NEA WEEKLY TALK PROGRAM

" The Himalayan Hazard: Post-Event Assessment of Thame's GLOF "

Speaker

ER.DR. KESHAB SHARMA

Geotechnical Engineer, BGC Engineering Inc., Canada

ON FRIDAY, 13 DECEMBER 2024

START AT 03:30 PM

ENGINEER BHAWAN, NEA TRAINING HALL, PULCHOWK, LALITPUR

Live on NEA Facebook page.

IN ASSOCIATION WITH

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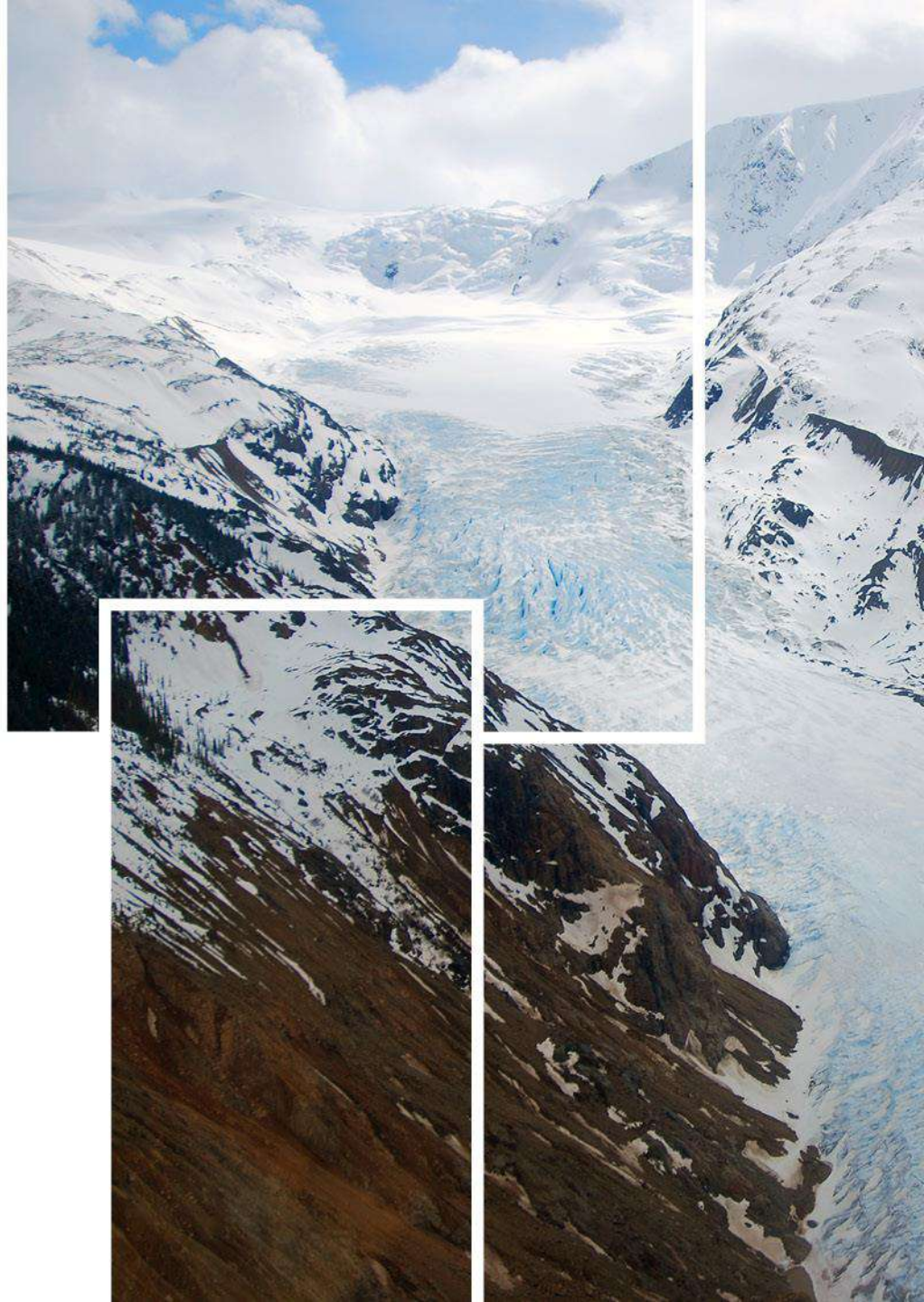
Website: www.ngeotech.org

Thame GLOF Field-Based Assessment

Keshab Sharma, PhD
BGC Engineering Inc., Canada

December 13, 2024



Keshab Sharma, PhD

PhD in Geotechnical Engineering
University of Alberta, Alberta, Canada

MSc in Civil Engineering
The University of Tokyo, Tokyo, Japan

BE in Civil Engineering
Pulchowk Campus

Diploma in Civil Engineering
Western Region Campus, Pokhara

Geotechnical Engineer-In-Training
BGC Engineering Inc.

Research Geotech Engineer
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Project officer
Save the Children International

Lecturer (part-time), Pulchowk Campus

Engineering, GON

Lecturer
Kathmandu Engineering College

Over 70 Published Research Papers

Keshab Sharma

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Geotechnical Earthquake E… Geodisaster Advanced Soil Mechanics a… Disaster Mitigation and Ma

TITLE	CITED BY	YEAR
The 2015 Gorkha Nepal earthquake: insights from earthquake damage survey K Goda, T Kiyota, RM Pokhrel, G Chiaro, T Katagiri, K Sharma, ... Frontiers in Built Environment 1, 8	357	2015
Field investigation on the performance of building structures during the April 25, 2015, Gorkha earthquake in Nepal K Sharma, L Deng, CC Noguez Engineering Structures 121, 61-74	185	2016
Reconnaissance report on geotechnical and structural damage caused by the 2015 Gorkha Earthquake, Nepal G Chiaro, T Kiyota, RM Pokhrel, K Goda, T Katagiri, K Sharma Soils and Foundations 55 (5), 1030-1043	90	2015
Challenges for reconstruction after M_W7.8 Gorkha earthquake: a study on a devastated area of Nepal K Sharma, A Kc, M Subedi, B Pokharel Geomatics, Natural Hazards and Risk 9 (1), 760-790	70	2018
Post disaster reconstruction after 2015 Gorkha earthquake: challenges and influencing factors K Sharma, KC Apil, M Subedi, B Pokharel Journal of the Institute of Engineering 14 (1), 52-63	39	2018
Database of rocking shallow foundation performance: Dynamic shaking AG Gavras, BL Kutter, M Hakhamaneshi, S Gajan, A Tsatsis, K Sharma, ... Earthquake Spectra 36 (2), 960-982	36	2020

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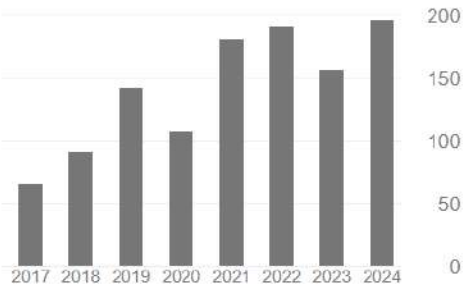

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7 articles 6 articles

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Based on funding mandates


APIL KC
Institute of Engineering, Pulchow…


Ioannis Anastasopoulos
Professor of Geotechnical Engin…


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Associate Professor of Civil Engi…


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Indra Prasad Acharya
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Sean Wilkinson
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Weian Liu, Ph.D., S.E.
Research Project Engineer at Jo…


Roberto Paolucci
Professor of Engineering seismol…


Prabin Acharya
Department of Civil and Environ…


Diwakar khadka
PhD Scholar, Tongji University, S…


Rishi Ram Parajuli
Arup


Kazuo Konagai
International Consortium on Lan…

Post-Disaster Reconnaissance and Resiliency Study

- *2011 Tohoku Earthquake, Japan (M_w ~9.0)*
- *Taiwan, 2012*
- *2015 Gorkha, Nepal, Earthquake (M_w 7.8)*
- *Chile, 2017*
- *Melamchi Debris Flow (2021)*
- *2023 Turkey Earthquake (Mw 7.8)*
- *2024 Flooding, Landslides, and Debris flow in Central Nepal*
- *Several other virtual reconnaissance study*

Selected OP-ED Articles

गलत नीतिको सिकार नब...
गुणस्तरीय शिक्षा र स्वास्थ्यमा सबैको समान पहुँच पुग्ना...

डा. केशव शर्मा

September 17, 2018

काठमाडौंमा मोनोरेल होइन मेट्रो |

Setopati

कस्तो हुनुपर्छ हाम्रो विश्वविद्यालय ?

डा. केशव शर्मा

काठमाडौंको अस्तित्व र स्याटलाइट सहर

प्रदेश राजधानी र विकासको प्रश्न

ARCHIVE.NAYAPATRIKADAILY.COM | BY NAYA PATRIKA

निजगढ विमानस्थल : निबन्धजस्तो प्रतिवेदन - Naya Patrika

निजगढ विमानस्थल : निबन्धजस्तो प्रतिवेदन देशलाई दोस्रो अन्तर्राष्ट्रिय विमान...

बहुउद्देश्यीय पूर्व–पश्चिम नहर
यो धेरै ठूलो परियोजना भएकाले यसको अध्ययन, डिजाइन, निर्माण र सञ्चालनका क्रममा हजारौं रोजगारी सिर्जना हुनेछन्

डा. शिव गौतम | इ. ओम राउत | डा. केशव शर्मा | डा. केशव भट्टराई | डा. अनिरुद्धप्रसाद अधिकारी

भूकम्पप्रतिरोधी संरचना निर्माण कसरी ?
रड र सिमेन्टजस्ता आधुनिक निर्माण सामग्रीको प्रयोग होसियारीपूर्वक मापदण्ड पुऱ्याएर गरिएन भने यसले झन् बढी जोखिम निम्त्याउँछ

बिजुला पोखरेल | केशव शर्मा

चितवन राष्ट्रिय निकुञ्जमा सुरुङ : यथार्थ कि खोक्रो आश्वासन ?
केशव शर्मा

पहिरोको बढ्दो प्रकोप
सर्भे तथा डिजाइनविना सडक खन्न नदिने व्यवस्था कडाइसाथ ...

डा. केशव शर्मा

सम्भव छ भूकम्पको पूर्वानुमान ?
सन् १९७९ देखि १९८९ को १० वर्षमा मात्रै ६.० म्याग्निच्युड वा सोभन्दा ठूला ४ वटा भूकम्प गए। त्यसकारण नेपालमा पनि हरेक ७५–८० वर्षमा महाभूकम्प जान्छ भनेर किटान गर्ने अवस्था छैन।

केशव शर्मा

किन डुब्दैछ काठमाडौं उपत्यका ?
...ज्याले घर बनाउनु हुँदैन भनेको ठाउँमा घर बनाउने अनि विपद् आएपछि राज्यलाई नै दोष दिने नराम्रो परिपाटी देखिँदैछ

केशव शर्मा

किन भत्किए पक्की घर ?
पक्की घर भत्किनुमा त्यहाँको माटोको प्रकार, पिलरको साइज तथा छडको मात्रा, चुरी (रिङ) प्रयोग, निर्माण सामग्रीको गुणस्तर, भवनको गतिशील गुणजस्ता थुप्रै कारण हुनसक्छन्।

केशव शर्मा पौडेल | हरिकुमार अधिकारी

विविध | कोरोनाविरुद्ध सचेतना

किन बढ्दै छ भरत...

डा. केशव शर्मा

September 17, 2021

बर्सेनि किन डुब्छ काठमाडौं ? |

Kantipur Daily

मापदण्डविपरीत सहरी सडक

केशव शर्मा

पुनर्निर्माणका चुनौती
पुनर्निर्माणको प्रमुख चुनौती जनताको उच्च आकांक्षा र विकासको अति राजनीतिकरण हो। ...

भूकम्प र दीर्घकालीन असर
केशव शर्मा पौडेल

गलत डिजाइनमा बनेको आठ लेनको रिङरोड

शिक्षा लिन नसकिए...

केशव शर्मा

भूकम्पप्रतिरोधी निर्माण
विगतको भूकम्पबाट शिक्षा लिने हो भने, बहुविपद्प्रतिरोधी संरचनामा अघि बढ्नको...

डा. केशव शर्मा

सडकले भन्छ हामी कति सडेका छौं
काठमाडौंमा निर्माण भएका र हुँदै गरेका सडक संरचना ठीक छन् ? के हाम्रा सडकमा पैदल यात्री, साइकल यात्री, अपांगता ठाउँ छ ? सवारी साधन नघटाई कतिन्जेल चौडा पारिरहने ?

रानीपोखरी पुनर्निर्माण क...
केशव शर्मा

निर्माणमा प्रविधि

डा. केशव शर्मा

June 29, 2021

मेलम्ची विपदको अन्तर्य र शिक्षा |

Naya Patrika Daily

बाँध सुरक्षाका चुनौती
मोहननाथ आचार्य | केशव शर्मा

शिक्षा लिन नसकिएको भूकम्प
गत भूकम्पबाट सिकेर कस्तो र कुन मात्राको विपद् आउँदा कुन तहको सरकारले कस्तो काम गर्ने भन्ने प्रस्ट तया...

डा. केशव शर्मा

Selected OP-ED Articles

THE KATHMANDU POST — SUNDAY, MAY 17, 2020 | 04

OPINION

Five years since the Gorkha earthquake, Nepal still falls short

The country being in a highly vulnerable seismic zone, one would think the government and society would plan better.

KESHAB SHARMA

Why monorail is bad for Kathmandu

One of the biggest downsides of monorails is when something goes wrong, or if a section of track needs to be repaired, the entire system needs to be shut down

Keshab Sharma

Schools at risk

Earthquake resistant features such as horizontal bands and stones at the corners are generally not provided in school buildings across Nepal

Keshab Sharma (Paudel)

Why heritage sites?

Setopati

República
Wednesday, August 21, 2019

What ails heritage reconstruction?

Local authorities have not really understood true spirit of heritage reconstruction. Decisions are being changed quite often

Keshab Sharma

Apil KC

to lead the 'Campaign to Rebuild Kasthamandap' after which four-party agreements were signed between NRA, DoA, Kathmandu Metropolitan City (KMC) and the campaigners, handing over the reconstruction process under direct participation of the campaigners. Few days after the agreement, Mayor of KMC said that reconstruction would take place under direct supervision of KMC.

Case of Rani Pokhari is no different. People rose in protest to halt the reconstruction process

among major stakeholders has been observed in this whole process of reconstruction. Similarly, local authorities have not really understood true spirit of heritage reconstruction. Decisions are being changed quite often.

ADDITIONAL ISSUES

According to recent data from DoA, permission has been granted for more than 50 reconstruction projects for heritage structures and

Keshab Sharma

NO TOURISM WITHOUT INFRASTRUCTURES

Reconstruction challenges in Nepal

Keshab Sharma/ Apil KC Tuesday, Apr 18, 2017 0 3638 reads

República
Tuesday, April 19, 2016

Go local

The NRA has proposed 17 different residential building models for post-quake rebuilding. Most of these models are defective

Keshab Sharma

e-paper

Learning from others

Often the question is whether villages should be rebuilt in their original locations or relocated to less disaster-prone areas

Keshab Sharma

Relocation of a settlement, whether necessitated by natural disasters or military conflicts, has always been difficult. An unofficial survey showed that 90 percent villagers rejected Indian government's relocation plans after the Gujarat earthquakes of 2001. The plan had to be aban-

take the following steps during reconstruction. First, it should coordinate with appropriate stakeholders and local communities to conduct detailed comparative analysis of disaster management including mitigation at existing settlements. It should work to keep communities together at the exist-

affected people. Compensation may be provided in different forms: cash, replacement land, small business grant or temporary/permanent project employment so that incomes and livelihoods can be restored. Special attention should be paid to the needs of the socially disadvantaged

Building safe homes

Local governments should take initiative for implementing building codes and by-laws. They should also monitor compliance of those laws

Keshab Sharma

not kill, poor buildings do. Ensuring proper building code understanding and enforcement may contribute to reducing future earthquake losses.

