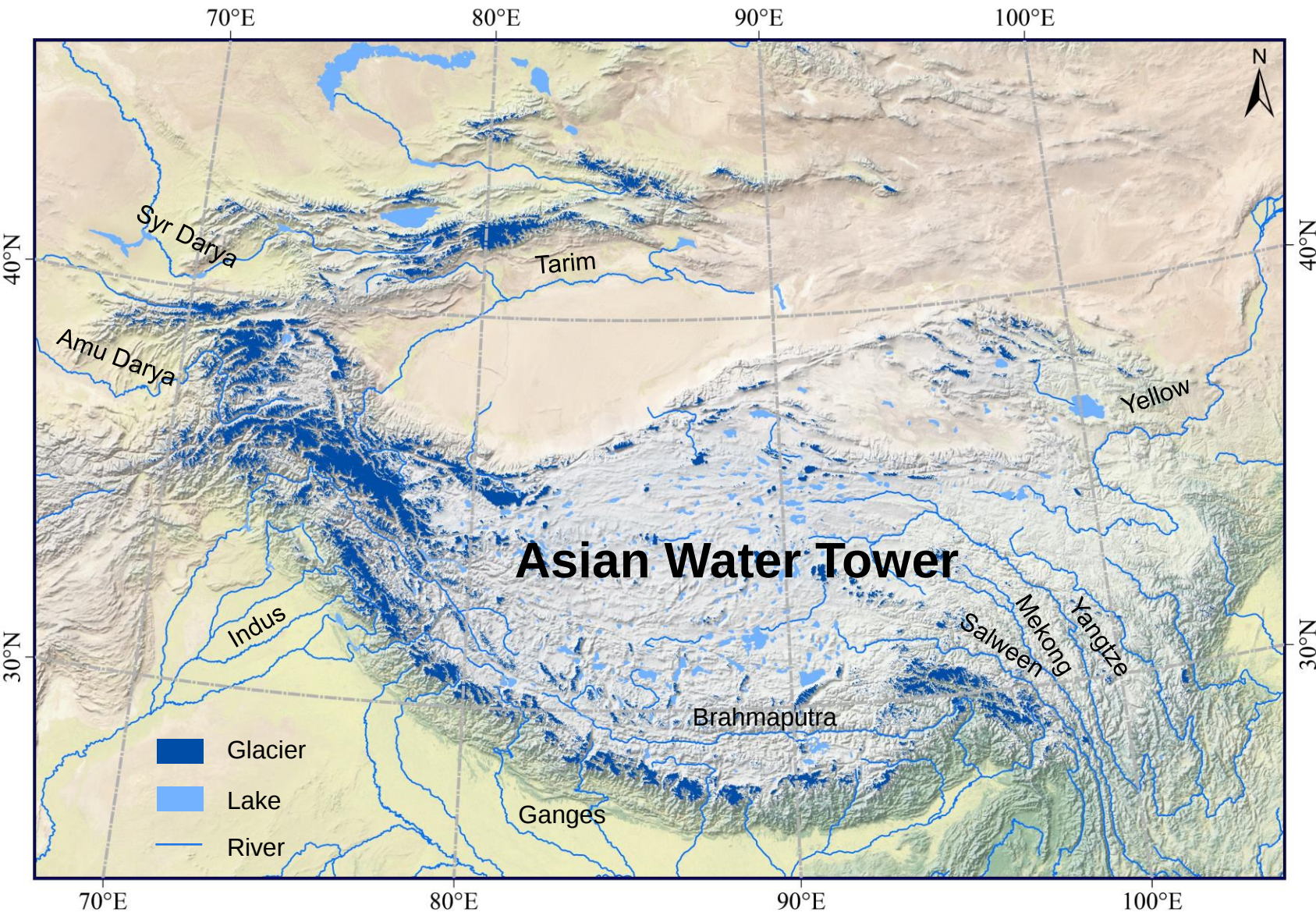




Glacial lake outburst floods (GLOFs) in the Third Pole: Process, risk assessment and early warning

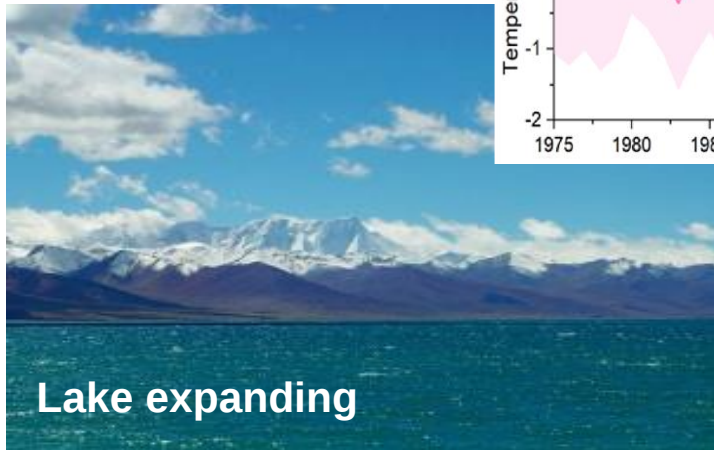
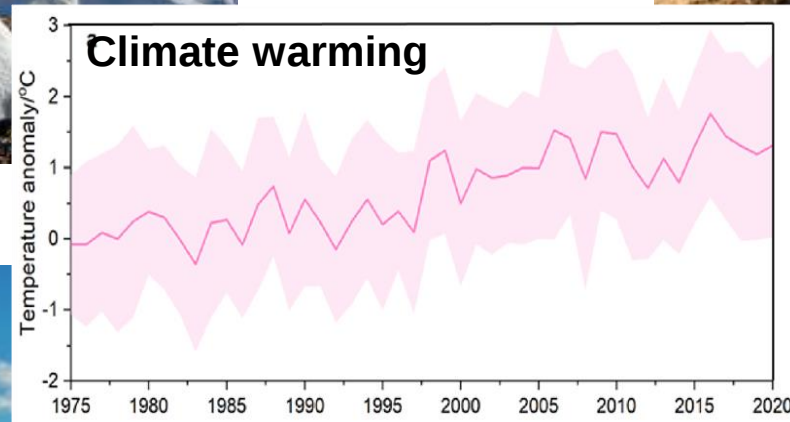
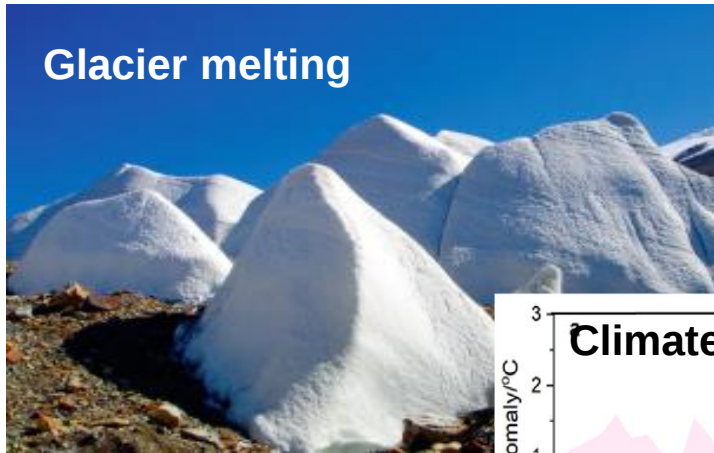
Third Pole--Asian Water Tower



