



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

**Enhancing GLOF Risk Resilience through Technology,  
Governance and Community Preparedness**



**Ashok Thakur, National Disaster Management Authority (NDMA)**

# Glacial Lake Outburst Floods (GLOFs)

- Heavy Rainfall
- Landslides
- Glacier Melting
- Earthquakes
- Avalanches

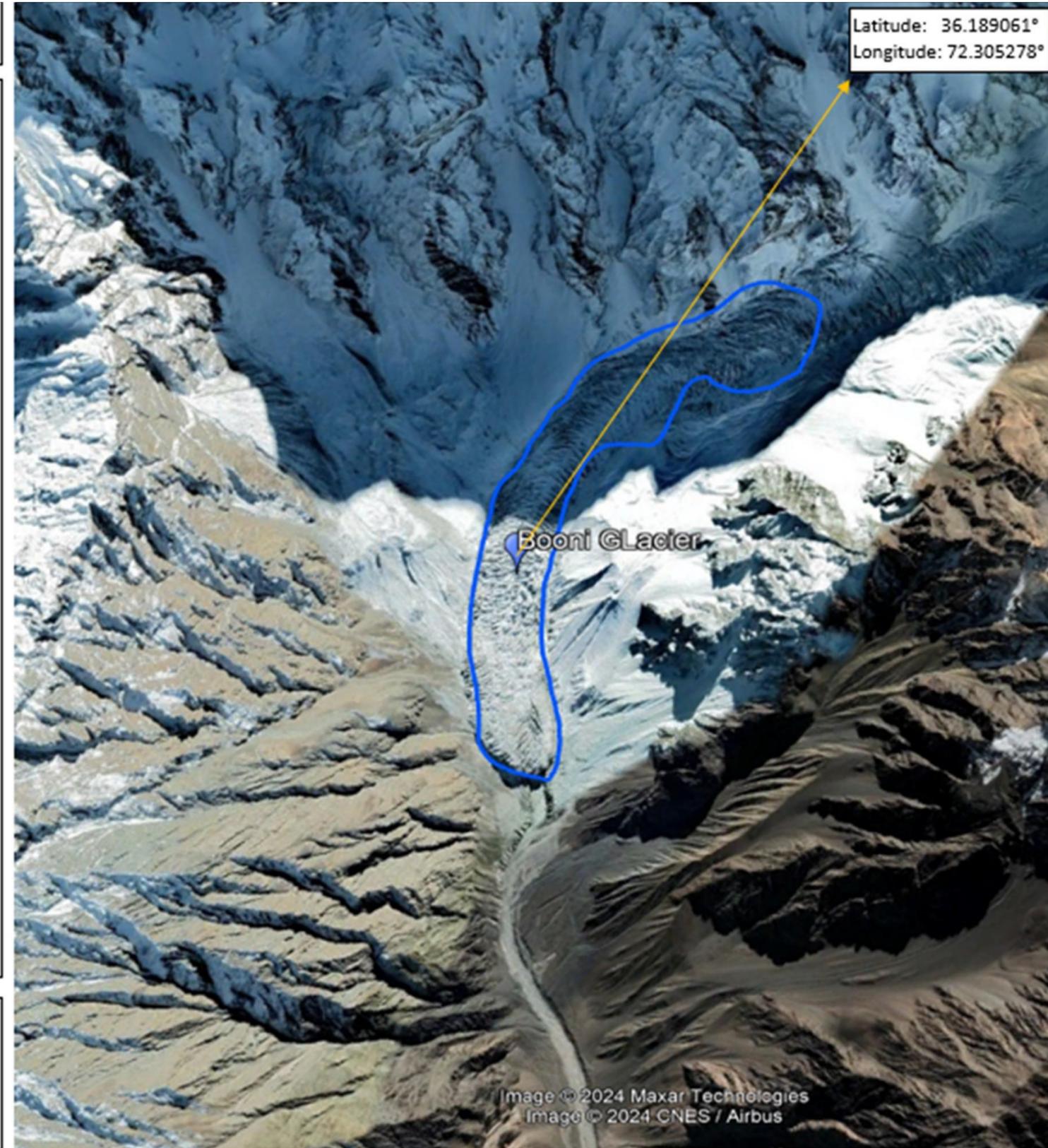


Singtam town

## Booni Glacier, Chitral Basin, (Pakistan)



- A Severe Glacial Lake Outburst Flood (GLOF) hit Booni Gloe Nullah in the Upper Chitral district affecting the local bridge, power house, and irrigation canals.

