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Climate  
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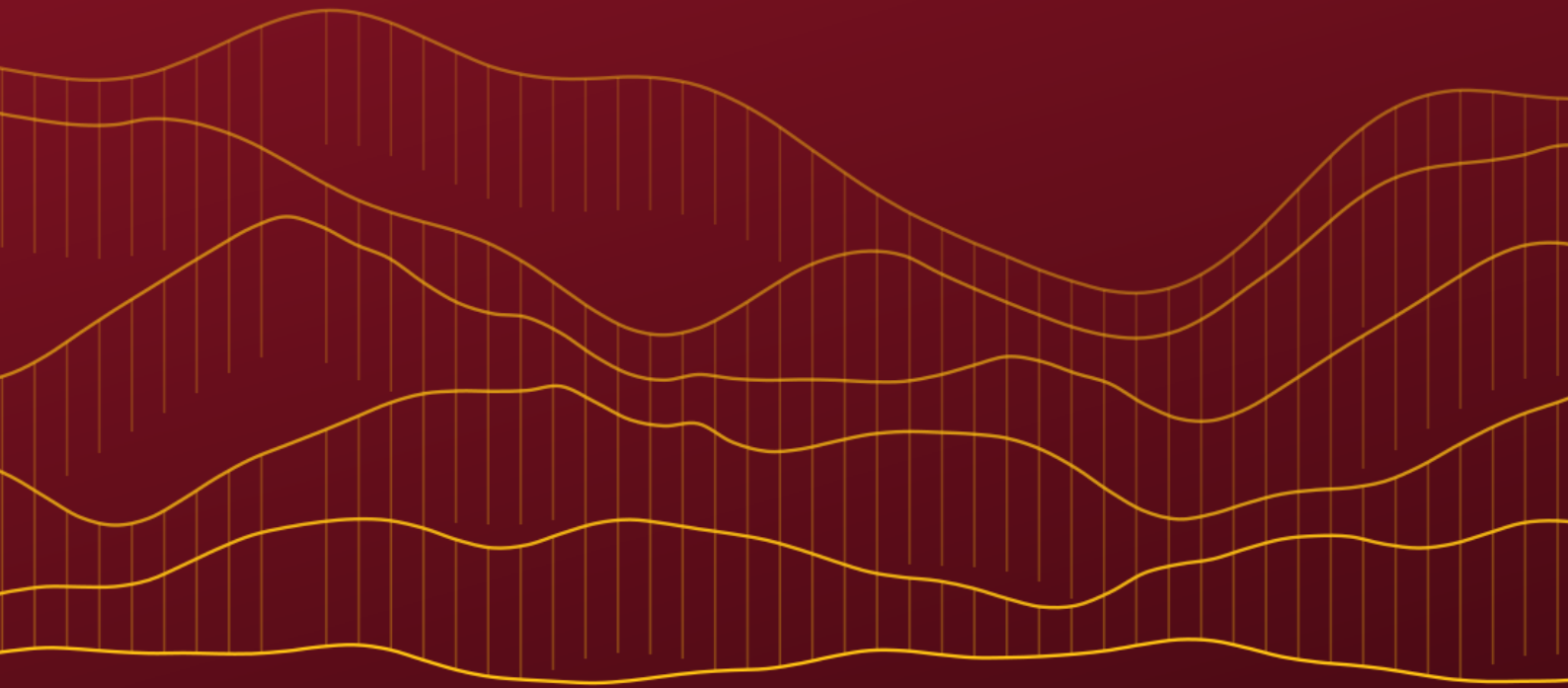


CONVENING REPORT

07 SEPTEMBER 2026

# Mountain Tsunami in the Himalaya

*Understanding the Plight,  
the Science and the Path to Resilience*



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Organized by Youth Innovation Lab, Red Cross Red Crescent Climate Centre, Kathmandu University and University of Twente in collaboration with Ministry of Energy, Water Resources and Irrigation (MOEWRI), Government of Nepal, Chengdu University of Technology, Utrecht University, Newcastle University, Chinese Academy of Sciences, United Nations Office for Disaster Risk Reduction (UNDRR), Tribhuvan University and Kathmandu University.

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This report documents the virtual convening «Mountain Tsunami in the Himalaya: Understanding the Plight, the Science and the Path to Resilience,» held 7 September 2026, prepared by Youth Innovation Lab with the Red Cross Red Crescent Climate Centre, Kathmandu University, University of Twente, Nepal's Ministry of Energy, Water Resources and Irrigation, Chengdu University of Technology, Utrecht University, Newcastle University, the Chinese Academy of Sciences, UNDRR, and Tribhuvan University.

All scientific results reported in this document were presented as preliminary. Volumes, velocities, casualty figures and damage estimates were changing while the convening was under way and continued to change afterwards. Every figure in this report carries the date and the source under which it was given. Readers should treat all of them as provisional and re-verify against the issuing institution before citing.

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# Acknowledgements

This report is a product of Youth Innovation Lab. It was prepared by a team comprising Pradip Khatiwada, Executive Director, Youth Innovation Lab; Madhab Uprety, Senior Technical Adviser, Red Cross Red Crescent Climate Centre; Sabin Dotel, Programs Manager, Youth Innovation Lab; and Anil Pokhrel, Former Chief Executive, NDRRMA.

The convening on which this report is based was organized by Youth Innovation Lab together with the Red Cross Red Crescent Climate Centre, Kathmandu University, and the University of Twente, in collaboration with the Ministry of Energy, Water Resources and Irrigation, Government of Nepal, Chengdu University of Technology, Utrecht University, Newcastle University, Chinese Academy of Sciences, United Nations Office for Disaster Risk Reduction (UNDRR), and Tribhuvan University. It was convened on three days' notice, in the middle of a live emergency response, and it succeeded only because a large number of people agreed to interrupt urgent work in order to put evidence on the public record.

The report is built on the presentations and interventions of Dr. Mohan Bahadur Chand, Prof. Xuanmei Fan, Academician Prof. Cui Peng, Dr. Chenxiao Tang, Prof. Cees van Westen, Ashok Dahal, Prof. Bethan Davies, Prof. Walter Immerzeel, Mr. Sanjeeb Baral, Dr. Archana Shrestha, Prof. Dr. Vishnu Prasad Pandey, Dr. Jagadishwor Karmacharya, Mr. Anil Pokhrel, Mr. Marco Toscano-Rivalta, and Mr. Pradip Khatiwada. Several of them were, at the time of speaking, still in the field or still feeding analysis to their governments.

Contributing institutions included Chengdu University of Technology, the Institute of Mountain Hazards and Environment of the Chinese Academy of Sciences, Utrecht University, Newcastle University, the Faculty of Geo-Information Science and Earth Observation of the University of Twente, Tribhuvan University, Kathmandu University, the Department of Hydrology and Meteorology, the Centre of Hydrology and Water Resources Research, and the United Nations Office for Disaster Risk Reduction Regional Office for Asia and the Pacific.

Sabin Dotel, Programs Manager at Youth Innovation Lab, led coordination of the convening from concept to delivery; managing speaker outreach and confirmation, participant registration, and the logistics that made it possible to organize this event on three days' notice. The technical production team at Youth Innovation Lab managed the platform, the recording, and the question-and-answer channel under difficult conditions.

Youth Innovation Lab is grateful to the 956 people who registered and to the more than 800 who attended, many of them from the affected districts, and many of whom submitted questions that shaped the discussion and that are carried forward in this report.

This report is dedicated to those who were lost on 26 August 2026 and to the families still waiting for news. It is published in the knowledge that the search and rescue were still under way as it went to press.

# Foreword

On 26 August 2026, a mass of rock and ice detached from Langtang Lirung at around 5,200 metres, fell more than a kilometre, and arrived at the Nepal and China border some seven to eight minutes later as a flood. By the time it reached the Trishuli and the Narayani it had passed through five districts. It is the deadliest single event in Nepal since the 2015 earthquake sequence, and it is the second catastrophic flood to strike this same river corridor in fourteen months.

This report is the record of a conversation held twelve days later, on 7 September 2026, one day before the eighty-first session of the United Nations General Assembly opened. That timing was deliberate. Nepal intended to take the climate dimension of this disaster to the international stage. A claim of that weight is strongest when the science behind it is visible, rigorous, and transparent. So, we asked the scientists who had been in the field, or in the satellite record, or in the seismic archive, to say plainly what they had found and, just as plainly, what they had not.

What they described is not a flood. It is a sequence: bedrock failure, glacier detachment, an avalanche that generated a blast wind more than a kilometre wide, frictional melting that turned ice into water, a debris flow that scoured its own channel and grew as it ran, a secondary landslide three hours later large enough to register as a magnitude 4.2 earthquake, a barrier lake, and a flood wave that crossed an international border before any institution on either side knew that anything had happened.

Three things emerged with unusual clarity. First, the physical evidence for a changing baseline under which the event occurred is strong, and it is local. The Langtang-Lirung Glacier above the failure zone has been shrinking for decades the retreat has accelerated sharply since 2010. Permafrost is degrading fastest in exactly the same elevation band where the where this catastrophic landslide occurred. The zero-degree isotherm has risen past the failure elevation within the working lifetime of the people who study it. Precipitation is shifting from snow to rain at these high elevations. The three days before the collapse were unusually warm.

Second, that is not the same as attribution, and the scientists in the room were careful to say so. A changing climate makes an environment more prone to this class of failure. Establishing how much it contributed to one specific collapse in one specific catchment requires event-specific, process-specific and catchment-specific evidence, and that work is under way rather than finished. This report does not close that question. It sets out what would be needed to close it. Third, and least comfortable, the governance findings were harsher than the scientific ones. Nepal does not have a fully functional national emergency operations centre. It does not have a common alerting protocol. It does not have a national stockpile facility under the authority that is legally supposed to hold one. Public hydropower assets built with taxpayers' money are uninsured. In 2024, four days of advance warning did not prevent the loss of around 450 lives. None of that is a scientific problem.

The mountains have given a warning. Science has helped us understand part of it. What happens now is a matter of collective responsibility, and it will be settled not by better models alone but by institutions, financing, and the willingness to act on evidence before the next event rather than after it.

This was not a one-off convening. It is the start of a continuing series of scientific exchange, and this report is the first instalment of the record.

**Pradip Khatiwada**

Executive Director  
Youth Innovation Lab

# Executive Summary

On 26 August 2026 a bedrock and glacier failure at approximately 5,200 metres on Langtang Lirung, about 64 kilometres north of Kathmandu and close to the Nepal and China border, initiated a cascading sequence that reached the Rasuwa Bhote Koshi within minutes and propagated downstream through the Trishuli and Narayani systems into Rasuwa, Nuwakot, Dhading, Gorkha and Chitwan districts. This is an exceptionally severe and complex disaster, with cascading impacts unfolding from the high mountains through interconnected river systems and downstream communities, and second catastrophic flood in this corridor in just fourteen months.

This report records and analyses a high-level convening held on 7 September 2026, twelve days after the event and one day before the opening of the eighty-first session of the United Nations General Assembly. Fourteen scientists, government officials and disaster risk practitioners from Nepal, China, the Netherlands, the United Kingdom, and the United Nations system presented preliminary findings to more than 800 participants.

## **The event was a cascade and system of interacting hazards, not a flood**

Presenters converged on a common physical narrative while disagreeing on its quantities. A mass of predominantly bedrock, with overlying and adjacent glacier ice, detached at around 5,100 to 5,200 metres and fell roughly 1,200 to 1,400 metres onto a debris-covered glacier. The impact scoured additional ice and debris. Frictional heating during the fall liquefied a substantial part of the ice, producing a highly mobile slurry rather than a dry rock avalanche. The avalanche generated a blast wind up to 1.3 kilometres wide that stripped vegetation from the valley sides. The flow entered the river system at about 2,900 metres, destroyed a hydropower station and its reservoir, and reached the Rasuwagadhi and Jirong border crossing roughly 21 to 22 kilometres away in seven to eight minutes. Approximately three hours later a secondary landslide, triggered by erosion at the foot of an oversteepened slope, generated ground shaking equivalent to a magnitude 4.2 earthquake and dammed the channel, forming a barrier lake that later released naturally.

## **The numbers are genuinely contested**

Three teams presented source volume estimates within twelve days. Kathmandu University estimated approximately 74 million cubic metres, of which about 44 million was ice. Chengdu

University of Technology, using a modelled failure surface, estimated 110 million cubic metres with about 20 million as ice. The State Key Laboratory of Geohazard Prevention, differencing pre-event and post-event digital elevation models, estimated approximately 130 million cubic metres with the glacier fraction below 20 per cent. The concept note prepared before the convening cited a range of 100 to 200 million cubic metres. These are not competing claims of fact so much as different methods with different assumptions about failure depth and entrainment. This report presents them side by side rather than reconciling them prematurely.

The same applies to the human toll. As of 7:00 PM, 7 September 2026 the National Disaster Risk Reduction and Management Authority reported 1,356 confirmed dead, 6,676 injured and approximately 4,894 missing, including around 587 foreign nationals from 34 countries. As of 6 September the figures given at the convening were 1,342 bodies recovered and 4,896 unaccounted for. Around 13,391 people had been rescued and an estimated 1.6 million affected nationally. On the China Tibetan side, 16 deaths and 546 missing were reported as of 31 August. Immediate economic damage was placed above NPR 500 billion, with indicative rebuilding costs as high as NPR 762 billion.

## **The climate change has clearly reshaped the baseline conditions at the failure site**

The evidence presented on the changing environment was consistent and locally specific. Glaciers in the South Asia East region have lost about 21 per cent of their year-2000 mass by 2023. In the Langtang catchment, glacier shrinkage ran at under 1 per cent per year from 1815 to 2010 and accelerated sharply thereafter. The tongue below the failure zone retreated 550 to 560 metres between 1964 and 2026, of which 373 metres occurred after 2010, and the terminus rose more than 200 metres in elevation, exposing steep surfaces and removing ice that had buttressed an over steepened slope. Mass balance in the catchment was near zero until about 1990 and has been increasingly negative since. Air temperature above 4,000 metres has risen about 0.3 degrees Celsius per decade.

Reanalysis for the failure pixel shows warming of about 0.17 degrees Celsius per decade since 1980. A 4 kilometre resolution regional simulation covering 2005 to 2025 shows monsoon warming of about 0.46 degrees Celsius per decade, far above the annual mean. The zero-degree isotherm has risen from around

5,200 metres in 2006 to above 5,350 metres, moving through the elevation at which the rock failed. Annual melt potential has increased significantly. Total precipitation shows only a slight and statistically insignificant increase, but its phase has shifted markedly from snowfall to rainfall, potentially increasing liquid water input and changing snow/ice conditions. An anomalous post-monsoon snowfall of more than 300 millimetres in October and November 2025 left an unusually large snowpack available for melt in the following spring and early monsoon. In the three days before the collapse, maximum temperatures at the failure elevation exceeded 10 degrees Celsius against a normal of about 6, with unusually large diurnal ranges.

Permafrost degradation was identified as the mechanism that connects these changes to the failure surface. The seasonally thawed layer of permafrost is deepening at more than 90% of sites across high-elevation Asia, indicating widespread permafrost degradation, with the largest changes in bedrock permafrost of low ice content, and progressive degradation concentrated between 4,500 and 5,500 metres, which is exactly the band in which the failure occurred.

Presenters were nonetheless explicit that a changing baseline is not attribution. One speaker noted that if the ice fraction of the released mass was under 20 per cent, the dominant material was bedrock, and bedrock failure is considerably harder to link to climate forcing than glacier or lake processes. A rapid attribution study by World Weather Attribution was under way at the time of the convening. The honest position on the public record is that slope failure occurred in a highly susceptible geological setting, but a strong climate change signal is evident in the changing baseline conditions at the failure site, through warming, changing precipitation phase and substantial changes in the cryosphere conditions (glacier ice, snow and permafrost). However, quantifying the contribution of these climate-driven changes to the specific 26 August collapse requires further event-specific attribution work that has not yet been completed.

### **Detection was possible; warning was not**

The most consequential finding for policy is that the event was not undetectable. Interferometric satellite analysis showed accelerating displacement at two points in the source area beginning around two months before the collapse, and approximately 15 centimetres of deformation over four months in late 2025. Tourist footage recorded a large dust cloud, probably from a precursor rock fall, roughly half an hour before the main event. Seismic networks in China and the international

catalogue recorded both the main collapse and the secondary landslide. None of this was being monitored operationally, and none of it was connected to any warning channel.

Conventional river-level monitoring offered no useful lead time at all. The flow arrived at the border faster than any water-level-triggered system could act, and six gauging stations were destroyed by the event itself. Seismic monitoring emerged as the most promising operational approach for remote high-mountain source zones, where instrument installation and maintenance at the source are impractical. A monitored catchment on the Tibetan Plateau has successfully issued seismic-based early warnings for comparable ice and rock avalanche to debris flow events.

### **The governance findings were the harshest**

Nepal's institutions were assessed as capable of handling localised events but unprepared for a multi-sector crisis of this scale. The country still lacks a functional national emergency operations centre, a common alerting protocol, interoperable risk information, a sectoral warning system for hydropower, and a stockpile facility under the disaster authority as required by law. Public hydropower assets remain uninsured, and the national disaster fund still framed around "acts of God" sites outside the Prime Minister's council. In 2024, four days' advance warning still failed to prevent roughly 450 deaths. Recovery finance is described as the binding constraint. Multilateral concessional loans are the main immediately available option; access to loss-and-damage and climate finance remains slow one project took six years to approve and 18 months more to become effective against reconstruction needs, including four prior unfinished recoveries, running into billions of dollars.

### **What follows**

The report proposes five workstreams: a full scientific autopsy of the event; a national inventory of comparable hazard source zones; a shift to whole-catchment monitoring integrating seismic, land-deformation, and hydro-meteorological data; an institutional reset giving the disaster authority real convening power and resources; and a formal transboundary mechanism with China for joint investigation, monitoring, and risk management. Chapter 5 sets these out by institutional category, as a basis for discussion rather than an assigned plan. A companion volume separately analyses the 956 registrants and what the audience composition reveals about demand for this evidence.

# About the Convening

The convening, “Mountain Tsunami in the Himalaya: Understanding the Plight, the Science and the Path to Resilience,” was held virtually on 7 September 2026, from 15:00 to 17:30 Nepal Standard Time, running for a total of three hours and one minute. It was organised by Youth Innovation Lab in collaboration with the Red Cross Red Crescent Climate Centre, Kathmandu University, and the University of Twente, together with the Ministry of Energy, Water Resources and Irrigation, Government of Nepal. Additional contributing institutions included Chengdu University of Technology, Utrecht University, Newcastle University, the Chinese Academy of Sciences, the United Nations Office for Disaster Risk Reduction (UNDRR), and Tribhuvan University bringing together an unusually wide, and unusually fast-assembled, coalition of national, regional, and international institutions around a single evidentiary question: what is currently known, and not known, about the disaster that struck the Bhotekoshi River corridor on 26 August 2026.

## Why it was held when it was

The timing of the convening was deliberate rather than incidental. On 1 September 2026, Nepal’s Prime Minister stated publicly that the disaster had occurred because of climate change, and that the response to it was therefore a matter of global, not merely national, responsibility; a position Nepal intended to carry into the eighty-first session of the United Nations General Assembly, which opened on 8 September. Given the weight such a claim carries on an international stage, the organisers judged that it needed to be accompanied by a transparent, public account of the underlying science, including its uncertainties and its limits. The convening was therefore scheduled for the day immediately preceding the opening of the General Assembly session, so that the emerging scientific evidence and, just as importantly, the boundaries of that evidence would be on the public record before, rather than after, the argument was made internationally.

## How this report was made

This report draws on four primary sources: the full recording and automatic transcript of the session; the concept notes and agenda circulated in advance; the speaker biographies

supplied directly by the presenting institutions; and the platform’s registration report. Chapters 1 through 5 are analytical in nature, synthesised from the presentations and discussion; Annex B provides an edited record of proceedings for readers seeking the fuller original context; and Annex C reconciles every quantitative figure cited anywhere in the report against the specific source and date under which it was originally given, in recognition of how rapidly such figures were changing at the time.

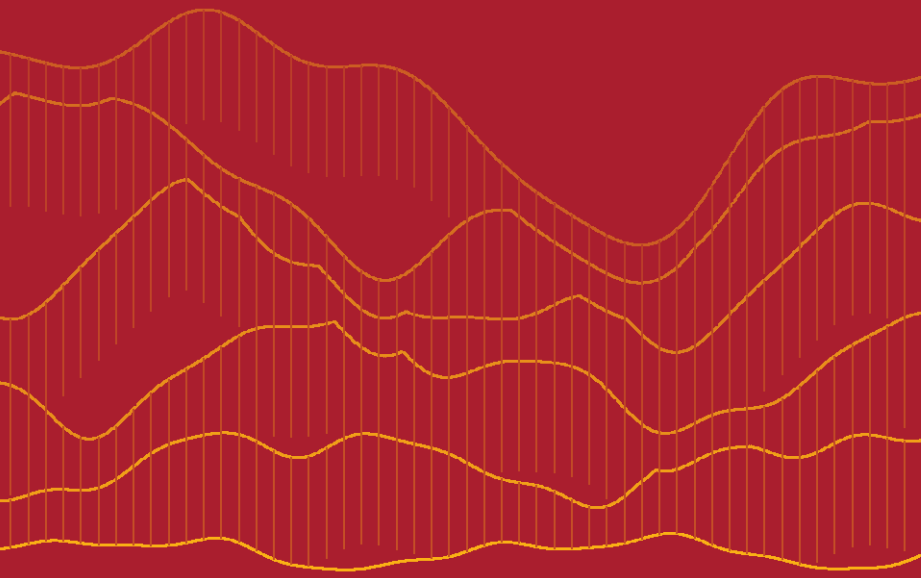
It should also be noted that the automatic transcript of the session mislabeled several speakers during portions of the discussion. Attribution throughout this report has therefore been corrected to follow the published agenda and the substantive content of each intervention, rather than the raw transcript labels as generated. Annex D sets out this issue, along with the other known limitations of the record, in full, so that readers can assess the reliability of specific attributions for themselves.

## What this report is not

Finally, it is important to be explicit about the boundaries of this document. This report is not an attribution study, not a post-disaster needs assessment, and not a peer-reviewed scientific paper. Every scientific result presented at the convening, and reproduced here, was offered by its presenter as preliminary; in most cases within twelve days of the event itself, and in several cases while the presenting team was still actively in the field or still feeding analysis to their own governments. The purpose of this report is narrower and, the organisers believe, more urgent: to place the state of scientific and institutional understanding as it stood on 7 September 2026 on the public record, together with an equally explicit account of what remained unknown at that time.

# Abbreviations

|          |                                                                                                   |
|----------|---------------------------------------------------------------------------------------------------|
| ADB      | Asian Development Bank                                                                            |
| BRCRN    | Building Resilience to Climate Related Hazards                                                    |
| CAP      | Common Alerting Protocol                                                                          |
| CAS      | Chinese Academy of Sciences                                                                       |
| CAT DDO  | Catastrophe Deferred Drawdown Option                                                              |
| CDUT     | Chengdu University of Technology                                                                  |
| CHWRR    | Centre of Hydrology and Water Resources Research                                                  |
| DEM      | Digital elevation model                                                                           |
| DHM      | Department of Hydrology and Meteorology                                                           |
| DoED     | Department of Electricity Development                                                             |
| DRR      | Disaster Risk Reduction                                                                           |
| DWRI     | Department of Water Resources and Irrigation                                                      |
| ERA5     | fifth generation atmospheric reanalysis of the European Centre for Medium-Range Weather Forecasts |
| EW4All   | Early Warnings for All                                                                            |
| EWS      | Early Warning System                                                                              |
| GCF      | Green Climate Fund                                                                                |
| GLOF     | Glacier Lake Outburst Flood                                                                       |
| HiCCDRRC | Himalayan Cryosphere, Climate and Disaster Research Center                                        |
| ICIMOD   | International Centre for Integrated Mountain Development                                          |
| InSAR    | Interferometric Synthetic Aperture Radar                                                          |
| IOE      | Institute of Engineering, Tribhuvan University                                                    |
| ITC      | Faculty of Geo-Information Science and Earth Observation, University of Twente                    |
| KU       | Kathmandu University                                                                              |
| MHEWS    | Multi-Hazard Early Warning System                                                                 |
| MoEWRI   | Ministry of Energy, Water Resources and Irrigation                                                |
| MoHA     | Ministry of Home Affairs                                                                          |
| NDRRMA   | National Disaster Risk Reduction and Management Authority                                         |
| NEA      | Nepal Electricity Authority                                                                       |
| NEOC     | National Emergency Operations Centre                                                              |
| NPR      | Nepali Rupee                                                                                      |
| NPT      | Nepal Standard Time                                                                               |
| PDD      | Positive Degree Day                                                                               |
| PDNA     | Post-disaster Needs Assessment                                                                    |
| PGV      | Peak Ground Velocity                                                                              |
| PPCR     | Pilot Program for Climate Resilience                                                              |
| SKLGP    | State Key Laboratory of Geohazard Prevention and Geoenvironment Protection                        |
| UNDRR    | United Nations Office for Disaster Risk Reduction                                                 |
| UNESCO   | United Nations Educational, Scientific and Cultural Organization                                  |
| UNGA     | United Nations General Assembly                                                                   |
| USGS     | United States Geological Survey                                                                   |
| WMO      | World Meteorological Organization                                                                 |
| WRF      | Weather Research and Forecasting model                                                            |
| WWA      | World Weather Attribution                                                                         |



## CHAPTER 1

# Understanding the Event

*Hazard genesis, cascading processes and what remains unknown*



On 26 August 2026 a mass of rock and ice left the north side of Langtang Lirung and, in less than eight minutes, became a flood at an international border twenty-two kilometres away. Twelve days later, four research teams from three countries set out in public what they had been able to establish about how that happened. This chapter assembles their accounts, sets their numbers side by side without averaging them, and states as precisely as the evidence allows what remains unknown.

## What happened on 26 August 2026

The initiation zone lies in Langtang National Park, in Uttargaya Rural Municipality, Rasuwa district, roughly 64 kilometres north of Kathmandu and close to the border with the Tibet Autonomous Region of China. It sits immediately north of the site of the 2015 avalanche that destroyed Langtang village during the Gorkha earthquake sequence, on the opposite flank of the same massif, south of the 7,200 metre Langtang Lirung peak.

The failure released bedrock together with glacier ice from an elevation of approximately 5,100 to 5,200 metres. Estimates of the vertical drop to the point of first impact range from about 1,200 metres, as circulated before the convening, to about 1,400 metres as presented by Kathmandu University. The mass struck the lower, debris-covered part of the glacier at around 3,800 metres. That impact was not the end of the sequence but the beginning of its most destructive phase.

At the point of impact, the descending mass scoured additional material from the debris-covered surface, including ice buried beneath the debris cover. It then dropped a second time, from roughly 3,800 metres to the valley floor at about 2,900 metres, where the Lhende Khola runs. A new depression was excavated by the force of the impact and a new pond formed at that location. From there the flow entered the Rasuwa Bhote Koshi and travelled downstream through Rasuwa, Nuwakot, Dhading, Gorkha and Chitwan districts by way of the Trishuli and Narayani systems.

## From avalanche to debris flow

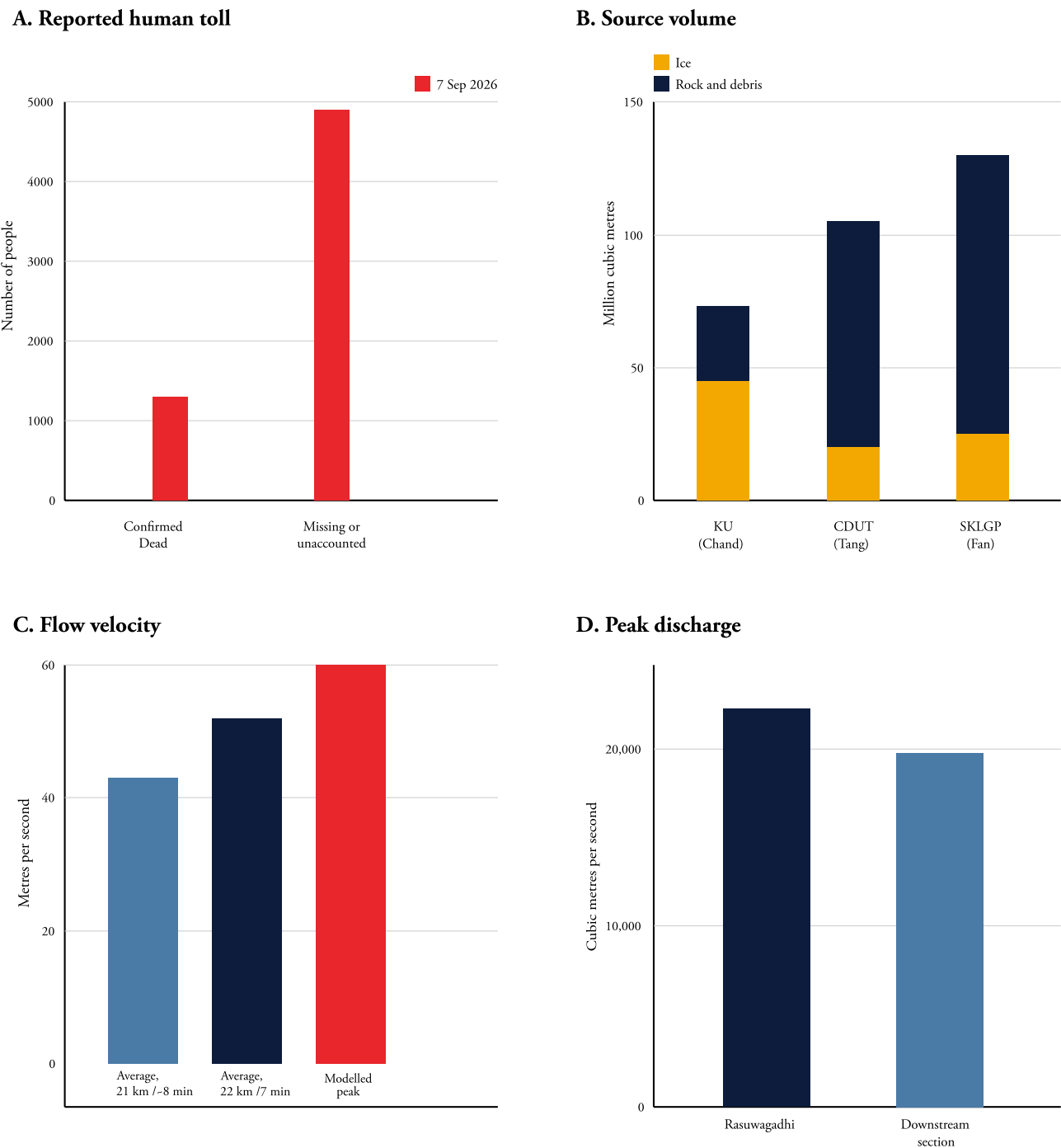
Several presenters emphasised that the flow changed character as it moved, and that this is what made it so mobile. The mass began as an ice and rock avalanche. Friction during the fall generated heat sufficient to liquefy a substantial fraction of the ice content. What arrived in the valley was therefore not a dry rock avalanche and not a conventional flood but a slurry, capable of moving considerably faster than either a rock avalanche or clear water in the same channel.

