



2025
International
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Preservation

**Launch of IYGP 2025 –
SIDE EVENT #35**
**Decades of Cryosphere Actions in
ICIMOD: From a Geopolitically
Sensitive Subject to a Flagship Initiative**

21 January 2025
07:00 – 08:30 UTC, and local time
Online | Kathmandu, Nepal

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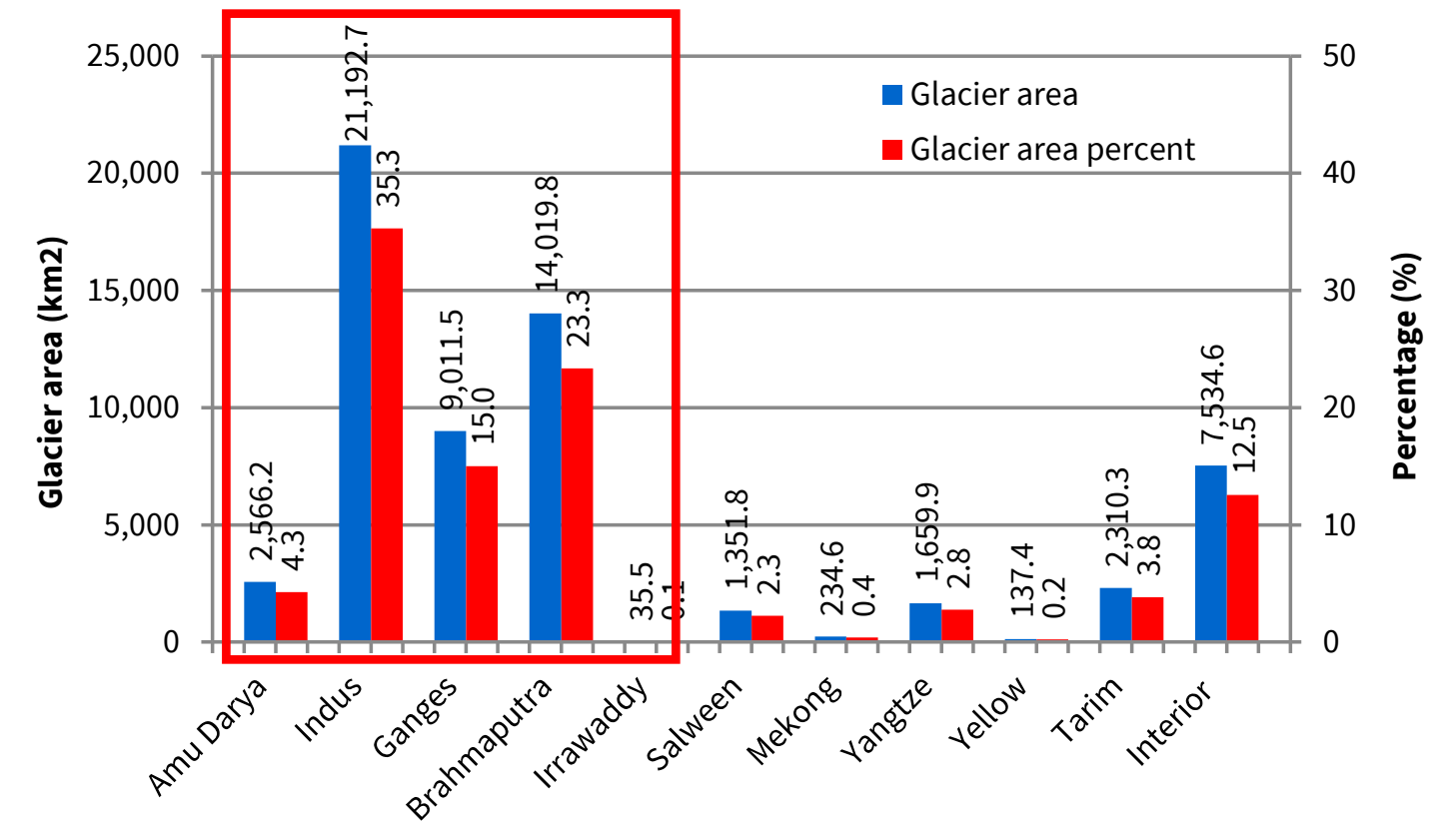
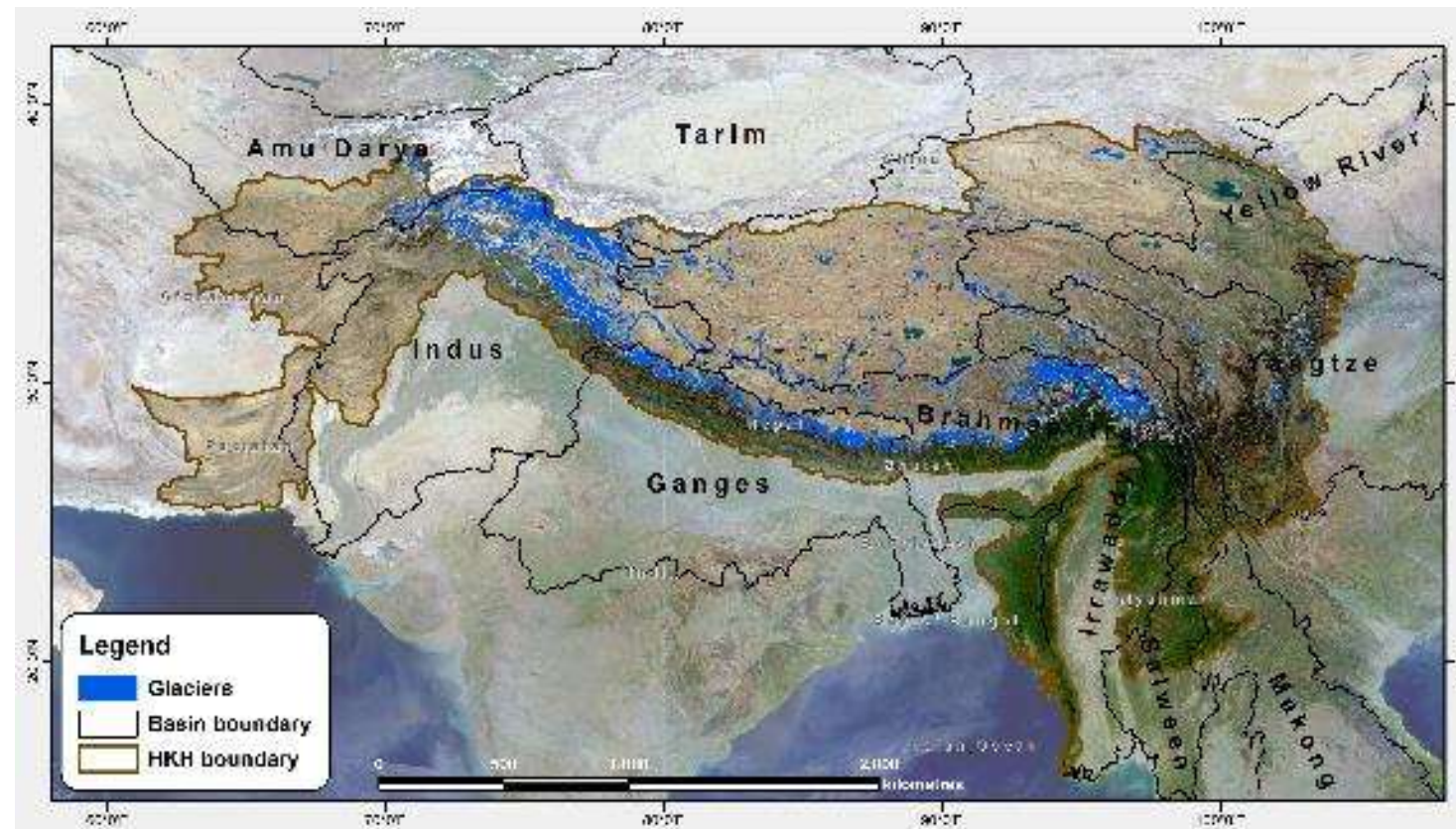


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Decades of Study on Glaciers and Glacial Lakes in the HKH Region

Sudan Bikash Maharjan
ICIMOD

The Hindu Kush Himalaya Region (Water Tower of Asia)



HKH area: 4.19 million km²

- **~9% of glaciers in globe**
- **240 million people** depend directly on HKH for their lives and livelihood
- **1.95 billion people depend** on the HKH for water, Food and Energy
- **>35% 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), Landslides/debris flows.

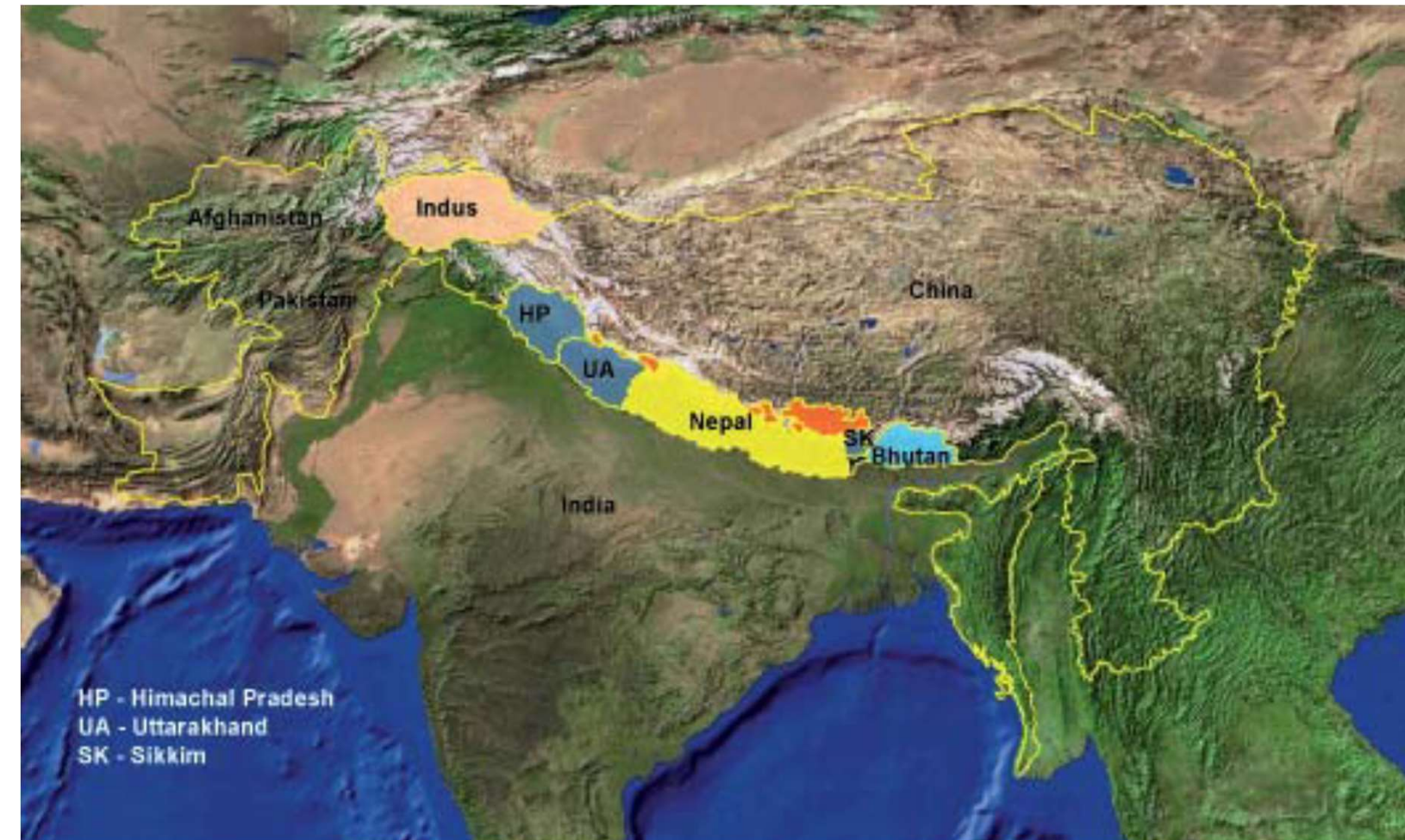
During 1999 – 2004: Inventorying of glaciers and glacial lakes

