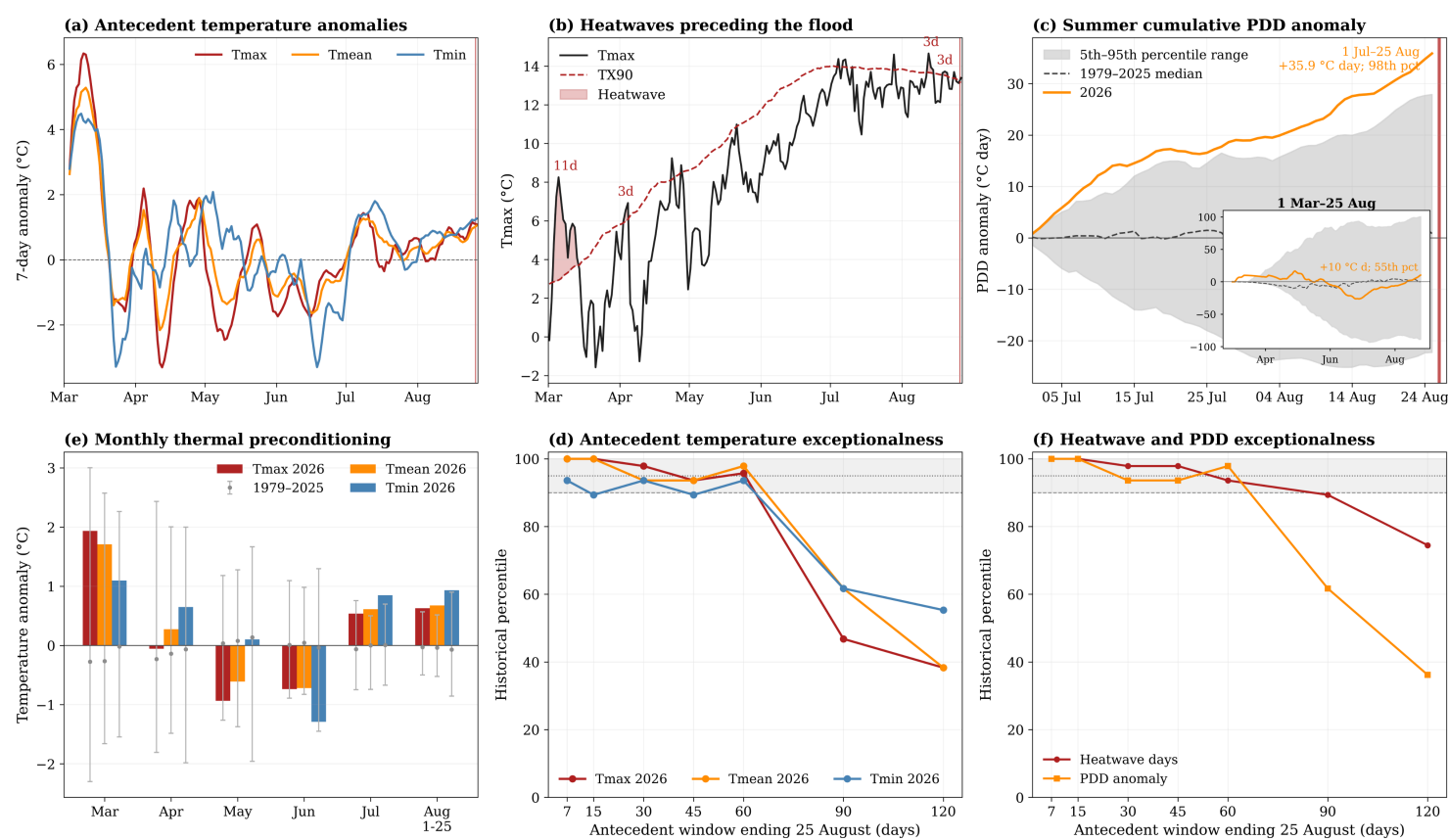


Figure 3

Timing and historical exceptionalness of antecedent thermal conditions. (a) Seven-day running anomalies of regional maximum, mean and minimum temperature from March to 25 August 2026. (b) Daily maximum temperature, climatological TX90 threshold and identified heatwaves. (c) Cumulative PDD anomaly during 1 July–25 August; inset, 1 March–25 August. (d) Historical percentile of antecedent temperature anomalies across windows ending on 25 August. (e) Monthly temperature anomalies. (f) Historical percentiles of heatwave-day counts and PDD anomalies across the same windows.