Field investigation by the Chinese Academy of Sciences team established a more detailed sequence. The initial detachment was predominantly rock, which brought down a section of glacier with it. That mass landed on a second, lower glacier, triggering an avalanche. Because the catchment contains extensive glacial moraine, the avalanche entrained large volumes of loose material. The avalanche generated a blast wind that stripped vegetation from the valley sides across a width measured at up to 1.3 kilometres. The material transport corridor itself was measured at about 470 metres wide in the upper reach. Where the river makes a bend, the avalanche component stopped; by that point the ice had melted and the flow had converted to a debris flow, which reached the catchment outlet, destroyed the hydropower station and its reservoir, and produced the flood.

Video evidence circulating on the internet supports this two-stage arrival. At the border crossing the avalanche front arrives first; approximately eight seconds later a distinct debris flow front is visible. The event that reached the outlet was therefore not a simple debris flow. It was an avalanche followed by a debris flow, and the distinction matters for how such events should be modelled and how their arrival should be interpreted by any warning system.

FIGURE 1.1 The 26 August event in numbers

Reported figures for the human toll rose sharply between the two reporting dates available to this report, and the search was still under way when it went to press. Three independent teams presented materially different estimates of the source volume within twelve days of the event, reflecting different methods rather than disputed observations. Velocity and discharge estimates are consistent in order of magnitude and were described by every presenter as provisional.



Sources: Figures as presented to the convening on 7 September 2026 by the National Disaster Risk Reduction and Management Authority’s situation report, Kathmandu University, Chengdu University of Technology and the State Key Laboratory of Geohazard Prevention and Geoenvironment Protection, *Note:* Panel B disaggregates each team’s estimate into its ice and rock components where the presenter provided that split; the Chengdu and SKLGP splits are inferred from the stated glacier fraction. All figures were presented as preliminary. See Annex C for the full reconciliation.

## The initiation zone

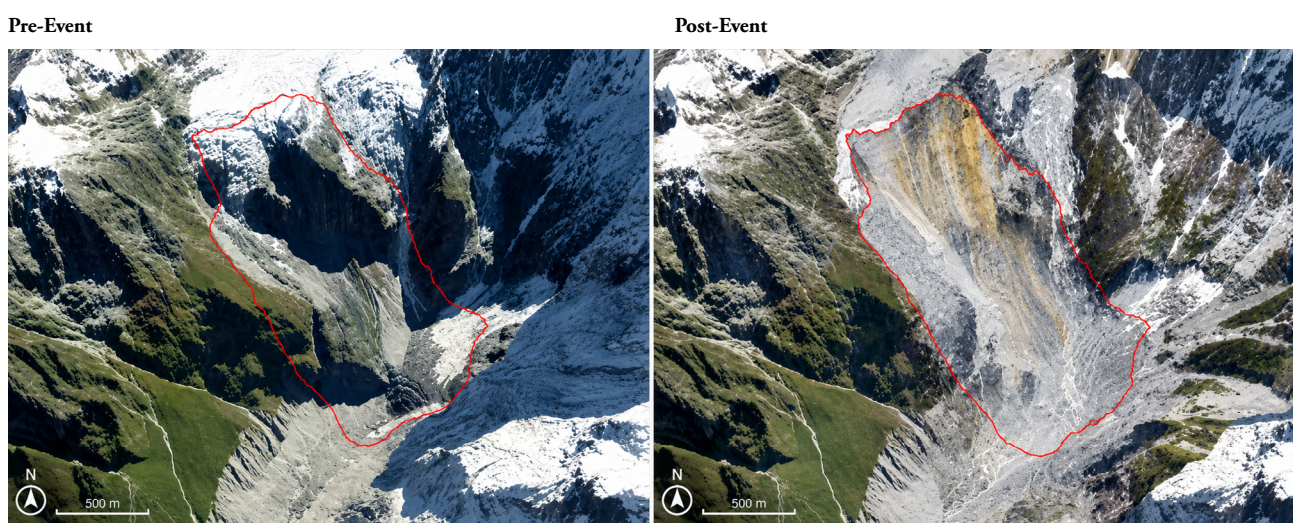
The Kathmandu University reconstruction mapped the glacier boundary from imagery acquired immediately before the event and separated the release area into components. The glacier area that collapsed, including a detached ice mass that had accumulated from avalanching off the steep upper slopes of Langtang Lirung where snow cannot rest, was estimated at approximately 0.68 square kilometres. Assuming a failure depth of about 50 metres, this yields roughly 34 million cubic metres of ice from the primary breakup. The rock fall area was described as comparable in extent but of uncertain depth, contributing an estimated 23 million cubic metres. To these were added material scoured during transit: approximately 6 million cubic metres from a three square kilometre debris surface assumed to be scoured to about two metres, and approximately 10 million cubic metres from 0.43 square kilometres of debris-covered glacier assumed

to be eroded to about 20 metres. The totals presented were approximately 44 million cubic metres of ice, including buried ice, and 29 to 30 million cubic metres of rock, for a combined release of about 74 million cubic metres.

Independent estimates from the Chinese teams were substantially larger. Both used post-event digital elevation models, which had not been available to the Kathmandu University team at the time of its analysis. The distribution of material between ice and rock also differs sharply: the Kathmandu University reconstruction attributes roughly 60 per cent of the released mass to ice, while both Chinese analyses place the glacier fraction below 20 per cent. This difference is not a detail. It bears directly on how strongly the event can be linked to cryospheric change, a point taken up in Chapter 2 and returned to in Box 2.2.

**FIGURE 1.2** The initiation zone before and after the failure

*Paired high-resolution imagery of the detachment zone on the north side of Langtang Lirung, showing the pre-event glacier tongues either side of the bedrock spur and the post-event scarp. The failure followed an existing structural depression in the bedrock.*



Source: Presentation by: Professor Fan, Chengdu University of Technology to the convening, 7 September 2026

## Why the slope failed

No presenter at the convening claimed to know the trigger of the collapse with confidence. Instead, several possible causes were offered, and presenters were clear that these are not mutually exclusive as several of them may well have acted together.

- **Glacier motion and crevassing.** The glacier was moving under its own weight over a very steep bed, and extensive surface crevassing was visible across it. Presenters explained that a loss of support from below, combined with movement from the opposite side of the slope, could have caused a progressive collapse, one that, once started, would have been capable of bringing down surrounding masses of ice and rock along with it.
- **Meltwater in crevasses and joints.** Water entering crevasses acts as a lubricant at the interface between ice and rock, reducing friction there. At the same time, hydrostatic pressure builds within water-filled fractures, increasing the driving force acting on the rock mass. Both effects work in the same direction: toward destabilising the slope.
- **Long-term weathering with accelerated freeze and thaw.** Exposed rock not covered by ice would have undergone long-term weathering over time. More recently, rising temperatures and continuous freeze-and-thaw cycling along existing cracks, fissures, and joints could have progressively reduced the rock's strength, leaving it more vulnerable to failure than it would otherwise have been.
- **Seismic legacy.** The rock mass sits in a highly seismically active setting. Since the 2015 Gorkha earthquake, more than 280 earthquakes of magnitude 4 or greater have occurred within a 300-kilometre radius of the site, with events exceeding one centimetre per second of ground velocity occurring at that location roughly once a year; a pattern of repeated shaking that may have gradually weakened the rock over nearly a decade.

### A framework for the mechanics

The University of Twente team framed these individual factors in terms of forces and resistances: gravity, hydrostatic pressure from water in crevasses, and cryostatic pressure from ice and its freeze-and-thaw cycles all act as driving forces, while the strength of the rock mass itself provides

the resistance. Failure occurs at the point where the driving forces come to exceed that resistance. High-resolution elevation data examined by the team show that the failure followed an existing structural depression in the bedrock between the two glacier tongues, which points to geological preconditioning as a necessary component of any complete explanation; the slope did not fail at a random point, but at one where a pre-existing structural weakness already existed.

### Corroborating imagery evidence

The Chinese Academy of Sciences team added two further observations, drawn from three-dimensional imagery. First, free surfaces were visible in the rock mass before the event occurred, and comparable free surfaces are identifiable in other ice and rock avalanche source zones across the region suggesting this feature could serve as a mappable diagnostic for identifying other at-risk slopes. Second, the epicentre of the 2015 magnitude 8 earthquake lies immediately adjacent to this site, within the accuracy of the epicentral location itself, which further reinforces the seismic damage hypothesis described above.

**BOX 1.1 Reconciling the source volume estimates**

Three teams presented source volume estimates within twelve days of the event. They differ by a factor of nearly two, and they disagree more sharply still on the proportion of ice. The differences follow from method, from data availability, and from assumptions about failure depth and entrainment, rather than from disputed observations. This report presents them side by side. Readers who need a single number for planning purposes should use the range and state the range.

**What each team did**

The Kathmandu University estimate was built from imagery acquired immediately before the event, with the glacier boundary mapped manually and the release volume computed as area multiplied by an assumed failure depth. That depth, about 50 metres for the ice and an acknowledged unknown for the rock, is the dominant uncertainty. The presenter described it explicitly as a rough estimate and stated that the depth of the rock collapse was not known.

The Chengdu University of Technology estimate used a polynomial surface to model the failure surface, differenced against a pre-event digital elevation model. This is a well-established approach for landslide volume estimation and does not require an assumed uniform depth, but its accuracy depends on how well a smooth surface represents the real failure plane.

The State Key Laboratory estimate differenced pre-event and post-event high-resolution digital elevation models directly. This is in principle the most reliable of the three methods, because it measures the volume actually removed rather than inferring it. The team noted that it had not yet separated the glacier and bedrock proportions rigorously, and gave the glacier fraction as probably below 20 per cent pending further calculation.

**Why the ice fraction matters more than the total**

The total volume governs the destructive potential of the flow. The ice fraction governs how strongly the event can be connected to a warming cryosphere. If ice accounted for around 60 per cent of the release, as the Kathmandu University reconstruction suggests, the event sits close to the centre of the class of hazards that cryospheric change is expected to make more frequent. If ice accounted for under 20 per cent, as both Chinese analyses suggest, then the event was dominantly a bedrock failure, and the climate connection has to be made through permafrost degradation and freeze and thaw processes in fractured rock rather than through glacier ice directly. That is a longer causal chain and a harder one to demonstrate. One presenter made this point directly, observing that bedrock failure may be very hard to link to climate change.

**What would resolve it**

A jointly agreed volume requires three things that were not available on 7 September 2026: a common pre-event digital elevation model of agreed provenance and date, a common post-event surface acquired after the secondary landslide, and an agreed convention for where the source area ends and entrainment begins. All three are achievable within months if the teams work from a shared dataset. This is the first and most tractable item on the scientific autopsy agenda set out in Chapter 5.

**TABLE 1.1** Source volume, velocity and discharge estimates as presented

Values are reproduced as given by each presenting team on 7 September 2026. No attempt has been made to reconcile them. Blank cells indicate that the team did not present a figure for that quantity.

| Quantity                           | Kathmandu University                                                              | Chengdu University of Technology | State Key Laboratory        | Pre-convening concept note        |
|------------------------------------|-----------------------------------------------------------------------------------|----------------------------------|-----------------------------|-----------------------------------|
| Total source volume                | ~74 million m <sup>3</sup>                                                        | 110 million m <sup>3</sup>       | ~130 million m <sup>3</sup> | 100 to 200 million m <sup>3</sup> |
| Ice component                      | ~44 million m <sup>3</sup>                                                        | ~20 million m <sup>3</sup>       | <20 per cent of total       |                                   |
| Rock component                     | 29 to 30 million m <sup>3</sup>                                                   | Majority of mass                 | 80 to 90 per cent of total  |                                   |
| Detachment elevation               | ~5,200 m                                                                          |                                  | ~5,200 m                    | ~5,200 m                          |
| Vertical drop                      | ~1,400 m to first impact                                                          | >1,000 m                         | ~1,200 m                    | ~1,200 m                          |
| Travel distance to outlet          | 22 km                                                                             | 21 km                            |                             |                                   |
| Travel time                        | 7 minutes                                                                         | ~7 to 8 minutes                  |                             |                                   |
| Mean velocity                      | ~52 m/s implied                                                                   | 40 to 48 m/s                     |                             | ~50 m/s                           |
| Modelled or observed peak velocity | ~60 m/s                                                                           |                                  |                             | ~180 km/h                         |
| Peak discharge                     | ~23,000 m <sup>3</sup> /s at Rasuwagadhi;<br>~20,000 m <sup>3</sup> /s downstream |                                  |                             |                                   |
| Maximum flow depth                 | ~50 m, greater in narrow gorges                                                   |                                  |                             |                                   |

Source: Presentations to the convening, 7 September 2026, Note: The Kathmandu University mean velocity is implied by the stated 22 kilometres in 7 minutes rather than presented directly. The concept note figure of 180 kilometres per hour is equivalent to 50 metres per second.

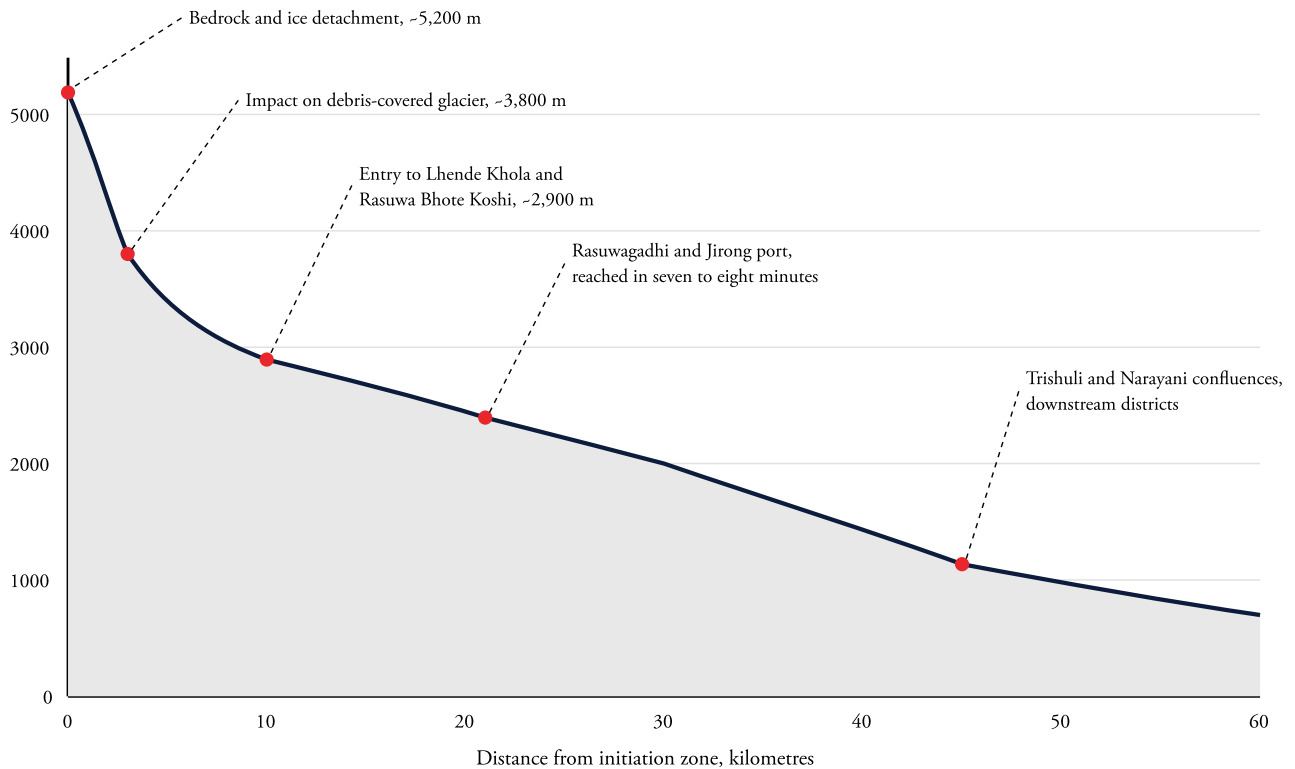


**FIGURE 1.3** Longitudinal profile of the 26 August cascade

The mass detached at approximately 5,200 metres, fell to a debris-covered glacier at around 3,800 metres, and dropped again to the valley floor at about 2,900 metres before entering the Rasuwa Bhoté Koshi. It reached the border crossing roughly 21 to 22 kilometres downstream within seven to eight minutes of initiation, then continued through the Trishuli and Narayani systems.

**A. Longitudinal profile of the 26 August cascade**

Elevation, metres above sea level



Sources: Constructed from elevations and distances stated in presentations to the convening, 7 September 2026, *Note:* The profile is schematic. Distances downstream of the border crossing are indicative and are drawn to show the continuity of the corridor rather than surveyed channel geometry.

**Figure 1.4.** Debris deposition and river channel impacts following the event

Aerial view of extensive debris and sediment deposition along the river, showing the impact of a high-magnitude flood or debris-flow event on settlements, agricultural land and the river channel along Trishuli Corridor.



Photo Source: Pradip Khatiwada, Youth Innovation Lab

## The cascade and what it entrained

Presenters returned repeatedly to a single point: the final volume was much larger than the initial release because of sediment entrainment along the path. The University of Twente team set out the general principle for Himalayan settings. Trigger mechanisms differ, and may be seismic, may involve large rock or ice avalanches, or may involve retreating glaciers and their associated hazards, but the effect on downstream valleys is broadly comparable. What differs between them is the available lead time for early warning, the impact heights, and the duration of disruption to major infrastructure. The design implication is uncomfortable and was stated plainly: in a Himalayan setting, infrastructure design can no longer avoid accounting for events of this class. The elements that must be represented in any adequate model of such a cascade were listed as: how each hazard transforms into the next; the role of temporary storage along the path; intermediate blockages, which played a role here; sediment entrainment, which is what makes the final volume exceed the initial release; and the effects on the infrastructure in the downstream area.

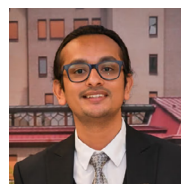
### A wave of interacting hazards, not one hazard

The analysis presented by the University of Twente team, completed within ten days of the event and described as research still in progress, reframed the event as a wave of hazards occurring at the same time or at different times and across a large spatial extent, from the top of the glacier to the end of the river catchment.

The components identified were: the seismic event generated by the collapse itself, large enough to have caused damage in its own right had settlements been closer; the debris flow and flood, which caused the majority of the damage and which has received almost all the public attention; landslides along the valley sides, caused by the flow having changed the geomorphology of slopes that had been stable before; the formation of landslide-dammed lakes, which in this case did not burst but which in other cases, such as the 2008 event referred to by the presenter, have caused severe secondary damage; and continuing erosion, which will not stop with the event but will proceed through the following monsoon as the deposited mass is remobilised and river channels are blocked downstream.

A further category was described as conditional rather than cascading. Research on the 2015 Gorkha earthquake showed that the rainfall season following the earthquake produced almost as many landslides as the earthquake itself. The presenter expressed confidence that the same pattern will follow this event, because the flood has created a large number of newly unstable slopes that have not yet been through a monsoon.

The consequences were described as extending beyond hazard into socioeconomic, epidemiological and trade effects: deaths, disease risk, loss of homes and land, and disruption to a trade corridor. An impact chain analysis of the kind used in Alpine settings was proposed as the appropriate analytical frame.



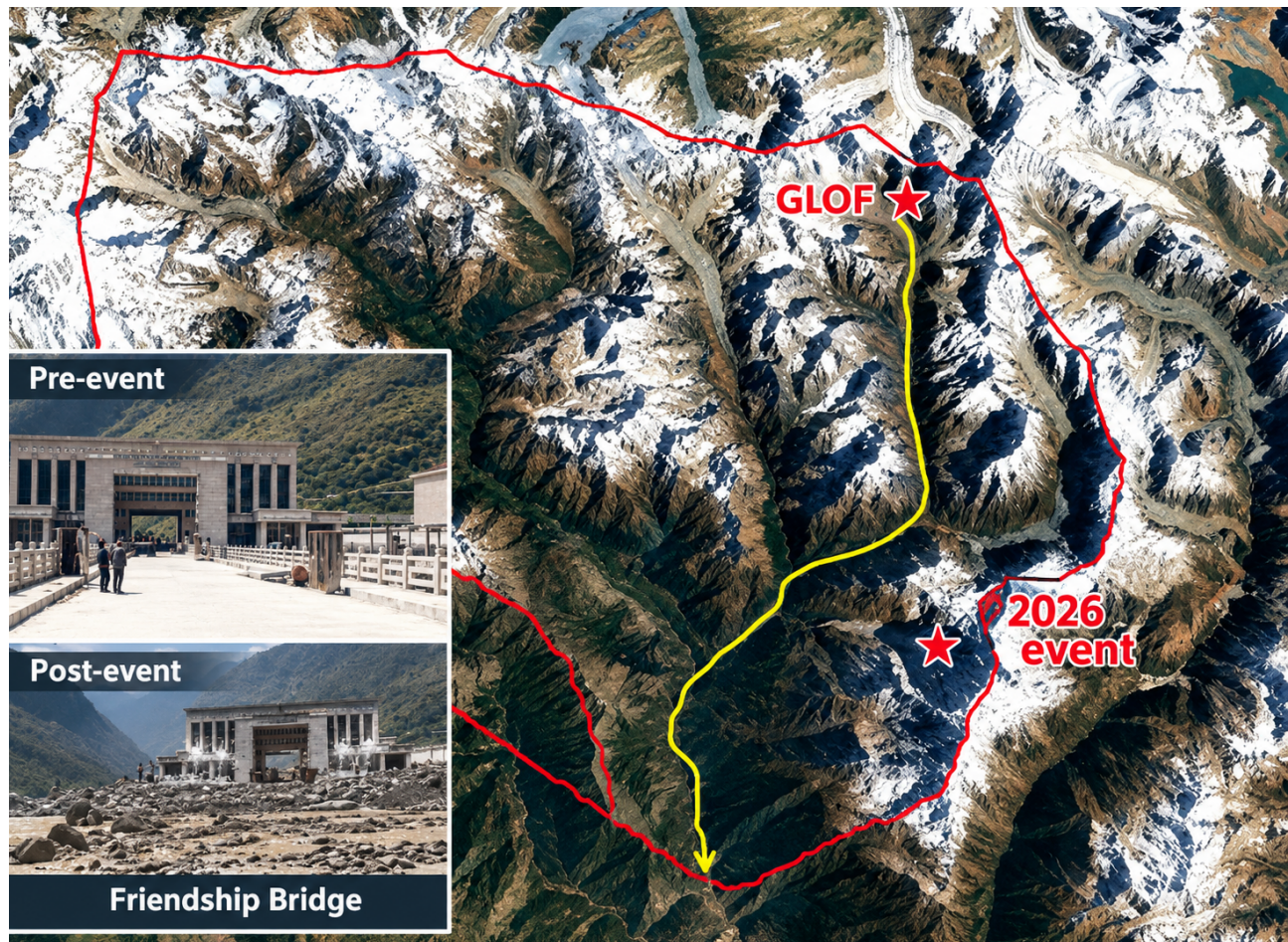
*“We are talking about this event as one single event, like a glacier collapse or a flood or a debris flow, but it is a combination of hazards. It is a wave of hazards.”*

Ashok Dahal, University of Twente, presenting with Prof. Cees van Westen



**FIGURE 1.5** The debris fan and the destroyed border infrastructure

*The flow destroyed a hydropower station and its reservoir before reaching the Rasuwagadhi and Jirong border crossing. Field survey by the Chinese Academy of Sciences team measured boulder sizes and channel conditions in the deposition zone.*



Sources: Presentations to the convening, 7 September 2026; Prof. Fan, Chengdu University of Technology.



*“This is a very important event, and a sad one, showing how cascading events devastate so many aspects of vulnerable society.”*

**Prof. Cees van Westen,**  
Professor of Multi-Hazard Risk Dynamics, University of Twente



## Secondary hazards

Approximately three hours after the main event, a large secondary landslide occurred, attributed to strong erosion at the foot of the slope by the passing flow. It generated ground shaking equivalent to a magnitude 4.2 earthquake, recorded both by the United States Geological Survey and by the Chinese seismic network. This landslide blocked the river and formed a barrier lake.

An important correction was made on this point. It had initially been assumed that a dam formed immediately after the release from the source area and that its failure produced the flood. The travel time makes this impossible: the flow covered 22

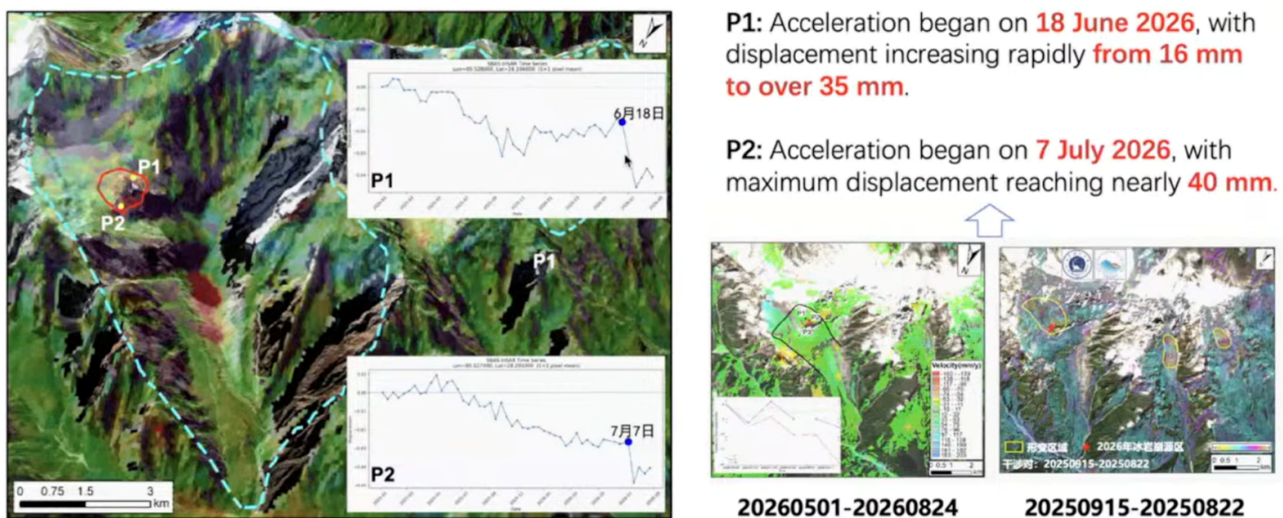
kilometres in about seven minutes, giving a velocity above 180 kilometres per hour, which does not allow for the impoundment and release of a lake in the interval. The barrier lake was a consequence of the flood, not its cause. It later released naturally without producing a second major flood wave.

Field video recorded four days after the event showed further debris flows from the source area, either from water released from the first pond or from continuing glacier melt, and numerous secondary failures in the deposition zone of the large secondary landslide. Hanging glacier ice remained visible in the source area and may continue to fall.

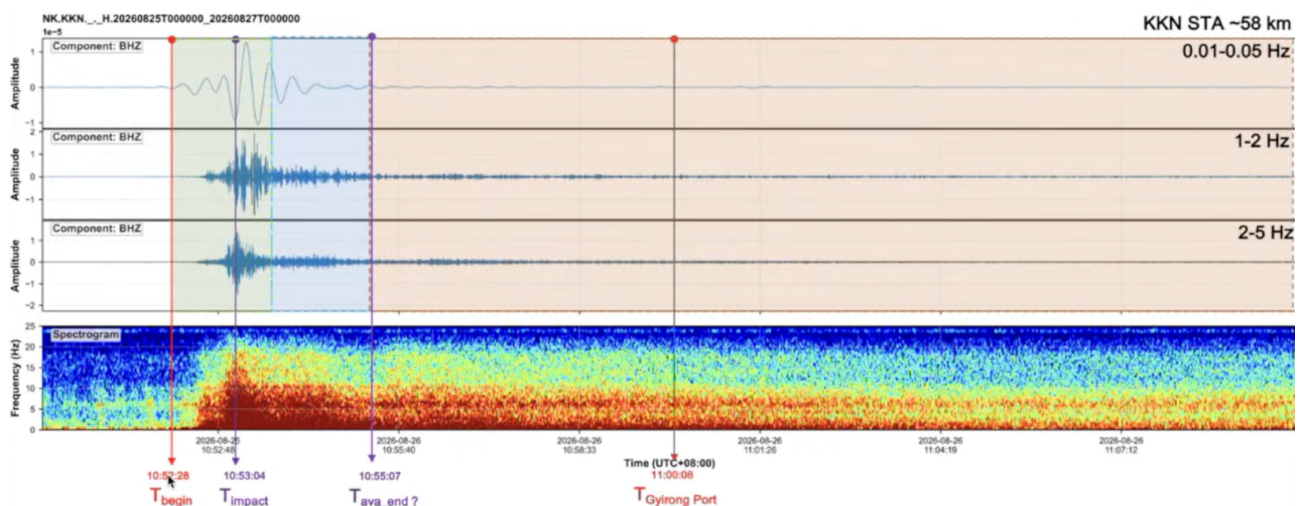
**FIGURE 1.6** Seismic signature and pre-event surface displacement

*The seismic record resolves the event into distinct phases with different frequency content, allowing the transition from avalanche to granular flow to debris flow to be timed. Interferometric analysis of the source area shows accelerating displacement in the months before the collapse.*

### A. Seismic Phase of the Main Event



### B. Seismic Magnitude Equivalents



Sources: Presentations to the convening, 7 September 2026; Prof. Fan, Chengdu University of Technology., *Note:* Panel A phase durations are drawn from the seismic interpretation presented and are approximate. Panel C shows cumulative displacement at the source area from interferometric analysis over July to November 2025, as presented.