First homogeneous compilation of Glaciers data of HKH region was carried out by ICIMOD

- ✓ Area coverage: Bhutan, Nepal, Pakistan, China (Koshi basin), Sikkim, Himachal Pradesh and Uttaranchal Pradesh, India
- ✓ Data Source : Topographic maps of 1963 to 1982 and Satellite images of 2000
- ✓ Methodology : Visual Interpretation and Manual digitization
- ✓ 15003 glaciers covering area of 33344 km²
- ✓ 8,790 glacial lakes, of which 203 were identified as potentially dangerous

<https://lib.icimod.org/record/7511>

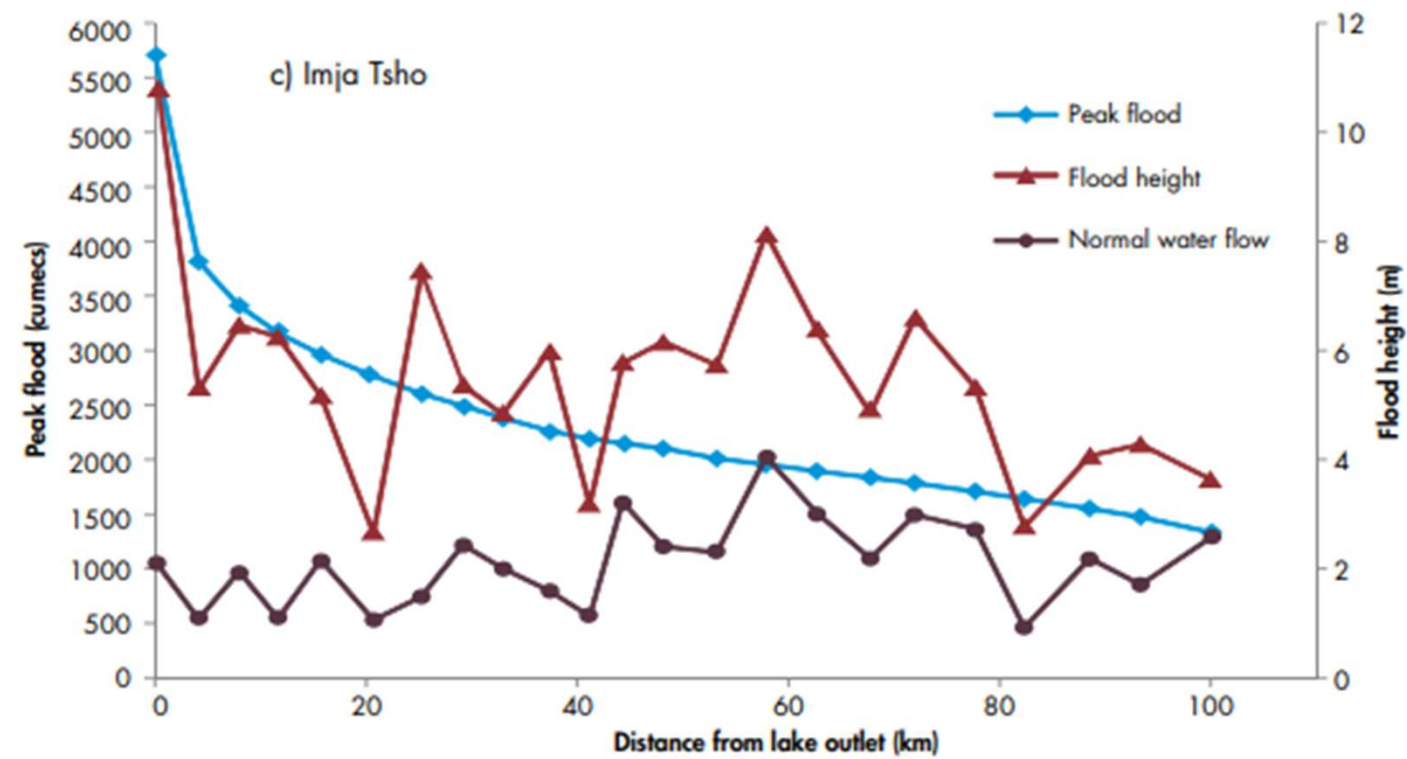
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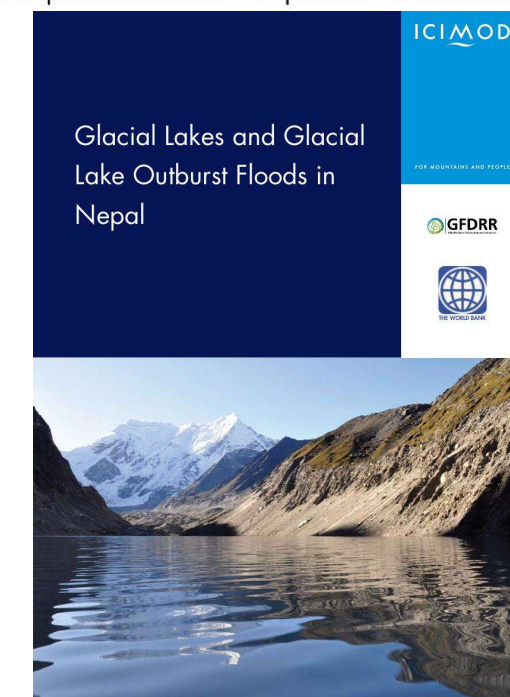
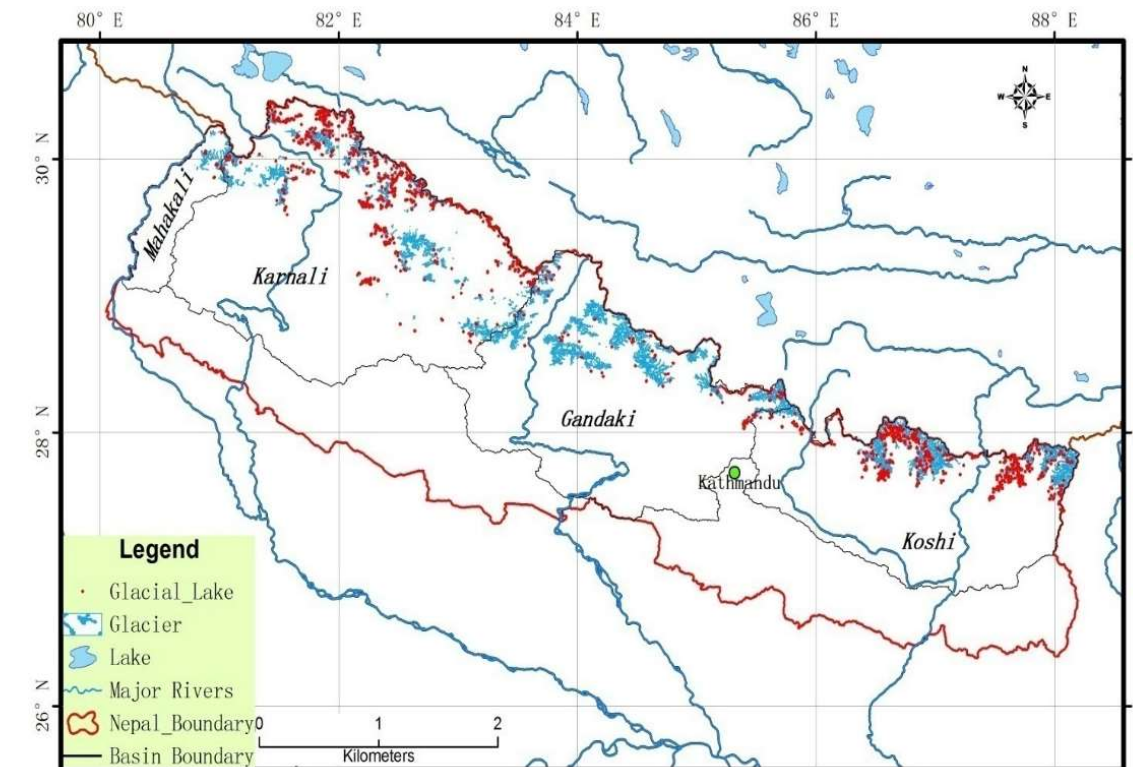
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During 2009 – 2010: Glacial lakes hazard and risk assessment in Nepal

- ✓ Data Source: Landsat ETM+ images of 2005±1
- ✓ 1,466 glacial lakes covering an area of 64.75 km².
- ✓ **21 lakes were identified as critical (potentially dangerous)** ones with 6 lakes defined as high priority lakes



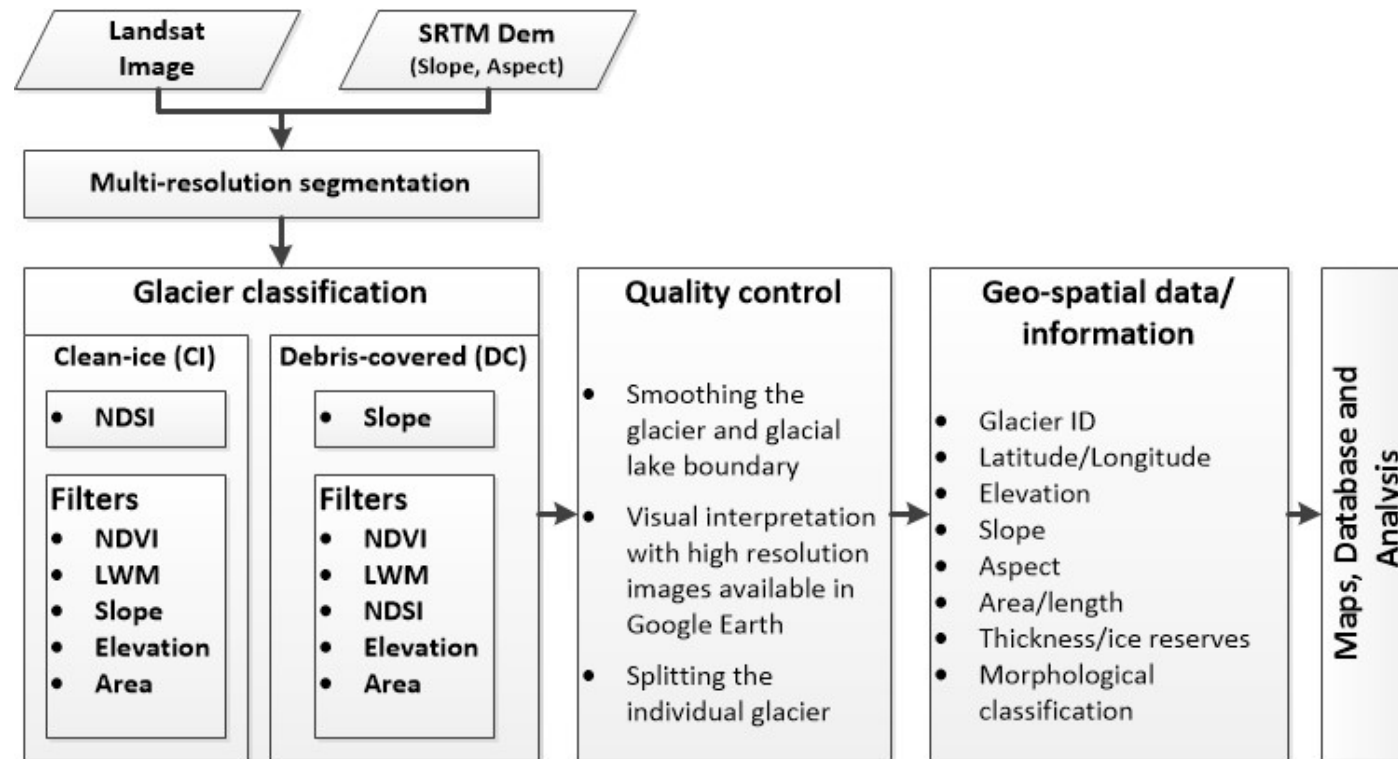
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During 2010 – 2011: Status of glaciers in the HKH Region.

