



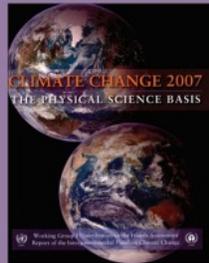
**CLIMATE-RESILIENT DAMS AND
HYDROPOWER INFRASTRUCTURE
INTEGRATING
ENVIRONMENTAL SUSTAINABILITY
IN PLANNING AND DEVELOPMENT**

**The Himalayan at Tipping Point: Climate Change,
Glacier Retreat and Water Security**

Dr. Ajay Pradhan, PhD

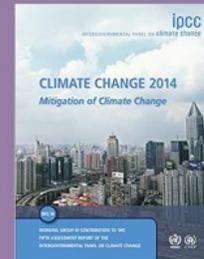
Vice President – 3i KIIT University & President & CEO

BACKGROUND



Climate change is the most prominent force of global change in the modern era

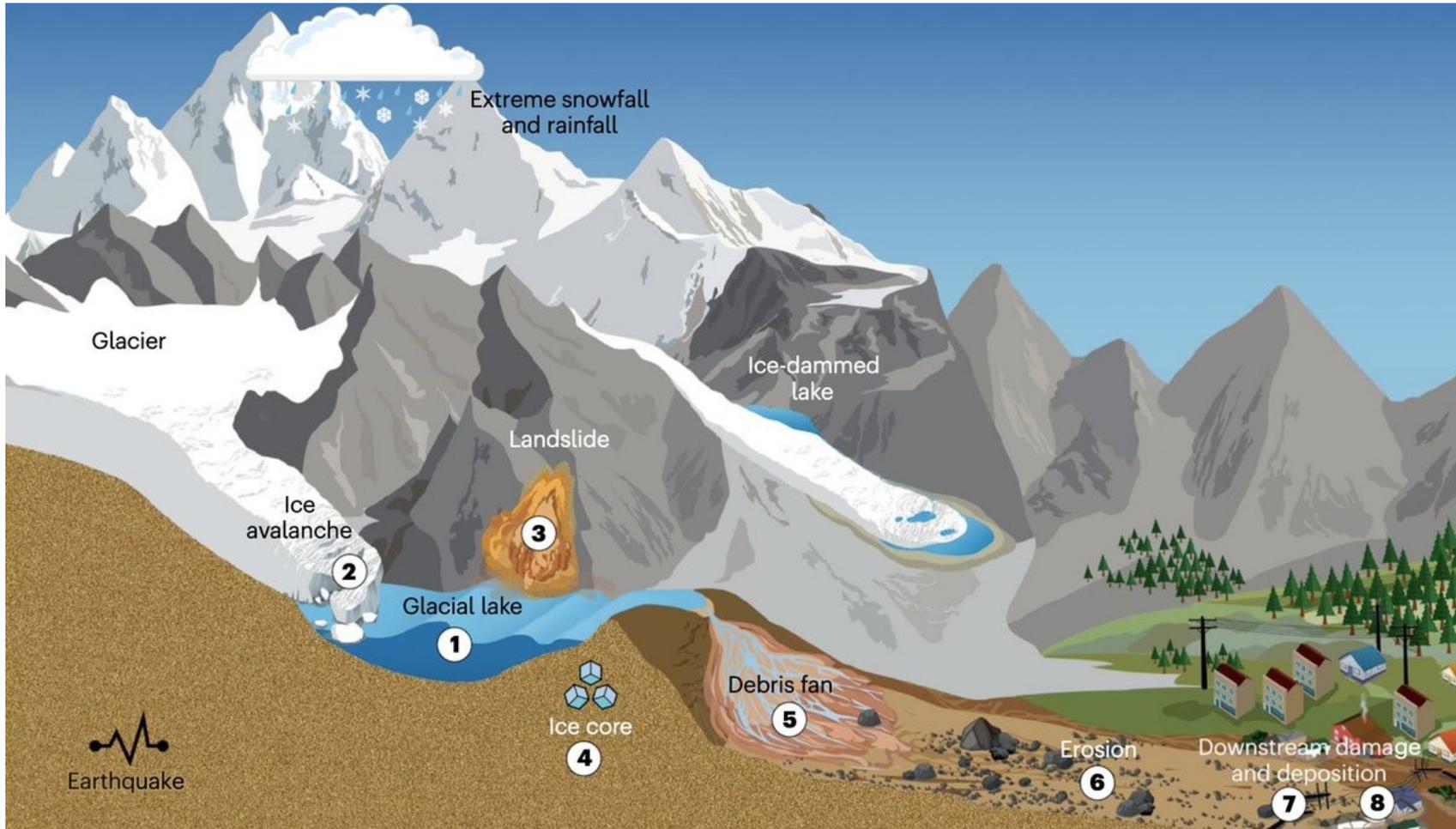
HKH region is seen as 'a data gap' area, lacking consistent long-term monitoring



