Glacial lake hazard assessment : Case studies from two potentially dangerous glacial lakes in the Nepal Himalaya.

Sudan Bikash Maharjan

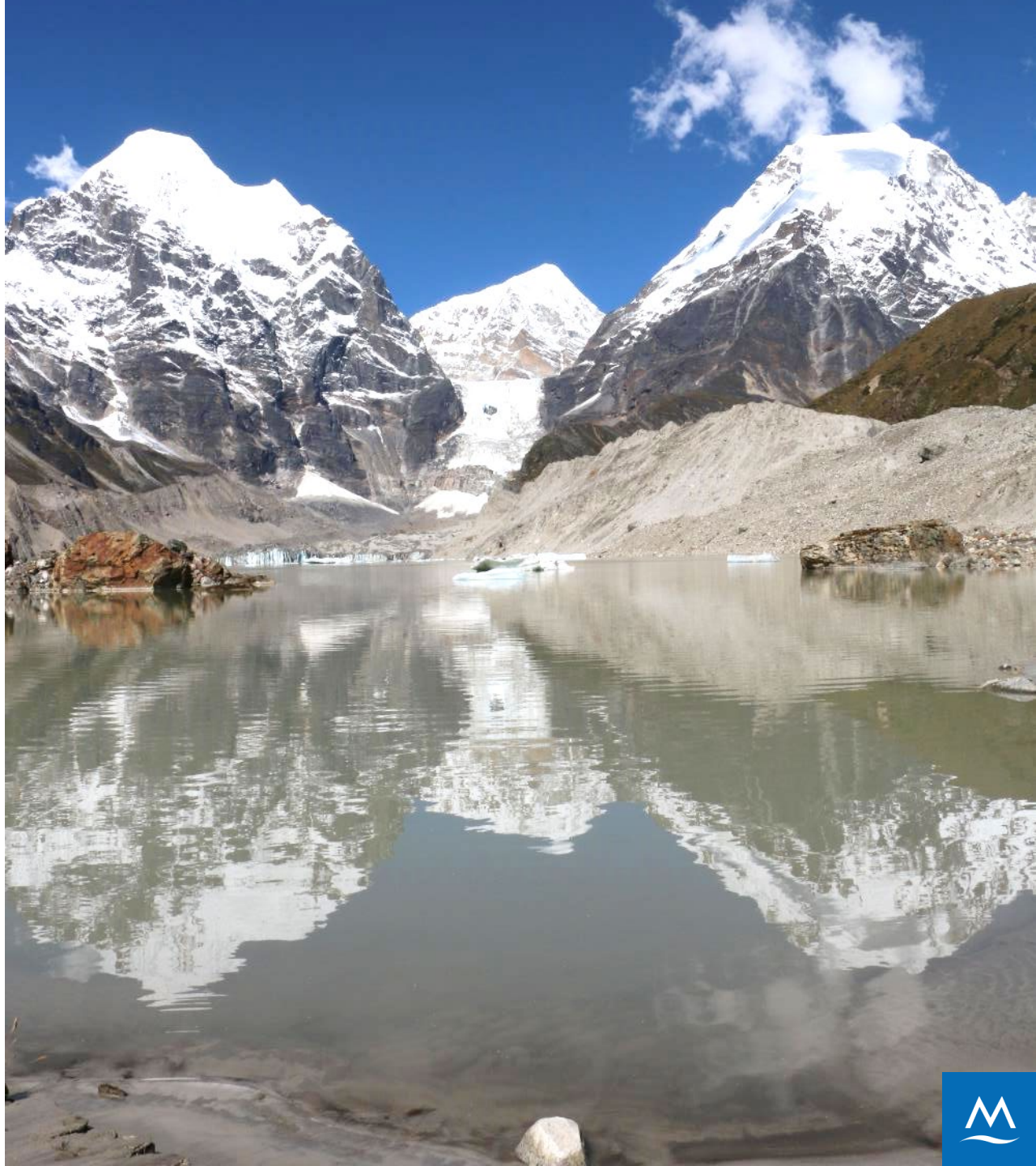
Remote Sensing Analyst - Cryosphere

Sharad P. Joshi, Tenzing C. Sherpa and Rakesh Kayastha

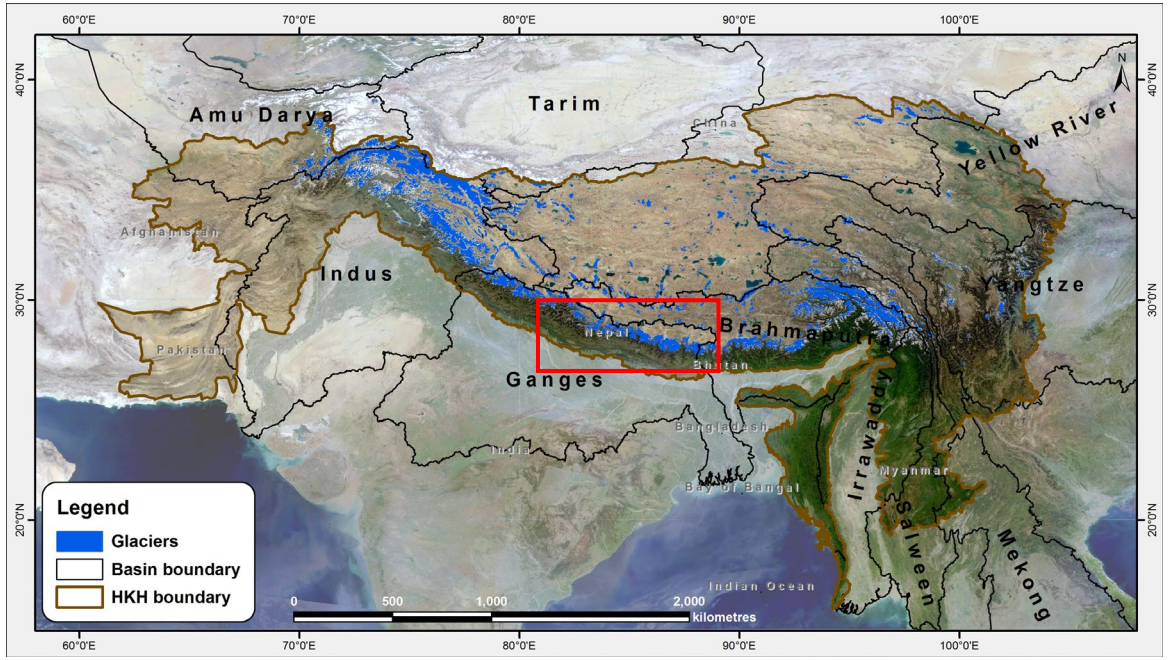
Cryosphere and related hazards in High Mountain Asia in a changing climate
1 – 4, November 2022, Almaty, Kazakhstan

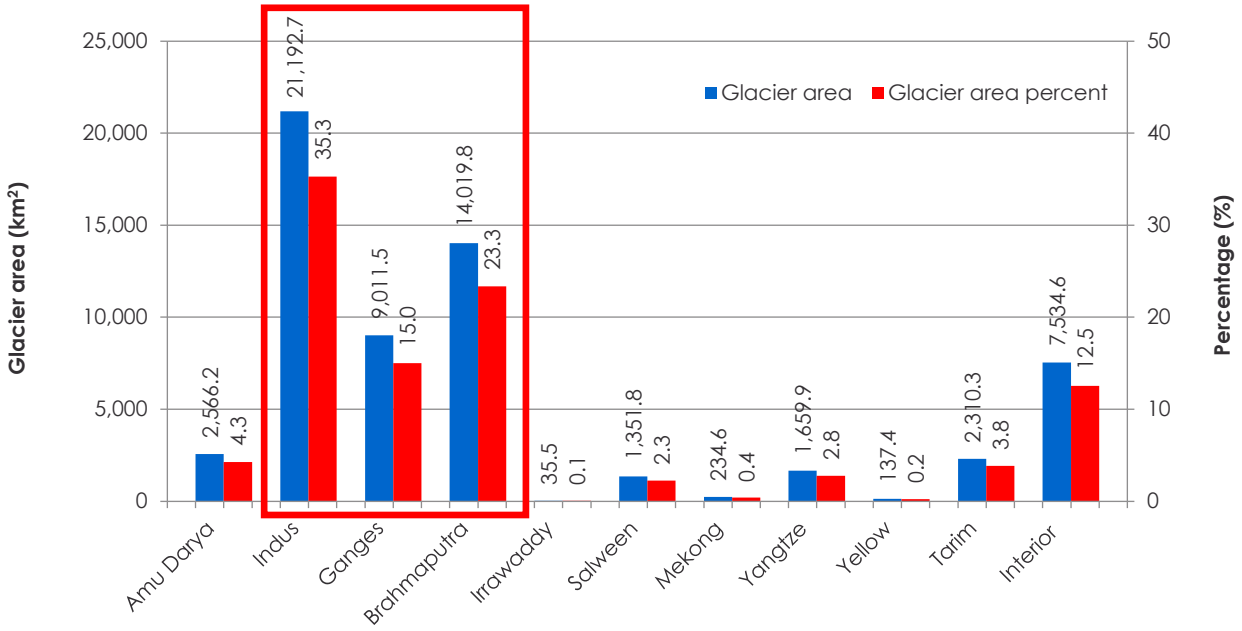
Outline

- Background
- Glacial lakes and GLOFs in 3 transboundary basins of Nepal
- Identifying potentially dangerous glacial lakes (PDGLs) (Action jointly with UNDP to support Nepal Government for GLOF risk reduction project development).
- Field survey and findings from Two PDGLs from Nepal.
- Information sharing
- Way forward



