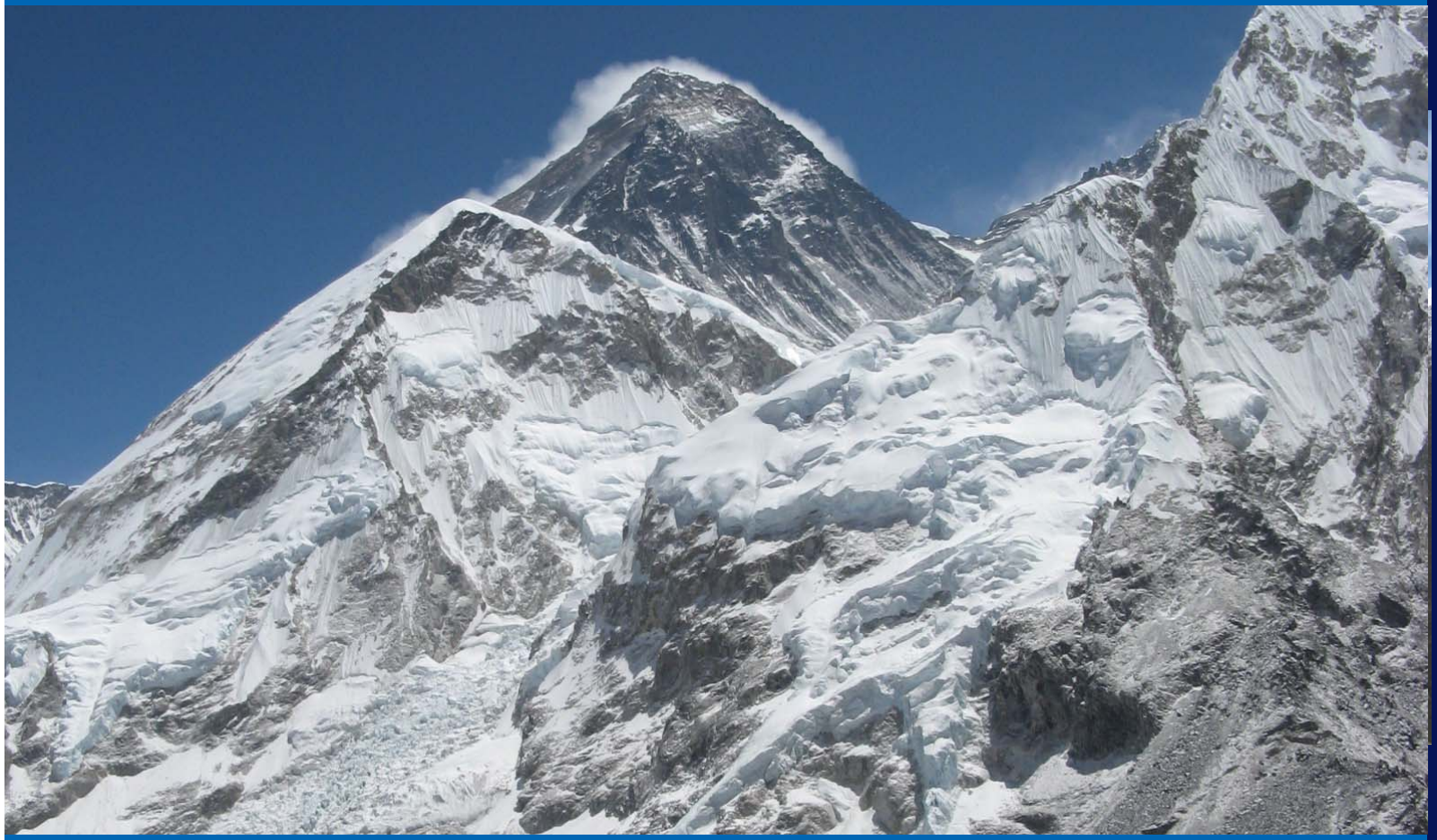
Implications of the Ice Melt: A Global Overview

Hindu Kush – Himalayas



Our Ice Dependent World

The 6th Open Assembly of the Northern Research Forum
Hótel Örk, Hveragerdi, Iceland
3rd - 6th September 2011

Pradeep Mool
International Centre for Integrated Mountain Development

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International Centre for Integrated Mountain Development

ICIMOD - an intergovernmental organisation with 8 member countries

A mountain learning and knowledge centre bridging research and policy

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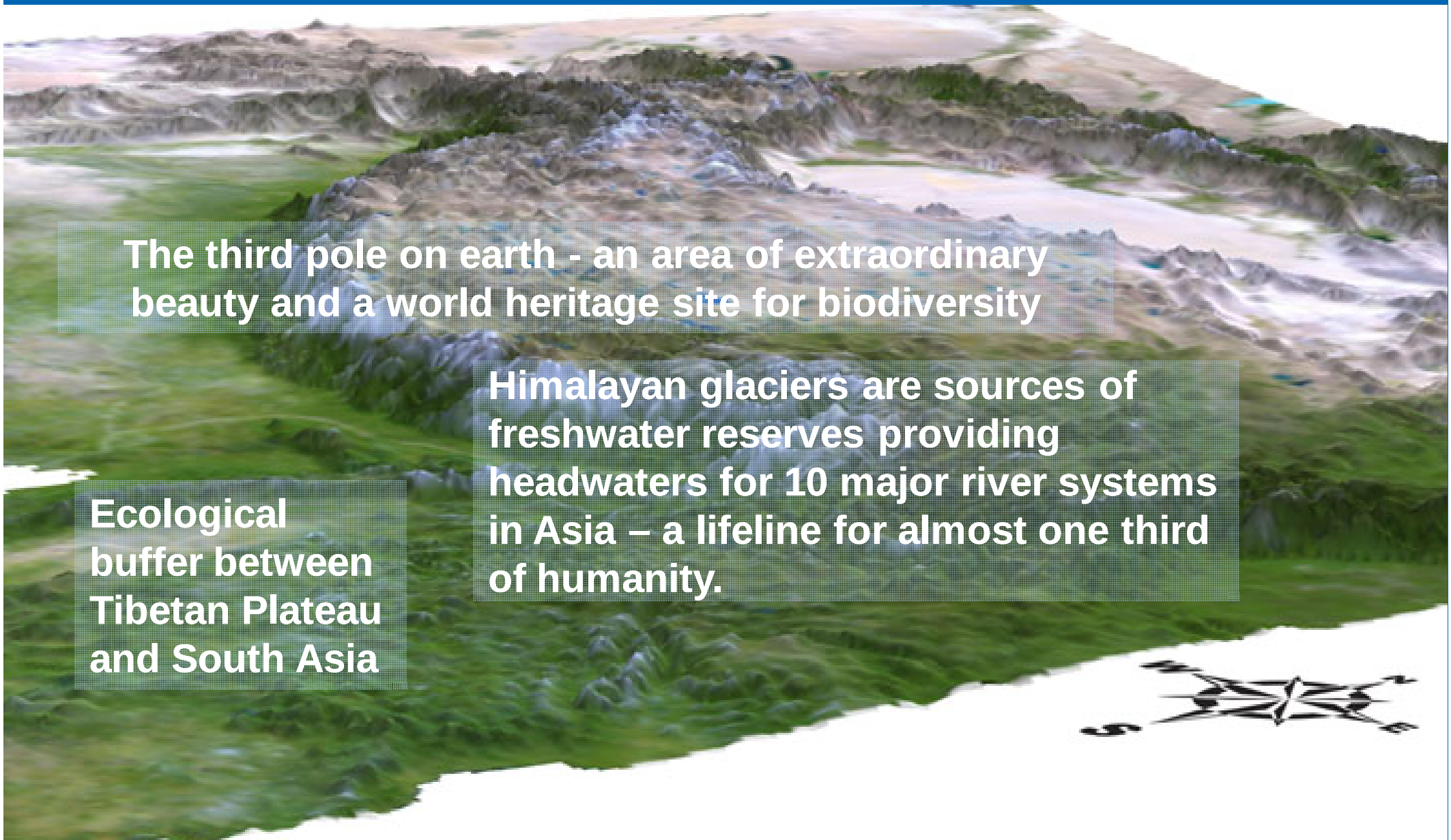
Vision: The mountain population of the greater Himalayas enjoys improved well-being in a sustainable global environment'