2014 IPCC AR5

HKH region still largely missing

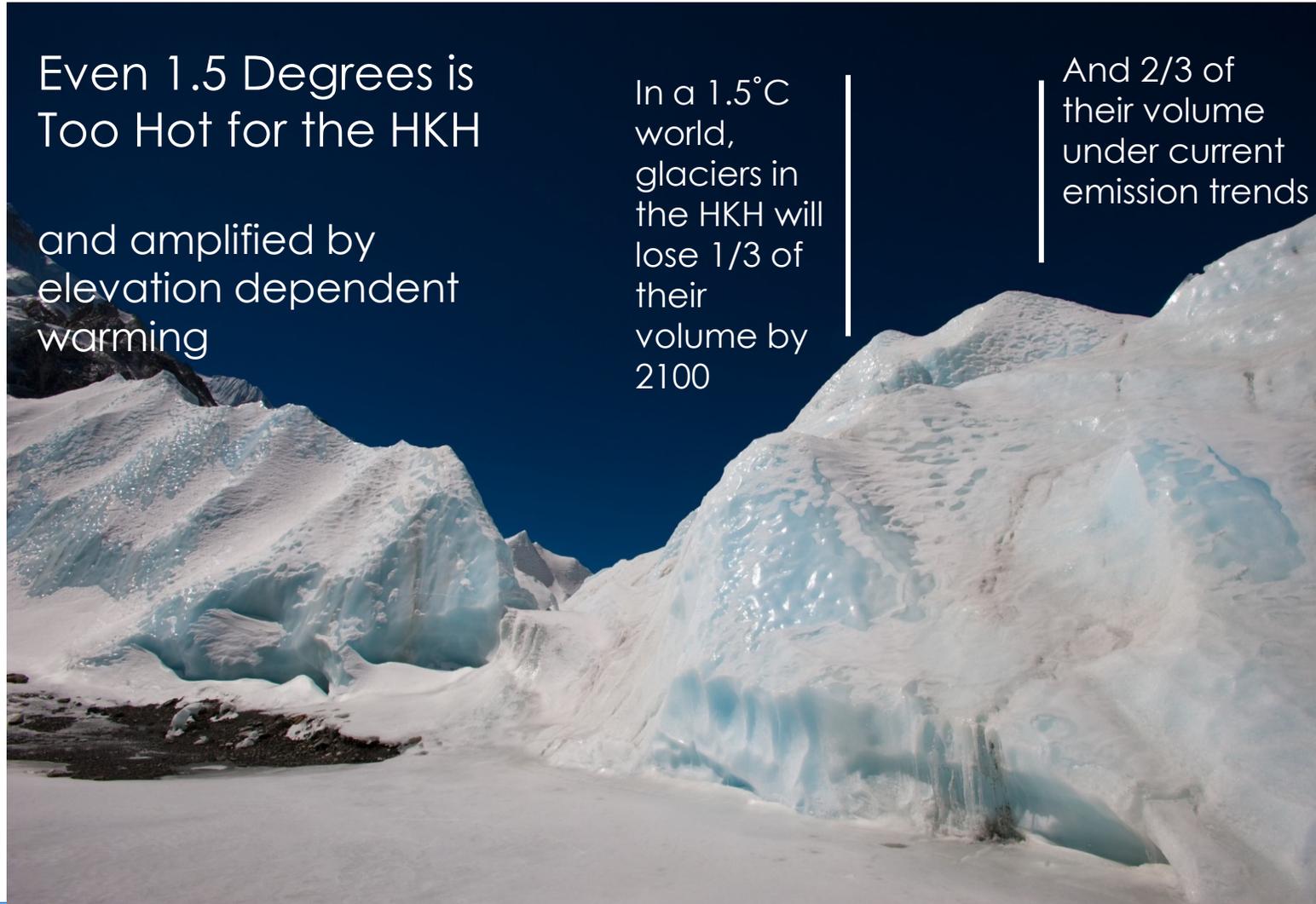
Glacial Fluvial Landforms



What happens here affects one-fourth of humanity



ELEVATION AND RISE IN TEMP



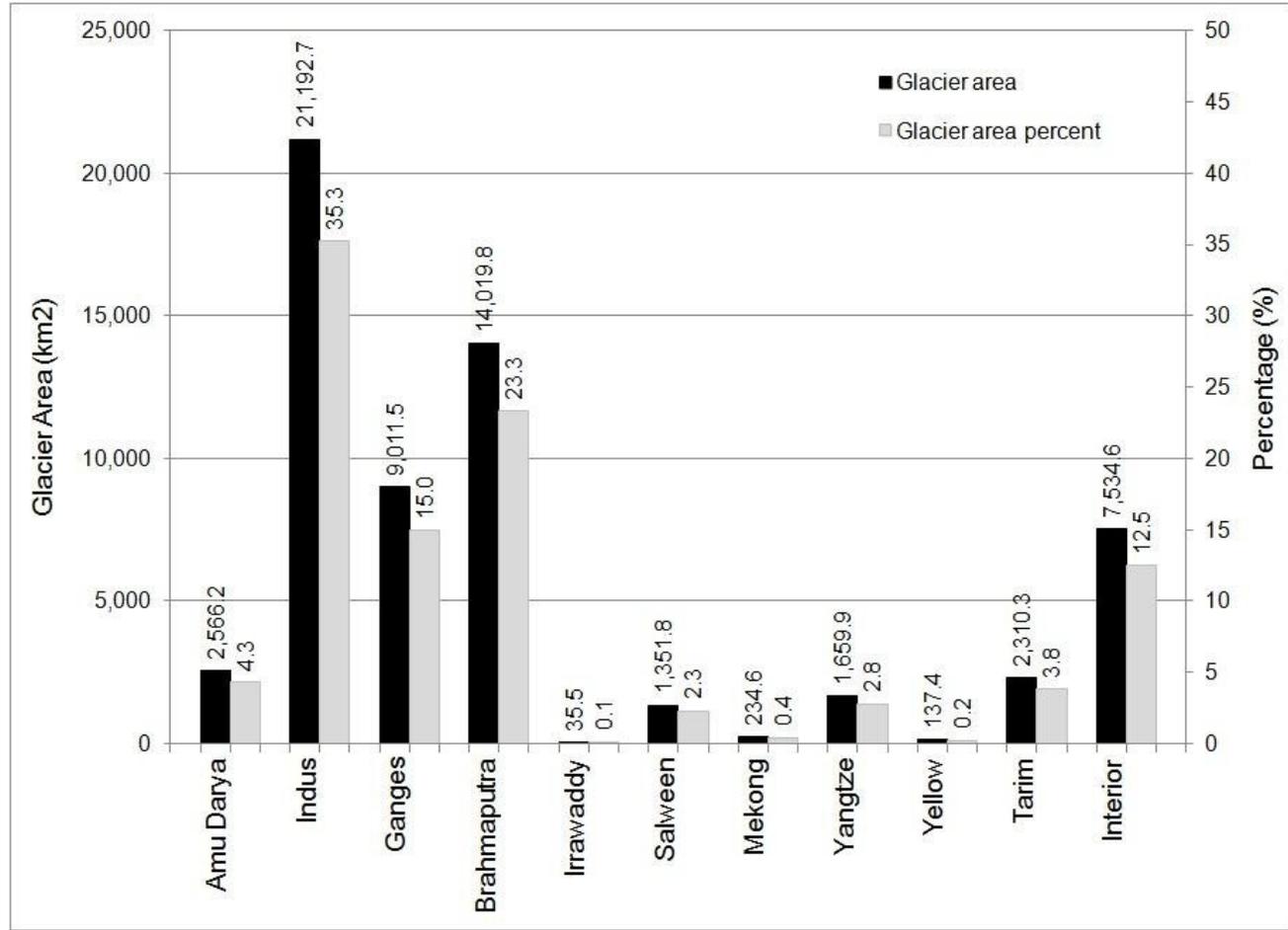
Hydrology

The rivers of the HKH region provide water for 2.5 billion people.