The Hindu Kush Himalaya Region



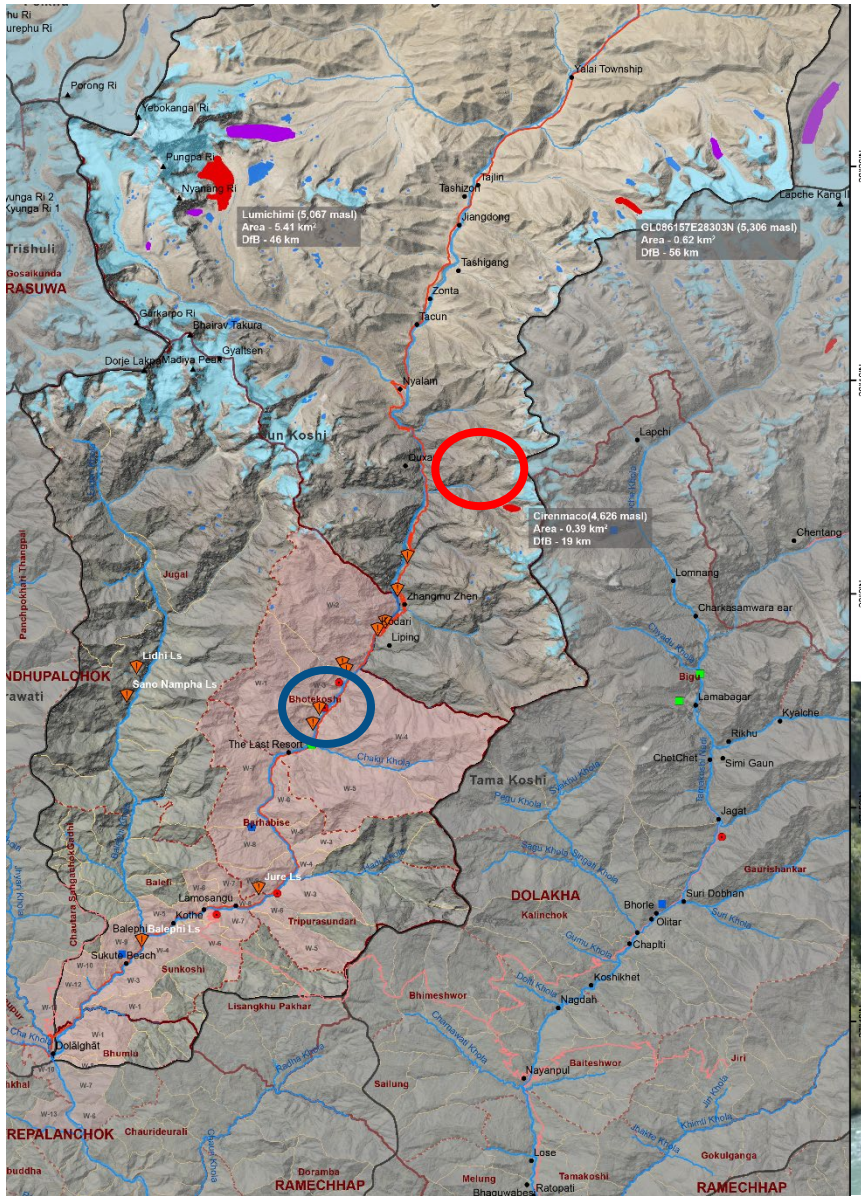


HKH area: 4.19 million km^2

- **~9% of glaciers in globe**
- **240 million people** depend directly on HKH for their lives and livelihood
- **1.9 billion people depend** on the HKH for water, Food and Energy
- **>30% of world population** benefits indirectly from HKH resources and ecosystem

- It is the source of countless perennial rivers that originate from glaciers.
- It is also the source of various natural disasters such as snow/ice avalanche, Glacial Lake Outburst Floods (GLOF).

Bhote Koshi GLOF in 2016

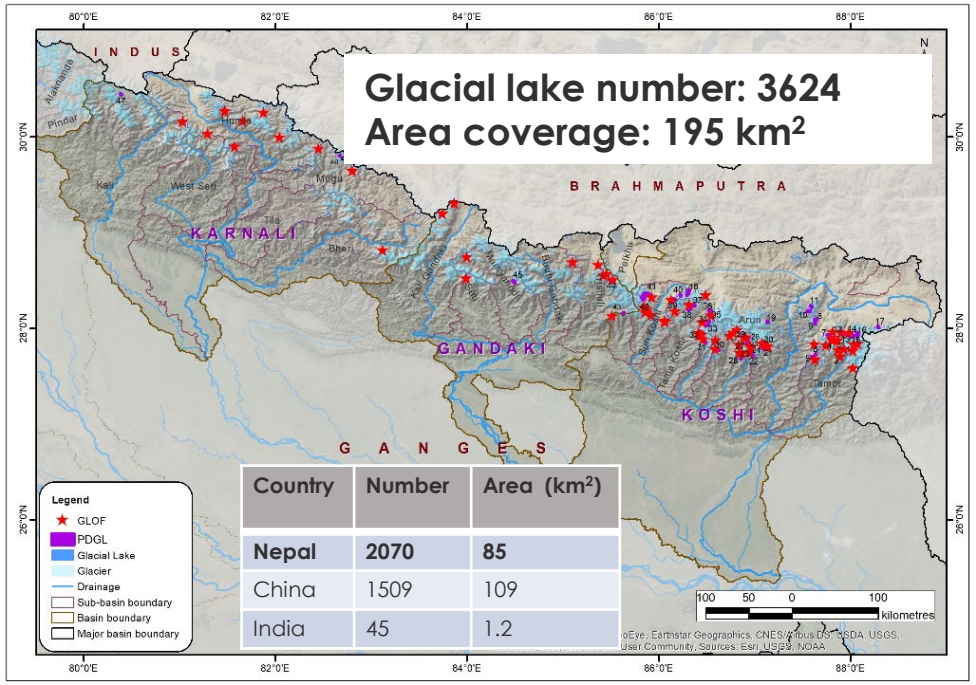


Damage in 45MW Bhote Koshi Hydropower Dam at 20 km downstream from Friendship bridge in the border.

