

Glacial Lake Outburst Floods Early Warning System to save lives and livelihood of the Nepal Himalaya communities:  
A case Study of Imja Glacial Lake, Nepal

Kc, D\*., Khatri, T., and Sharma, R. (\*Institute of Earth Science, University of Lausanne , kc.deepak@unil.ch)

- Nepal , a **multi hazards prone country**, including Glacial Lake Outburst Floods (GLOFs) and Nepal has already experienced more than **26 GLOFs**;
- Imja G Lake, at altitude of **5010 m** in the **Mt. Everest Region** of Nepal;
- Since 1962, it is expanded more than **4000 times** in **54 years ( 1.28 sq km)**
- Identified as one of the **critical glacial lakes** for potential GLOF in 2010;



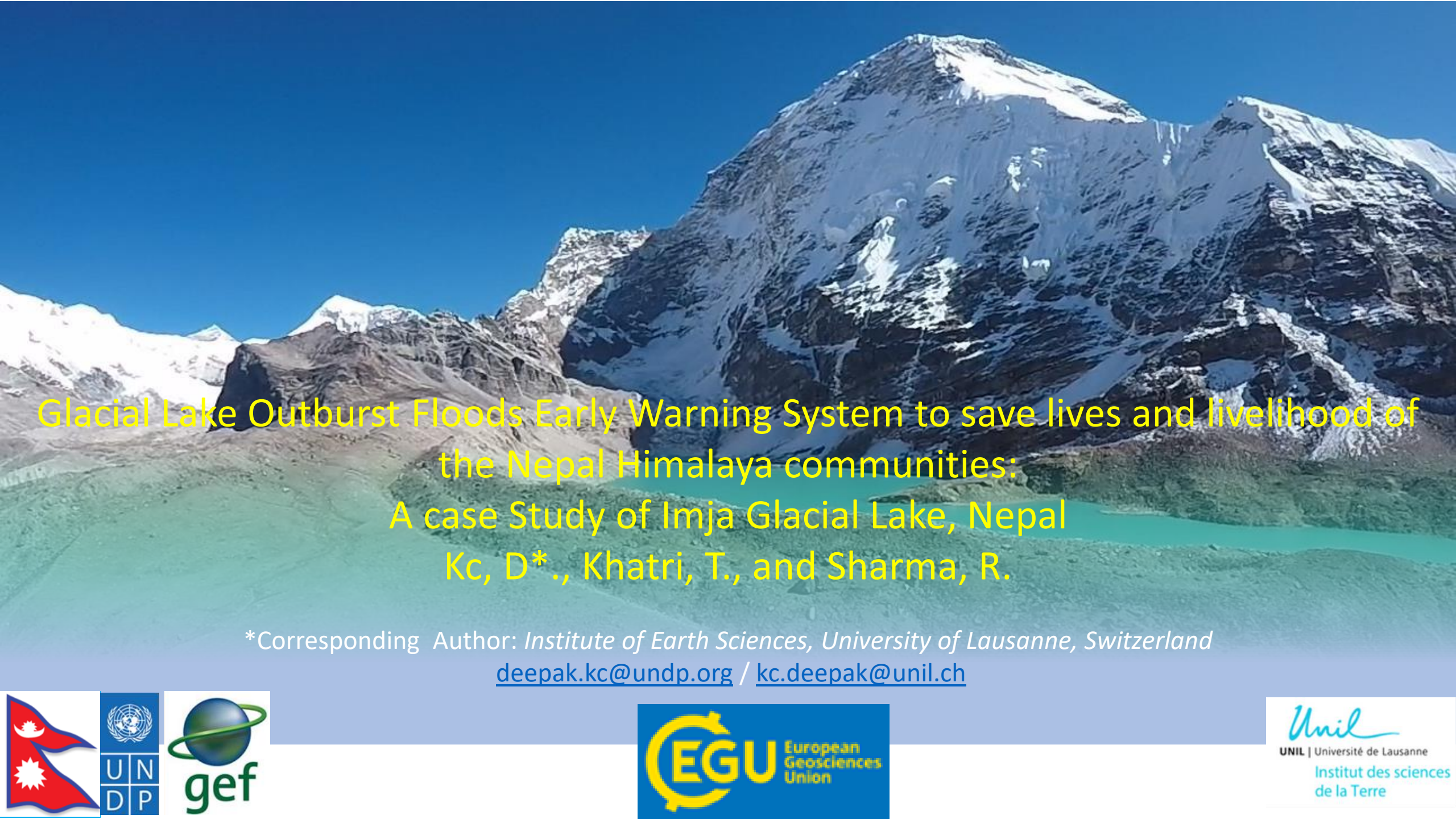
- A joint initiative of Government of Nepal, UNDP in Nepal and Global Environment Facility as **Community-based Flood and Glacial Lake Outburst Risk Reduction Project (CFGORRP)**;
- strengthened the **capacity of the local communities** to adapt with;
  - reduced the **lake level by 3.4 m.** through an open channel and;
  - established **hydro-met stations and Early Warning system.**

- Hydro-met **stations**, GLOF **sensors** & automated early warning **sirens** & linked with **Dynamic Mass SMS Alert system** polygon;
- Benefits more than **71000 vulnerable people** (27 settlements), both local and the tourists visiting the Everest Region of Nepal
- Potential for **replication and upscaling** - **21 critical lakes** in **Nepal** and 25 in Tibet, China;
- Integration of **climate actions** in the regular planning and its' implementation is essential for **resilient and Sustainable Development of Nepal.**