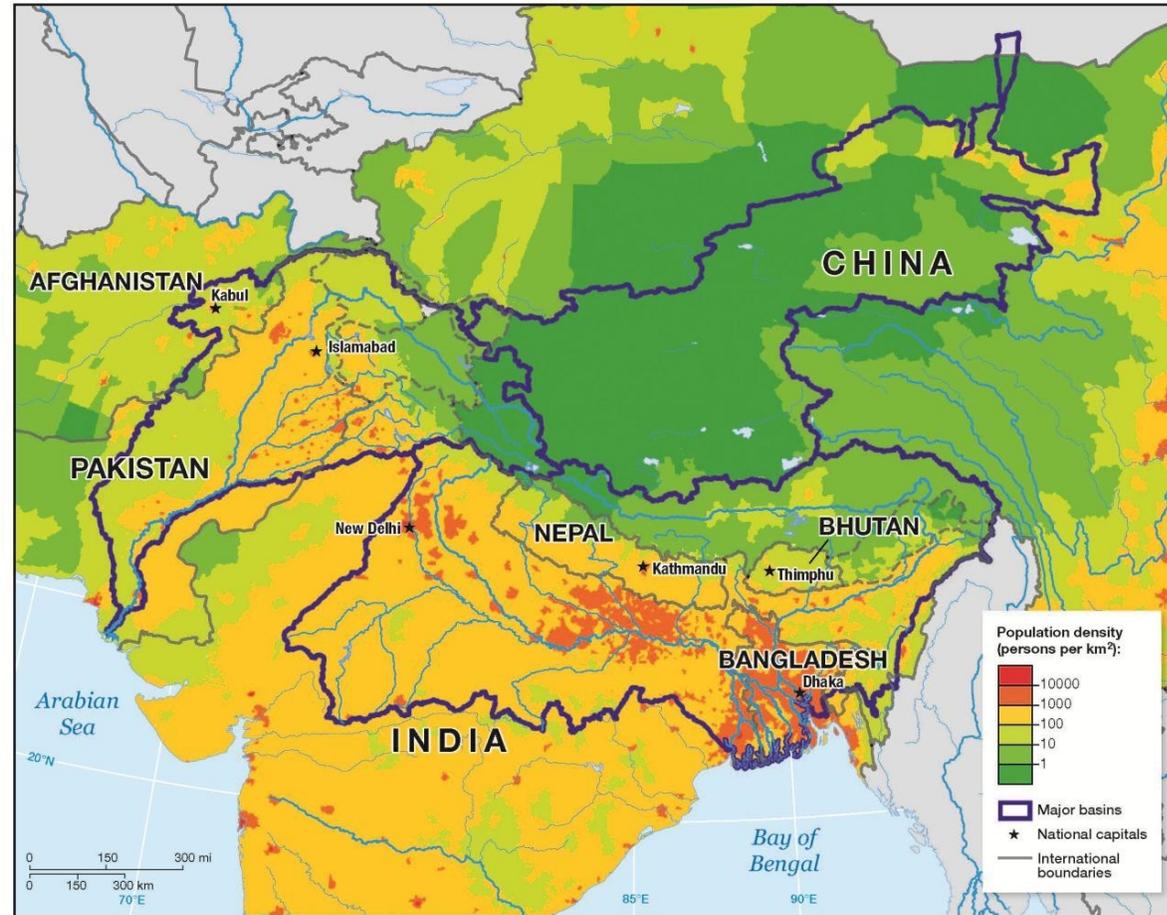
HYDROLOGY

Only the **Indus, Ganges, Brahmaputra**, and the **rivers of the Tibetan Plateau** contain more than five percent of the region's glacier area and are most likely to be affected by glacier retreat.

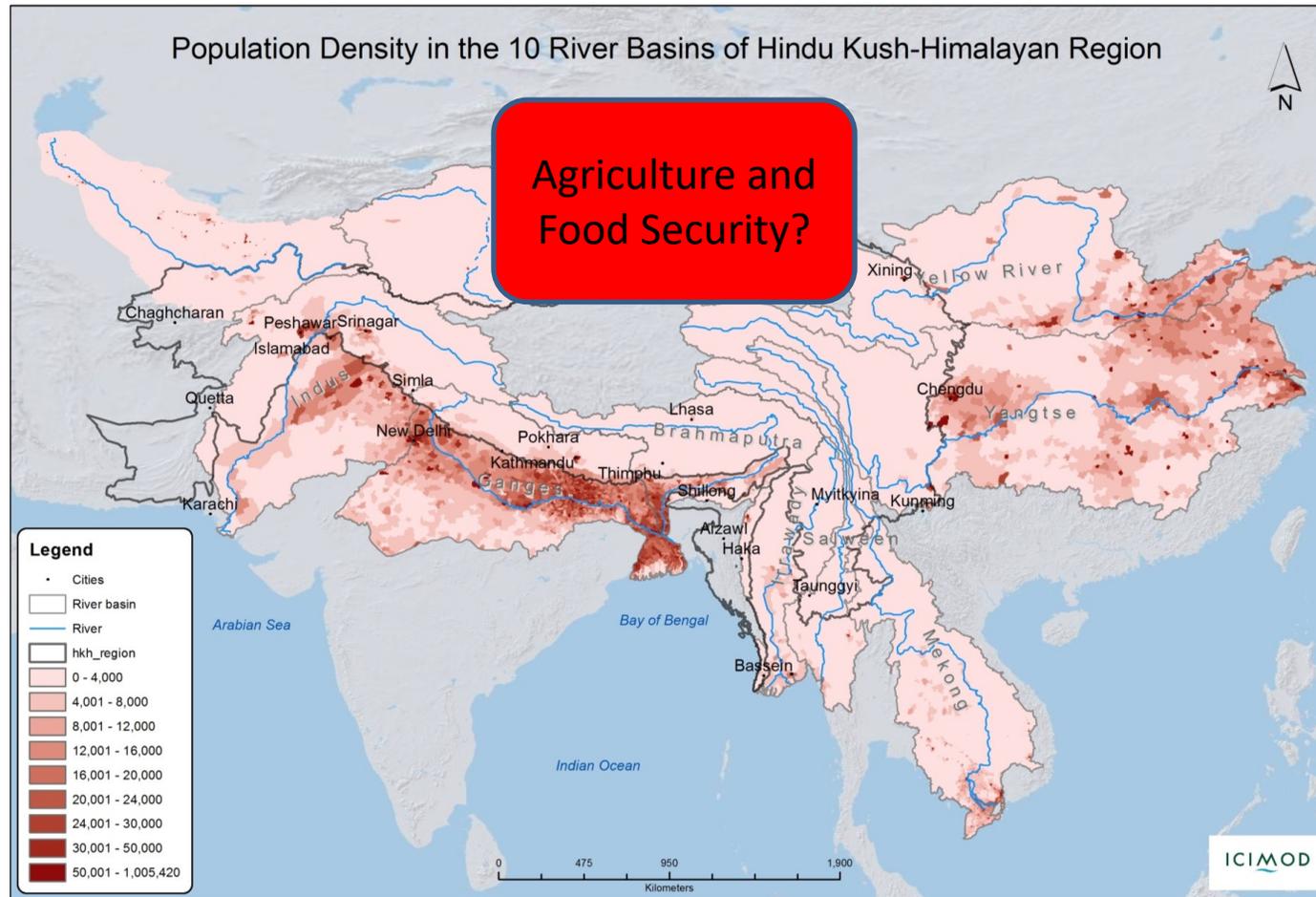


Demographic Scope

The densely populated basins of the **Indus**, **Ganges**, and **Brahmaputra** are most likely to be affected by glacier-related changes in water supply.