~100,000 km² of glaciers, and
~8,000 Gigaton of ice volume

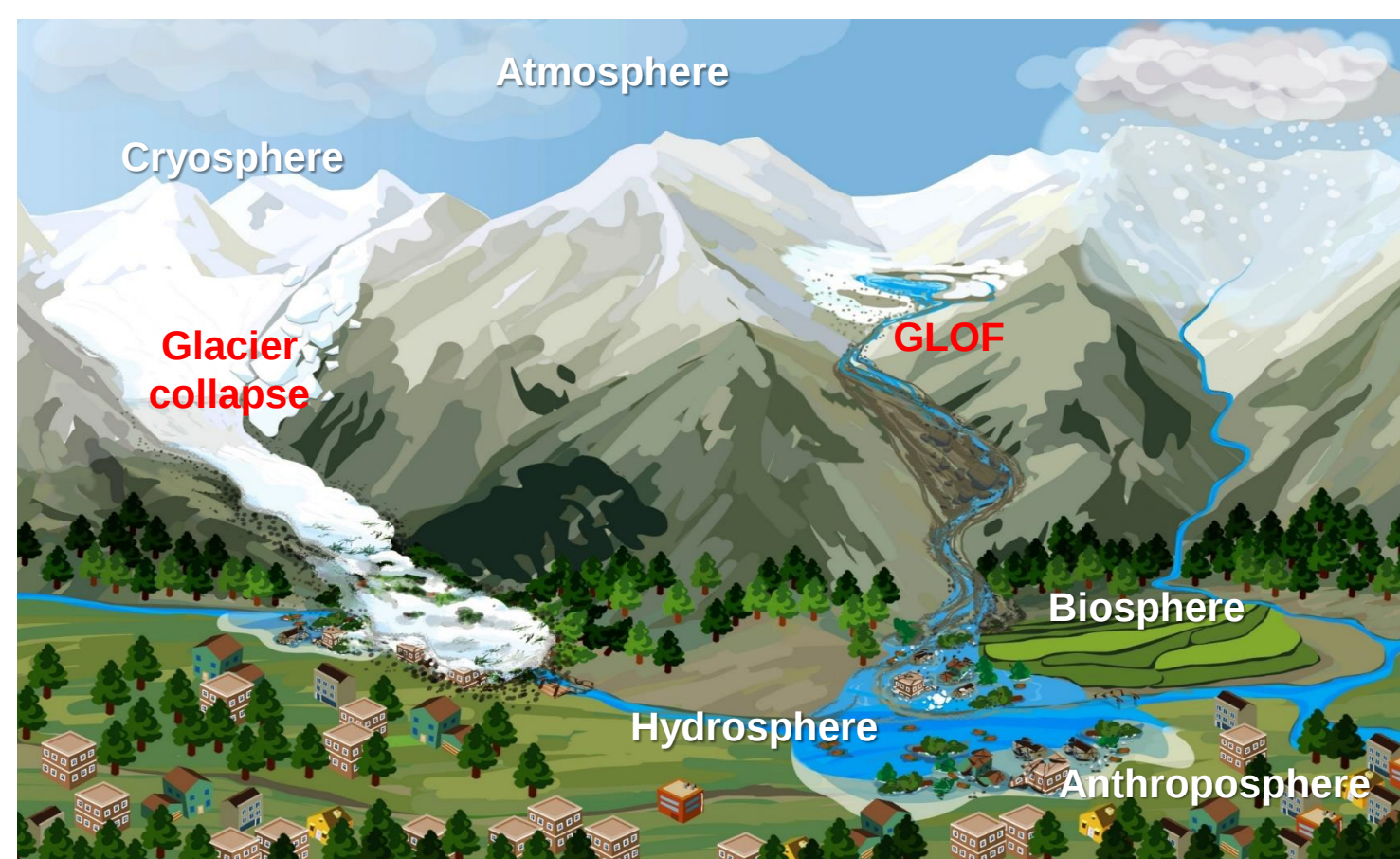
2 billion people from more than 10
countries depend on the Asian
Water Tower

Climate warming induced imbalance of the Asian Water Tower, causing serious consequences

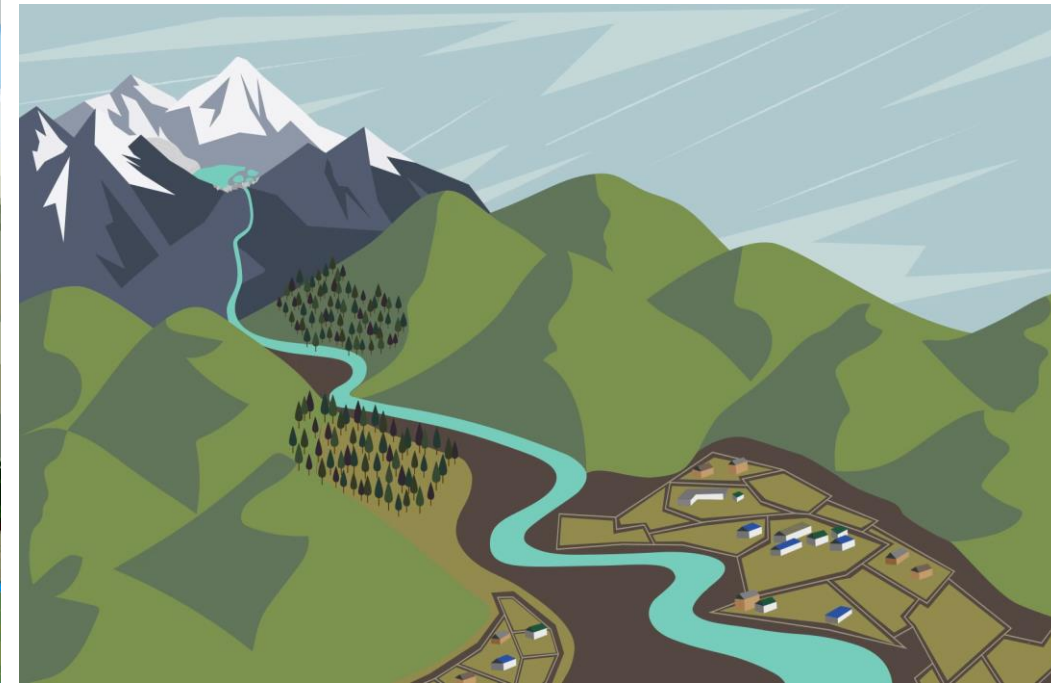


With climate warming, the Asian Water Tower is experiencing imbalanced changes, resulting in unique land-surface processes.

GLOF is one of the glacier-melt related hazard over the imbalanced Asian Water Tower



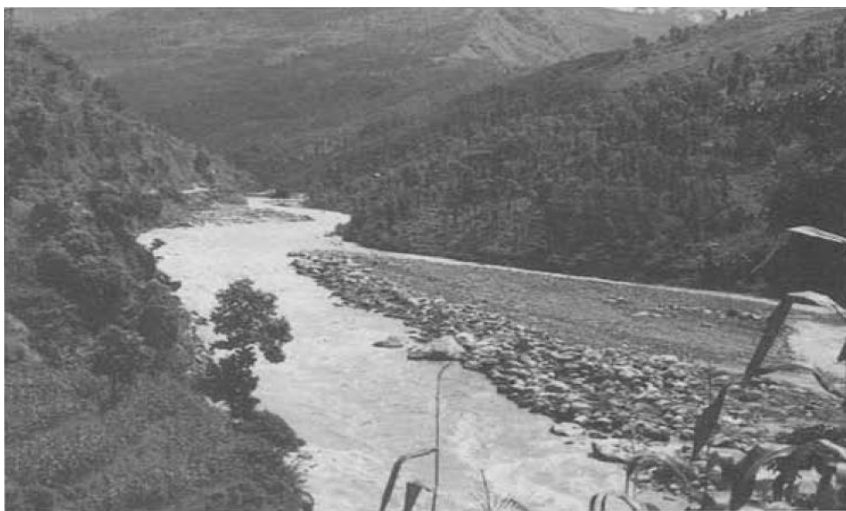
GLOF: Glacial lake outburst flood



Source: ICIMOD

Rapid glacier change results in disaster risk

The devastating impacts of GLOF call for risk reduction



Cirenmaco GLOF (1981)



Gongbatongshaco GLOF (2016)