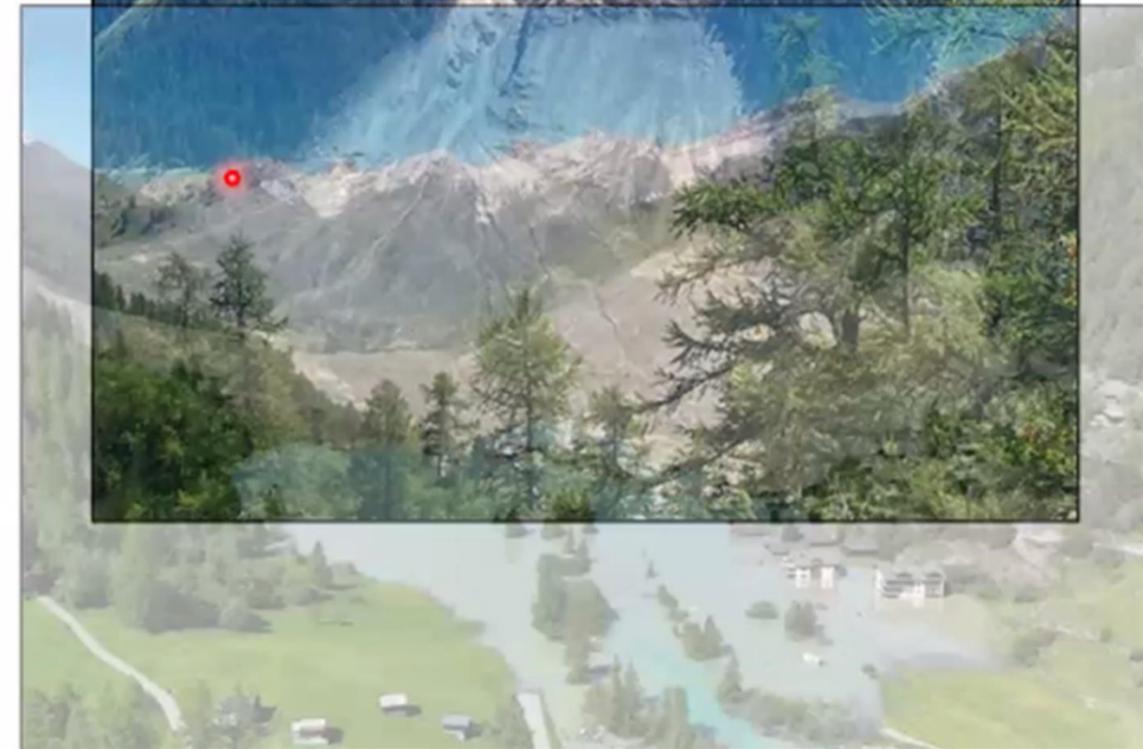


# Blatten

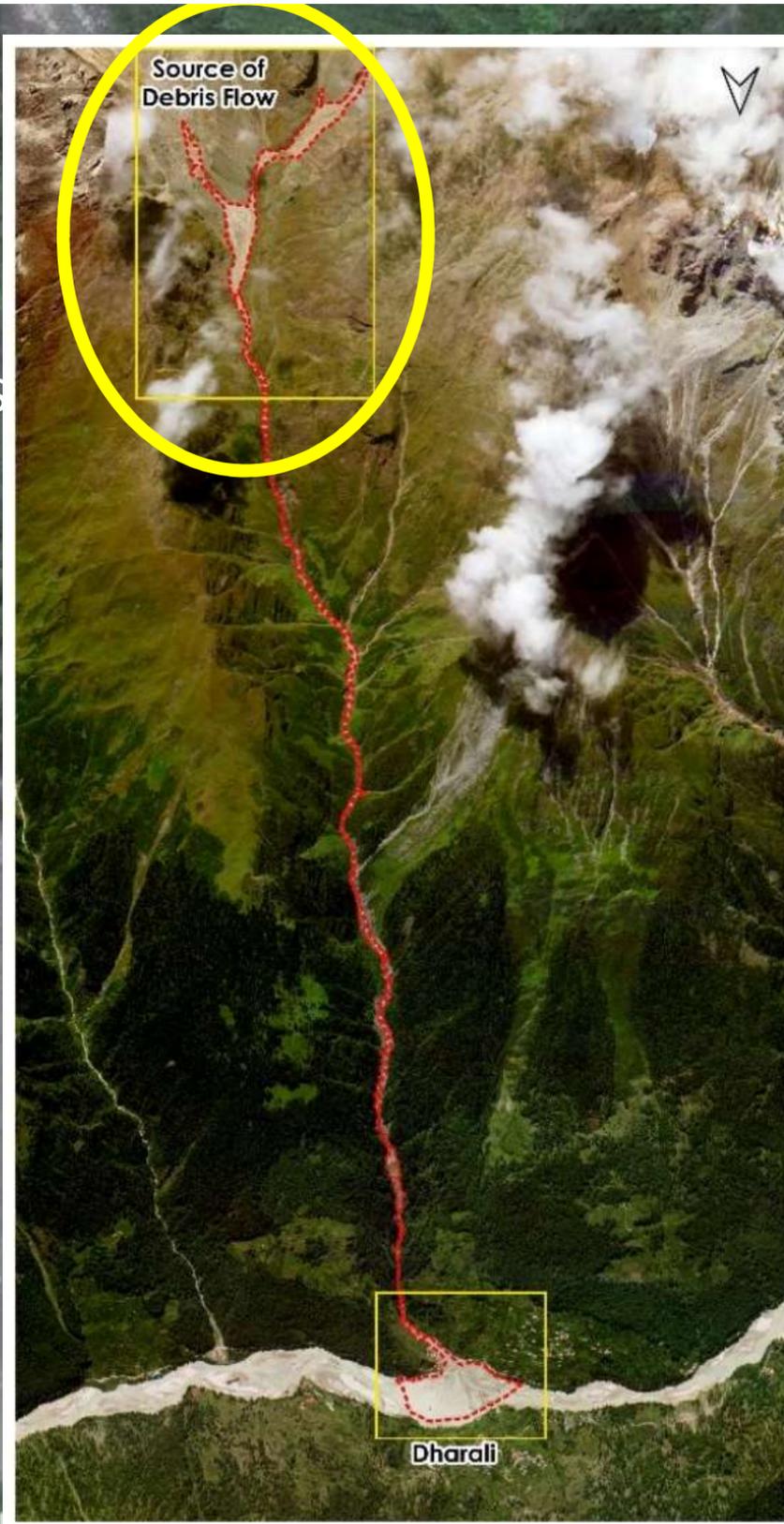
Rapid Mapping Overflight  
30 May 2025



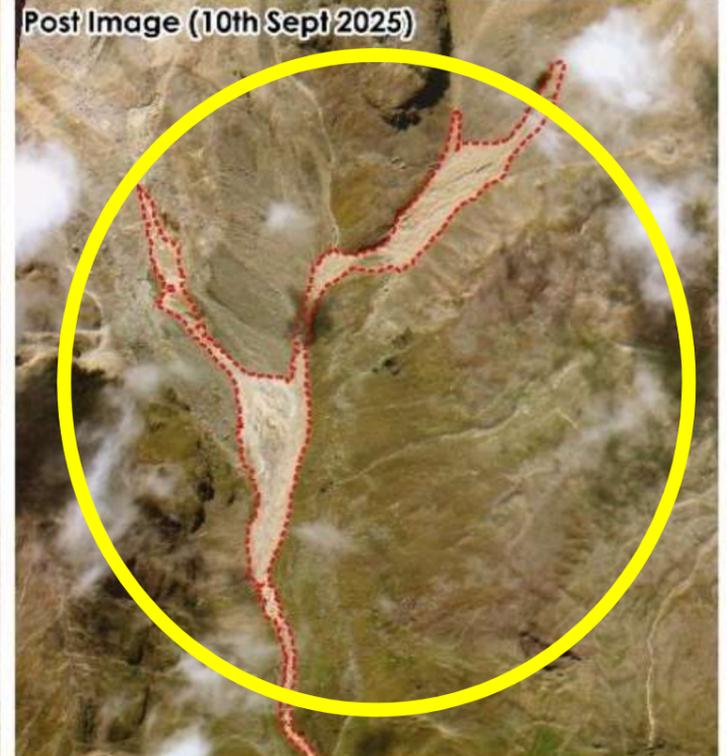
map.geo.admin.ch, SRF



WS



**Source of Debris Flow**



**Dharali**



**Debris Flow Path** 

Image Source: Planetscope (3m), Satellogic(0.7m)



# Consequences of GLOF



- ❑ Loss of Life
- ❑ Infrastructure Damage
- ❑ Economic Disruption





# Chungtham Hydel Dam



1200 MW  
INVESTMENT —  
RS 16000  
CRORE





# Environmental Consequences: Erosion, Sedimentation, and Ecosystem Disruption



## Riverbed Erosion

The powerful floodwaters can scour and erode riverbeds, changing the landscape and habitats.

## Sedimentation

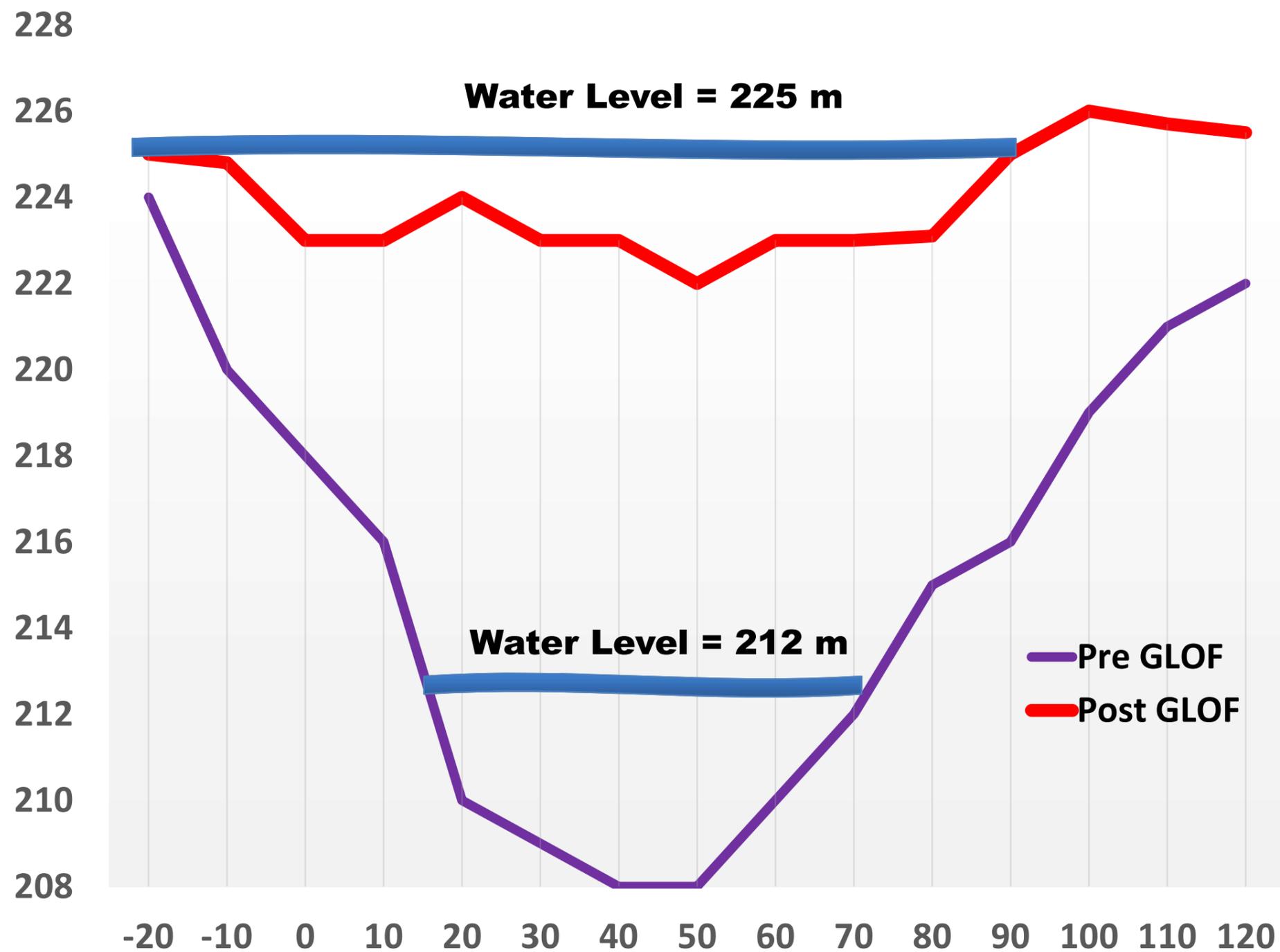
The flood waters carry massive amounts of debris and sediment, which can bury and downstream ecosystems.

## Ecosystem Disruption

The physical and chemical changes to the environment can devastate local flora and fauna, disrupting food chains.