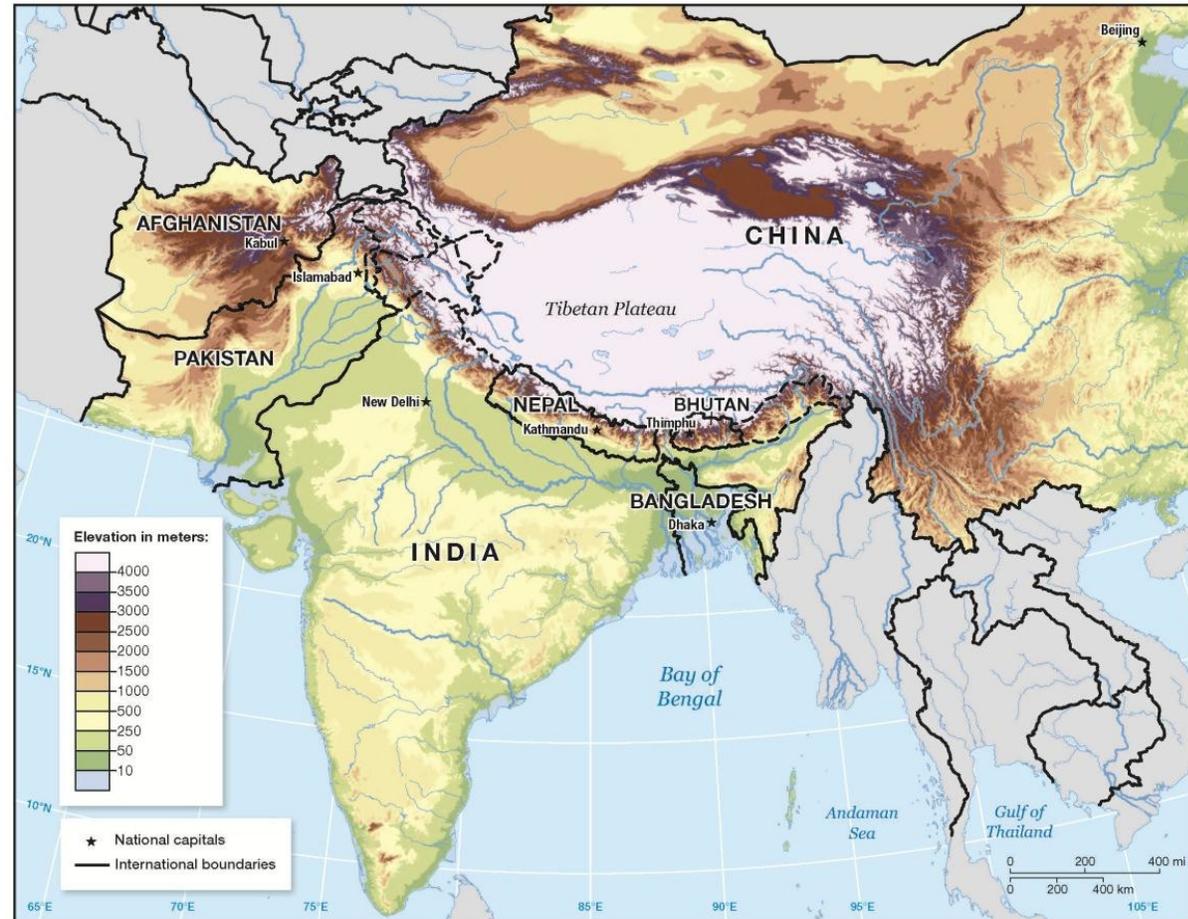
Basins Support some of the Most Populated Areas on the Globe



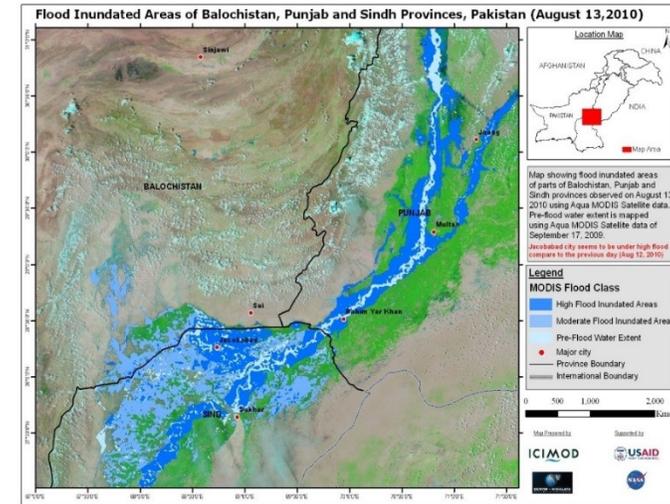
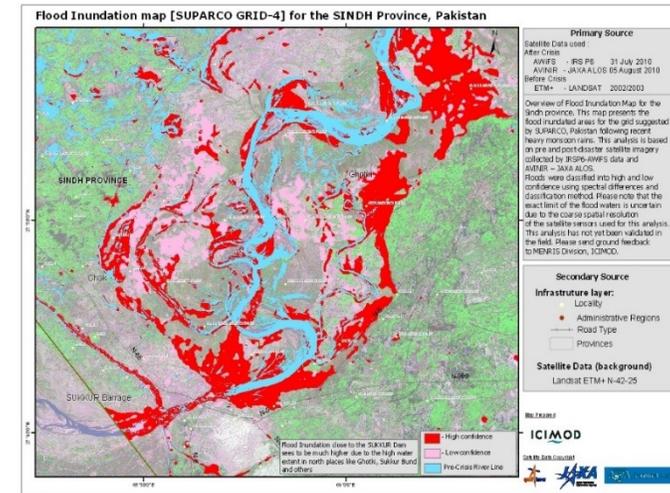
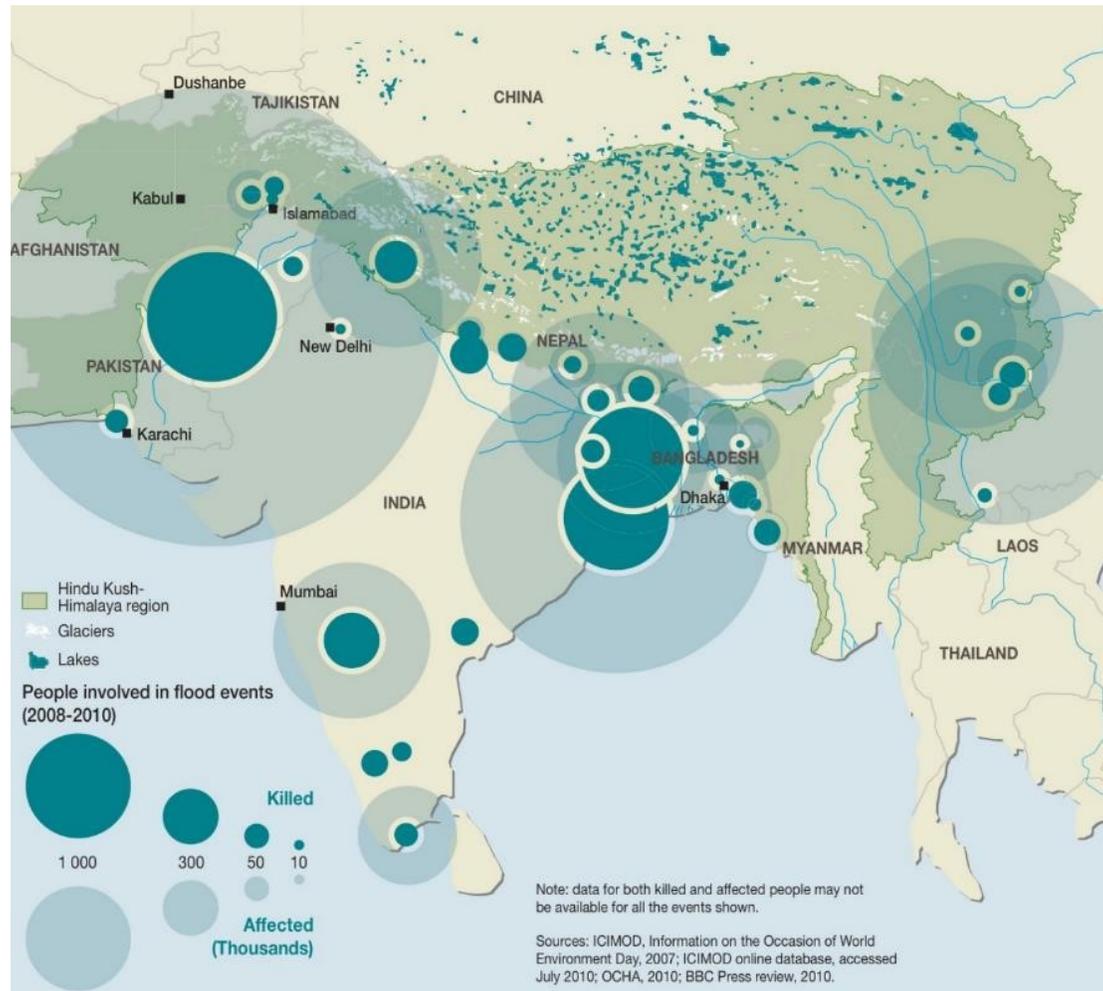
A Vast and Varied Region