**BOX 1.2 What the seismic record shows**

Seismology turned out to be the single most informative instrument for this event, and not because anyone had installed it for that purpose. It timed the cascade, sized the mass, distinguished the main collapse from the secondary landslide, and, in a monitored catchment on the Tibetan Plateau, has already been used to issue operational early warnings for the same class of hazard.

**Timing the cascade**

Working in Chinese standard time, the SKLGP team placed the initiation at approximately 10:52. A high-frequency signal characteristic of the ice and rock avalanche arrives first and lasts less than one minute. The signal then changes character as the flow converts to something closer to a granular flow, lasting about two minutes. It then converts again into a debris flow and travels down to the border crossing between Nepal and China, after which it becomes a flooding-type flow. This is a preliminary interpretation, and the team intends to link the numerical simulation to the seismic record for a more rigorous reconstruction.

**Sizing the mass**

A moment tensor inversion using near-field and teleseismic stations, drawing on around fifty stations at distances up to 2,000 kilometres, gave a mass loss of approximately 720 million kilograms and forces in the east, north and vertical directions on the order of  $10^9$  newtons. The presenter offered a comparison for scale: a force equivalent to around a thousand kilograms of high explosive. The collapse produced a seismic event equivalent to magnitude 5.2 and was recorded as far away as Kathmandu and beyond.

**Precursors**

Two independent lines of evidence indicate that the failure was preceded by detectable activity. Interferometric analysis showed displacement at one point in the source area entering an accelerated stage from the middle of June, with a second measurement point showing acceleration approximately two months before the event. Separately, tourist footage posted to social media shows a strong dust cloud, probably generated by a precursor rock fall, roughly half an hour before the main event. The teams are searching the seismic records of several stations for a corresponding signal.

Neither of these observations was available operationally. Both were reconstructed after the fact. The presenter's conclusion was that the event really did have precursors and that something can probably be recovered from the seismic signal, which is precisely the argument for building the monitoring described in Chapter 3.



**FIGURE 1.7** The barrier lake formed on 27 August

The secondary landslide dammed the channel and impounded a barrier lake, creating a secondary outburst risk that shaped the emergency response for several days before the lake released naturally.

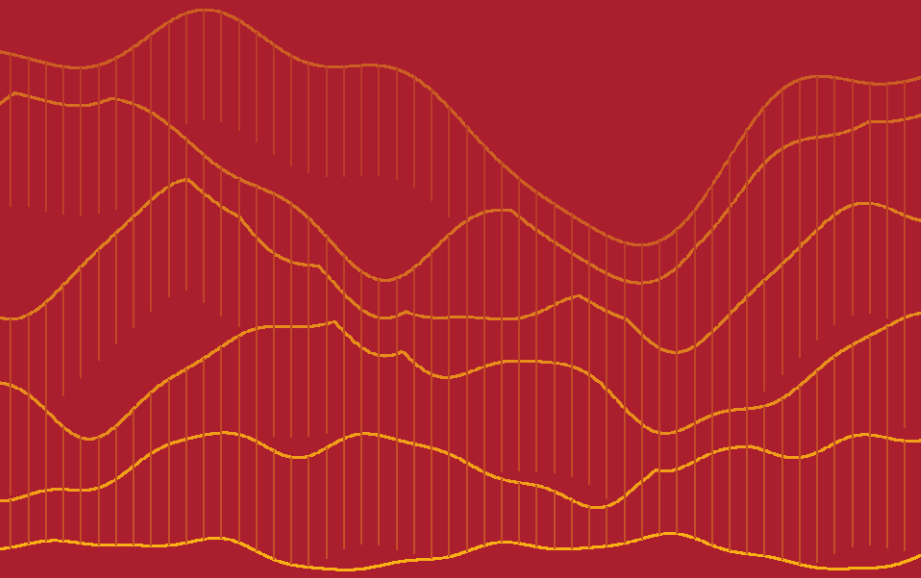


Sources: Presentations to the convening, 7 September 2026; Prof. Fan, Chengdu University of Technology.

## Known unknowns

The convening was explicit about the limits of what had been established. Six questions were left open.

1. The trigger. Multiple plausible mechanisms were offered and none was demonstrated. Distinguishing between progressive glacier-driven destabilisation, hydrostatic pressure in water-filled fractures, permafrost-related loss of cohesion, and seismic damage accumulation requires modelling of the specific failure surface with the specific geology, not general argument.
2. The volume. A factor of nearly two separates the highest and lowest estimates, and the ice fraction differs by a factor of three. Box 1.1 sets out what would resolve this.
3. The water. Where the water came from is not established. Ice was released and a large volume of water is visible in the footage, but how the water volume formed during the process remains unclear. Frictional melting accounts for part of it. Water beneath the ice, and possibly small englacial or supraglacial ponds in the upper release area, may account for more, although the slope makes ponding less likely there.
4. The seismic legacy. Whether the 2015 earthquake sequence left a durable legacy effect on this rock mass was raised repeatedly and answered by nobody with confidence. The proximity of the 2015 epicentre and the record of more than 280 magnitude 4 or greater events within 300 kilometres since then make it plausible; plausibility is not evidence.
5. The frequency. Whether this class of event is becoming more frequent, more intense, or simply more consequential because exposure has grown, is a question the literature can begin to answer but has not answered for this region at the resolution required.
6. The next one. No systematic inventory exists of comparable source zones across the Nepal Himalaya. The methods to build one, mapping free rock surfaces with hazard potential, estimating volumes with a slip surface model, and running rapid run-out simulation for each, were demonstrated at the convening and could be applied at scale.



## CHAPTER 2

# Climate Change and the Changing Himalayan Hazard System

*The changing baseline, and the limits of what can be attributed*

The question the convening was called to address was whether climate change caused the disaster. The answer given by the scientists who study this catchment was more useful than a yes or a no. The environment in which the failure occurred has changed measurably and rapidly, in ways that make this class of failure more likely. Whether it caused this particular collapse is a different question, requiring different evidence, and that evidence is not yet complete.

## The regional cryospheric baseline

Global glacier change between 2000 and 2023 provides the frame. For the South Asia East region, which contains the study area, glaciers had lost about 21 per cent of the mass they held in the year 2000 by 2023. The region as a whole is deglaciating rapidly. Annual mass balance has been increasingly negative over the last twenty years, and this tracks rising temperatures in Nepal over the same period.

Presenters were careful to distinguish between what is happening across the region and what is happening in this catchment. Regional averages are a poor guide to slope stability at a single site. The value of the Langtang catchment is that it has been studied intensively, with observations running since 2012 in one long-running programme and a published reconstruction of glacier extent going back to the Little Ice Age.

## Langtang: two centuries of glacier change

A newly published study of the Langtang catchment, immediately on the other side of the mountain from the failure zone, maps glacier area across time periods from the Little Ice Age maximum of about 1815 through to 2023. Over that interval the glaciers have consistently shrunk, and the rate of shrinkage over the last twenty years is much faster than over the twentieth century. The rate of recession is accelerating.

As the glaciers shrink, they fragment. Termini separate, exposing more bedrock within and around the ice. The glaciers thin overall, and the zone of thinning migrates progressively up-glacier. Mass balance in the catchment was positive or close to zero until about 1990, and has become significantly and increasingly negative since. Alongside this, air temperature at the elevations above 4,000 metres where these glaciers sit has risen by about 0.31 degrees Celsius per decade.

## The glacier above the failure zone

Before the collapse, the glacier on Langtang Lirung covered about 7 square kilometres, with two main tongues descending from the accumulation area on either side of a bedrock spur. A large scarp is visible in pre-event imagery, continuing beneath the glacier, with extensive crevassing where the ice passes over the steep slope beneath.

The failure occurred at about 5,100 metres, under the flatter section of the glacier, and removed bedrock together with about 0.27 square kilometres of glacier ice. The reconstruction of glacier extent at this specific site shows the same acceleration seen across the catchment. Shrinkage ran at under 1 per cent per annum between 1815 and 2010, then accelerated significantly.

The northern tongue, on the glacier right, is the critical one. Its terminus retreated about 550 to 560 metres between 1964 and 2026, but the majority of that occurred after 2010: 373 metres of retreat in the fifteen years to 2026, with the terminus rising more than 200 metres in elevation over the same period. That is the mechanism described in Box 2.1. A large volume of ice was removed from the foot of a very steep slope that had previously been glaciated, leaving an oversteepened and unsupported face.

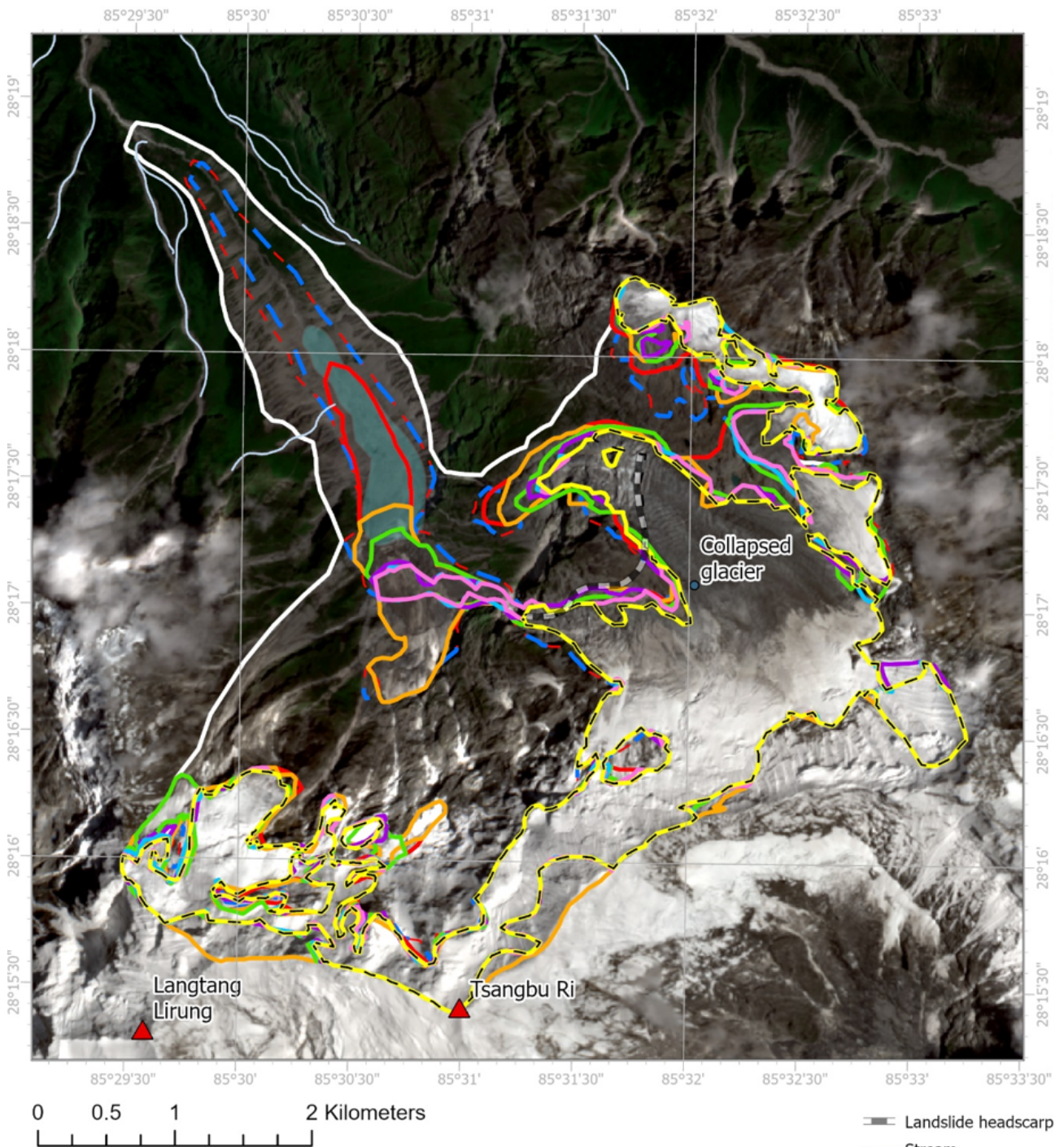
Elevation change data covering 2015 to 2019 show thinning across the whole area, with buried ice on the valley floor thinning strongly and particular thinning on the tongue below the failure zone. The presenter's conclusion was that this thinning likely contributed to the debuttressing of the steep slope.



***“The exact statistical attribution of this particular event to climate change is going to be a huge challenge, but in my opinion it is likely that climate change has played a role in this.”***

**Prof. Walter Immerzeel**, Utrecht University



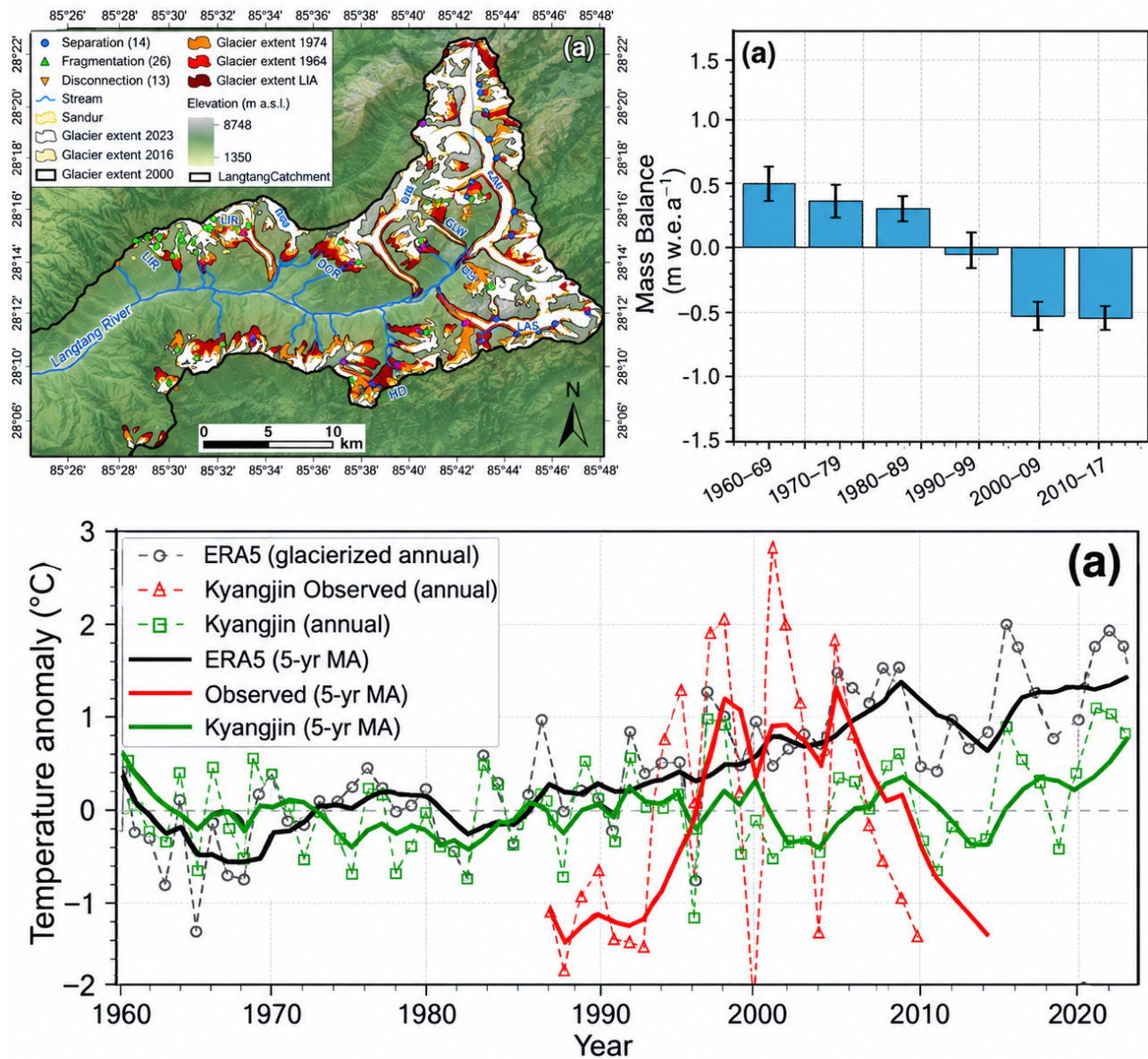
**Figure 2.1:** Mapped glacier extent on Langtang Lirung, 1815 to 2026

Sources: Mapped glacier extent on Langtang Lirung, 1815 to 2026, with the landslide boundary and the pre- and post-event ice margins. Presentations to the convening, 7 September 2026; Prof. Davies, Newcastle University.



**FIGURE 2.2** Glacier change in the Langtang catchment

Glacier loss in the region containing the study area has been rapid, and in the Langtang catchment specifically the rate of shrinkage has accelerated markedly since 2010. Most of the terminus retreat measured on the tongue below the failure zone since 1964 occurred in the last fifteen years of the record.



Sources: Presentation by Prof. Bethan Davies, Newcastle University, to the convening, 7 September 2026., Note: Panel D is an illustrative reconstruction of the described mass balance history rather than a published series. Panels A to C reproduce figures stated in the presentation.

**BOX 2.1 Debuttressing: How a Shrinking Glacier Destabilises a Slope**

The most direct physical link between glacier retreat and rock slope failure does not run through meltwater, and it does not run through ice loss occurring on the failing rock mass itself. Rather, it runs through a more fundamental mechanical process: the gradual removal of physical support at the foot of the slope, a process known in glacial geomorphology as debuttressing.

A glacier occupying a steep valley or cirque does not simply sit passively within its confines; it exerts substantial lateral pressure against the rock walls that contain it. Over long periods of time; often centuries, the ice performs two distinct but related functions. First, it mechanically supports those confining rock walls, bearing some of the structural load that would otherwise fall entirely on the rock itself. Second, it physically shields the rock from the elements, insulating it from weathering processes and, critically, from the diurnal temperature cycling that drives repeated freeze-and-thaw stress on exposed rock. Under this sustained ice cover, the surrounding rock mass gradually adjusts to a particular, ice-supported state of mechanical stress; one it has typically maintained for a very long time.

The problem arises when that equilibrium is disturbed. As the ice thins and the glacier's terminus retreats, the mechanical support that rock wall had relied upon is removed, often rapidly relative to the geological timescales on which the rock itself adjusts. The consequences are twofold. First, the rock wall is left oversteepened: without the ice buttressing it from the side, the wall now stands at an angle steeper than it can mechanically sustain on its own. Second, that same rock wall is newly exposed to a temperature regime with daily freeze-and-thaw cycling in particular; that it has not experienced in perhaps centuries, since it was previously insulated beneath the ice. Under this combination of oversteepening and new thermal exposure, stress within the rock begins to redistribute, working existing joints open further and propagating new fractures through the rock mass over time.

This process of destabilisation is not instantaneous. Debuttressing operates across a wide range of timescales from a matter of years in the fastest cases to many centuries or even millennia in others. This is precisely why paraglacial slope failures are frequently observed to continue occurring long after the glacier ice that originally conditioned the rock's instability has already retreated or disappeared entirely.

At the site examined in this report, this sequence is not a matter of theoretical inference but one that is directly documented in the observational record. The glacier tongue situated below the eventual failure zone lost 373 metres of length and rose more than 200 metres in elevation over the fifteen years leading up to 2026. Critically, that same ice had sat directly at the foot of the slope that ultimately failed. Its removal over this comparatively short window therefore constitutes a textbook debuttressing event, occurring on a timescale short enough that the rock mass above it had no meaningful opportunity to mechanically equilibrate to its newly unsupported condition before failure occurred.

It is worth being precise, however, about what debuttressing does and does not explain. On its own, it does not account for the specific timing of the failure; it cannot tell us why the slope gave way on 26 August 2026 rather than some other date. What it does explain is why the slope was mechanically available to fail at all. The immediate trigger that converted that latent vulnerability into an actual collapse whether hydrostatic pressure building within water-filled fractures during an unusually warm three-day period, progressive degradation of permafrost within the rock, the cumulative accumulation of seismic damage over nearly a decade, or some combination of these factors acting together remains the open question addressed directly in Chapter 1.

## Permafrost degradation

The failure zone lies within an area of mountain permafrost, defined as perennially frozen ground where temperatures remain below zero. Globally, permafrost is degrading. Active layer thickness, the depth that freezes and thaws seasonally, has increased at more than 90 per cent of monitored sites in High Mountain Asia. The largest changes have been observed in mountain permafrost in bedrock, particularly bedrock with low ice content, which describes the site in question.

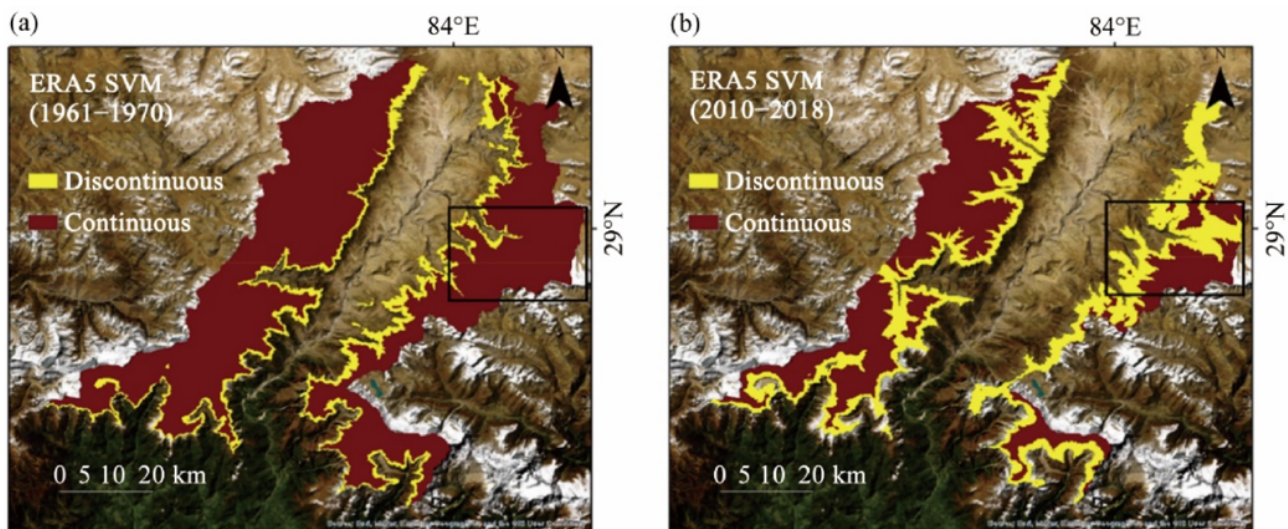
Direct permafrost monitoring in Nepal is sparse. A study of a catchment somewhat to the west provides the closest analogue. It shows that the area of stable, permanently frozen and continuous permafrost has shrunk between the 1960s and 1970s baseline and the 2010 to 2018 period, replaced by a growing area of discontinuous permafrost with more freeze and thaw activity. Degradation is progressive below 5,500 metres, and the largest changes fall in the elevation band between 4,500 and 5,500 metres.

That band is precisely where this failure occurred. The site is probably close to the lower limit of permafrost, and therefore within a zone that is changing rapidly and is prone to degradation.

The mechanism proposed connects this to the rock directly. The bedrock is fractured, and likely damaged by previous earthquakes. Within those fractures are joints containing ice and meltwater. As permafrost degrades, that ice within the fractures can melt, or can cycle periodically through freezing and thawing. Either process removes cohesion, allowing fractures to open and to slip more easily. The conclusion offered was that the failure was strongly conditioned by the geological conditions at the site, with climate change acting upon that geological baseline and modulated through changes in the cryosphere, specifically glacier ice, snow and permafrost.

**FIGURE 2.3** Permafrost degradation in High Mountain Asia

*Active layer thickening is near-universal across monitored sites, and the elevation band showing the greatest loss of continuous permafrost contains the failure zone.*



Sources: As presented to the convening, 7 September 2026.



## Weather and climate across three timescales

The most systematic attempt to connect climate to the event examined three timescales with three different datasets: the long term from 1980 using reanalysis; the medium term from 2005 to 2025 using a 4 kilometre resolution regional weather simulation; and the weeks immediately before the event using station observations from the Langtang Valley collected under a long-running programme.

### The long term

Reanalysis for the pixel containing the failure, at approximately 9 by 9 kilometre resolution and therefore coarse relative to the site, shows annual warming of about 0.17 degrees Celsius per decade since 1980. Warming is present in all seasons and has been particularly strong in the most recent decade, with notable monsoon warming in recent years. Total precipitation shows a modest increase over the last 45 years

### The medium term

The regional simulation at 4 kilometre resolution, interpolated to the altitude at which the failure occurred, is more representative of the site. Seasonal temperature anomalies show that in the monsoon there is a gradual and consistent warming, whereas other months alternate between warm and cold years. Isolating the monsoon, defined as 15 June to 15 September, gives warming of about 0.46 degrees Celsius per decade, much stronger than the annual average and highly statistically significant.

Two consequences follow. First, temperature lapse rates computed from the Langtang Valley observations locate the zero-degree isotherm at around 5,200 metres in 2006, rising to above 5,350 metres by the time of the event. That is the elevation band immediately above where the failure occurred, and the zero-degree isotherm is a direct indicator of the freeze and thaw processes operating there. Second, melt potential computed as accumulated positive degree days has increased substantially over the twenty-year period.

Precipitation in the regional simulation shows no strong trend, with a slight and statistically insignificant increase in both annual and monsoon totals. The partitioning, however, has changed markedly. Snowfall has decreased over the last twenty years and rainfall has increased. The consequence is more liquid water in the system, which matters for hydrostatic pressure in fractures and for the availability of water to lubricate ice and rock interfaces.

### The weeks before

Station observations from the Langtang Valley reveal an anomalous post-monsoon season in 2025. More than 300 millimetres of snowfall was recorded in a small number of events in October and November, an amount the observing scientist described as unlike anything previously seen at that site. That snow would not have begun to melt until the following spring, leaving an unusually large volume available for melt during the late spring and early monsoon of 2026.

Temperature in the two weeks before the event, lapsed to the failure elevation, shows that the three days immediately preceding the collapse were unusually warm. Maximum temperatures at that elevation exceeded 10 degrees Celsius against a normal maximum of about 6 degrees, reaching about 12 degrees. The diurnal temperature range, the difference between daily maximum and minimum, was also much larger than the long-term average in those days, which intensifies freeze and thaw cycling.

The Department of Hydrology and Meteorology provided an independent line of station evidence from the Kyanjing station at 3,850 metres in Rasuwa district, the closest station to the site although on the southern rather than the northern slope. It records continuous precipitation from 20 August through to the morning of 26 August, with temperatures above zero degrees throughout. Comparison of August 2026 against August 2025 at the same station shows a warmer August in 2026. The department also noted that 2026 is a strong El Niño year.

**FIGURE 2.4** ERA5-Land reanalysis for the pixel containing the failure site: mean annual two-metre temperature and annual precipitation by phase, fifty years.