Mission: Enabling and facilitating equitable and sustainable well-being of the people of the greater Himalayas supporting sustainable mountain development and regional co-operation

The Hindu Kush – Himalayas



Changing Glacier Environment

"ISRO:75% of Himalayan glaciers retreating" (ToI, 16 May 2011)

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Fast retreating Gangapurna glacier at the northern slope of Annapurna Range, Manang Lake and Manang Village, Nepal

Data gap in the HKH region

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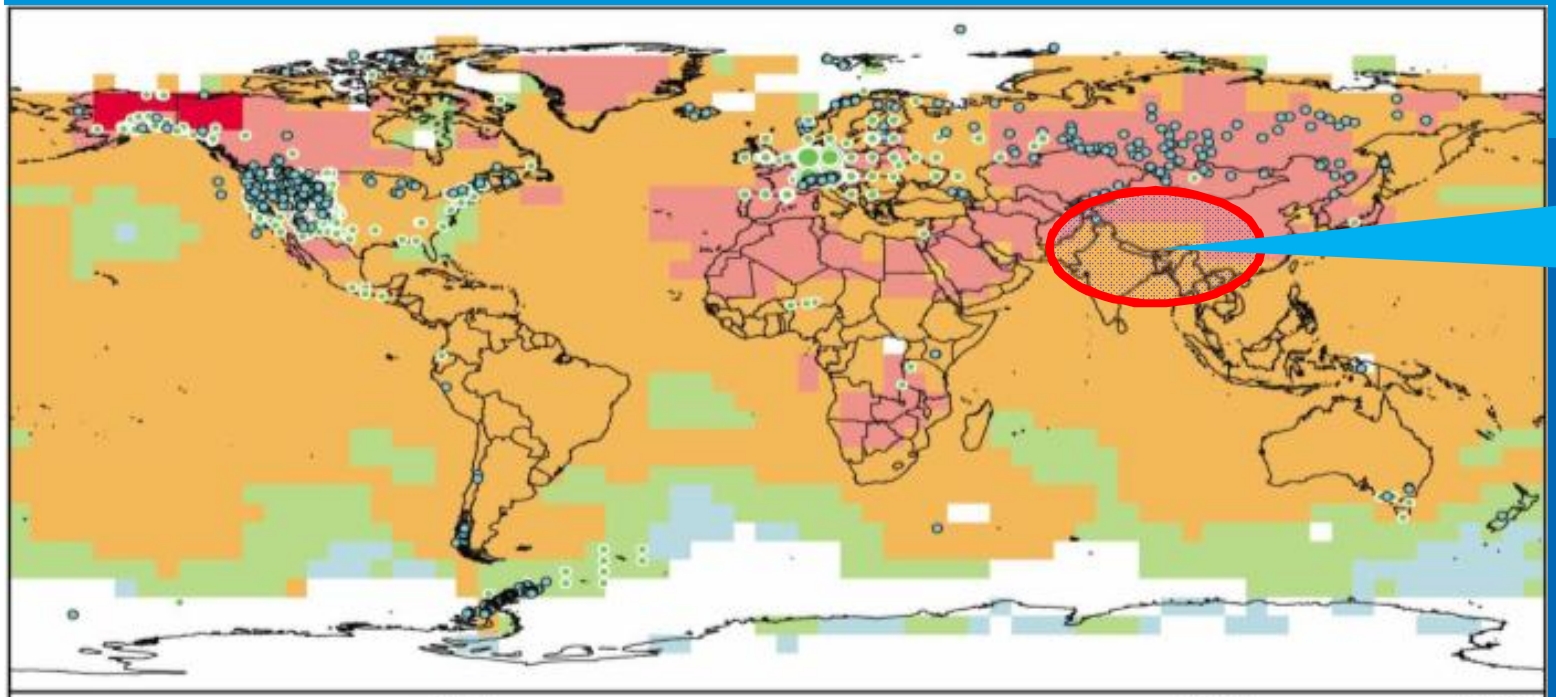
Himalayas: A blank spot in IPCC AR4



NAM		LA		EUR (28,115)		AFR		AS		ANZ		PR*		TER (28,586)		MFW**		GLO (28,671)	
355	455	53	5	119		5	2	106	8	6	0	120	24	764		1	85	765	
94%	92%	98%	100%	94%	89%	100%	100%	96%	100%	100%	–	91%	100%	94%	90%	100%	99%	94%	90%

Observations

- Physical systems (snow, ice and frozen ground; hydrology; coastal processes)
- Biological systems (terrestrial, marine, and freshwater)

Europe ***
1-30
31-100
101-800
801-1200
1201 -7500

Temperature change °C
1970-2004

-1.0 -0.2 0.2 1.0 2.0 3.5

Physical	Biological
Number of significant observed changes	Number of significant observed changes
Percentage of significant changes consistent with warming	Percentage of significant changes consistent with warming

* Polar regions include also observed changes in marine and freshwater biological systems.
** Marine and freshwater includes observed changes at sites and large areas in oceans, small islands and continents.
*** Circles in Europe represent 1 to 7,500 data series.