THANK YOU ☺ 🙏





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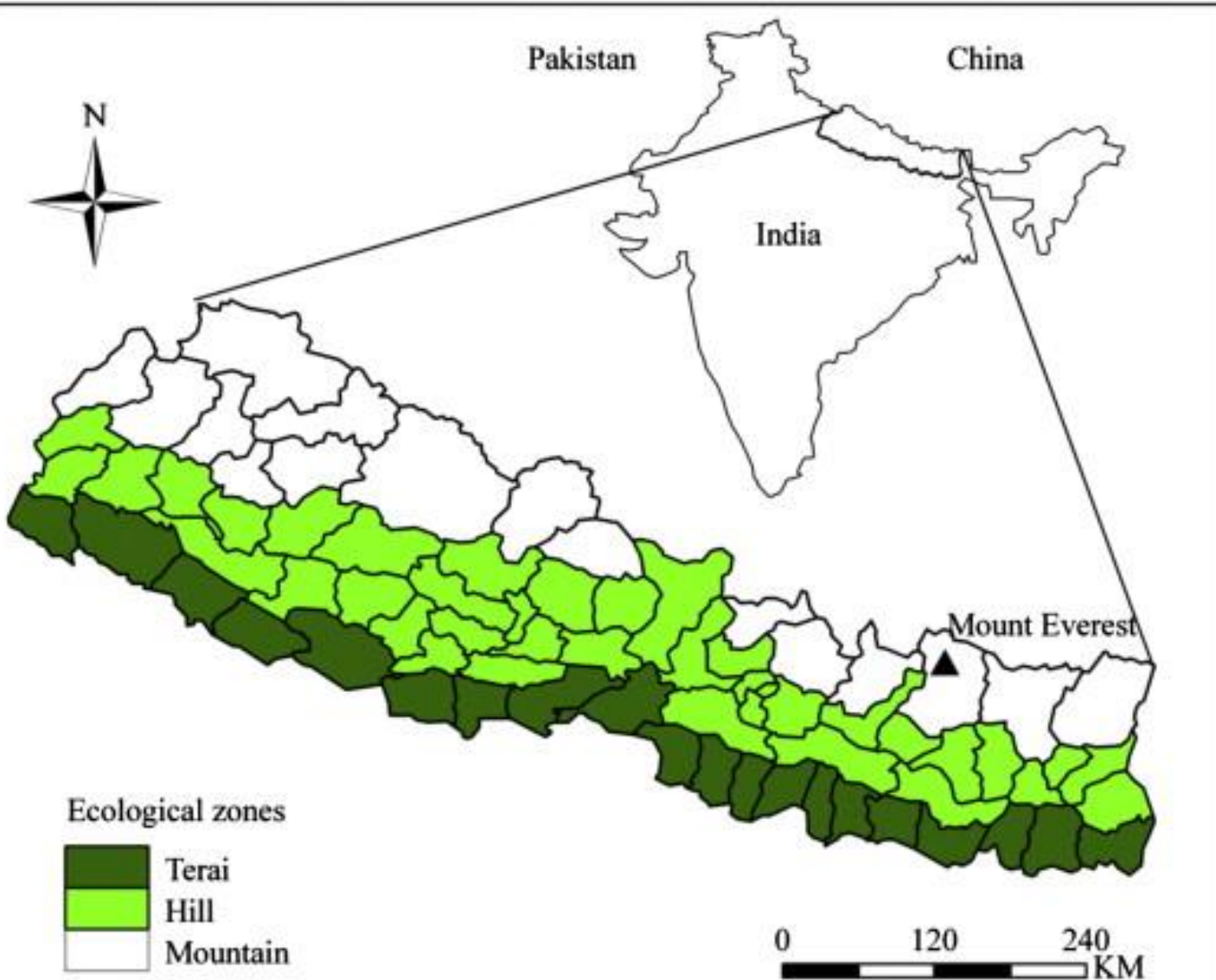


# Outlines

- **Nepal's Vulnerability in the face of Climate Change**
- **Temperature rise and Glacier Melting**
- **Glacial Lake Outbursts Floods in Nepal**
- **Nepal's Priority for Climate Risk Management**
- **GLOF Risks and Govt. of Nepal and UNDP's Efforts towards GLOF Risk Reduction: Imja GL Risk Reduction**
- **Future GLOF Risk**
- **Conclusions/ Lesson Learned**
- **Reference and Acknowledgement**



# Nepal's Vulnerability in the face of Climate Change



- Multi-hazards prone country;
- Fragile Geology with high mountain, steep slope to flat region (*60metre-8848.6 metres ( Mount Everest)*)
- Active tectonic/ seismic zone with Micro climate/weather
- Aggravated by impact of Climate Change/variability on various sectors
- Unsustainable development practices (eg. rural road construction

# Nepal's Vulnerability : Climate Variability and Change

- A changing climate results in **unprecedented extremes** with high **frequency, intensity, spatial extent** ( IPCC/SREX, 2012) with multi-sectoral impacts;
- Annual maximum temperature increment in Nepal was significantly positive, **at 0.056°C/yr over 1971–2014** (DHM 2017);
- Greater warming rate of **0.086°C/year** in the **Higher Himalaya** over that period;
- Even if the global warming is kept to 1.5°C by the end of 21st century, the warming in HKH region will likely be at least **0.3°C higher** (Wester et. al. 2019).
- **Nepal loses 333 lives and property worth over USD 17.24 million** (NPR 2,099 million) each year to extreme climate events, Nepal Disaster Report, MoHA 2019);

## Agriculture

- Reduced crop production due to climate related events such as drought, heavy rain, hailstorm and so on;
- Loss of fertile land due to flood, landslide, soil erosion;
- Introduction of new fungal and bacterial diseases;
- Famine and food scarcity due to regular crop failure.