Shortfalls in compliance with building codes have been identified as a serious problem that contributes to high losses in earthquakes. Though Nepal developed building codes 21 years before 2015 earthquake, Nepal is still struggling to implement them. Immediately after the devasta-

Far-Western of Nepal which could trigger an earthquake of higher magnitude. Are we prepared to cope with the situation if it happens? Have we taken precautionary measures to lessen the losses in case of such eventuality?

As things stand, except in few municipalities, most residential and public buildings do not comply with building codes. Though most municipalities have a system of granting building permits to collect the

building codes. First, the owners of the illegally built homes should be barred from receiving government services such as electricity and water. Selling of the illegally-built structures should be strictly prohibited.

The government could provide a period of a year to retrofit weak building to comply with building codes or pull down their illegally-built structures. With these efforts, the government can free the cities from illegally built homes. As many people cannot afford

East West Grand Canal Of Nepal, Part II

We propose to utilize the freely available canal-top air space for installation of solar panels to produce electricity and to reduce evaporative water loss in the canal while allowing for water navigation on the canal

By Ambika P. Adhikari, Shiva Gautam, Om Raut, Keshav Bhattarai, Keshab Sharma | July 29, 2020, 10:55 a.m.

COLUMNS

Five years since the Gorkha earthquake, Nepal still falls short

ierable seismic zone, one would think the government and

July 29, 2020

East West Grand Canal Of Nepal, Part 2 | Spotlight Nepal

Ensuring dam safety

While dam construction is gaining pace, Nepal does not have dam safety legislation and policies to enforce effective dam safety management program

Mohanath Acharya

Keshab Sharma

need to be improved. Implementing effective emergency management program can be one of the most effective methods of reducing and managing risks associated with existing dams and hydropower projects and those in planning and construction phases.

Upstream flooding is also a concern in Nepal's lowland areas due to the location and poor operational practices utilized by existing dams. Subsequence incidents have become common in Indo-Nepal borders where a large

There should be adequate public consultation during the phase of planning, site selection

Opinion

Fire safety planning: Give it due consideration

By RAJIB DHAKAL AND KESHAB SHARMA
Published: 01:00 pm Mar 15, 2021

Heritage and history

Keshab Sharma

Apil KC

Imagine there are no literary works of Laxmi Prasad Devkota and there is nothing like *Muna-Madan*, because in the 21st

Our cultures and heritages uphold our identity as a civilized and culturally enriched nation.

Broken lives

An important aspect of post-disaster recovery is participation of survivo

Keshab Sharma

quickly, often simultaneously. But there is at present no mechanism in place for the project's proper implementation, nor have the local communities been involved in decision-making. This situation has deprived people of even minimum goods and services.

Lack of awareness is also

Nepal. Moreover, construction artisans in the area are not formally trained.

Social problems such as poverty, inequality and unemployment increase people's vulnerability and hinder their return to normal life. People who have physical, social and personal vulnerabilities have suffered the

Failure of tim
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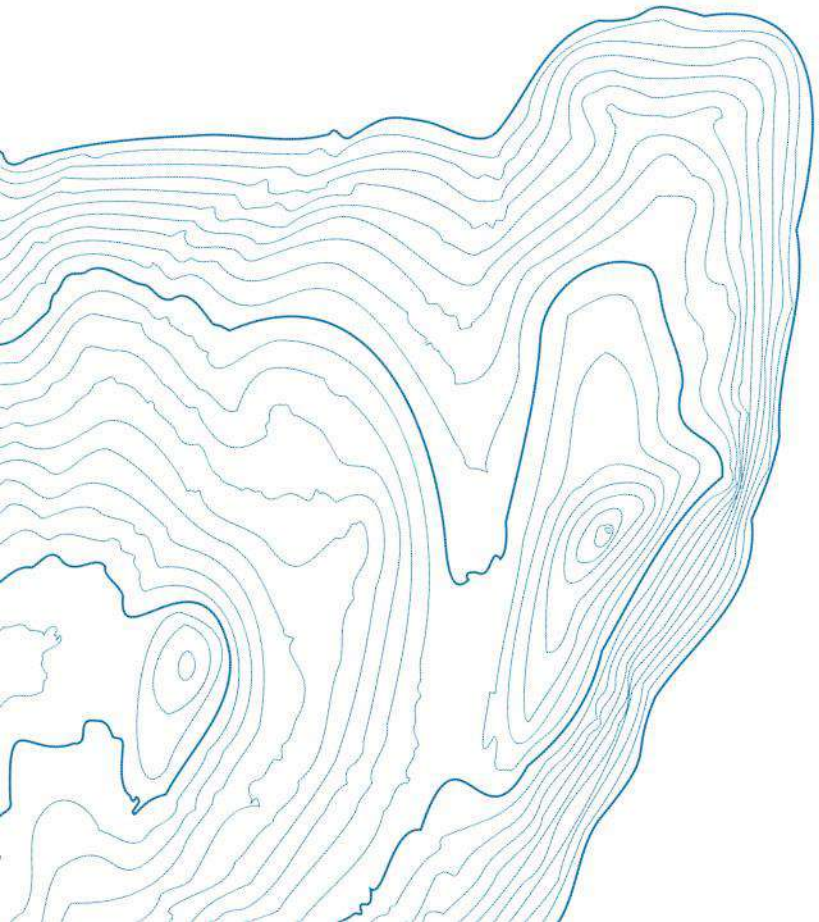

Introduction to BGC Engineering

BGC Engineering

- International consulting firm
- Geoscientists & geo-engineers
- Earth science specialists
- Geohazard risk management specialists
- ~ 800 people

BGC Offices


Edmonton
Calgary
Canada
Sudbury
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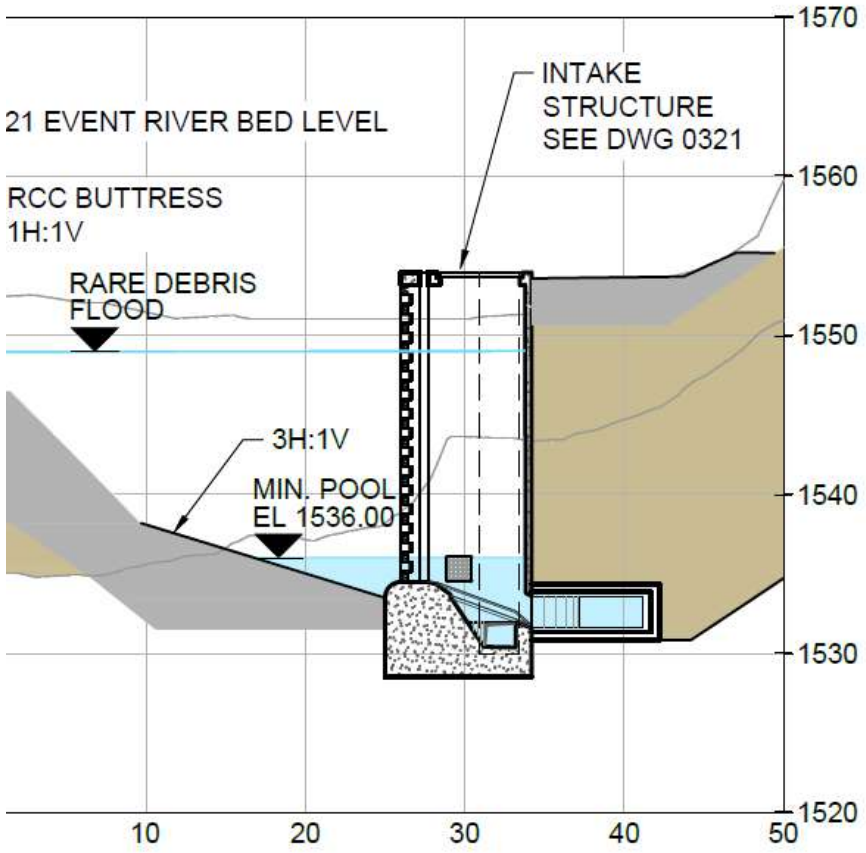
Quebec City
Kamloops
Montreal
Vancouver
Fredericton
Victoria
Halifax
Kelowna
USA
Ottawa
Kingston
Nashville
Golden
Dominican Republic
Santo Domingo
Santiago
Chile
Australia
Brisbane

BGC led conceptual design of a flood resilient water supply intake following the 2021 Melamchi glacial lake outburst and debris flood

Melamchi water supply intake in November 2022



Flood resilient intake design

BGC's experience in Nepal spans academic, professional, and philanthropic projects

Graduate research on landform evolution in response to the 2015 Gorkha Earthquake

Terrestrial Laser Scanning

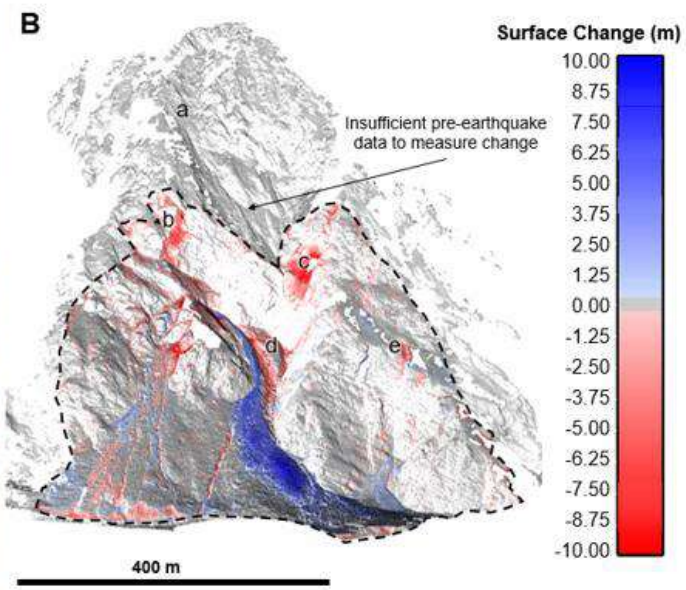
High-Resolution Photography

Satellite Imagery

Aerial Photogrammetry

Application of a range of remote-sensing techniques to evaluate co-seismic and post-seismic landform evolution in the Upper Bhote Koshi Valley, Sindhupalchok.

Google Earth, December 2017



Terrestrial Laser Scan: 2016-2012 ± 0.25 m

SFU SIMON FRASER UNIVERSITY ENGAGING THE WORLD

UNIVERSITY OF ALBERTA

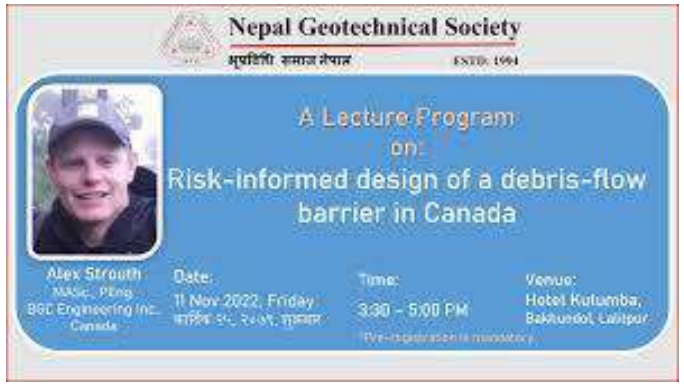
Durham University

BGC

Canada

BGC has collaborated with Nepali organizations, academic institutions, and colleagues

Nepal Library Foundation
Geohazard design support for new library



Invited lecturers on advances in landslide assessments and liquefaction within Kathmandu Valley (Dr. Andrew Mitchell, Dr. Keshab Sharma, Lauren on, Dr. Alex Strouth)

Hosted five Nepali researchers in our Geo-Engineering & Geoscience Research Accelerator (GeoRA) from universities in Nepal and Canada

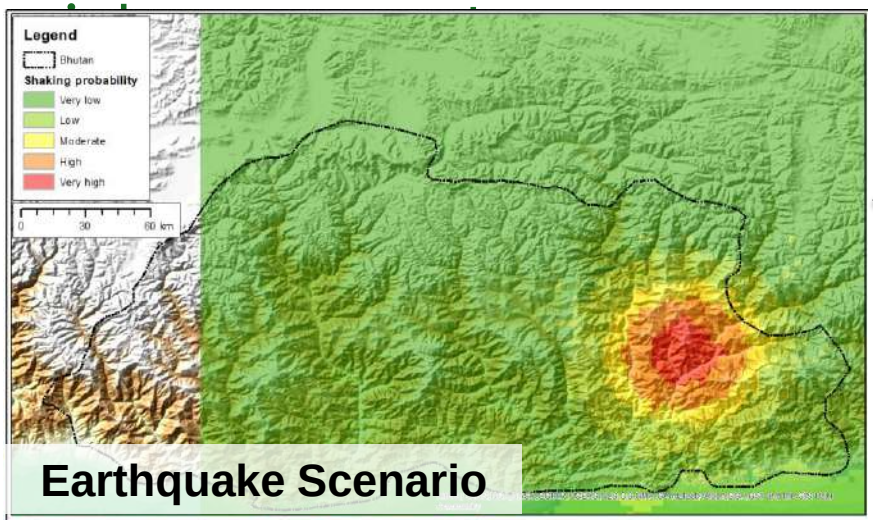
Nepal Geotechnical Society
भूप्रविधि समाज नेपाल
(EST 1994)

2nd GeoMandu
NGS international conference series (Since 2023)

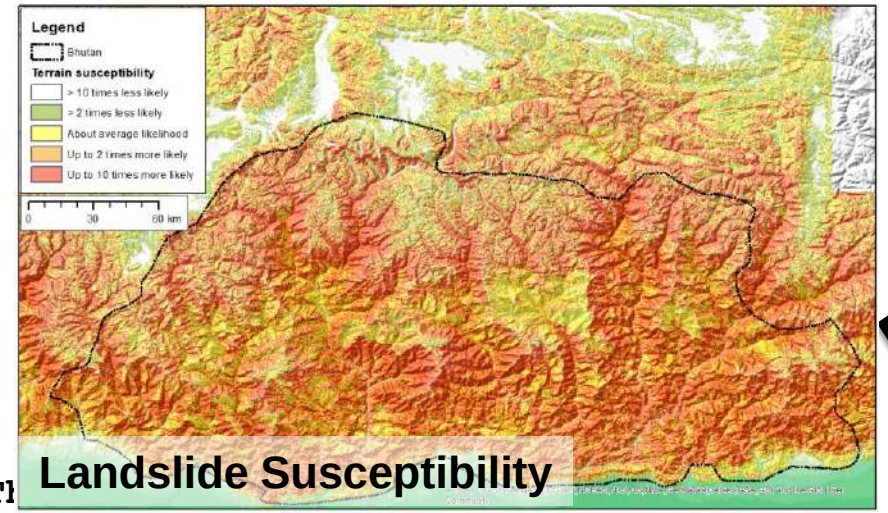
1st GeoMandu
NGS international conference series (Since 2023)

BGC worked with the Thimphu office of Geohazards International to deliver country-scale, co-seismic landslide susceptibility maps for Bhutan