### ERA5-Land: 50 years

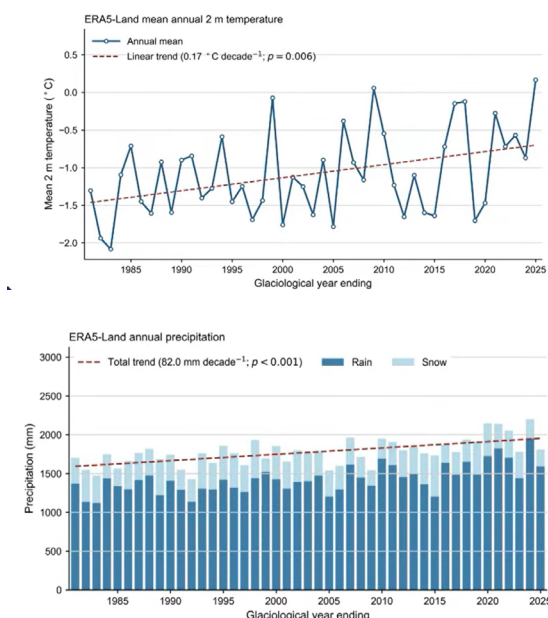
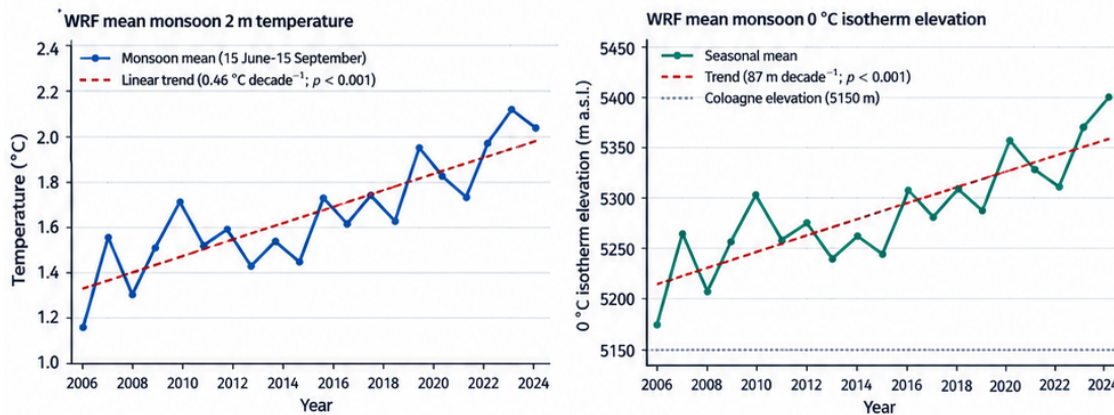
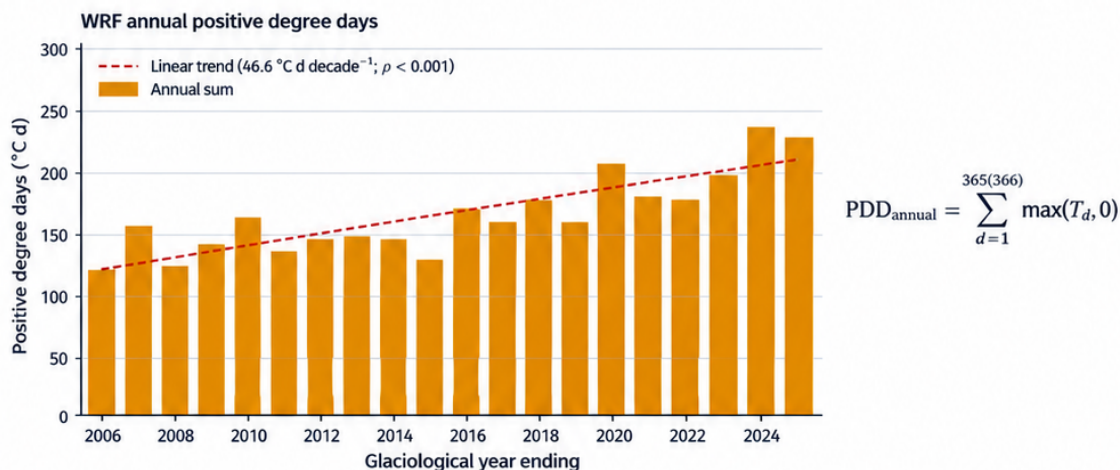


FIGURE 2.5: Monsoon Warming, Melt Potential and Monsoon Precipitation on WRF Simulations

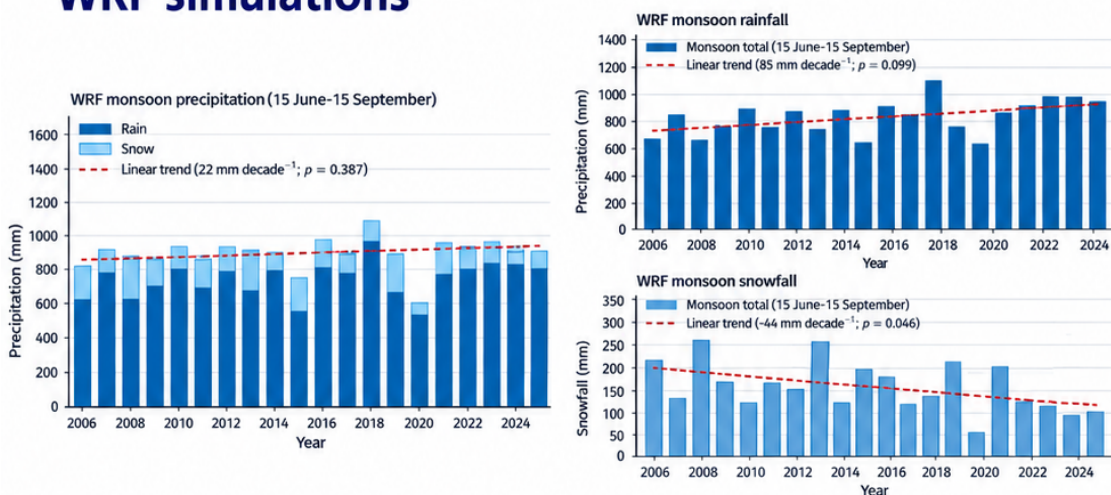
## Monsoon warming based on WRF simulations (5150m)



## Melt potential at 5150 meter based on WRF simulations



## Monsoon precipitation at 5150 meter based on WRF simulations



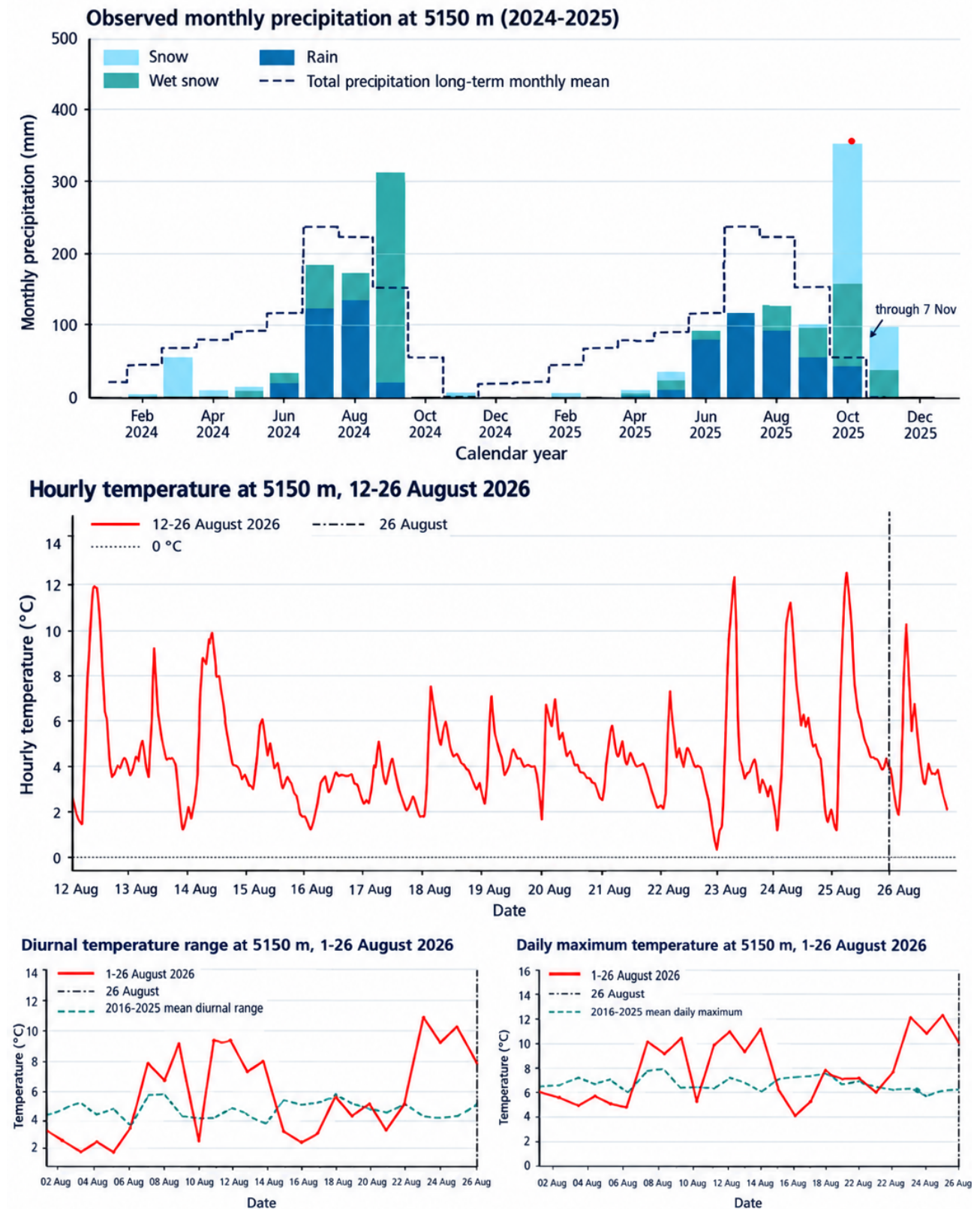
Note: The 4-kilometre regional simulation at 5,150 metres: monsoon warming, annual melt potential as positive degree days, and monsoon precipitation split between rain and snow.



**FIGURE 2.6** Weather and climate signals across three timescales

Warming at the failure site is present in reanalysis over four decades, is far stronger in the monsoon in higher-resolution simulation over two decades, and translates into a rising zero-degree isotherm that has passed through the failure elevation. Precipitation totals are broadly unchanged, but the phase has shifted from snow to rain, and the days immediately before the event were anomalously warm with large diurnal ranges.

## Weather before the disaster (Langtang observations)



Sources: Presentation by Prof. Walter Immerzeel, Utrecht University, to the convening, 7 September 2026; Department of Hydrology and Meteorology of Nepal., Note: Panels C, D and E are reconstructions of the patterns described in the presentation, drawn to the stated magnitudes and directions; they are illustrative of the described results and are not the published series. Panels A, B and F reproduce stated values.

**TABLE 2.1** Climate and cryosphere indicators for the Langtang catchment as presented

Indicators are grouped by the timescale on which they were computed and by the dataset used. All were presented as preliminary.

| Indicator                                           | Value as presented                       | Period            | Basis                                  |
|-----------------------------------------------------|------------------------------------------|-------------------|----------------------------------------|
| Regional glacier mass loss, South Asia East         | -21 per cent of year-2000 mass           | 2000 to 2023      | Global glacier change assessment       |
| Air temperature above 4,000 m                       | +0.3 °C per decade                       | Recent decades    | Langtang observations                  |
| Annual warming at failure pixel                     | +0.17 °C per decade                      | 1980 to 2025      | ERA5-Land reanalysis, ~9 km            |
| Monsoon warming at failure elevation                | +0.46 °C per decade                      | 2005 to 2025      | WRF simulation, 4 km                   |
| Zero-degree isotherm elevation                      | ~5,200 m rising to >5,350 m              | 2006 to 2026      | Lapse rates from Langtang observations |
| Annual melt potential                               | Substantial increase                     | 2005 to 2025      | Positive degree day accumulation       |
| Total precipitation trend                           | Slight, not statistically significant    | 2006 to 2024      | WRF simulation, 4 km                   |
| Precipitation phase                                 | Snowfall decreasing, rainfall increasing | 2005 to 2025      | WRF simulation, 4 km                   |
| Post-monsoon snowfall anomaly                       | >300 mm in few events                    | Oct to Nov 2025   | Langtang Valley station                |
| Maximum temperature at failure elevation            | >10 °C against -6 °C normal              | 23 to 26 Aug 2026 | Station observations, lapsed           |
| Glacier shrinkage rate, Langtang Lirung             | <1 per cent per annum                    | 1815 to 2010      | Mapped glacier extent                  |
| Glacier shrinkage rate, Langtang Lirung             | Significantly accelerated                | 2010 to 2026      | Mapped glacier extent                  |
| Terminus retreat, glacier right tongue              | 550 to 560 m total                       | 1964 to 2026      | Mapped glacier extent                  |
| of which since 2010                                 | 373 m, terminus rose >200 m              | 2010 to 2026      | Mapped glacier extent                  |
| Glacier area lost in failure                        | 0.27 km <sup>2</sup>                     | 26 Aug 2026       | Pre and post-event mapping             |
| Permafrost active layer                             | Thickening at >90 per cent of sites      | Recent decades    | High Mountain Asia synthesis           |
| Permafrost degradation band                         | 4,500 to 5,500 m                         | 1960s to 2018     | Analogue catchment study               |
| Local temperature rise relative to plateau average  | Up to four times                         | Not stated        | SKLGP climatic analysis                |
| Station warming, Kala Pokhari and Pyramid, ~5,600 m | 0.106 to 0.11 °C per year                | 1971 to 2024      | DHM station analysis                   |
| Station warming, nearest station, annual            | 0.132 °C per year                        | 1971 to 2024      | DHM station analysis                   |

Source: Presentations to the convening, 7 September 2026. Note: Station warming rates are reported per year as stated by the presenter and are an order of magnitude larger than the per-decade figures above them; readers should note the different units. Values reported per year should be treated with particular caution pending publication.

## BOX 2.2 What can and cannot be attributed

Every scientist who addressed the climate question at the convening drew the same distinction, and it is worth stating precisely because it will be contested in both directions. A changing climate has changed the conditions under which high-mountain hazards occur. That is established. How much it contributed to this specific collapse is not, and the honest answer as of 7 September 2026 is that the work is not finished.

### What can be said with high confidence

High Mountain Asia is warming faster than the global average, with profound consequences for glaciers, snow, permafrost and hydrological systems. These changes alter the physical conditions of high-mountain environments, including the stability of ice and rock on steep slopes and the characteristics of downstream catchments. The frequency of glacial and periglacial mass-movement events in the region has been rising, and downstream exposure has grown alongside it. High-mountain hazards are becoming increasingly interconnected, with ice and rock avalanches, permafrost degradation, debris flows, glacial lake outburst floods and landslide dam breaches capable of combining into complex cascading events.

For this catchment specifically, the evidence assembled at the convening is unusually strong: two centuries of mapped glacier retreat with sharp post-2010 acceleration; documented debuttressing of the exact slope that failed; permafrost degradation concentrated in the exact elevation band; a zero-degree isotherm that has risen through the failure elevation within two decades; a monsoon warming trend far above the annual mean; and a shift from snowfall to rainfall that increases liquid water in the system.

### What cannot yet be said

Scientists recognized that attributing climate change to this particular 26 August collapse event is going to be complex task. Establishing such a connection requires quite rigorous event-specific, process-specific and catchment-specific data analysis and evidence. One presenter put the difficulty in terms of the material: if less than 20 per cent of the contribution to the debris flow came from ice or glacier, and the bulk came from bedrock collapse and failure, then the dominant process is one that is very hard to link to climate change directly. Another, having assembled the strongest climate case presented, concluded that exact statistical attribution of this particular event will be a huge challenge, while stating that in his opinion it is likely that climate change played a role.





### Where the two positions actually differ

Less than it appears. Both accept that the environment has changed. Both accept that bedrock failure is harder to attribute than glacier or lake processes. They differ on how much weight to give the permafrost pathway, which is the mechanism by which climate forcing reaches fractured bedrock. That is an empirical question about the ice content of joints in this particular rock mass, and it is answerable.

### What is under way

A rapid attribution study by World Weather Attribution was in progress at the time of the convening, with two of the presenting scientists contributing to it. Its findings were not available on 7 September 2026 and are not anticipated in this report. Readers should treat that study, when published, as the authoritative source on the attribution question and this chapter as the record of what was known before it.

### Why the distinction matters politically

Nepal intended to carry the climate dimension of this disaster to the General Assembly the day after the convening. A claim of that weight is strongest when the science behind it is visible, rigorous and transparent, including its limits. Overstating the attribution invites a rebuttal that will be used to dismiss the whole case. Understating the changing baseline concedes ground that the evidence does not require conceding. The defensible position, and the one this report adopts, is that climate change has made this class of event more likely in this environment, that the quantitative contribution to this event is under investigation, and that the case for climate justice does not rest on a single event in any case.



## A hazard class on the rise

Beyond this catchment, presenters set the event in a regional pattern. Because of global warming, the Himalaya is experiencing several types of cascading hazard: glacier collapse, ice and rock avalanche, glacial lake outburst flood, and glacier debris flow. Events of this specific type, an avalanche converting into a debris flow and then into flooding, were described as becoming more frequent in the region.

The same river corridor was struck fourteen months earlier. A glacial lake outburst flood in July 2025 destroyed a bridge at the border and affected substantially the same catchment. That event originated from a supraglacial lake. The 2026 event originated from a bedrock and ice detachment. Different mechanisms, same corridor, same transboundary consequence, fourteen months apart.

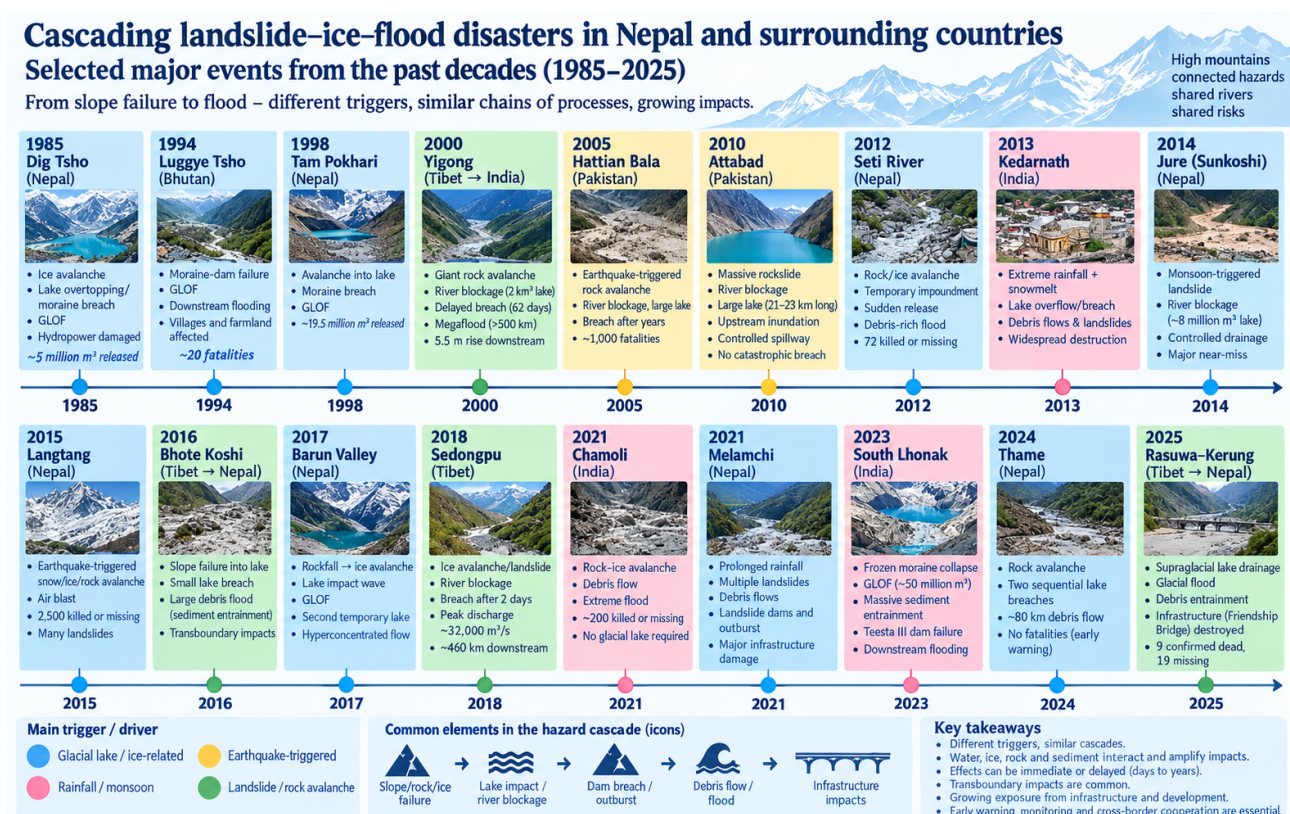
The regional temperature analysis presented by the SKLGP team found that temperature rise in this specific region is up to four times higher than the average for the Tibetan Plateau and Himalaya region as a whole. The presenter's assessment was that the cause of the event must be linked with the very fast warming in this region, combined with the post-seismic effect of the 2015 earthquake, while noting that more data are needed to support that estimate.

The Department of Hydrology and Meteorology set out a decade of Nepali events that had no precedent in the national record, presented as evidence of a changing climate rather than as attribution of any one of them. Nepal recorded its first ever tornado in 2019. In 2021 a flash flood occurred in Manang, a rain-shadow district where such events had not been recorded, and in the same year the Melamchi landslide-dam cascade occurred in June, followed by a three-day extreme rainfall event in the post-monsoon that devastated the annual paddy production of the country. In August 2023 a flash flood occurred in Mustang, also a rain-shadow district. A small glacier-break outburst flood occurred in 2024, and a small glacial lake outburst flood at Tila in Humla in May 2025.

The department also presented spatial analysis of observed temperature trends from 1971 to 2024, not yet published at the time of the convening, showing that the Langtang region specifically has a higher rate of temperature increase than the Himalayan region as a whole, in both mean and minimum temperature, and that warming is elevation-dependent, with the high Himalaya and high mountain regions warming faster than the lower mountains in all seasons.

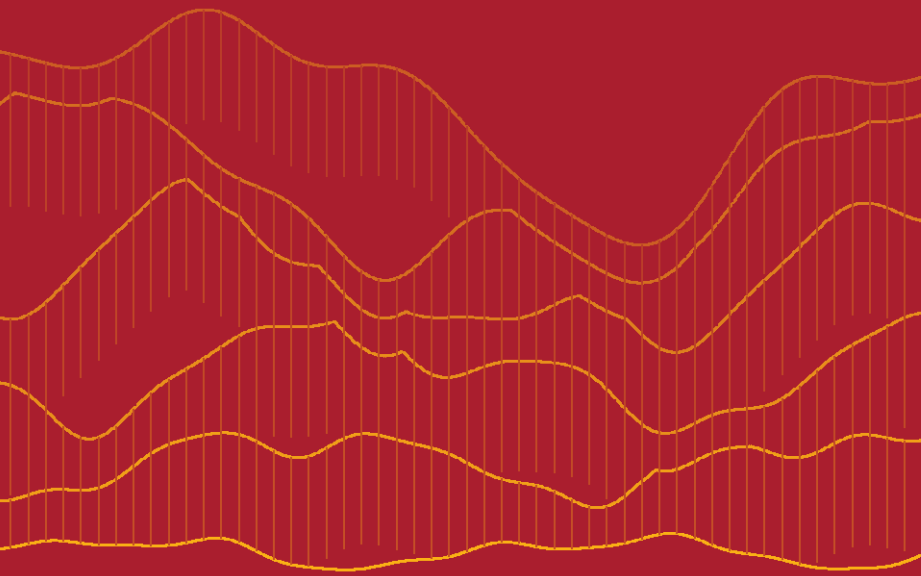
**FIGURE 2.7** Recent unprecedented and cascading events in Nepal, 1985 to 2025

*The University of Twente, Netherlands presented the selected major cascading landslide-ice-flood disasters and surrounding countries from the past decades from 1985 to 2025.*



Sources: Presentation by Prof. Cees Van Westen, Professor of Multi-Hazard Dynamics, University of Twente, Netherlands to the convening, 7 September 2026.





## CHAPTER 3

# Monitoring, Forecasting and Early Warning

*From what was detected to what could have been acted on*

Nobody knew the disaster had occurred. That sentence, spoken by one of the presenters about the source area, is the finding of this chapter. The event was not undetectable. Two independent precursor signals existed in data that had already been collected. A third, the seismic signature of the collapse itself, was recorded within seconds by networks in two countries. None of it was connected to anything that could issue a warning, and the flow reached the border before any institution on either side knew that anything had happened.

## **What existing systems could and could not detect**

Nepal's operational hydro-meteorological monitoring is built on river-level observation and rainfall measurement. For monsoon flooding, which is the dominant recurrent hazard, this is the correct architecture and it works. For this event it offered nothing.

The reason is arithmetic. The flow travelled 21 to 22 kilometres to the border in seven to eight minutes. Any system triggered by a rise in water level at a gauge upstream of a settlement provides lead time equal to the travel time between the gauge and the settlement, minus processing and dissemination time. In this corridor, on this event, that quantity was negative for the border settlements and small for those further downstream. The presenter who leads the national hydrological research centre put the underlying problem plainly: the system is built on water level rise during flood time, and once the gauging station has been washed away the system does not work.

Six gauging stations were destroyed by this event. The same pattern was described for previous extreme floods: during extreme events, the gauging stations are washed away. A monitoring architecture whose sensors are destroyed by the events they exist to detect has a structural rather than an incremental problem.

### **What was in the data**

Three signals existed.

- Interferometric surface displacement. Satellite radar analysis of the source area showed accelerating displacement from the middle of June 2026 at one measurement point and from approximately two months before the event at a second. A separate analysis showed around 15 centimetres of deformation on the bedrock

face over the four months from July to November 2025, indicating significant rock fracturing within the bedrock itself. The presenting team stated that if the site had been actively monitored, the potential danger could at least have been seen.

- A visible precursor rock fall. Footage recorded by tourists and posted to social media shows a strong dust cloud, probably generated by a precursor rock failure, approximately half an hour before the main event.
- The seismic signature of the collapse itself. High-frequency seismic energy characteristic of an ice and rock avalanche was recorded at the moment of initiation by networks in China and by the international catalogue, and the character of the signal changed as the flow converted through its successive phases.

The first two were reconstructed after the event. The third existed in real time and was not being read for this purpose.

## **Seismic monitoring as the operational answer**

The strongest practical proposal at the convening was that seismic networks are probably the best way to detect this class of hazard in remote source regions, because other monitoring sensors are extremely difficult to install and maintain at the source area itself. This is not a theoretical claim. It has been demonstrated operationally.

The distinguishing property of seismic detection is that the instrument does not need to be in the hazard zone. A network at a safe distance detects an event at its source, in seconds, regardless of cloud cover, darkness or the destruction of infrastructure in the valley. For an event whose entire useful warning window is measured in minutes, that is the difference between a system that can act and one that cannot.

## **Hydrological monitoring must be rebuilt, not repaired**

The Centre of Hydrology and Water Resources Research set out a programme of change for the national network. Existing gauging stations should be reviewed against their performance in extreme events. Robust stations are required, moving from single-stage automated water level sensors to two-stage sensors, so that a secondary monitoring sensor continues to function and to transmit during extreme flood conditions when the primary is lost. Traditional systems need to be modernised into robust and adaptive systems capable

of operating during extreme floods rather than only during ordinary ones.

More fundamentally, the basis of monitoring must change. Existing forecasting and warning is developed around water level rise. It should be integrated with land movement sensing based on seismic signals and on land settlement and deformation measurement, linked together. Glacial lakes across the country represent a distinct and high risk requiring their own robust monitoring, with forecasting and warning built on it.

The measurement scope must also widen. Water-induced disaster in Nepal has been treated largely as flood, and measurement has been of water alone. The event demonstrated that it is linked to a multi-hazard system, and that sediment, landslide and disaster management dimensions must be measured together with water.

## **From detection to lead time to action**

The convening was clear that detection is necessary and insufficient. The reference case is the 2024 floods in central Nepal, where around 450 lives were lost despite advisories issued nearly four days in advance by the Department of Hydrology and Meteorology and processed by the disaster authority. The conclusion drawn was direct: had there been an effective or functional early warning system in the country, those lives would not have been lost.

The gap between a forecast and an action is filled by risk communication, by protocols, and by institutions. The convening heard that Nepal does not have an early warning system in the operational sense, but rather silos of its elements, with what was described as abysmally poor risk communication, no interoperable and actionable risk information, no simple broadcasting mechanism, no common alerting protocol, and no sectoral warning system targeting the hydropower sector. Those are the subject of Chapter 4.

## **Transboundary detection and data sharing**

The source area is in Nepal. The first infrastructure destroyed was at the border. The downstream impact was in Nepal, and there were casualties on the Chinese side. No monitoring data existed for the source area, and the presenter from the Chinese Academy of Sciences was explicit about the consequence: because there was no data from the Nepal part

of the source area, nobody knew the disaster had occurred until it had destroyed the buildings and facilities along the valley.

Three joint mechanisms were proposed from the Chinese side: a joint investigation team to produce a list of potential disaster sites in the area, which was described as very important for reconstruction planning and requiring a risk assessment and a resource system map; a joint observation and early warning system with shared data; and a joint risk management mechanism to share information and take joint action in an emergency, including preparation planning.

From the Nepali side, the Ministry of Energy, Water Resources and Irrigation described the existing base to build on. Nepal openly provides its real-time hydrological observations through its website, and has bilateral agreements with India and Bangladesh to share real-time hydrological data. As an upstream country for those neighbours, this was described as a responsibility. The corresponding mechanism with China does not exist, although Chinese counterparts had shown interest in establishing one shortly before the disaster and had shown keen interest in providing support and sharing information after it.

**BOX 3.1 Lessons from a monitored catchment on the Tibetan Plateau**

The argument that seismic monitoring can deliver operational early warning for ice and rock avalanche to debris flow cascades does not rest on theory. It rests on a catchment that has been monitored for more than three years and where warnings have been successfully issued.

The catchment became highly active after a large earthquake, and has produced several events every year since. Ice and rock avalanches detach from a section of slope, fall, and convert into debris flows. The catchment contains an enormous volume of loose sediment: deposits more than 360 metres thick in places, about 65 million cubic metres of deposition at the monitored site, and roughly 800 million cubic metres of source material in the catchment as a whole.

**What the record shows**

For an event in 2023, the seismic record shows precursory rock falls that generated heavy dust and a recorded signal, followed shortly afterwards by a debris flow producing a characteristic high-frequency signal, followed by two further rock fall or ice avalanche signals after the main event. For a later event, dust generated by an ice and rock avalanche initiating from the top of the slope was visible, the flow converted rapidly into a debris flow, and both seismic and infrasound signals correlated closely with the timing established from video.

The presenting team stated that it has successfully issued early warnings for events in this catchment using this information.

**Why this is transferable**

The sequence recorded in this catchment is, phase for phase, the sequence recorded at Langtang Lirung on 26 August: a precursory dust-generating rock fall, a main ice and rock avalanche with distinctive high-frequency content, conversion to debris flow, and secondary failures afterwards. The team drew the comparison explicitly, describing the recorded events as very similar to the recent Nepal event.

The method requires seismic stations, infrasound sensors where feasible, a catalogue of signal signatures for the relevant hazard types, and an automated detection and alerting chain. None of that requires instrumentation at the source. What it requires is sustained operation, which is an institutional and financing question rather than a scientific one.

**The wider programme**

The same team has published on transboundary cascading hazards and what can be learned from past events, and in 2026 launched a scientific programme supported by UNESCO focused specifically on mountain cascading hazards, with an open invitation for collaboration under transboundary conditions. A hazard atlas covering the wider region, including parts of Tajikistan, Afghanistan, Nepal, India, Bhutan and Myanmar, mapping flooding, landslide, earthquake, freeze and thaw hazards, landslide dams and glacial lake outbursts, was described as due for publication by the end of 2026 with an English edition in 2027. It includes a page prepared specifically for this event.