## Forestry & Biodiversity

- Changes in composition and distribution of species;
- Accelerate the rate of species extinction;
- New pests and more forest fire.

## Hydro-met hazards

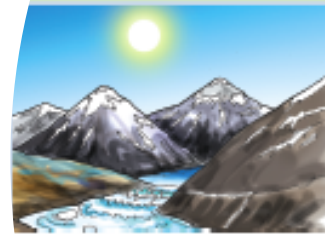
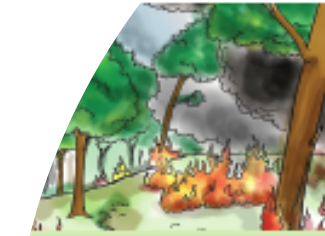
- Enhanced frequency and intensity of floods, landslide and droughts;
- Rapid melting of glaciers and snows increasing threat to glacial lake outburst flood (GLOF)

## Health

- Mosquitoes move to higher altitude due to warming increasing prevalence risk of Malaria, Japanese Encephalitis;
- Water borne diseases during disaster events;
- Heat stress and heat wave

## Water Resources

- Variation in river runoff;
- Unreliable and unpredictable river flow pattern affecting hydroelectricity power plants;
- Enhanced frequency and intensity of flood and droughts;
- Rapid melting of glaciers and snows increasing threat to Glacial lake outburst flood;
- Shrinkage of fresh water due to rapid melting





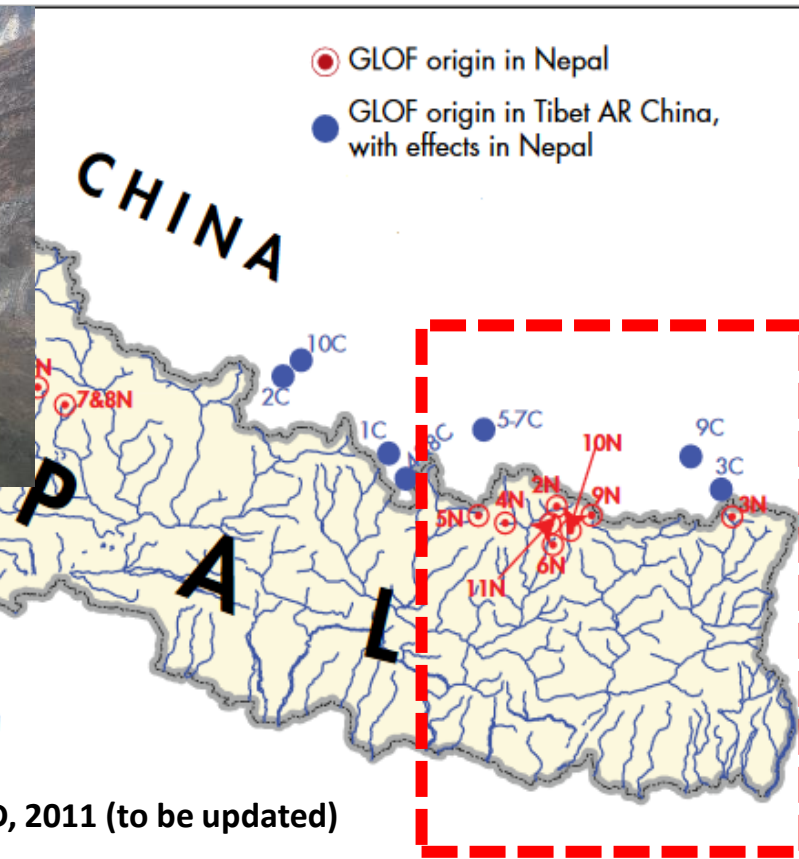
# Glacial Lake Outbursts Floods in Nepal

- So far 15 in Nepal ( Recent 20 April 2017, Barun Valley)
- More than 11 GLOFs originated from Tibet Region (Recent: July 05 2016 ( Poique Basin - damaging Bhotekoshi region))



GLOF at Barun Valley 2017

Map Source: ICIMOD, 2011 (to be updated)



## GLOF EVENTS SINCE THE 1980s THAT HAVE CAUSED DAMAGE IN NEPAL

S. No.	Date	River basin	Location
1.	23 June 1980	Tamor	Nagma Pokhari
2.	11 July 1981	Bhote Koshi	Cirenmacho Lake, Zhangzangbo Valley
3.	4 August 1985	Dudh Koshi	Dig Tsho
4.	12 July 1991	Tama Koshi	Chubung
5.	3 September 1998	Dudh Koshi	Sabai Tsho (Tam Pokhari)
6.	15 August 2003	Madi	Kabache Lake
7.	8 August 2004	Madi	Kabache Lake
8.	5 July 2016	Bhote Koshi	TAR, China
9.	20 April 2017	Barun Valley	Near Lower Barun



# Bhotekoshi Hydropower - Before and After the GLOF ( 2016)



The total **Value at risk** under the modelled GLOF scenario of **Thulagi** is USD 406.73 million (Khanal et al. 2015).