Glacier No.1 Urumqi, Tien Shan, China
43°07' N 86°48’ E; 3800 - 4200 m asl
Longest recorded glacier mass balance monitoring in ICIMOD RMCs

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1962

1988

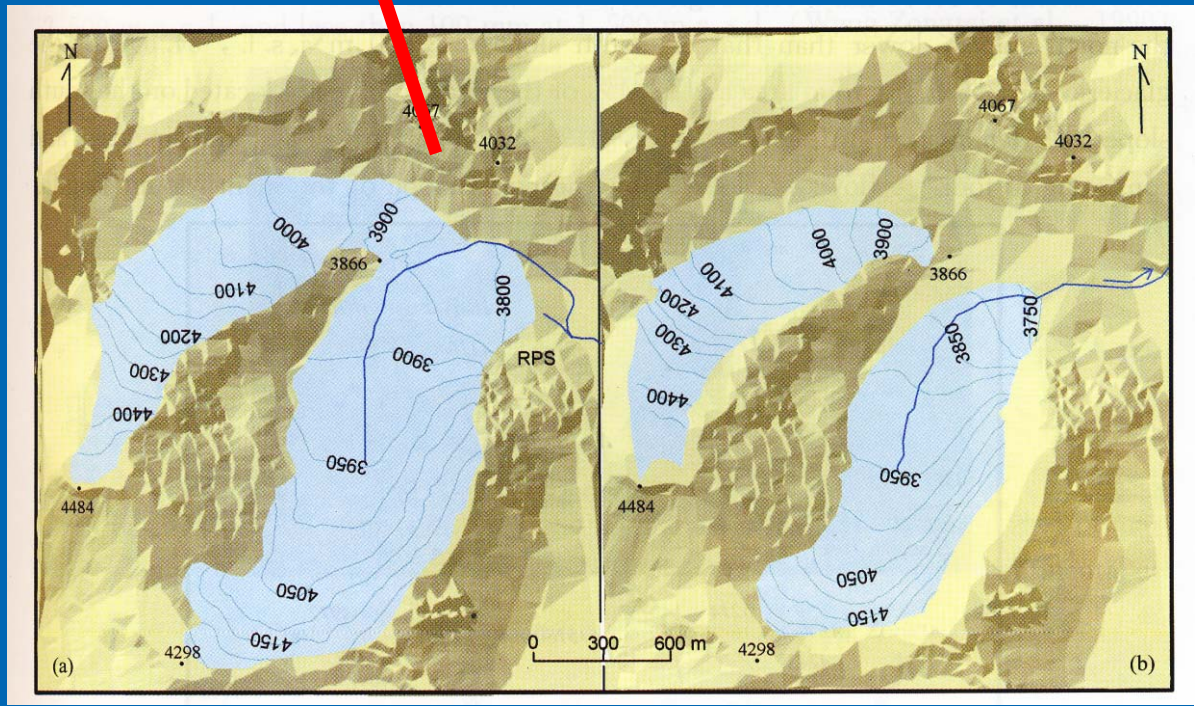
1993

1996

2001

2005

Morphological changes of Urumqi Glacier No. 1 in the years 1962, 1988, 1993,1996, 2001 and 2005. Source: Zhongqin et al., 2008



1962 1994

(a) Based on topographic map in 1962;
(b) Based on terrestrial phograpmmetry map in 1994 ;
Source: Shi Yafeng et.al. 2008 , Glaciers and related environments in China

Name	Lat (N)	Long (E)	Elevation (m)		Length (km)	Area (km sq)	Monitoring Dates	Institute	Observations
Glacier No.1	43.083	86.817	3800	4200	2	1.68	1959-1967; 1980-	CAREERI	mass balance, climate, hydrology, velocity

Glacier Mass Balance Study Areas in HKH (India, China and Nepal)

Fragmented, uncoordinated and generally very short term measurement series

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Glacier	z-max [m a.s.l.]	Area [km^2]	Record years (#)
Changmekhan (India)	5300	4.5	1981 – 1986 (**6**)
Dunagiri (India)	5150	2.56	1986 – 1990 (**5**)
Shaune Garang (India)	5360	4.94	1982 – 1990 (**9**)
Gor Garang (India)		2	**1977** – 1984 (**8**)
Tipra Bank (India)	5730	7	1986 – 1988 (**3**)
Neh Nar (India)	4925	1.7	**1980** – 1984 (**5**)
Kolahoi (India)	5000	11.9	1984 (**1**)
Shishram (India)	4900	9.9	1984 (**1**)
Dokriani Glacier (India)		7	1993 – **2000** (**6**)
Chhota Shigri (India)	6263	15.7	2003 – **2006** (**4**)
Langtang (Nepal)	7000	74.8	1987 – 1997 (**11**)
Rika Samba (Nepal)		1	1999 (**1**)
AX010 (Nepal)	5360	0.568	1996 – 1999 (**4**)
Meikuang (China)	5520	1.1	1989 – 1998 (**9**)
Chongce i.c. (China)	6374	16.4	1987 (**1**)
Xiaodongkemadi (China)	5926	1,767	1989 – 1998 (**10**)

Dyurgerov & Meier (2005) - INSTAAR 58; Wagnon et al. (2007) - J.Glac. 53(183)

Under-representation of meteorological observation in the High Himalayas

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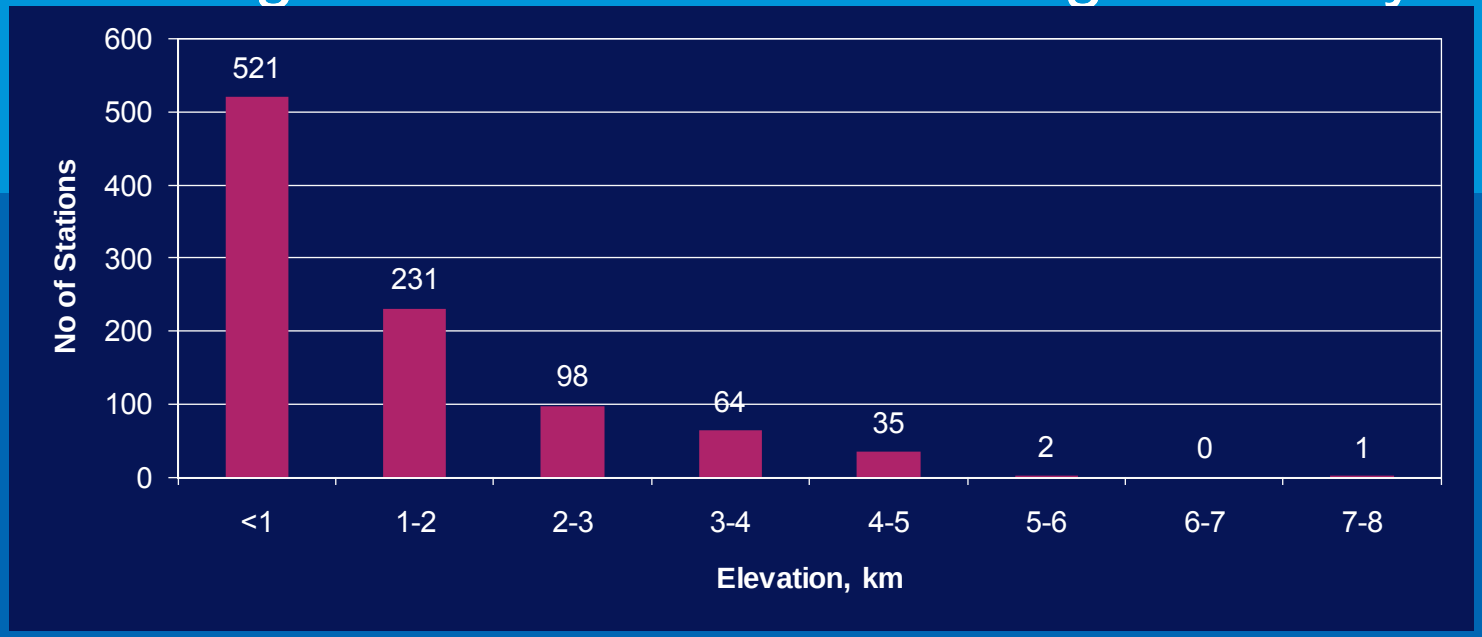