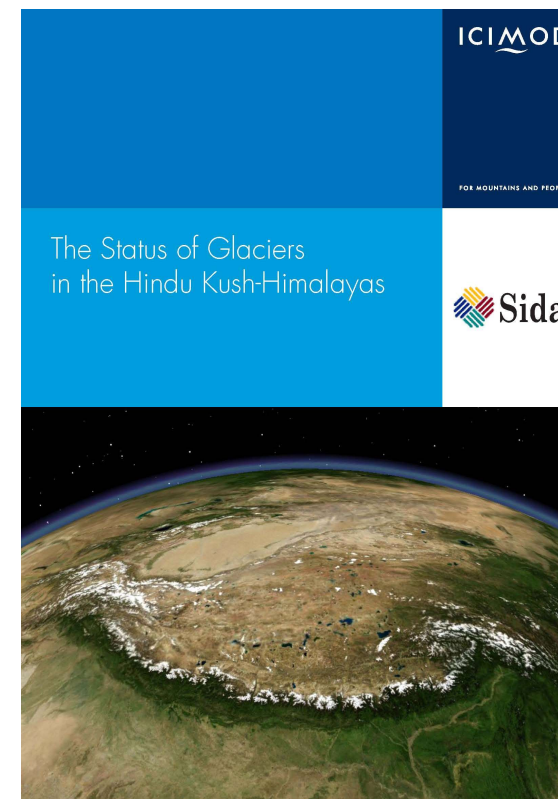
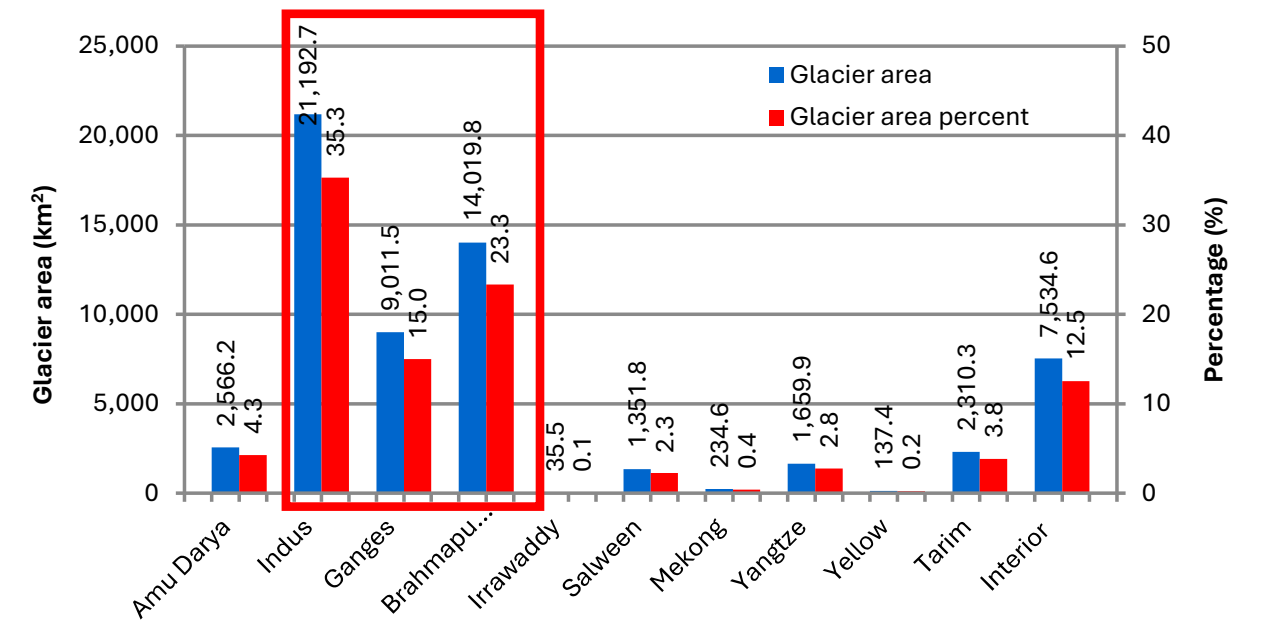
Semi-automatic – Object-based image classification



Data Source - Landsat ETM+ images of 2005±3 years

Mapping scale – 1:50,000

Area threshold : 0.02 km²



Glacier cover in HKH: 1.4%

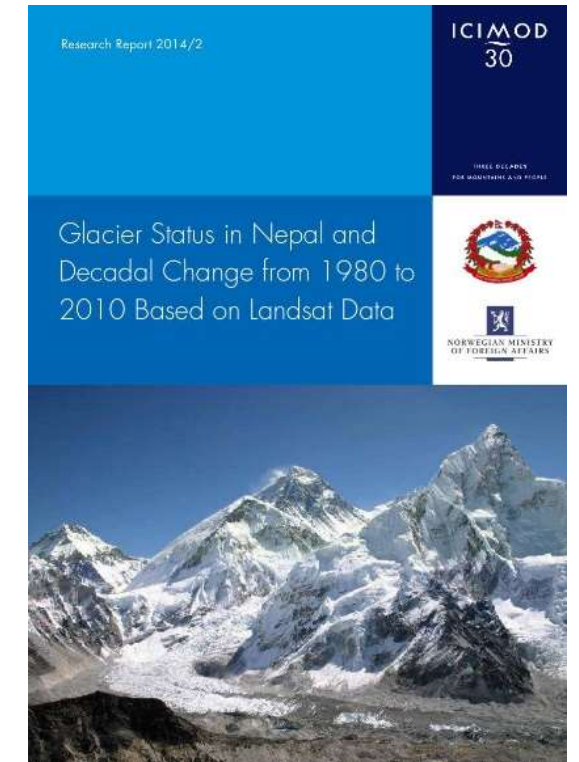
Total glacier: 54,252

Total glacier area: 60,054 km²

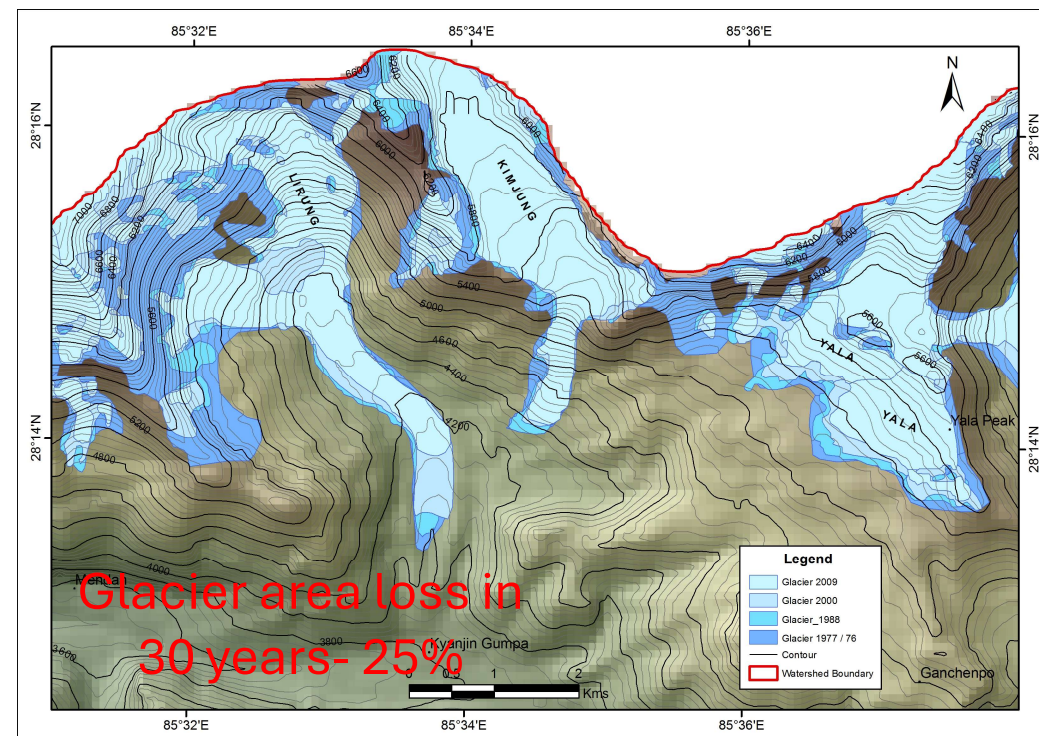
<https://lib.icimod.org/record/9419>

During 2012 – 2014: Decadal Change of Glaciers in Nepal (1980 – 2010)

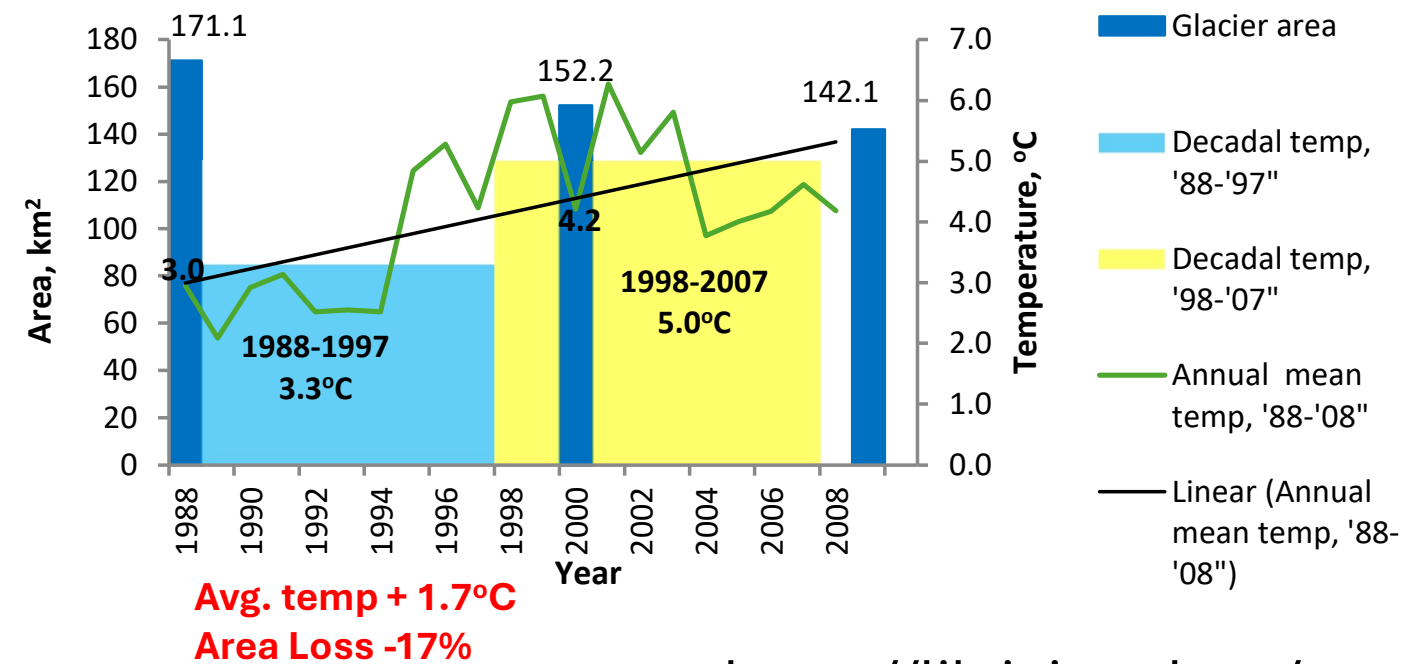
Glacier attribute	Decade (Year)				Decadal change							
	~1980	1990	2000	2010	~1980–1990		1990–2000		2000–2010		~1980–2010	
Number	3,430	3,656	3,765	3,808	226	7%	109	3%	43	1%	378	11%
Area (km ²)	5,168	4,506	4,211	3,902	-662	-13%	-295	-7%	-308	-7%	-1266	-24%
Estimated ice-reserves (km ³)	441	370	343	312	-72	-16%	-27	-7%	-31	-9%	-129	-29%