# Nepal's Priority of Climate Risk Management

## GL Risk Reductions to save lives and livelihoods

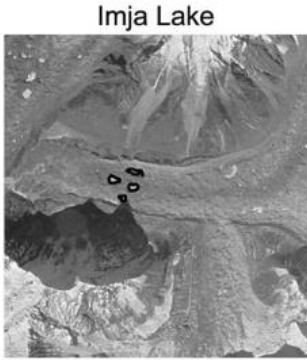
- Nepal's Constitution
- **NAPA (2010), NDC/e-NDC (submitted)** –(Parties to the UNFCCC /Paris Agreement), **NAP (ongoing)**
- **National DRR Policy (2018) and National DRR Strategic Action Plan (2018- 2030)** - Sendai Framework for DRR ( GL Lowering – 7, and multi- hazards EWS by 2030;
- **NPC's Periodic Plans** - Agenda 2030 for Sustainable Development ( Prosperity, People and Planet - **11 Goals**- more specific goal no 13 on CC.





# Imja Glacial Lake, changing its face

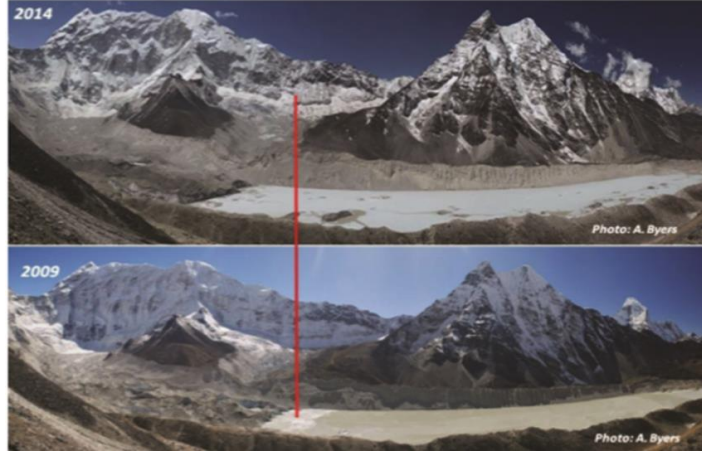
15 Dec 1962 CORONA Image



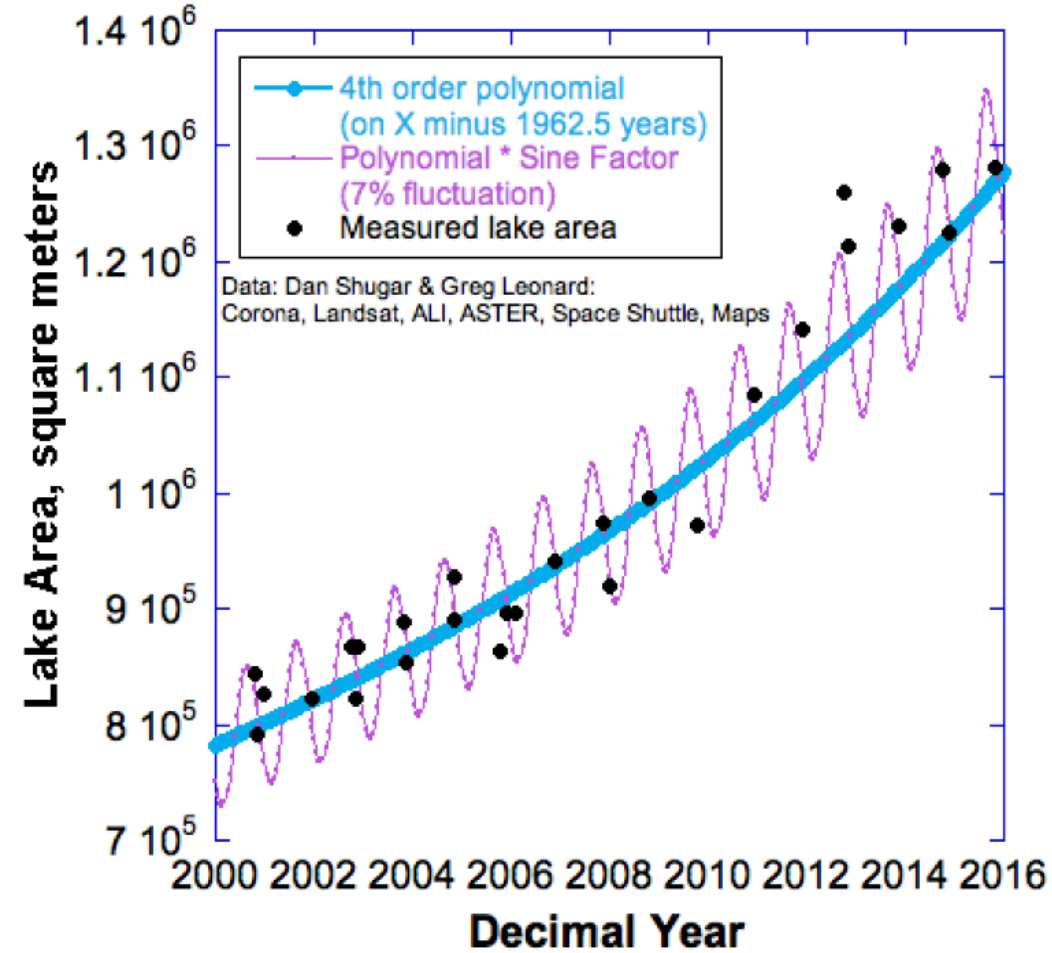
2 Dec 1983 Space Shuttle Mission



30 Oct 2000 Landsat ETM+



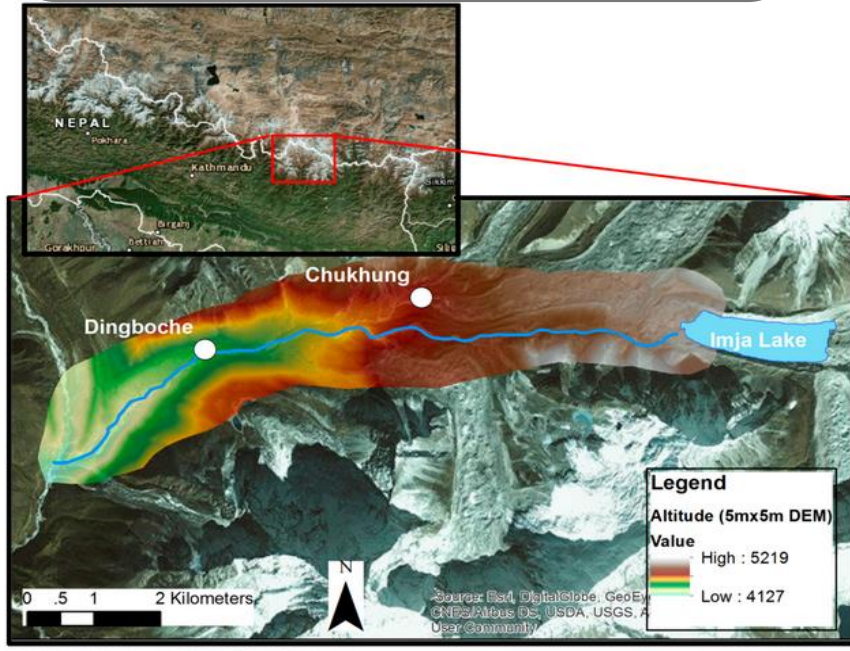
**Imja Lake Growth- With Annual Oscillation**  
(2000-2016, no error bars)





# Framework of Intervention GLOF Risk Reduction

Science and People's Knowledge based **Multi Hazards RISK ASSESSMENT** and Mapping



**CAPACITY BUILDING**  
(Community and Local Govt. Officials' Empowerment)



**C B DRR Preparedness , Mitigation and Adaptation Measures**



**Mainstreaming CRM in the sectoral planning process**

**Coordination, Linkages and Networking**

**Knowledge Sharing and Replication**

**Resilient Communities**



# GLOF RISK REDUCTION: IMJA GLACIAL LAKE (Nepal)

Studies on Rapid Field Assessment, GLOF Scientific Data, and Vulnerability Assessment conducted : 2013

Community Based Early Warning System (CBEWS) Study : 2014

GLOF Hazard Zonation and Safety and Evacuation Plan: 2014

Hazard mapping along 50 km downstream from Lake

Engineering Survey and Design  
Electrical Resistivity Tomography (ERT)  
Ground Penetration Radar (GPR)  
Bathymetry