# Raising of the river bed

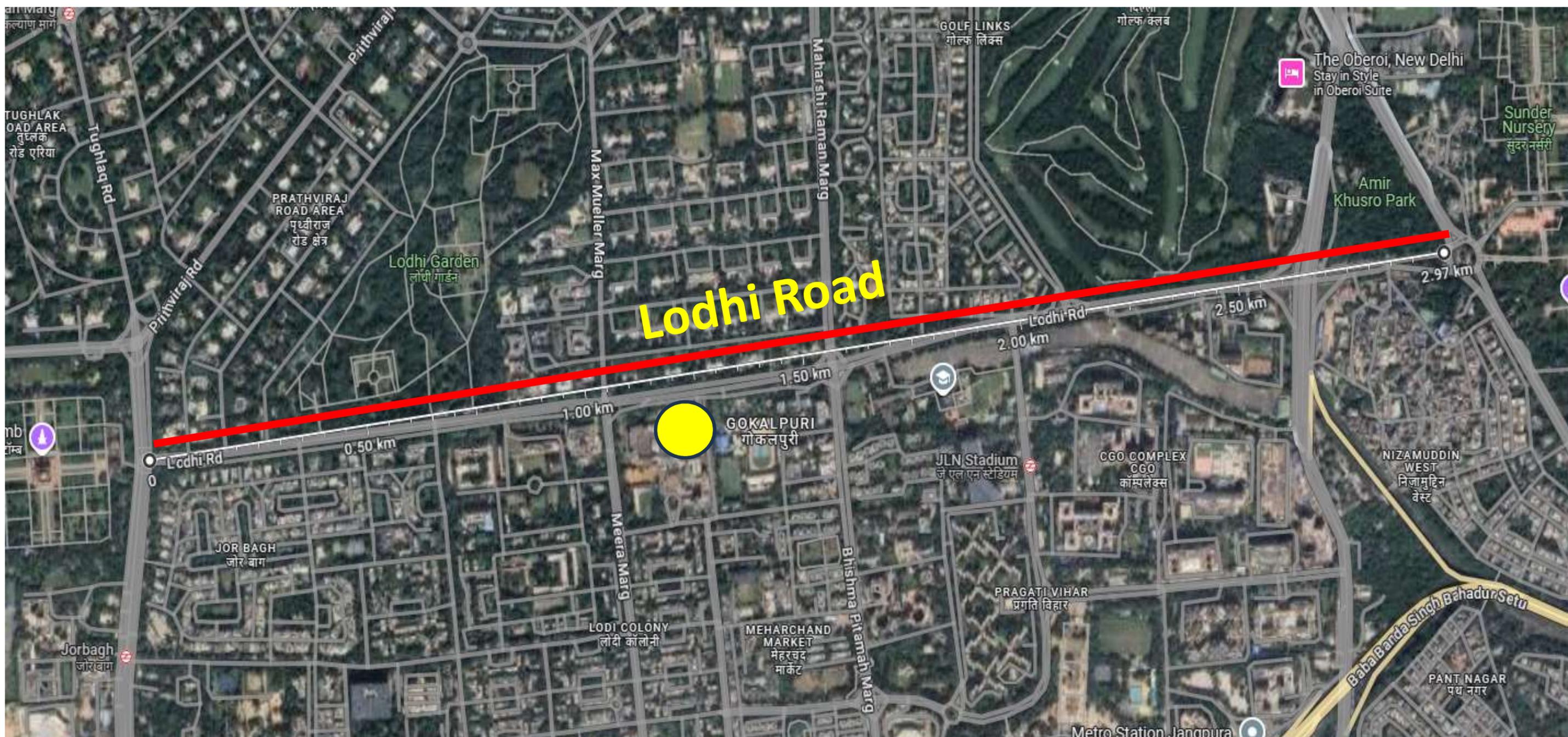


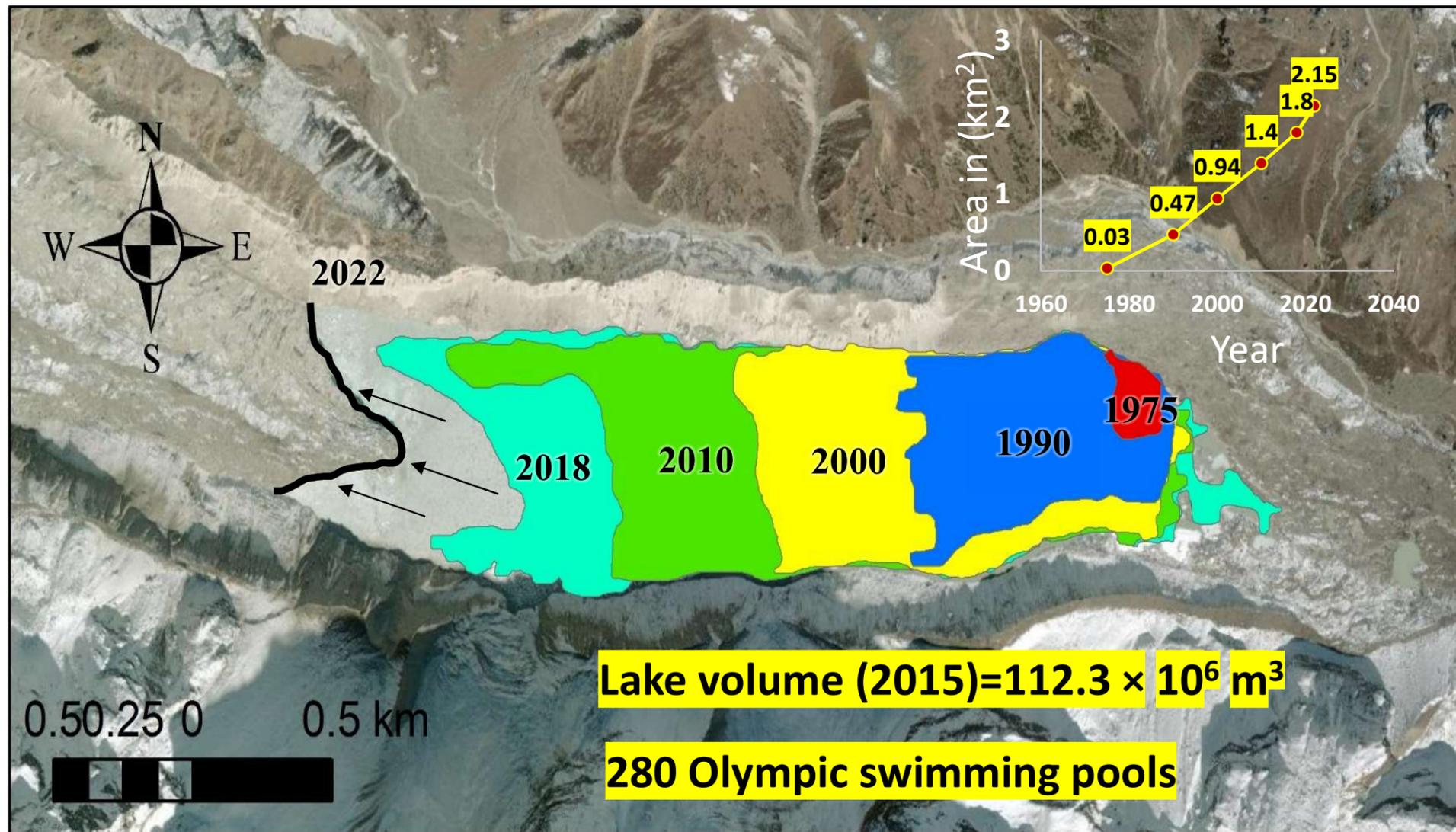
SOURCE: CWC

Affected everyone

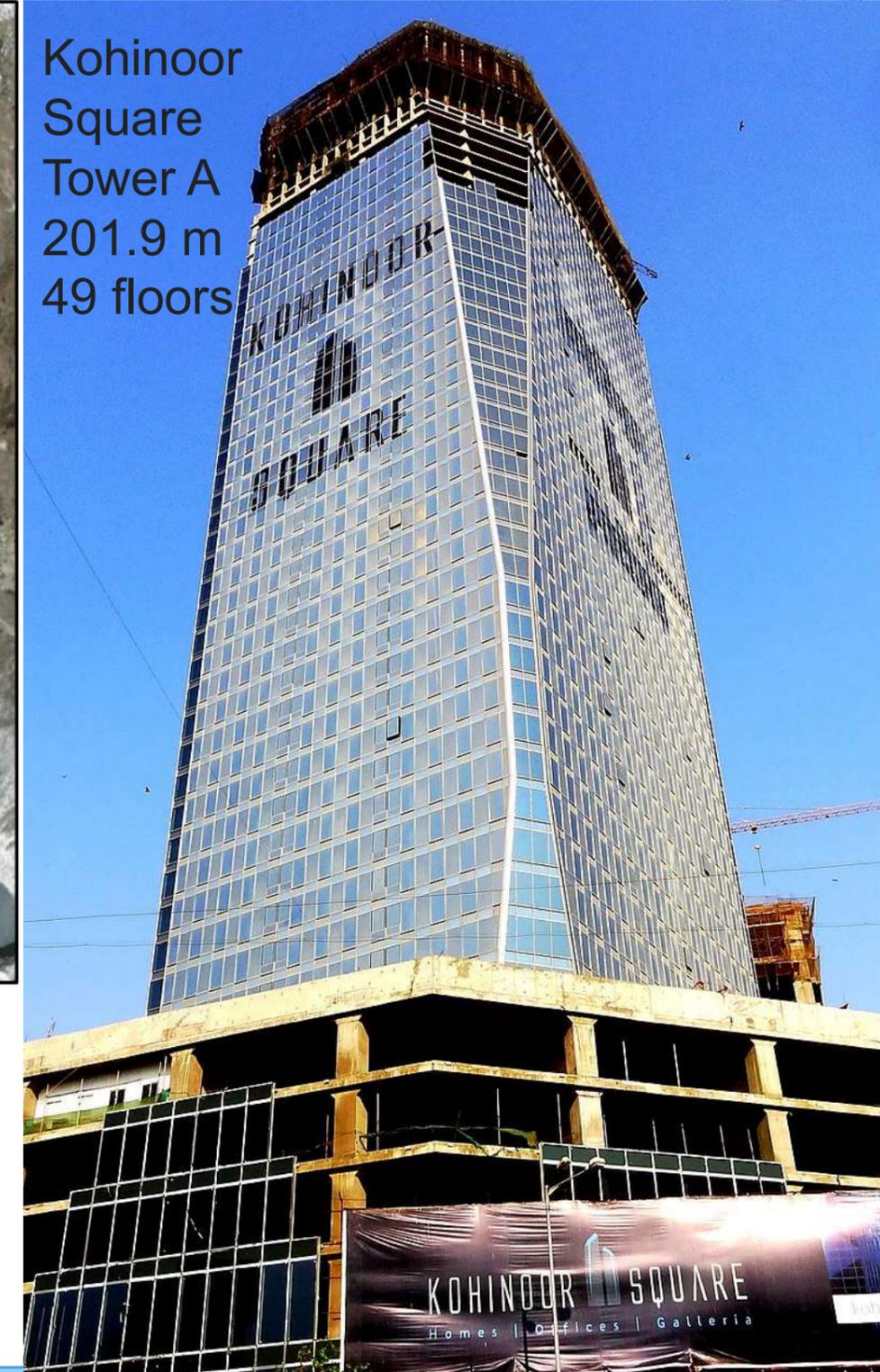


# Development of Glacial Lake (Ghephang Gath GL, LS,HP)





Kohinoor Square Tower A  
 201.9 m  
 49 floors



**THE DEEPEST KNOWN GLACIAL LAKE IN THE HIMALAYA**

**THE LOWER BARUN LAKE, NEPAL HIMALAYA**

**MAXIMUM DEPTH = 205 m**



## Kazakhstan



Each year, preventive measures are promptly carried out to reduce breakthrough risks at 15-18 moraine lakes. These include:

- expanding and deepening flow channels,
- installing and activating siphons with diameters from 200 to 300 mm, and
- pumping water from lakes using high-capacity motor pumps.