**TABLE 3.1** Detectability of each stage of the 26 August cascade

Each phase of the cascade is assessed against the monitoring that existed on 26 August 2026 and against monitoring that is technically available today. The gap between the two columns is the subject of the recommendations in Chapter 5.

| Stage                                            | Detectable in 2026 as configured | Technically detectable today   | What would be required                                                                                            |
|--------------------------------------------------|----------------------------------|--------------------------------|-------------------------------------------------------------------------------------------------------------------|
| Progressive rock fracturing, months before       | No                               | Yes, weeks to months           | Routine interferometric monitoring of a defined inventory of source zones, with an analyst and a referral pathway |
| Precursor rock fall, ~30 minutes before          | No                               | Possibly, minutes              | Regional seismic network with automated signature detection; cloud-free optical or camera coverage                |
| Main detachment                                  | Recorded but not acted on        | Yes, seconds                   | Automated seismic detection with a direct link to an alerting authority                                           |
| Conversion to debris flow                        | No                               | Yes, seconds to minutes        | Seismic signature library for the relevant hazard classes; infrasound where feasible                              |
| Arrival at border, 7 to 8 minutes                | No                               | Yes, if the above are in place | Common alerting protocol; pre-agreed cross-border notification; sectoral alerting for hydropower                  |
| Secondary landslide, ~3 hours later              | Recorded but not acted on        | Yes, seconds                   | Same seismic chain, plus a standing post-event monitoring protocol                                                |
| Barrier lake formation and outburst risk         | Partially, by satellite          | Yes, hours to days             | Tasked satellite acquisition, breach modelling capacity, downstream evacuation protocol                           |
| Post-event slope instability through the monsoon | No                               | Yes, seasonally                | Conditional hazard mapping and monsoon-season monitoring of newly destabilised slopes                             |

Source: Assessment by Youth Innovation Lab based on presentations to the convening, 7 September 2026.



***“We do not have an early warning system in this country. A lot of people might argue with that, but what we have is silos of its elements and abysmally poor risk communication.”***

**Anil Pokhrel**, Former Chief Executive, National Disaster Risk Reduction and Management Authority

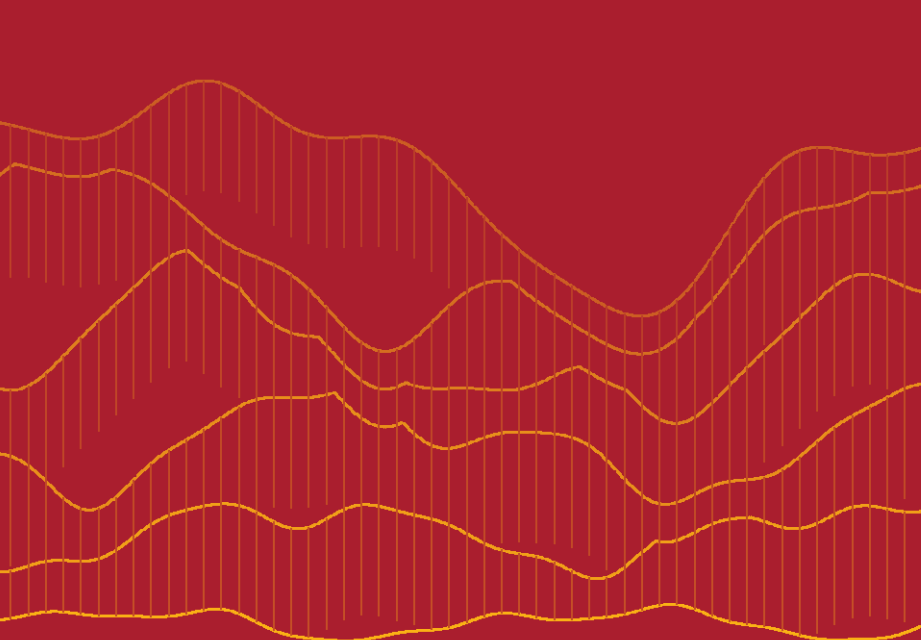
## Connecting meteorology to the cryosphere

The Department of Hydrology and Meteorology set out what it considers necessary to close the gap between weather observation and mountain hazard anticipation. A Himalayan climate monitoring and analysis system is required to generate quality data usable for multi-hazard early warning, and investment in it is required. Beyond monitoring, the National Framework for Climate Services recommended by the World Meteorological Organization should be implemented across five sectors: energy, water resources, agriculture, disaster risk reduction and health.

The framework was described as requiring co-production of products with thematic stakeholders from central to local government, and as needing to span the full range from real-time data sharing through short-term forecasting and seasonal prediction to climate projection. In the context of a developing strong El Niño, the department identified the monitoring of glacial and cascading events specifically as a priority.

The Ministry of Energy, Water Resources and Irrigation identified an institutional obstacle that no amount of technology addresses. Describing practice in the United Kingdom, where the flood forecasting unit is housed inside the meteorological office building, the presenter contrasted his own experience: while leading the Department of Hydrology and Meteorology, he was not able to convene even a single meeting with the Department of Mines and Geology to discuss the possibility of developing a landslide warning system. A functional mechanism for relevant government agencies to interact regularly, and to strengthen data and knowledge sharing, was placed first among the priorities.

The convening also heard that Nepal's hydro-meteorological modernisation over the last decade, through programmes including the Pilot Program for Climate Resilience and related investments, has delivered real progress in forecast products, satellite monitoring and capacity, and that much of the credit belongs to international support from India, China, Korea, Japan and others, including access to satellite data. The argument made was therefore not for building a new national system from scratch but for bringing together existing and innovative technical know-how with sustained investment, and for strengthening collaboration among countries in the region and with global organisations rather than reinventing the wheel domestically.



## CHAPTER 4

# Risk Reduction, Resilience and Governance

*Three scales of management, and the institutional fault lines  
between them*

The scientific findings presented at the convening were provisional and contested at the margins. The governance findings were neither. They were delivered by people who had run the institutions in question, and they described a system capable of handling localised disasters and structurally unprepared for the class of crisis that occurred on 26 August.

### Three scales of risk management

The framing offered for how Nepal should manage water-induced disaster risk in changing mountain river systems distinguished three scales, drawn from post-event study of the 2021 Melamchi flood. It began from a premise that was stated bluntly: complete mitigation of water-induced disaster risk at this scale is not possible. Experts and the public have raised the argument that with an early warning system and adequate monitoring stations the risk could have been minimised. It could have been minimised. It could not have been mitigated completely.

#### Project scale

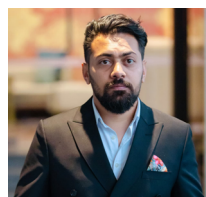
All hydro-related projects are related to rivers, so siting them away from rivers or at higher elevation is not logical. Resilience must instead come from selecting lower-risk locations within that constraint, designing so that structures can withstand high multi-hazard loads, installing early warning with adequate lead time so that project components such as tunnels can be made safe by closing gates, and using risk transfer mechanisms such as insurance. Several of these are already pursued in some contexts; the proposal was to systematise them and make them mandatory.

#### River reach scale

This is the scale at which settlements and livelihoods sit, and they go together. Risk zonation, definition of safe operating areas for different types of activity, and strict enforcement of those zones are the instruments. The government had been reported as moving to relocate high-risk settlements to safer areas. The response to that was conditional support with a warning: it needs to be done very carefully, because it has many socio-political dimensions.

#### Catchment or basin scale

Dynamics at this scale are ultimately expressed at the reach and project scales. Managing an entire catchment to minimise risk is not economically feasible; monitoring and managing extremely vulnerable areas within it is. Hydro-meteorological monitoring helps to understand monsoon-driven disaster but is not adequate to understand events of this kind. Monitoring of land movement using interferometric radar and of seismic signals could be, if integrated properly with data sharing and early warning. That implies multidisciplinary collaborative effort for the entire Himalayan region, in partnership with the countries in the basin and beyond.



***“Our science must be capable of understanding this complexity. These mountains do not recognise political boundaries. The rivers do not stop at borders. The sediment does not stop at borders. And disasters certainly do not stop at borders.”***

**Pradip Khatiwada**, Executive Director, Youth Innovation Lab



**FIGURE 4.1** Three scales for managing water-induced disaster risk

*Instruments differ by scale, and each scale requires a different institutional owner. The framework derives from post-event study of the 2021 Melamchi flood and was applied to this event at the convening.*

### A. Three scales for managing water-induced disaster risk

|                                                                                   |                                                                                                                                                    |                                                                                                                                                                                      |
|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <p><b>Catchment / Basin scale</b></p> <p>Transboundary monitoring - land deformation and seismic signals - data sharing - basin-scale planning</p> | <ul style="list-style-type: none"> <li>● Transboundary monitoring</li> <li>● Land deformation and seismic signals</li> <li>● Data sharing</li> <li>● Basin-scale planning</li> </ul> |
|  | <p><b>River Reach scale</b></p> <p>Risk zonation - safe operating zones - settlement relocation - enforcement</p>                                  | <ul style="list-style-type: none"> <li>● Risk zonation</li> <li>● Safe operating zones</li> <li>● Settlement relocation</li> <li>● Enforcement</li> </ul>                            |
|  | <p><b>Project scale</b></p> <p>Low-risk siting - multi-hazard design - early warning with lead time - risk transfer</p>                            | <ul style="list-style-type: none"> <li>● Low-risk siting</li> <li>● Multi-hazard design</li> <li>● Early warning with lead time</li> <li>● Risk transfer</li> </ul>                  |

*Sources:* Presentation by Prof. Dr. Vishnu Prasad Pandey, Institute of Engineering, Tribhuvan University, to the convening, 7 September 2026.

### Institutional fault lines

The most direct account came from the person who served the first full five-year term as Chief Executive of the national disaster authority. The assessment was that Nepal can manage small and localised disaster events but is far from prepared for large multi-sector crises of the kind it has just experienced. Legal and policy frameworks for crisis preparedness and emergency management were described as strong. The implementation was not.

A series of specific gaps was set out.

- Disaster classification. The event is classified under the national disaster response framework as a mega disaster. The proposal was that this needs revisiting along the lines of a graded categorisation comparable to that used for hurricanes, so that a category can carry an unambiguous instruction. As it stands, risk cannot be communicated at all.
- Institutional placement and maturity. The authority was established in 2019 to lead cross-sectoral preparedness and response and was described as still in its infancy seven years later. Being mapped under the Ministry of Home Affairs, its focus for response relies mostly on the security agencies: the army, the armed police force and the police.
- No national emergency operations centre. There is no war room in which command and coordination can happen with real-time data and joint action, with desks from central ministries covering roads, energy, agriculture and housing. A facility of similar character exists in Kathmandu near the airport but is not run by government, is run as a project, and has a poor infrastructure base. Under the law the national emergency operations centre was to be handed to the disaster authority; that has never happened.
- No national stockpile facility. There is no national warehouse under the disaster authority in which stockpiles and emergency search and rescue equipment can be pre-positioned, although the law requires one. The consequence was illustrated by an operational example: during the presenter's tenure it took almost six days to move rafts a distance of about twelve kilometres. Logistics and service capacity for managing a crisis was described as nearly non-existent.

- No common alerting protocol and no sectoral warning. There is no simple broadcasting mechanism and no common alerting protocol, and no sectoral warning system targeting the hydropower sector, which is precisely the sector this event destroyed.
- The disaster fund. The national disaster fund still carries a name that frames disasters as acts of God, is still run by a body other than the national council chaired by the Prime Minister, and has not been handed over as intended.

#### **BOX 4.1 Anatomy of the response: what worked and what did not**

The convening was held on the thirtieth day after the disaster, the day marking the formal end of the intense mourning period. It is possible to record what the response achieved and what it exposed without diminishing either.

##### **What worked**

The Council of Ministers convened within a few hours of the event, which the former chief executive of the disaster authority described as unprecedented in speed in his experience. Response and relief operations proceeded on an unprecedented scale. Approximately 12,000 people were rescued. The response drew in security forces, volunteers, doctors, journalists, technical experts and international responders working together. Chinese counterparts, who had shown interest in a bilateral data-sharing mechanism shortly before the disaster, showed keen interest afterwards in providing support and sharing information.

##### **What did not**

The response revealed that Nepal's preparedness architecture is built for events that stay inside a district. This event did not. Attention concentrated on the upper reaches of Rasuwa and Nuwakot districts and to a lesser extent Dhading, and the downstream impacts were slower to be captured. The loss of a section of national highway severed the main connectivity to Kathmandu, turning an existing cooking gas shortage into a national-level crisis. The presenter's observation was that had the highway not gone down, much of the rest of society might not have been substantially affected at all.

##### **The attention problem**

A theme returned to repeatedly was that this disaster, unlike the 2015 earthquake, has not shaken the nation as a whole. Videos circulated of people celebrating festivals while the search continued. The fear expressed was that policy makers may lose the sense of gravity within a couple of months, as has happened after previous disasters, because the memory span is short. After the 2015 earthquake, the fifty-six seconds of shaking that changed everything faded from public consciousness and with it the demand for safety.

##### **The human dimension**

Thousands of families were unable to perform final rites in the usual way. Families used dummies made of holy grass to represent the missing in order to undertake the rituals marking the transition of the deceased. That detail belongs in a technical report because it describes a category of loss that no damage assessment captures, and because the number of families in that position is a direct function of how many people remain unaccounted for.

## Financing the recovery

The financing picture presented was the most constrained element of the whole account. The national disaster fund together with donations will likely cover most of the search, rescue and relief operations. Whether anything will remain to support reconstruction and recovery was doubted.

Contingent financing instruments from the World Bank and the Asian Development Bank were described as the only readily available funds to support reconstruction and recovery, with the important qualification that these are concessional loans and not grants. To the cost of this event must be added the still-pending reconstruction from the 2023 earthquake, the 2024 floods and landslides, and the Ilam devastation of 2025. The combined financing need was described as hard to imagine, running into billions of dollars. Access to international climate finance was described as impractically slow for post-disaster use. Processes to access the loss and damage fund and other climate finance architectures were characterised as very slow, with one Green Climate Fund project taking nearly six years to process and a further eighteen months to become effective.

A specific and avoidable exposure was identified in the hydropower sector. Hydropower plants built with taxpayers' money are not insured, meaning taxpayers absorb the loss. Only privately owned hydropower projects carry insurance, and their premiums will now rise sharply.

## Infrastructure, settlement and land use

The design implication drawn from the physical analysis was that in a Himalayan setting, infrastructure design can no longer avoid accounting for events of this class. Alongside early warning systems, redesign of infrastructure so that it accounts for the recurrence of such events should carry very heavy emphasis.

This connects to a broader argument made at the convening about the development model itself. The devastation occurred along major economic corridors, and the pattern of investment that concentrated hydropower, transmission, roads and settlements in narrow valley floors is the reason the physical event became an economic catastrophe. Rethinking the overall approach to disaster risk governance was framed as inseparable from rethinking the development model followed for decades.

The forward-looking risk assessment was not reassuring. Comparable risks were identified in the Gandaki river basin,

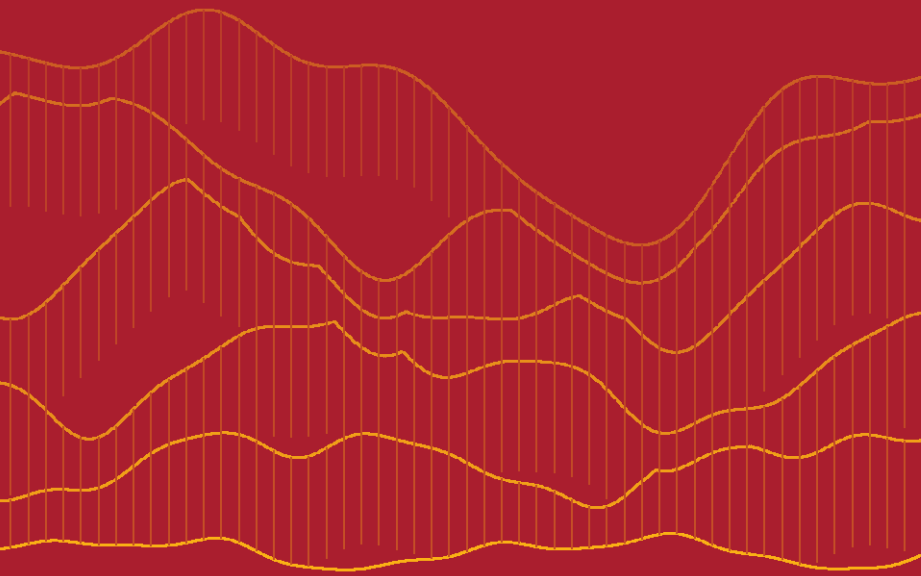
with reference to what has already happened in the Seti and other basins, and in the Koshi basin, where dozens of glacial lakes are growing at a fast pace on the Tibetan Plateau side. The scenario described was one that might exceed even the highest category of a graded classification.

## Risk communication and inclusion

Two arguments closed this part of the discussion. The first concerned the interface between hazard and vulnerability. Multi-hazard understanding is necessary but insufficient, because it is not just multi-hazard, it is also multi-vulnerability, and the two are strongly interconnected. Some people were disabled by this disaster, temporarily or permanently, and persons with disabilities, women and other vulnerable groups must be at the centre of scientific reasoning, policy making and investment rather than considered afterwards.

The second concerned local knowledge. Substantial work has been done in Nepal to strengthen local communities, and the recovery is an opportunity to combine scientific knowledge with local knowledge, translate both into national and local plans and measures, and communicate the result to the wider community. Risk information sharing that generates an increasingly wide understanding of disaster risk was placed alongside the technical strengthening of the warning system as an equal priority.

The United Nations Office for Disaster Risk Reduction commended the work Nepal has already put into developing a national roadmap for strengthening the national early warning system and identified its adoption as important guidance for international development partners wishing to support Nepal. The recovery and reconstruction phase itself was identified as the vehicle through which the early warning system should be strengthened, and scientific understanding was described as needing to inform the rebuilding so that existing vulnerabilities and exposures are addressed rather than reproduced.



## CHAPTER 5

# Priorities and the Path to Resilience

*From evidence to collective action*



The webinar closed with a question rather than a summary: what next? This chapter converts the answers offered into a programme of work, assigns each item to an actor, and states an indicative timeframe. Nothing here is invented. Every item was proposed at the convening by someone with the standing to propose it.

## **A scientific autopsy**

The first task proposed was a full multidisciplinary investigation of the event itself. The framing was deliberate. Multiple presentations gave multiple perspectives; what is needed now is depth. The questions to be answered are what the sequence of physical processes actually was, what was known, what was missed, where models and modelling systems worked, where they failed, and what science still cannot answer.

A caution accompanied it. The complexity should not be reduced to a simple linear climate change narrative. A changing climate is transforming the conditions under which Himalayan hazards occur, but attributing an individual event requires event-specific, process-specific and catchment-specific evidence. The Himalaya is a complex system undergoing a complex transformation, and the science must be capable of understanding that complexity.

Practically, the autopsy has four tractable components identified in this report. First, a jointly agreed source volume built from a shared pre-event and post-event elevation dataset with an agreed convention on where source ends and entrainment begins, which would resolve Box 1.1. Second, a determination of the ice content of joints in the failed rock mass, which is the empirical question on which the permafrost pathway of Box 2.2 turns. Third, a reconstruction linking numerical run-out simulation to the seismic record, which both Chinese teams identified as their intended next step. Fourth, a water balance for the event, since where the water came from remains unresolved.

## **An inventory of the next ones**

The methods to identify comparable source zones were demonstrated at the convening and are ready to be applied at scale. Rock masses with free surfaces and high hazard potential can be mapped across the Himalaya from three-dimensional imagery. For each, volume can be estimated with a slip surface model. For each, run-out can then be

modelled, and tools exist that can simulate multiple scenarios over a very large area within minutes.

The output would be a national inventory of potential source zones with modelled run-out, which is the necessary input to credible safe and unsafe zoning, to settlement and infrastructure planning, and to prioritising where monitoring should be installed first. This is the single highest-value scientific product identified at the convening and it does not require new science.

## **Whole-catchment monitoring**

The shift proposed is from river-level monitoring to integrated whole-catchment monitoring. Its components are a regional seismic network read continuously for mass-movement signatures with automated detection; routine interferometric monitoring of the source zone inventory; hardened two-stage hydrological gauging that survives the events it measures; glacial lake monitoring; and a Himalayan climate monitoring and analysis system producing quality data for multi-hazard early warning. These must be integrated rather than operated in parallel, and integrated with an alerting chain that can actually reach people.

## **An institutional reset**

The governance proposals were specific. The disaster authority should be mapped within the Prime Minister's Office, with work on medium-level category three and four emergency response resting with the Ministry of Home Affairs. The authority needs to be legally empowered with convening authority, technical capacity, full staffing and resources. A national emergency operations centre must be established and handed over as the law requires. A national stockpile facility must be built under the authority. A common alerting protocol and a sectoral warning system for hydropower must be introduced. Disaster classification should be reformed into a graded scale that communicates severity unambiguously.

The reasoning offered for the elevation was scaled to the hazard rather than to this event. The world has warmed roughly 1.2 to 1.3 degrees and this disaster occurred at that level of warming. At 1.5 or 2 degrees, which translates to a considerably higher increase in the mountains, the institutional mandate for anticipating and responding to such events has to correspond to that scenario.

## A transboundary mechanism

The proposals from both sides converge. A joint investigation team to produce a list of potential disaster sites with an associated risk assessment and resource map for reconstruction. A joint observation and early warning system with shared data. A joint risk management mechanism to share information and take joint emergency action, with a preparation plan. On the Nepali side, the model already exists in the bilateral real-time hydrological data-sharing agreements with India and Bangladesh; what is required is the equivalent with China, for which counterpart interest exists.

The wider frame offered was that risk understanding itself must become transboundary, requiring Nepal, China, India and the wider Himalayan region to work together with the global scientific community, the best available science and satellite capability, modelling technology and field knowledge. The insistence was on timing: this cannot be cooperation after disasters, it has to be cooperation before the next one occurs.

## Recommended Actions

The convening surfaced a wide range of proposed actions to strengthen understanding of, and resilience to, cascading high-mountain hazards in Nepal. Rather than assigning specific ownership or timeframes at this early stage, these are presented here as recommendations for further discussion and prioritization by the relevant institutions.

### 1. Government of Nepal

Much of the discussion centered on the institutional and policy gaps exposed by the 26 August response from the disaster authority's limited convening power to the absence of a graded warning system communities could act on. Participants proposed:

- Establish a national emergency operations centre and transfer it to NDRRMA, as required by law.
- Establish a national stockpile facility under NDRRMA.
- Relocate the disaster authority to the Office of the Prime Minister, with convening authority and resources.
- Reform disaster classification into a graded scale that communicates severity.
- Adopt a common alerting protocol and a sectoral warning system for hydropower.
- Adopt and finance the national early warning system

roadmap.

- Define credible safe and unsafe zones in affected and comparable corridors, and enforce them.
- Embed multi-hazard design standards and gate-closure protocols in hydropower and road projects.
- Insure public hydropower assets and mandate risk transfer for new projects.
- Place persons with disabilities, women, and other vulnerable groups at the centre of recovery planning.

### 2. Hydro-meteorological and geological agencies

With almost no lead time before the 26 August flood, participants focused on the physical monitoring infrastructure needed to detect the next event earlier. Proposed actions include:

- Establish continuous seismic monitoring for mass-movement detection in priority catchments.
- Initiate routine interferometric monitoring of the source zone inventory.
- Monitor sediment flow across Himalayan rivers.
- Replace single-stage gauges with hardened two-stage sensors in high-risk corridors.
- Establish a Himalayan climate monitoring and analysis system.
- Implement the National Framework for Climate Services across five sectors.
- Build a national inventory of ice and rock avalanche source zones with modelled run-out.

### 3. Academic and research institutions

Speakers repeatedly noted that key physical facts about the 26 August event; its volume, ice fraction, and triggering mechanism remain contested or unconfirmed. Recommendations to close this evidence gap include:

- Convene a joint scientific autopsy of the 26 August event on a shared dataset.
- Agree a single source volume and ice fraction from common pre- and post-event elevation data.
- Link numerical run-out simulation to the seismic record for the full cascade.
- Determine the ice content of joints in the failed rock mass to test the permafrost pathway.

### 4. Transboundary and international cooperation

Because the hazard originated across the Nepal–China border,

participants agreed that no purely domestic monitoring system can fully close the warning gap. Proposed actions include:

- Establish a bilateral hydrological and hazard data-sharing mechanism with China.
- Establish a joint investigation and joint risk management mechanism for the shared basin.

Several of these actions are sequenced: the source zone inventory, for instance, is a prerequisite for both credible zoning decisions and the prioritization of monitoring installations.

Taken together, these recommendations point to a single underlying message from the convening: Nepal's exposure to cascading high-mountain hazards is a scientific, institutional, and diplomatic challenge in equal measure, and progress on any one front; evidence, monitoring, governance, or cross-border cooperation will be limited without corresponding progress on the others. What began as an urgent response to a single catastrophic event should, participants argued, become the starting point for sustained investment in understanding and managing risk across the wider Hindu Kush Himalaya region.

## A continuing platform

The final commitment made at the convening was that this is not a one-off event. It is intended as a starting point for a continuing series of scientific exchange, information sharing and collaboration, bringing together new evidence as it emerges, connecting scientists across countries and disciplines, and translating that science into decisions that governments and communities can actually use.

Two immediate follow-through commitments were made and are recorded here as obligations rather than aspirations. First, the questions submitted through the question and answer channel during the session, which were numerous and which could not be addressed because the discussion segments were compressed, will be collected and put to the individual speakers, with the responses forming part of the documentation of the convening. Annex B carries the record. Second, the outputs of the convening will be shared with high-level authorities to inform ongoing policy processes.

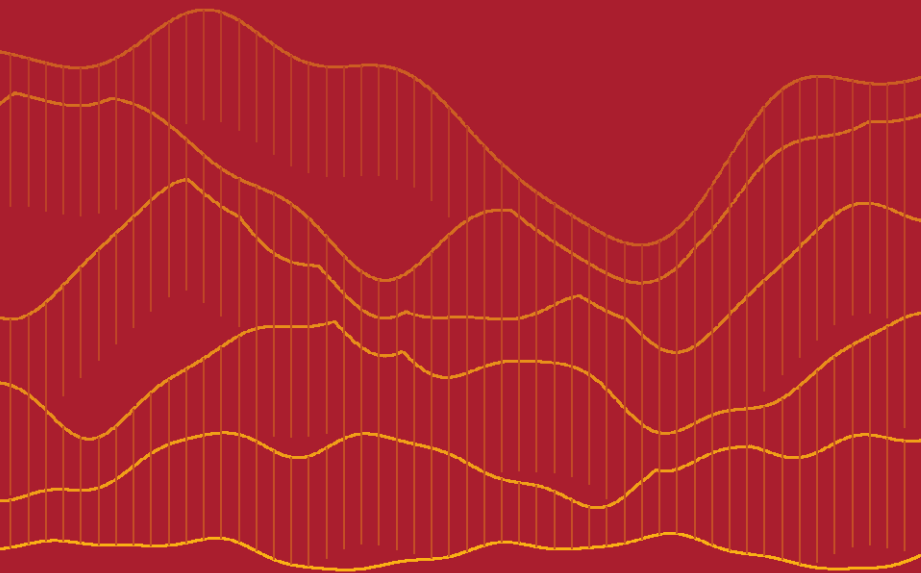
A parallel invitation was extended from the scientific side. A special session on the cascading events in Nepal is being organised within the geohazard component of the International Association of Engineering Geology World Conference in the Netherlands. A UNESCO-supported

scientific programme on mountain cascading hazards launched in 2026 is open for collaboration, with an explicit focus on transboundary conditions. A visiting programme at the Chinese Academy of Sciences is open for academic exchange.

## What this report asks of its readers

Three things. First, treat every number in it as provisional and check it against the issuing institution before citing it. Annex C exists for that purpose. Second, do not let the attribution question, which is genuinely unresolved, become a reason to defer the actions that do not depend on it. The inventory of source zones, the seismic monitoring, the common alerting protocol, the emergency operations centre and the insurance of public assets are all justified by the hazard as it already exists. Third, hold the institutions named in Table 5.1 to the timeframes attached to them, and treat the next convening in this series as the occasion to report against them.

The mountains have given a strong warning. Science has helped to understand it, to some extent. Turning that understanding into action is a collective responsibility, and it has to be turned into resilience in the Nepal Himalaya and across the Himalayan scale beyond it.