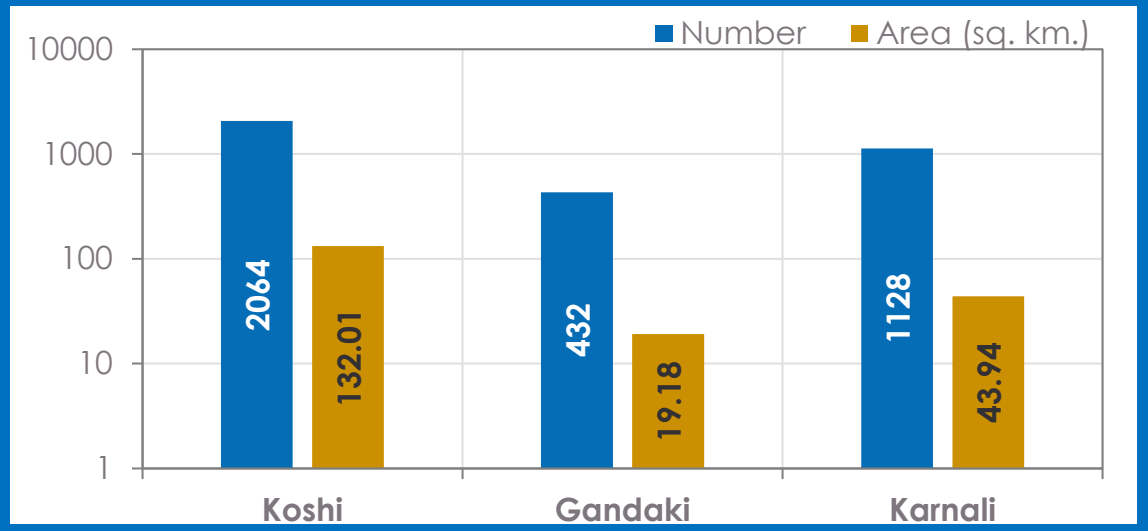
Before GLOF

After GLOF

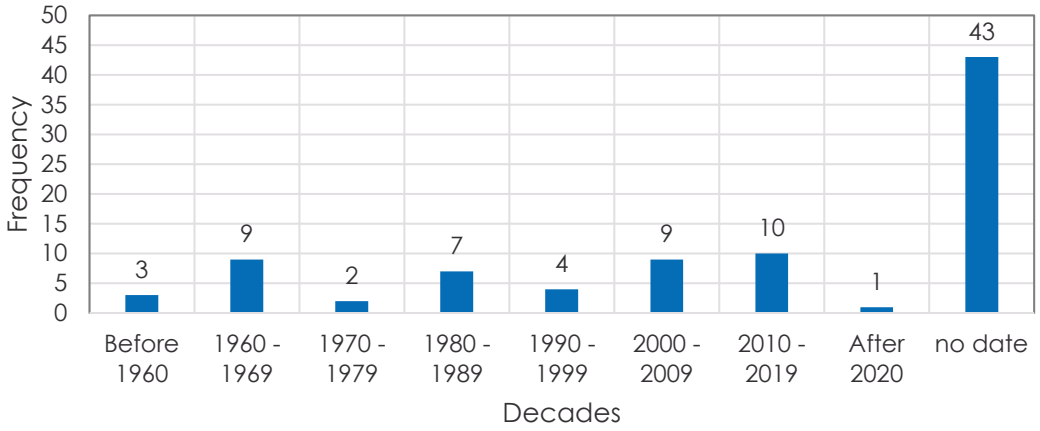
Glacial Lakes and GLOFs

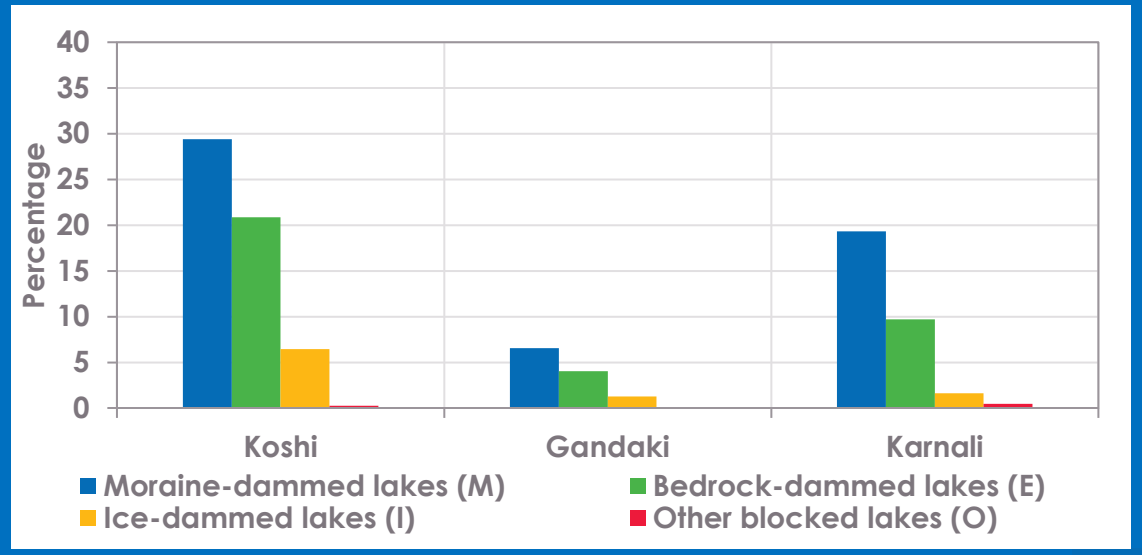


Country	Number	Area (km²)
Nepal	**2070**	**85**
China	1509	109
India	45	1.2



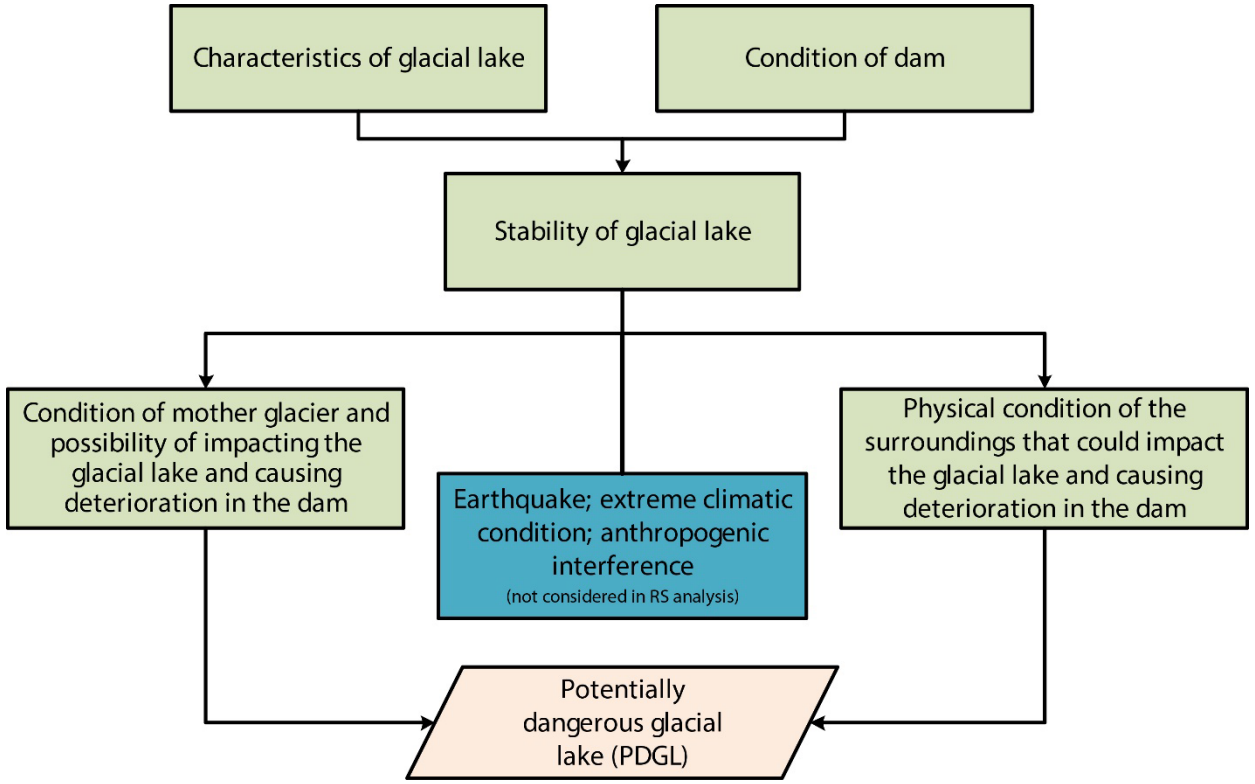
Total GLOF event in Koshi, Gandaki & Karnali : 88

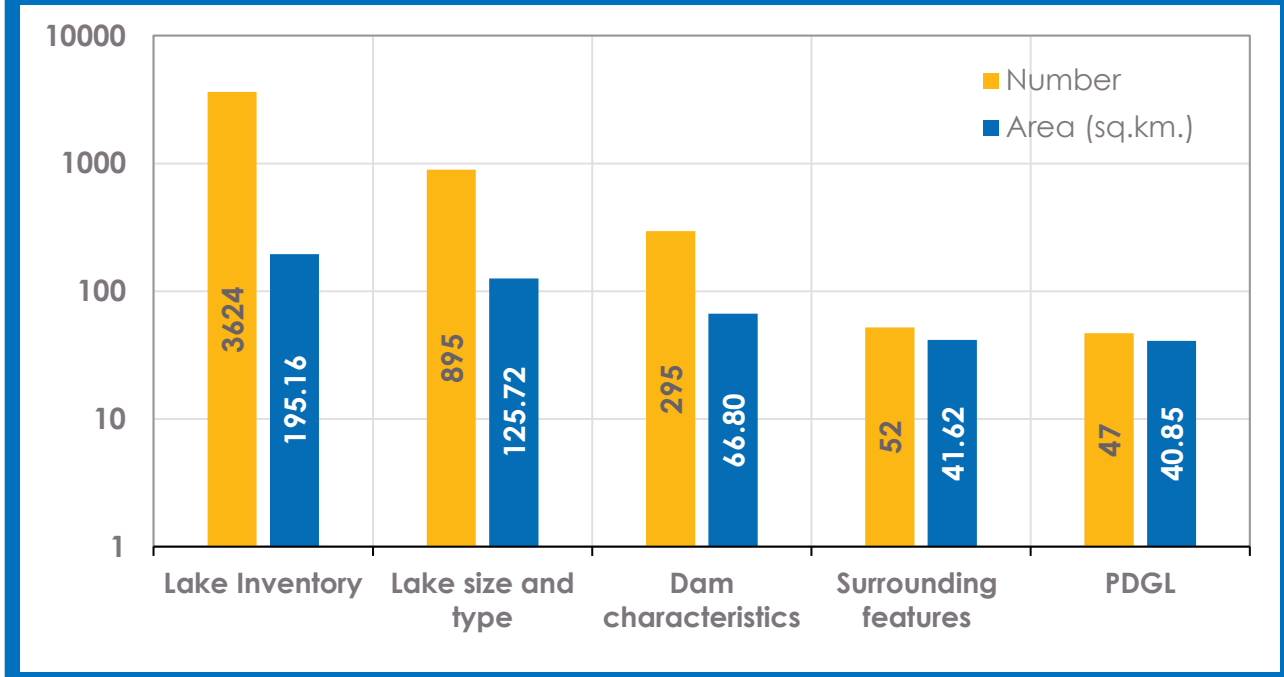


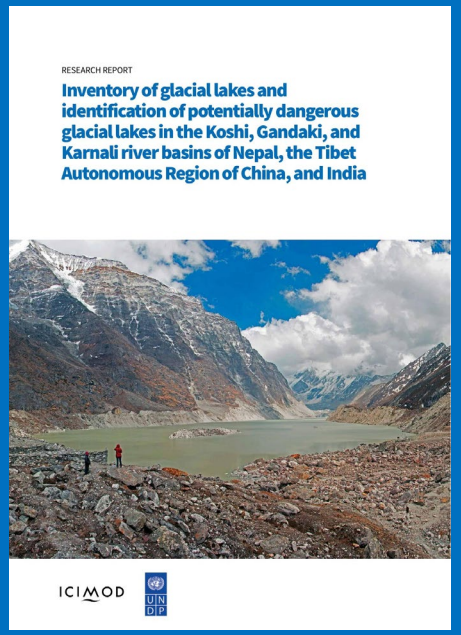


Identification of Potentially Dangerous Glacial Lakes

Level 1: Lake characteristics
Level 2: Dam characteristics
Level 3: Characteristics of source glaciers
Level 4 : Physical condition of surroundings