GLOF risk reduction efforts under the support of TPE and STEP

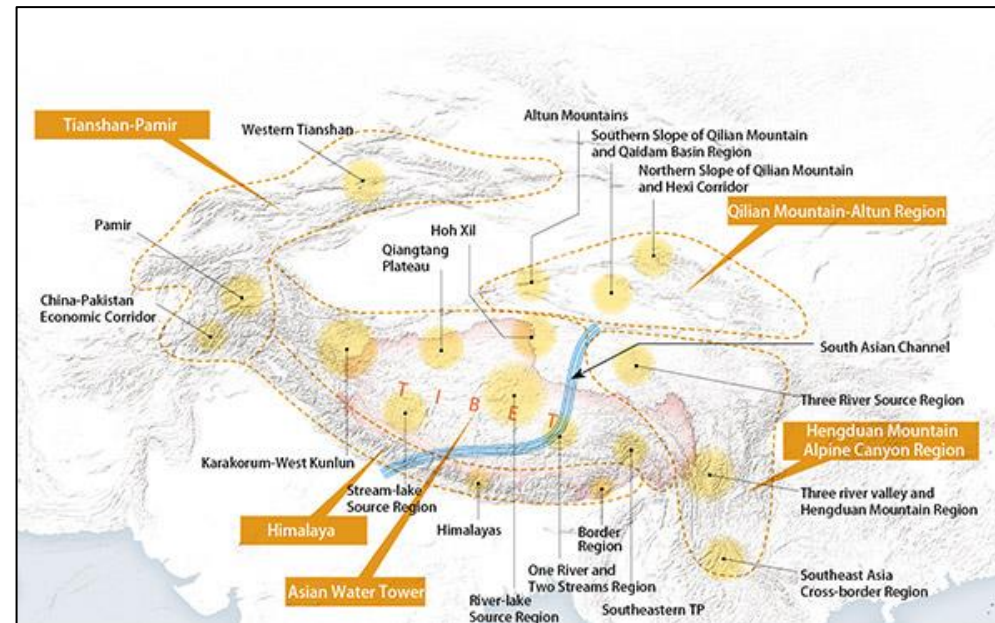
Third Pole Environment (TPE)

TPE is an international program for the interdisciplinary study of the relationships among water, ice, air, ecology and humankind in the Tibetan Plateau and beyond

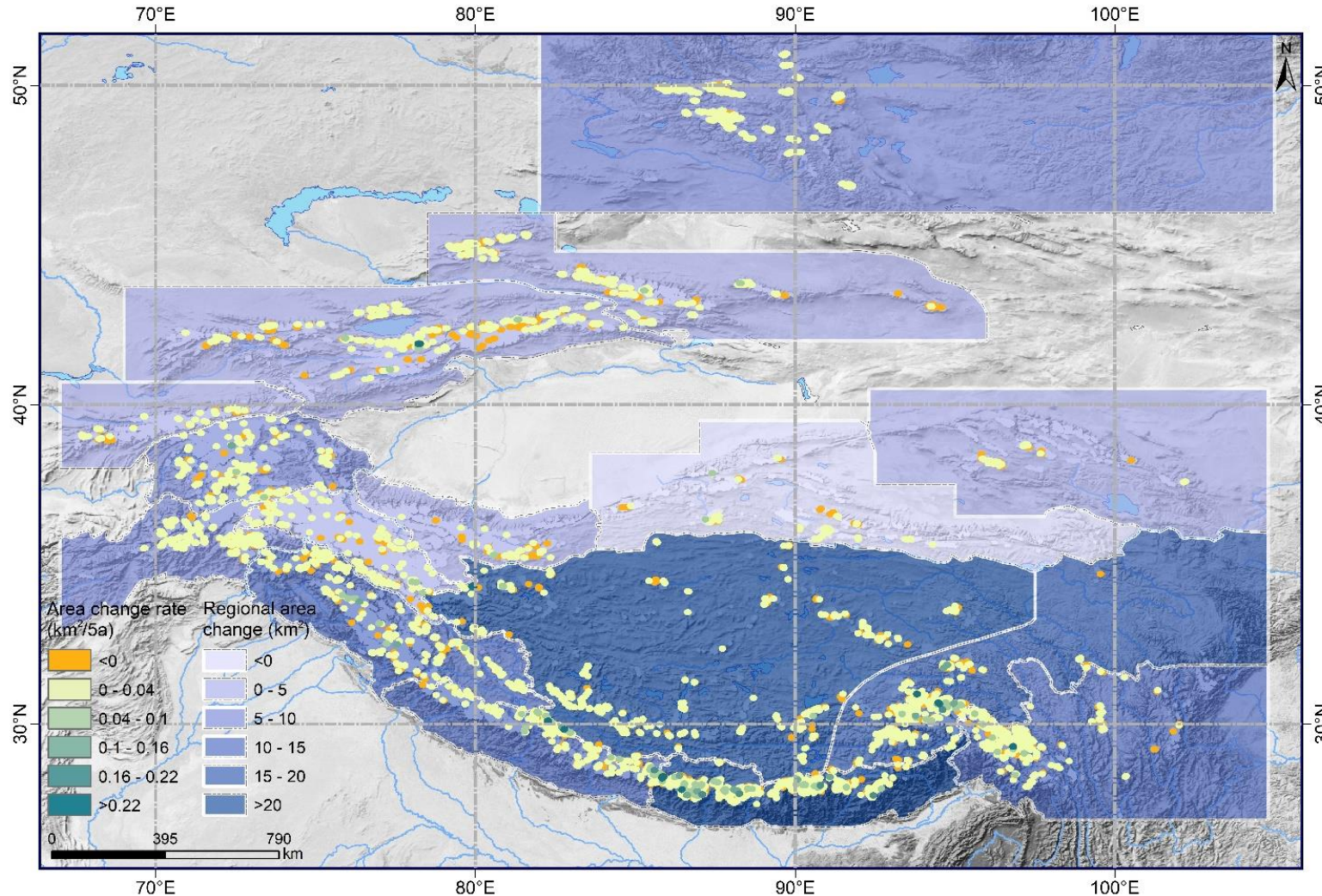


The Second Tibetan Plateau Scientific Expedition and Research (STEP)

STEP is a program launched focusing on environment changes and their impact and adaptation on the Tibetan Plateau