Langtang Valley



Kyanging, Langtang valley

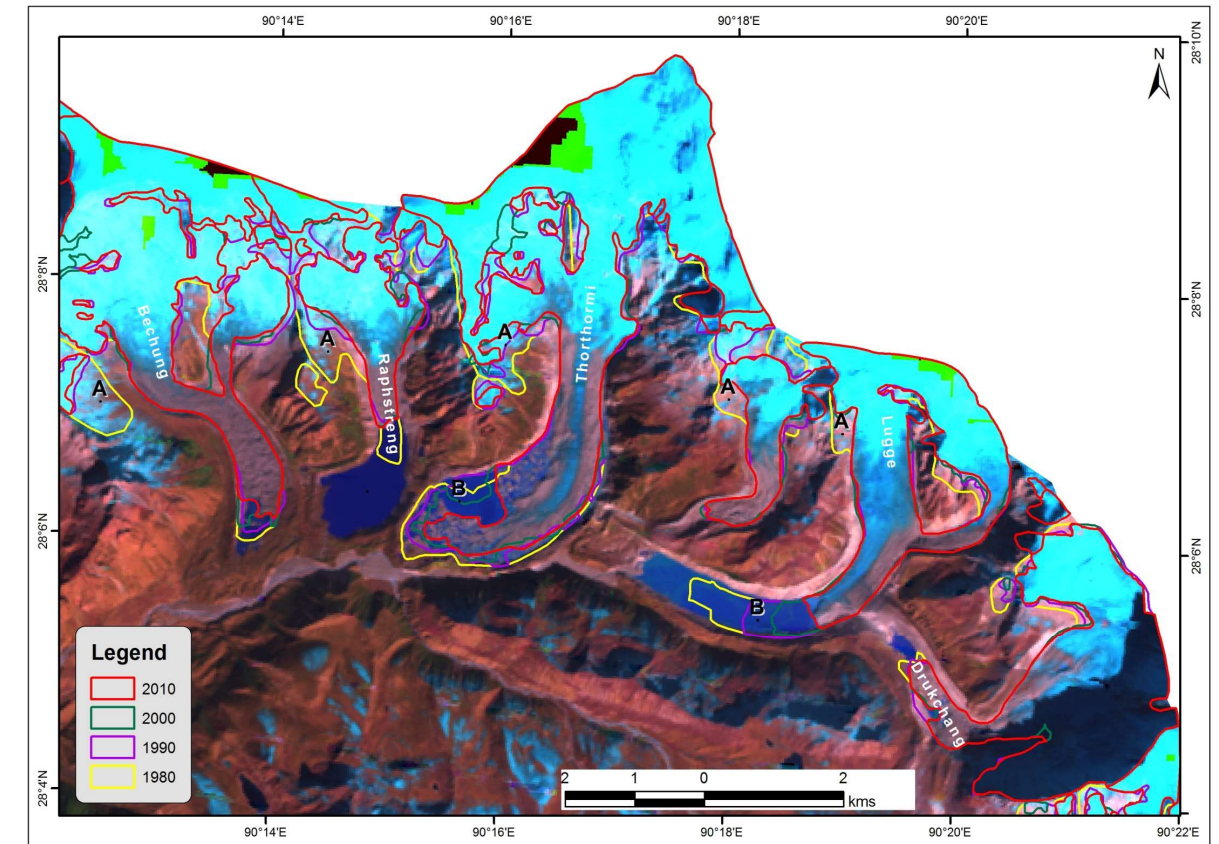
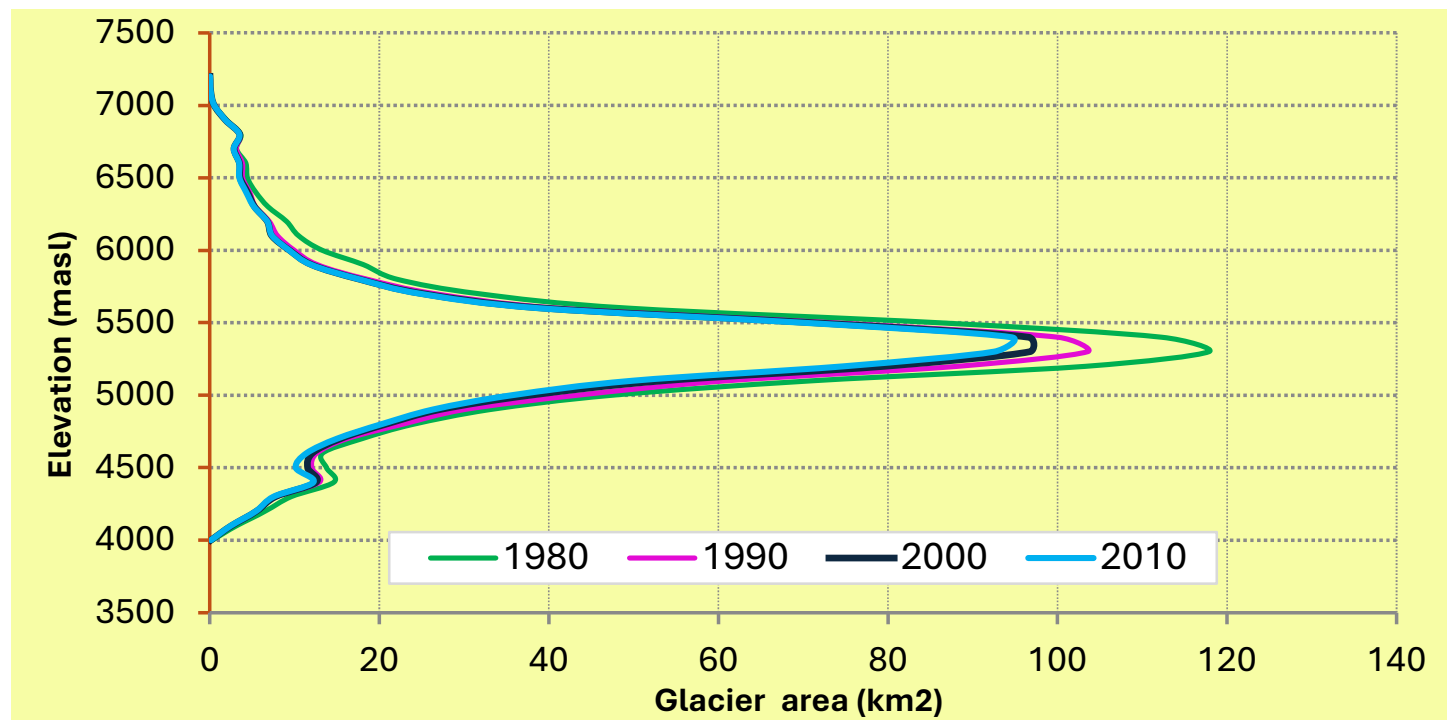


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During 2012 – 2014: Decadal Change of Glaciers in Bhutan (1980 – 2010)

Years	Glacier Area (km ²)			Change in Glacier Area (%)		
	Clean-ice	Debris-covered	Total	Clean-ice	Debris-covered	Total
1980	757.4 ± 26.05	80.2 ± 1.61	837.6 ± 28.81			
1990	654.6 ± 14.74	86.2 ± 0.96	740.7 ± 16.67	-13.6 ± 1.2	7.5 ± 0.9	-11.6 ± 1.2
2000	598.2 ± 14.3	90 ± 0.79	688.2 ± 16.45	-8.6 ± 0.1	4.4 ± 0.2	-7.1 ± 0.1
2010	550.7 ± 13.83	91.4 ± 0.71	642.1 ± 16.12	-7.9 ± 0.1	1.6 ± 0.1	-6.7 ± 0.1
1980-2010				-27.3 ± 0.9	14 ± 1.2	-23.3 ± 0.9



<https://lib.icimod.org/record/29316>

Annals of Glaciology 55(66) 2014 doi: 10.3189/2014AoG66A125

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The status and decadal change of glaciers in Bhutan from the 1980s to 2010 based on satellite data

Samjwal Ratna BAJRACHARYA, Sudan Bikash MAHARJAN, Finu SHRESTHA

International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal
E-mail: sabajracharya@icimod.org

ABSTRACT. In order to monitor changes in the glaciers in the Bhutan Himalaya, a repeat decadal glacier inventory was carried out from Landsat images of 1977/78 (~1980), 1990, 2000 and 2010. The base map of glaciers was obtained by the object-based image classification method using the multispectral Landsat images of 2010. This method is used separately to delineate clean-ice and debris-covered glaciers with some manual editing. Glacier polygons of 2000, 1990 and ~1980 were obtained by manual editing on 2010 by separately overlaying respective years. The 2010 inventory shows 885 glaciers with a total area of ~642 ± 16.1 km². The glacier area is 1.6% of the total land cover in Bhutan. The result of a repeat inventory shows 23.3 ± 0.9% glacial area loss between ~1980 and 2010, with the highest loss (11.6 ± 1.2%) between ~1980 and 1990 and the lowest (6.7 ± 0.1%) between 2000 and 2010. The trend of glacier area change from the 1980s to 2010 is -6.4 ± 1.6%. Loss of glacier area was mostly observed below 5600 m.a.s.l. and was greater for clean-ice glaciers. The equilibrium-line altitude has shifted upward from 5170 ± 110 m.a.s.l. to 5350 ± 150 m.a.s.l. in the years ~1980-2010.