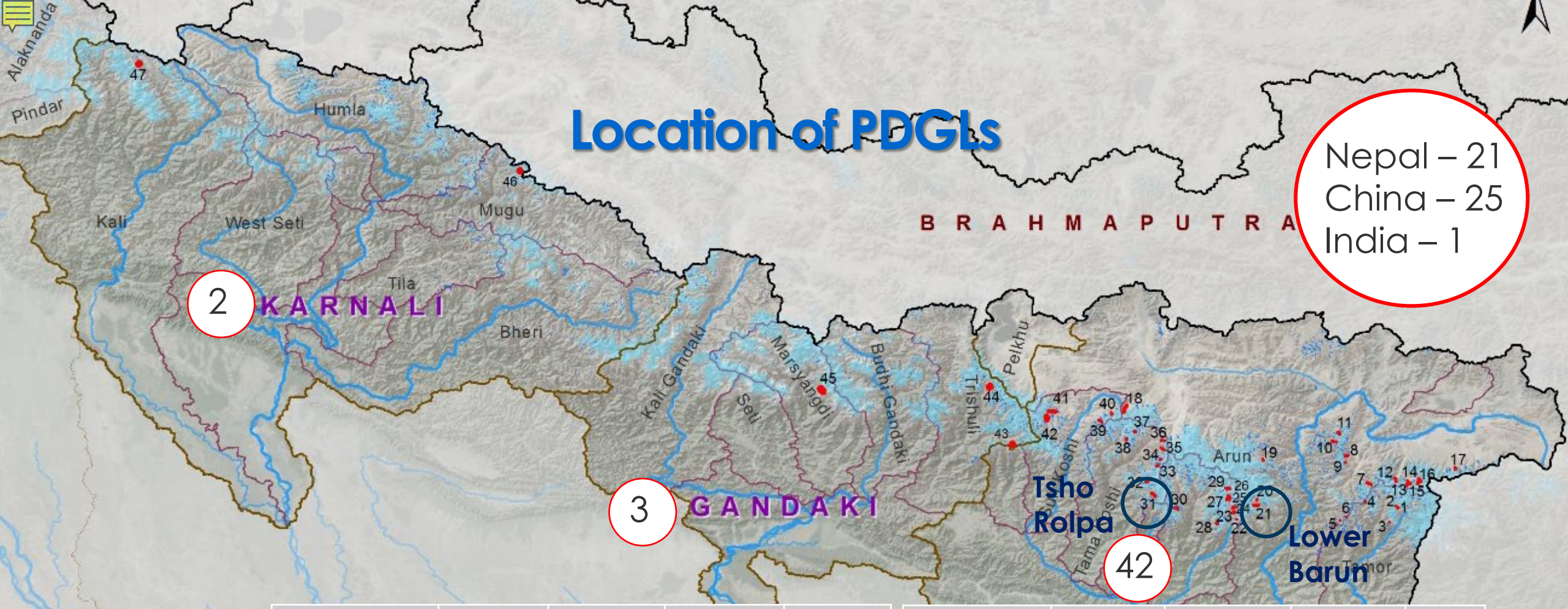






https://lib.icimod.org/record/34905

Location of PDGLs



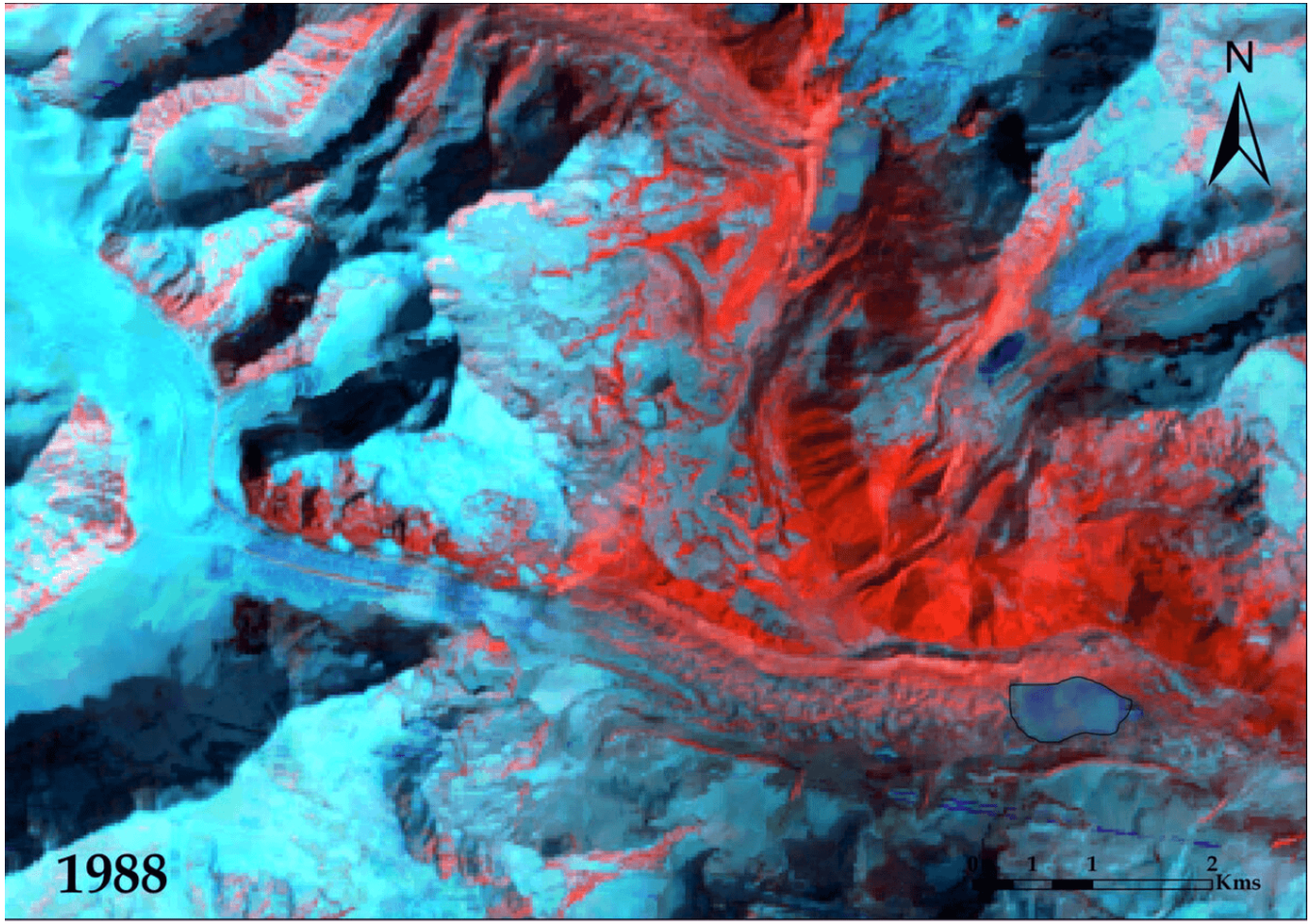
Nepal – 21
China – 25
India – 1

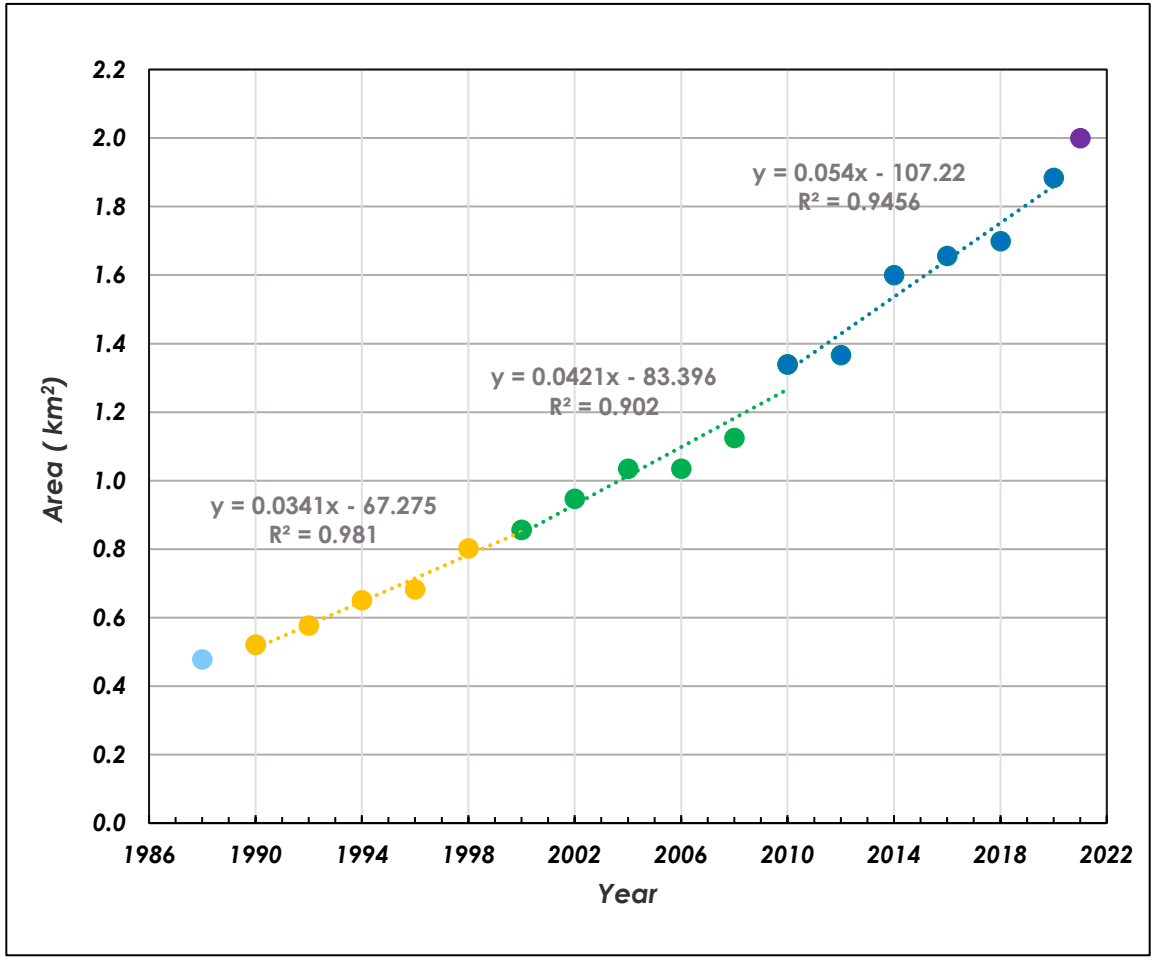
Country	Rank I	Rank II	Rank III	Total
Nepal	15	3	3	21
TAR, China	15	9	1	25
India	1	x	x	1
Total	31	12	4	47