# Bhutan - EWS



	2009 (m)	2010(m)	2011(m)	2012(m)	Total(m)
Main Lake	0.86	1.37	1.45	1.36	5.04
Subsidiary Lake I	0.85 <sup>*</sup>	1.20	-	1.61	3.66
Subsidiary Lake II	0.82	2.30	1.10	0.86	5.08



ENERGY

# Lake lowering efforts in Himalaya Nepal's first hydropower from a glacial lake



Turning global warming into opportunity, melting Himalayan glacier is harnessed for electricity  
<https://www.downtoearth.org.in/news/energy/nepal-s-first-hydropower-from-a-glacial-lake-80250>

## Lake lowering efforts in Himalaya

Langtang Microhydro Electricity Project



2015

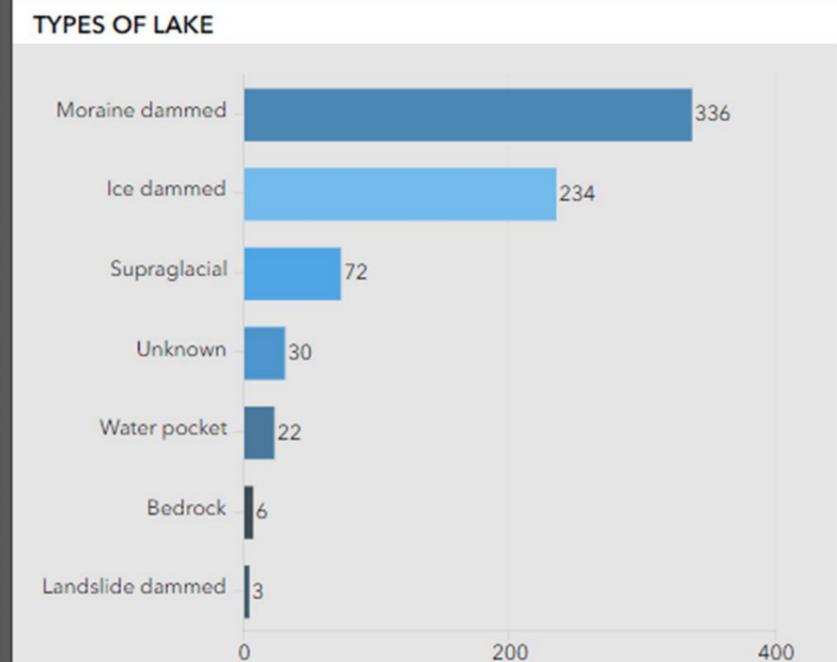
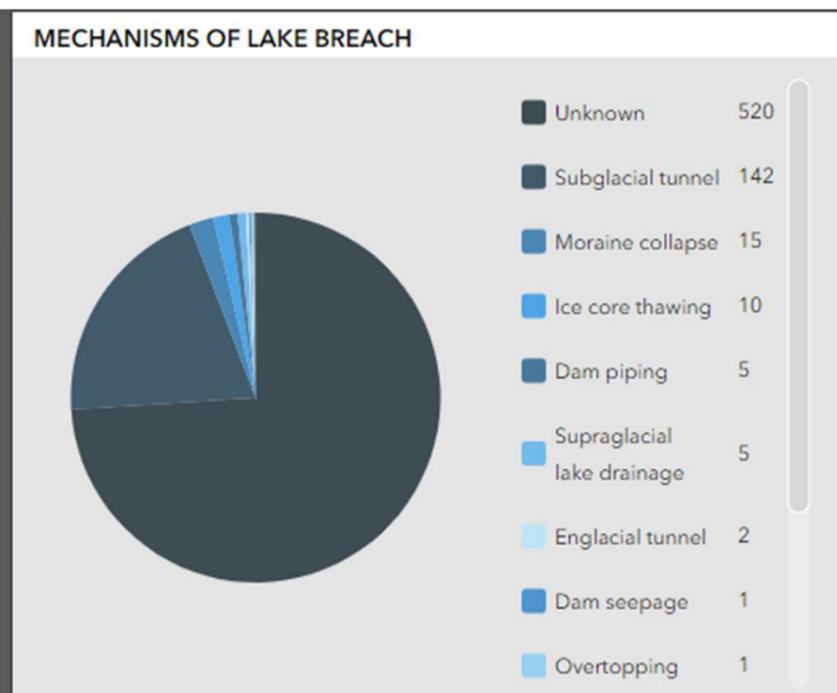
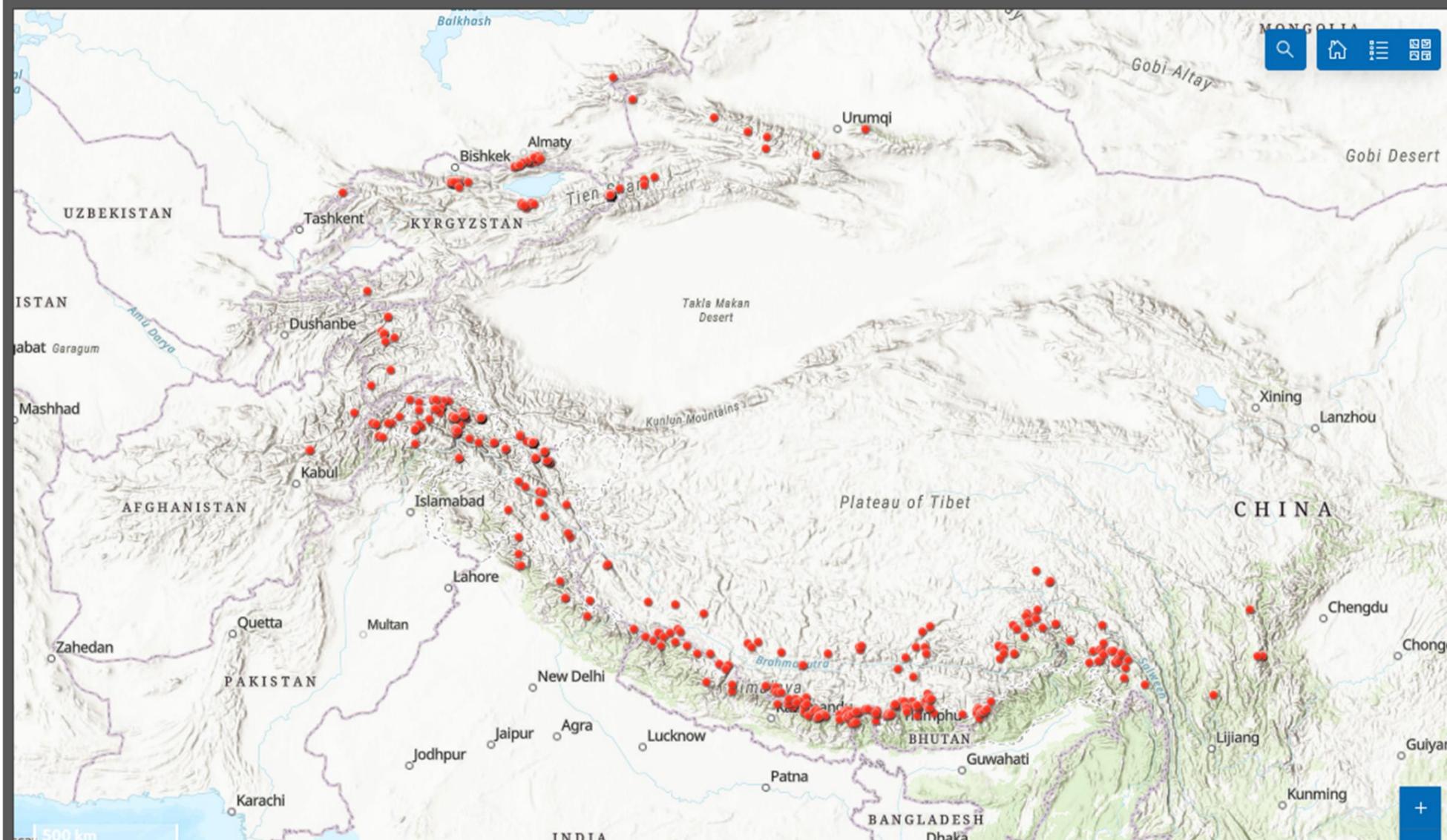


powerhouse that **generates 100kW of electricity**, providing 24 hours of electricity to **120 households and tourist lodges in Kyanjin and Langtang.**