## ANNEX A

# Programme and Speakers

*Annex A*



**TABLE A.1 Programme as delivered**

*Scheduled times are those circulated in advance. The session ran approximately thirty minutes beyond its scheduled close, and both discussion segments were compressed in order to protect presentation time.*

| Time (NPT)     | Item                                                                                                                              | Speaker                                                                                                                                               |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| 15:00 to 15:10 | Opening and context setting                                                                                                       | Madhab Uprety, Senior Technical Adviser, Red Cross Red Crescent Climate Centre                                                                        |
|                | PART 1 UNDERSTANDING THE EVENT: HAZARD GENESIS, CASCADES, CLIMATE CHANGE                                                          |                                                                                                                                                       |
| 15:10 to 15:19 | What triggered the Rasuwa flood? The known unknowns. Physical genesis of the event and current scientific understanding           | Dr. Mohan Bahadur Chand, Assistant Professor, Department of Environmental Science and Engineering, Kathmandu University                               |
| 15:19 to 15:28 | A hazard class on the rise? Ice and rock avalanche, debris flow and GLOF chains across the Himalaya                               | Prof. Xuanmei Fan, Director, State Key Laboratory of Geohazard Prevention and Geoenvironment Protection, Chengdu University of Technology             |
| 15:28 to 15:37 | The landslide-dammed lake: from hazard to scenario. Debris-flow dynamics and breach-risk assessment                               | Academician Prof. Cui Peng, Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, with Dr. Chenxiao Tang                        |
| 15:37 to 15:46 | Anatomy of a cascading disaster: how multiple hazards interacted and amplified impacts                                            | Prof. Cees van Westen, Professor of Multi-Hazard Risk Dynamics, ITC, University of Twente, with Ashok Dahal                                           |
| 15:46 to 15:55 | Changing cryosphere and high mountain hazard system: historical glacier change in the Langtang catchment                          | Prof. Bethan Davies, Professor of Glaciology, Newcastle University                                                                                    |
| 15:55 to 16:04 | The Trishuli disaster and the role of climate change: establishing a changing baseline                                            | Prof. Walter Immerzeel, Professor of Mountain Hydrology, Utrecht University                                                                           |
| 16:04 to 16:25 | Question and answer, reflection I: genesis, cascading processes, climate change                                                   | All                                                                                                                                                   |
|                | PART 2 WHAT NEXT? MANAGING RISK IN A CHANGING MOUNTAIN ENVIRONMENT                                                                |                                                                                                                                                       |
| 16:25 to 16:32 | Could we assess water-induced disaster risk differently? From river forecasting to whole-catchment and transboundary perspectives | Mr. Sanjeeb Baral, Executive Director, Centre of Hydrology and Water Resources Research                                                               |
| 16:32 to 16:39 | Beyond the weather event: weather, climate and emerging mountain risks                                                            | Dr. Archana Shrestha, Director General, Department of Hydrology and Meteorology, Nepal                                                                |
| 16:39 to 16:46 | Managing water-induced disaster risk in a changing mountain environment                                                           | Prof. Dr. Vishnu Prasad Pandey, Institute of Engineering, Tribhuvan University                                                                        |
| 16:46 to 16:53 | From evidence to collective action: what do we need to invest in?                                                                 | Dr. Jagadishwor Karmacharya, Joint Secretary, Ministry of Energy, Water Resources and Irrigation, Nepal                                               |
| 16:53 to 17:00 | Institutional response and the case for stronger disaster risk governance                                                         | Mr. Anil Pokhrel, Former Chief Executive, National Disaster Risk Reduction and Management Authority                                                   |
| 17:00 to 17:20 | Question and answer, open reflection: what next                                                                                   | All                                                                                                                                                   |
| 17:20 to 17:30 | Closing remarks and immediate next steps                                                                                          | Mr. Marco Toscano-Rivalta, Chief, Regional Office for Asia and the Pacific, UNDRR, and Mr. Pradip Khatiwada, Executive Director, Youth Innovation Lab |

Source: Agenda circulated 7 September 2026 and the session recording.



***“This webinar shouldn’t be seen as a one-off conversation about one-off event, but a starting point for something deeper, and beginning of long term collaboration on research and knowledge on mountain hazards and climate change”.***

**Moderator. Madhab Uprety**, Senior Technical Adviser, Asia and the Pacific Lead, Red Cross Red Crescent Climate Centre



**FIGURE A.1** Speaker portraits



**Mr. Anil Pokhrel**

Former Chief Executive  
NDRRMA, Nepal



**Dr. Archana Shrestha**

Director General  
Department of Hydrology  
and Meteorology, Nepal



**Prof. Bethan Davies**

Professor of Glaciology  
Newcastle University, UK



**Prof. Cees Van Westen**

Professor of Multi-Hazard Risk Dynamics  
ITC, University of Twente, Netherlands



**Prof. Cui Peng**

Academician of Chinese Academy  
of Sciences, Institute of Geographic  
Science and Natural Resource Research,  
CAS



**Dr. Jagadishwor Karmacharya**

Joint Secretary  
Ministry of Energy,  
Water Resources, and Irrigation



**Dr. Mohan Bahadur Chand**

Assistant Professor  
Department of Environmental Science  
Kathmandu University, Nepal



**Mr. Sanjeeb Baral**

Executive Director  
Centre of Hydrology and  
Water Resources Research



**Prof. Walter Immerzeel**

Professor of Mountain Hydrology  
Utrecht University, Netherlands



**Prof. Dr. Vishnu Prasad Pandey**

Professor of Water Resources,  
Institute of Engineering,  
Tribhuvan University



**Prof. Dr. Xuanmei Fan**

Director, State Key Laboratory of  
Geohazard Prevention and Geo  
Environment Protection, Chengdu  
University of Technology, China



Closing Remarks

**Mr. Marco Toscano-Rivalta**

Chief, Regional Office for Asia and  
the Pacific, United Nations Office for  
Disaster Risk Reduction (UNDRR)



Closing Remarks

**Mr. Pradip Khatiwada**

Executive Director,  
Youth Innovation Lab



Moderator

**Mr. Madhab Uprety**

Senior Technical Adviser and  
Asia Pacific Regional Lead,  
Red Cross Red Crescent Climate Centre



## Speakers

### Madhab Uprety

*Senior Technical Adviser, Red Cross Red Crescent Climate Centre · Moderator*

Madhab Uprety moderated the convening and framed the three questions around which it was organised: what triggered the cascade, what role a warming climate played, and how disaster risk governance must evolve as mountain risk changes.

### Dr. Mohan Bahadur Chand

*Assistant Professor, Department of Environmental Science and Engineering, and researcher at the Himalayan Cryosphere, Climate and Disaster Research Center, Kathmandu University*

A Himalayan glaciologist with over thirteen years of field and research experience. His work focuses on glacier and snow dynamics, permafrost degradation, glacial lakes, glacial lake outburst floods and glacio-hydrological modelling in the Nepal Himalaya.

He holds a PhD in Environmental Science from Hokkaido University, Japan, where he also completed a postdoctoral fellowship, along with an MS by Research in Glaciology from Kathmandu University. He is a National Geographic Society Explorer and a recipient of Nepal's Bidhya Bhusan Padak, and has led fieldwork on high-altitude glaciers across the Hindu Kush Himalaya region.

### Prof. Xuanmei Fan

*Director, State Key Laboratory of Geohazard Prevention and Geoenvironment Protection, Chengdu University of Technology, China*

She received her PhD in Engineering Geology from the University of Twente and previously worked as a disaster risk reduction specialist for the United Nations Institute for Training and Research. Her research focuses on earthquake- and climate-change-induced geological hazards.

Her recent work has advanced understanding of climate-change-induced hazard chains including ice and rock avalanche to debris flow sequences and glacial lake outburst floods on the Tibetan Plateau. She has published more than 140 papers in journals including *Nature Geoscience* and *Reviews of Geophysics*, is ranked among the top 2 per cent of scientists worldwide by citation impact, and delivered a distinguished lecture at Tribhuvan University's Central Department of Geology in Kathmandu in December 2024.

### Academician Prof. Cui Peng

*Academician of the Chinese Academy of Sciences and researcher at the Institute of Mountain Hazards and Environment, where he heads the Key Laboratory of Mountain Hazards and Earth Surface Process*

Widely regarded as China's leading debris-flow scientist and ranked first globally in Scopus for debris-flow publications, his research established core theory on debris-flow initiation, movement and disaster-chain mechanisms, including the dynamics of landslide-dammed lakes.

He has led disaster risk reduction and mitigation efforts following major events across the region, including the institutional response after Nepal's 2015 earthquake sequence and the management of a large landslide-dammed lake crisis in Pakistan. He serves as Co-Director on the Chinese side of the China-Pakistan Joint Research Center on Earth Sciences and as Chief Editor of the *Journal of Mountain Science*.

### Dr. Chenxiao Tang

*Institute of Mountain Hazards and Environment, Chinese Academy of Sciences*

Presenting with Prof. Cui Peng, Dr. Tang set out the field investigation results, the drone photogrammetry and elevation modelling, the volume estimate derived from a modelled failure surface, and the regional hazard mapping programme, including the hazard atlas in preparation for the wider region.

### Prof. Cees van Westen

*Professor of Multi-Hazard Risk Dynamics, Faculty of Geo-Information Science and Earth Observation, University of Twente, the Netherlands*

A physical geographer specialising in remote sensing and geographic information systems for natural hazard and risk assessment, he has worked on landslide, volcanic and multi-hazard risk in mountain regions across Asia, Europe and the Americas, and directed the UNU-ITC Centre on Geoinformation for Disaster Risk Management from 2005 to 2015.

His current research focuses on how climate change, land-use change and population growth are reshaping multi-hazard risk in mountain settings.

**Ashok Dahal**

*Faculty of Geo-Information Science and Earth Observation, University of Twente*

Presenting with Prof. van Westen, Ashok Dahal set out the interferometric pre-event deformation analysis, the seismic moment tensor inversion of the collapse, the regional earthquake context, and the framing of the event as a wave of hazards rather than a single hazard. He has conducted extensive research on the 2015 earthquake and its associated events and worked in Rasuwa after that earthquake.

**Prof. Bethan Davies**

*Professor of Glaciology, Newcastle University, United Kingdom*

A glacial geologist specialising in the interaction between glaciers and climate across multiple timescales, combining field observations, remote sensing and numerical modelling to understand glacier change and its implications for mountain environments.

Her recent research includes work on glacier change in the Langtang catchment of the Nepal Himalaya, examining long-term and recent glacier change and its implications for regional hydrology and associated geohazards. She is the founder of AntarcticGlaciers.org, an established platform for glaciological research communication and public engagement. She is a contributor to the ongoing World Weather Attribution study of the August event.

**Prof. Walter Immerzeel**

*Professor of Mountain Hydrology, Utrecht University, the Netherlands*

A leading scientist working at the interface of mountain hydrology, climate change and glaciology, with a particular focus on the Himalaya. He has more than twenty years of experience in hydro-meteorological monitoring, remote sensing, modelling and spatial analysis, and has conducted research on Himalayan hydrology since 2002.

His research examines how changes in glaciers, snow, climate and mountain landscapes influence water resources and hydrological processes, including the emergence of hazards such as landslides, debris flows and floods. His group has maintained observations in the Langtang Valley since 2012. He is a contributor to the ongoing World Weather Attribution study of the August event.

**Mr. Sanjeeb Baral**

*Executive Director, Centre of Hydrology and Water Resources Research*

Formerly Director General of the Department of Water Resources and Irrigation, Province Secretary of Bagmati Province, Joint Secretary of the Government of Nepal and Deputy Director General in the Department of Water Resources and Irrigation, with more than twenty years of experience in the hydropower, irrigation and water resources sector.

He was Project Director of the Bheri Babai Diversion Multipurpose Project, a national pride project, of the Water Resources Project Preparatory Facility and of the Budhi Ganga Hydropower Project, and has worked in the Department of Electricity Development, the Nepal Electricity Authority and Butwal Power Company. He holds a Master's in Water Resources Engineering from the Institute of Engineering, Pulchowk Campus, and an executive MBA from Pokhara University. He was awarded the Suprabal Janasewa Shree by the Government of Nepal and the Youth Professional Award 2012 by the Nepal Engineers' Association, and completed a Hubert H. Humphrey Fellowship at Cornell University.

**Dr. Archana Shrestha**

*Director General, Department of Hydrology and Meteorology, Nepal, and Permanent Representative of Nepal to the World Meteorological Organization*

She leads the government agency responsible for national weather forecasting, meteorological observation and hydrological monitoring across the country, and oversees the department's work on climate research and adaptation frameworks.

This includes efforts to expand seasonal and sub-regional localised weather forecasting, to manage climate risk preparedness for phenomena such as El Niño, and to strengthen international collaborative data-sharing arrangements. As Permanent Representative to the World Meteorological Organization she represents Nepal's technical authority on weather- and water-related hazards internationally.

**Prof. Dr. Vishnu Prasad Pandey***Institute of Engineering, Tribhuvan University*

A water resources and hydrology researcher whose post-event study of the 2021 Melamchi flood produced the three-scale framework for managing water-induced disaster risk that he applied to this event at the convening: project scale, river reach scale and catchment or basin scale.

**Dr. Jagadishwor Karmacharya***Joint Secretary, Ministry of Energy, Water Resources and Irrigation, Nepal*

Previously Director General of the Department of Hydrology and Meteorology, the agency mandated to monitor hydrological and meteorological activity across the country, including river hydrology, snow and glacier hydrology, flood forecasting and climate data.

Over his career he has worked at the intersection of hydro-meteorological monitoring, water resources policy and national early warning services, bringing both technical and institutional experience of water- and weather-related hazards in Nepal.

**Mr. Anil Pokhrel***Former Chief Executive, National Disaster Risk Reduction and Management Authority, Nepal*

Mr. Pokhrel served for five years as the first Chief Executive of Nepal's National Disaster Risk Reduction and Management Authority, leading the Government of Nepal's efforts to coordinate disaster risk management and crisis response, including the institutional response to major floods, earthquakes and glacial lake outburst flood events. He led operations during the 2021 Melamchi flood, relevant to the 2026 Rasuwa floods.

Over a career spanning more than two decades he has worked extensively on disaster, climate and water issues with Nepali and international non-governmental organisations, the Asian Development Bank and the World Bank. He holds a master's degree from the Yale School of Forestry and Environment, where he was also a Fulbright Fellow.

**Mr. Marco Toscano-Rivalta***Chief, Regional Office for Asia and the Pacific, United Nations Office for Disaster Risk Reduction*

Mr. Roscao-Rivalta brings over twenty-five years of experience in international cooperation with the United Nations and other international organisations, at headquarters and in the field, across sustainable development, disaster risk management, humanitarian relief, and refugee, internally displaced person and human rights protection.

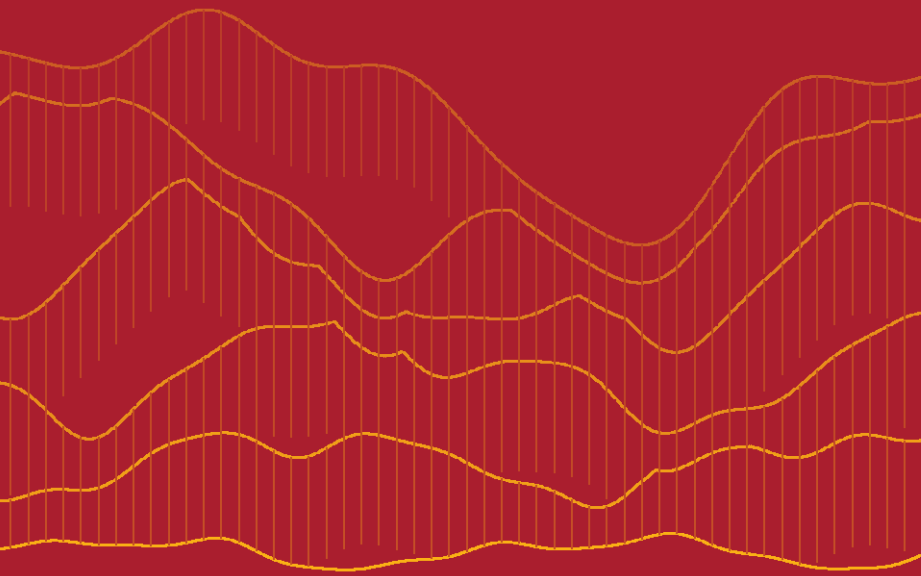
In his current role he leads the office's regional work on disaster risk reduction policy and coordination, Sendai Framework monitoring, risk knowledge and analysis, and stakeholder engagement across Asia and the Pacific, the world's most disaster-prone region, including efforts to strengthen early warning systems for all.

**Mr. Pradip Khatiwada***Executive Director, Youth Innovation Lab, Convener*

Mr. Pradip Khatiwada is Founder and Executive Director of Youth Innovation Lab, a Nepal-based non-profit working to bridge science, technology, and policy. He led the technical development of Nepal's national disaster information system (Bipad Portal) and coordinated the 5,000-volunteer National Volunteering Program following the 2015 earthquake, and currently chairs the U-INSPIRE Alliance, a global youth science-policy network.

Khatiwada convened the session and delivered the closing remarks, setting out the concept of a scientific autopsy of the event, the case for transboundary risk understanding, and the commitment to continue the convening as a standing series of scientific exchange.





## ANNEX B

# Edited Record of Proceedings

*Annex B*

This annex is an edited record. It follows the order of the session and preserves the substance and, wherever possible, the phrasing of each speaker. Repetition, technical interruptions and false starts have been removed. Automatic transcript labels have been corrected against the agenda; see Annex D. Nothing has been added.

## Madhab Uprety

### *Opening and context setting*

Good afternoon, good morning, and maybe good evening depending on wherever you are joining from. Welcome to this conversation in the wake of the extraordinary disaster we witnessed on 26 August 2026 near the Nepal and China border.

It is a difficult time for us all as the consequences of the 26 August event continue to unfold. The latest figures from the National Disaster Risk Reduction and Management Authority, as of 6 September, confirm that 1,342 bodies have been recovered and that 4,896 people remain unaccounted for. The preliminary damage assessment is equally sobering: thousands of houses affected, major roads damaged, bridges collapsed, and the major infrastructure relating to energy, hydropower and transmission systems destroyed. The preliminary assessment indicates that total loss and damage could be in the hundreds of billions of Nepali rupees.

Today is a mourning day here in Nepal to remember the victims of this disaster. On behalf of all of us convening this webinar, I extend our deepest condolences to the families who have lost loved ones, to those who remain without news of them, and to all the communities whose lives and livelihoods have been devastated.

The 26 August event was extraordinary not simply because of the scale and magnitude of its impact but because of the nature of the hazard itself. What began very high in the mountains evolved through a sequence of interacting processes involving ice, rock, debris and water, and ultimately produced devastating impacts downstream. It challenged the way we have been thinking about disaster risk. The significance of this event extends well beyond the immediate disaster footprint, because the Himalaya is a connected system. What happens in a high mountain catchment propagates downstream very quickly, across borders and through interconnected infrastructure and communities.

There are three urgent questions to confront. First, what triggered this extraordinary cascade of hazards, and what do

we still not know? Second, what was the role of the warming climate, and how clear are we about what we know, what we can infer, and what remains to be established? As Nepal takes the climate dimension of this disaster to international discussions, the scientific evidence needs to be visible, rigorous and transparent. Third, how must our disaster risk governance evolve as mountain risk changes, and what does that imply for the development model we have followed for decades, given where the devastation occurred along our major economic corridors?

## Dr. Mohan Bahadur Chand

### *Kathmandu University: the physical genesis of the event*

The event occurred in Langtang National Park, in the local administrative region of Rasuwa, on the northern side of the site of the avalanche that occurred in 2015 during the Gorkha earthquake, just south of Langtang Lirung peak at about 7,200 metres. The release area was on the northern part of that mountain.

Ice and rock collapsed from almost 5,200 metres down to 3,800 metres at the lower part of the glacier, which is a debris-covered glacier. That is a vertical drop of around 1,400 metres. With the impact of that drop there was substantial scouring from the lower debris-covered parts, with significant ice content as well as debris. That material then dropped directly to the river, which is located at about 2,900 metres. A new depression was created by the force and a new pond formed at that location.

I mapped the glacier boundary using imagery from immediately before the event. The glacier area that collapsed is almost 0.68 square kilometres. Assuming about 50 metres of depth for the breakup, that gives 34 million cubic metres of ice. The rock fall area is of significant size, although we do not know the depth of the rock collapse; in total about 23 million cubic metres of rock also collapsed. Scoured debris material over a total area of three square kilometres, with a surface cover of about two metres, may contribute up to 6 million cubic metres. Of the debris-covered glacier, about 0.43 square kilometres eroded by about 20 metres gives about 10 million cubic metres. In total, 44 million cubic metres of ice including the debris-covered parts and 29 million cubic metres of rock, so about 74 million cubic metres of ice and rock released from the source area.

It entered the river with very high velocity and very high kinetic energy. Because of friction during the high-velocity

movement, the ice mass is assumed to have liquefied, and it became a slurry material that can move very fast compared with a normal or pure landslide.

How it collapsed is a very important question, and right now we have only hypotheses. The glacier moves by its nature, and we can see many cracks on the surface of the glacier due to that movement over a very steep slope. With no support from below and movement from the opposite side, it may have collapsed, and that in turn would help to collapse the surrounding masses. A second hypothesis is meltwater availability within those crevasses, acting as a lubricant between the ice and rock interfaces. A third is that exposed rock not covered by ice may have undergone long-term weathering, and that recent increases in temperature and continuous freeze and thaw activity on cracks, fissures and joints may also have triggered the collapse of the rock and its surroundings, which then took the whole ice mass with it. There may be others. What actually happened, we need to explore more.

It was initially assumed that there was a dam immediately after the release. But the flood reached Rasuwagadhi, about 22 kilometres from the source area, in seven minutes. That means the velocity was more than 180 kilometres per hour. We cannot imagine that there was damming before the release of water. There was a huge landslide after the flood which blocked the river, and a barrier lake formed. That was a consequence, occurring perhaps a few hours after the flood. That lake was later released naturally, so there was not a second huge flood.

On flood volume, considering water only, at Rasuwagadhi we estimate about 23,000 cubic metres per second, and further downstream about 20,000. The speed is almost 60 metres per second, which is more or less similar to the speed calculated from seven minutes over 22 kilometres. In most cases the depth of flood is 50 metres, and in some narrow gorges more than that, although this needs to be validated and verified.

It remains difficult to know how the water volume formed during the process. Ice was released, and a significant amount of water is visible. There might be water under the ice, and there could be some englacial ponds in the upper release area, although the chance at that slope is low.

#### **Prof. Xuanmei Fan**

*Chengdu University of Technology: cascading hazard chains and precursors*

Due to global warming, the Himalaya region is suffering three or four major types of cascading hazard: glacier collapse, ice and rock avalanche, glacial lake outburst flood, and glacier debris flow.

We recorded the source area by helicopter. The mass came down from about 5,200 metres, fell into the gully and formed a small pond. There was then a landslide, which occurred about three hours after the main event, probably due to strong erosion at the foot of that slope. Downstream you can see strong erosion of the previous moraine deposits in the valley.

We obtained a pre-event high-resolution digital elevation model and a post-event model, so we calculated the source volume: about 130 million cubic metres. That is higher than the previous speaker's figure. We have not rigorously estimated the proportion of glacier and bedrock, but based on the elevation model difference the glacier proportion is probably less than 20 per cent of the total volume, with the remainder, around 80 to 90 per cent, probably bedrock.

The secondary landslide generated ground shaking equivalent to about a magnitude 4.2 earthquake, recorded by both the United States Geological Survey and the Chinese seismic network. We sent a team to the field shortly after the event. Four days after the event there were further debris flows from the source area, either from water coming out of the first pond or from glacier melting, and quite a lot of secondary failures.

We did a preliminary interferometric analysis and found signals before the event. From the middle of June the displacement in the source area at point P1 was entering an accelerated stage, and a second measurement point also showed acceleration about two months before the event. We need more analysis, but so far it seems there are precursors.

The seismic signal analysis places the event, in Chinese time, at about 10:52. The high-frequency signal of the ice and rock arrives and continues for less than one minute. It then travelled down and converted, probably into a rock and debris flow, a more granular flow at that stage, lasting about two minutes. It then converted into a debris flow and travelled to the Jirong port between Nepal and China, after which it converted into a more flooding-type flow downstream.

Another interesting point comes from social media. Some tourists filmed a strong dust cloud, probably generated by a rock fall or rock failure, about half an hour before the event occurred. We are trying to find the corresponding signals

from several seismic stations. This gives us an idea that this event really did have precursors and that we can probably find something from the seismic signal.

Using the calculated source volume we ran a rapid numerical simulation, and the modelled speed and arrival time at downstream locations compared well with our seismic interpretation. This is preliminary; we want to link the numerical simulation with the seismic record more rigorously. Last year there was a glacial lake outburst flood here which destroyed a bridge at the border, and the recent event occurred in roughly the same catchment, causing transboundary hazard again. Last year it was a supraglacial lake. We have also done climatic analysis: in this region the temperature rise is four times higher than the average for the Tibetan Plateau and the Himalaya region. My estimation is that the cause of this event must be linked with the very fast warming in this region, combined with the post-seismic effect of the 2015 Gorkha earthquake, although we need more data to support that.

This type of failure is becoming more frequent in the Himalaya region. In one of our study catchments on the Tibetan Plateau, ice and rock avalanches often fall from a section of slope and convert into debris flow. We have monitored that catchment for more than three years. It became very active after a large earthquake, and almost every year there are a few events. There is a huge amount of loose sediment there: thickness more than 360 metres, about 65 million cubic metres of deposition and roughly 800 million cubic metres of source material in the catchment. We are using the seismic signal for early warning there. For one event in 2023 the seismic signal shows pre-failure rock falls generating heavy dust, then shortly afterwards a debris flow with a high-frequency signal, and after the main event two further rock fall or avalanche signals. We have successfully issued early warnings for events in that catchment.

Coming back to the recent Nepal event, we think using the seismic network for early warning is probably the best way in such a remote region, where other types of monitoring sensor are really hard to install at the source area. Last year we published a paper in *Nature Geoscience* on transboundary cascading hazards and what we learned from past events. How we respond quickly to this kind of cascading hazard is the next step. This year we launched a scientific programme supported by UNESCO focused on mountain cascading hazards, and we hope more people can join and collaborate, especially under transboundary conditions.

### Academician Prof. Cui Peng

*Chinese Academy of Sciences: emergency analysis and joint mechanisms*

Our team has been working in the field survey and helping with emergency treatment, and part of the team has been working with the ministry responsible for emergency treatment in Beijing. Every day they analyse the processes and the data, reach judgements, make calculations and give suggestions on how to carry out the emergency response. That is why we did not have time to prepare a presentation. We reconstructed the spatial and temporal evolution of the disaster using pre-event and post-event satellite imagery, the seismic record, video footage and post-event survey data. We also carried out in-depth analysis of the conditions and initiation mechanism, the cascading transformation mechanism, the exceptional mobility mechanism and the extremely destructive mechanism.

Having understood the physical processes of the ice and rock avalanche and debris flow disaster, we have made suggestions to government for the future. As we analyse the phenomena and understand the risk, we have to take action on how to treat this kind of disaster, especially transboundary disaster.

First, we should immediately set up a joint team to carry out investigation in this area so that we can work out a list of the potential disaster sites. That is very important for reconstruction. We have to make the risk assessment and work out a resource system map for post-disaster construction.

Second, we have to set up a joint observation and early warning system. From this disaster we can see that in the source area, on the Nepal side, we did not have any data. That is why, when the disaster occurred, nobody knew it had occurred, and in a very short time it destroyed all of the buildings and facilities along the river valley. Whether China or Nepal, we should work together to set up the early warning system and share the data.

Third, we need a joint risk management mechanism so that we can share information, share problems and take joint action in response to an emergency, and work out a plan for preparation for this kind of disaster. In that case both China and Nepal can take action to prepare for the next disaster and work out a good post-disaster reduction plan.

### Dr. Chenxiao Tang

*Chinese Academy of Sciences: field investigation and volume estimation*

This event destroyed not only the Jirong port but also a



hydropower station and its reservoir downstream, causing the devastating flood in Nepal. During the investigation we used drones for photogrammetry to obtain elevation models, and colleagues were in the field surveying boulder size and the condition of the channels.

Our summary of the event is as follows. First, a collapse of majorly, we say, rock. It brings down a piece of the glacier, and it drops on another glacier. In the second phase it caused an avalanche, because there is a lot of glacier moraine in this catchment. When the avalanche initiated it caused a blast wind affecting the vegetation along the slopes. The widest part of that blast wind was 1.3 kilometres. We also measured the width of the channel where the material transported: on the upper reach it is about 470 metres wide. After the river makes a bend the avalanche stops, and during the movement the ice melted and created debris flow, which reached the outlet of the catchment, destroyed the hydropower station and caused the flood.

Before the post-event elevation model was available we estimated the volume using a small application we developed, which uses a polynomial surface to model the failure surface. The modelled elevation difference against the pre-event model gives a volume of 110 million cubic metres, which fits reasonably with what Professor Fan presented. The volume of glacier was estimated at 20 million cubic metres. It is majorly a rock mass. The drop height was more than one kilometre. From the seismic data, from event initiation to when the run-out reaches the outlet of this catchment it takes a bit more than seven, nearly eight minutes, travelling about 21 kilometres, so the average velocity was about 40 to 48 metres per second.

From videos on the internet, the avalanche reached the port first, and after about eight seconds we can see the debris flow front. So this event is not a simple debris flow when it reaches the outlet. It is avalanche first, then debris flow later.

We did background surveying using hazard points from the Tibetan expedition project. Most of these valleys in the Himalaya are high or medium-high hazard. When we zoom to the event area, the epicentre of the magnitude 8 earthquake is located just next to this event. Although there is about ten kilometres of accuracy on that point, it signals that the rock mass of this area is heavily affected by earthquake movement. We also consider that freeze and thaw affect fissure development in the rock mass. If you look at a three-dimensional image you can see the free surfaces of the

pre-event rock mass, and if you look at other ice and rock avalanche events you find these free surfaces too. We consider they have high hazard potential. What we think for later is to map rock masses with hazard potential across the Himalayas, estimate their volume using the slip surface model, and do run-out modelling for every one of them. Colleagues at ITC have a fast tool that can simulate multiple scenarios for a very large area in a few minutes.

We are also preparing a hazard atlas, to be published by the end of the year, with an English version in 2027. It covers the entire region including parts of Tajikistan, Afghanistan, Nepal, India, Bhutan and Myanmar, mapping flooding, landslide, earthquake, freeze and thaw hazards, landslide dams and glacial lake outbursts, with analysis of the most dangerous areas. One page has been made specially for this event.

#### **Prof. Cees van Westen**

*University of Twente: the multi-hazard frame*

This is a very important event, and a sad one, showing how cascading events devastate so many aspects of vulnerable society. I am presenting together with my colleague Ashok Dahal, who is from Nepal and has done a lot of research on the 2015 earthquake and associated events. We were both in Rasuwa after that earthquake, looking at the devastation and at how severely the hydropower projects there were affected. It has happened again in that area.