Lake lowered by 3.4 metre  
**(November 23, 2016 )**









# GLOF RISK REDUCTION: IMJA GLACIAL LAKE ( Nepal)- in images







## Transportation of equipment and materials by MI-17 Helicopters and horses







Lake level reduction



Water Flow in the Open Channel

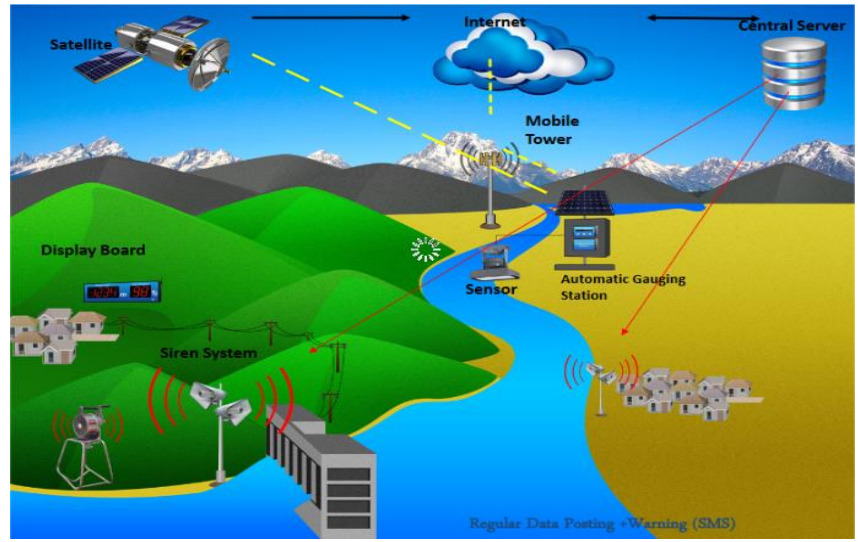


# Controlled channel for Lake Lowering





# GLOF RISK REDUCTION/Preparedness : Hydro-met Stations and EWS





# Community-based GLOF Early Warning System

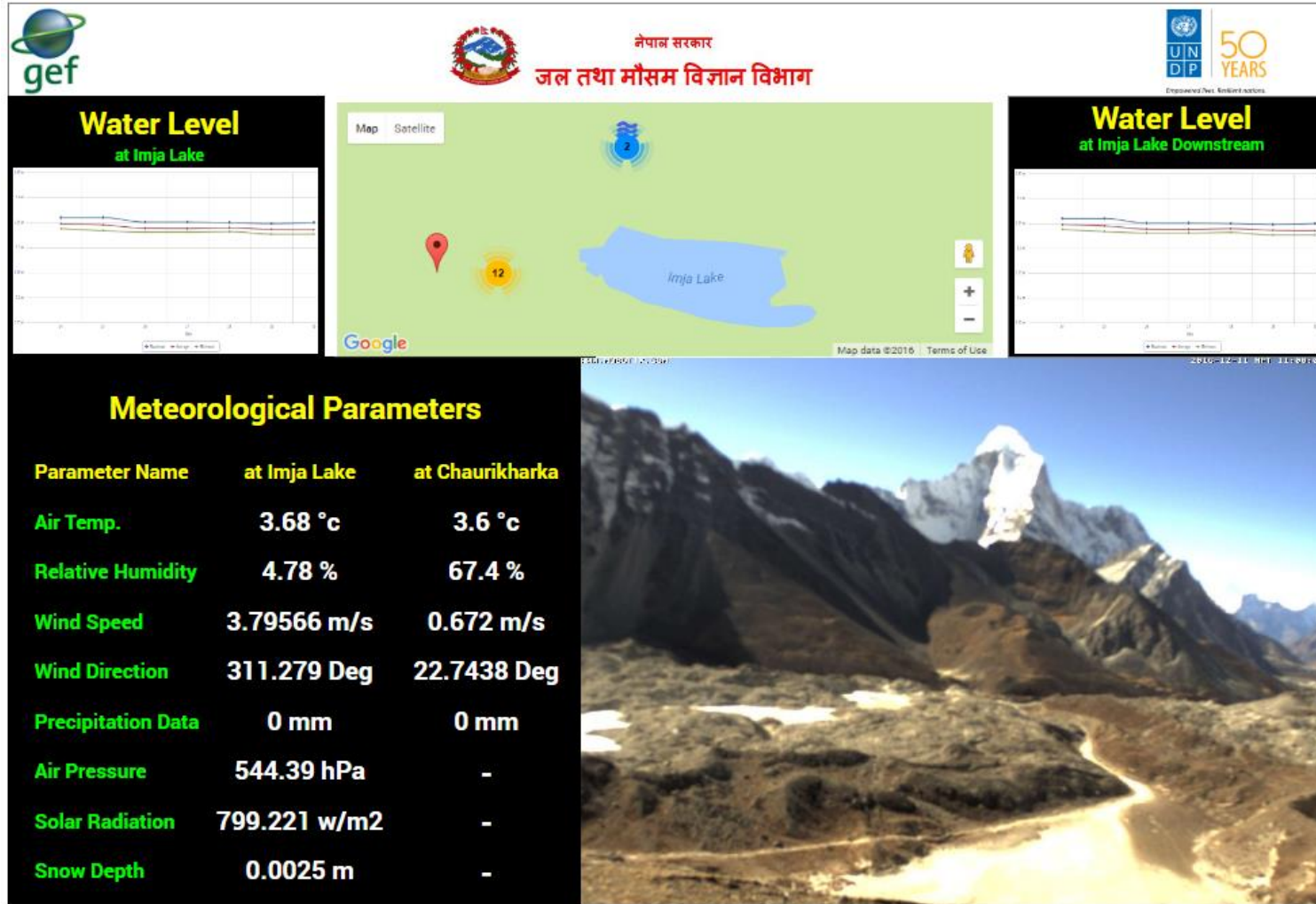


## Legend

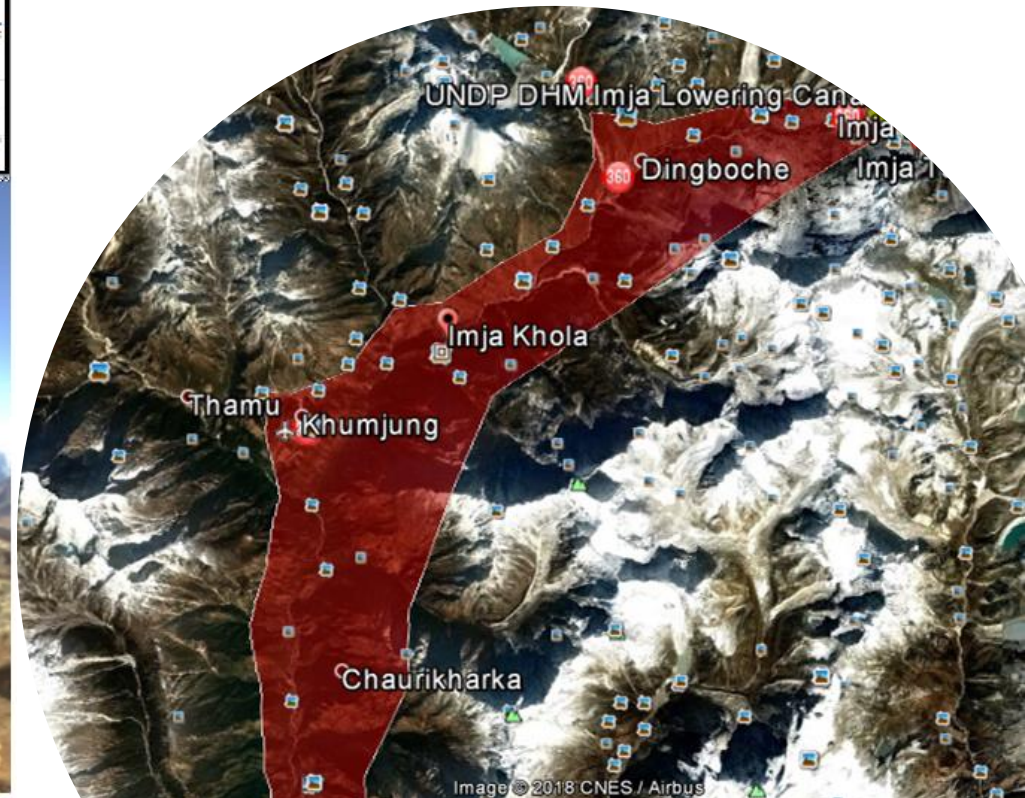
- Villages
- Extent of Study Area
- River
- VDCs



# Dynamic Mass SMS Alert Imja Watershed



<http://hydrology.gov.np/display/imja/#/>





# Community Based Engagement

Community based Institutions,  