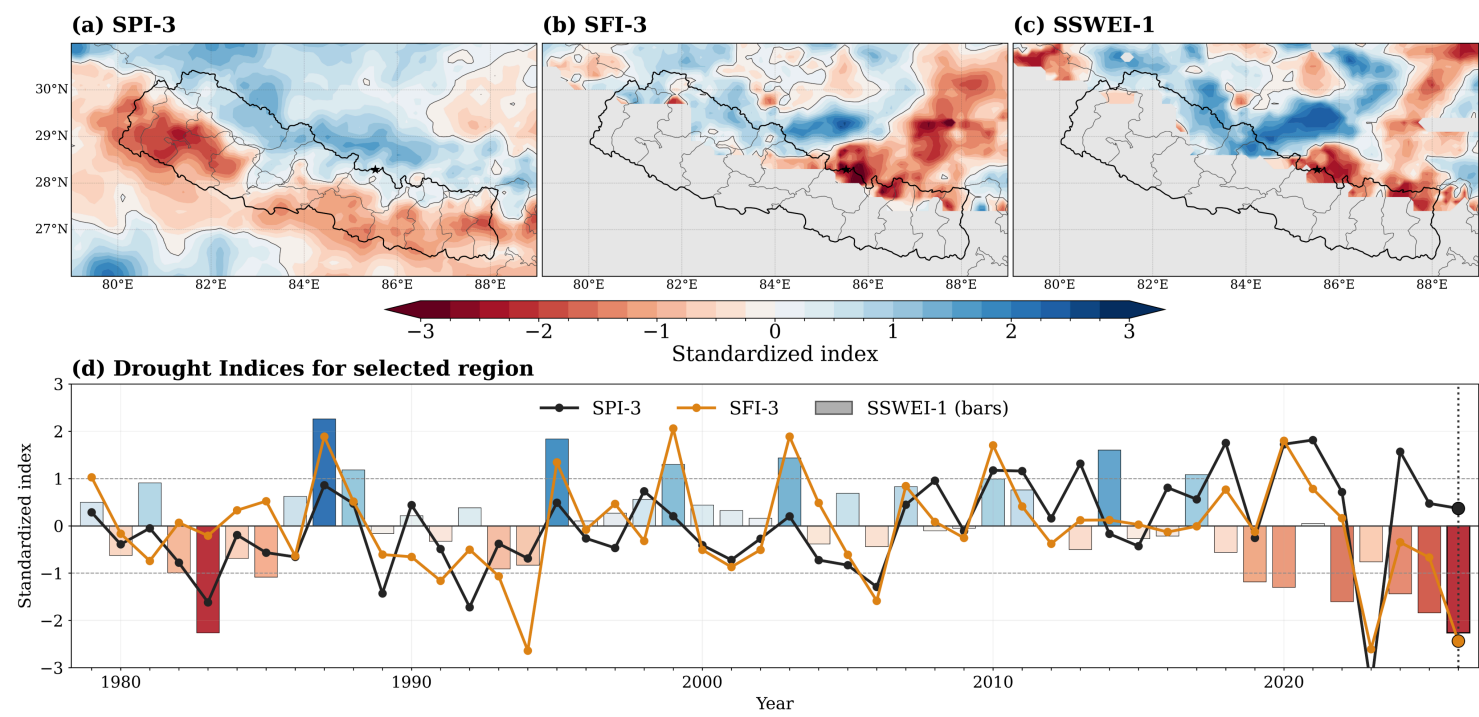


Figure 4

Acute snowfall and snow-storage deficits despite normal seasonal precipitation. (a–c) Spatial distributions of three-month SPI, three-month SFI and one-month SSWEI for windows ending in August 2026. (d) Historical August-ending evolution of SPI-3, SFI-3 and SSWEI-1 over the selected region during 1979–2026. The 2026 endpoints highlight above-normal antecedent precipitation concurrent with severe recent snowfall and August snow-water-storage deficits.