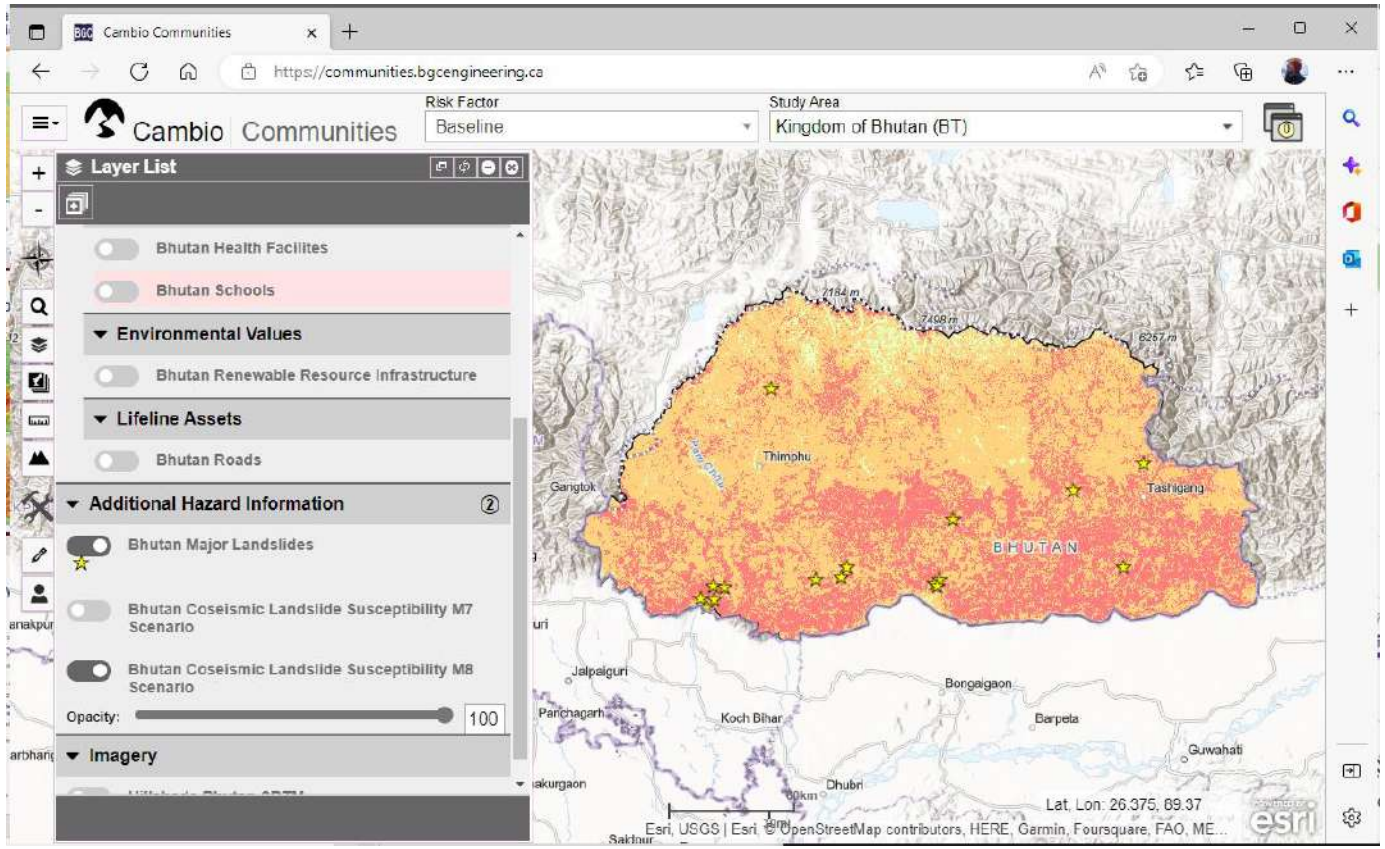
Engagement with Government of Bhutan provides a framework for multi-geohazard



Earthquake Scenario



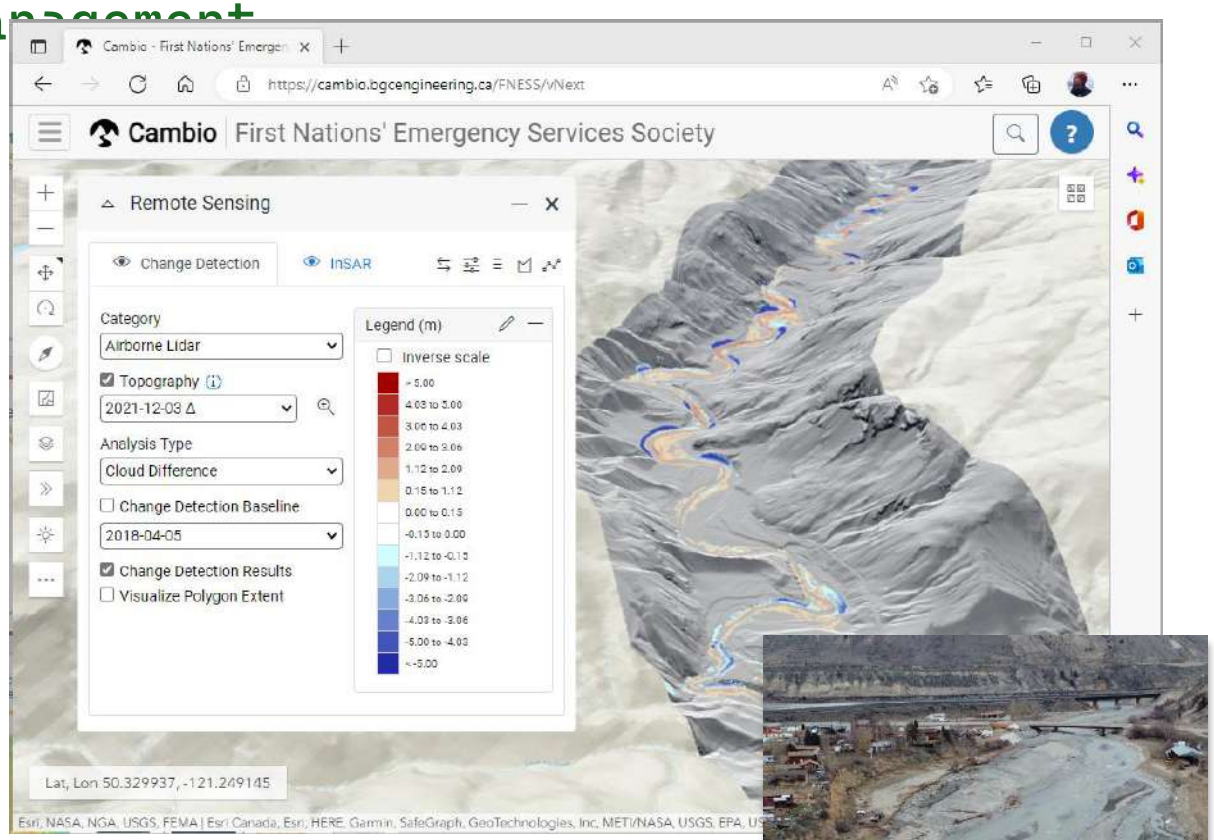
Landslide Susceptibility



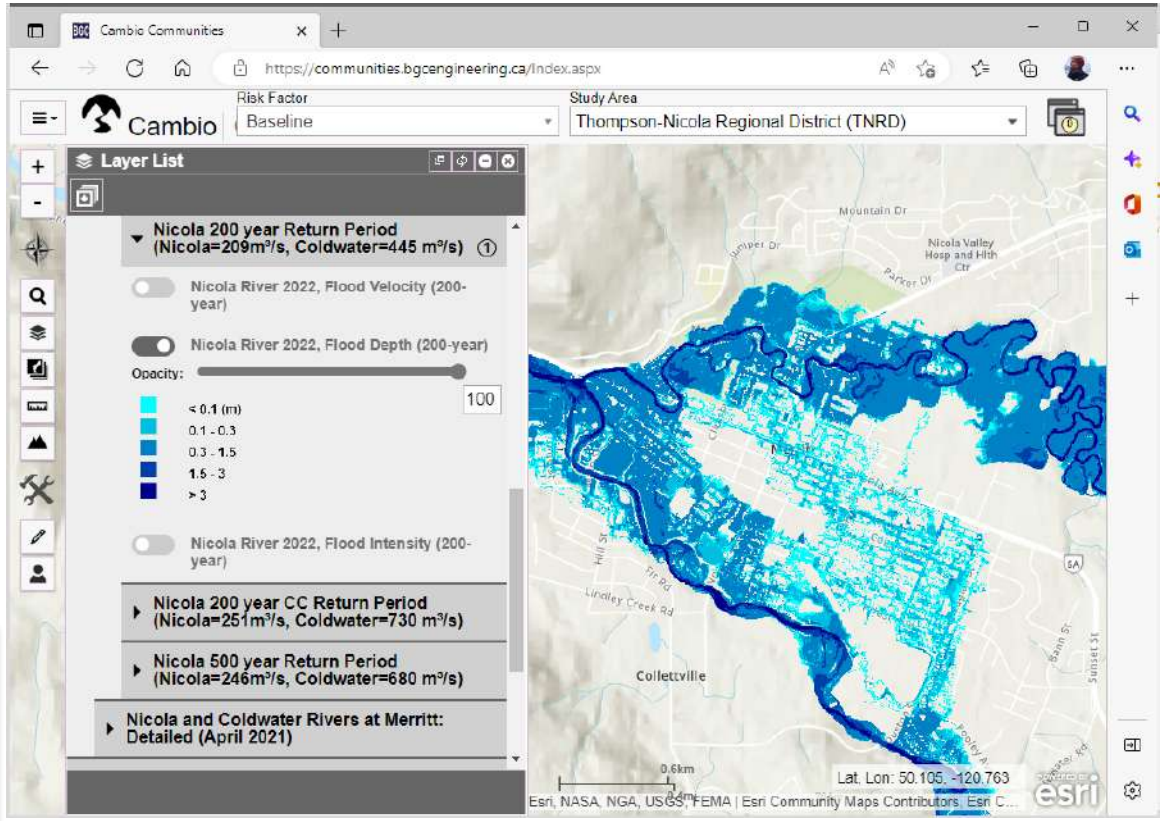
Co-seismic Landslide Susceptibility

BGC led multi-hazard risk prioritization studies across large areas of mountainous Western Canada

The work connects regional & local decision makers across steps of risk management



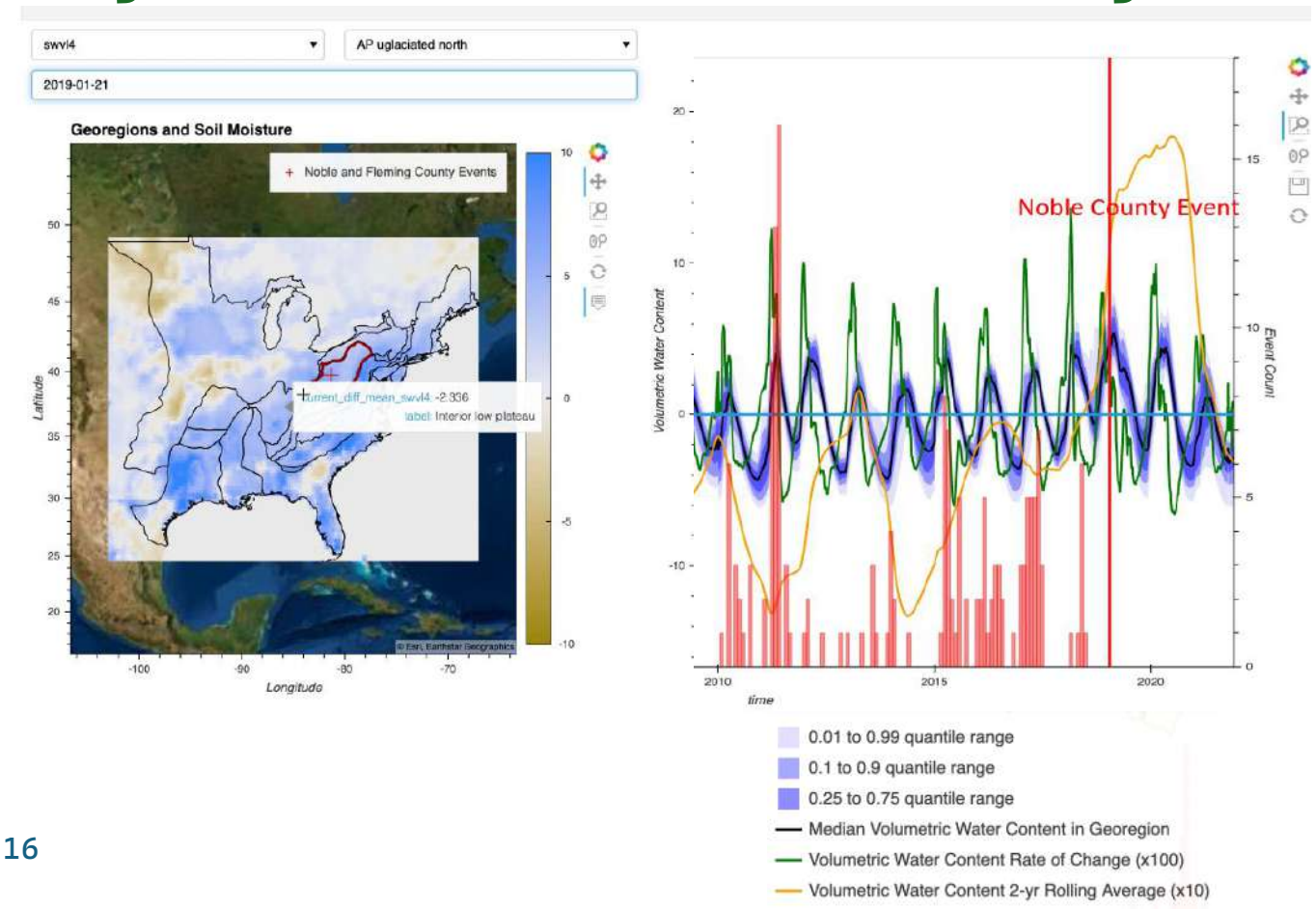
Remote sensing, lidar change detection

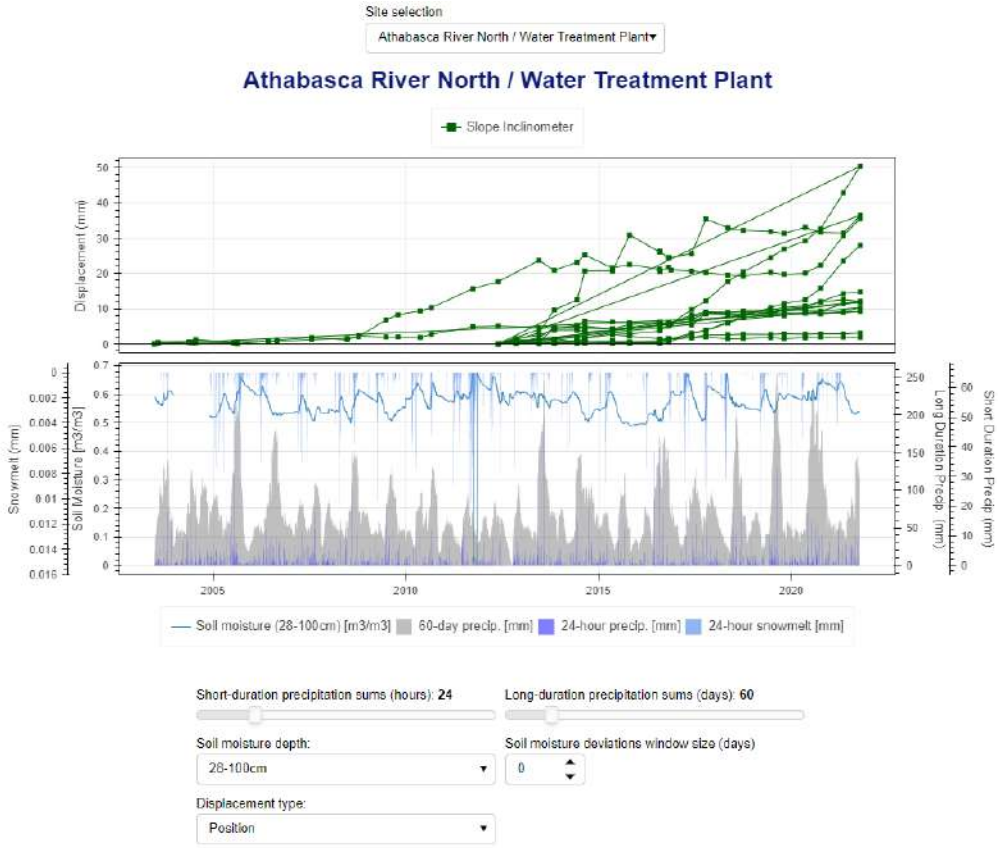


Flood modelling

BGC operates many landslide and flood early warning systems at the regional scale

What is the probability that antecedent climate conditions will lead to a change in landslide conditions for a given location…and what do the





