https://doi.org/10.5194/egusphere-2026-7263
Preprint. Discussion started: 26 November 2026
© Author(s) 2026. CC BY 4.0 License.

Brief communication: When hazards change what early-warning systems can see

Carlos Garcia-Soto

Spanish National Research Council (CSIC), 39004 Santander, Spain

Correspondence to: Carlos Garcia-Soto (carlos.soto@csic.es)

Abstract. When a cascading hazard changes physical regime, the observations that reveal danger can change with it. The 26 August 2026 Nepal–Tibet disaster shows why early-warning systems should be stress-tested not only for component performance, but also for diagnostic handoffs — whether they can recognize shifts in the diagnostic value of observations as the hazard evolves, before actionable time is lost.

1 Event anomaly

On 26 August 2026, a large high-mountain mass movement involving ice and rock began near the Nepal–Tibet border at about 08:37 local time. A seismic signal recorded its onset almost immediately (USGS, 2026a, b). Three minutes later, at 08:40, the last publicly reported reading from the Rasuwagadhi hydrometric station was 1.62 m — well below its 6-m warning and 7-m danger thresholds (FFD, 2026). By the next scheduled reading at 08:50, the station had stopped transmitting (DHM, 2026; FFD, 2026). Automatic monitoring stations in the upper Bhote Koshi–Trishuli corridor, including Rasuwagadhi (16 km), Syaphrubesi (23 km), and Betrawati (49 km), were later reported to have been swept away, with their last recorded water levels below warning thresholds (FFD, 2026). Farther downstream, the same disturbance became progressively easier to follow hydrometrically: gauges at Phurke (86 km), Kalikhola (109 km) and Devghat (126 km) recorded the flood wave over the following hours, while successive warnings were issued to downstream districts (FFD, 2026).

This sequence does not show that the thresholds were wrongly calibrated or the gauges malfunctioned. It illustrates something potentially more important: the same event was not equally legible to the same modes of observation throughout its evolution and propagation.