The question now is whether this is becoming more frequent and whether it is changing in intensity. Looking over the past decades, a literature study shows a whole number of different events in the Himalayan region with a range of trigger mechanisms, but which all result in massive flooding and debris flows downstream. Himalayan valleys are really at risk, because although the triggers might differ, being earthquake related, or large rock or ice avalanches, or retreating glaciers with their associated hazards, the effect these cascades have on the downstream valleys is very comparable. The differences are the expected lead time for early warning, the impact heights, and how long they affect major infrastructure.

The key lesson is that within the Himalayan setting you have to deal with such events in the design of infrastructure. You cannot avoid that anymore. The questions are how frequent such events are, whether they are becoming more frequent, and whether they are related to each other in time. Does the event that has just happened have a legacy effect of the 2015

earthquake? That is important to investigate further.

We tend to focus a lot on supraglacial lakes, which are expanding, but there are many other mechanisms. As we have seen with Chamoli and other recent events, massive rock and ice avalanches can also cause these events. We need to look at how hazards transform from one to the other, at how temporary storage in the cascade plays a role, at intermediate blockages, which also played a role here, and at sediment entrainment, so that the volumes at the end are much bigger than the initial release volumes. And at the effects on the infrastructure downstream, and how that should be redesigned to take into account that these events may reoccur for many different reasons. Next to early warning systems, redesign of these infrastructures should be very much the emphasis. Transboundary cascades and collaboration across borders is extremely important, as the two previous speakers from China have said.

### Ashok Dahal

*University of Twente: a wave of hazards*

This is research in progress, from within ten days of the disaster. We are talking about this event as one single event, a glacier collapse or a flood or a debris flow, but it is a combination of hazards. It is a wave of hazards, occurring at the same time or at different times, over a big spatial extent, from the top of the glacier to the end of the river catchment. Before this event happened we saw a lot of deformation, which is rock fracture. From the satellite time series, from July to November 2025, in four months there was around 15 centimetres of deformation on the bedrock face. It shows there was a significant amount of rock fracturing going on within the bedrock itself. That fracture did not destabilise the glacier at that moment, and it was frozen in the winter season. This year, after the ice melt in the summer, water seepage went through the rock fractures causing this big event. That is our hypothesis. If we had been monitoring it actively, we could at least have seen that this could be a potential danger in the coming future.

Nepal is a highly seismically active area. Within a 300 kilometre radius of the glacier collapse there were more than 280 earthquakes of magnitude 4 and greater since the 2015 Gorkha earthquake, with significant ground velocity. If we put a threshold of at least one centimetre per second, it happens almost once every year for that location. So this glacier and the rock mass it was sitting on was getting a lot

of seismic perturbation over the past ten years. We cannot conclusively say this is a legacy effect of 2015, but I would assume there has been some effect.

Before the event there was also a substantial surface air temperature anomaly, around three degrees in the upper Himalayan region compared with the Ganges basin. That is mostly underestimated because we do not have good instrumentation in the high Himalaya.

When the rock and glacier collapsed together, an inversion I ran with the seismic stations shows around 720 million kilograms of mass loss, creating an earthquake equivalent to magnitude 5.2. The force in the east, north and up directions was on the order of ten to the power nine, a massive amount of force equivalent to about a thousand kilograms of explosive. Using nearby stations and teleseismic stations up to 2,000 kilometres away, we could see this glacier collapse causing a seismic event recorded up to 2,000 kilometres away. That is one of the cascading hazards. Fortunately there were not many houses within a few kilometres of it.

The flood was the cascade that caused the major damage, and it has been covered much more than the other hazards. Then there are the landslides, because the river channel now runs against big mountains that were stable before, and the flow has changed the geomorphology of those mountain structures. There is one large one and many downstream. It also created glacial lakes, and fortunately these did not burst and create a second wave of flooding. There have been many cases where a landslide-blocked river has caused massive damage, such as the 2008 event, where the flood itself was quite massive.

With such a massive flow there comes erosion. There has been some already but it will continue to happen, because after the monsoon season next year all of this mass will be swept away, causing bigger erosion and blocking the river channels downstream.

So this is a wave of cascades. The effects are not only on hazard; it also poses threats of other kinds, such as socioeconomic problems, deaths, epidemiological problems, and many people losing their home and land, as well as trade problems. We should look at these hazards as a wave of different effects. I am showing an example of an impact chain from Austria; we should create something similar for this event.

There is also a category which is not part of cascading hazards but which is called conditional hazard. My own research shows that after the 2015 Gorkha earthquake there were

many landslides, but after the rainfall season the hazard was almost similar to the co-seismic one. The rain after the 2015 earthquake created almost as many landslides as the earthquake itself. I am quite sure this will be the case for this event too, because the flood has created many unstable slopes.

### **Prof. Bethan Davies**

*Newcastle University: the changing cryosphere in the Langtang catchment*

I want to talk about how the cryosphere, all the frozen ice and snow and permafrost and glacier ice, has changed in the Langtang area, and then reflect on what that might mean for these hazards.

In the broader context, global glacier change from 2000 to 2023 shows that region 15, South Asia East, which is our study area, has lost 21 per cent of the glacier mass it had in the year 2000. As a region the whole area is deglaciating very rapidly, and mass losses have been increasing over the last twenty years. This is related to high temperatures. Temperatures in Nepal have been increasing over the last twenty years.

Zooming in to the Langtang catchment, we have just published a study on this area on the other side of the mountain. Mapping glacier area across time periods from the Little Ice Age, about 1815, up to 2023, the glaciers have consistently shrunk, and the rate of shrinkage is much faster over the last twenty years than in the twentieth century. The rate of recession is accelerating. As the glaciers shrink they are becoming more fragmented, the termini are separating and exposing more bedrock in between and around the glaciers, and the glaciers are thinning, with the zone of thinning migrating up-glacier.

If you think of mass balance as a bank account, where more incoming than outgoing means a positive balance, then in the Langtang catchment the mass balance of these glaciers was positive or around zero until about 1990, and after 1990 we have significant losses and increasingly negative mass balance. Alongside this there has been a real increase in air temperature at that key elevation above 4,000 metres, of about 0.3 degrees per decade.

Looking closely at Langtang Lirung, prior to the collapse the glacier covered about seven square kilometres, with two main tongues descending from the accumulation area either side of a bedrock spur. There is a big scarp which carries on

underneath the glacier, and lots of crevasses as the glacier goes over that steep slope. The failure occurred at about 5,100 metres. The mass of ice and rock collapsed down to the valley floor, along with 0.27 square kilometres of glacier ice. The failure occurred under the flatter area of the glacier.

I was interested in what the glacier had been doing over the last few decades, because that can be important in terms of destabilising the slopes. These are provisional results. Overall the glacier is shrinking at under 1 per cent per annum between 1815 and 2010, so quite a slow rate, with really significant acceleration after 2010, and really rapid shrinkage of that glacier over the last ten years.

Looking in particular at the northern or glacier-right tongue, although the terminus has retreated up-slope by about 550 to 560 metres from 1964 to 2026, the majority of that occurred since 2010. Over the last fifteen years it has retreated 373 metres and risen by over 200 metres. That means this steep slope has lost a lot of ice at the foot of the slope, and that can contribute to debuttering. You have an oversteepened slope that was previously glaciated, and then you have removed that ice, and that can contribute to an unstable steep slope.

The whole area is thinning. From 2015 to 2019 the buried ice in the valley floor shows significant thinning, and the glacier as a whole is thinning with particular thinning on that tongue, which likely contributed to the debuttering.

The area is also an area of permafrost, perennially frozen ground where temperatures are below zero. On a global scale we are seeing degradation of permafrost. Active layer thickness has increased at more than 90 per cent of sites in High Mountain Asia, and critically the biggest changes have been in mountain permafrost in bedrock, particularly with low ice content, such as the site we are looking at here.

There are not many direct observations of permafrost in Nepal, but a study of a catchment a little further west shows that the amount of stable, permanently frozen and continuous permafrost has shrunk from the 1960s and 1970s to the 2010 to 2018 period, with a growing area of discontinuous permafrost with more freeze and thaw activity. There is progressive degradation particularly below 5,500 metres, and the biggest changes are in the elevation band 4,500 to 5,500 metres, exactly the zone in which this catastrophic landslide occurred. We are probably quite close to the lower limit of permafrost, but certainly within a zone that is changing rapidly.

Because permafrost is closely related to air temperatures, and

because air temperatures are rising very rapidly, we have a warming climate significantly reducing glacier coverage and removing permafrost. The Langtang glacier has been shrinking for decades, exposing steep surfaces and removing glacier buttressing. Permafrost degradation is occurring specifically at this altitude. So I would say that this failure was strongly conditioned by the geological conditions at the site. The bedrock is fractured and likely damaged by previous earthquakes. But within those fractures we have joints with ice and melt in them, and as permafrost degrades that ice within the fractures can melt or periodically freeze and unfreeze, which can make it less stable and less strong.

What we are seeing is climate change acting upon this geological baseline, modulated through changes in the cryosphere, specifically glacier ice, snow and permafrost. That means it has made the environment in which this failure occurred more prone to failure, it has made the failure more likely, and it means the failure was potentially very significant because of the ice and the water within the environment.

### **Prof. Walter Immerzeel**

*Utrecht University: the role of climate change*

I am very impressed by all the other presentations, and it is incredible what science has produced in such a short period. We have been doing observations in the Langtang Valley since 2012, so I am closely related to this region, and my heart goes out to all the people in Nepal.

Understanding the role of climate change is a very complex question. First we need to understand what the trigger was, what processes are involved in the triggering mechanism, and on what timescale. Then, how warming and precipitation changes influence those processes, and what we actually know about temperature and precipitation changes in the region. Everything I present today is preliminary analysis.

There is consensus now that the rock wall failed and there was a glacier on top. As Bethan already said, the geology definitely played an important role. A very high resolution two metre elevation model of the rock outcrop between the two glacier tongues shows that the failure followed an existing structural depression in the bedrock. So it is quite likely that geological conditions played an important role.

What causes the collapse of such a rock wall relates to the force on it and to its resistance. Once the force exceeds the resistance, the wall can fail. Force can be induced by gravity, by hydrostatic pressure due to water in crevasses, and by

cryostatic pressure due to the force of ice and the freeze and thaw cycles it undergoes. So if you want to make the link with climate change, we have to show how climate change is influencing both these forces and these resistances.

I looked at three timescales. First, the weather in the weeks before the disaster, using observations from the Langtang Valley collected by our group and through a long-term collaboration with ICIMOD. Second, a twenty-year timescale, using a Weather Research and Forecasting simulation from 2005 to 2025 at four kilometre resolution; these data had just been finished, which was a coincidence. Third, the longer term, using ERA5-Land reanalysis.

Starting with the long term, the temperature pattern since 1980 at the pixel where the failure occurred, noting that one pixel is about nine by nine kilometres so it is really coarse, shows annual warming of about 0.17 degrees Celsius per decade. That is strong warming. Seasonally there has been quite strong warming in the last decade, and the monsoon has warmed quite a bit in recent years. Long-term precipitation shows a modest increase over the last 45 years.

At four kilometre resolution, interpolated to the altitude where the failure occurred, the seasonal temperature anomalies show that in the monsoon we see a very gradual, consistent warming, while in other months some are hot and some are cold. Looking purely at monsoonal temperature trends, defining the monsoon between 15 June and 15 September, we see very strong warming, much stronger than the annual average: about 0.46 degrees per decade, and a highly significant trend.

Using our observations in the Langtang Valley we computed the temperature lapse rate and tried to see where the zero degree isotherm was and how it has moved upwards. In 2006 it was around 5,200 metres and it has now gone up to over 5,350 metres. That is exactly the area right above where the failure occurred. That is an important clue, because the zero degree isotherm is a good indicator of the freeze and thaw processes occurring there. I also computed the potential for melt using the degree day method, adding up all the positive degree days during a year, and the melt potential over this twenty-year period has increased quite a bit.

Precipitation based on the model results shows no very strong trend, more or less constant with a slight increase, but not a significant trend. The same is true for the monsoon. But when we look at the partitioning of this precipitation, some very interesting patterns emerge. There is a shift from snowfall to



rainfall. Snowfall is decreasing over the last twenty years and rainfall is increasing. This gives us much more liquid water in the system, which can play an important role.

Then the weather. Monthly precipitation from February 2024 until December 2025, with the different phases separated into rainfall, wet snow and dry snow, shows something very interesting: last October and November we had a very anomalous post-monsoon season, with a huge amount of snowfall. More than 300 millimetres was recorded in a few events. That was also at the time when we were in the field, and I had never seen anything like it. This could be an important clue, because that snow would only start to melt again after spring this year. So there was a huge amount of snow available for melt during the late spring and the early monsoon. There was a lot of liquid water available.

Looking at temperature right before the event, lapsed to the elevation of the failure, from 12 to 26 August, in the three days before the event it was actually quite warm, with maximum temperatures at this elevation above ten degrees. The diurnal temperature range, the difference between maximum and minimum on a day, was also much larger in the few days before the event. Normally the maximum is about six degrees; in the few days before the event it was about twelve.

So what can we conclude? There has been strong annual warming and an increase in precipitation over the last fifty years. The monsoon has warmed at a very fast pace and the zero degree isotherm has risen. The annual melt potential has increased significantly. Precipitation between 2006 and 2024 shows only a slight increase, but there has been a strong phase shift from snowfall to rainfall. The extreme snowfall in the post-monsoon of 2025, in combination with the warm monsoon of 2026, likely generated a very large amount of meltwater. And the three days before the disaster were characterised by high maximum temperatures and large diurnal temperature ranges.

The potential processes influenced by climate change are permafrost degradation, thawing of ice-filled fractures, melting in the joints and cracks that removes cohesion and allows fractures to open and slip more easily, glacier thinning and loss of buttressing, increased meltwater infiltration, and the shift from snowfall to rainfall increasing the amount of liquid water in the system. These can all contribute to this terrible disaster. The exact statistical attribution of this particular event to climate change is going to be a huge

challenge, but in my opinion it is likely that climate change has played a role in this.

### Mr. Sanjeeb Baral

*Centre of Hydrology and Water Resources Research: assessing risk differently*

We need to manage water-induced disaster risks differently. The first thing is that we need to understand the risks differently and in a better way. We need to understand our situation, our topography, our geological system, our hydrology and our rainfall pattern very closely, and for that we need to do more research and study.

Second, our system is unique, and understanding among the different stakeholders needs to be on the same horizon. What a planner is planning, what a policy maker is formulating and implementing, and what local communities and people understand should be on the same platform. We have been talking about water-induced disaster mainly in terms of flood only, but if you see this disaster, it is linked with a multi-hazard system, and we are measuring for water only. We need to see the sediment aspects, the disaster management aspects and landslide together. For this the government has recently established the Centre of Hydrology and Water Resources Research, so that we can look at the hydrological and water resources aspects together.

Third, we need to implement a new approach of research-based planning, design and regulation. For example, we need to prepare hazard maps in the river corridors and risk maps, analyse the risks, and implement infrastructure in a planned way.

Fourth, we need to review our existing hydrological measuring stations. If you look at this and past disaster events, during extreme flood events all the gauging stations were washed away. This time also six of our stations were washed away. We need to develop robust gauging stations. From single-stage automated water level sensors we need to move towards two-stage water level monitoring sensors, so that during extreme flood times the secondary monitoring sensor works and gives data continuously. Traditional systems need to be modernised into robust and adaptive systems.

Fifth, we need to change our existing practice of flood monitoring, forecasting and warning. We basically develop our system based on water level rise during flood time, but once the gauging station is washed away our system does not work. We need to integrate our existing system with

systems based on seismic signals and on land settlement and movement sensors linked together. As a previous speaker highlighted, this is important, and we are also at high risk from different glacier lakes, so we need to implement robust monitoring systems and develop forecasting and warning based on them.

At the same time we need to focus on collaboration and cooperation. We need transboundary cooperation, and to establish a mechanism with the Chinese government upstream. We need to see the basin at a holistic level and plan it in an integrated manner. And finally we need to focus on preparedness, communication systems and coordination between different stakeholders.

### Dr. Archana Shrestha

*Department of Hydrology and Meteorology: weather, climate and emerging mountain risks*

This catastrophic event of 26 August is very much a reality that we see today. It is one of the examples, from the climatic and meteorological perspective, of how Nepal, its communities, its natural resources and its development path are at risk due to global warming induced climate change.

If we look into the past ten years of extreme events: in 2019 Nepal recorded its first ever tornado in its historical records. We never had a tornado recorded before 2019. In 2021 we had a flash flood in Manang, which is a rain-shadow region of Nepal. The same year we had the Melamchi landslide dam, a high mountain cascading disaster, in June. In the same year, during the post-monsoon season, we had a three-day very heavy rainfall event, especially in western Nepal, which devastated the annual paddy production of the country. In August 2023 we had a flash flood in Mustang, which is also a rain-shadow area, where we never had this kind of flash flood event. In the cryosphere and high mountain region we had a smaller glacier-break outburst flood in 2024, and in May 2025 a small glacial lake outburst flood at Tila in Humla. And this year, in August 2026, we have this Himalayan tsunami. These are very stark climatic events that are very unusual, and we think it is due to climate change.

On how temperature is changing: the high Himalayan region and high mountain region in all seasons have a higher temperature trend per year compared with Nepal as a whole and with the lower mountains. We see the same in minimum temperature. It is elevation-dependent temperature increase, and we can clearly see how it is accelerating.

This is the spatial variability of the observed temperature trend from 1971 to 2024, which we are about to publish. We can clearly see in the Langtang region a higher temperature increase rate, even relative to the temperature trend for the whole Himalayan region. From the spatial variability perspective this region has a higher rate, almost up to 0.1, and in minimum temperature we see a similar higher increasing rate.

This is the temperature and precipitation since 20 August 2026 at Kyanjing station at 3,850 metres above sea level in Rasuwa district, which is the closest station to the avalanche site. The avalanche site is on the northern slope and this is on the southern slope. We can see continuous precipitation from 20 August until the morning of 25 or even 26 August. We can also see the temperature, which is above zero degrees throughout. This station has only two years of data, so we compared 2025 in red with 2026 in blue. We can clearly see that this year we have a higher temperature in August than last year. And this year is a very strong El Niño year.

Looking at station-wise temperature increase, it is even higher than the overall Langtang region. At Kala Pokhari and Pyramid, which is about 5,600 metres, we see 0.106 to 0.11. At the station closest to this region we had 0.1 to 0.2 in winter and 0.132 annually, and in the monsoon also. So we can clearly see the high temperature increase.

As a way forward, we really need a Himalayan climate monitoring and analysis system for quality data, which will be useful for a multi-hazard early warning system, and we need to invest in that. For climate-resilient infrastructure and climate-resilient development we need to implement the National Framework for Climate Services, which the World Meteorological Organization has recommended, mainly in five sectors the department is planning for: energy, water resources, agriculture, disaster mitigation and health. For this we need co-production of the products with thematic stakeholders from central government to local government, and the framework should cover real-time data sharing, short-term forecasts, seasonal prediction and climate projection. And for the coming very strong El Niño, we need to monitor these kinds of glacial or cascading events which are at risk.

### Prof. Dr. Vishnu Prasad Pandey

*Tribhuvan University: three scales of risk management*

Water-induced disaster risk in changing mountain river systems is triggered by both natural and anthropogenic

stressors, as highlighted by earlier presentations. Complete mitigation of water-induced disaster risk of this scale, and of this flood scale, is in my understanding not possible. Sometimes experts and the public raise the concern that if we had an early warning system, if we had adequate monitoring stations, the risk could have been minimised. Yes, it could have been minimised, but not mitigated completely.

Water-induced disaster risk in a changing mountain river environment needs to be looked at on three scales, which is our learning from the post-event study of the Melamchi flood in 2021 as well. One is the project scale, second the river reach scale, and third the catchment or basin scale.

At the project scale, although all hydro-related projects are related to rivers, moving them away or to a higher elevation from the river is not logical. However, making the project resilient by selecting low-risk locations, designing so that they can withstand high multi-hazard risk, installing early warning with adequate lead time so that project components such as tunnels can be made safe by closing gates, and risk transfer mechanisms like insurance, are some of the ways of minimising risk at the project scale. Some of them are already pursued in different contexts, but systematising them and making them mandatory may help.

Second, the river reach scale. This is the scale where settlements and livelihoods are more relevant. Both go hand in hand. Risk zonation, defining safe operating areas or zones for different types of activity, and strictly enforcing them could be the way to minimise risk at this scale. We have heard from the news that the government is moving forward in relocating high-risk settlements to newer, safer areas. If that is the case, it needs to be done very carefully, because it has many socio-political dimensions. If it is possible, that will be really welcome.

At the catchment or basin scale, dynamics are reflected ultimately at the river reach or project scale. Managing the entire catchment to minimise risk is not economically feasible. However, monitoring and managing extremely vulnerable areas could be feasible. Monitoring of hydro-meteorological phenomena at different scales helps to understand monsoon-induced disaster, but is not adequate to understand events like the Rasuwa flood. Monitoring of land movement using interferometric radar, as Professor Fan mentioned, and seismic signals could be helpful in this endeavour if integrated properly with data sharing and early warning. It means multidisciplinary collaborative efforts

for the entire Himalayan region, in partnership with the countries in the basin as well as beyond.

Looking into the broader landscape beyond this flood and this basin, events like the Rasuwa flood of 2026 cannot be understood with 100 per cent clarity, given the remoteness and the context of inadequate monitoring and investment. But they are likely to be repeated in the future in the same river system, in other river systems in Nepal, and beyond in South Asia in systems fed by Himalayan rivers. We need to make up our minds accordingly and get ready to face those in future too.

Climate change could be a trigger for glacier melting, permafrost thawing and associated risks. However, events like the Rasuwa flood are unique. As indicated by Professor Fan in her presentation, far less than 20 per cent of the total contribution to the debris flow is by ice or glacier, and largely those debris are from bedrock collapse and failure, which has no link to climate change. Bedrock failure, I think, might be very hard to link to climate change. However, it is the right time to raise our voice to the international community for climate justice by gathering the evidence of climate attribution available so far, even if not with this event, maybe with others. It is the right time to mobilise all tracks of diplomacy to realise our quest for multidisciplinary collaboration in the higher Himalayan region, by monitoring land deformation, seismic activity and other things as well. This will help us to work together through investment in data, risk assessment and transboundary cooperation. This incident should be viewed as a wake-up call for triggering large-scale collaboration in the region for disaster risk management at the river basin scale, the river reach scale and the project scale.

#### **Dr. Jagadishwor Karmacharya**

*Ministry of Energy, Water Resources and Irrigation: what to invest in*

Nepal is a country prone to multiple geophysical hazards. Firstly, our government should give priority to sectors connected with environmental and geophysical risk reduction. This prioritisation should be reflected in the government's plan, programme, budget and other resource allocations.

Secondly, a functional mechanism should be developed so that all relevant government agencies can interact regularly to strengthen data and knowledge sharing. For example,

to strengthen close collaboration in the United Kingdom, the flood forecasting unit is housed inside the Met Office building. While I was at the Department of Hydrology and Meteorology, I was not even able to convene a meeting with the Department of Mines and Geology to discuss the possibility of developing a landslide warning system.

Thirdly, collaboration between operational government entities and academic institutions should be further strengthened to carry out targeted research on geophysical monitoring and forecasting. Similarly, Nepali diaspora researchers and scientists working in various leading institutions can be called upon to contribute to our efforts to better monitor, understand and forecast Himalayan geophysical conditions. We are very pleased to see one of our Nepali colleagues working under a renowned professor in today's programme as well, and many of our colleagues and students are doing their PhDs or postdoctoral work in renowned institutes in China and elsewhere.

Furthermore, our agencies can request global organisations such as the World Meteorological Organization to provide support and strengthen these systems. Thanks to the modernisation of our hydro-meteorological system over the last decade, through projects including the Pilot Program for Climate Resilience and related programmes, we have made some progress in our hydro-meteorological service. But as I have been saying over the years, much of the credit goes to the international support we received from India, China, Korea and Japan, especially in forecast products, satellite monitoring and capacity building, such as satellite access. This has been very helpful in our monitoring and in enhancing our forecast capacity.

Nepal has also been playing its part in regional collaboration by openly providing its real-time hydrological observations through its website. On top of that we have bilateral agreements with India and Bangladesh to share real-time hydrological data. Being an upstream country, it is our responsibility as well.

Given the scale of the Himalayan hydro-meteorological disasters we face every year, our institutions and our government should put a consolidated effort into establishing a similar mechanism with our Chinese counterparts. They showed their interest in this matter very recently, just a month or two before this disaster, and it is up to us to expedite this process so that we have a functional mechanism established. Even after this disaster they are showing keen interest and

providing support in sharing information.

To establish an effective monitoring and multi-hazard early warning system over the Himalaya demands bringing together existing as well as innovative scientific and technical know-how and sustained, substantial investment, instead of reinventing the wheel and making huge additional domestic investment. Our priorities should be to strengthen collaboration among our countries, the region and global organisations to support this endeavour, to make this Himalayan region relatively safe through the provision of effective multi-hazard early warning for all.

### **Mr. Anil Pokhrel**

*Former Chief Executive, NDRRMA: institutional response and disaster risk governance*

As someone who was the first Chief Executive to lead Nepal's National Disaster Risk Reduction and Management Authority for a full five-year term, I find the human plight and the human suffering hard to describe. Today happens to be the thirtieth day of the disaster and marks the formal ending of the intense mourning period and the transition of the deceased from an unsettled state to what we call in Nepali the ancestral guardian, the pitri. Unfortunately, thousands of families have not been able to do those final rites in the usual way. Families had to use dummies made of holy grass, what we call kush, to represent the missing ones in order to undertake these rituals. I would like to take a moment to recall all the souls we have lost, and to recall the heroic and tireless efforts of the responders, the security forces, the volunteers, doctors, journalists, technical experts and international responders working together.

Reflecting on our legal framework, the government's disaster classification under the national disaster response framework classifies this as a mega disaster, a mahabipad, which I personally feel seriously needs revisiting along the lines of calling it a category X or category Y disaster, in the way that we do for hurricanes. A category five would mean a serious disaster and everyone who can should do the best possible. Here, we are not able to communicate risk at all. It should start with categorising a disaster, especially in the mountain environment.

The Council of Ministers sat down immediately after the disaster, a few hours right after the event, which to my understanding has never happened so quickly in our history. The response and relief operations are going on at

an unprecedented scale. What we see here is not only in Nepal or the Nepal Himalaya; nowhere in the world have we witnessed a disaster of such ferocity and characteristics. I personally have never seen it. We can tell from our experiences, not only from this one but also from the 1993 Kulekhani extreme rainfall event where we lost around 1,400 people, from the Melamchi floods in 2021 where I happened to lead the operations, and from the 2024 floods and landslides, which the World Weather Attribution study attributed with a strong climate connection.

The event we witnessed thirteen days ago was not only a colossal loss and damage, it also exposed major fault lines in Nepal's preparedness for response. We tend to relate only with the upper reaches of Rasuwa and Nuwakot districts, and a little of Dhading district, but we have not really been able to capture the downstream impacts. It is too early to say, but what we have seen is that it cascaded further downstream to the loss of part of our national highway, which got aggravated, and we have lost the connectivity to Kathmandu, the only major connectivity there. Cooking gas supplies were already in shortage, but with the loss of this highway it is now a national level crisis. Perhaps had the highway not gone down, the rest of society would perhaps not have been affected much. We see videos and reels of people celebrating festivals. Compared with the earthquake, which shook the entire nation, what I find a bit appalling is that this has not shaken the nation as a whole. My fear is that policy makers might lose this sense of gravity in a couple of months. We have witnessed this in previous disasters as well, where the memory span really is low. After the fifty-six seconds of shaking during the 2015 earthquake, people tended to lose that fear and that need for safety.

On coordination, this is the most critical thing for an effective disaster response. Nepal has built its nodal institution, the national disaster management authority, for managing and reducing risk from disasters. But from a crisis preparedness perspective, if you analyse the gaps, what we can infer is that Nepal can manage small and localised disaster events but is far from being prepared for large multi-sector crises such as the one we witnessed recently. Legal and policy frameworks for crisis preparedness and emergency management are strong. But the authority, established in 2019 to lead cross-sectoral preparedness and response, is still in its infancy even after seven years. Given that it is mapped under the Ministry of Home Affairs, its focus for response happens to rely mostly

on the security agencies, the army, the armed police force and the police.

I must candidly say that our country does not have an early warning system. A lot of people might argue with that, but what we have is silos of its elements and abysmally poor risk communication. There is no interoperable, actionable risk information. We do not have simple broadcasting, nor a common alerting protocol. We totally lack a sectoral warning system targeting the hydropower sector. This was exposed not only by this disaster but also during the 2024 floods in central Nepal, where we lost around 450 people despite a warning nearly four days in advance produced by the Department of Hydrology and Meteorology and processed by the authority. We had advisories coming out four days in advance, and despite that we lost nearly 450 people. Had we had an effective or functional early warning system in this country, we would not have lost these many people.

The government has a national disaster fund still with a name that considers disasters an act of God. It is still run by a body other than the national council, which is actually headed by the Right Honourable Prime Minister, and it is yet to be handed over. The available fund and the donations will likely cover most of the search and rescue and relief operations, but I fear there will hardly be any remaining funds to support reconstruction and recovery. The contingency funds from the World Bank and the Asian Development Bank are the only readily available funds to support reconstruction and recovery. By the way, these are concessional loans, not grants. Add to this the cost of reconstruction and recovery for the 2023 earthquake, which is still pending, the 2024 floods and landslides, and last year's Ilam devastation, and the financing need is really hard to imagine. The numbers are coming out into billions of dollars. The processes to access funds from the loss and damage fund and from other climate change financing architectures are very slow. One project from the Green Climate Fund has taken nearly six years just to process, and then another year and a half to become effective. All these give nightmares to our finance ministries.

Add to this the fact that we are at fault for not insuring the hydropower plants built with taxpayers' money. These are not insured, so we as taxpayers would be the ones suffering it. Only the private sector-owned hydropower projects have been insured, and the premium for which will now soar high. I would like to bring to your knowledge that Nepal does not have a national emergency operations centre, often visualised



as a war room where command and coordination could happen with real-time data and joint action, with desks from various central ministries such as the road, energy, agriculture and housing sectors. It does not exist in the Nepali context. There has been hesitation, especially by some individuals within the ministries, to stop that from happening. The Ministry of Home Affairs runs something in name for preparedness and response, hardly staffed, and it has removed the words from its signboard. As per the law it was supposed to be handed over to the authority; it has never happened despite many pleas.