BGC designs geohazard risk reduction measures at all scales

Cheekeye debris-flow barrier in Squamish, British Columbia, Canada

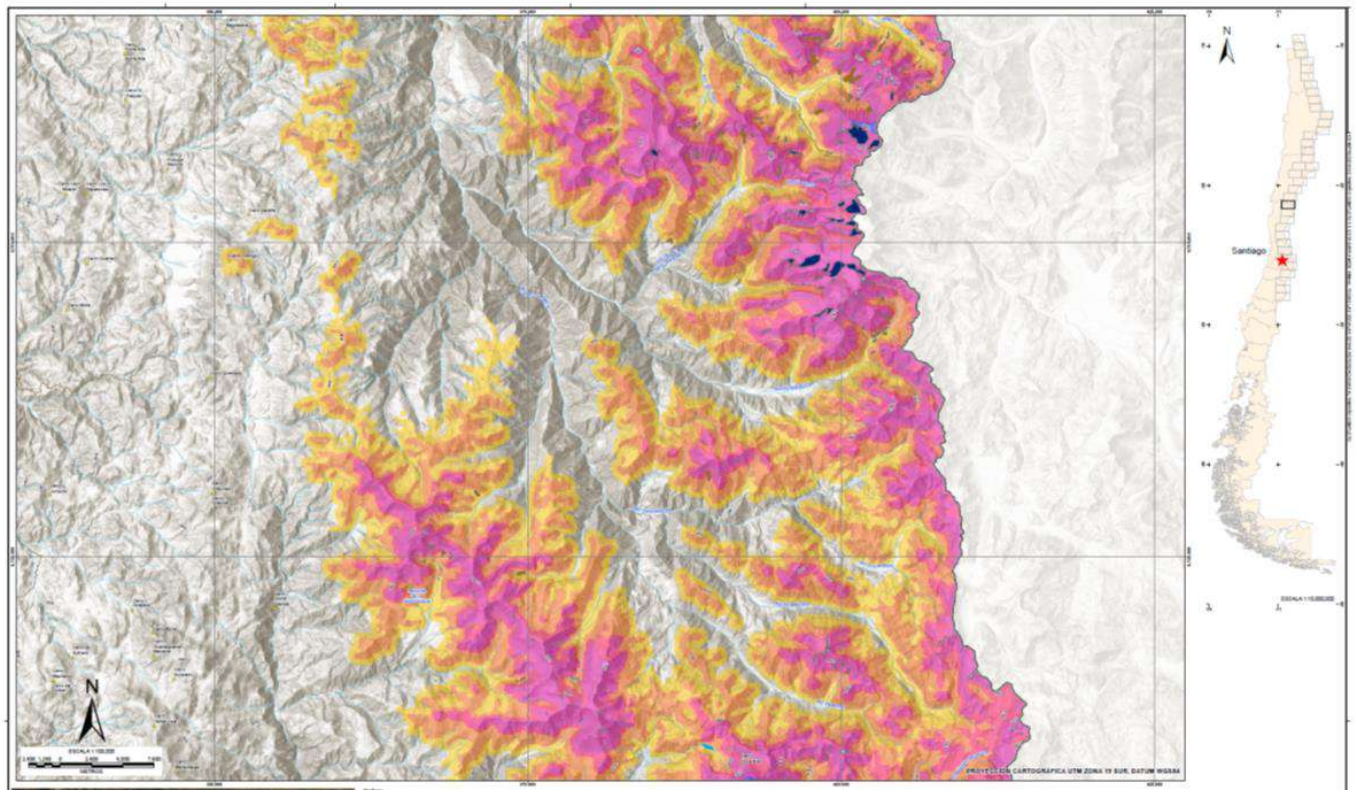
Design event:

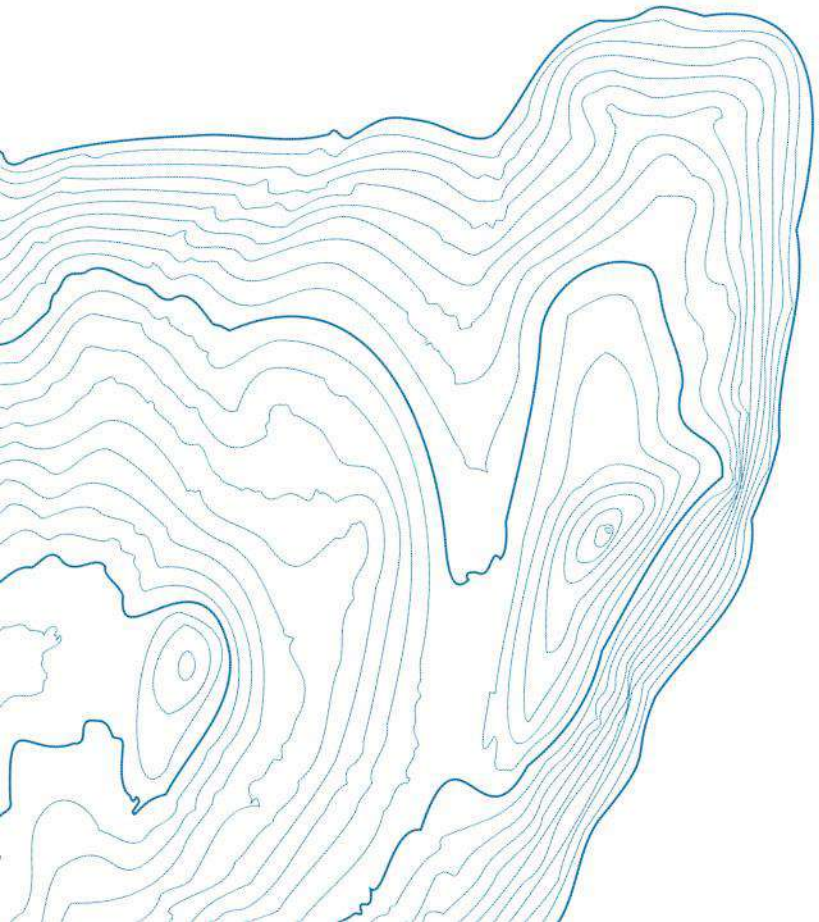
- 2.8 Mm^3 rock-avalanche generated debris flow
- Peak discharge of 15,000 m^3/s

Digital rendering of the Cheekeye barrier. Barrier is about 25 m tall

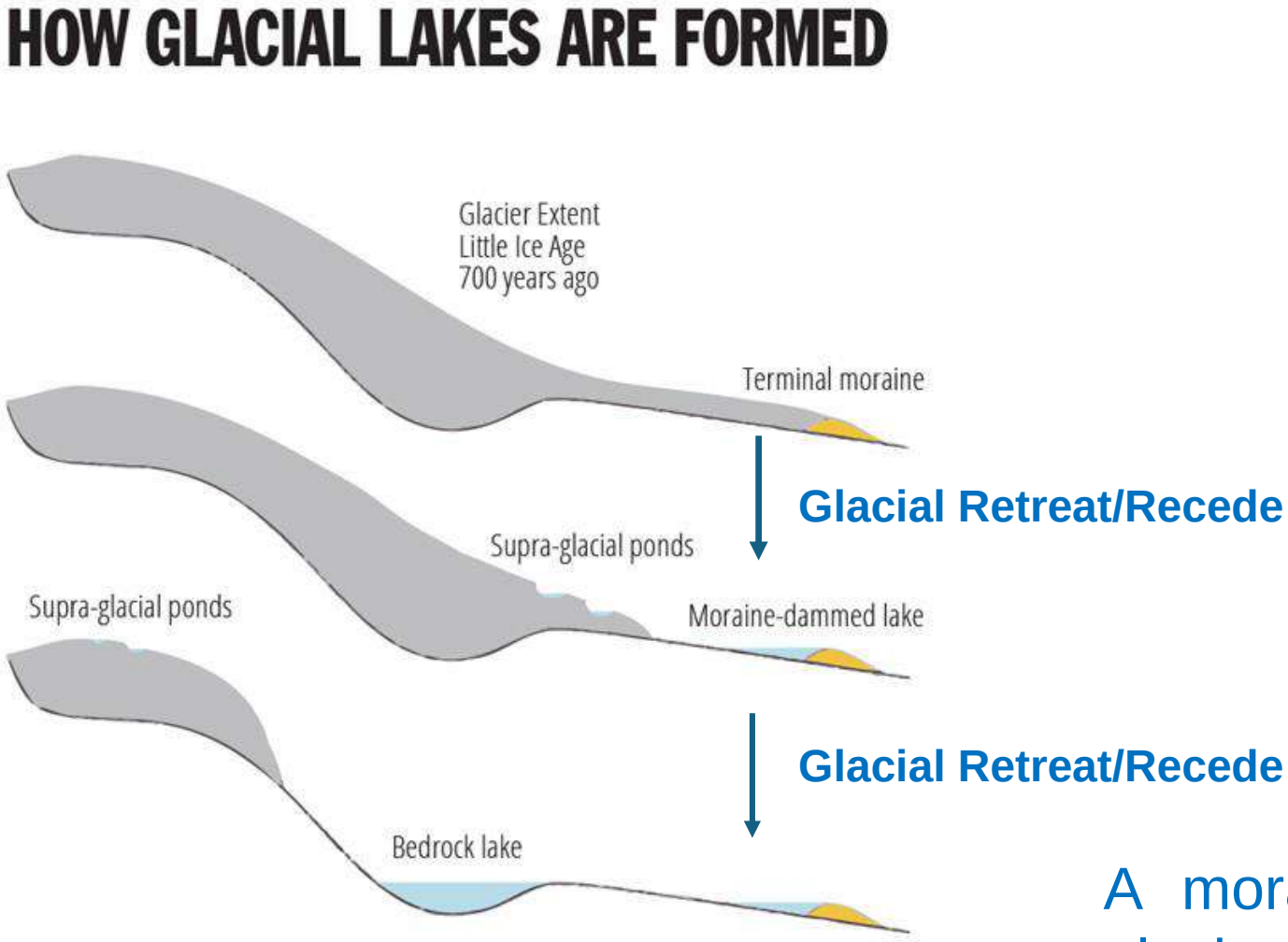
BGC is a leader in characterizing permafrost and glaciers

Understanding permafrost distribution is vital to better asses how it currently influences mountain hydrology and how this may change in the future

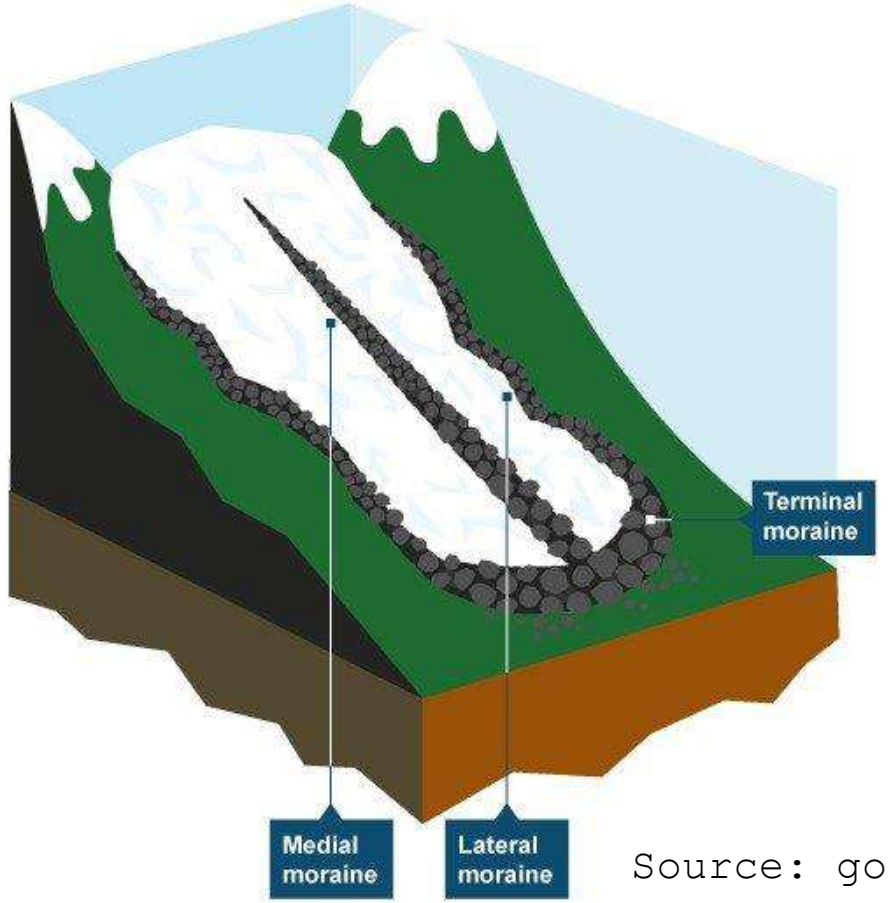




Thame GLOF



Nepalitimes.com

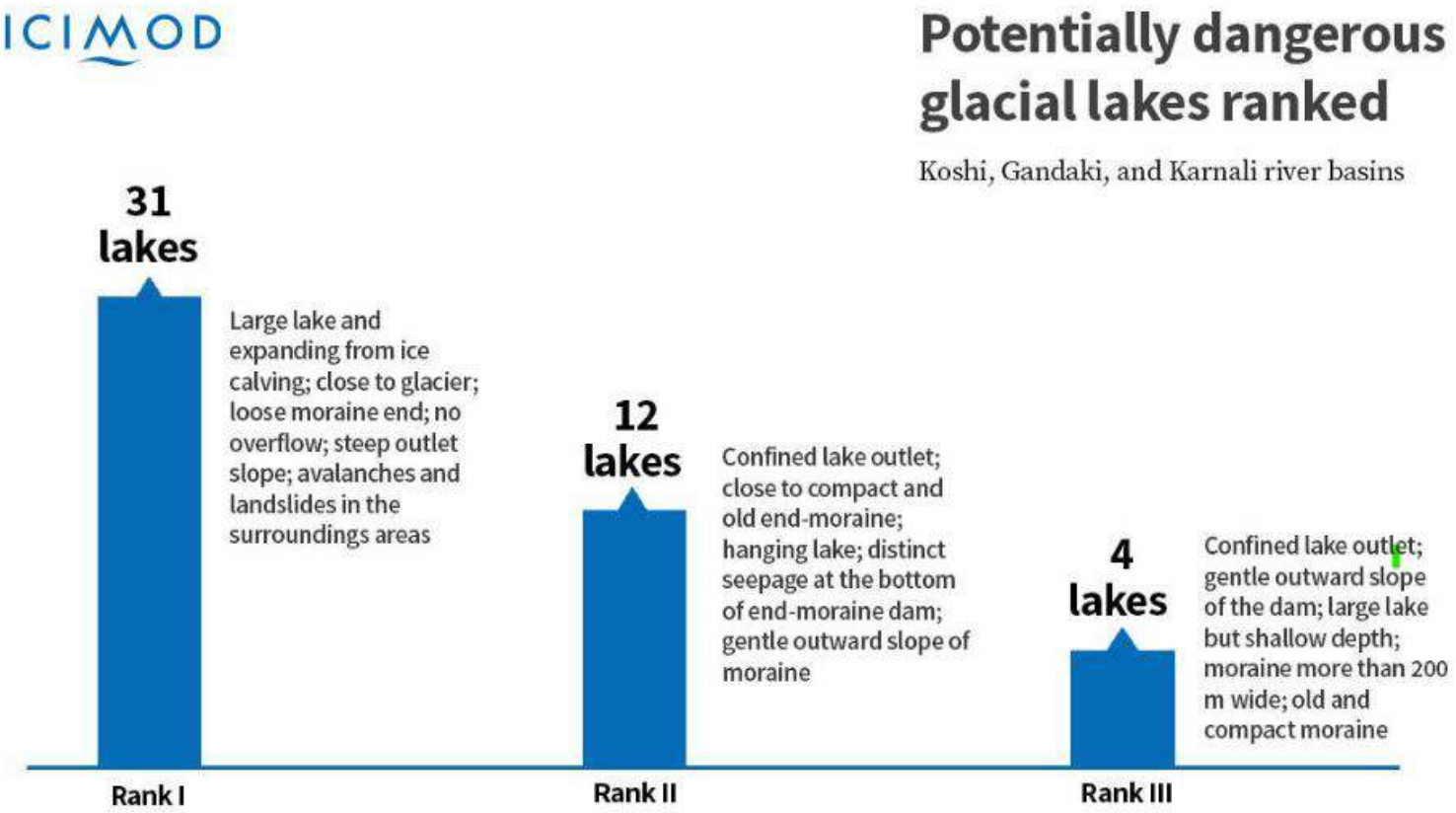


Source: google

A moraine is a landform created by glaciers that consists of a pile of earth and stones, or debris, that has been deposited or pushed up by the glacier.