Basin	Rank I	Rank II	Rank III	Total
Koshi	28	10	4	42
Gandaki	2	1	x	3
Karnali	1	1	x	2
Total	31	12	4	47

Legend
PDGL
Glacial Lake

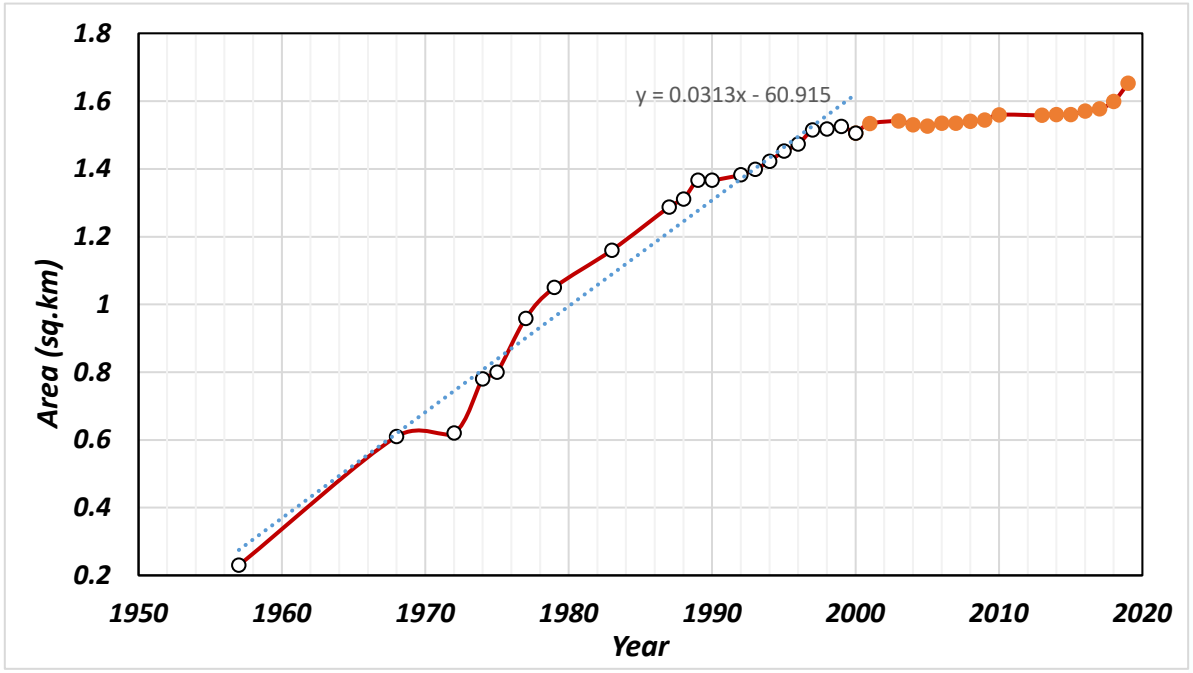
Development of the Lower Barun GL



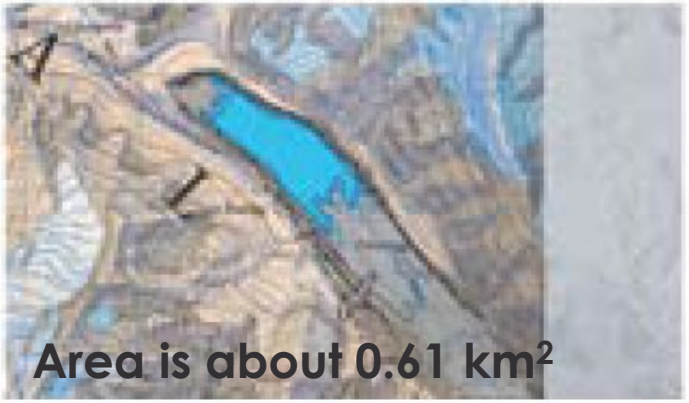


Lake area expansion rate 0.041 km² per year
Higher rate in recent five year .

Development of the Tsho Rolpa GL



1957-59, Survey of India Topography Map



1960 - 68, Schneider Map

21 November 1973, Corona Image

Field survey

- Topographic Survey – dGPS
- Unmanned Aerial Vehicle (UAV) survey
- Bathymetry survey
- GPR survey for end-moraine
- Grain-size analysis of end-moraine
- Investigating surrounding Features
- Investigate immediate downstream settlements.

→ Morphological characteristics of end-moraine dam and its surrounding

→ Lake depth, bed topography & lake water volume

→ Existence of ice and thickness in end-moraine dam

→ Sediment size distribution of beach model.

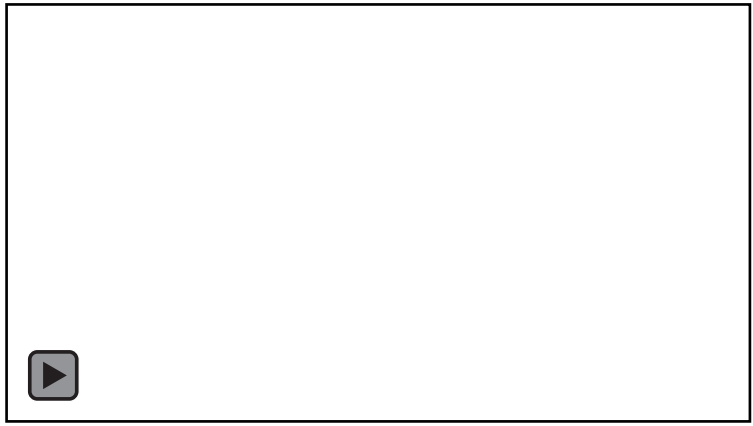
→ Potential sites of avalanches, debris flow, condition of cascading lakes etc.

Field survey

Topographic survey using UAV and dGPS

Geophysical survey of end moraine dam

Lake depth measurement



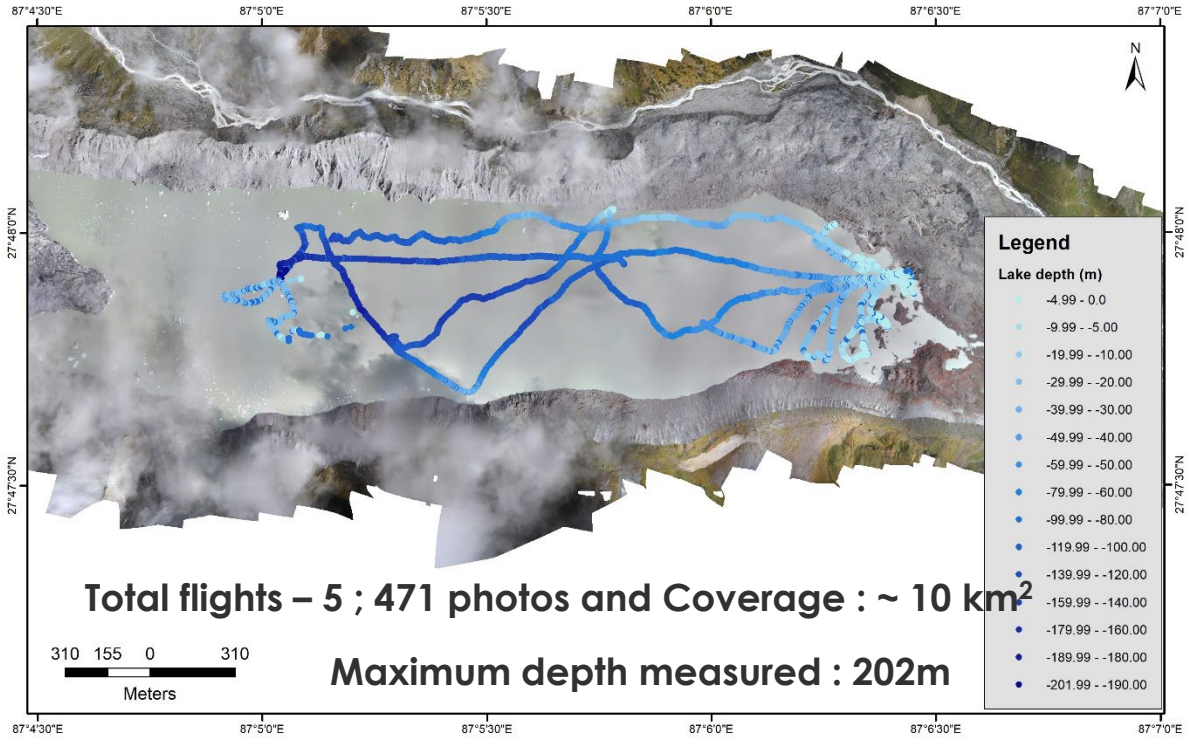
Exposed ice at the bottom of left lateral moraine