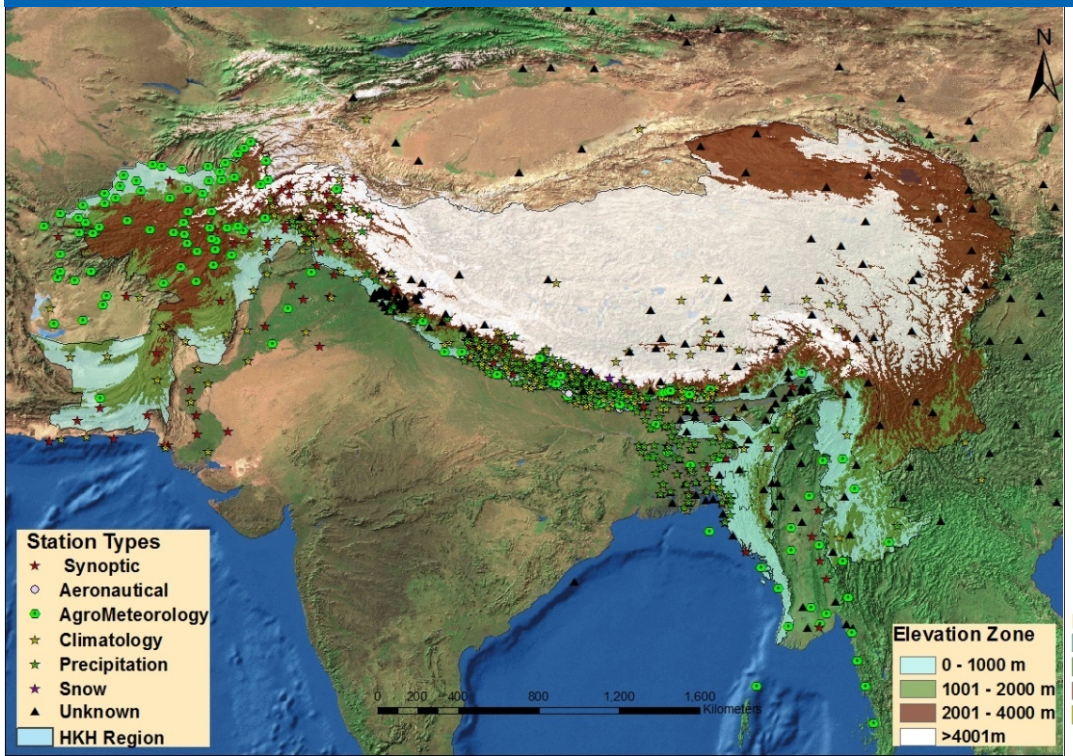

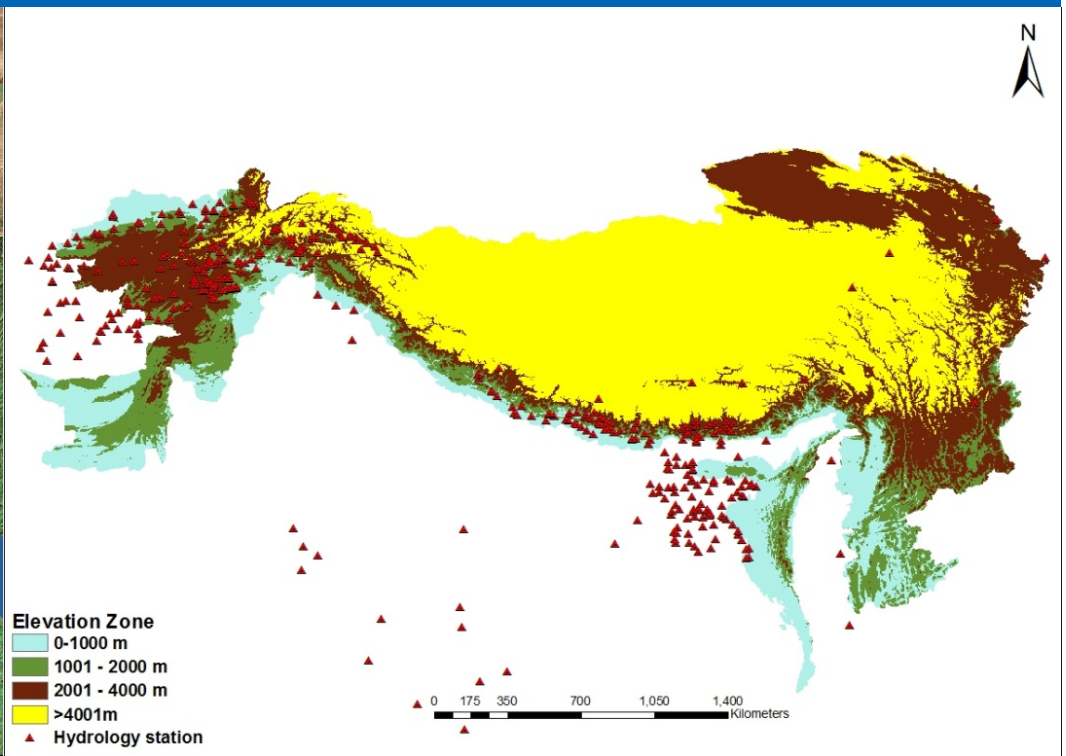

Glacier monitoring in Nepal Himalayas

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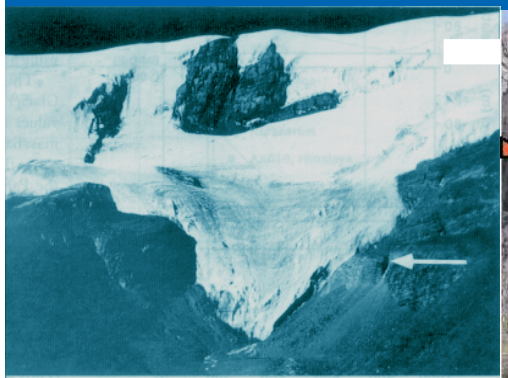
S No.	Glacier Name	Latitude (N)	Longitude (E)	Elevations (masl)		Area (km sq)	monitoring times	Institute	Station name/ Observation
1	Rika Samba, Hidden Valley, Dhaulagiri	28°49'60.00"N	83°29'60.00"E	5250	5985	4.8	1999	GEN / DHM	mass balance
2	AX010, Dudh Kosi region of Shorong Himal	27°42'0.01"N	86°33'59.99"E	4950	5360	0.57	1996 – 1999	GEN / DHM	mass balance
3	Mera	27°43'23.17"N	86°52'52.13"E	5387	6472	4.6	2007-	DHM, Nepal / IRD, France	mass balance; climate; hydrology;
4	Yala, Langtang	28°14'60.00"N	85°36'60.00"E	5574	5746	2.57	2009-	CDHM/TU and ITP	mass balance; climate;