KEYWORDS: glacier mapping, mountain glaciers, remote sensing

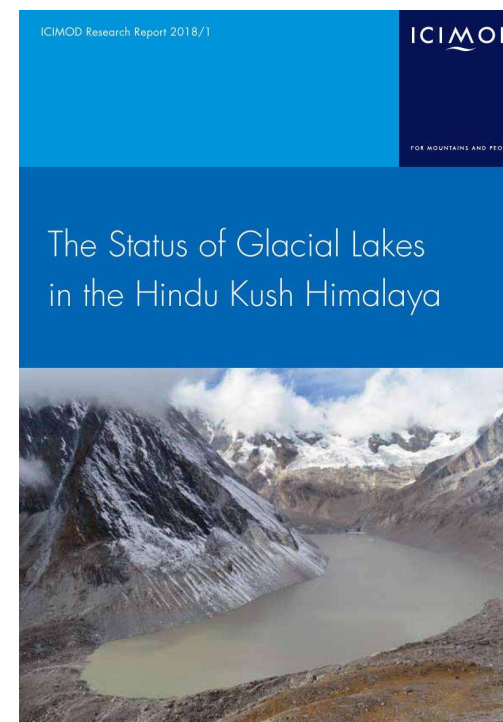
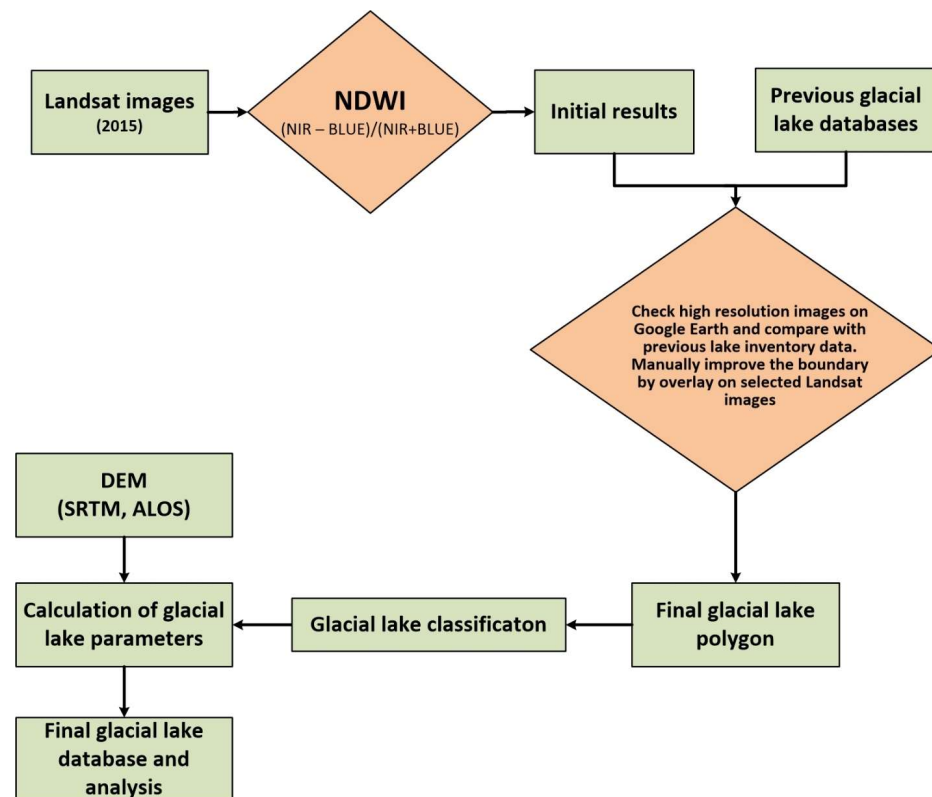
Annals of Glaciology, Volume 55, Issue 66, 2014, pp. 159 - 166

DOI: <https://doi.org/10.3189/2014AoG66A125>

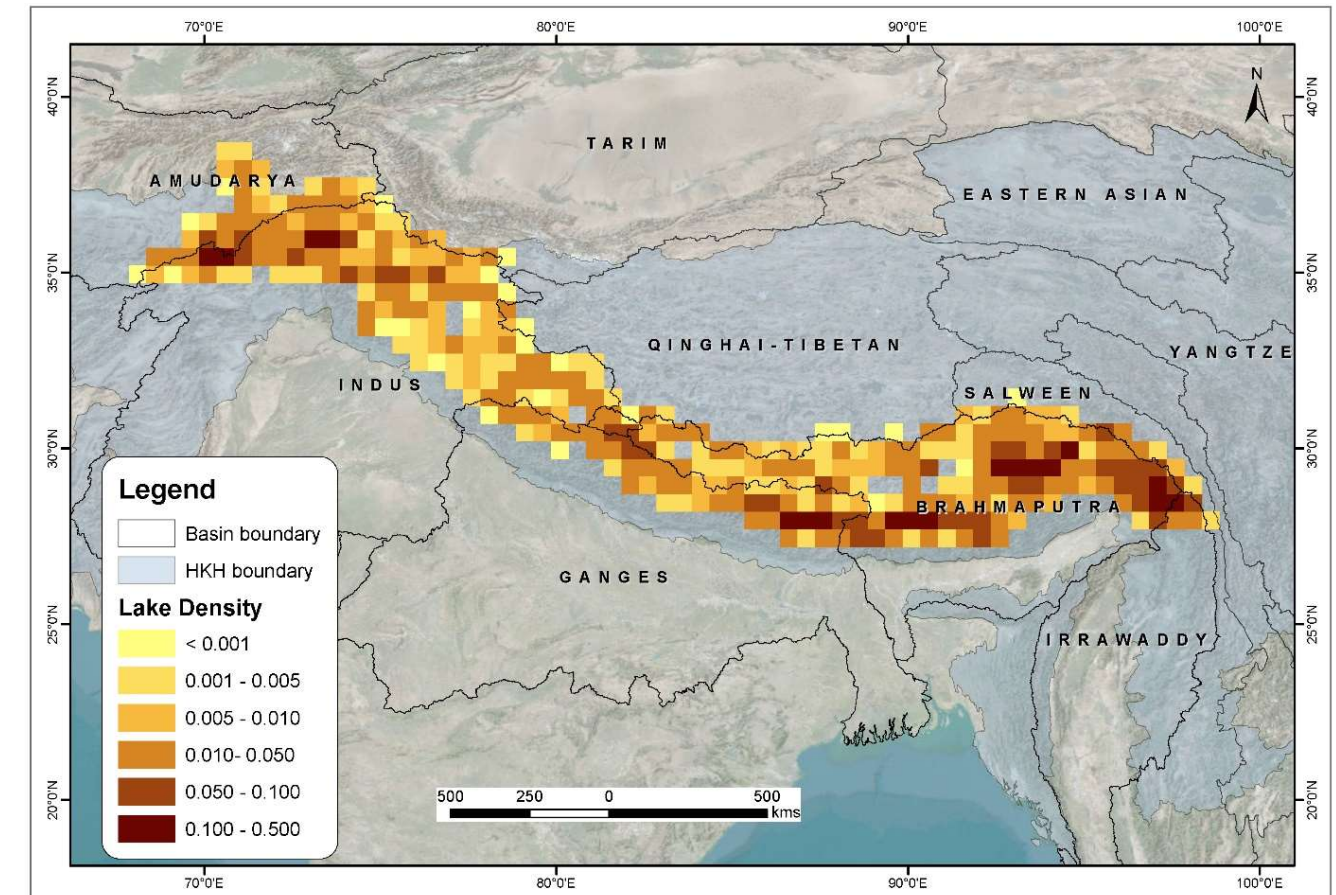
<https://www.un-glaciers.org/>

During 2016 – 2018: Status of Glacier Lakes in the HKH Region

- Water bodies in front of and on or beside a glacier or in the lowland formed by paleo-glaciation are the object of glacial lake inventory.
- Fill gaps in HKH region
- Narrower temporal base (2005 ± 2)
- Single source of data (Landsat TM/ETM+)
- Good data quality for glacial lake change detection
- Lake size greater than 0.003 km² were mapped.
- Regional data integration
- Consistent classification schemes of glacial lakes



<https://www.un-glaciers.org/>



Basins	Number	Area (km ²)
Amu Darya	1,474	66.10
Indus	5,689	260.54
Ganga	4,082	208.59
Brahmaputra	13,642	883.55
Irrawaddy	525	16.15
Mansarover	202	9.27
Total	25,614	1,444.2

Type	Number	Area
Moraine-dammed lake (M)	M(e)	2,636
	M(l)	290
	M(o)	5,378
Ice-dammed lake (I)	I(s)	1,253
	I(v)	27
Bedrock dammed lake (B)	B(c)	2,842
	B(o)	12,392
Others (O)	O	811
Total	25,614	1,444.2

<https://lib.icimod.org/record/33736>

During 2018 – 2020: Potentially Dangerous Glacial lakes in Koshi, Gandaki and Karnali River Basins

Step by step categorization using 22 various factors:

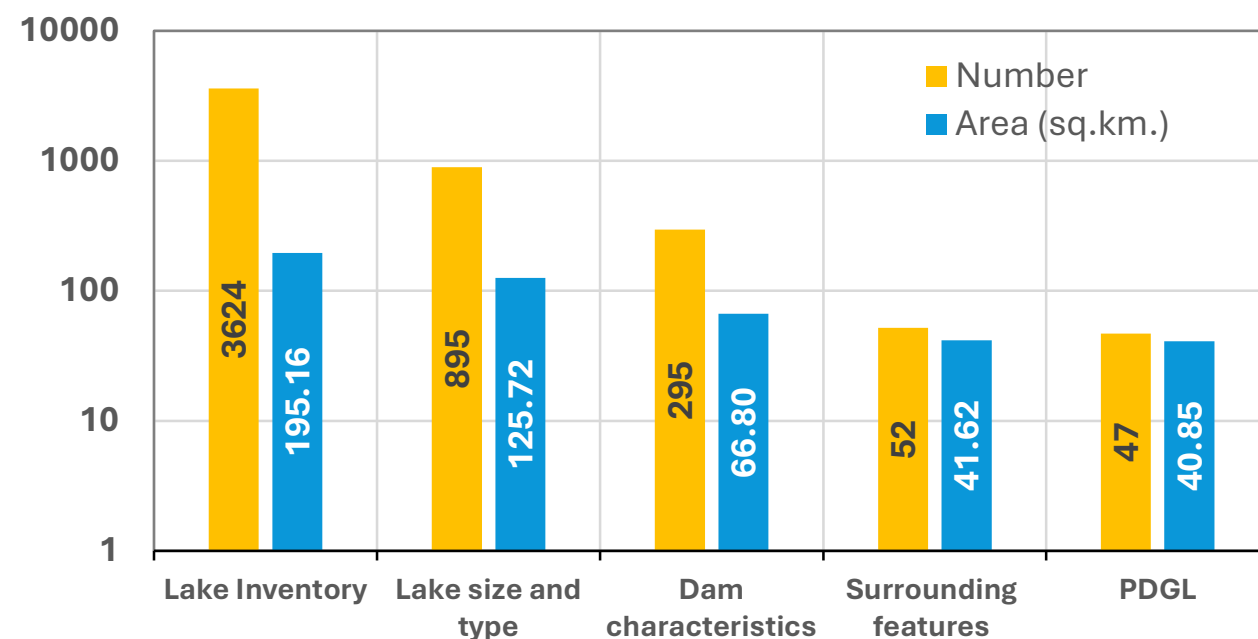
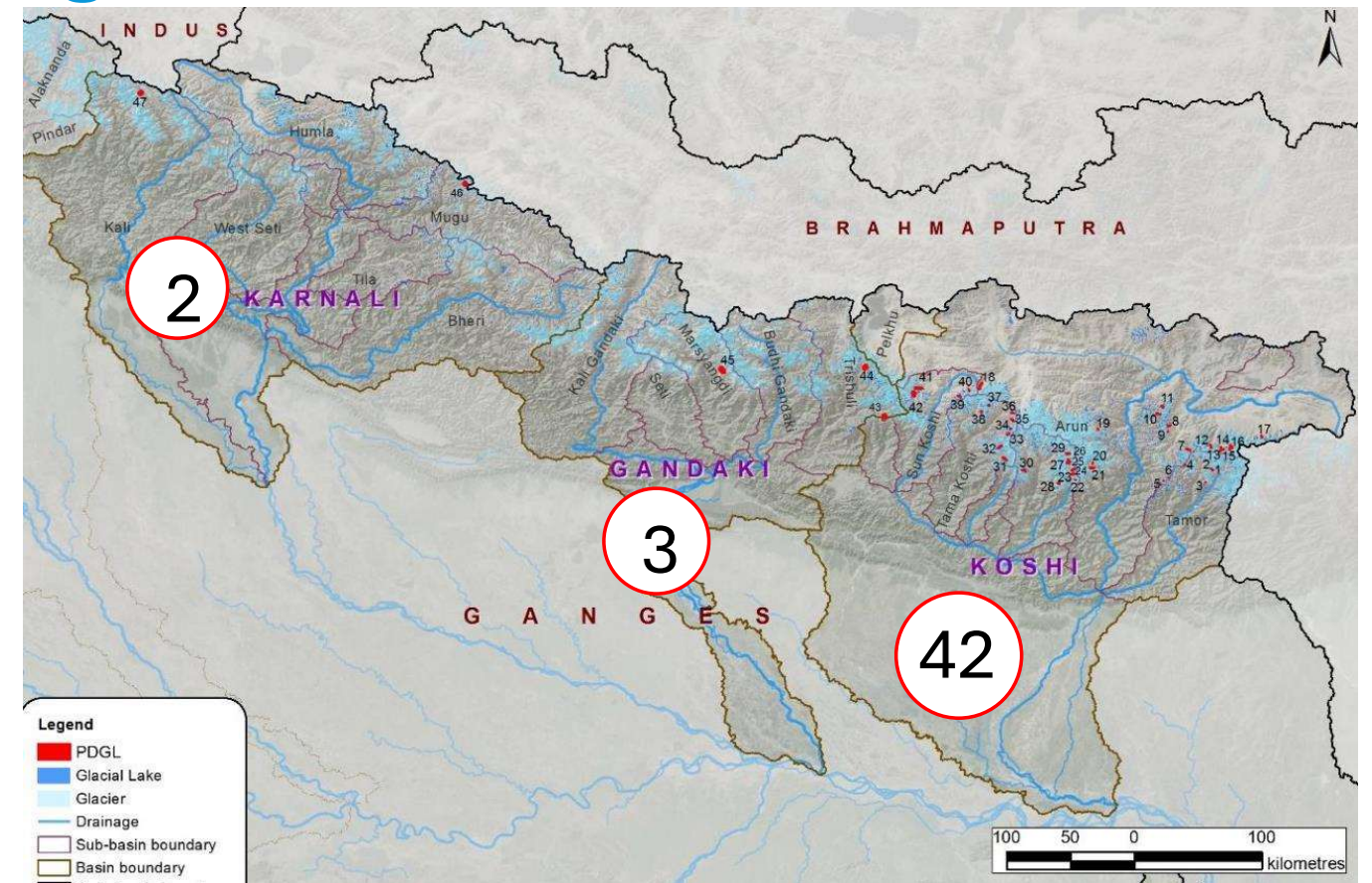
Level 1: Lake characteristics