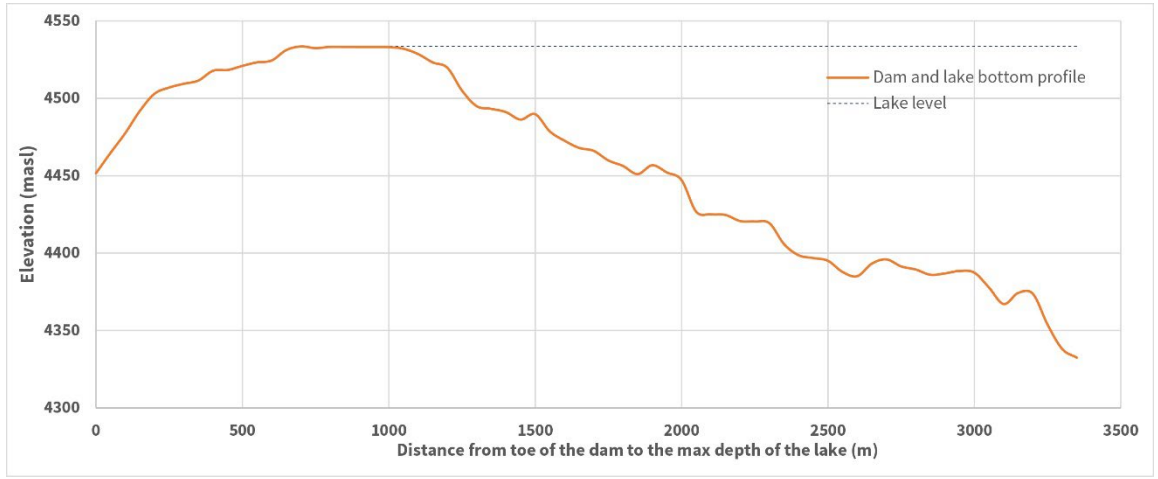
Erosion, rockslide and drainage on the lateral moraine of the lake.

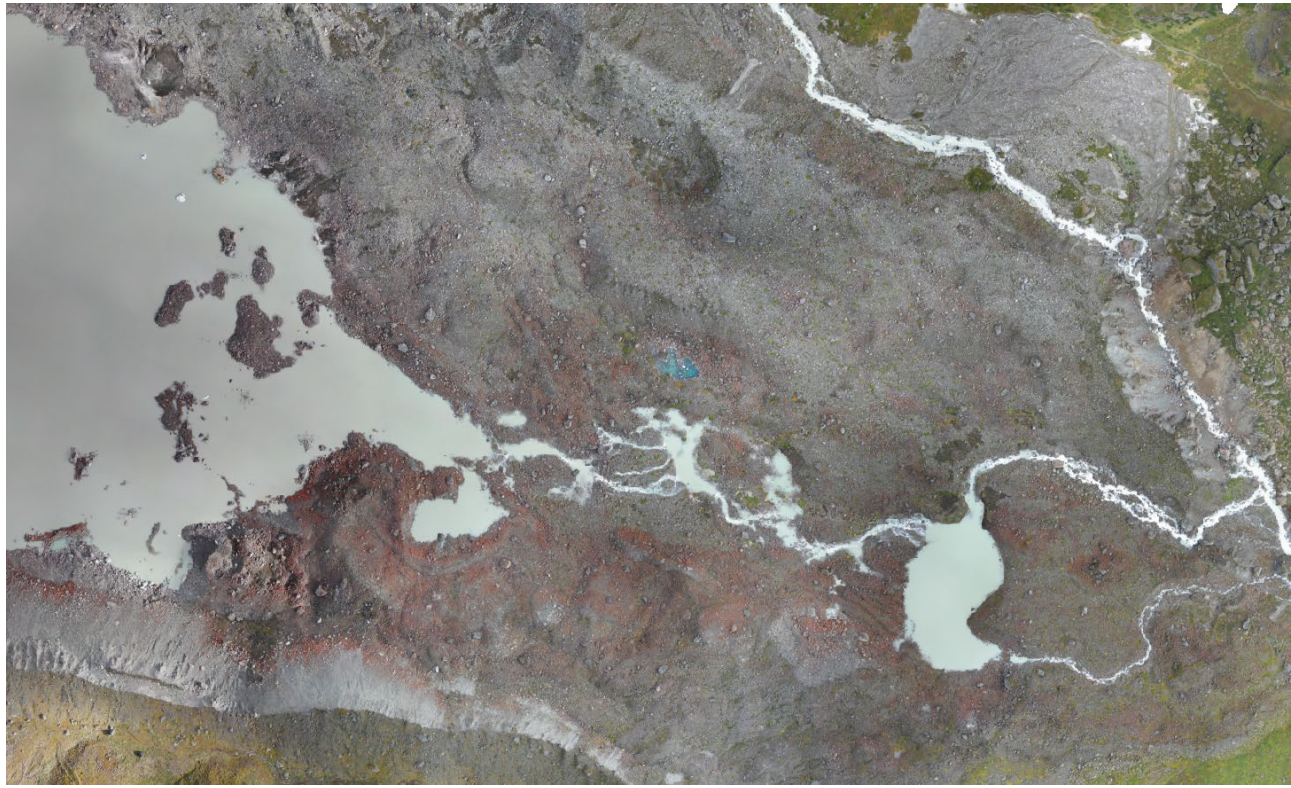
Riverbed and lateral moraine is at same level, high chance flood water flow into the lake

GPS node installation

Lower Barun Glacial lake



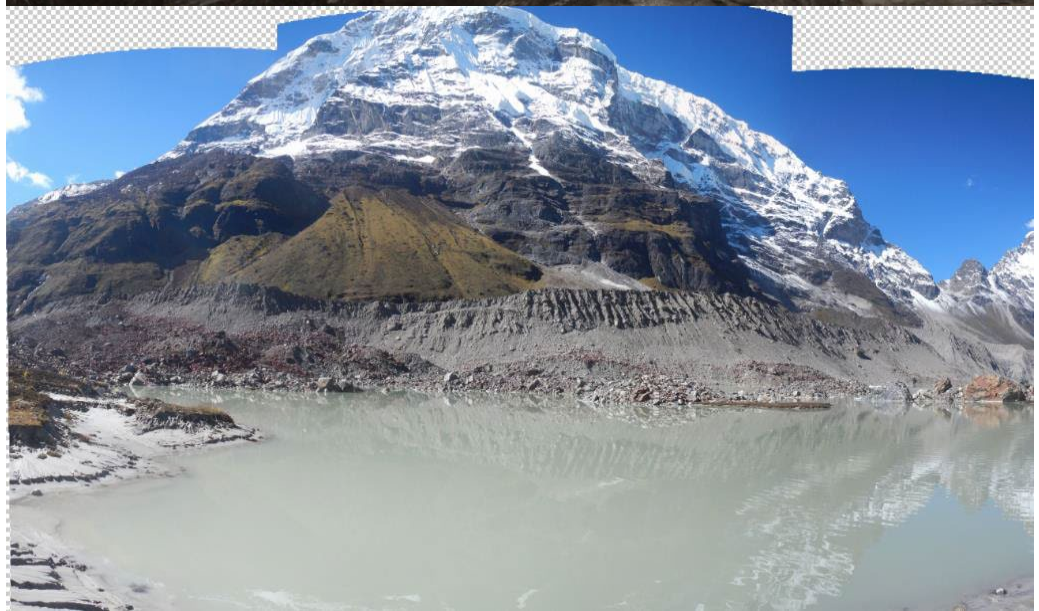




Unconsolidated boulder deposits of end moraine dam

Lower Barun Glacial lake

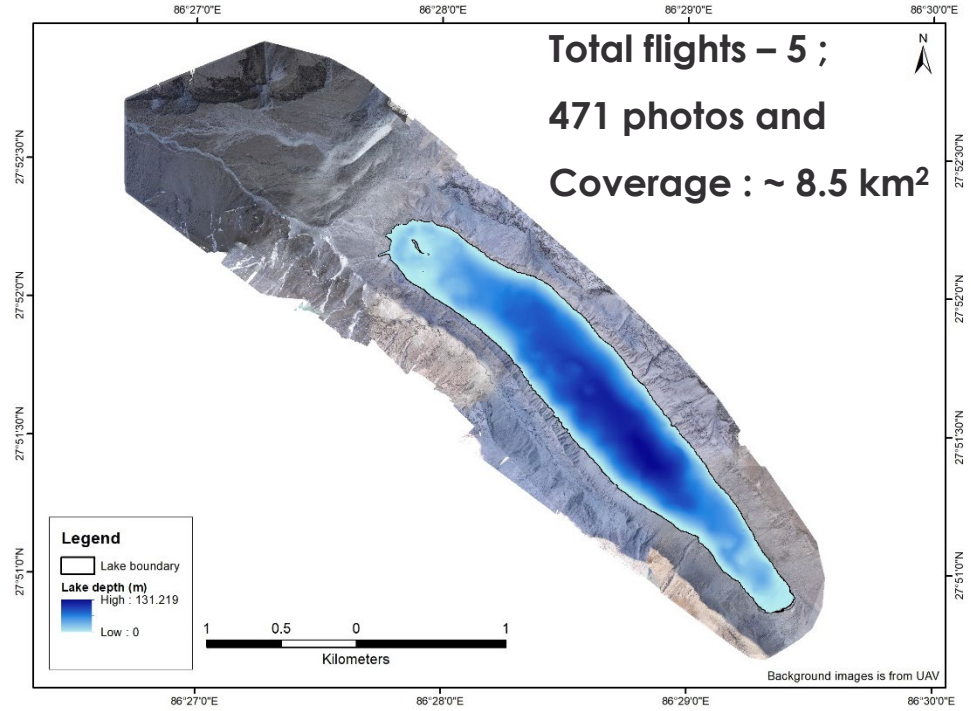
Hanging glacier and Ice/snow avalanches at right lateral moraine side