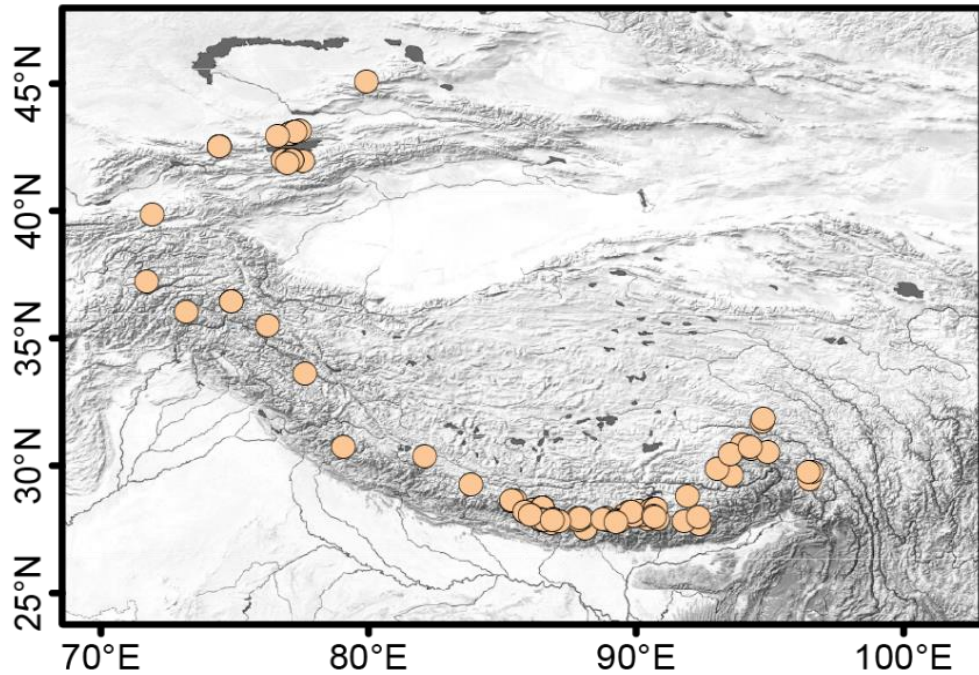


Glacial lake inventory and change

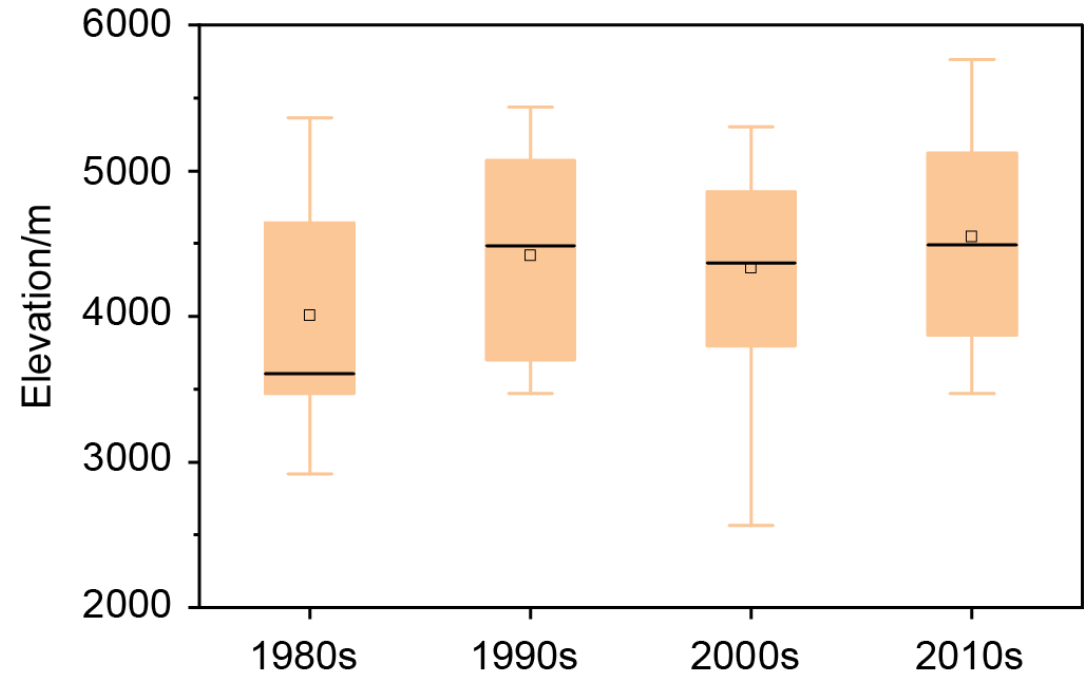


- ❑ A total of **5,894** glacial lakes were mapped in the region in 2022, with a combined area of **748.79 km²** and a combined volume of **20.13 km³** ;
- ❑ From 2018 to 2022, the glacial lake area expanded by 22.68 km², and 83% of this total increase was contributed by proglacial lakes

