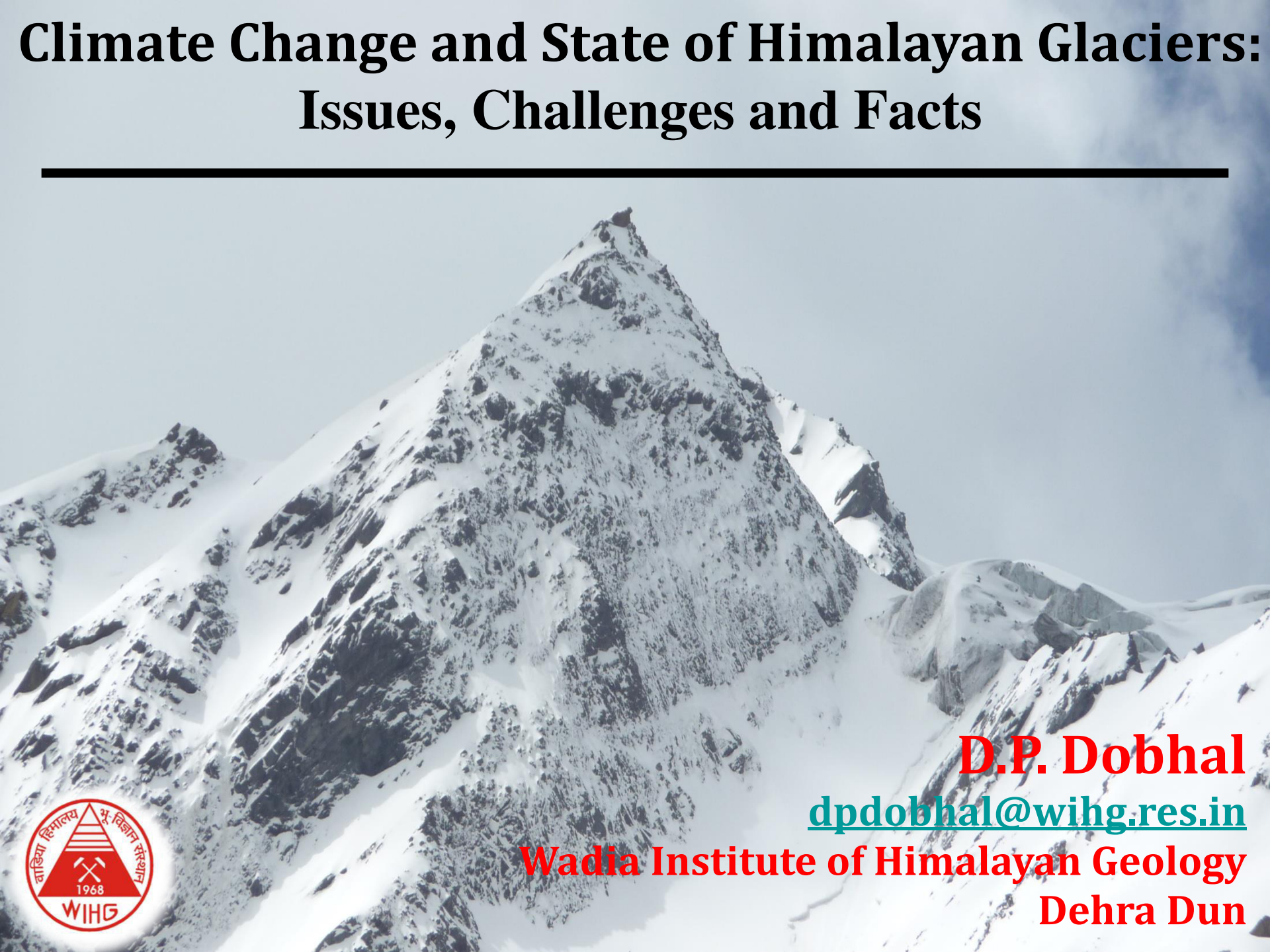
Climate Change and State of Himalayan Glaciers: Issues, Challenges and Facts



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Dehra Dun

Major Issues

- Are the Himalayan glaciers receding rapidly?
  - What are the main controlling factors
- Is the recession more to global warming or due to the inadequate precipitation?
- What is the relationship between mass balance and frontal fluctuation?
  - What are the main influencing agents
- Is it possible to decipher influence of each factor?

- Are Himalayan glaciers affected by naturally occurring cause of ‘Climate Change’ or present recession trends are transient expressions of long term cyclic variation?

- Can relationship between Glacier mass and climate change be used to understand mechanism of glacier recession?

- What methodology is best suited to assess the recession of Himalayan glaciers?