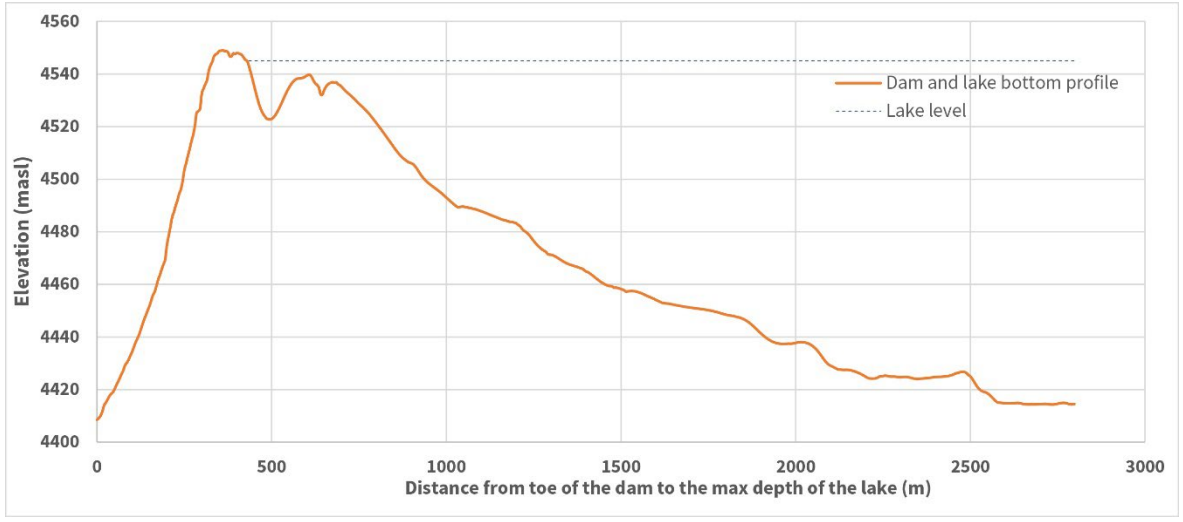
Erosion and debris slides from lateral moraine;

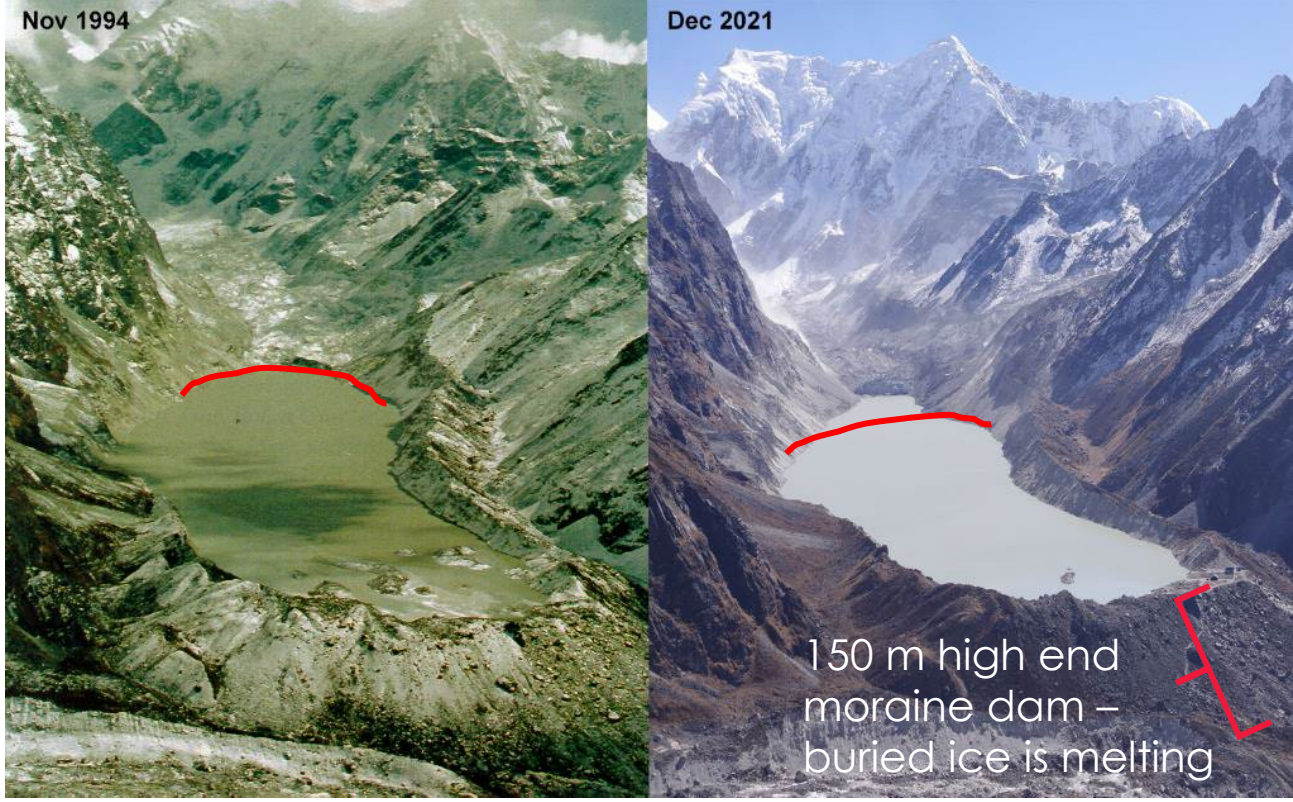
Lateral moraine and Barun riverbed are at same level with high chance of water flow into lake during high flow in the river