Spatial distribution of GLOFs



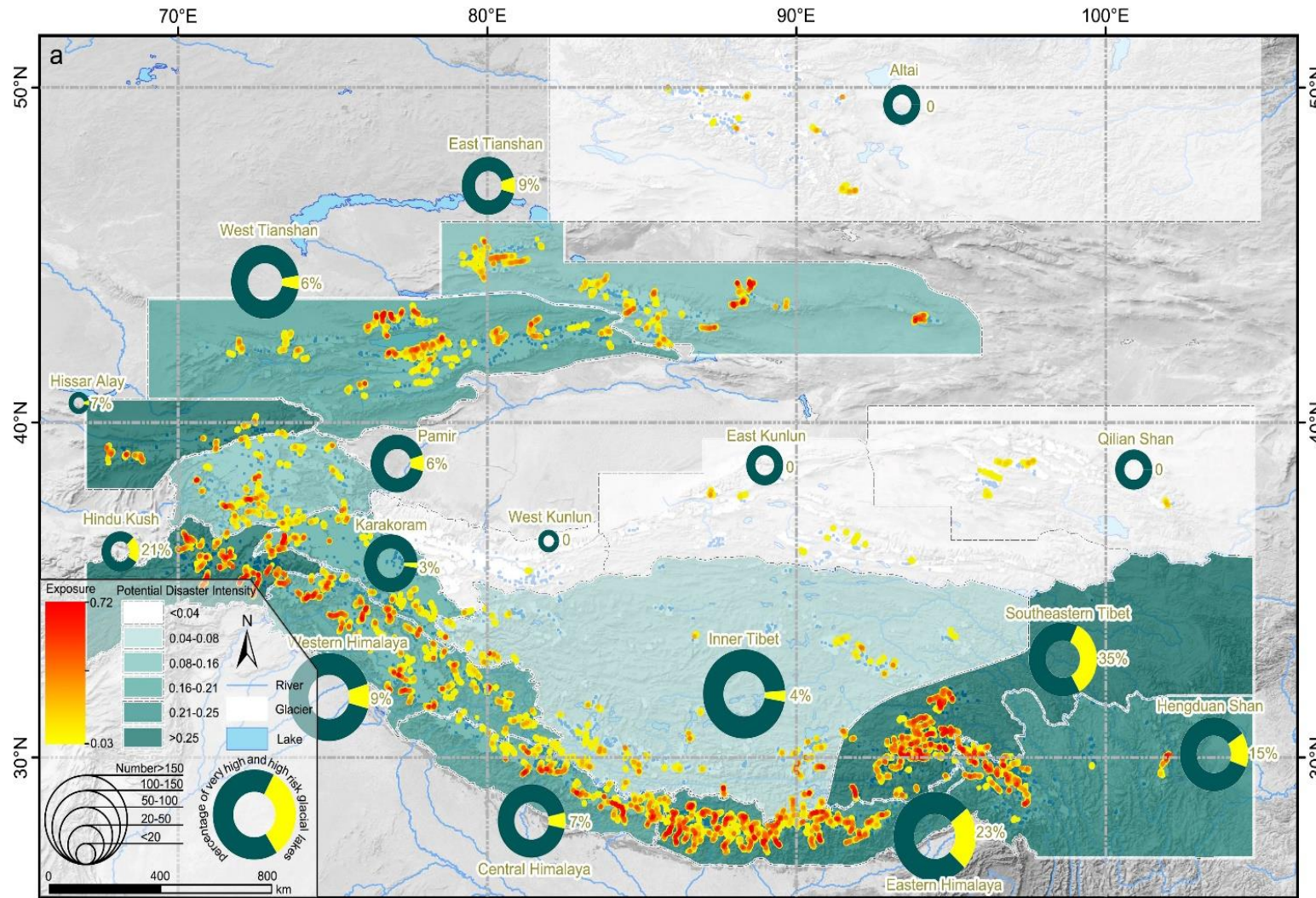
Spatial Distribution of GLOFs



Altitudinal distribution of GLOFs

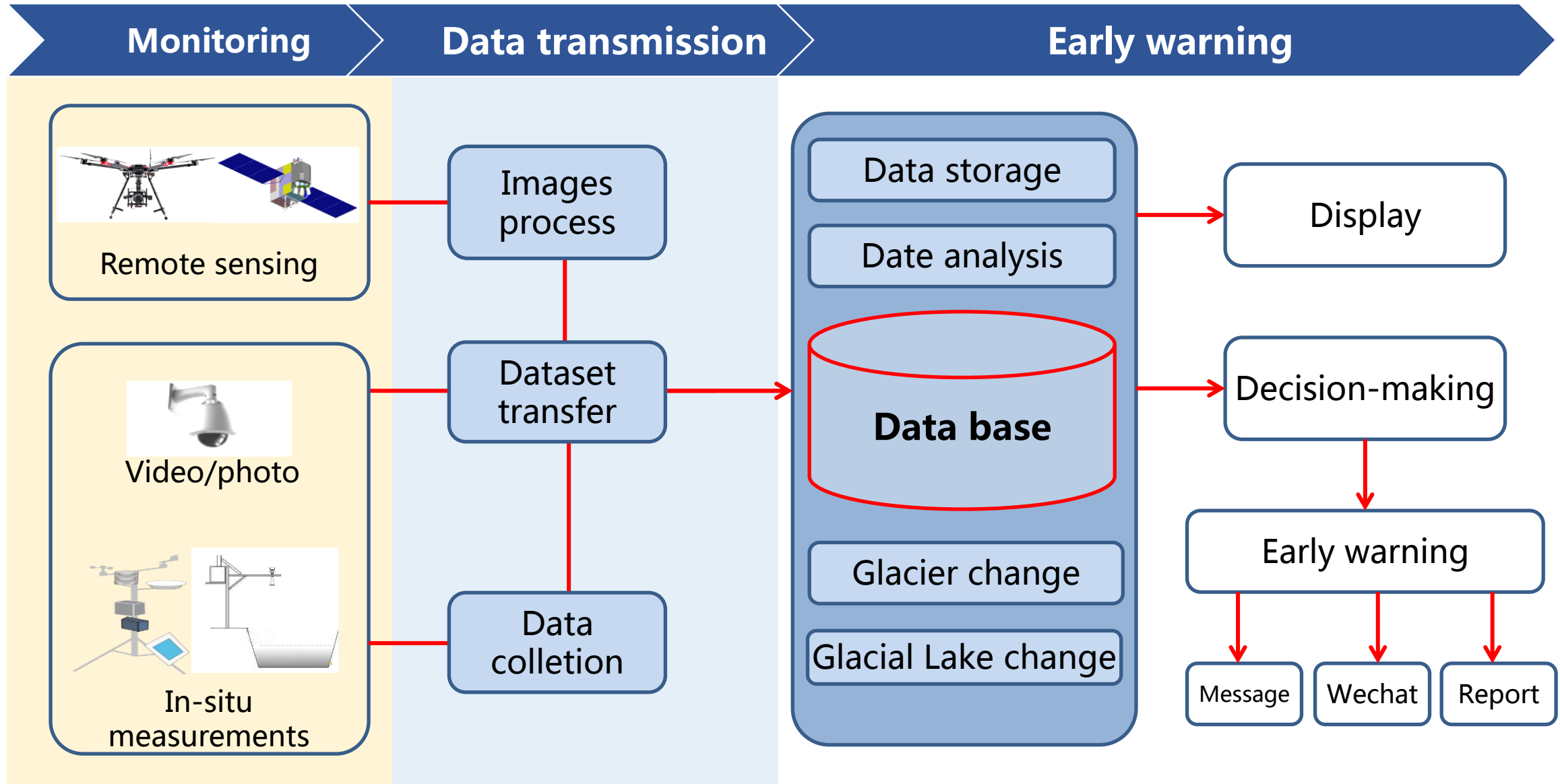
- Since 1980, a total of **93** GLOFs have been reported in the Third Pole, most of the events are located in the southeast Tibetan Plateau and Eastern Himalayas
- 40 events occurred in the region along the China-Nepal border
- GLOFs originate at higher elevations

Assessment of GLOF risk

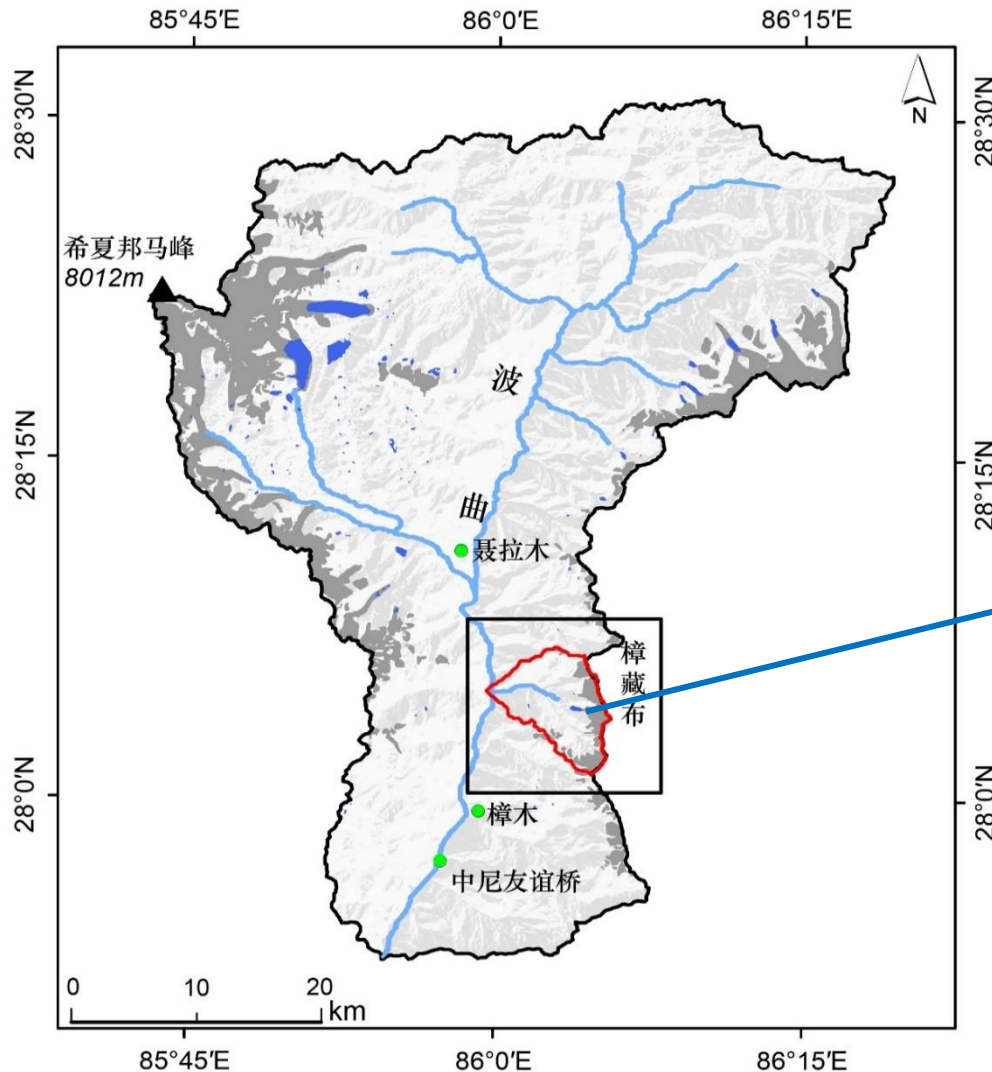


- Approximately **190,000** lives, **55,808** buildings and **5,005** km roads are threatened by the potential GLOFs
- Identify **85** lakes as posing a very high risk, mostly distributed in eastern and central Himalayas and southeast Tibetan Plateau

Early warning system (EWS) represent promising tools for adapting and mitigating GLOF risk



EWS for Cirenmaco glacial lake



- ❑ The Cirenmaco glacial lake have drained three times in 1964, 1981, and 1983, respectively. The 1981 flood moved over 50 km along the downstream Poiqu/Sun Koshi River, destroyed one hydropower facility, resulting in 200 fatalities.
- ❑ Recently, Cirenmaco has expanded rapidly, and been evaluated as dangerous glacial lake.