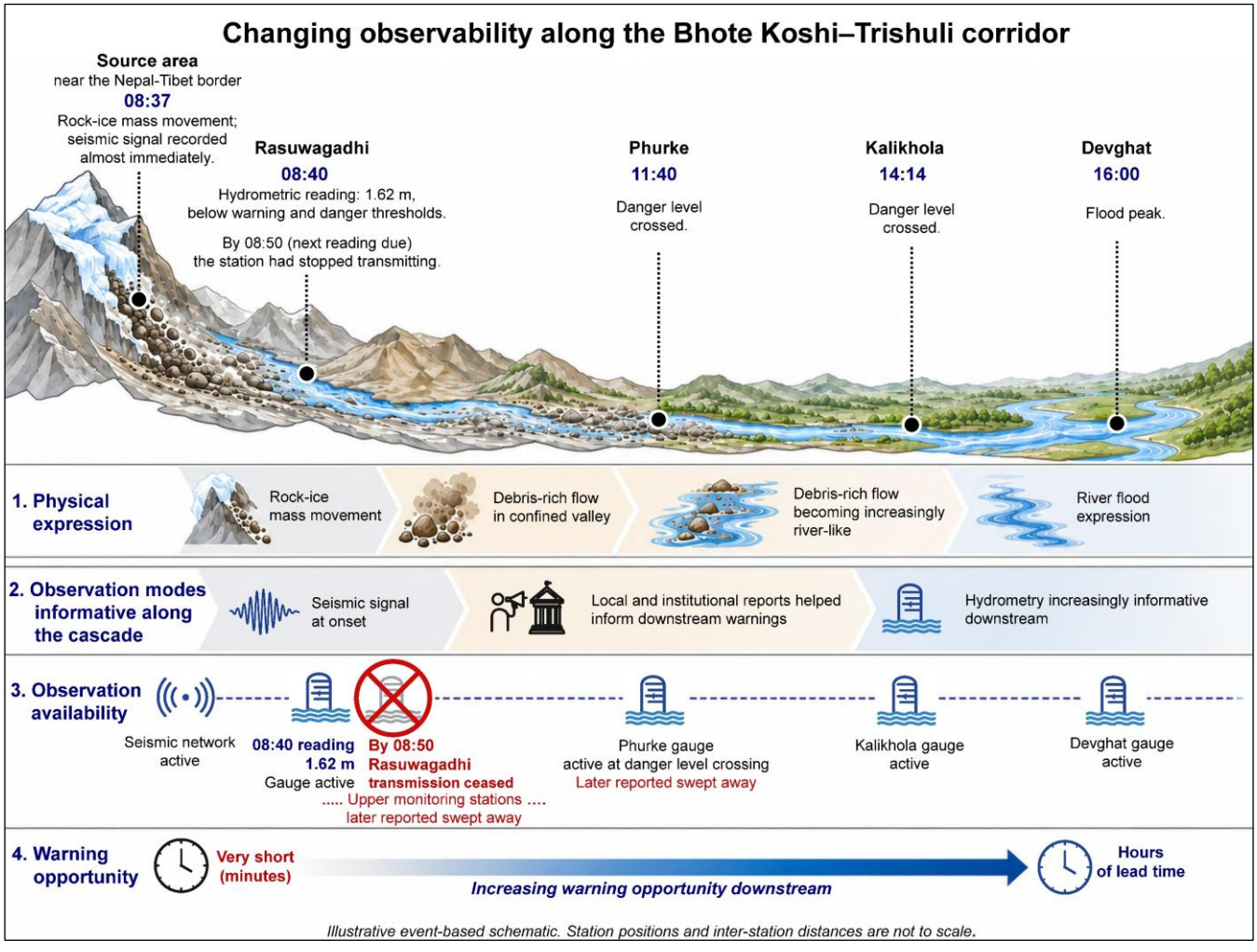
2 Different observation regimes

The physical process itself changed rapidly. Current reconstructions identify an initial rock–ice collapse from Langtang Lirung that mobilized water and sediment into a fast debris-rich flood (ICIMOD, 2026a; Fakhruddin et al., 2026). Farther

https://doi.org/10.5194/egusphere-2026-7263
Preprint. Discussion started: 26 November 2026
© Author(s) 2026. CC BY 4.0 License.

downstream, the disturbance became increasingly expressed as a river flood. The relative contributions of glacier water, river-water entrainment, temporary blockage and release, and other intermediate processes remain uncertain, but the broad transition from a high-mountain mass movement to a progressively more river-like disturbance is clear.

That transition was accompanied by a change in which observations were most informative. Seismic observations recorded the initial mass movement (Adhikari et al., 2026). As the disturbance entered and propagated through the river corridor, hydrometric observations became increasingly informative downstream (FFD, 2026; Fakhruddin et al., 2026). As automated monitoring became unavailable in parts of the corridor, reports relayed through local authorities and observers helped inform downstream warnings (FFD, 2026; Poudel, 2026). The disturbance therefore moved not only through physical regimes, but through observational regimes (Fig. 1).



https://doi.org/10.5194/egusphere-2026-7263
Preprint. Discussion started: 26 November 2026
© Author(s) 2026. CC BY 4.0 License.

Figure 1: Physical and observational evolution of the 26 August 2026 Nepal–Tibet cascade.

This event-based schematic shows how the physical expression of the disturbance, the observation modes informative along the cascade, observation availability and warning opportunity changed downstream from the source area to Rasuwagadhi, Phurke, Kalikhola and Devghat. Selected timings (Nepal Time, UTC+05:45) indicate key points in the sequence, including seismic onset (~08:37), the last reported Rasuwagadhi hydrometric reading (1.62 m at 08:40) before the station was swept away, cessation of transmission by 08:50, danger-level exceedance at Phurke (~11:40) and Kalikhola (14:14), and the Devghat peak (~16:00). The chronology draws on USGS records (2026a, b), the Flood Forecasting Division's event report (FFD, 2026), and DHM hydrometric observations documenting the 10-min reporting interval (DHM, 2026). Station positions, river geometry and inter-station spacing in the schematic are not to scale. Approximate straight-line distances from the mapped source area to the six stations discussed in Sect. 1 — Rasuwagadhi, Syaphrubesi, Betrawati, Phurke, Kalikhola and Devghat — are 16, 23, 49, 86, 109 and 126 km, respectively, calculated from geographic coordinates using WGS84. These are not along-channel distances. The increase in warning opportunity downstream partly reflects travel time and is not shown as a consequence of physical-regime transformation.