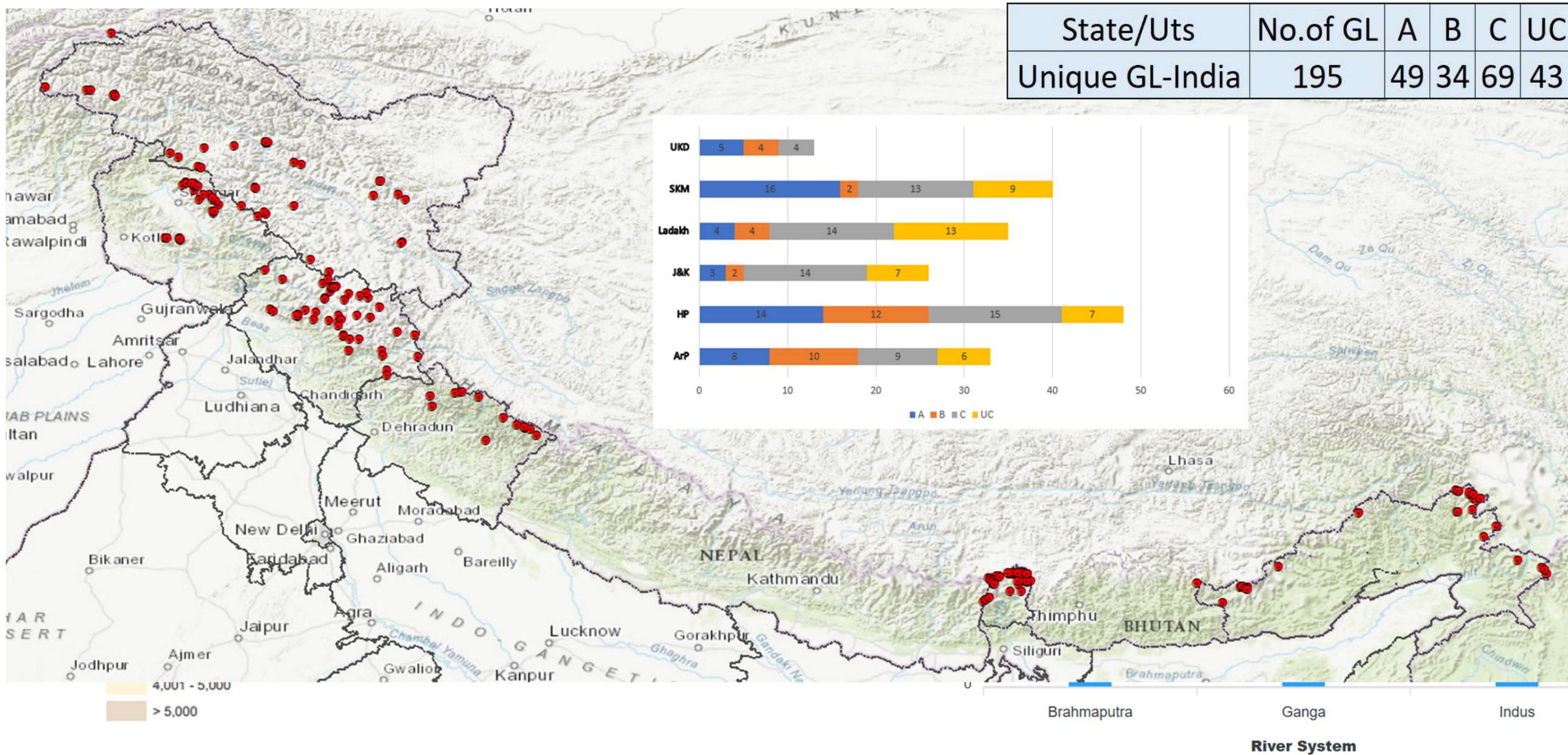
Climate-Resilient Dams and Hydropower Infrastructure: Integrating Environmental Susta

# GLOFs in High Mountain Asia

<b>GLOFs</b> <b>703</b>	<b>FATALITIES</b> <b>7,008</b>	<b>INJURIES</b> <b>20,076</b>	<b>DISPLACED PEOPLE</b> <b>91,950</b>	<b>LIVESTOCK LOST</b> <b>1,917</b>
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# High Risk Glacial Lakes in Indian Himalayan Region





# NRSC GLOF Atlas for Entire IHR Basin-v

## GLACIAL LAKE ATLAS OF INDUS RIVER BASIN

Prepared under: National Hydrology Project



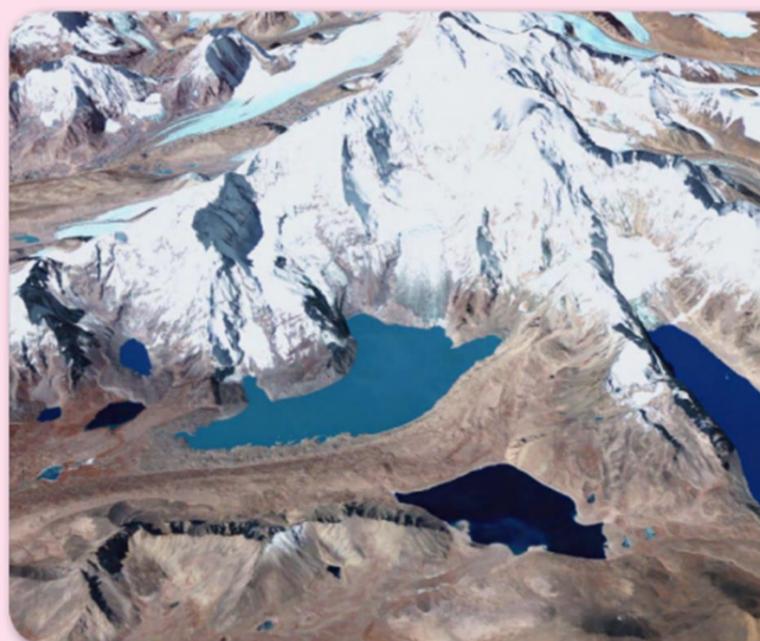
National Remote Sensing Centre  
Indian Space Research Organisation  
Department of Space, Government of India  
Hyderabad - 500 037



November 2020

## GLACIAL LAKE ATLAS OF GANGA RIVER BAS

Prepared under: National Hydrology Project

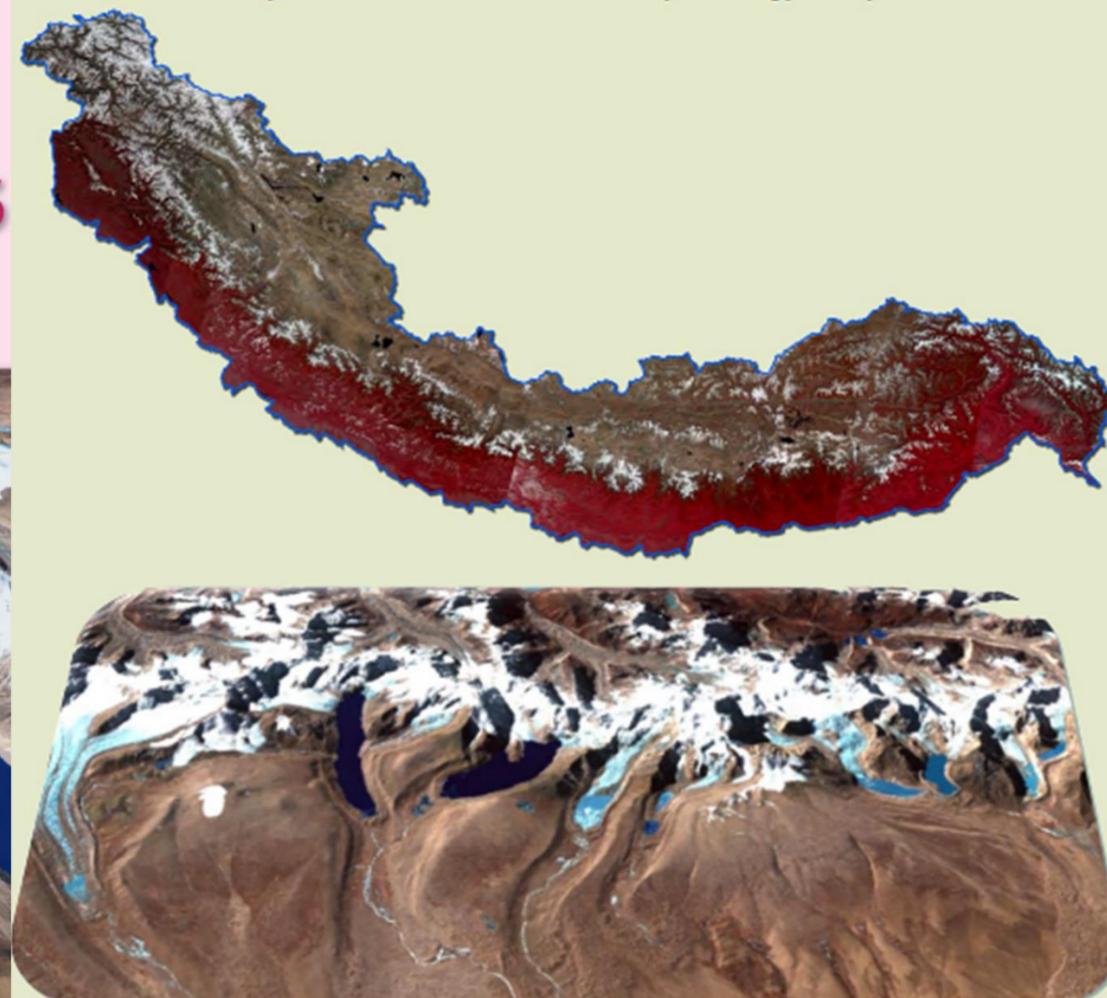


National Remote Sensing Centre  
Indian Space Research Organisation  
Department of Space, Government of India  
Hyderabad - 500 037