The Cirenmaco GLOF EWS is under establishing

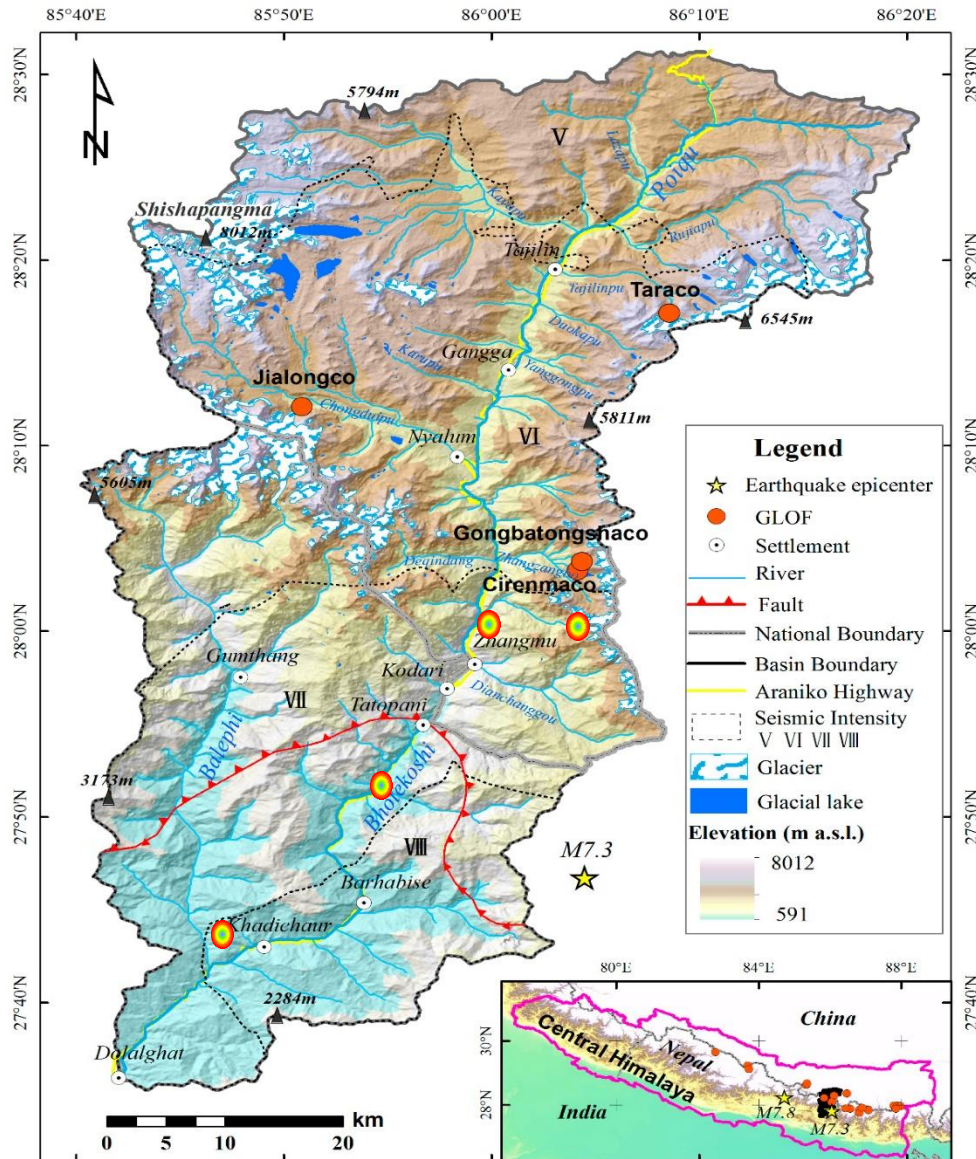


Monitoring

Data transmission

Early warning

Monitoring system



Source: Liu et al. 2020



upstream

Glacial lake

1 Water level monitoring

2 Meteorological monitoring

3 Image and video monitoring

4 Moraine displacement monitoring

5 Seismic monitoring

midstream

Zhangzangbo

6 Water level monitoring

7 Meteorological monitoring

8 Image and video monitoring

9 Seismic monitoring

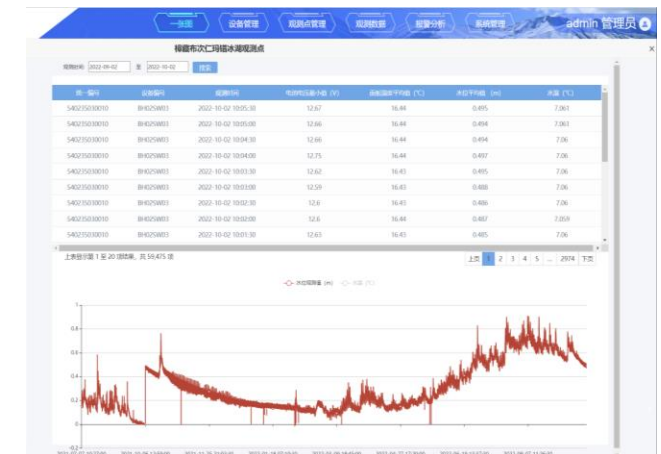
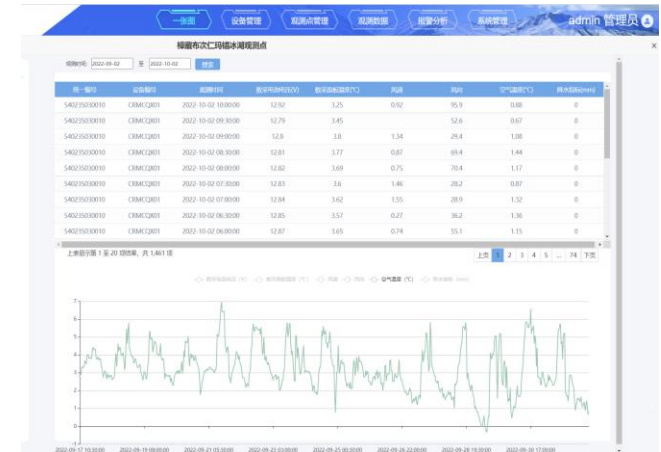
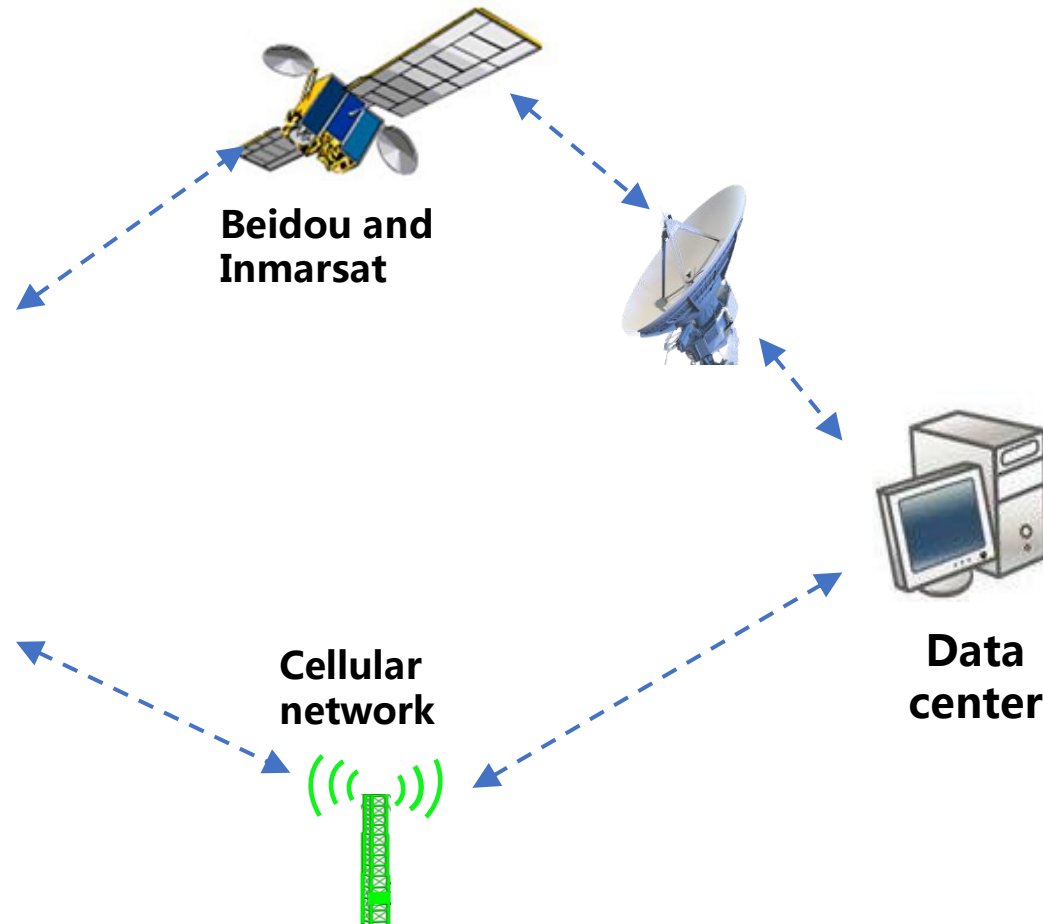
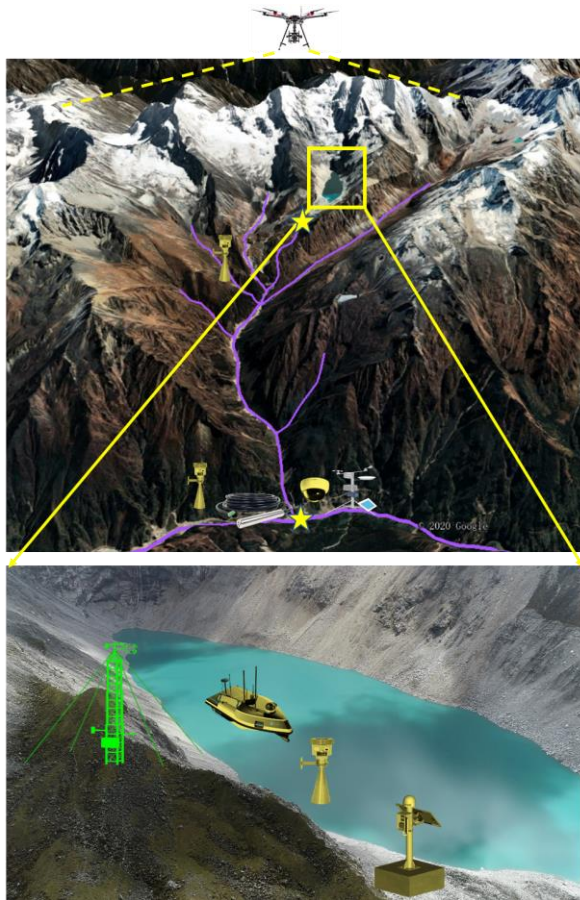
downstream