Glacial Terminologies:

- **Retreat:** Shrinking of a glacier due to more melting than snowfall accumulation.
- **Recede:** The glacier's endpoint moves back compared to its previous extent.
- **Glaciolacustrine**: Sediments and processes involving lakes receiving glacier meltwater, accumulating at lake margins or bottoms.
- **Glaciofluvial:** Erosion or deposition by meltwater streams originating from glaciers, ice sheets, or ice caps.



Mapped 3,624 glacial lakes equal to or larger than 0.003 km^2 (~ 2.4 times bigger than a standard Olympic size swimming pool) in the three basins.

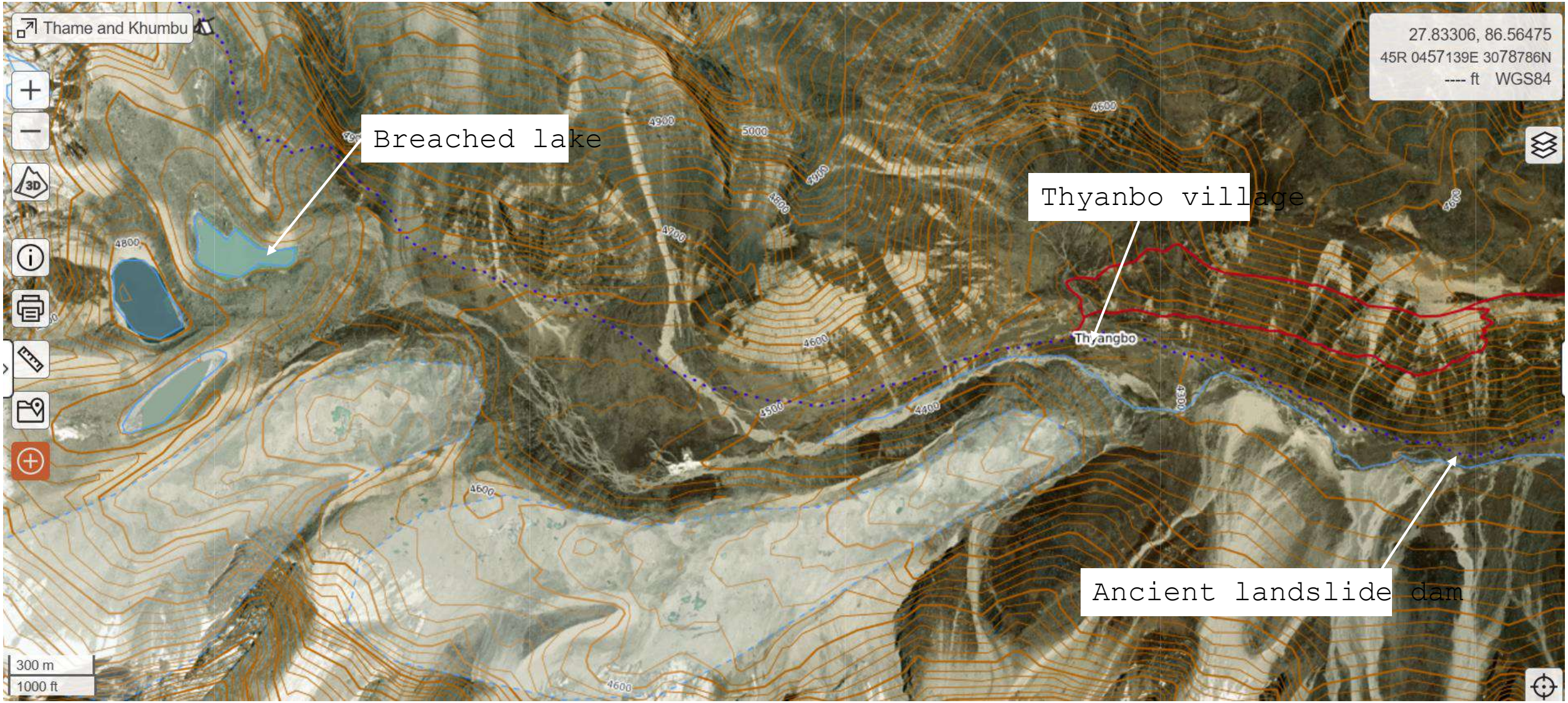
ICIMOD, 2020

- 47 identified potentially dangerous : 25 in China, 21 in Nepal, and 1 in India,
- 42 are within the Koshi basin 3 are in Gandaki and 2 are Karnali basins

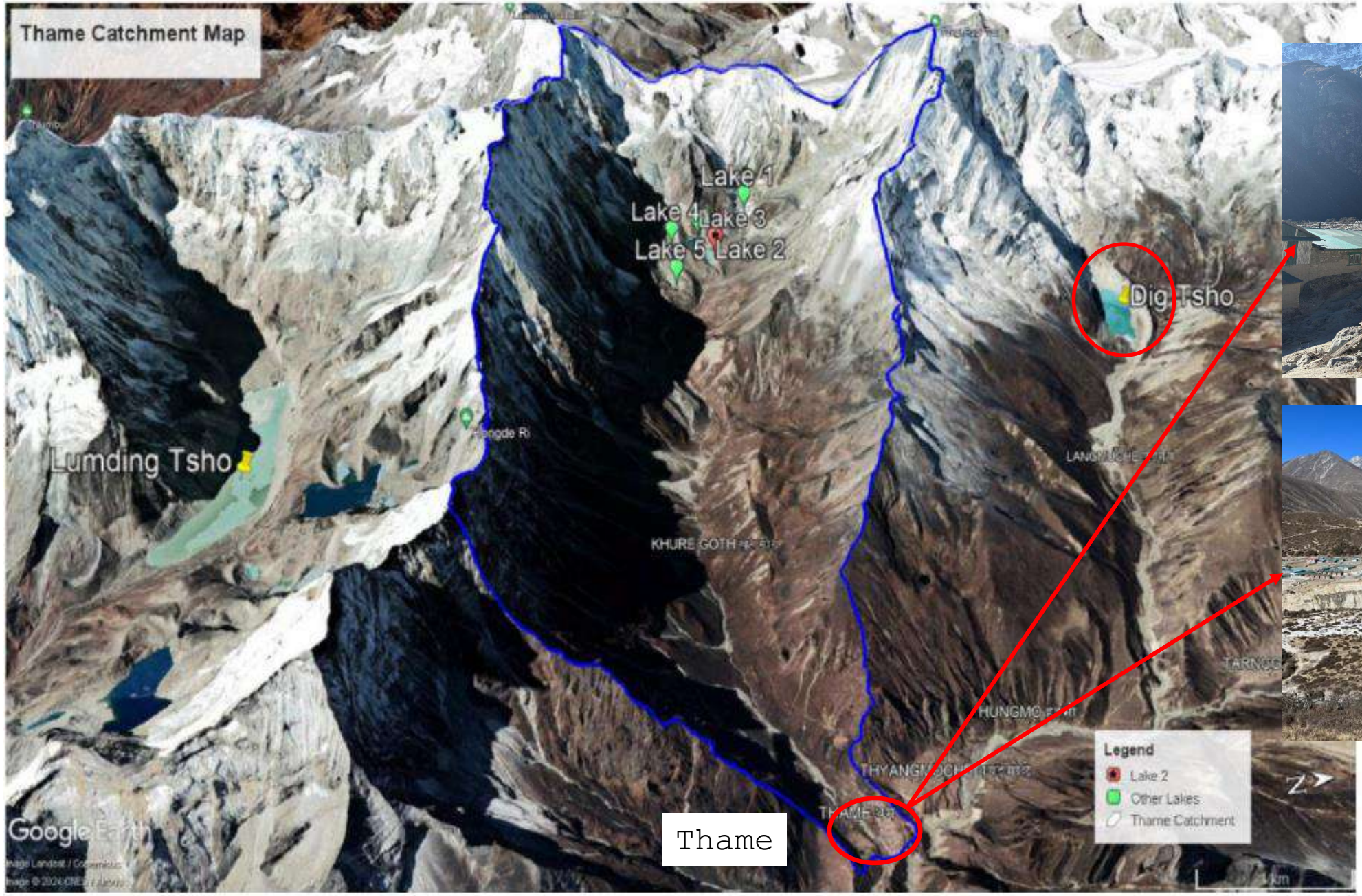
ICIMOD, 2020

Thame GLOF

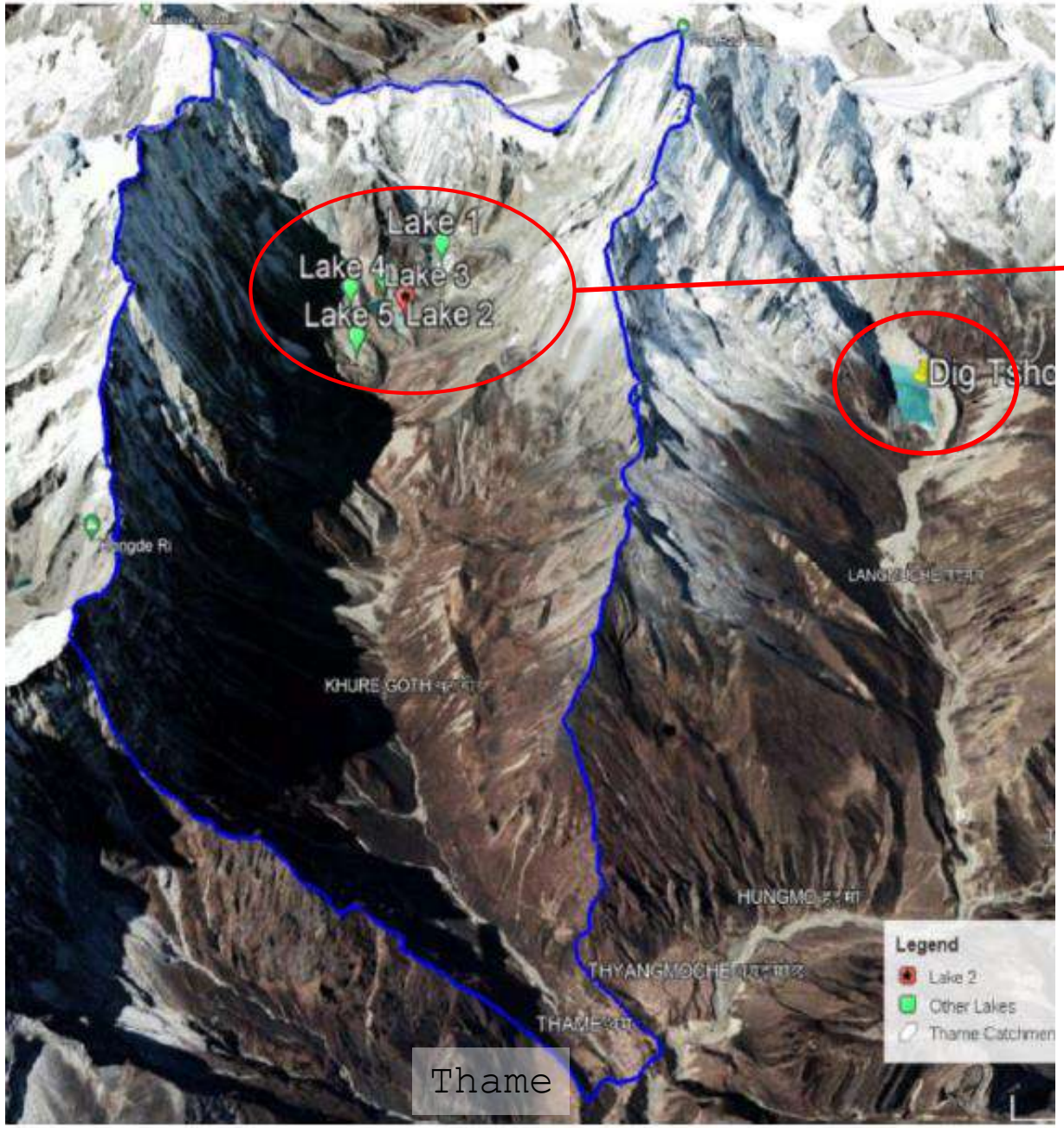
- GLOF on 16 August 2024 (originated from Upper and Lower Tso Mutse, also called Thyanbo lakes)
- Devasted a sherpa settlement located at 3800 meters elevation
- Destroyed 20 houses, an elementary school, and a clinic, and displayed about 135 people
- Threaten to ~ 200 households, a school, a health post, and a micro-hydropower?

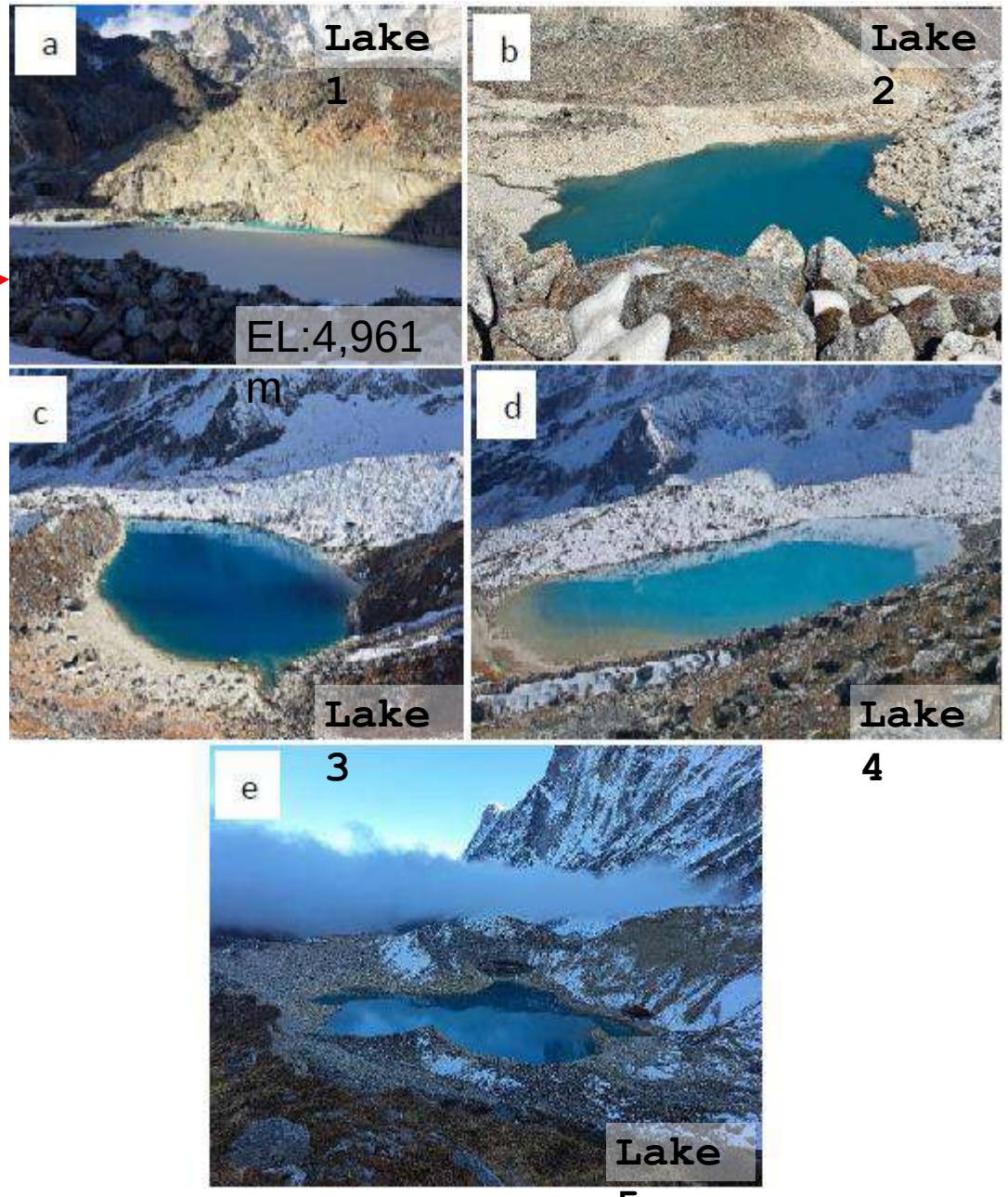


*This satellite imagery is from prior to the event. The post-event terrain looks very different.