The HKH, rising from its base in the alluvial Indo-Gangetic Plain near sea level to the great heights of the HKH (~8,000 m) in a distance of 100 to 400 km, has a very high climatic gradient across the region. The region's climate ranges from tropical at the base of the foothills to permanent ice and snow at the highest elevations.

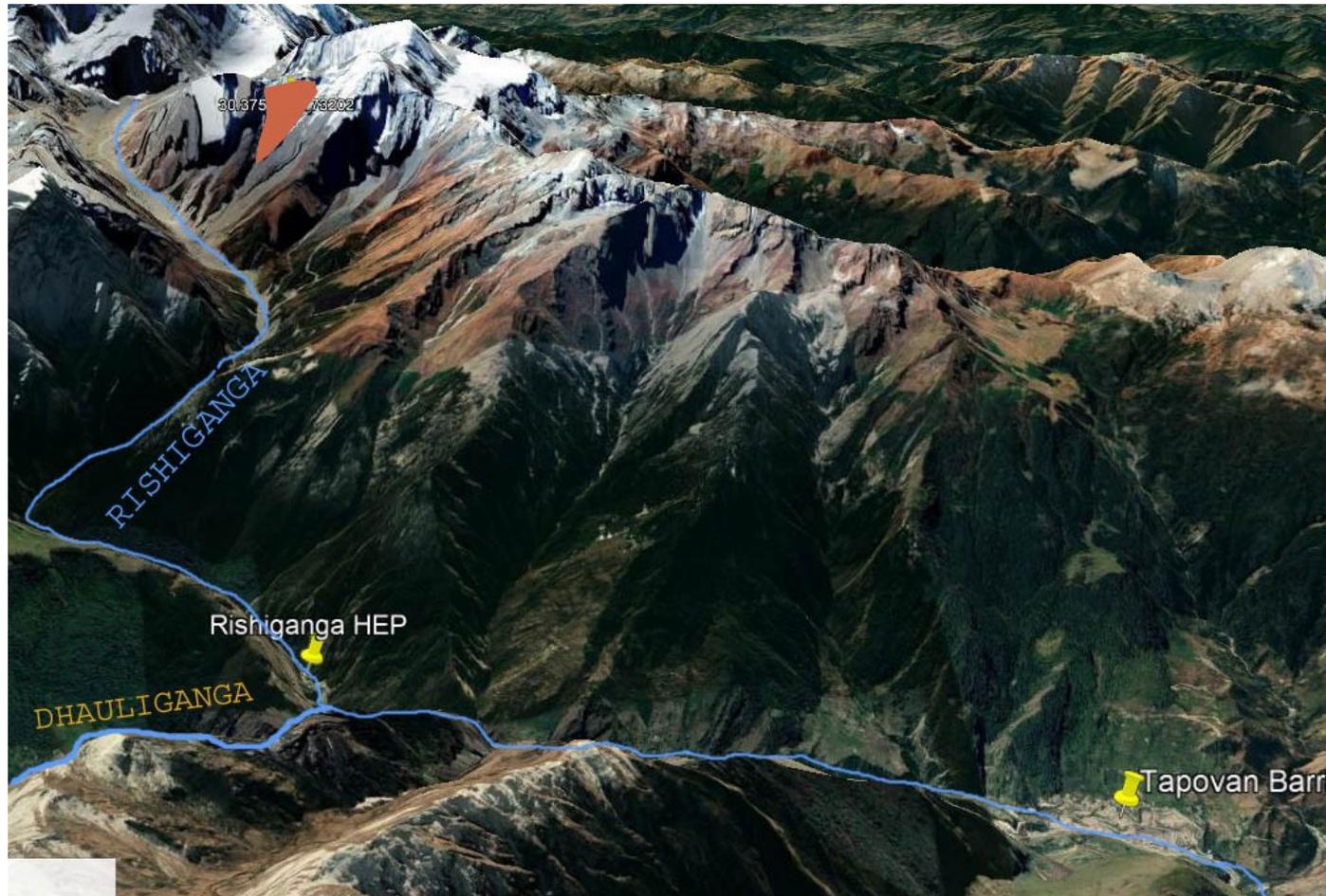
The climatic gradient is strong not only across, but also along the arc of the Himalayas. In the west, most precipitation falls as snow in the winter, while in the east, precipitation is dominated by the summer monsoon.