Rika Samba



AX010

Yala

Mera

Cryosphere Monitoring Programme

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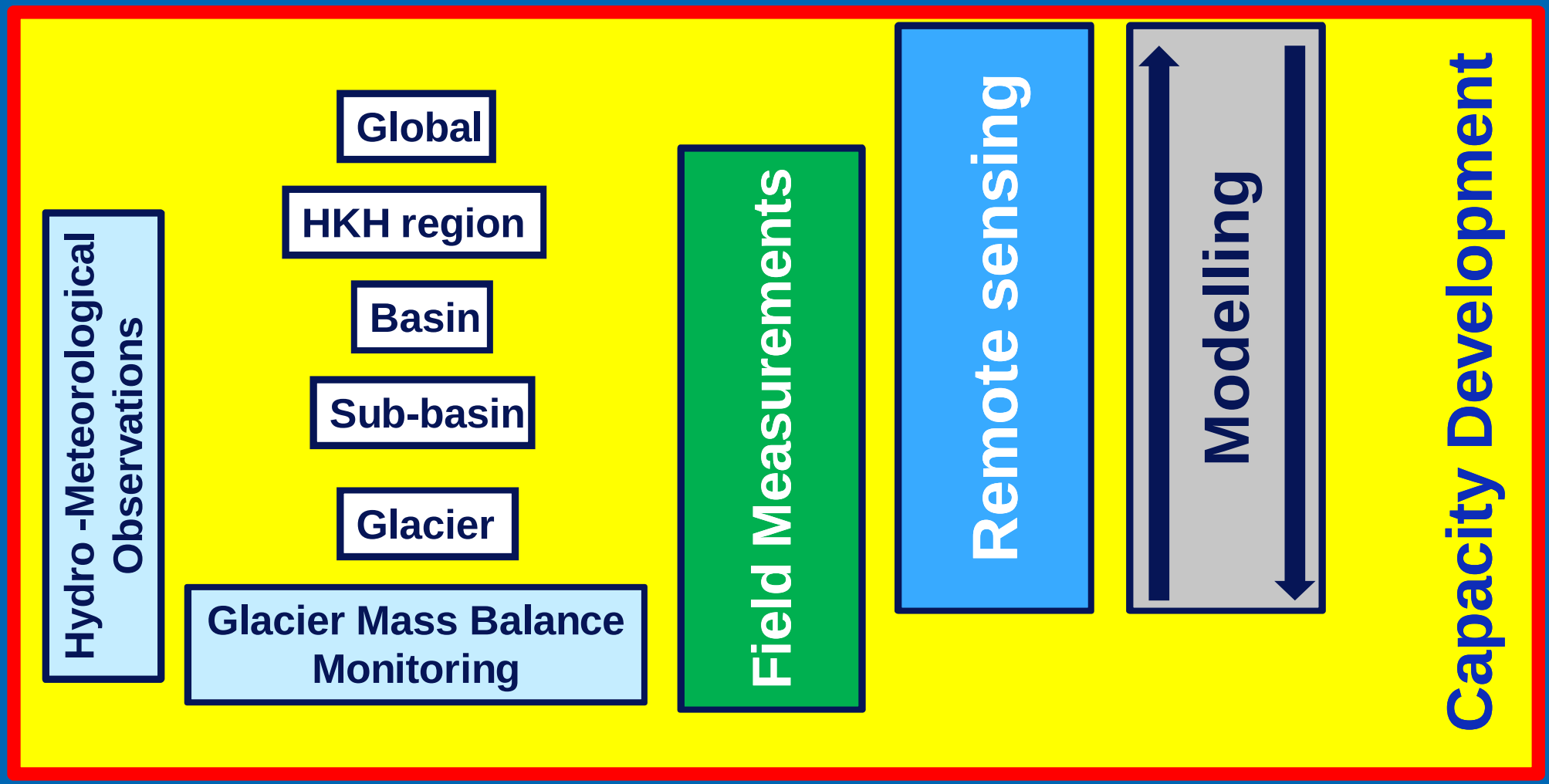

Regional Cryosphere Knowledge Hub

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Regional Focus

- **Regional Cryosphere Knowledge Hub** for storage, analysis, sharing and disseminating knowledge for relevant operational services and research in the HKH region and internationally
- Regional snow and glacier mapping using remote sensing data
- Regular field based glacier and glacio- hydrological monitoring
- Global, Regional and National linkages: WGMS/Zurich, NSIDC/Colorado, TPE/China, CAREERI/China, CoG/India, GCISC/Pakistan, HiCCDRC/Nepal