Level 2: Dam characteristics

Level 3: Characteristics of source glaciers

Level 4 : Physical condition of surroundings

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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

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

RESEARCH REPORT
Inventory of glacial lakes and identification of potentially dangerous glacial lakes in the Koshi, Gandaki, and Karnali river basins of Nepal, the Tibet Autonomous Region of China, and India





Trainings and on-the-job trainings



- Afghanistan
- Nepal
- Bhutan
- Pakistan
- Myanmar

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2017 ICIMOD publication

Training Manual on Application of Remote Sensing and Geographic Information Systems for Mapping and Monitoring of Glaciers: Part 1 – Glacier mapping using eCognition; ICIMOD Manual 2017/10

Bajracharya, S. R., Maharjan, S. B., Shrestha, F.

Download Main document

Main Record Main record

Pages: 32
Language: English
Published Year: 2017
Publisher Name: International Centre for Integrated Mountain Development (ICIMOD)
Publisher Place: Kathmandu, Nepal

Summary

This manual provides detailed information on a customized methodology for glacier mapping using a remote sensing based semi-automatic technique for quick delivery. Based on this methodology, studies on the status of the glaciers of the Hindu Kush Himalaya and decadal glacier change since the 1980s have been carried out in selected areas and basins. The data and results derived from this methodology have been published in several journals, book chapters, and reports. A summary of the results and publications is presented here, and in global level glacier mapping initiatives. Reviews of the methodologies adopted by global initiatives like World Glacier Monitoring Service (WGMS), Global Land Ice Measurement from Space (GLIMS), and GlobGlacier are also presented in this manual. The methodology can be applied with little knowledge of remote sensing and geographic information systems. This is true not only for glacier mapping, but also for mapping the earth's physical features.

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2017 ICIMOD publication

Training Manual on Application of Remote Sensing and Geographic Information Systems for Mapping and Monitoring of Glaciers: Part 2 - Glacier Database Generation using ArcGIS; ICIMOD Manual 2017/11

Maharjan, S. B., Shrestha, F., Bajracharya, S. R.

Download Main document

Main Record Main record

Pages: 16
Language: English
Published Year: 2017
Publisher Name: International Centre for Integrated Mountain Development (ICIMOD)
Publisher Place: Kathmandu, Nepal

Summary

This manual provides an introduction to Geographic Information Systems (GIS) and ArcGIS software. The ArcGIS platform and tools are explained so that they can be used for generating glacier database, analysis on glacier database and preparing glacier maps. The manual is divided into three parts – first part includes the introduction of GIS and descriptions of some of the fundamental terms used in GIS. The second part includes the hands-on exercise on ArcGIS to make you familiar on the software and the third part includes the detail exercise for generating different attribute of the glacier polygon with some analysis.

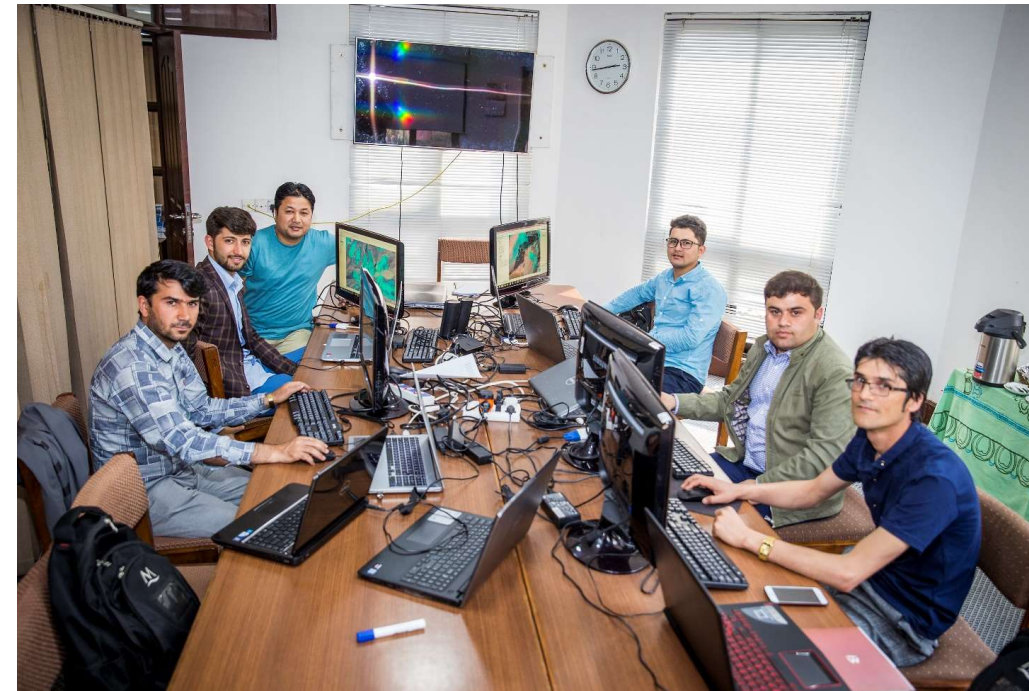
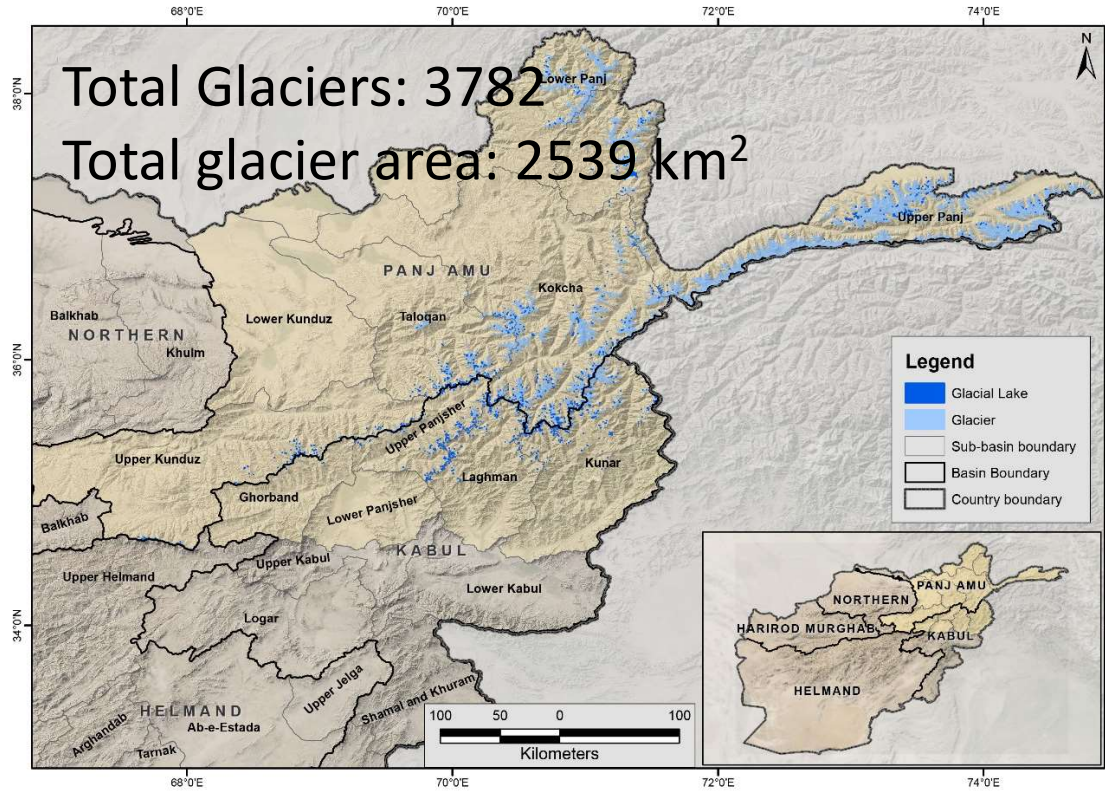
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During 2018 – 2020: Decadal Change of glaciers in Glaciers and Glacial Lakes in Afghanistan (1990 – 2015)

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RESEARCH REPORT
Glaciers in Afghanistan
Status and changes from 1990 to 2015



Chapter 11 Monitoring of Glaciers and Glacial Lakes in Afghanistan

Sudan Bikash Maharjan, Finu Shrestha, Fayezurahman Azizi, Esmatullah Joya, Birendra Bajracharya, Mohammad Tayib Bromand, and Mohammad Murtaza Rahimi

11.1 Introduction

During the needs assessment in Afghanistan, the General Directorate of Water Resources (GDWR) of the National Water Affairs Regulation Authority (NWARA) (previously Water Resource Department (WRD) of the Ministry of Energy and Water (MEW)) emphasized that the compilation of comprehensive data on the glaciers in the country is a national priority.