Similarly, we do not have a national warehouse where we could store our stockpiles, a civil structure where we could pre-position stockpiles and emergency search and rescue equipment under the authority. As per law this has to be within the authority. It does not exist. A facility with similar characteristics does exist in Kathmandu near the airport, but it is not run by the government, it is run as a project, and it has a poor infrastructure base. During my tenure as chief executive it took me almost six days to move some rafts from hardly twelve kilometres apart. That is the kind of logistics base we have. The issue of capacity for managing logistics and service capacity is nearly non-existent.

On what should be done next: the world has warmed roughly by 1.2 to 1.3 degrees. This disaster has happened with something around 1.3 or 1.4 degrees, yet to be ascertained. Now imagine a scenario where we reach 1.5 degrees or two degrees. That might translate to a much higher increase up in the mountains, and that would give us collectively a much more nightmarish scenario. This is where the need for a significant amendment to the legal mandate of an institutional structure for anticipating and responding to such category five disasters, and for managing these complex and cascading risks, has to correspond to that 1.5 degrees or, for the mountain environment, a much higher degree.

My submission, based on my five years of experience but also having worked in this disaster and climate change domain for the last twenty odd years, is that this agency has to be mapped within the Prime Minister's Office, and only the work on medium level category three and four disaster emergency response has to rest with the Ministry of Home Affairs. This would mean that the authority needs to be legally empowered with convening authority, technical capacity, full staffing and resources. This is important not only because of this disaster. Our risks are many in the Gandaki river basin.

We have seen what has happened in the Seti and other river basins, and there are many likely in the Koshi basin, because we have dozens of glacial lakes growing at a much faster pace on the Tibetan plateau side of China, which might lead to a catastrophe perhaps even beyond category five.

I would like to close with the statement that the mountains, the Himalayas, have given us a strong warning. The science has helped us to understand it to some extent. Now it is our collective responsibility. It is through these kinds of discourse that we come to a common understanding, and it is only through our collective responsibility that we can turn this understanding of science into action, and that action has to be turned into building resilience in the Nepal Himalaya, extending much beyond to the entire Himalayan scale.

#### **Mr. Marco Toscano-Rivalta**

*UNDRR Regional Office for Asia and the Pacific: closing reflections*

It is an honour to be here with you. I congratulate the organisers for making this event happen, and I have seen that it has had a very high level of participation. Raising awareness and joining forces in understanding not only what has happened but, as you put it in your concept note, what we do next, is important.

First, I want to join all those who have been sending their thoughts for the affected people, for the people who lost their lives, for the communities and for the survivors. This is a moment to continue showing solidarity and persistence, and to keep it up for a long time, before the headlines disappear from the papers. Nepal and the Nepalese have shown on many occasions a strong resilience, and that is why it is important for all of us to stand by and to proactively and actively support the work ahead. This is still an important moment in which humanitarian assistance is of great relevance, and it is important to provide all the affected communities with the necessary means to face this extremely difficult set of circumstances.

The third thing is what you have been discussing in this webinar. There is a lot that needs to be pulled together, and I thank all of you who have been sharing very important scientific insight on what has happened. There will certainly be a lot of work that goes into further analysis of the dynamics and the different drivers of this, and how it generated what it generated. It is really important to keep joining forces in shaping that common understanding. But it is also important

to keep in mind how to use this common understanding. There is an important recovery and reconstruction phase ahead of us, so it is critical to use the scientific understanding to inform the recovery, the reconstruction and the rebuilding phase, so that existing vulnerabilities or exposures can be taken care of during that process.

I would like to commend Nepal for the important work that has been put into developing a national roadmap for the strengthening of the national early warning system. Such an adoption will be very important, and will be important guidance to all the international development partners that want to support Nepal in the further strengthening of national systems. Of course it is critical that these systems are plugged into a much wider international cooperation set of mechanisms. But we need to take the lead from the understanding that the country has developed and put ourselves behind it in terms of supporting this national roadmap, its implementation and its financing.

Several speakers have mentioned the importance of risk communication. The phase ahead has to be a phase in which not only do we strengthen the national early warning system, but there is also a strong focus on continuing to support the communities and the sharing of risk information in a way that generates an increasingly wider understanding of disaster risk and how that can be communicated effectively.

I hope that the recovery and reconstruction can support the strengthening of the early warning system, and that international development partners, in support of national priorities, can support how to further integrate scientific knowledge, technology and innovation in the way forward. Regrettably, what has happened strengthens again the importance of having a multi-hazard understanding. But it is not just multi-hazard, it is also multi-vulnerability, because the two things are strongly interconnected. It poses a question about how to support the strengthening of existing infrastructure, and the rebuilding of new infrastructure needs to happen in a way that follows the scientific understanding you have put forward so strongly. A lot of work has been done in Nepal to strengthen local communities, and here again is an important circumstance in which to combine scientific knowledge while leveraging and supporting local knowledge, and translating that into national and local plans and measures, and communicating it to the wider communities.

There will also be important aspects in terms of transboundary

risk management. We now have the technical capacities to share this information, and it is really important that we increasingly do so across boundaries. Attention needs to go not only to strengthening the national system but to the interface across borders, and to how different institutions, including in far away countries, can keep strengthening risk understanding in any given country, making the best use of science, technology and the instruments at our disposal.

Last but not least, the question of inclusion does remain and needs to remain at the centre of our scientific reasoning, policy making and investment in future measures. There will be a lot of people with disabilities who have been impacted, and there will probably be people who face disabilities, temporarily or permanently, because of the disaster. It is critical that we put persons with disability, women and vulnerable groups at the centre of our understanding, because it is not just about the hazard, it is also about understanding how hazard and vulnerability interface. This is a plea to international development partners to support the wider spectrum of human needs and necessities and rights, because we are speaking about rights as well. We in UNDRR are committed to supporting the government and its partners in the way forward, including the recovery and the reconstruction phase and the post-disaster needs assessment.

### **Mr. Pradip Khatiwada**

#### *Youth Innovation Lab: closing remarks and next steps*

On behalf of Youth Innovation Lab I express our sincere gratitude to every speaker who joined us today, many at very short notice. We have had more than 800 participants, and despite the technical challenges we had a large audience join today. I especially thank you all for your comments and suggestions, and for making it a very engaged event.

I would like to thank Dr. Mohan Chand, Professor Fan, Professor Cui Peng, Professor Ceas, Professor Davies and Professor Walter for helping us unpack the science, from the physical genesis of this event and its cascading processes to the changing cryosphere, hydrology and the larger Himalayan hazard system. I would also like to thank Sanjeeb Baral, Dr. Archana Shrestha, Professor Vishnu, Dr. Jagadishwor and Anil for moving us from understanding this event towards the much more difficult question of what we do next, across water resources, monitoring, investment, institutions and disaster risk governance. And thank you, Marco, for bringing the regional disaster risk perspective into this conversation.

I would also like to recognise all the institutions that made this dialogue possible, especially the Government of Nepal's institutions, particularly the Ministry of Energy, Water Resources and Irrigation, and the Red Cross Red Crescent Climate Centre, Kathmandu University, the University of Twente, Chengdu University of Technology, Utrecht University, Newcastle University, the Chinese Academy of Sciences, Tribhuvan University, and all our collaborating scientific and technical partners.

But I do not want to end today by simply summarising what we have heard. I want to end with one question: what next?

The message emerging very strongly from today's discussion is that what happened in the Himalaya cannot be understood through a single discipline. We are dealing with interactions between ice, rock, glaciers, permafrost, water, sediment, slopes, weather and climate, and then infrastructure, settlements and human exposure downstream. These processes can interact and cascade in ways that are extremely difficult to anticipate.

So perhaps our first task after today is what I would call a scientific autopsy of this event. We need to understand precisely what happened. There were so many presentations that gave us multiple perspectives, but we need to go deeper. What was the sequence of physical processes? What did we know? What did we miss? Where did our models and modelling systems work, and where did we fail? And what are the questions that science still cannot answer?

We must also be careful not to reduce the complexity to a simple linear climate change narrative. A changing climate is transforming the conditions in which Himalayan hazards occur, but attributing an individual event requires event-specific, process-specific and catchment-specific evidence. The Himalaya is a complex system undergoing a complex transformation. Our science must be capable of understanding this complexity.

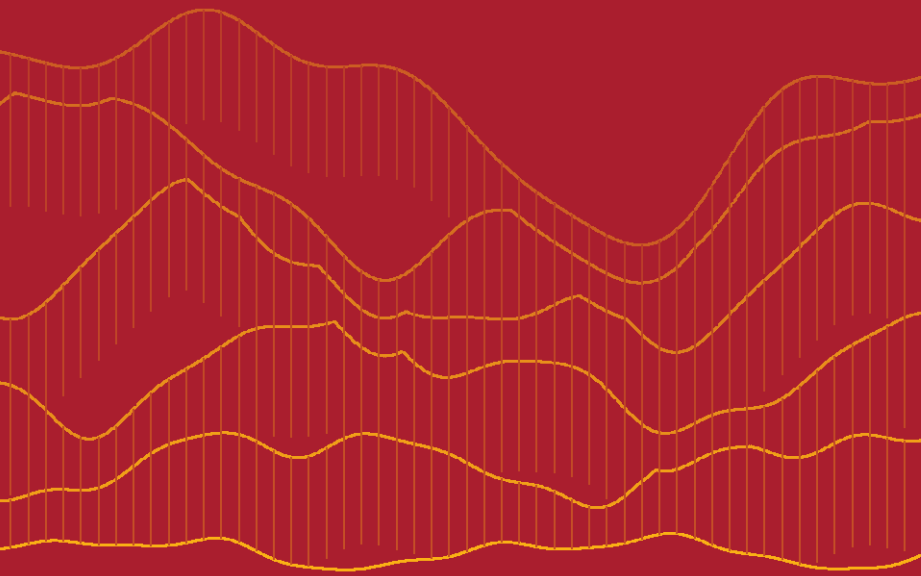
And that brings me to perhaps the most important point. No single country can do this alone. These mountains do not recognise political boundaries. The rivers do not stop at borders. Sediment does not stop at borders. Climate does not stop at borders. And disasters certainly do not stop at borders. A hazard originating in one part of the Himalayan system can have consequences across multiple countries, and we have just seen that in our recent events. The very nature of this rapidly unfolding cascading hazard raises questions that cross administrative and national boundaries. So risk

understanding itself must become transboundary. We need Nepal, China, India and the wider Himalayan region to work together. And we need the global scientific communities we heard from today, and other scientists throughout the world, the best minds, the best available science and satellite capabilities, modelling technology and field knowledge, to work together alongside us. This cannot be cooperation after disasters. We need to cooperate before the next disaster occurs.

I see several immediate directions coming from today's conversation. We need to bring together the available scientific evidence and undertake a deeper multidisciplinary investigation of this event. We need to build strong mechanisms for transboundary scientific collaboration, monitoring and data sharing. We need to identify similar high-risk locations and translate that knowledge into credible safe and unsafe zones. We need to rethink our settlement and infrastructure planning based on the emerging risk landscape. And we need to strengthen monitoring, forecasting, early warning and early action for hazards that may develop in minutes rather than hours.

There is one final commitment I want to make today. This is not a one-off event. Today's webinar is a starting point. We want it to become a continuing series of scientific exchange, information sharing and collaboration, bringing together new evidence as it emerges, connecting scientists across countries and disciplines, and most importantly translating that science into decisions that governments and communities can actually use. We began today by trying to understand one devastating event, but perhaps the larger task before us is to understand how the Himalayan risk landscape itself is changing.

The outputs of today's event will be shared with high-level authorities, which will be really helpful for our further endeavours. Thank you very much everyone for joining, and I hope to connect again in future.



## ANNEX C

# Figures Cited and Source Reconciliation

*Every quantitative claim in this report, with its source and date*

This annex exists because the figures in this report disagree with each other. That is a property of the evidence rather than a defect of the reporting. Numbers were changing hourly during the emergency, several were presented by teams still in the field, and independent methods gave independent answers. Nothing here has been averaged, rounded towards a consensus, or silently reconciled. Where two sources conflict, both are given with the date and the issuing body, and the conflict is stated.

## How to use this annex

Every figure carries the date on which it was stated and the body that stated it. Before citing any figure in this report,

check it against the issuing institution. Figures marked as provisional were described as provisional by the person who presented them. Figures marked as inferred were derived by Youth Innovation Lab from stated quantities and are identified as such.

Three areas of genuine disagreement should be treated with particular care: the source volume and its ice fraction, where three methods give a range of nearly two to one; the human toll, where two reporting dates four days apart give materially different figures and the search continued afterwards; and the damage and reconstruction estimates, where the dollar equivalents cited in the source material imply inconsistent exchange rates.

**TABLE C.1 Reconciliation of figures cited across sources**

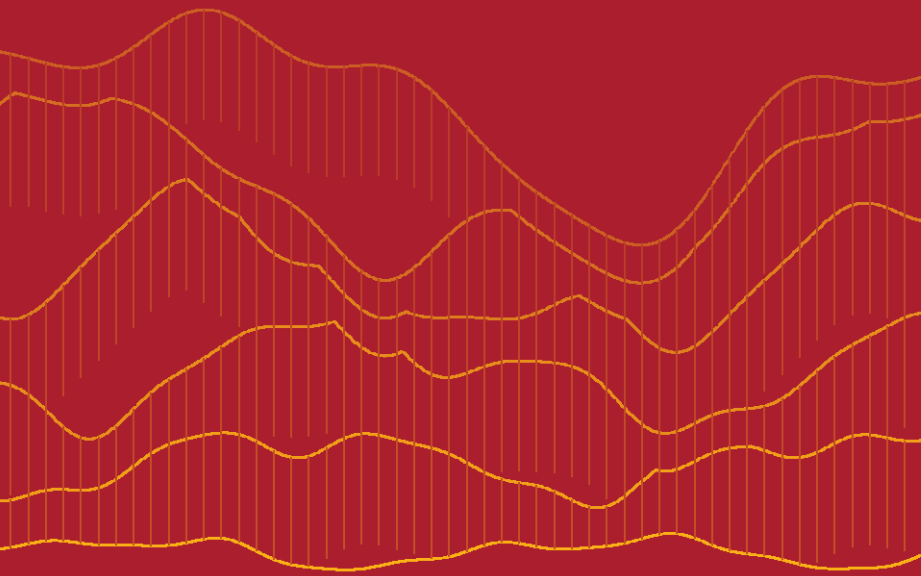
*Values are grouped by subject. Where a row shows more than one value, those values were given by different sources or on different dates and have not been reconciled.*

| Figure                          | Value                             | Source                           | Date stated | Status      |
|---------------------------------|-----------------------------------|----------------------------------|-------------|-------------|
| Bodies recovered                | 1,356                             | NDRRMA via situation report      | 7 Sep 2026  | Provisional |
| Confirmed dead                  | 1,356                             | NDRRMA via situation report      | 7 Sep 2026  | Provisional |
| Missing or unaccounted          | 4,894                             | NDRRMA via situation report      | 7 Sep 2026  | Provisional |
| Foreign nationals among missing | 587 from 34 countries             | NDRRMA via situation report      | 7 Sep 2026  | Provisional |
| People rescued                  | ~13,396                           | NDRRMA via situation report      | 7 Sep 2026  | Provisional |
| People affected nationally      | ~1.6 million                      | NDRRMA via situation report      | 2 Sep 2026  | Provisional |
| Immediate economic damage       | Over NPR 500 billion              | NDRRMA via situation report      | 2 Sep 2026  | Provisional |
| Indicative rebuilding cost      | Up to NPR 762 billion             | NDRRMA via situation report      | 2 Sep 2026  | Provisional |
| Source volume                   | ~74 million m <sup>3</sup>        | Kathmandu University             | 7 Sep 2026  | Preliminary |
| Source volume                   | 110 million m <sup>3</sup>        | Chengdu University of Technology | 7 Sep 2026  | Preliminary |
| Source volume                   | ~130 million m <sup>3</sup>       | SKLGP                            | 7 Sep 2026  | Preliminary |
| Source volume range             | 100 to 200 million m <sup>3</sup> | Assessment Report                | 5 Sep 2026  | Provisional |
| Ice component                   | ~44 million m <sup>3</sup>        | Kathmandu University             | 7 Sep 2026  | Preliminary |
| Ice component                   | ~20 million m <sup>3</sup>        | Chengdu University of Technology | 7 Sep 2026  | Preliminary |
| Glacier fraction of total       | Under 20 per cent                 | SKLGP                            | 7 Sep 2026  | Preliminary |
| Glacier area collapsed          | ~0.68 km <sup>2</sup>             | Kathmandu University             | 7 Sep 2026  | Preliminary |
| Glacier ice lost in failure     | 0.27 km <sup>2</sup>              | Newcastle University             | 7 Sep 2026  | Preliminary |
| Detachment elevation            | ~5,200 m                          | Kathmandu University; SKLGP      | 7 Sep 2026  | Preliminary |
| Detachment elevation            | ~5,100 m                          | Newcastle University             | 7 Sep 2026  | Preliminary |
| Vertical drop to first impact   | ~1,400 m                          | Kathmandu University             | 7 Sep 2026  | Preliminary |
| Vertical drop                   | ~1,200 m                          | Assessment Report                | 5 Sep 2026  | Provisional |
| Travel distance to outlet       | 22 km                             | Kathmandu University             | 7 Sep 2026  | Preliminary |
| Travel distance to outlet       | 21 km                             | Chinese Academy of Sciences      | 7 Sep 2026  | Preliminary |
| Travel time                     | 7 minutes                         | Kathmandu University             | 7 Sep 2026  | Preliminary |
| Travel time                     | Nearly 8 minutes                  | Chinese Academy of Sciences      | 7 Sep 2026  | Preliminary |
| Mean velocity                   | 40 to 48 m/s                      | Chinese Academy of Sciences      | 7 Sep 2026  | Preliminary |



| Figure                                      | Value                            | Source                         | Date stated | Status      |
|---------------------------------------------|----------------------------------|--------------------------------|-------------|-------------|
| Flow speed                                  | ~60 m/s                          | Kathmandu University           | 7 Sep 2026  | Preliminary |
| Flow speed                                  | ~50 m/s, ~180 km/h               | Assessment Report              | 5 Sep 2026  | Provisional |
| Peak discharge at Rasuwagadhi               | ~23,000 m <sup>3</sup> /s        | Kathmandu University           | 7 Sep 2026  | Preliminary |
| Peak discharge downstream                   | ~20,000 m <sup>3</sup> /s        | Kathmandu University           | 7 Sep 2026  | Preliminary |
| Maximum flow depth                          | ~50 m, more in gorges            | Kathmandu University           | 7 Sep 2026  | Preliminary |
| Blast wind width                            | Up to 1.3 km                     | Chinese Academy of Sciences    | 7 Sep 2026  | Preliminary |
| Transport corridor width, upper reach       | ~470 m                           | Chinese Academy of Sciences    | 7 Sep 2026  | Preliminary |
| Main collapse seismic equivalent            | Magnitude 5.2                    | University of Twente           | 7 Sep 2026  | Preliminary |
| Secondary landslide seismic equivalent      | Magnitude 4.2                    | SKLGP; USGS; CSN               | 7 Sep 2026  | Preliminary |
| Secondary landslide timing                  | ~3 hours after main event        | SKLGP                          | 7 Sep 2026  | Preliminary |
| Mass loss from moment inversion             | ~720 million kg                  | University of Twente           | 7 Sep 2026  | Preliminary |
| Barrier lake volume                         | ~2 million m <sup>3</sup>        | Concept note                   | 5 Sep 2026  | Provisional |
| Precursor dust cloud                        | ~30 minutes before event         | SKLGP; from social media       | 7 Sep 2026  | Preliminary |
| InSAR acceleration onset                    | Mid-June 2026; ~2 months prior   | SKLGP                          | 7 Sep 2026  | Preliminary |
| Pre-event deformation                       | ~15 cm over 4 months             | University of Twente           | 7 Sep 2026  | Preliminary |
| Earthquakes M4+ within 300 km since 2015    | More than 280                    | University of Twente           | 7 Sep 2026  | Preliminary |
| Regional glacier mass loss, South Asia East | 21 per cent since 2000           | Newcastle University           | 7 Sep 2026  | Published   |
| Terminus retreat, 1964 to 2026              | 550 to 560 m                     | Newcastle University           | 7 Sep 2026  | Preliminary |
| Terminus retreat since 2010                 | 373 m; rose over 200 m           | Newcastle University           | 7 Sep 2026  | Preliminary |
| Warming above 4,000 m                       | ~0.3 °C per decade               | Newcastle University           | 7 Sep 2026  | Preliminary |
| Annual warming, failure pixel               | ~0.17 °C per decade              | Utrecht University             | 7 Sep 2026  | Preliminary |
| Monsoon warming, failure elevation          | ~0.46 °C per decade              | Utrecht University             | 7 Sep 2026  | Preliminary |
| Zero-degree isotherm                        | ~5,200 m in 2006 to over 5,350 m | Utrecht University             | 7 Sep 2026  | Preliminary |
| Post-monsoon 2025 snowfall                  | Over 300 mm in a few events      | Utrecht University             | 7 Sep 2026  | Preliminary |
| Maximum temperature, 3 days prior           | Over 10 °C against ~6 °C normal  | Utrecht University             | 7 Sep 2026  | Preliminary |
| Local warming vs plateau average            | Up to four times                 | SKLGP                          | 7 Sep 2026  | Preliminary |
| Permafrost active layer thickening          | Over 90 per cent of HMA sites    | Newcastle University           | 7 Sep 2026  | Published   |
| Permafrost degradation band                 | 4,500 to 5,500 m                 | Newcastle University           | 7 Sep 2026  | Published   |
| Gauging stations destroyed                  | 6                                | CHWRR                          | 7 Sep 2026  | Stated      |
| Lives lost, 2024 central Nepal floods       | ~450                             | Former Chief Executive, NDRRMA | 7 Sep 2026  | Stated      |
| Advance warning, 2024 floods                | Nearly 4 days                    | Former Chief Executive, NDRRMA | 7 Sep 2026  | Stated      |
| Lives lost, 1993 Kulekhani event            | ~1,400                           | Former Chief Executive, NDRRMA | 7 Sep 2026  | Stated      |
| GCF project processing time                 | ~6 years plus ~18 months         | Former Chief Executive, NDRRMA | 7 Sep 2026  | Stated      |
| Global warming at time of event             | ~1.2 to 1.4 °C                   | Former Chief Executive, NDRRMA | 7 Sep 2026  | Stated      |
| Registration page views                     | 3,348                            | Platform registration report   | 7 Sep 2026  | Recorded    |
| Completed registrations                     | 956                              | Platform registration report   | 7 Sep 2026  | Recorded    |
| Cancelled registrations                     | 7                                | Platform registration report   | 7 Sep 2026  | Recorded    |
| Reported peak attendance                    | More than 800                    | Convener, closing remarks      | 7 Sep 2026  | Stated      |
| Session duration                            | 3 hours 1 minute 35 seconds      | Session recording              | 7 Sep 2026  | Recorded    |

All data and recommendations presented in this section reflect the discussions and presentations delivered by experts and speakers during the webinar. Participant figures were extracted from the webinar platform's analytics report., *Note:* Rows sharing a figure name with differing values are unreconciled with disagreements between sources or reporting dates. NDRRMA figures were changing continuously therefore, the latest situation report of the Rasuwa-Bhotekoshi as of 7:00 PM, 07 September 2026, has been used as the data reference.



## ANNEX D

# Method and Limitations

*What this record is, and what it cannot support*

## Sources

This report draws on four primary sources. The first is the recording and automatic transcript of the session of 7 September 2026, running three hours, one minute and thirty-five seconds. The second is the concept note and agenda circulated before the session. The third is the set of speaker biographies supplied by the presenting institutions. The fourth is the platform registration report covering 963 registration records, of which 956 were active and 7 cancelled.

## Speaker attribution

The automatic transcript mislabelled a number of speakers, in most cases because a presentation was delivered from a colleague's connection or because a single account was used for successive interventions. The following corrections have been applied throughout, on the basis of the agenda and the content of each intervention.

- The presentation on cascading hazard chains and seismic precursors, logged under a colleague's name, is attributed to Prof. Xuanmei Fan, in accordance with the agenda and the content.
- The intervention on hydrological monitoring and gauging stations, logged under the convener's name, is attributed to Mr. Sanjeeb Baral.
- The presentation on weather, climate and station trends, logged under the convener's name, is attributed to Dr. Archana Shrestha.
- The intervention on investment priorities and international collaboration, logged under the convener's name, is attributed to Dr. Jagadishwor Karmacharya.
- The intervention on institutional response and disaster risk governance, logged under the convener's name, is attributed to Mr. Anil Pokhrel, on the basis of the speaker's own self-identification within the intervention.
- The second half of the University of Twente presentation is attributed to Ashok Dahal, following the explicit handover in the recording.

No correction has been applied where attribution was uncertain. Where a name is spelled inconsistently in the transcript, the spelling used in the speaker biographies has been adopted.

## Transcription quality

The automatic transcript contains substantial errors in proper nouns, place names and technical terms, and it garbled several numerical statements. Where a figure appeared ambiguous, it has been cross-checked against the concept note, against the internal consistency of the presentation in which it appeared, or omitted. Two categories of statement have been excluded from this report: figures that could not be reconciled to a plausible value, and statements whose meaning could not be recovered from the transcript with confidence.

One example illustrates the issue. A stated bedrock area of 3,400 square metres is inconsistent with the surrounding quantities in the same presentation and has been omitted rather than reported or silently corrected. Readers who need that figure should obtain it from the presenting institution.

## What the figures in this report are

Charts in this report fall into three categories, identified in each figure note. Some reproduce values stated in a presentation directly. Some are reconstructions of a described pattern, drawn to the stated magnitude and direction where the underlying series was shown on screen but not read out; these are always identified as illustrative. Some are assessments by Youth Innovation Lab derived from stated quantities, and are labelled as such.

No figure in this report reproduces a presenter's slide. Where imagery is essential to the argument, a placeholder has been left for the original material to be inserted with the permission of the institution that produced it.

## Limitations

- This is a record of one session on one day. It is not a systematic review of the literature, nor an independent investigation of the event.
- Every scientific result reported here was presented as preliminary, most within twelve days of the event, several by teams still in the field or still supporting an emergency response.
- The two discussion segments in the programme were compressed to protect presentation time. Questions

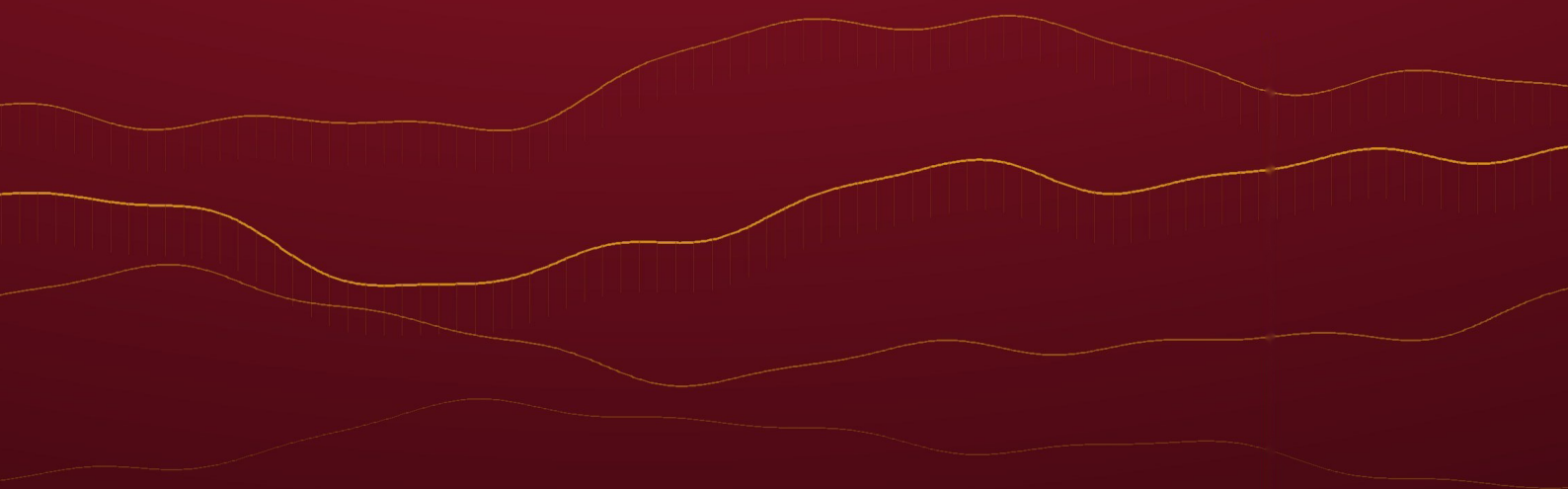
submitted through the question and answer channel were not addressed live. Those questions and the responses subsequently obtained from speakers are not included in this edition and will form part of a subsequent output.

- No representative of the affected communities spoke at the convening. That is a material gap in the record and it should be closed in the next instalment of the series.
- The attribution question was open at the time of publication. A World Weather Attribution study was under way and its findings are not anticipated here.
- Casualty and damage figures were changing continuously and both reporting dates cited in this report were superseded after publication.

## Editorial conventions

Quantities are given in the units in which they were stated. Metric units are used throughout. Nepali rupee amounts are given as stated, with the dollar equivalents cited in the source material reproduced without recalculation; those equivalents imply inconsistent exchange rates and should be recalculated before use. Dates are given in day, month, year order. Times are Nepal Standard Time unless otherwise stated, except where a presenter used Chinese standard time, which is identified where it occurs.

Institution names follow the form used by the institution itself. Where an abbreviation is used, it is defined in the Abbreviations list. Speaker titles are those held at the time of the convening.



*In collaboration with*