HiCCDRC, 2024





HiCCDRC, 2024

On August 4, 1985, a rock and ice avalanche plunged into the lake, driving a surge wave approximately 5-meters high over the naturally-formed dam. Dig Tsho, a naturally dammed glacial lake, burst toward Thame valley, destroying a newly built hydroelectric power plant, over a dozen bridges, homes, and arable land with the release of 177 million cubic feet (5 million cubic meters) of water. – Credit: mattwestoby/Flickr


Layers
Gorge

Overflow from Upper Lake. Ice, snow avalanches, rock fall, or seepage?

Area of the lake before outburst ~0.035 km^2

Area of the lake after outburst ~ 0.08 km^2

Amount of water released ~ 300,000 m^3

Source: Kathmandu Post, video posted on Muncipality Facebook page


Pre-event water level
(12 m above current level)

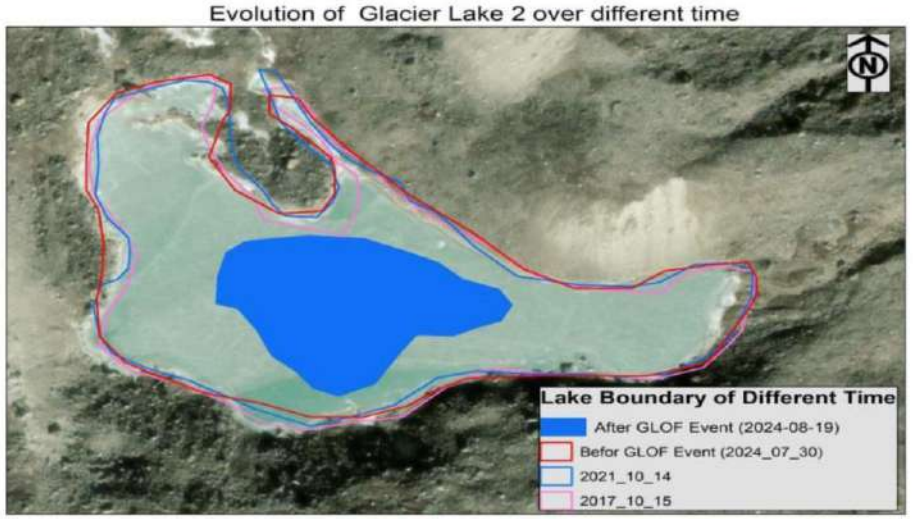


Figure 5: Surface area of the lake before and after the outburst (the darker yellow area indicates the current surfac area after the outburst, base map: Google earth pro December 2017).

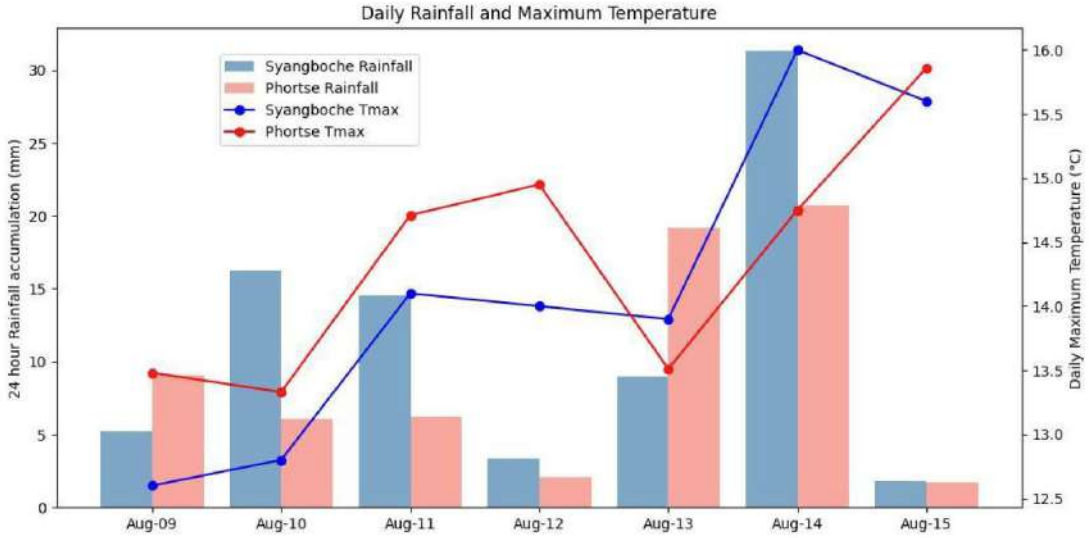


Figure 4: Rainfall and maximum temperature recorded at Syangboche and Phortse between August 9 and 15

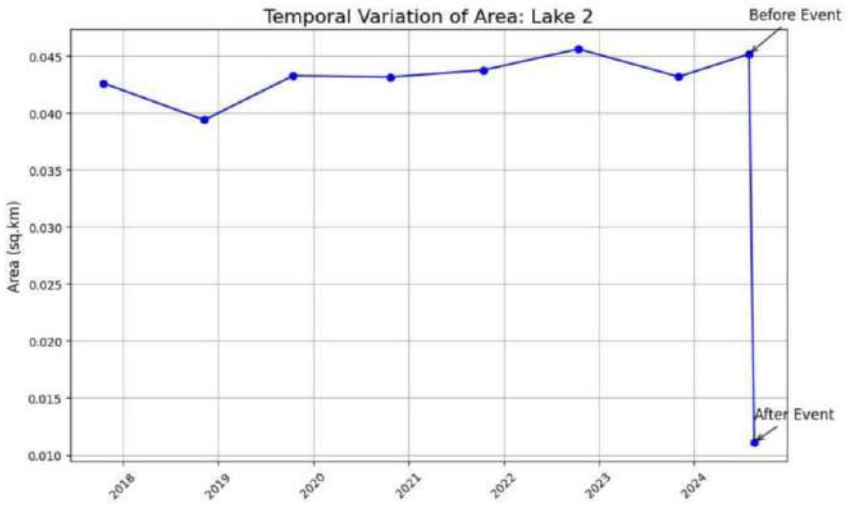


Figure 6: Comparison of the surface area of Lake 2 before and after the outburst.

- Significant amount of rainfall in the previous week
- Increase in temperature
- Glacier/ice melt or avalanches may have caused the upper lake to overflow into the lower leading to the outburst of the lower lake

From 2024 DHM report

*A **glacier is like a river of ice (**a large, perennial accumulation of crystalline ice, snow, rock, sediment, and often liquid water, that originates on land and moves


100 m x 250 m x 12 m
= ~300,000 m³ water
outflow
Person
Breach

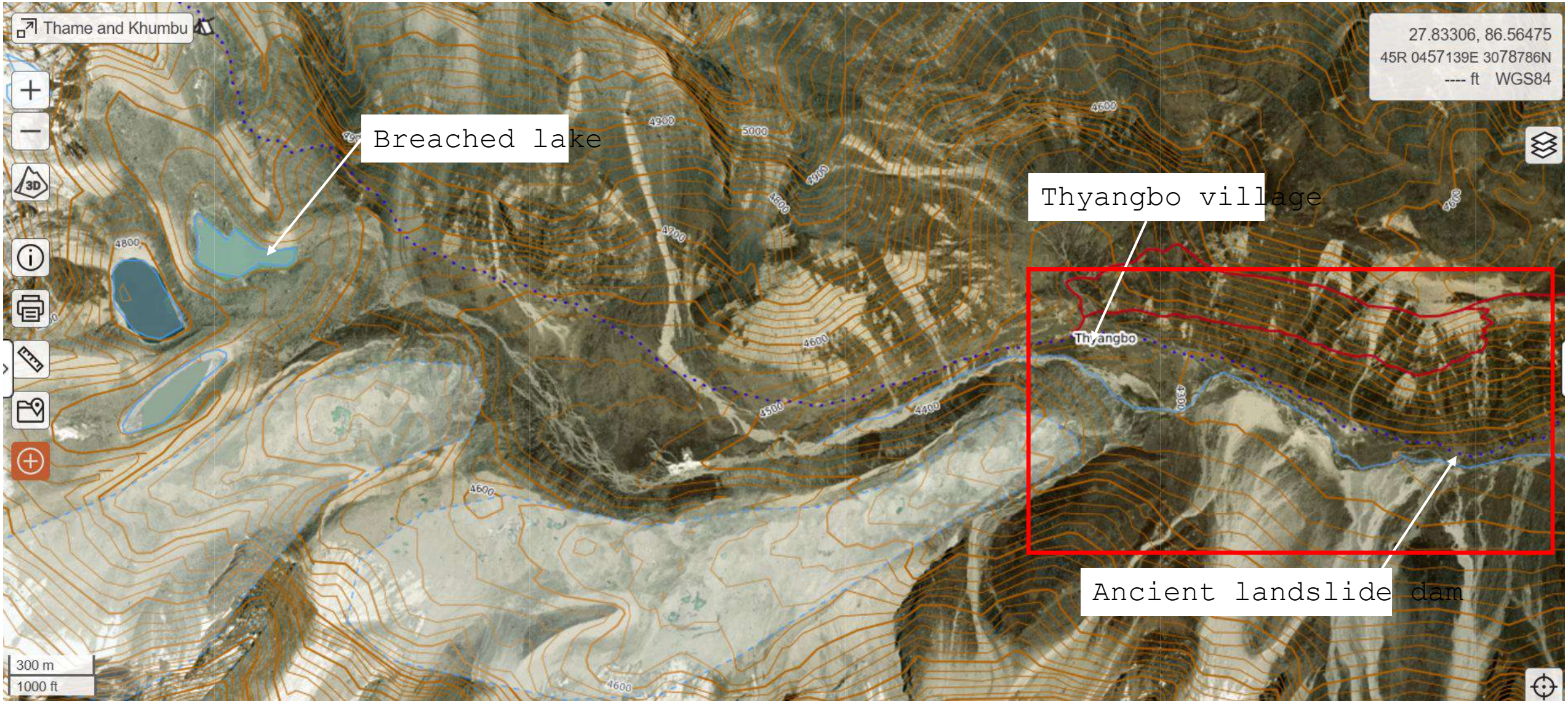

100 m x 250 m x 12 m
= ~300,000 m3 water
outflow
Breach


Glacio-lacustrine silt:
Silt and fine sand deposited in the glacial lake

Glaciolacustrine deposit, Varved structure


Breach
50 m
wide at
base

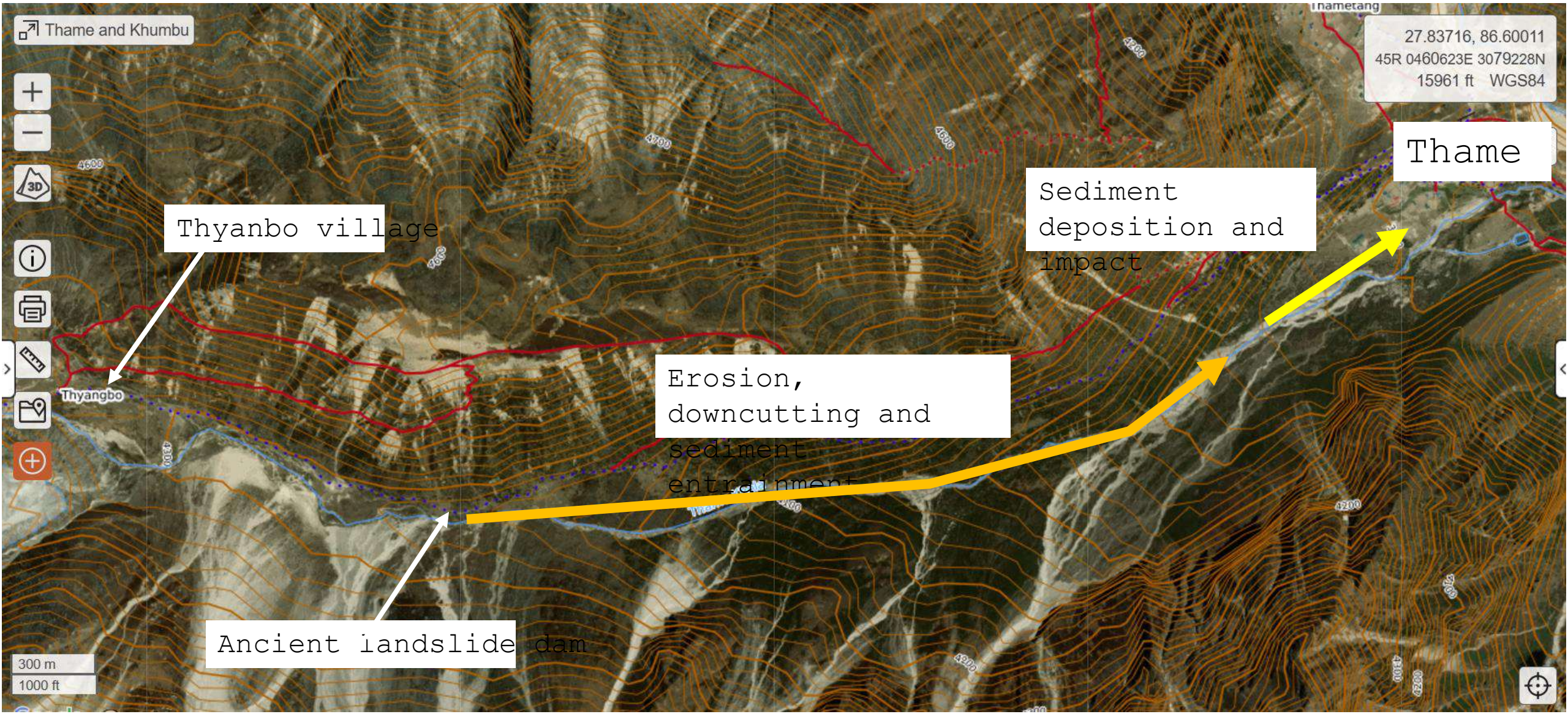

30 m
50 m



*This satellite imagery is from prior to the event. The post-event terrain looks very different.


Ancient dam:
debris flow fan and landslide
Sand
Boulders


Past
GLOF
Boulders
Sand

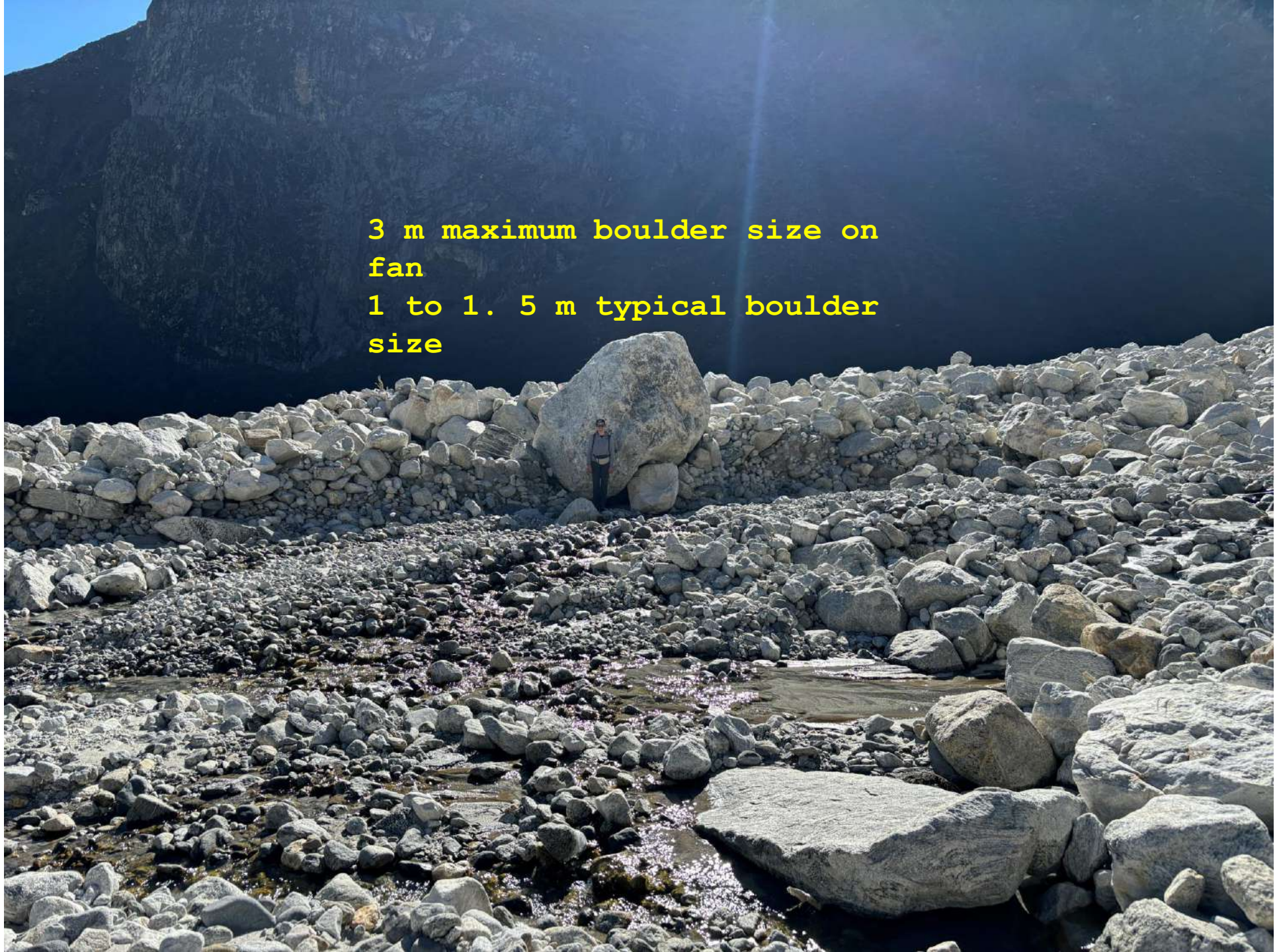


*This satellite imagery is from prior to the event. The post-event terrain looks very different.