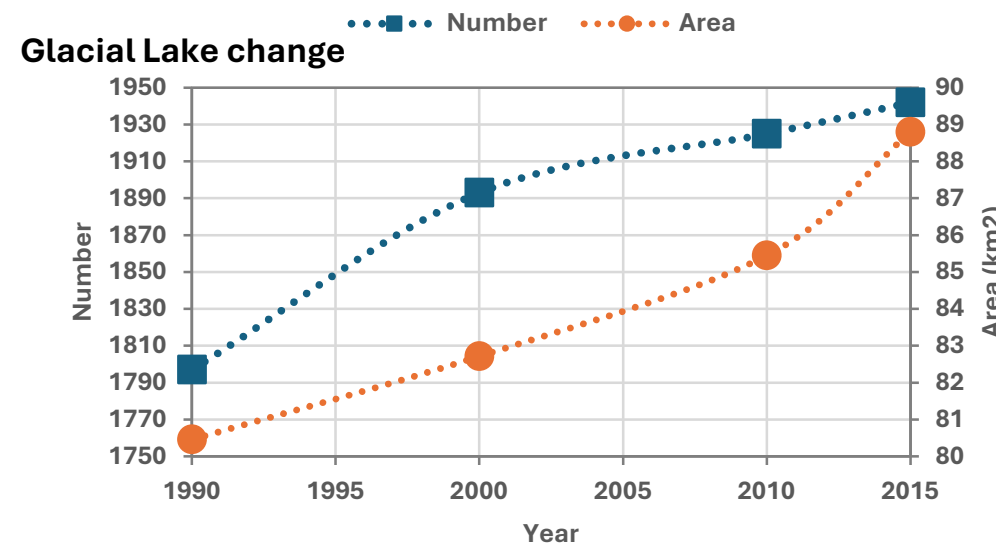
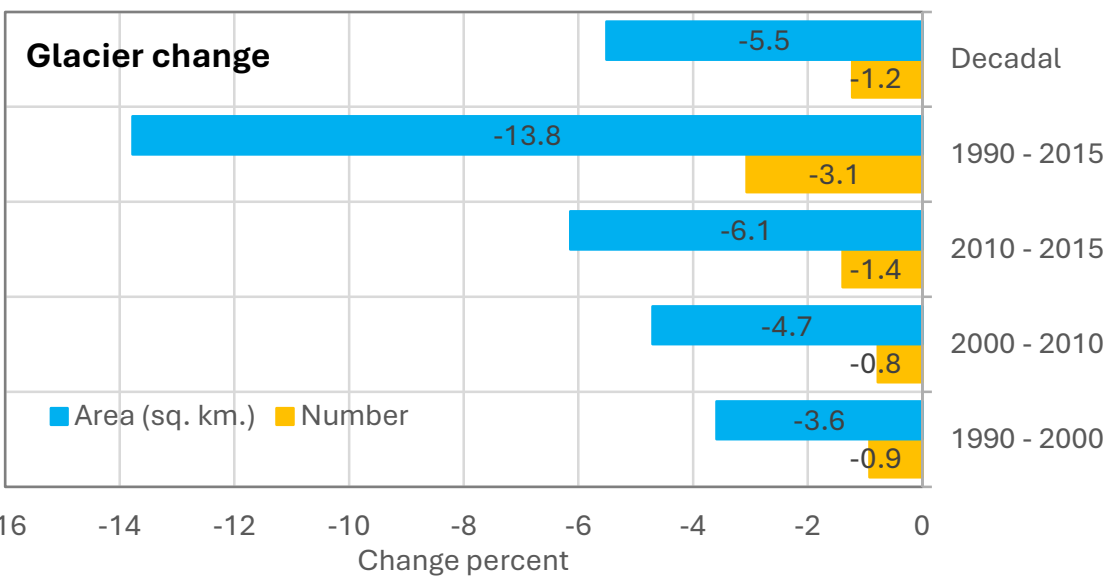
Glaciers are of paramount importance in arid and semi-arid places like Afghanistan and serve as sources of freshwater for a large proportion of its population. Globally, the considerable evidence on retreat and shrinkage of glaciers, and the formation and expansion of glacial lakes have become a hot topic for researchers, scientists, and policymakers. The clear evidence of glacial retreat in Afghanistan, as found by ICIMOD's studies, poses a serious threat to the country's water security.

Worldwide, most glaciers have undergone major retreat since the end of the Little Ice Age (Marshall 2014; Zemp et al. 2014). This retreat was first noticed in the 1960s (Grotzbach 1964; Gilbert et al. 1969; Braslan 1972), and it accelerated in the last three decades (Gardent et al. 2014; Bajracharya et al. 2014a, b; Mernild et al. 2013). The HKH region has the highest concentration of snow and glaciers outside the polar regions and they play a pivotal role in supplying water to 10 major river basins (Bajracharya and Shrestha 2011). Glacial changes are also a valuable indicator of climate change (Wester et al. 2019; Nie et al. 2017; Song et al. 2017; Bajracharya et al. 2014a). By the end of the twenty-first century, the global surface

S. B. Maharjan (✉) · F. Shrestha · E. Joya · B. Bajracharya · M. M. Rahimi
International Centre for Integrated Mountain Development, Kathmandu, Nepal
e-mail: sudan.maharjan@icimod.org; bika@shrestha@gmail.com

F. Azizi · M. T. Bromand
General Directorate of Water Resources, National Water Affairs Regulation Authority, Kabul, Afghanistan

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B. Bajracharya et al. (eds.), *Earth Observation Science and Applications for Risk Reduction and Enhanced Resilience in Hindu Kush Himalaya Region*,
https://doi.org/10.1007/978-3-030-73569-2_11

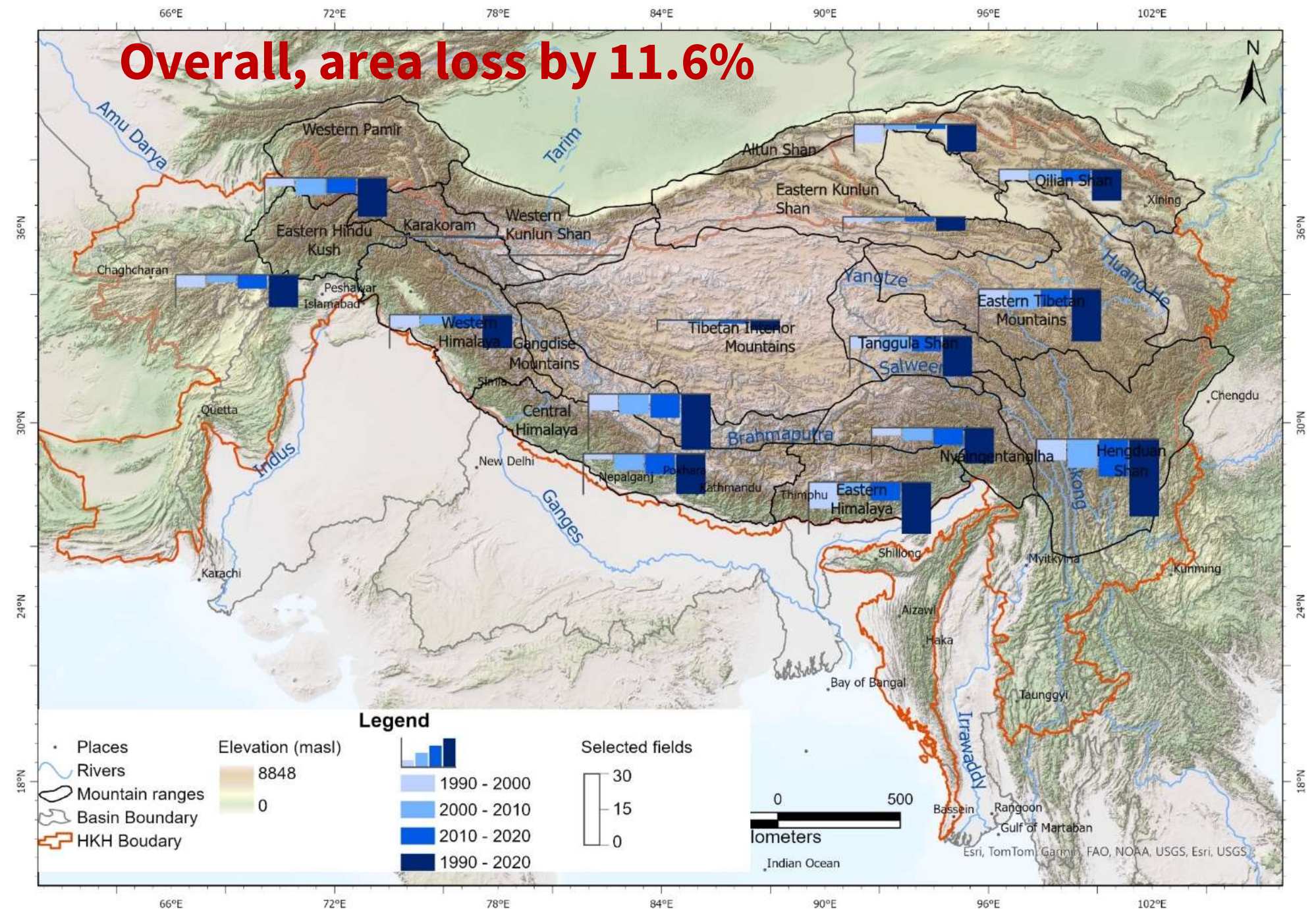


https://link.springer.com/chapter/10.1007/978-3-030-73569-2_11

<https://www.un-glaciers.org/>

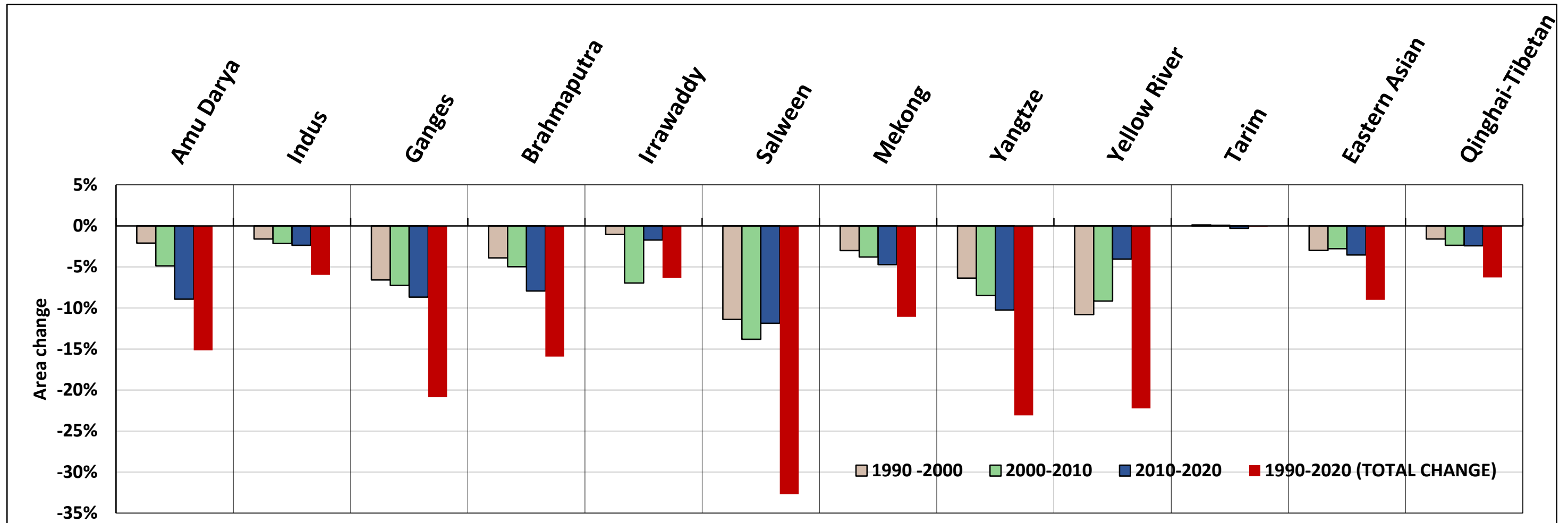
Decadal Changes of Glaciers in the HKH Region (1990 – 2020)

- Consistent data source – Landsat satellite images
- Spatial resolution – 30m
- Narrow Temporal resolution - \pm one year
- Accuracy and Quality : checking with other inventories and high-resolution images
- Area Threshold: 0.02 km²
- Mapping Scale: 1:50000





Inter-Decadal Glacier Area Changes in Major River Basins (1990 – 2020)



The Ganges, Brahmaputra and Indus experienced the greatest loss of area.