May 2021

## GLACIAL LAKE ATLAS OF INDIAN HIMALAYAN RIVER BASINS

Prepared under: National Hydrology Project



National Remote Sensing Centre  
Indian Space Research Organisation  
Department of Space, Government of India  
Hyderabad - 500 037



March 2023



## NDMA 2020 Guidelines: Pillars

- Standardized identification & mapping of dangerous lakes
- Early Warning Systems (risk knowledge, monitoring, dissemination, response)
- Structural & non-structural mitigation; mainstreaming into development
- Capacity-building of institutions; community preparedness & drills



### NATIONAL DISASTER MANAGEMENT AUTHORITY GUIDELINES MANAGEMENT OF GLACIAL LAKE OUTBURST FLOODS (GLOFs)



October 2020



NATIONAL DISASTER MANAGEMENT AUTHORITY  
MINISTRY OF HOME AFFAIRS  
GOVERNMENT OF INDIA



Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
Confederaziun svizra

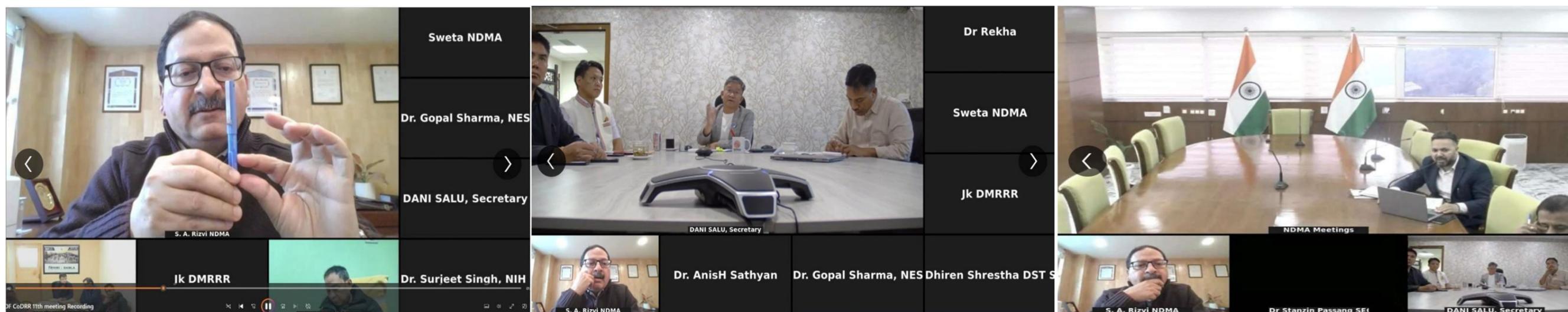
Swiss Agency for Development  
and Cooperation SDC



# GLOF Risk since October 2023



1. South Lhonak
2. CoDRR – coordination, consistency, communication
3. Clarity on role
4. Clarity on objective – mitigation
5. Plan for scale





## Prioritization by NDMA



- Lakes mentioned by one or more agencies in Category **‘High Risk’**, it is classified as **‘NDMA-Category A’**.
- Lakes mentioned by one or more agencies in Category- **‘medium risk’** - classified as **‘NDMA-Category B’**. and similarly, for **‘NDMA-Category C’**
- Lakes without mention of risk category have been categorized as **‘Unclassified’**.

### All these are:

- Within Indian Territory
- Either larger than 50 Ha
- Or expanded >20% during 2019-21



# GLOF Risk Profiling - Criteria by CWC Committee



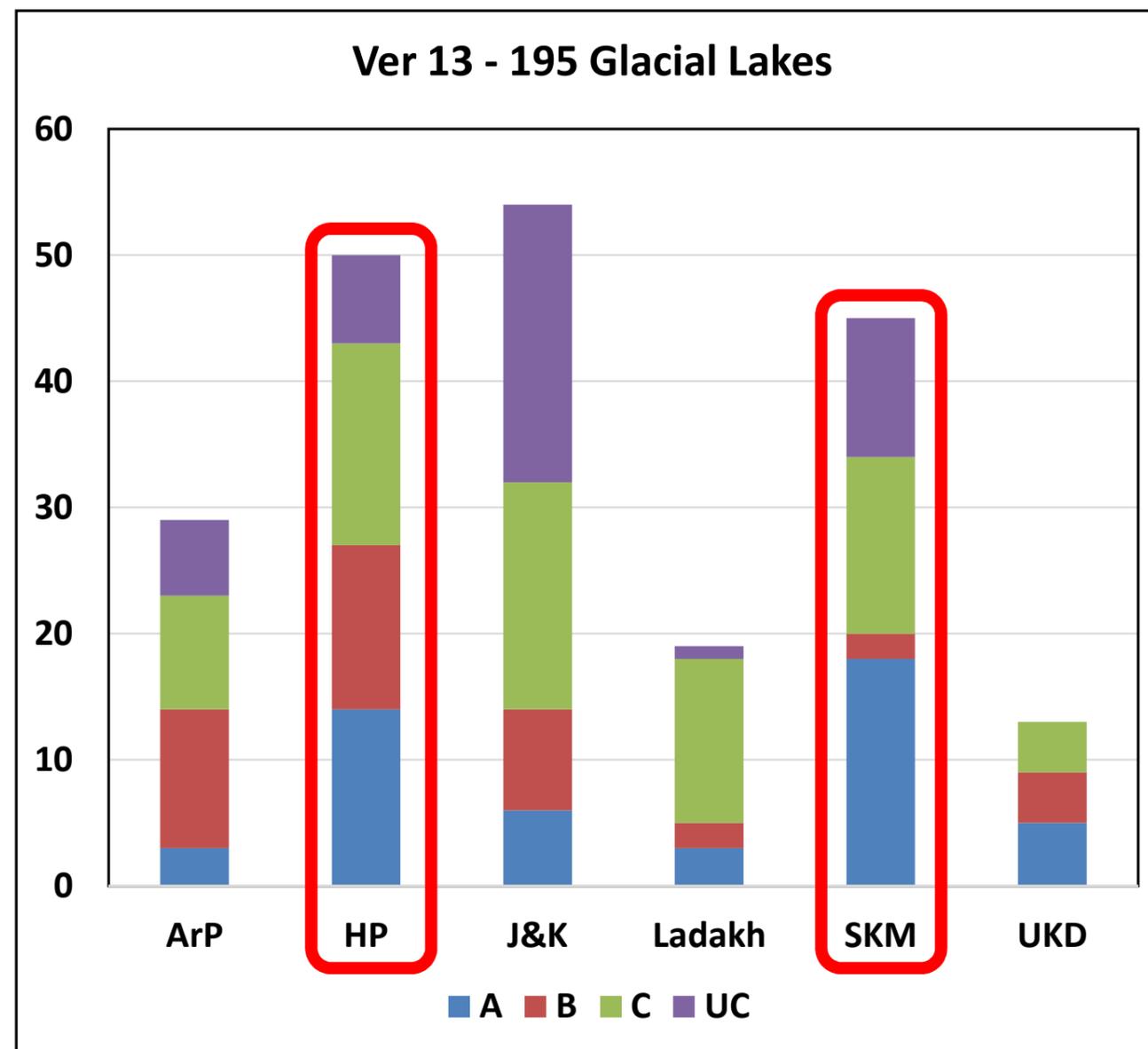
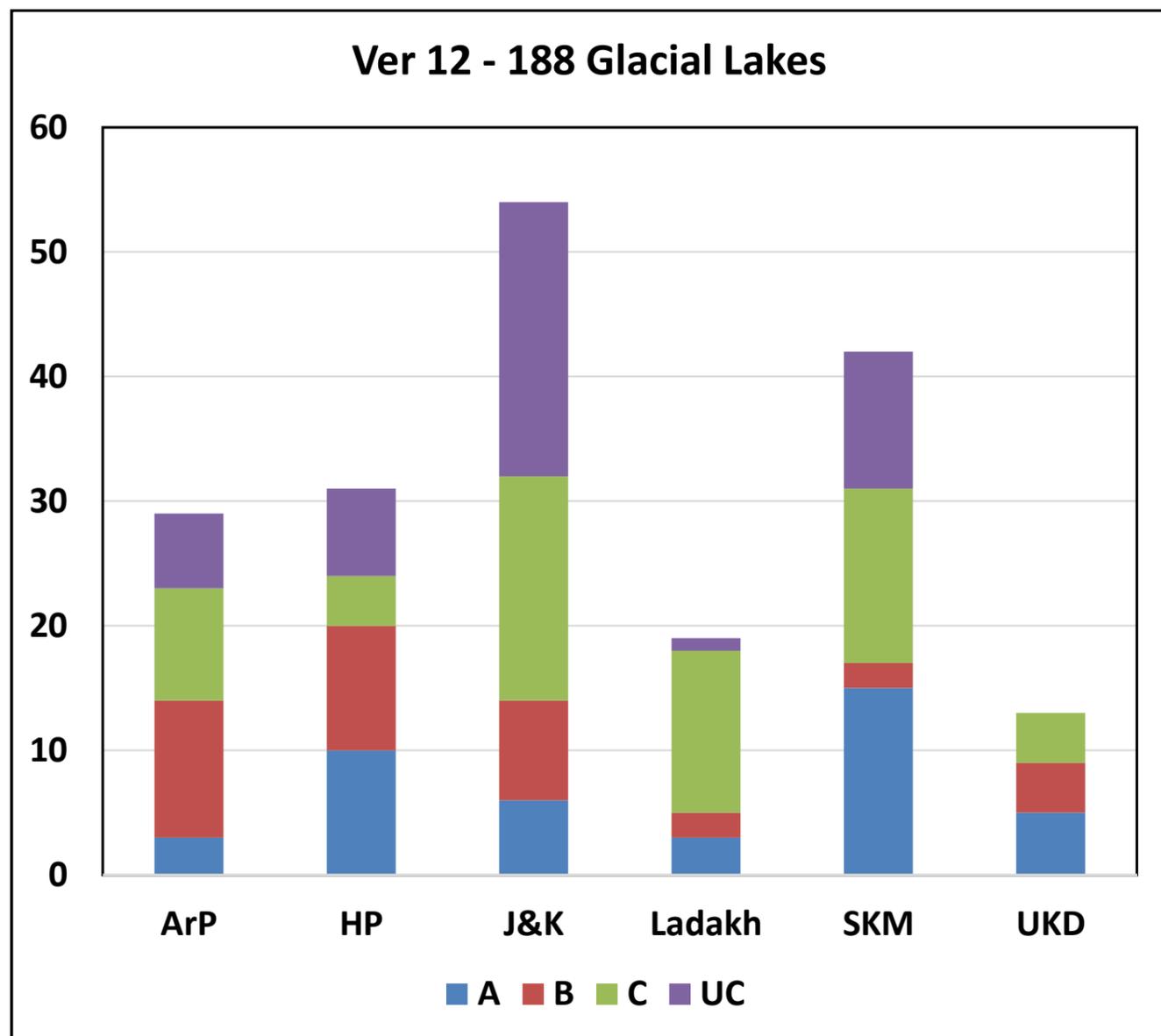
Glacial lake (45)					
1	2		3		
Parameters	Size (ha) of GL		Type of GL		Change in years/av
Total Score	15		5		
Score break-up	Size (ha)	Score	Type	Score	Statu
	A>100	15	Moraine dammed	5	Increa (>25'
	50<A<=100	12	Ice dammed	3	Increasir 25%
	25<A<=50	8	Glacial Erosion	2	Increasir 20%
	10<A<=25	5	Other	1	Increasir 15%
	A<=10	3			Change(+/- 10' Decre (>10'