Nepal

10 Water level monitoring

Data transmission system

The real-time monitoring data were transmitted via BeiDou and Inmarsat satellites and cellular network to the data center for analysis.



Warning system

Water level threshold

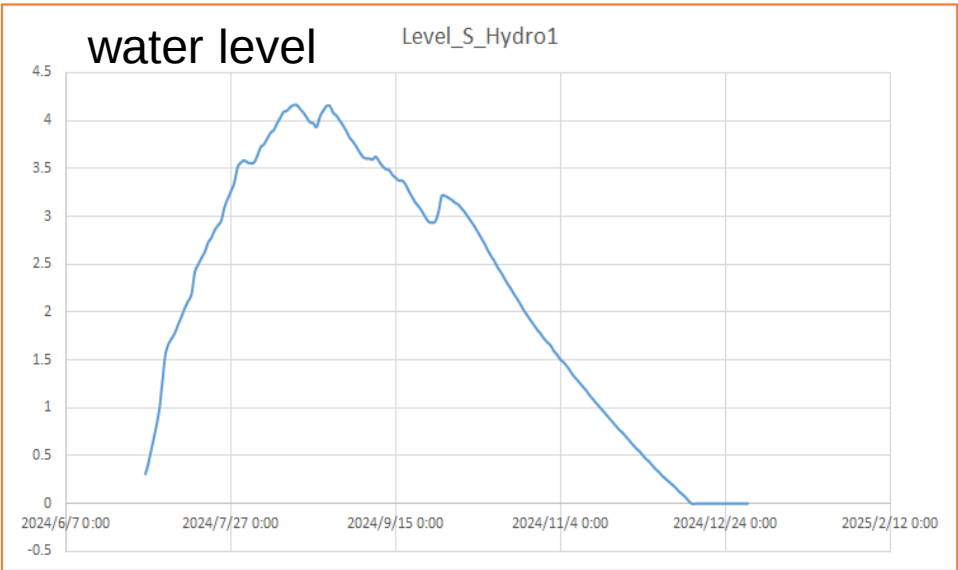
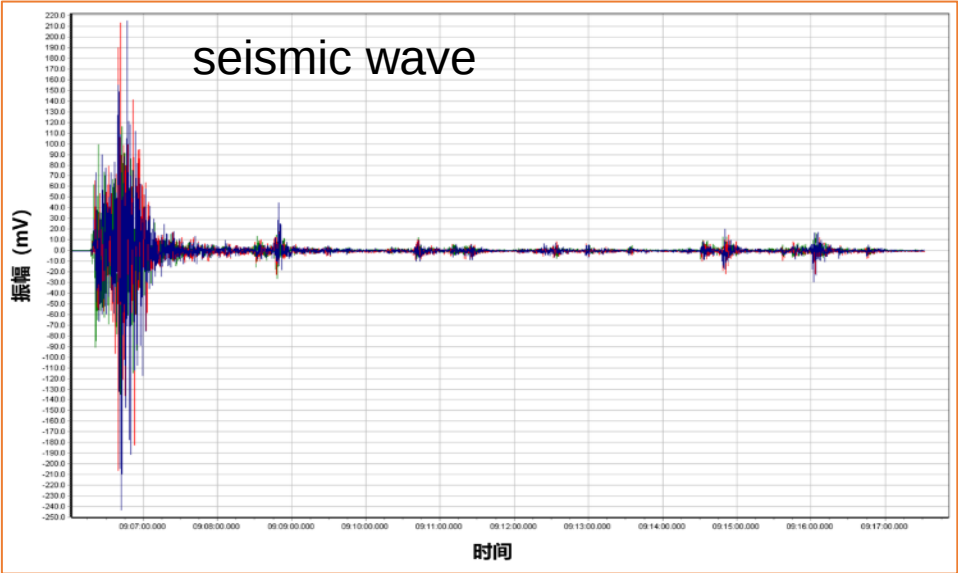
- Water level change $> 30\text{cm}/30\text{s}$, issue early warning alerts to relevant local authorities in a timely manner

Precipitation threshold

- Precipitation $> 10\text{mm/h}$, issue early warning alerts to relevant local authorities in a timely manner

Seismic wave amplitude

Cirenmaco EWS function in recent 6.8-magnitude earthquake in Tibet



Future perspectives on GLOF risk management

Monitoring potentially dangerous glacial lakes



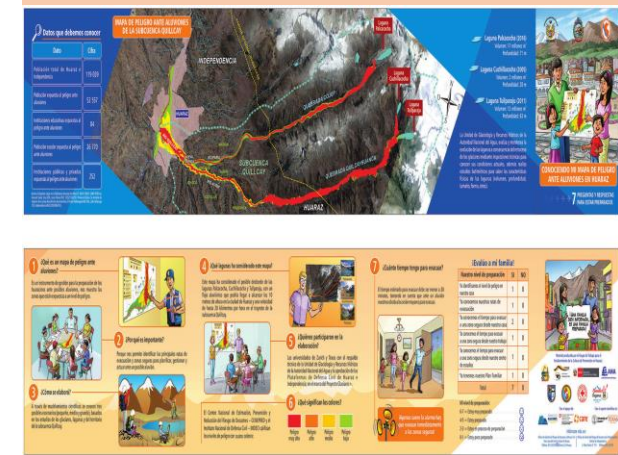
Building GLOF EWS for high-risk glacial lakes