Melting of Glaciers in Himalaya and formation of glacial lakes

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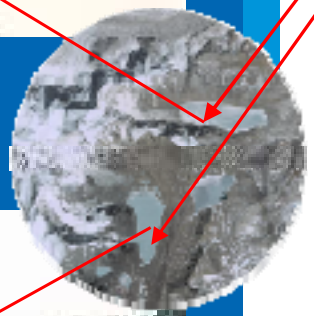
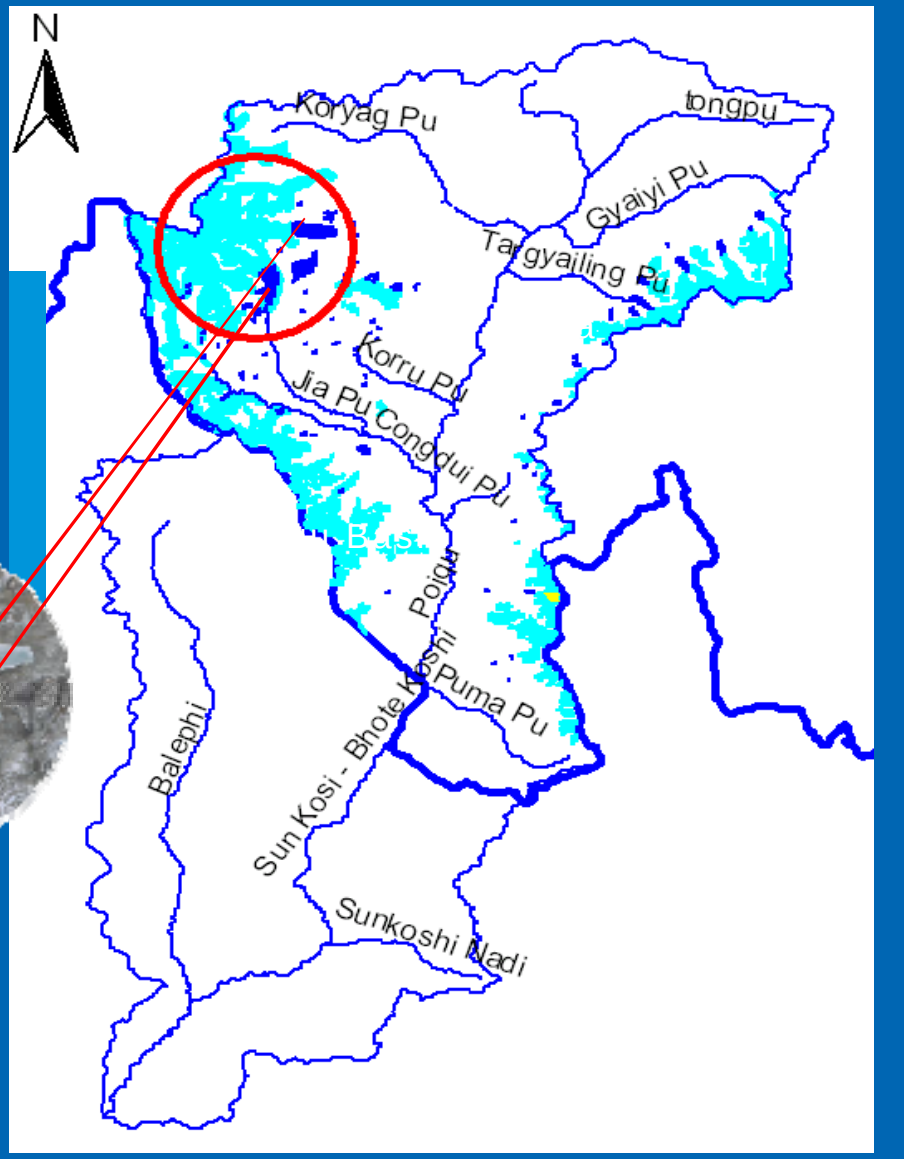
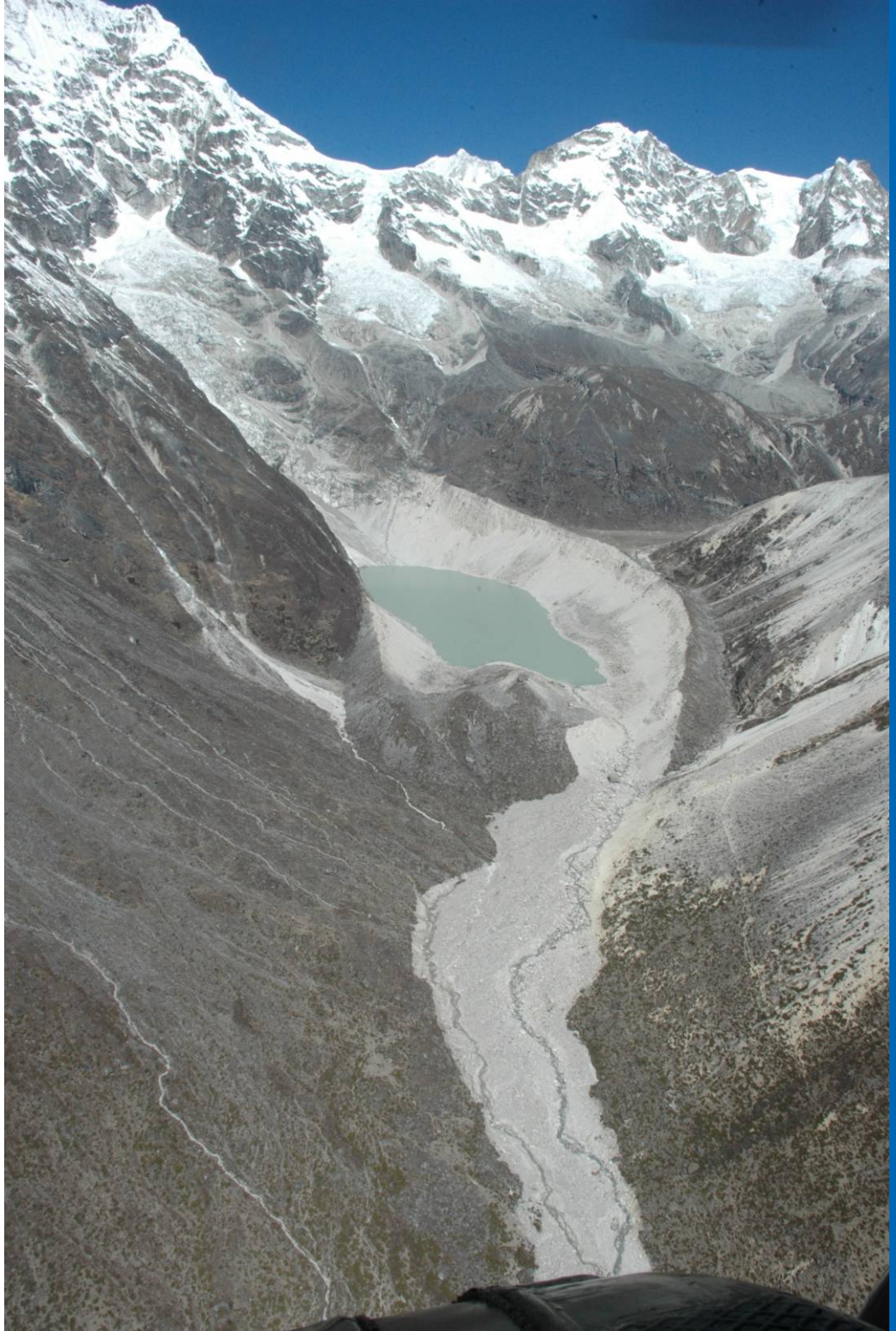
Gangxi Co lake at the tongue of Glacier 50191C0009 in 1987