Increasing Frequency and Magnitude of Disaster



Location of Hanging Glacial Burst



09 February 2021

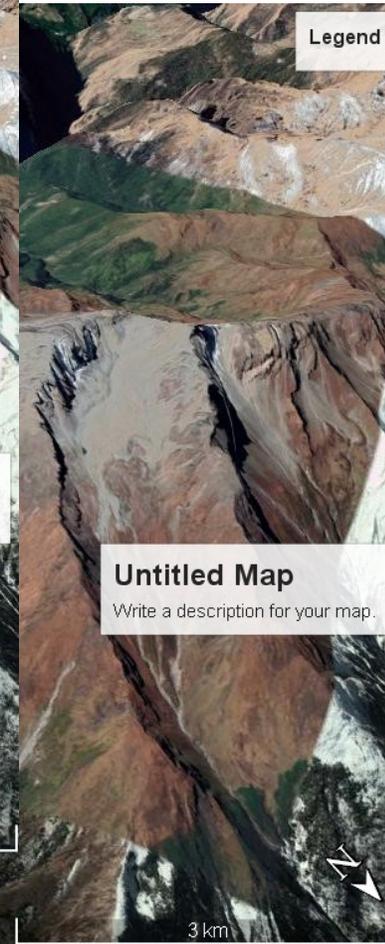
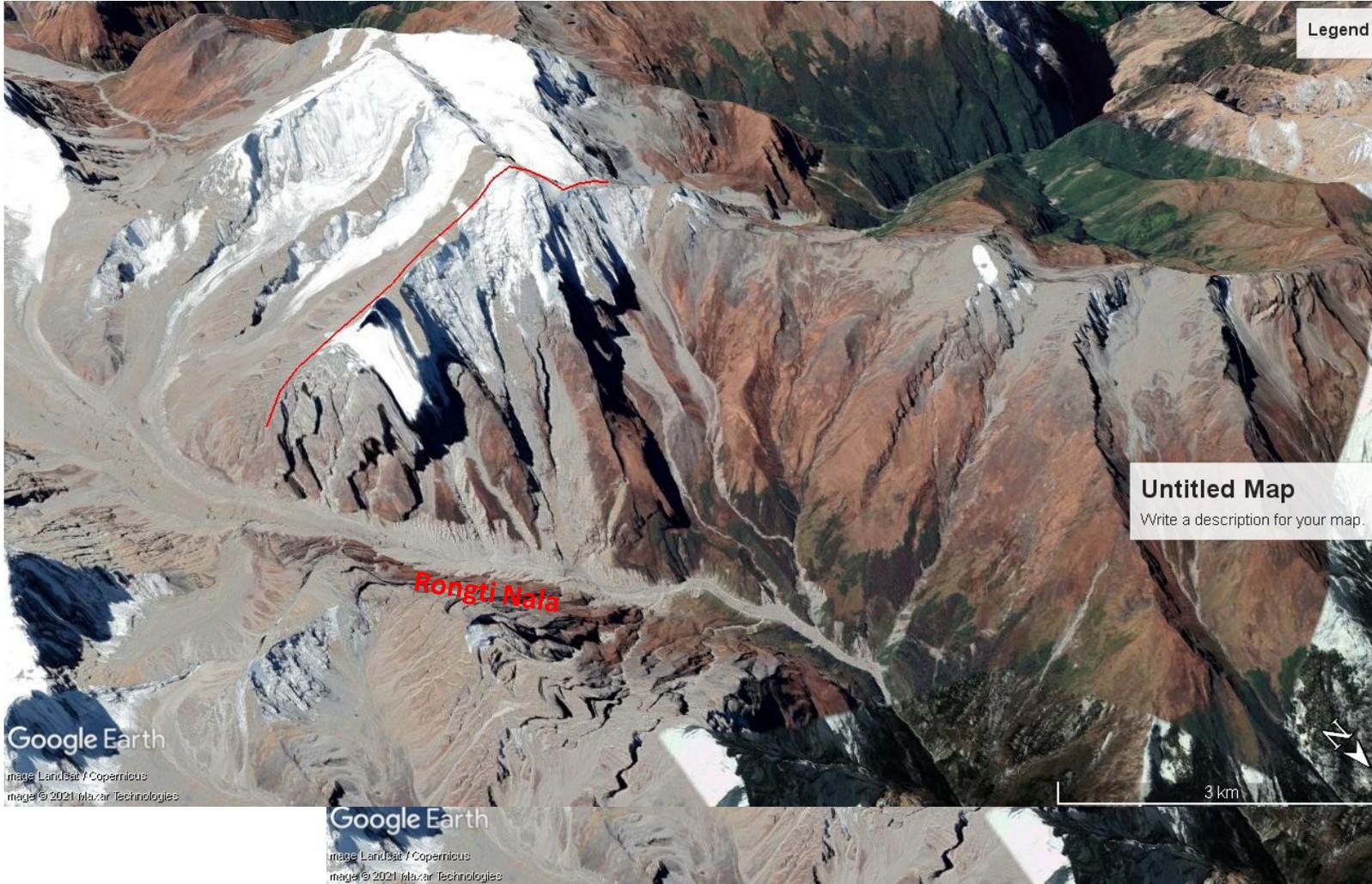
Path of debris after hill slope failure at Glacier Heading