3 Observability is not fixed

An early-warning system does not observe 'hazard' directly. It observes variables that stand in for dangerous physical states. River stage, seismic motion, rainfall, satellite imagery, cameras and human reports can each be informative under particular conditions. Their diagnostic value, however, need not remain constant as a process transforms.

A river-stage gauge may be effective for rainfall- or seasonal melt-driven rises, yet provide little diagnostic information about an upstream rock–ice collapse before its effects reach the gauge. The ensuing debris-rich flood may then render the gauge itself unavailable.

The same corridor illustrates why this also matters between events. The July 2025 disaster was attributed to rapid drainage from a supraglacial lake (Parajuli et al., 2026), whereas the August 2026 event began with a rock–ice mass movement (ICIMOD, 2026a). Both reached the same downstream river system through different upstream process chains. A warning network may be well equipped to recognize one familiar signature without being equally informative while a different initiating process is evolving towards a similar downstream flood.

Observability should not be treated as a fixed property of a warning system; it depends on physical regime, location along the cascade and the availability of particular observation modes.

A sensor can function as designed while the variable it measures is temporarily less informative about the dangerous state that matters most. Conversely, an observation that is informative early in an event may become less useful later, while another becomes more diagnostic. The problem is therefore not simply whether observations remain available, but whether the system recognizes when the relationship between an observation and the physical state of concern has changed.

https://doi.org/10.5194/egusphere-2026-7263
Preprint. Discussion started: 26 November 2026
© Author(s) 2026. CC BY 4.0 License.

4 Integration is not the same as diagnostic continuity

Modern multi-hazard early-warning systems are already designed as end-to-end systems rather than collections of sensors. Risk knowledge informs what is monitored; observations and forecasts feed warning decisions; and warnings connect to preparedness and response (WMO, 2018). Value-chain approaches emphasize the interfaces between technical and institutional functions (Golding et al., 2019), while recent work combines multiple observation modes, proxies and decision processes in complex climate-risk warning (Reichstein et al., 2025).

The literature following the event has strengthened the case for greater use of seismic, hydrological and satellite observations in operational warning decisions (ICIMOD, 2026a; Fakhruddin et al., 2026). That leads directly to the next design question: when the hazard changes physical regime, how should a warning system recognize that the diagnostic value of those observations has changed too?

Systems theory applied to accident modelling has long shown that components can operate as intended while the system as a whole becomes unsafe if the internal representations guiding those components diverge from the process being controlled (Leveson, 2004).

Integration can connect observations, warnings and actions without guaranteeing that the diagnostic meaning carried between them remains valid as the process itself changes. What matters across the transition is not that every observation sees the same thing, but that the system recognizes which observations best represent danger at each stage and how their meaning changes as the process evolves.

This is diagnostic continuity: observations and their interpretation continue to correspond to the relevant physical state, while the warning logic they support remains compatible with the lead time still available. End-to-end integration seeks to connect the parts. Transforming hazards add a narrower test: does the diagnostic relationship carried across those connections remain valid as the hazard changes?

5 Stress-test diagnostic handoffs

For plausible transforming-hazard scenarios, the transitions between observation regimes should themselves become objects of early-warning-system testing. In a scenario moving from slope failure to debris-rich flow and then to river flood, for example, the test should go beyond asking whether each component functions. It should ask what observations are diagnostic in each regime, when another source becomes more informative, whether the associated interpretation or threshold still represents danger, whether that observation remains available and communicable, and how much actionable lead time remains when the transition occurs.