Comparatively, recent decade has higher rate of shrinkage

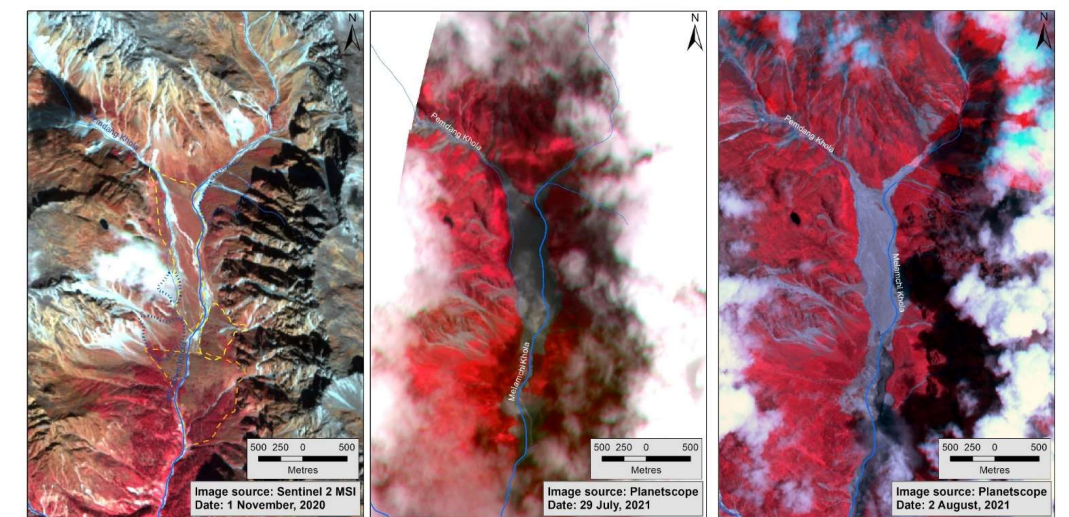
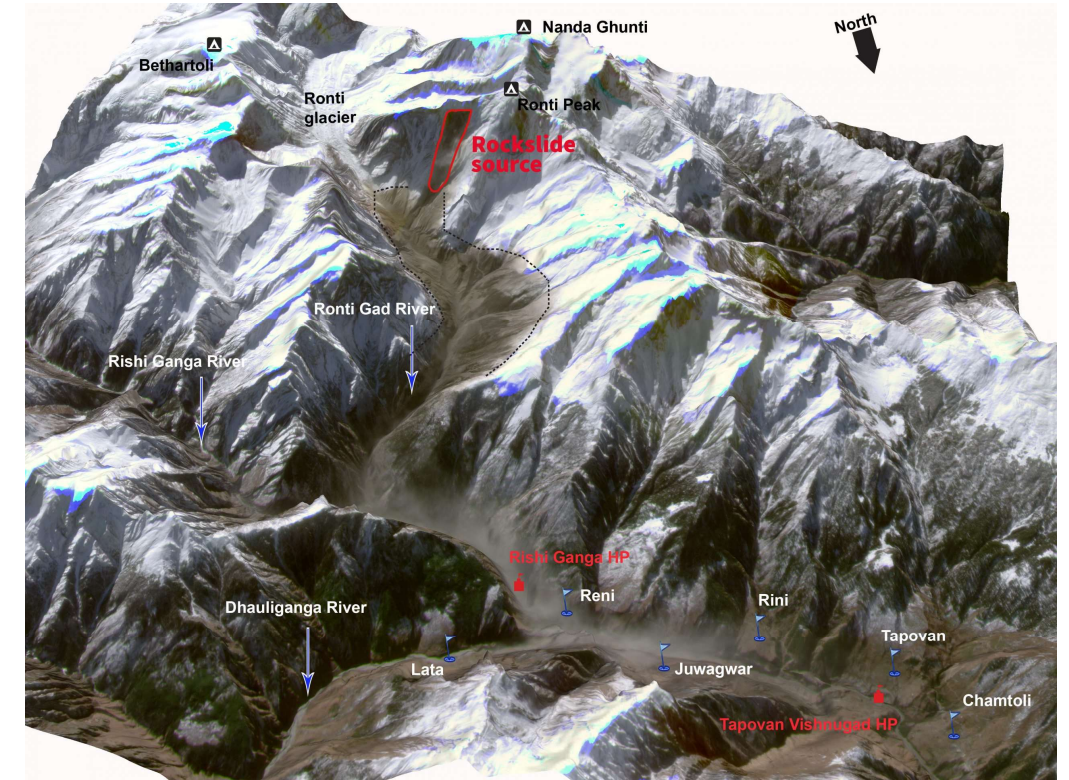


Consequences of Melting Glaciers

- Thame Flood, August 2024
- Ice Avalanche in Mustang, 2022
- Melamchi Flood Disaster, 2021 (10.53055/ICIMOD.981)
- Chamoli Flash Flood, Feb 2021
- GLOF in Panjshir Valley, Afghanistan, 2018
- Seti Flash Flood 2012

Disaster Responses

<https://www.icimod.org/article/understanding-the-chamoli-flood-cause-process-impacts-and-context-of-rapid-infrastructure-development/>



<https://www.un-glaciers.org/>



Data Visualizations

<http://geoapps.icimod.org/glacier/>

Glacier Dynamics in Afghanistan - Google Chrome

Not secure | geoapps.icimod.org/glacier/afglacier/

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Glacier Dynamics in Afghanistan

HKH Afghanistan Bhutan Nepal

Glacier Statistics

Afghanistan

Select Basin

Panj Amo

Select SubBasin

Upper Panj

[View Statistics](#)

Layer Legend

- Country Outline
- Basin
- SubBasin
- Glacier 2015
- Glacier 2010
- Glacier 2000
- Glacier 1990

Related Dataset

- Glaciers of Afghanistan 1990
- Glaciers of Afghanistan 2000
- Glaciers of Afghanistan 2010
- Glaciers of Afghanistan 2015

Glacier Area/Est. Ice Reserve in Afghanistan

Year	Count	Area	Est. Ice Reserve
1990	4000	3000	500
2000	4000	2800	500
2010	4000	2700	500
2015	4000	2500	500

Hypsograph of Glaciers in Afghanistan

Legend: 1990 (red), 2000 (blue), 2010 (green), 2015 (black)

About

The application showcases changes in the glaciers in Afghanistan from 1990 to 2015. The interactive glacier maps were prepared for 1990, 2000, 2010, and 2015 using a uniform data set and methodology, which provide a scientific basis for understanding the changes taking place in the glacial environment of Afghanistan.

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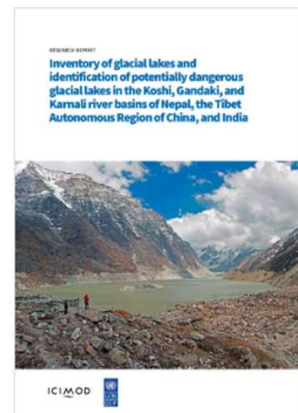
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2020

ICIMOD publication



Inventory of glacial lakes and identification of potentially dangerous glacial lakes in the Koshi, Gandaki, and Karnali river basins of Nepal, the Tibet Autonomous Region of China, and India

Samjwal Ratna Bajracharya, Sudan Bikash Maharjan, Finu Shrestha, Tenzing Chogyal Sherpa, Nisha Wagle, Arun Bhakta Shrestha

Summary

Glaciers in the Himalaya have been melting at an unprecedented rate since the mid-20th century, impacting flow regimes in major associated river basins. The resultant formation of new lakes and the expansion of existing glacial lakes increase glacial lake outburst flood (GLOF) risks. The present report provides an update on the status and changes in the number and area of glacial lakes in the Koshi, Gandaki, and Karnali river basins, along with a detailed methodology for the identification of critical glacial lakes in remote and inaccessible mountain terrain using remote sensing tools and technologies. Based on the information made available, hazard assessment and mitigation work could be implemented to secure the lives and livelihoods of mountain and downstream communities.

Download main document

DOI: 10.53055/ICIMOD.773
 Pages: 54
 Language: English
 Published Year: 2020
 Publisher Name: International Centre for Integrated Mountain Development (ICIMOD); United Nations Development Programme (UNDP)
 Publisher Place: Kathmandu, Nepal

Keywords: Potentially dangerous glacial lakes, PDGL, glacial lakes, global warming



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Regional Database System

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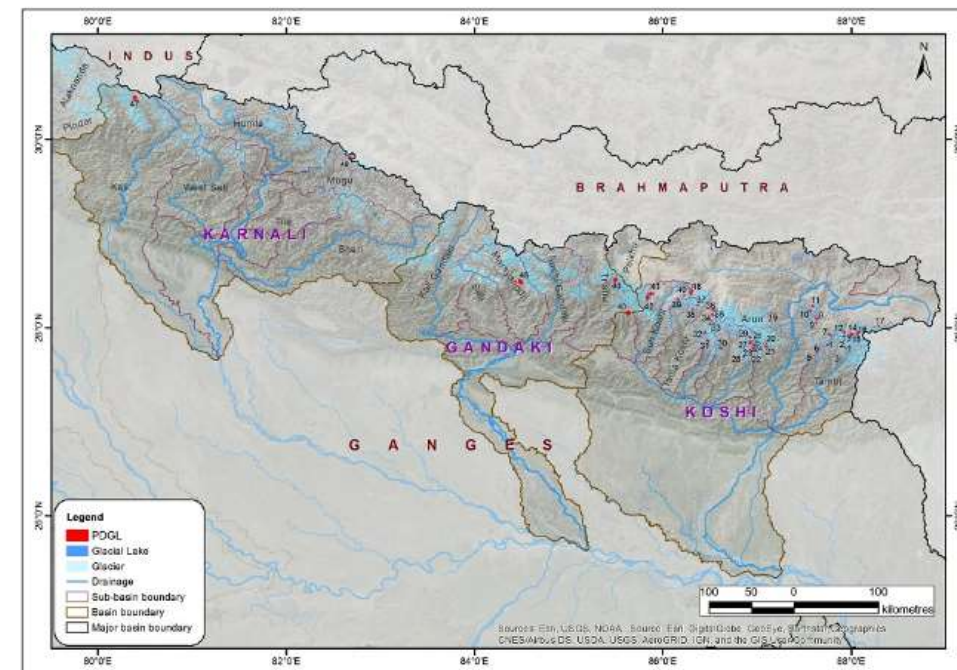
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Potentially dangerous glacial lakes in the Koshi, Gandaki, and Karnali river basins of Nepal, the Tibet Autonomous Region of China, and India

UPDATED DATE: 9/16/2020 1:46:17 PM

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The potentially dangerous glacial lakes were identified on the basis of the glacial lake inventory dataset using Landsat imagery from 2015. The following criteria were used for classifying the lakes: I) lake characteristics, II) dam characteristics, III) source/associate glacier characteristics, and IV) physical conditions of surroundings. Various parameters required for classifying such lakes were generated by using 5 m ALOS DEM for Nepal and 12.5 m ALOS DEM for China and India. Data include detailed analyses of land features and conditions using high-resolution images with 3D visualization on Google Earth. The dataset provides the size, type, and altitudinal distribution of such lakes, including the hazard rank of each lake. This dataset was prepared to support the Green Climate Fund project proposal formulated by UNDP Nepal.





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THANKS