Hill slope failure at Glacier Heading in Rongti Nala



RONGIT NALA

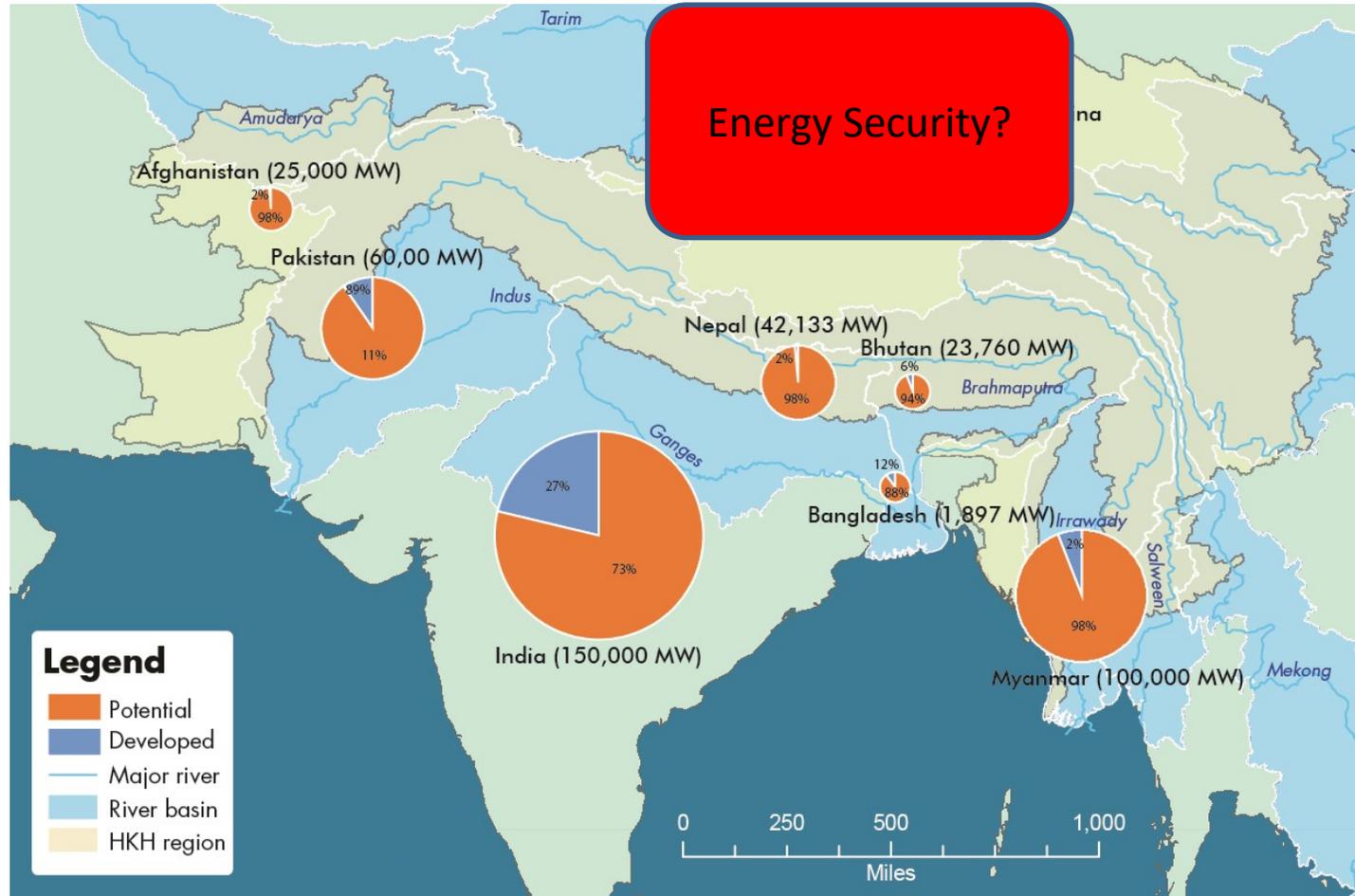


Large Lake Formed



Lake due to river damming at confluence of Rishiganga and its tributary

HEP Potential in the Region



Flooding of Tapovan Vishnugarh HEP Barrage

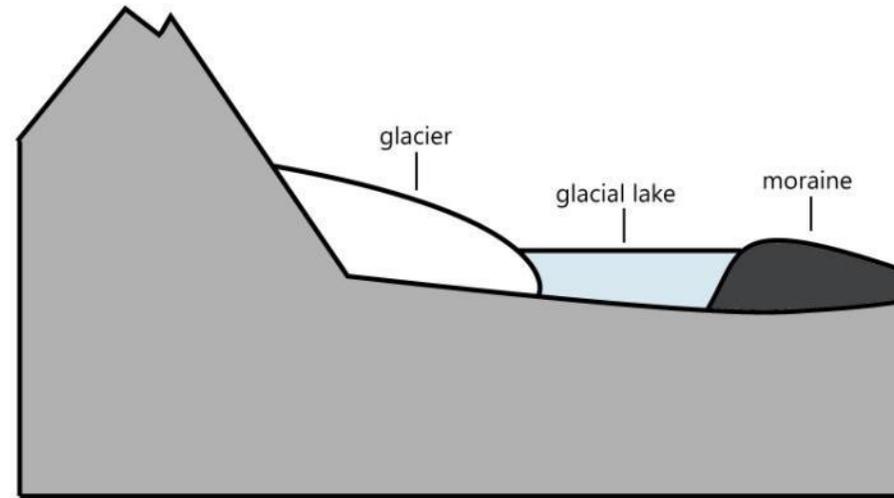


NTPC Barrage at Tapovan



Climate Change-Induced Hazards

- Glacial retreat is unlikely to lead to flows of water large and rapid enough to cause flooding, but the region does face other hazards.



A moraine-dammed glacial lake formed by glacial meltwater. Failure of the confining moraine dam leads to an outburst flood. Outburst floods include both Glacial Lake Outburst Floods (GLOFs) and Landslide Lake Outburst Floods (LLOFs).

- For upstream populations, GLOFs and LLOFs are the dominant physical hazard risk.

For downstream populations in the central and eastern Himalayas, floods from changes in monsoon rainfall and cyclones are more likely to be important.

Chorabari GLOF – Kedarnath 2013



Kedarnath Shrine



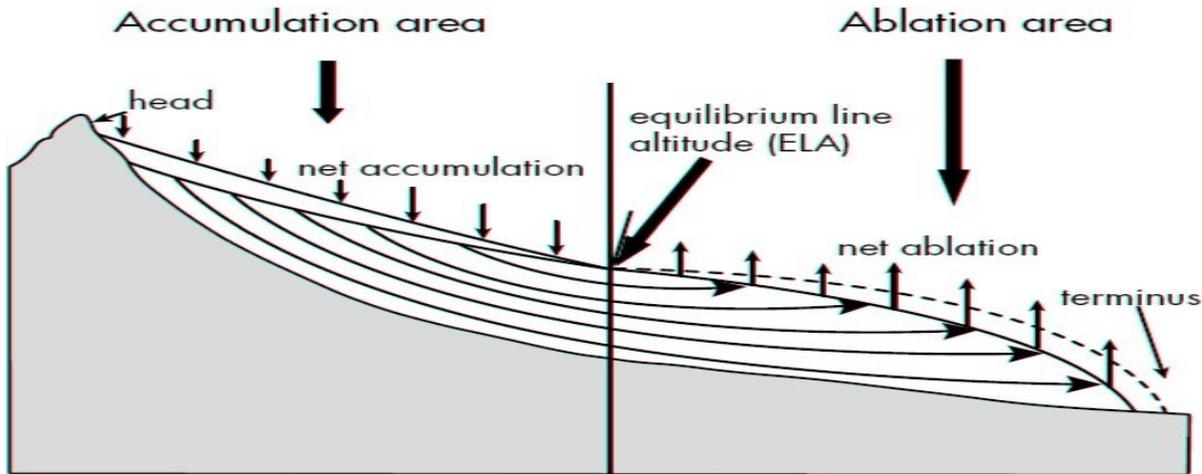
Khirao Ganga 2013



Consequences of Vsihnuprayag Hydro 2013



Glacier Retreat



GLACIAL MASS BALANCE:

Glacial Retreat Occurs When:
Ablation > Accumulation

Climate change & retreating Himalayan snowline

Gaurav Talwar
@timesofindia.com

Dehradun: From Uttarakhand's river valleys to the slopes below Mount Everest, scientists are recording a steady upward retreat of snowline across large parts of Himalayas, offering one of the clearest and most visible signals yet of accelerating climate change in the world's highest mountain range.