This transition can be treated as a diagnostic handoff. A handoff need not mean that one instrument switches off and another switches on. Sources can overlap, and their relative diagnostic value can change gradually. The handoff may be between seismic and hydrometric observations, between automated sensing and human reports, or between local sensing and satellite- or model-based information. The test is whether the system has anticipated the conditions under which one source no longer

https://doi.org/10.5194/egusphere-2026-7263
Preprint. Discussion started: 26 November 2026
© Author(s) 2026. CC BY 4.0 License.

carries enough diagnostic information on its own, which other source or interpretation can then better represent the hazardous state, and whether that change occurs while useful lead time remains. A scenario would expose a potential diagnostic discontinuity if the warning logic remained reliant on a signal that no longer adequately represents the evolving hazardous state, without a timely way to recognize and compensate for that loss of diagnostic value. This differs from an instrument outage and from an unavoidable lack of physical lead time; neither alone establishes a failed diagnostic handoff.

Process-specific multimodal monitoring already shows how different observations and thresholds can support warning at different stages of a hazard cascade. In the Sedongpu Valley, geophones have been used to monitor ice–rock collapse and debris flow, while water-level monitoring supports warning of river blockage (Yang et al., 2023). Recent work on the Bhote Koshi–Trishuli corridor also proposes combining seismic, hydrological and remote-sensing information within a broader warning and preparedness framework (Fakhruddin et al., 2026). The narrower question here is whether transitions in the diagnostic value of observations are explicitly anticipated and stress-tested.

6 Do not wait for the next hazard to look like the last one

The interpretation of individual links in the August 2026 cascade remains constrained by uncertainties about water sources, possible intermediate blockage or breach, monitoring loss, warning dissemination and operator decisions (FFD, 2026; ICIMOD, 2026a; Fakhruddin et al., 2026; Poudel, 2026). The event was still being reconstructed when another major mountain flood struck Nepal's Budhi Gandaki basin on 11 October. Satellite analysis subsequently confirmed another rock avalanche and glacier collapse (ICIMOD, 2026b). The sequence was different, and it does not establish the same diagnostic problem. But the recurrence of Himalayan floods reinforces a further point: warning systems across the region can confront another cascade before the previous one has been fully reconstructed.

The prospective lesson of the August 2026 disaster is that warning systems should become not process-agnostic, but process-robust: designed and tested for the possibility that the observation carrying the most useful information at one stage may not do so at the next. Sensors, thresholds and communications may each function as intended; the further test is whether diagnostic information can be handed off across plausible changes in physical regime before actionable time is lost.

For transforming hazards, effective warning depends not only on whether danger can be observed, but on whether the system recognizes when the way it observes danger must change.

Data availability

No new datasets were generated for this brief communication. The observations and event information are drawn from the cited sources. Historical DHM hydrometric observations for Rasuwagadhi and Syaphrubesi were accessed on 3 September 2026. These records are no longer displayed on the respective station webpages. Screenshots captured at that time are available from the author for verification.

https://doi.org/10.5194/egusphere-2026-7263
Preprint. Discussion started: 26 November 2026
© Author(s) 2026. CC BY 4.0 License.

Author contributions

C.G.-S. conceived the study, conducted the analysis, prepared Fig. 1, and wrote the manuscript.

Competing interests

The author declares no competing interests.

Acknowledgements

The illustrative background artwork in Fig. 1 was generated using ChatGPT (OpenAI). The figure was subsequently assembled and edited by the author. All scientific annotations, observational data and interpretations were added and verified by the author against the cited sources.

Financial support

No funding was received for this research.

References

Adhikari, L. B., Subedi, S., Hetényi, G., Bollinger, L., Li, L., Hicks, S. P., Karplus, M. S., Diaz, J., Thapa, H. R., Pokharel, T., Timsina, C., Poudel, A., Pokhrel, K., Bhattarai, S., Weiskopf, E., Sharma, R., and Bhattarai, M.: Tsangbu Ri slope failure triggers massive flash flood across the Himalaya and shakes the globe – the seismic observations, Seismica, 5(2), https://doi.org/10.26443/seismica.v5i2.3433, 2026.

DHM (Department of Hydrology and Meteorology, Government of Nepal): Bhotekoshi at Rasuwagadi, station 446.22, https://dhm.gov.np/hydrology/hms-Single/4913 (last access: 3 September 2026), 2026.