Ancient dam:
debris flow
fan
Ancient dam:
landslide


Breach of ancient
landslide dam


Thame Fan Apex
50 m wide
5 m deep


3 m maximum boulder size on fan
1 to 1. 5 m typical boulder size


Ancient debris flood deposits in upper fan

Thame GLOF

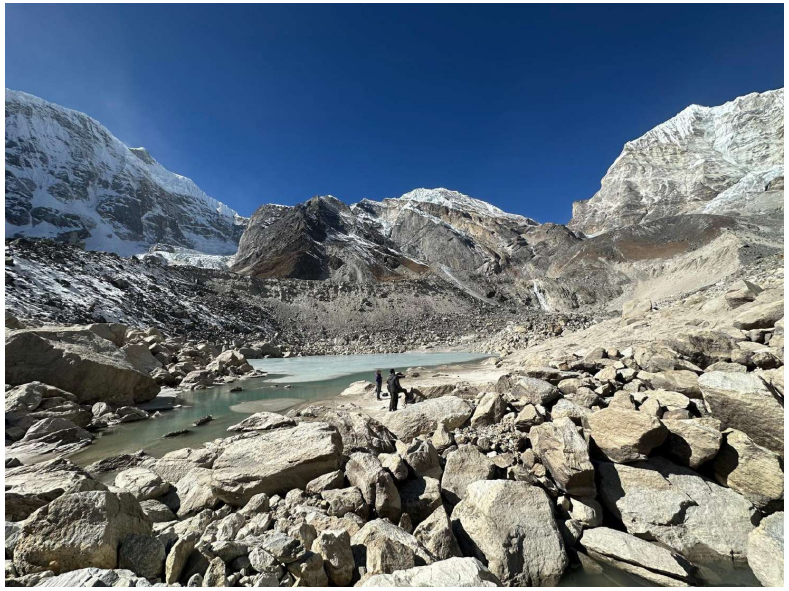
Potential Future GLOF

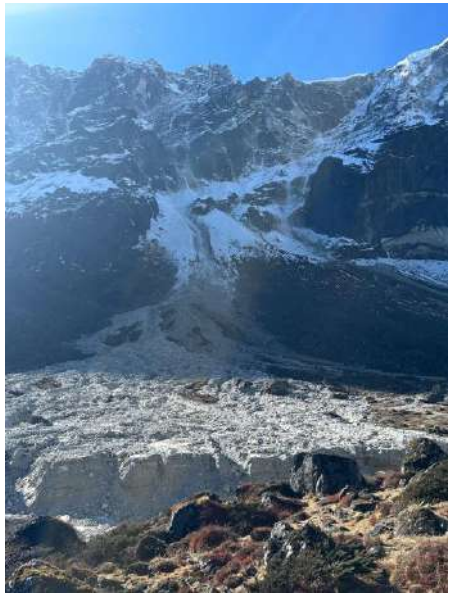
Description

- Outburst flood from other glacial lake

Comments

- Need further assessment/study
- Assess the risk of all four glacial maps (boundary of lake, end moraine, overflow, outlet slope, avalanches and landslides in the surrounding area
- Monitor all the lakes using satellite images (Optical and SAR) in every year at least during pre-monsoon and monsoon periods.





Consequences of the GLOF

Effects of GLOF were different even within a small-town Thame because of topography, geomorphology and geology are different with in Thame, so never generalize the disaster and its impact.

Thame GLOF

Consequences of Flooding during Monsoon

- New channels direct flows toward the community
- Monsoon flows could cause erosion and flooding within the community
- Build diversion berms on upper fan to encourage flow towards south channels, away from the community

Thame GLOF

Canada

Slide 54

Thame GLOF

Bank erosion near Debris Fan

Description

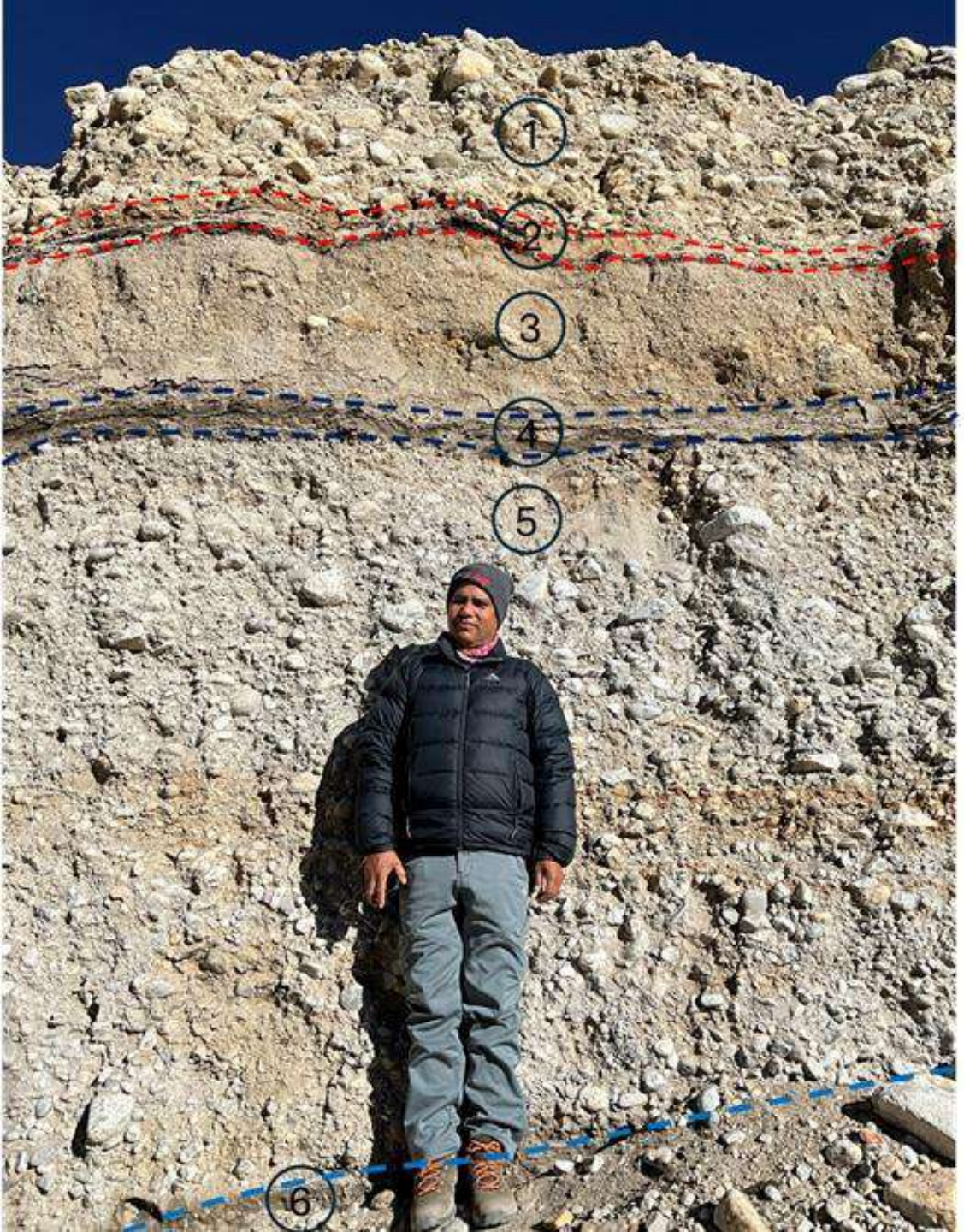
- New channels direct flows toward community
- Erosion of banks in heavy flow undermines buildings
- Buildings collapse into the channel

Comments

- Build diversion berms on upper fan to encourage flow towards south channels, away from the community
- Build erosion protection at critical slopes within the community
  - Masonry walls
  - Gabion walls

Effects of GLOF were different even within a small-town Thame because of topography, geomorphology and geology, so never generalize the disaster and its impact.

1



1.2 m	1	GRAVEL, Fine to Coarse, cobbles, Sandy, well graded, loose, rounded, gray and whitish, dry, heterogeneous, classic structure, maximum size 300 mm
0.3 m	2	ORGANIC SOIL, Fine-grained, traces of roots, low plastic, soft, black, wet, soft
0.9 m	3	SAND, Coarse sand, traces of gravel and cobbles, gap-graded, loose/compact, rounded, gray (with reddish lenses with corrosion), dry, non-stratified, poorly cemented
0.3 m	4	ORGANIC SOIL, Fine-grained, fine sand, wet, non-plastic, black, trace of roots, soft
>2.3 m	5	GRAVEL: Fine to Coarse, Sandy, traces of cobbles, well graded, loose, rounded, gray (and with reddish lenses with corrosion), dry, heterogeneous, classic structure, traces of roots, maximum size 300 mm
	6	ORGANIC SOIL, Fine-grained, fine sand, wet, non-plastic, black, trace of roots, soft

2


si
lt
~10 m of
erosion

2

Thame GLOF


Landslide in Glacio-
Lacustrine silt


Glacio-Lacustrine silt
DEFYING
MOTHER NATURE





Glacio-Lacustrine Silt

Thame GLOF

Thame GLOF

Thame GLOF


Moraine
(sand and gravel)
Ancient lake
(Glaciolacustrine deposit,
silt)

- No tension cracks were observed immediately after the event
- Significantly large rainfall occurred in a month of the event

- Rainwater further eroded the riverbed, leading to slope destabilization.

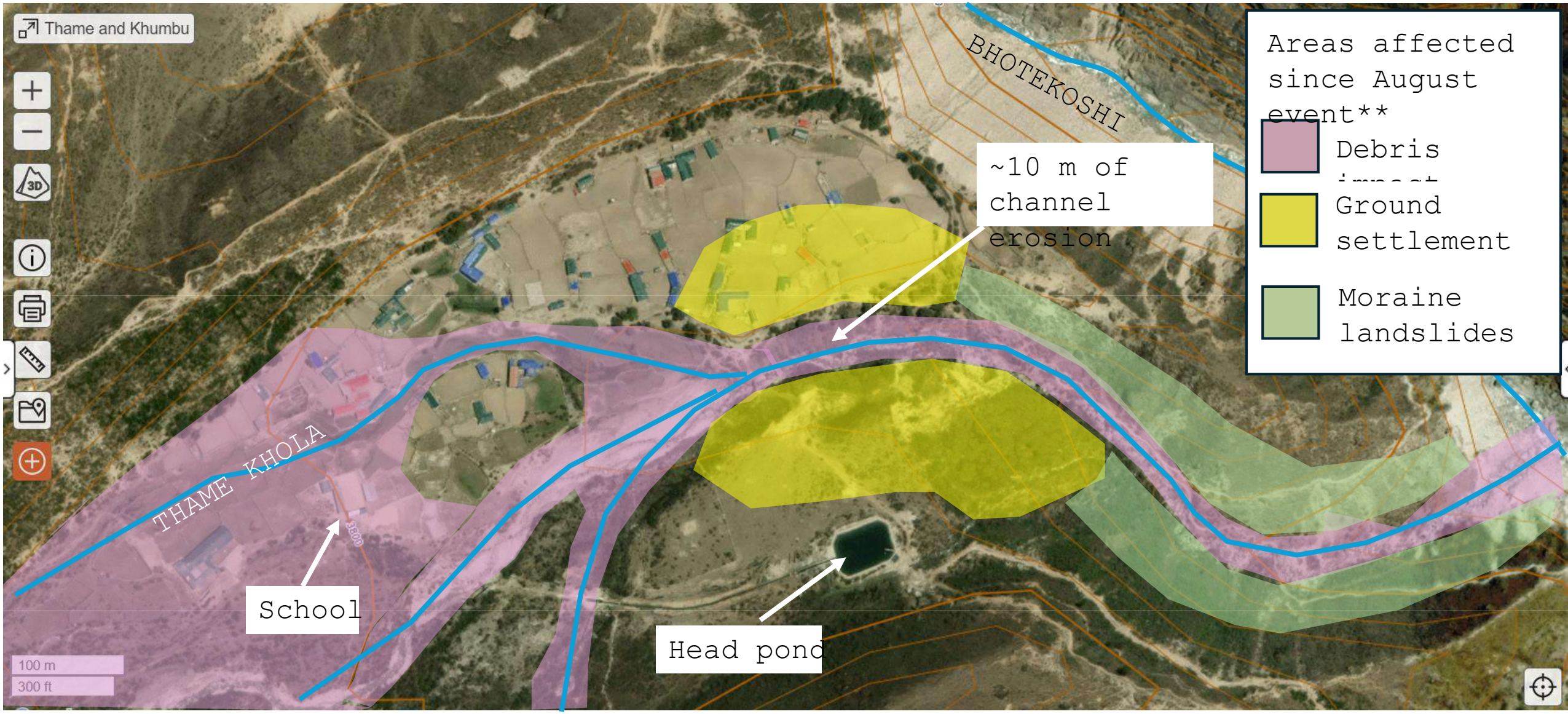
Ground settlement/tension cracks related to landslide

Description

- Ancient glacial lake filled with silt
- Significant erosion of channel during the GLOF – channel cut downwards
- Slopes destabilized
- Deep-seated, retrogressing landslides
- Tension cracks and settlement at surface

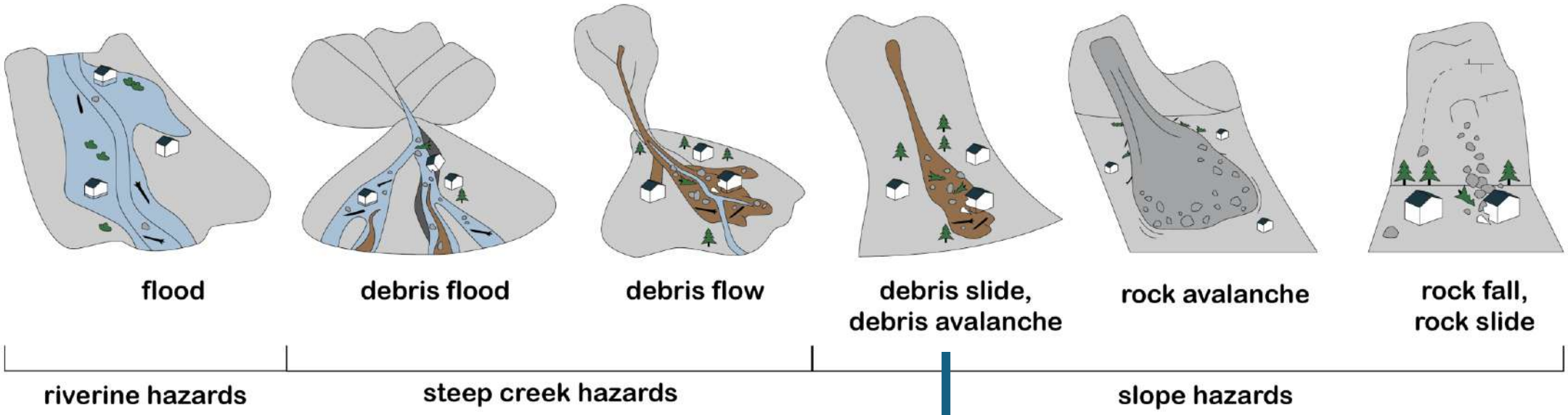
Comments

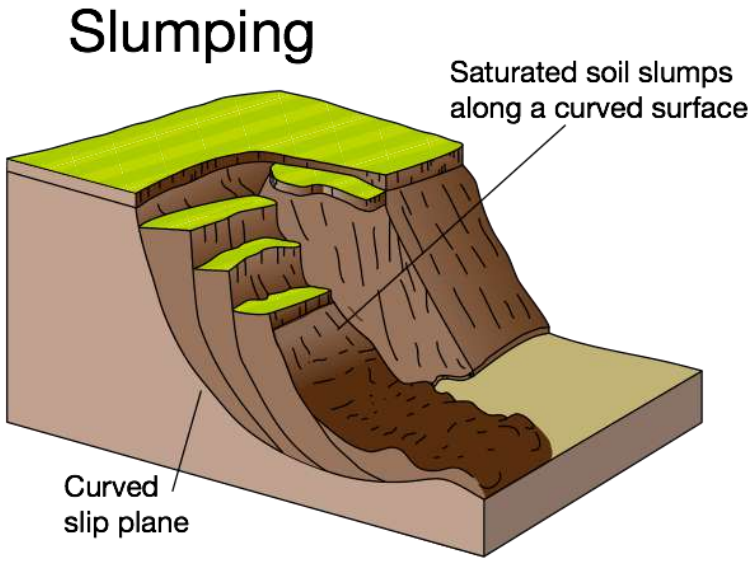
- Plan for retrogression and settlement
- Monitor tension cracks and ground movement to understand rate of change
- Avoid introducing water to surface
- Relocate buildings off of landslide



*This satellite imagery is from prior to the event. The post-event terrain looks very different.