Incidentally, snowfall across much of the Indian Himalayan region has been significantly below normal this winter, deepening concerns among scientists about thinning snowpacks, early melt and long-term impacts on water security.

"There is clear evidence that the seasonal snowline has shifted upward in many parts of the Himalayas over the past 2-3 decades," said professor Anjal Prakash, an IPCC author and research director at Bharti Institute of Public Policy of the Indian School of Business. "Warmer temperatures and reduced snowfall are exposing more rock and ice at elevations that were previously snow-covered during winter and spring," Prakash added.

Snowfall across much of the Indian Himalayan region has been below normal this winter, deepening concerns among scientists

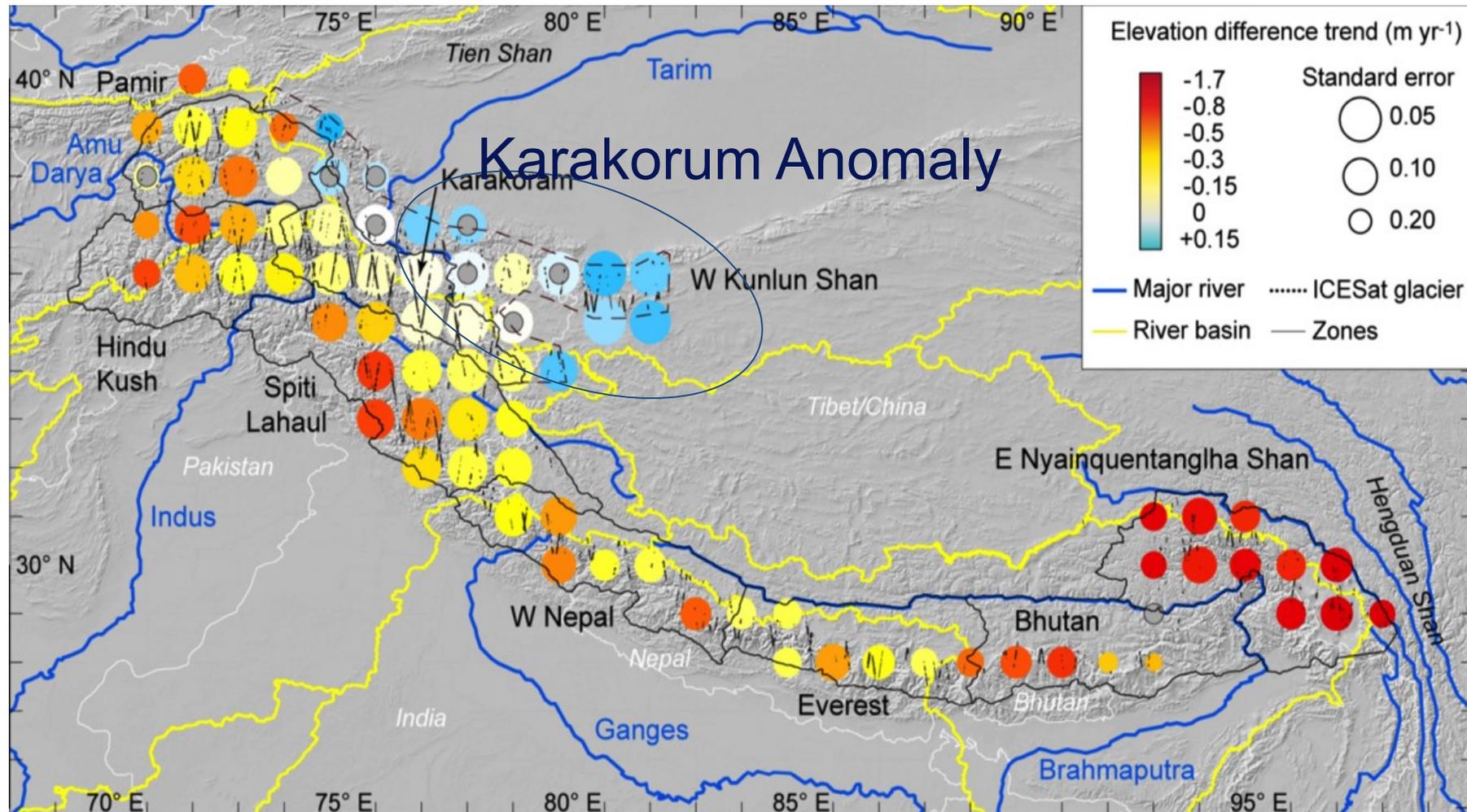
Scientists from Kumaon University, using satellite data from 1990 to 2022, found the average snowline in Gori Ganga watershed rose by about 520m, at over 16m per year. The study also documented a parallel upward shift in vegetation and treeline boundaries, indicating broader ecological response to changing climate. "Snowline, vegetation line, treeline and the citrus fruit belt in Gori Ganga basin shifted from lower elevations to higher ground," said professor DS Parihar of Kumaon University.

Similar signals are emerging farther east. A recent Nasa study recorded unusually high winter snowlines in Mt Everest region, where snow retreated upslope by nearly 490 feet within two months during the 2024-25 winter. Scientists said the findings suggest snow is increasingly failing to accumulate at lower elevations even during peak winter months.

"Himalayas are warming faster than the global average," Prakash said. "Even small temperature increases push the 0-degree isotherm upslope, meaning precipitation that fell earlier as snow is now increasingly falling as rain." Scientists warn a rising snowline weakens the Himalayas' natural water storage system, disrupts river flows and further heightens long-term risks to water security, ecosystems and livelihoods across the Indian subcontinent.

January 19, 2026

Most glaciers are losing ice volume



Glacier Retreat

- Glaciers in the **eastern** and **central** HKH are **retreating** at accelerated rates.
- The rates of glacier retreat in the HKH region are comparable to other parts of the world.
- Glaciers in the **western** HKH appear to be **more stable**, and perhaps even growing.
- Projected temperature increases will continue to contribute to glacier retreat. Future precipitation changes are less certain, but shifts in the location and intensity of rain and snowfall could affect the rate of glacial retreat.

Conclusion

- Most glaciers in the HKH region are retreating, and the consequences for the region's water supply are nuanced
- At lower elevations, shifts in the location, intensity, and variability of rain and snow will have a greater impact on water supply than changes in glacier retreat rates
- There is significant variability in the climate, hydrology, and glacier behavior as well as the demographics and water use patterns.
- Groundwater depletion and increasing water use will have a greater impact in the short term.
- Key responses
 - Monitor and measure
 - Make existing water management as effective as possible and Hazard Mitigation Systems

Way Forward

It is required to maintain reliable information on real time basis in terms of

- *Topography*
- *Morphology*
- *Geology*
- *Drainage Pattern*
- *Glaciology*

For Catchment area in river basin of steep gradient.