Fakhruddin, B. S. M., Pradhananga, D., Aryal, K., Torterat, L., and Bhatta, R.: Cascading ice–rock avalanche multi-hazard early warning in the Bhote Koshi–Trishuli River corridor, Water, 18, 2671, https://doi.org/10.3390/w18212671, 2026.

FFD (Flood Forecasting Division, Hydrology and Water Resources Research Center): Press release [in Nepali], Government of Nepal, 27 August 2026, https://hydrology.gov.np/cm/files/report_bhotekoshi_1787808964794.pdf, 2026.

Golding, B., Mittermaier, M., Ross, C., Ebert, B., Panchuk, S., Scolobig, A., and Johnston, D.: A value chain approach to optimising early warning systems, Contributing Paper to GAR 2019, UNDRR, https://www.undrr.org/publication/value-chain-approach-optimising-early-warning-systems, 2019.

ICIMOD (International Centre for Integrated Mountain Development): Understanding the Gyirong–Rasuwa disaster of 26 August 2026: A preliminary synthesis, https://doi.org/10.53055/ICIMOD.1150, 2026a.

https://doi.org/10.5194/egusphere-2026-7263
Preprint. Discussion started: 26 November 2026
© Author(s) 2026. CC BY 4.0 License.

ICIMOD (International Centre for Integrated Mountain Development): Second major Himalayan flood in seven weeks raises alarm over compounding mountain hazards, press release, 13 October 2026, https://www.icimod.org/press-releases/second-major-himalayan-flood-in-seven-weeks-raises-new-questions-about-mountain-risk/, 2026b.

Leveson, N. G.: A new accident model for engineering safer systems, Saf. Sci., 42, 237–270, https://doi.org/10.1016/S0925-7535(03)00047-X, 2004.

Parajuli, B., Joshi, S., Mishra, S., Dukuchhu, B., Zoowa, B., and Joshi, K.: Flood Forecasting and Early Warning Report 2082, Issue No. 05 [in Nepali], Department of Hydrology and Meteorology, Government of Nepal, https://dhm.gov.np/uploads/dhm/downloads/1778482397_a2953669596972378250.pdf, 2026.

Poudel, S.: Nepal sent its disaster alert 38 minutes after the glacier collapse. It wasn't enough, The Kathmandu Post, 2 September 2026, https://kathmandupost.com/national/2026/09/02/nepal-sent-its-disaster-alert-38-minutes-after-the-glacier-collapse-it-wasn-t-enough, 2026.

Reichstein, M., Benson, V., Blunk, J., Camps-Valls, G., Creutzig, F., Fearnley, C. J., Han, B., Kornhuber, K., Rahaman, N., Schölkopf, B., Tárraga, J. M., Vinuesa, R., Dall, K., Denzler, J., Frank, D., Martini, G., Nganga, N., Maddix, D. C., and Weldemariam, K.: Early warning of complex climate risk with integrated artificial intelligence, Nat. Commun., 16, 2564, https://doi.org/10.1038/s41467-025-57640-w, 2025.

USGS (U.S. Geological Survey): M 5.2 Landslide – 55 km NW of Kodāri, Nepal, earthquake event page, 26 August 2026, https://earthquake.usgs.gov/earthquakes/eventpage/us7000tbwb/executive, 2026a.

USGS (U.S. Geological Survey): 2026 Nepal debris avalanche and flash flood, Landslide Hazards Program, 27 August 2026, https://www.usgs.gov/programs/landslide-hazards/science/2026-nepal-debris-avalanche-and-flash-flood, 2026b.

WMO (World Meteorological Organization): Multi-hazard Early Warning Systems: A Checklist, https://community.wmo.int/sites/default/files/EWS_Checklist_0.pdf, 2018.

Yang, W., Wang, Z., An, B., Chen, Y., Zhao, C., Li, C., Wang, Y., Wang, W., Li, J., Wu, G., Bai, L., Zhang, F., and Yao, T.: Early warning system for ice collapses and river blockages in the Sedongpu Valley, southeastern Tibetan Plateau, Nat. Hazards Earth Syst. Sci., 23, 3015–3029, https://doi.org/10.5194/nhess-23-3015-2023, 2023.