Tsho Rolpa Glacial lake



Maximum depth measured : 131m

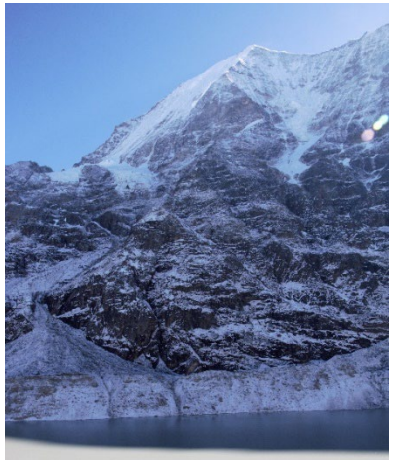




End moraine dam stability of the Tsho Rolpa

Exposed ice found at Lama island at the lake

Exposed ice at the bottom of left lateral moraine

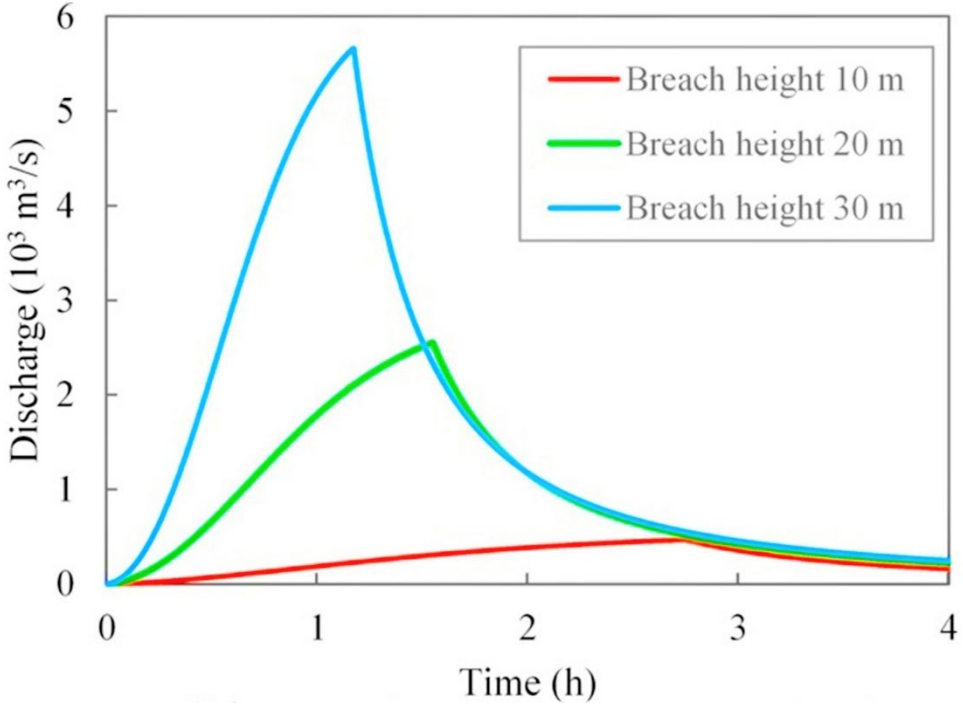


Fractured hanging glacier at right lateral moraine side

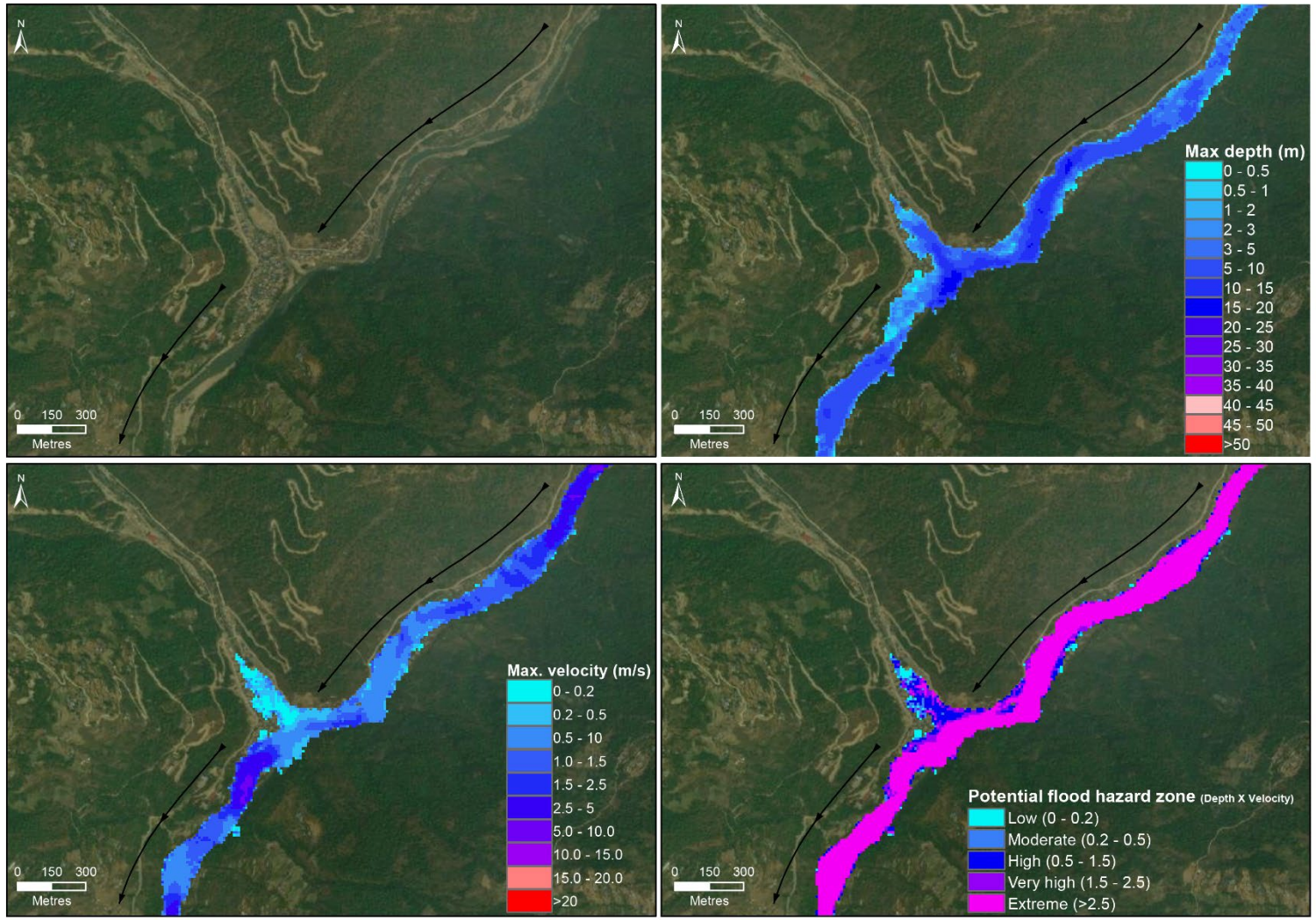
Calving glacier (60m high) and icebergs

Erosion, rockslide and drainage on the lateral moraine of the lake.

GLOF modeling of the Tsho Rolpa GL

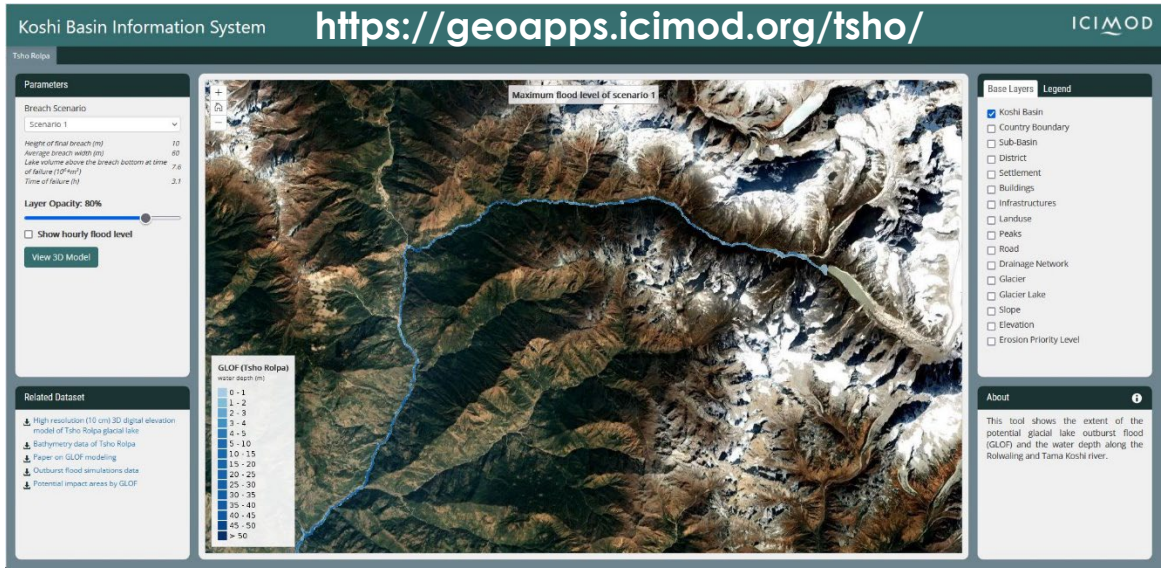


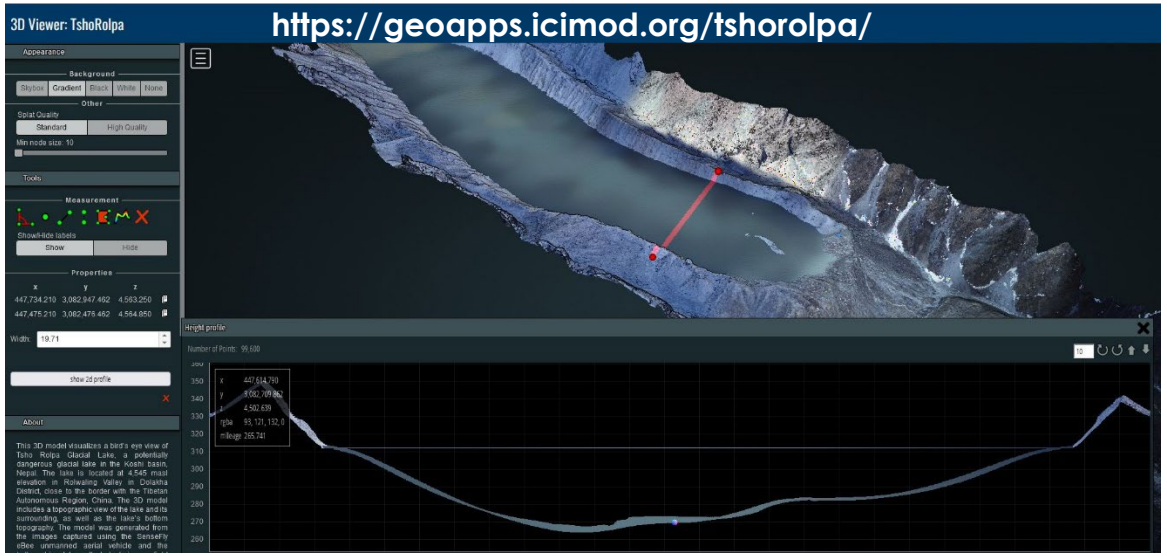
Dam breach hydrograph at different breached height from current water level of Tsho Rolpa.



Potential flood inundation map at 40 km downstream from Tsho Rolpa based on the 10 m lake breach from the current water level condition.

Information sharing





Way forward

- **GLOFs are becoming frequent** - due to increasing glacier melt and the formation and expansion of glacial lakes due mainly to the warming climate.
- **Field survey and monitoring is essential** to understand actual condition of lake and its hazard level
- **Important of research** ➔ Hydro-power plant, socio-economic, tourism and growing infrastructures at the downstream
- To Mitigate Lake lowering, set up EWS and AWS
- To performed flood simulations and then constructed a hazard map for GLOF & flood prone area along the downstream river valley.
- To raise awareness for downstream local community.
- **Transboundary collaboration is required.**

Acknowledgement

NORWEGIAN MINISTRY OF FOREIGN AFFAIRS

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

UKRI Natural Environment Research Council

Thank you

Cryosphere and related hazards in High Mountain Asia in a changing climate
1 – 4, November 2022, Almaty, Kazakhstan

unesco

Aga Khan Agency for Habitat

ICIMOD

CARGC

GLOFCA

ADAPTATION FUND