Capacity building Trainings on  
GLOF Risk Reductions – First Aid,  
Safe Evacuation, Search and  
Rescue , Early Warning System  
among other





# Respect to Local Culture





# News of Imja Lake lowering covered by more than 10 International Media

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Asia China India

## Nepal drains dangerous Everest lake

By Navin Singh Khadka  
Environment reporter, BBC World Service

31 October 2016 | Asia



**IRIN**  
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## Global warming turns up the heat on glacial lake risk in the Himalayas

Photo feature

Nepal recently lowered the level of a lake that was in danger of bursting its banks

msn news

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- <https://www.thethirdpole.net/2016/12/02/photo-story-draining-nepals-dangerous-glacier-lake/>
- **TIMES**
- **The DAILY UK**

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**NEWS**  
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- <http://www.msn.com/en-in/news/world/nepal-drains-dangerous-imja-tsho-glacial-lake-near-mount-everest/ar-AAjDIEB?li=AAgfYGb>

## Nepal announces completion of dangerous Himalayan Lake's lowering project

Source: Xinhua 2016-11-24 12:58:25

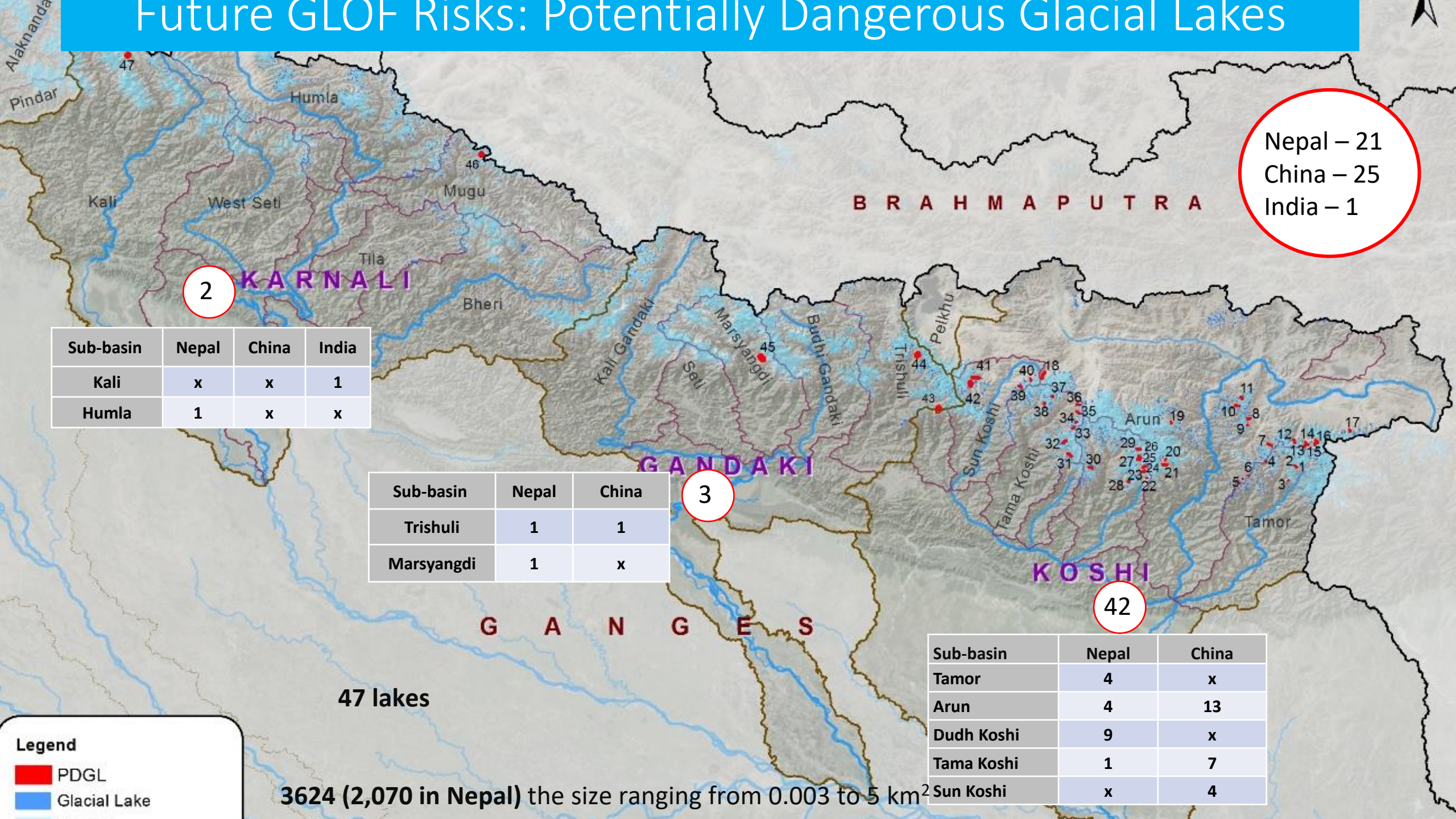
SOLUKHUBMU, Nepal, Nov. 24 (Xinhua) -- Nepal on Wednesday formally announced the completion of much-awaited Imja Lake Lowering Project' that has been executed above 5000 meters in the Everest region of the country.