Risk Score Classification		
Sl No	Score (S)	Classification
1	S>70	Category-1
2	60<S<=70	Category-2
3	50<S<=60	Category-3
4	S<=50	Category-4

- 2.2.1 Size of Glacial Lake: .....
- 2.2.2 Type of Glacial Lake: .....
- 2.2.3 Change in Size of Glacial Lake: .....
- 2.2.4 Stability of Glacial Lake side slope (surrounding topography): ....
- 2.2.5 Glacial Lake inlet to snout distance: .....
- 2.2.6 Glacial Lake inlet to snout slope: .....
- 2.2.7 Glacial Lake in the vicinity and connected (>1 ha) within 1 Km: ..
- 2.2.8 Nearest downstream Habitation Distance (likely to be affected):..
- 2.2.9 Distance to nearest downstream Dam: .....
- 2.2.10 Distance to nearest downstream Bridge: .....
- 2.2.11 Historical GLOF events:.....
- 2.2.12 Seismic Zones:.....



# CoDRR – Interaction with States





# Mitigation Measures:



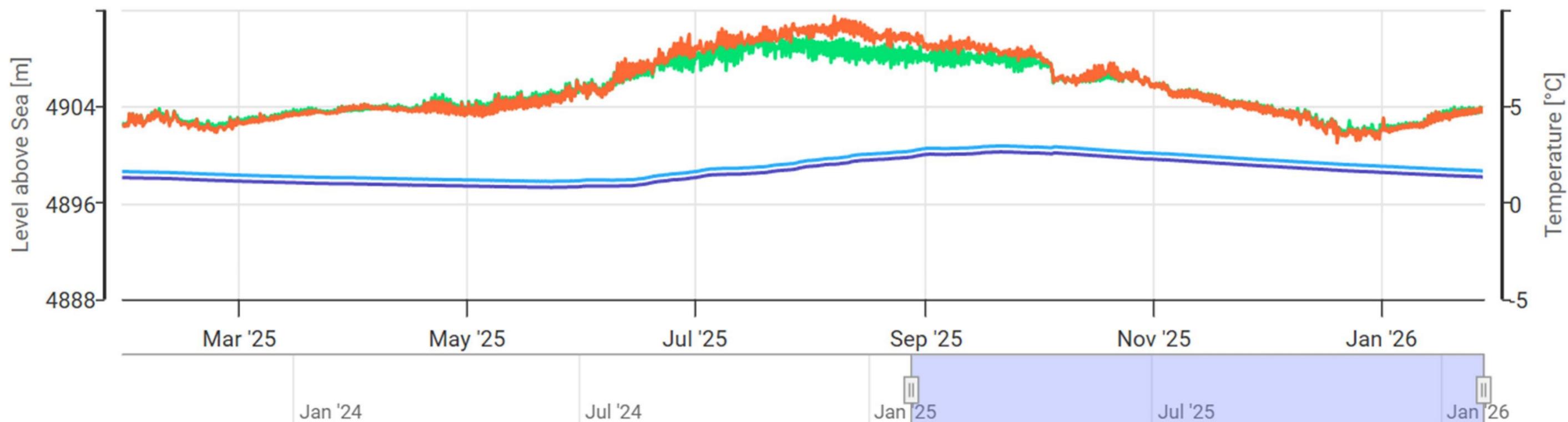
## Probes

Last value from: 01/28/2026, 2:20 PM



Range 1d 1w 1m 3m **1y** All

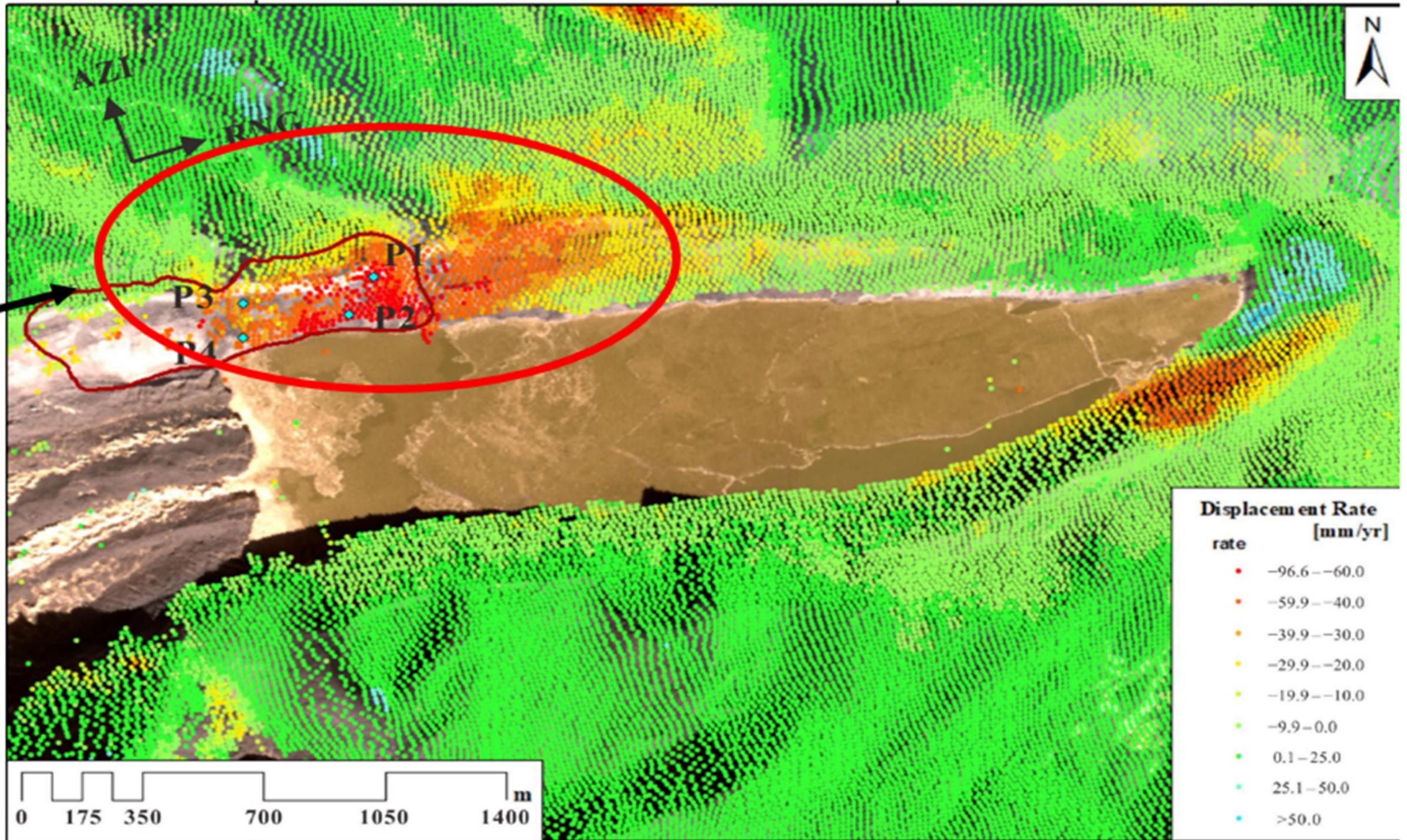
From 28 Jan 2025 To 28 Jan 2026



- Lake Level P1 AVG
- Lake Level P2 AVG
- Temperature P1 AVG
- Temperature P2 AVG
- Water Level P1 AVG
- Water Level P2 AVG
- Pressure P1 AVG
- Pressure P2 AVG
- Lake Level Diff P1 AVG
- Lake Level Diff P2 AVG
- Air pressure [mbar] AVG