Assessing future GLOF hazards and risks

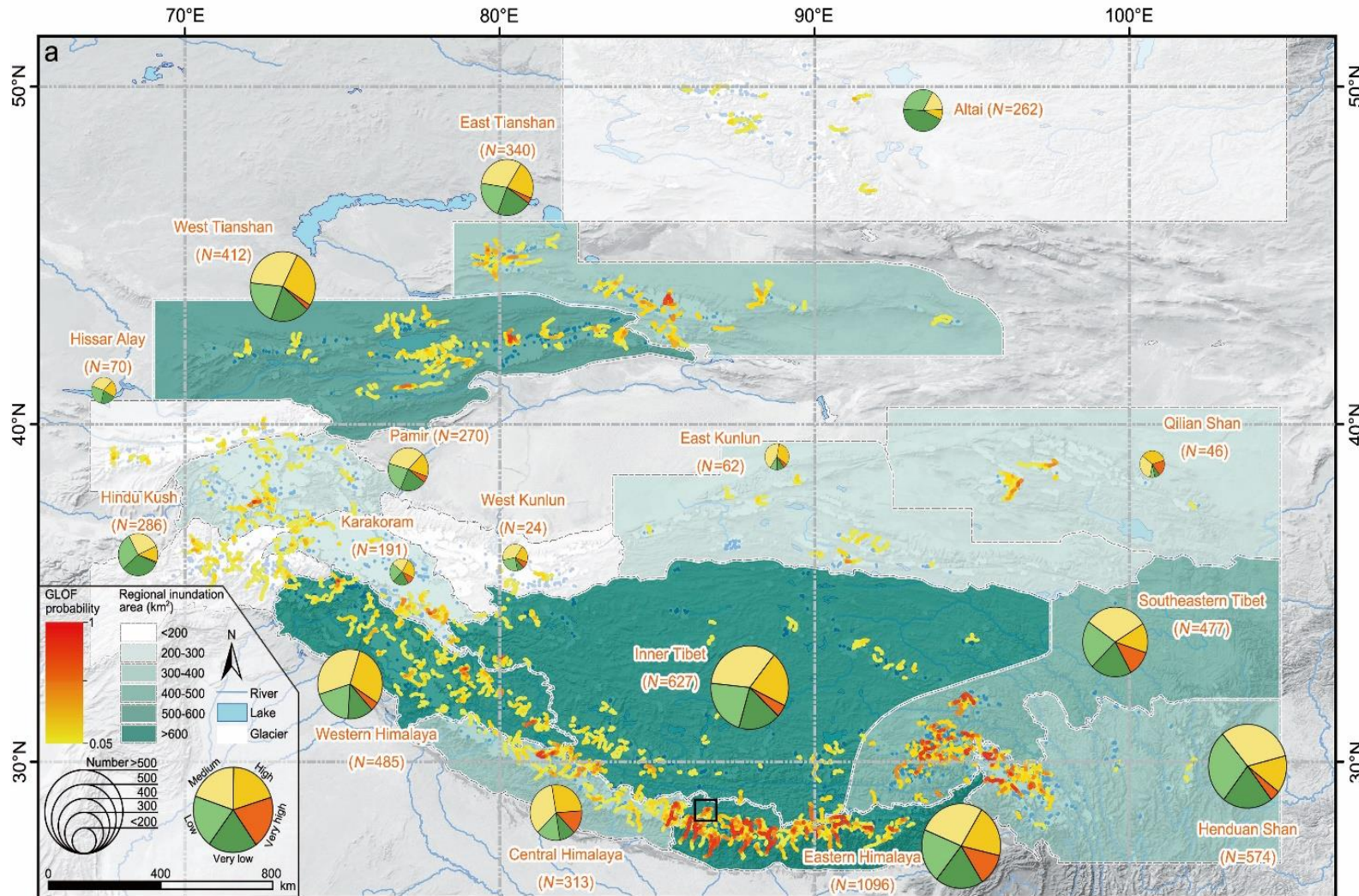


Training downstream communities



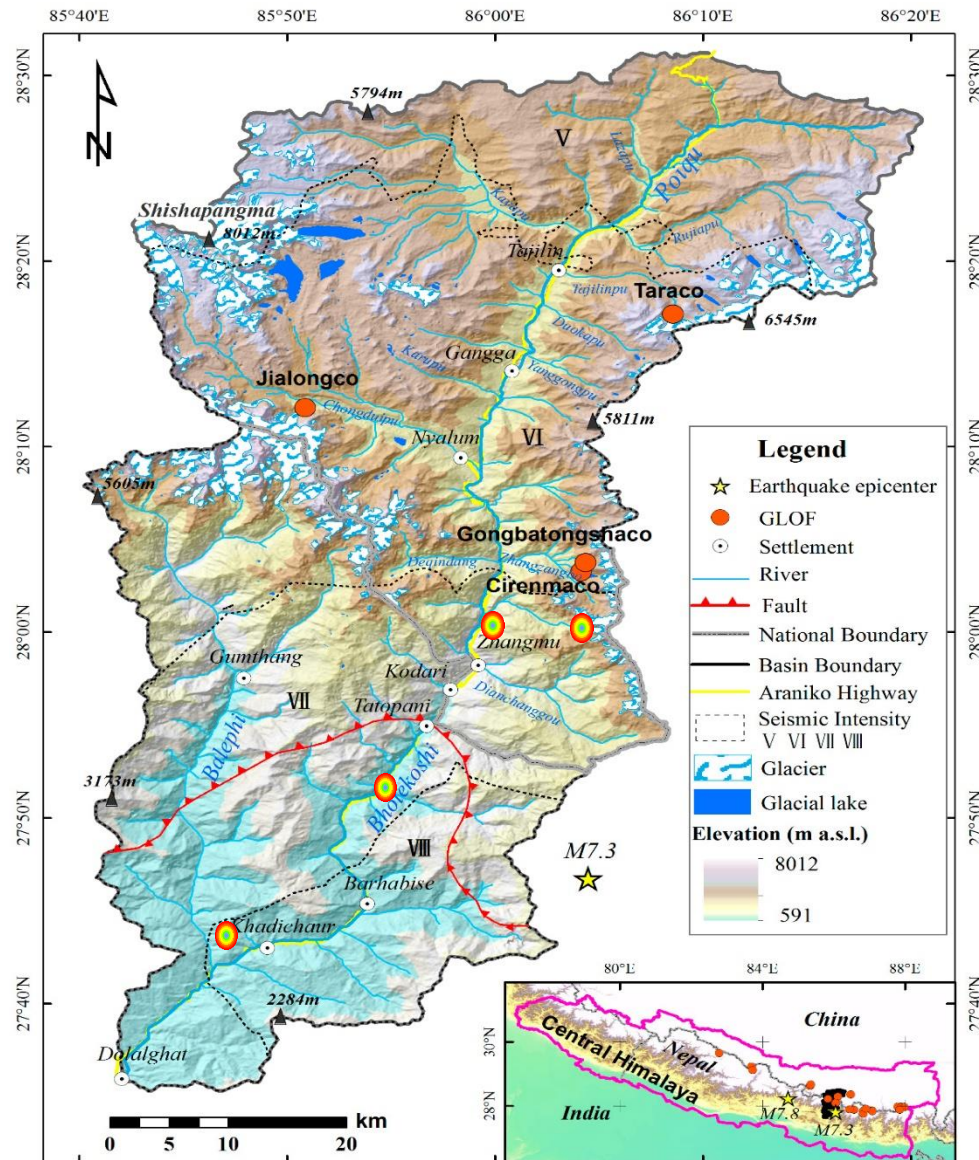
Thank you very much!

Potentially dangerous glacial lakes



- ❑ A total of **379** glacial lakes were classified as having a very high hazard level
- ❑ Identify **112** potential GLOFs with transboundary threats, including **55** along the China-Nepal border

Cross-border EWS for Cirenmaco GLOF



- To establish a cross-border early warning system for GLOF disasters covering the upper, middle, and lower reaches, we built upon the existing system and set up early warning platform in two cross-sections in Nepal.



Glacial lake

Zhangzangbo

Sun Koshi river