** This map shows the approximate limit of the areas currently damaged. The lake deposit landslides that are causing ground settlement may continue to progress af


flood
debris flood
debris flow
debris slide,
debris avalanche
rock avalanche
rock fall,
rock slide
riverine hazards
steep creek hazards
slope hazards


Slumping
Saturated soil slumps
along a curved surface
Curved
slip plane


Moraine: sand, gravel, boulders
GLOF deposit: gravel, boulders
Glacio-lacustrine: silt

Thame GLOF

GLOF and landslide damage at hydropower head works

Description

- Deep-seated, retrogressing landslides encroach on head pond
- Intake damaged by GLOF debris impact and erosion

Comments

- Monitor landslide tension cracks
- Make plans for relocating the head pond
- Relocate intake and desander to toe of moraine to minimize exposure to GLOFs
- Move head pond if landslide continues to encroach on headpond

Desander

Water Intake

D/S of Thame

D/S of Thame Need to monitor these landslides

Landslides below penstock

Description

- Shallow, steep landslides in coarse moraine have potential to undermine the penstock

Comments

- Monitor changes in the landslide to recognize encroachment on the penstock
- Develop plans to locally stabilize penstock or to move the penstock into the slope


SMALL HYDRO POWER PLANT
THAME-NAMCHE
AUSTRIA-NEPAL
DEVELOPMENT COOPERATION
Inaugurated on 9th October 1995
INAUGURATED BY
उद्घाटन

Thame GLOF

Thame GLOF

Thame GLOF


Flow area:
24 m x 5 m = 120 m²
8% gradient
Perhaps Q = 500 to
700 m³/s

Thame GLOF

Thame GLOF

Thame GLOF

Lesson Learnt

- The Thame GLOF event is particularly important for understanding mountain hazards and risks in the Himalayas, because the Thame lake had not been identified as a “Potentially Dangerous Glacial Lake” in the ICIMOD inventory. This suggests that a wider assessment of glacial lake and multi-hazard risk is necessary.
- Employ advanced technology, continuous monitoring, and nature-based solutions to track glacial lakes and reduce risks effectively.
- Foster collaboration between academia, researchers, governments, donors, and communities to enhance preparedness and response strategies.
- Prioritize GLOF disaster management through coordinated efforts to protect vulnerable communities from escalating climate change impacts.
- Understanding of geomorphology and geology is crucial for site specific risk assessment

What should we do?

Closing

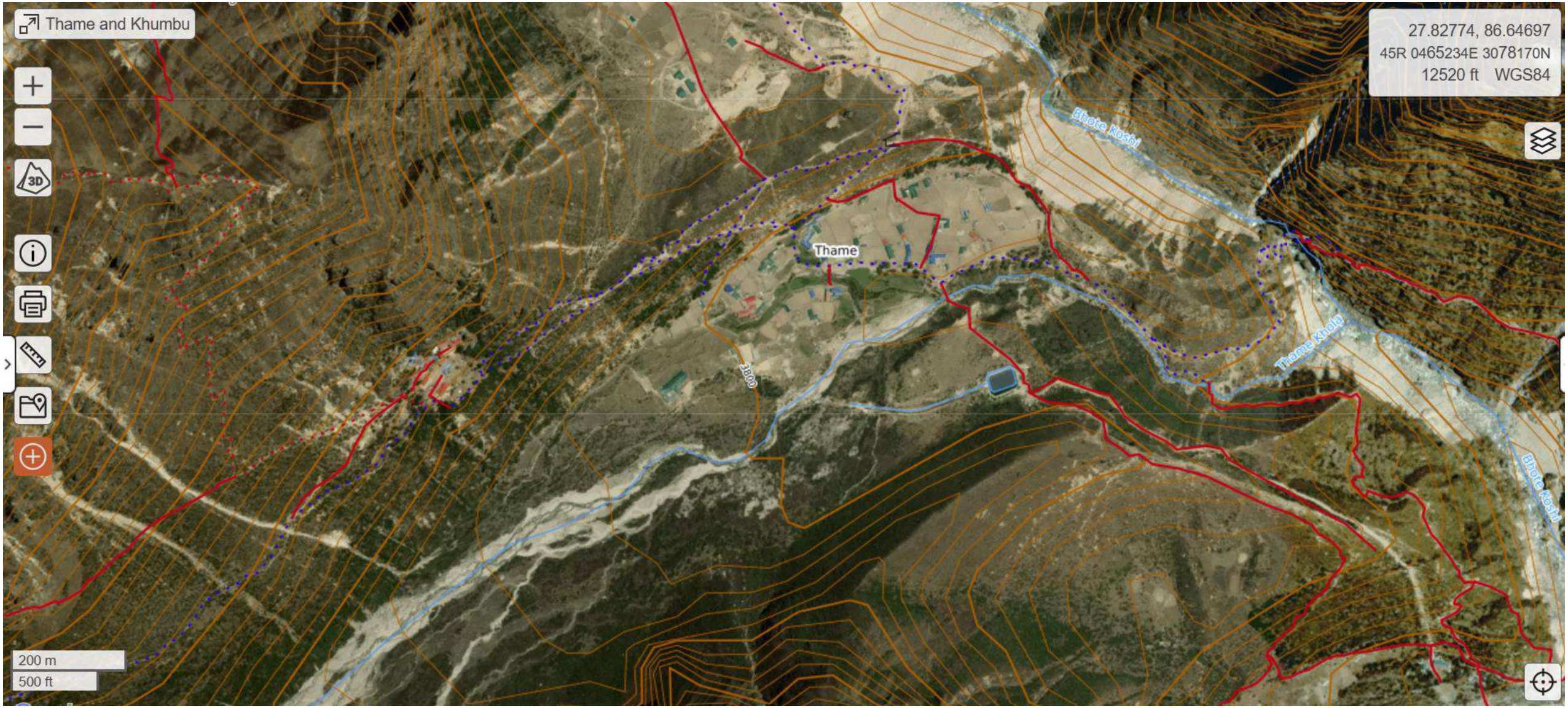
This presentation required a number of complex issues to be reduced to general concepts in a series of concise bullet points, photographs, and/or diagrams. The content of this presentation is not intended for design decisions or construction. This presentation is for general informational purposes only. BGC Engineering Inc.'s report(s) may contain more specific details concerning the issues identified in this presentation. Please consult BGC for further clarification if you have any questions or concerns.

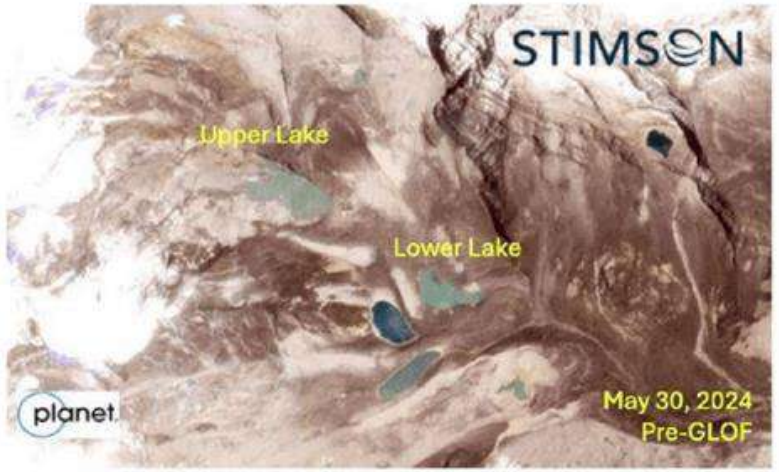
Prepared by:
Alex Strouth

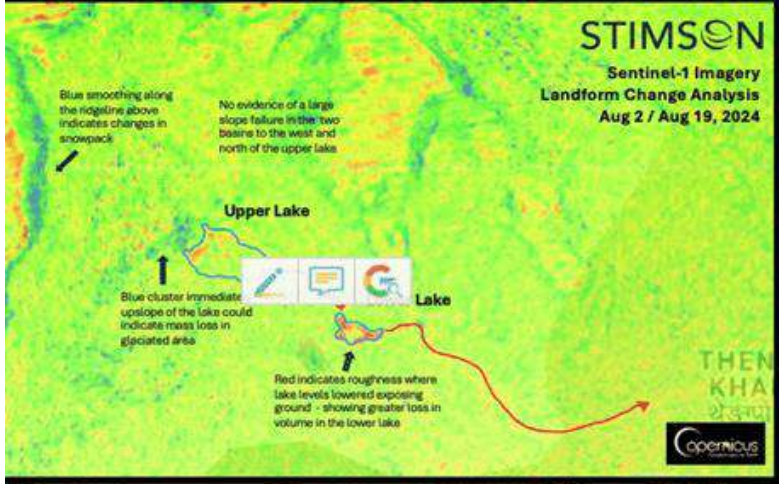
Reviewed by:
Emily Mark

Client:
Asian Development Bank

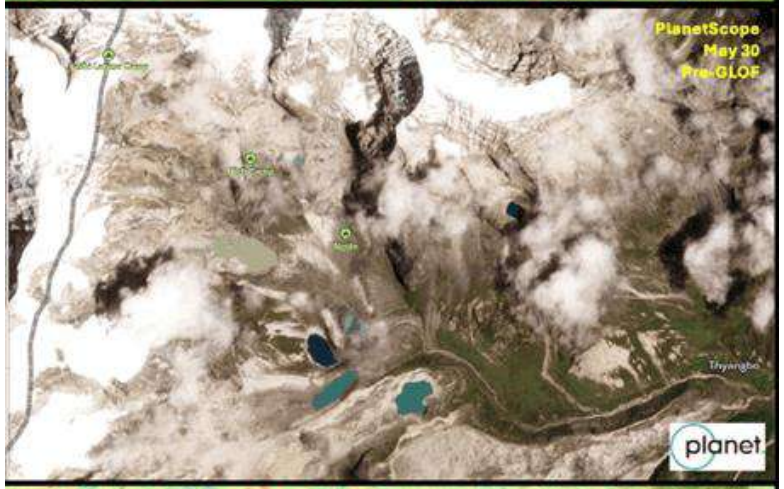
Date:
December 6, 2024

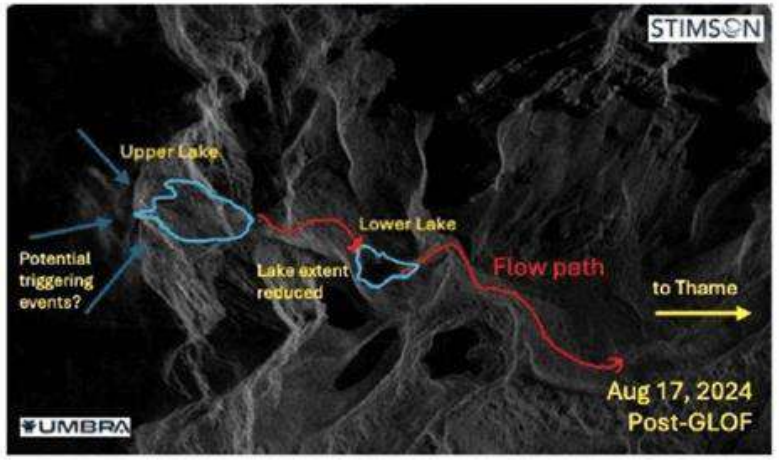

Thame and Khumbu
27.82774, 86.64697
45R 0465234E 3078170N
12520 ft WGS84
Thame
Bhote Kosi
Thame Khola
3800
200 m
500 ft

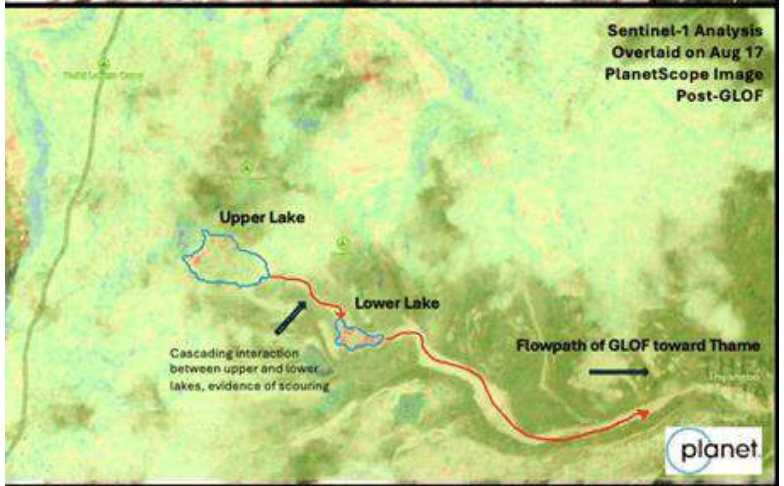

STIMSON
Upper Lake
Lower Lake
planet
May 30, 2024
Pre-GLOF


STIMSON
Sentinel-1 Imagery
Landform Change Analysis
Aug 2 / Aug 19, 2024
Blue smoothing along the ridgeline above indicates changes in snowpack
No evidence of a large slope failure in the two basins to the west and north of the upper lake
Upper Lake
Blue cluster immediate upslope of the lake could indicate mass loss in glaciated area
Lake
Red indicates roughness where lake levels lowered exposing ground - showing greater loss in volume in the lower lake
Copernicus


Upper Lake
scouring between lakes
Lower Lake
to Thame
GLOF widened channel
planet
Aug 17, 2024
Post-GLOF


PlanetScope
May 30
Pre-GLOF
planet


STIMSON
Upper Lake
Potential triggering events?
Lower Lake
Lake extent reduced
Flow path
to Thame
Aug 17, 2024
Post-GLOF
UMBRA


Sentinel-1 Analysis
Overlaid on Aug 17
PlanetScope Image
Post-GLOF
Upper Lake
Lower Lake
Cascading interaction between upper and lower lakes, evidence of scouring
Flowpath of GLOF toward Thame
planet