Bal Krishna Khand, Nepalese Minister of Defense and Jaya Dev Joshi, Minister of Population and Environment jointly inaugurated the Community Based Flood and Glacial Lake Outburst Risk Reduction Project Thursday at the Imja Lake premise, some 11 km from the world's highest peak Mount Everest in Solukhumbu district.

Imja Lake, one of the biggest glacial lakes in the Himalayan country, is located at an altitude of 5010 meters above the sea level. The depth of the glacial lake is 150 meters.



# Future GLOF Risks: Potentially Dangerous Glacial Lakes



Nepal – 21  
China – 25  
India – 1

2

Sub-basin	Nepal	China	India
Kali	x	x	1
Humla	1	x	x

3

Sub-basin	Nepal	China
Trishuli	1	1
Marsyangdi	1	x

42

Sub-basin	Nepal	China
Tamor	4	x
Arun	4	13
Dudh Koshi	9	x
Tama Koshi	1	7
Sun Koshi	x	4

47 lakes

3624 (2,070 in Nepal) the size ranging from 0.003 to 5 km<sup>2</sup>

**Legend**

- PDGL
- Glacial Lake



# Conclusion/ Lesson Learned

- A total of **71,752 vulnerable** people have been benefitted from this intervention;
- GLOF Risk Reduction needs **adequate** and multi-faceted actions;
- **Lake Lowering is costly means** of GLOF risk reduction; but is the best way to reduce existing risks considering a landscape approach linking **upstream and downstream watersheds**;
- **Engagement with Nepal Army was successful experience and upscaling** and replication is possible for other critical glacial lakes;
- **People's participation is essential and building community based DRR institutions** was proven to be the best way of engaging the community to ensure sustainability;



# Conclusion/ Lesson Learned

- **Updates on climate information, knowledge** about its changing pattern and possible impacts is important for the success of any risk reduction measure;
- Research - Monitoring / Assessment of Glaciers, Glacial lake and its surrounding should be continued;
- Regional and International collaboration for GLOF risk reductions/mitigation is required;
- **Role of academia/research institutions** is key for all kinds of research ( priority- **Action Research**) with engagement of **local communities**;
- Mechanism for **inter -governmental collaboration on data sharing** and information are essential, different level of collaboration should be explored and prioritized;
- **Global, Regional and National Policies/ strategies** should prioritize addressing anticipated risk of GLOF and inform development towards its contributions to achievement of **SFDRR, SDGs and Paris Agreement**;



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31 October 2016 | Asia



Nepal's army says it has finished draining a dangerous glacial lake near Mount Everest to a safe level.

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IMJA LAKE/NEPAL, 5 January 2017

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Imja Lake, one of the biggest glacial lakes in the Himalayan country, is located at an altitude of 5010 meters above the sea level. The depth of the glacial lake is 150 meters.



# Project in Media

<https://www.irinnews.org/photo-feature/2017/01/05/global-warming-turns-heat-glacial-lake-risk-himalayas>

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- <http://www.msn.com/en-us/news/world/nepal-drains-dangerous-everest-lake/ar-AAjCQRx?li=BBnbcA1>
- <http://kathmandupost.ekantipur.com/news/2016-12-03/dammed.html>
- [ICIMOD VIDEO LINK on You Tube](#)



# Everest Region in Nepal Welcomes you.....



SEE YOU in NEPAL !!!





Measuring Discharge @ Lower Barun GL Outlets 20 Nov 2019

*Photos – Deepak KC except that of Slide 6 (Bhotekoshi damage), facts/figures - Sources are highly acknowledged.*



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**Thank You for your Attention!!!**



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  - [www.neoc.gov.np](http://www.neoc.gov.np)
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