Lumu Chimi lake at the tongue of Glacier 50191B0029 in 1987







Glacial Lake Outburst Floods (GLOFs)

- Impact of climate change is well observed in the Himalaya
- Several studies show that most of glaciers in Himalaya are shrinking at accelerated rates in recent decades
- Glacial lakes formed by rapid retreat of glaciers
- Water volume increase in these lakes from the glacier melt
- Lakes retained by unconsolidated moraine dams and ice core
- Moraine failure due to piping and overtopping
- Triggered by many factors
- Damaging impact downstream
- Common in Nepal, Tibet/China, Bhutan and other parts of HKH

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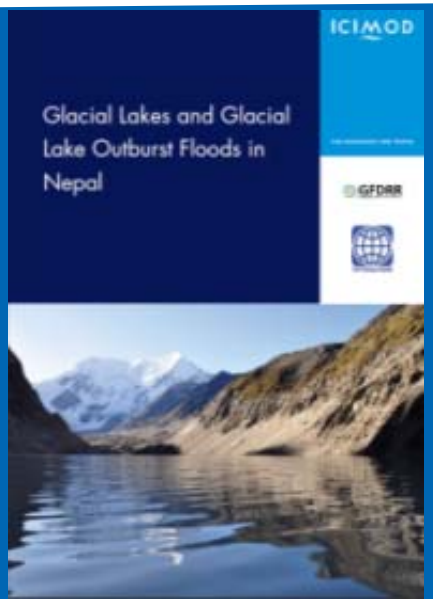
Comprehensive report on glacial lakes and GLOF of the HKH region

http://books.icimod.org/demo/index.php/downloads/pd/692

Ives, JD; Shrestha, RB; Mool, PK (2010) *Formation of glacial lakes in the Hindu Kush-Himalayas and GLOF risk assessment.* Kathmandu: ICIMOD



Comprehensive report on glacial lakes and GLOF of Nepal

http://www.icimod.org/publications/index.php/search/publication/750
http://www.icimod.org/dvds/201104_GLOF/

ICIMOD (2011) *Glacial lakes and glacial lake outburst floods in Nepal. Kathmandu: ICIMOD*

Glacial lake mapping of five river basins of HKH region

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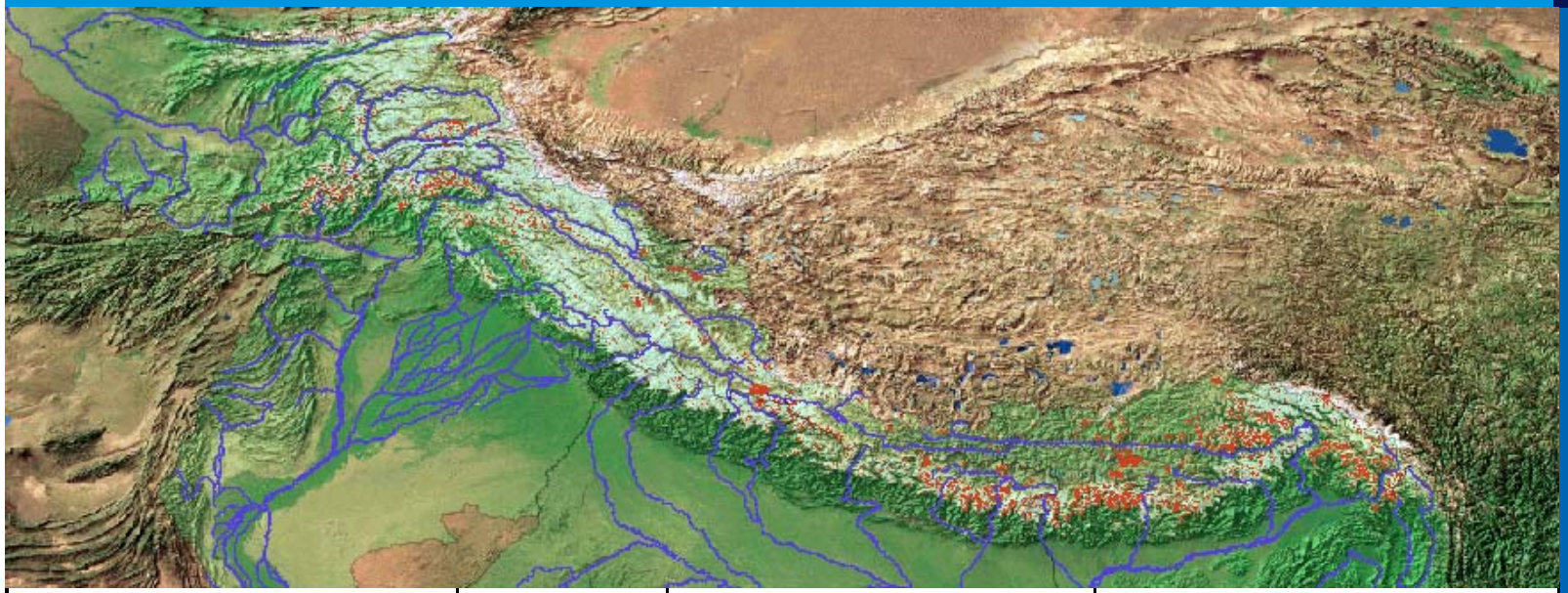

Basin Name	Basin Code	Lake Number and Percent		Lake Area (sq km) and percent	
		No	%	Area	%
Amu Darya	Am	1521	7.4	129.35	3
Brahmaputra	Br	10097	49.3	2367.48	54.8
Ganges	Ga	3840	18.7	598.05	13.8
Indus	In	4889	23.9	1217.64	28.2
Irrawaddy	Ir	138	0.7	7.86	0.2
Total		**20485**	**100**	**4320.39**	**100**

Growth of Lakes (Tsho Rolpa, Imja &Thulagi)