# INSAR STUDY

Slope deformation





# Mitigation Measures



MITIGATION OPTIONS

## Lake lowering at Shako Chho lake, Thangu using solar pumping



## Retention structure at Goma chu watershed, Dolma Sampa





# 15<sup>th</sup> Finance Commission Allocations (FY22-26)



\$30 bn = Rs.2.28 lakh crore

- Preparedness and capacity-building (10%)
- Mitigation (20%)

} **Pre-Disaster**

**Disaster** —————

- Response and Relief (40%)
- Recovery and Reconstruction (30%)

} **Post-Disaster**



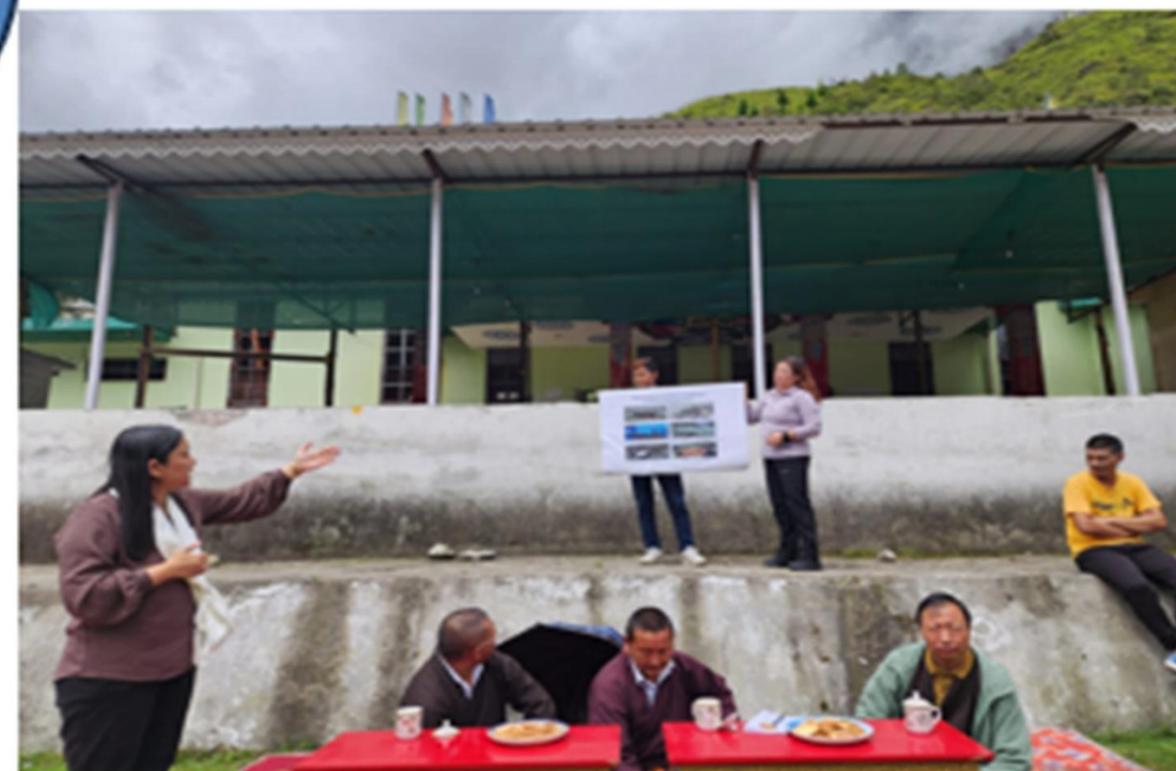
# National GLOF Risk Mitigation Programme (NGRMP)

## Programme Component

- **Hazard and Risk Assessment (15% Budget):** This component focuses on creating a comprehensive inventory of glacial lakes. The inventory will classify these lakes based on hazard potential, vulnerability of surrounding areas, and overall GLOF risk.
- **Monitoring and Early Warning System (35% Budget):** This involves setting up a robust monitoring system using remote sensing techniques, advanced seismometers, water level sensors, cameras, and trigger lines. Early detection of potential breaches is crucial for timely evacuation and disaster response.
- **Mitigation Measures (40% Budget):** This focuses on site-specific interventions to reduce the risk of GLOFs. This could involve reinforcing unstable moraine dams holding back glacial lakes or controlled drainage of lake water to lower pressure.
- **Community Awareness and Capacity Building (10% Budget):** The program recognizes the importance of community preparedness. This component involves raising awareness about GLOF risks and building capacity among local communities for better disaster response.



**PRA Exercise at  
Lachung:  
Raising  
Awareness on  
GLOF Dangers  
and Creating  
Evacuation Maps  
for Residents**



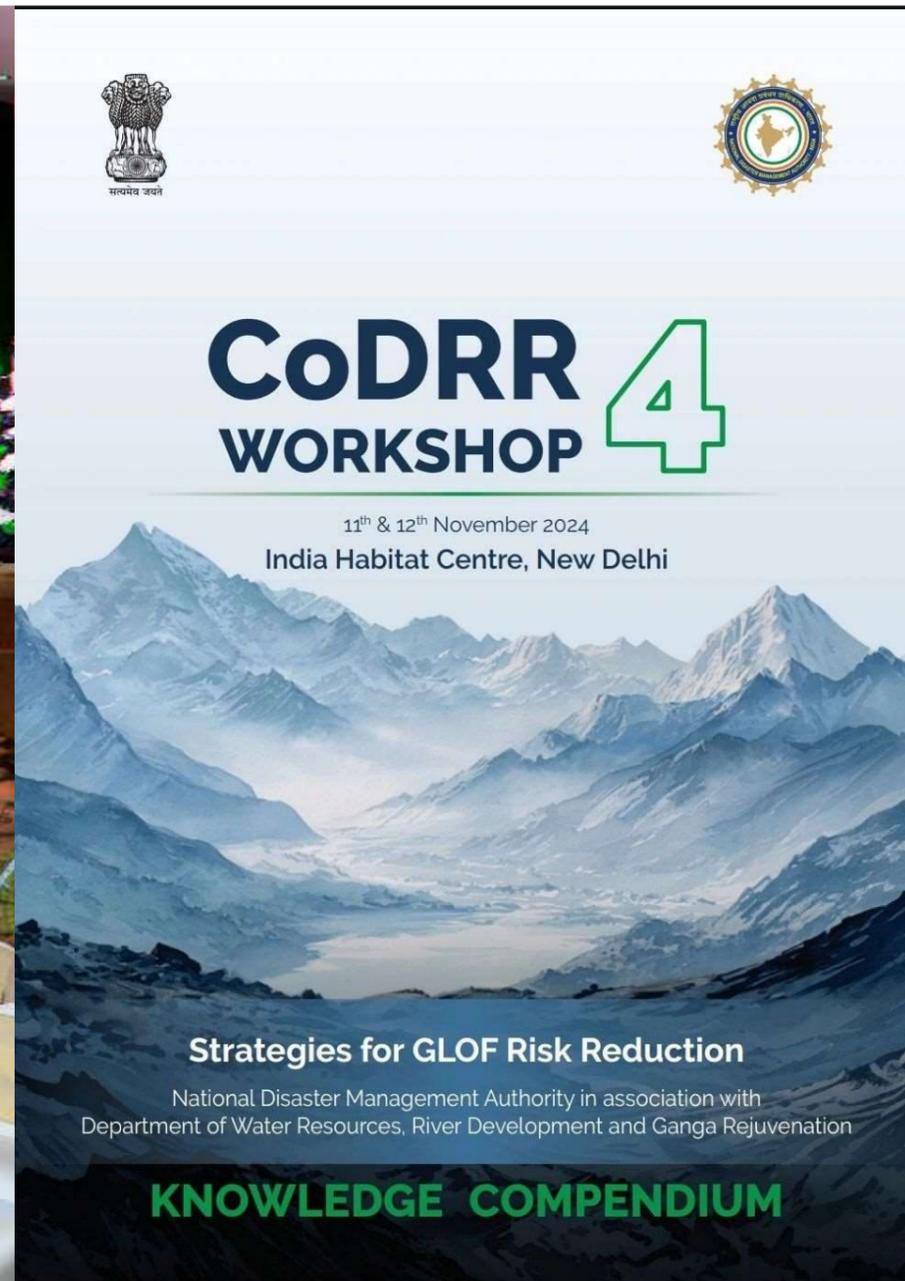


Tenchungkha Lake  
Sikkim





# Two-day international workshop titled "*Strategies for GLOF Risk Reduction*" 11th and 12th November 2024 at India Habitat Centre, New Delhi





## Summary:-



**NDMA has taken significant initiatives for Glacial Lake Outburst Flood (GLOF) risk management in the Himalayan region.** The South Lhonak GLOF event in Sikkim (2023) highlighted the urgent need for proactive measures. Key highlights include:

- **Prioritization of 141 High Risk glacial lakes** based on risk profiling and categorization of high-risk lakes.
- Development of **comprehensive NDMA Guidelines (2020)** for GLOF management covering preparedness, mitigation, and response.
- Installation of **early warning systems (AWS & cameras)** at South Lhonak and Shako Cho lakes for real-time monitoring.
- Launch of the **National GLOF Risk Mitigation Programme (NGRMP)** with a ₹150 crore budget for hazard assessment, monitoring, mitigation, and community awareness.
- Regular **expeditions, surveys, capacity-building programs, and community awareness drives** in vulnerable Himalayan regions.



**Thank You**