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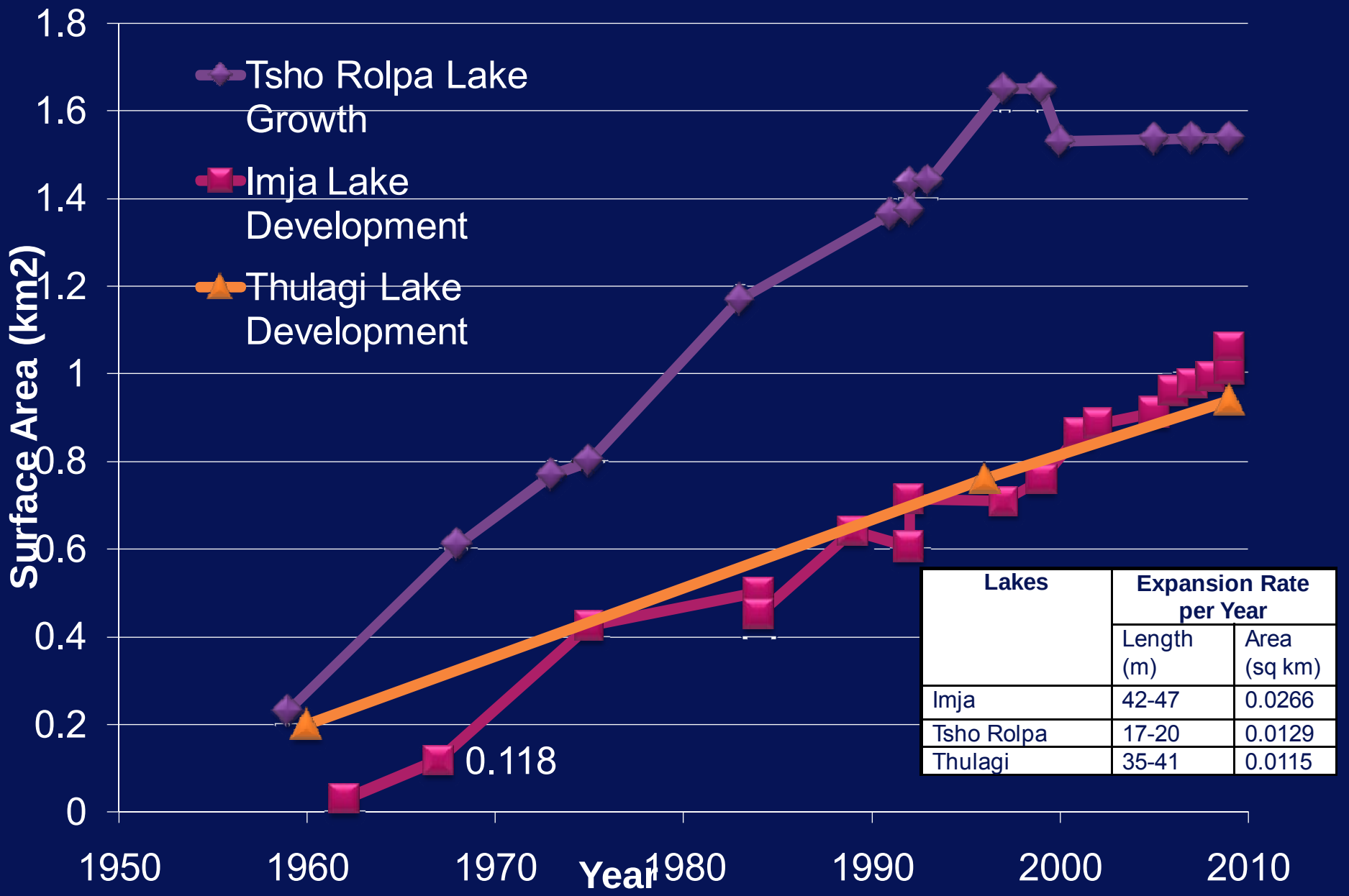

Lakes	Expansion Rate per Year	
	Length (m)	Area (sq km)
Imja	42-47	0.0266
Tsho Rolpa	17-20	0.0129
Thulagi	35-41	0.0115

Past GLOF events in the HKH region

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About 56 past GLOF events in the HKH Region (Bhutan - 4, China - 29, Nepal - 14, Pakistan - 9) recorded with about 10 of them of trans-boundary nature.

GLOF events from Tibet/China affecting also inside Nepal in downstream area

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	Date	River basin	Lake	Source	Cause of GLOF	Losses	Latitude	Longitude
15	Aug-35	Sun Koshi	Tara-Cho	Tibet (China)	Piping	66,700 m^2 of wheat field, livestock etc	28° 17′ 00″	86° 08' 00″
16	21-Sep-64	Arun	Gelhaipco	Tibet (China)	Glacier surge	Highway and 12 trucks	27° 58' 00″	87° 49' 00″
17	1964	Sun Koshi	Zhangzangbo	Tibet (China)	Piping	No remarkable damage	28° 04' 01″	86° 03' 45″
18	25-Aug-64	Trisuli	Longda	Tibet (China)	Not known	Not known	28° 37′ 01″	85° 20′ 58″
19	1968	Arun	Ayaco	Tibet (China)	Not known	Road, bridges etc	28° 21′ 00″	86° 29' 00″
20	1969	Arun	Ayaco	Tibet (China)	Not known	Not known	28° 21′ 00″	86° 29' 00″
21	1970	Arun	Ayaco	Tibet (China)	Not known	Not known	28° 21' 00″	86° 29' 00″
22	11-Jul-81	Sun Koshi	Zhangzangbo	Tibet (China)	Glacier surge	Hydropower station	28° 04' 01″	86° 03' 45″
23	27-Aug-82	Arun	Jinco	Tibet (China)	Glacier surge	Livestock, farmland	28° 00' 35″	87° 09' 39″
24	6-Jun-95	Trisuli	Zanaco				28° 39′ 44″	85° 22′ 19″

GLOF Risk Management

- Institutional Development
  - Institutional establishment
  - Strengthining & development
- Regulation & Enforcement
  - Acts & Regulations Review Committee
  - Review & update Acts & Regulations
  - Amendments
- Trans-boundary GLOF issues
  - Mechanism of information sharing
  - To carry out bi-lateral meetings
  - Promote & conduct trans-boundary collaboration
- Emergency Preparedness & Response
  - Response plans at river sub-basins of PDLs
  - Formulation of ERT
  - DDC Level preparedness plans
  - Loss assessment & rehabilitation
- Public Awareness & Education
  - Annual status report on GLOF hazard
  - Development of Awareness Generation material
  - GLOF Hazard Awareness campaign
  - Information dissemination on GLOF
  - Exercise & rehearsal of emergency plans
  - Mobilize NGOs & Volunteer Groups
  - Develop District to Community level preparedness plans
- GLOF Hazard, Vulnerability & Risk Assessment
  - Mapping of Glacial Lake
  - Potential Dangerous Lake
  - Field Investigation
- GLOF Risk Mitigation
  - Mitigation Measure Identification
  - Design and planning of Mitigation measures
  - Implementation of Mitigation measures
- Research & Development
  - Monitoring
  - Early Warning
- Capacity Building & Training
  - GLOF education in school/colleges
  - Knowledge products developments
  - Training of Professionals
  - Curriculum development & inclusion

Thank you

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