Challenges

Himalaya is experiencing rapid recession of glaciers like all glaciated regions of the world

- **What should we expect from glacier changes?**
- **What will be the consequences?**
- **What will we need to adapt ?**

GLACIERS RETREAT - FACTS

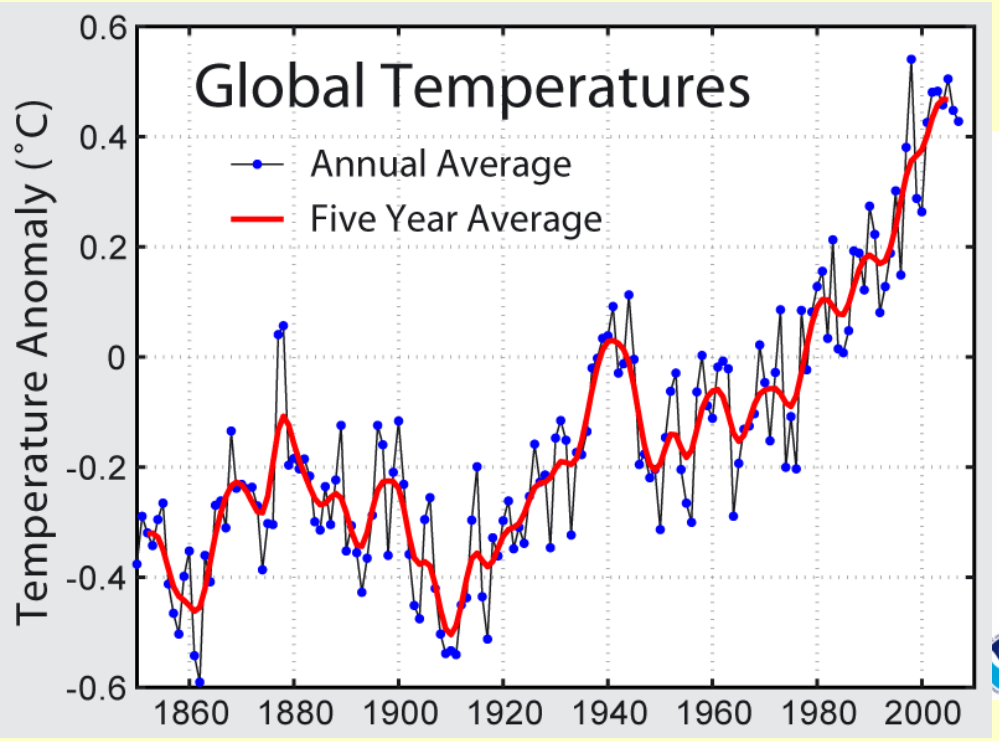
- **Glacier retreat is a natural phenomenon / real**
- **Glaciers have been retreating worldwide**
- **Accelerated retreat reported after 1980**
- **Sensitive to climate, and to be considered an indicator of climate change**

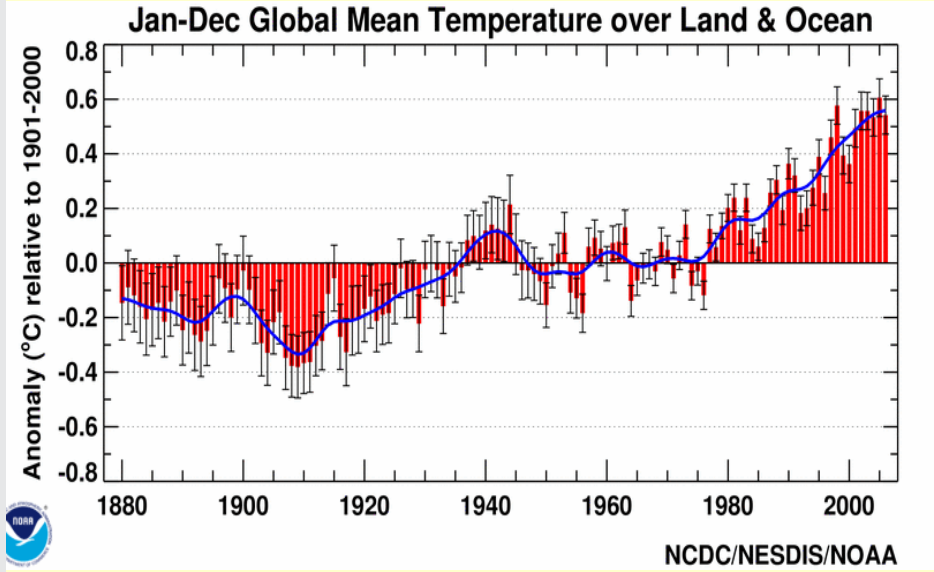
Climate is a natural phenomenon:

Major causes:

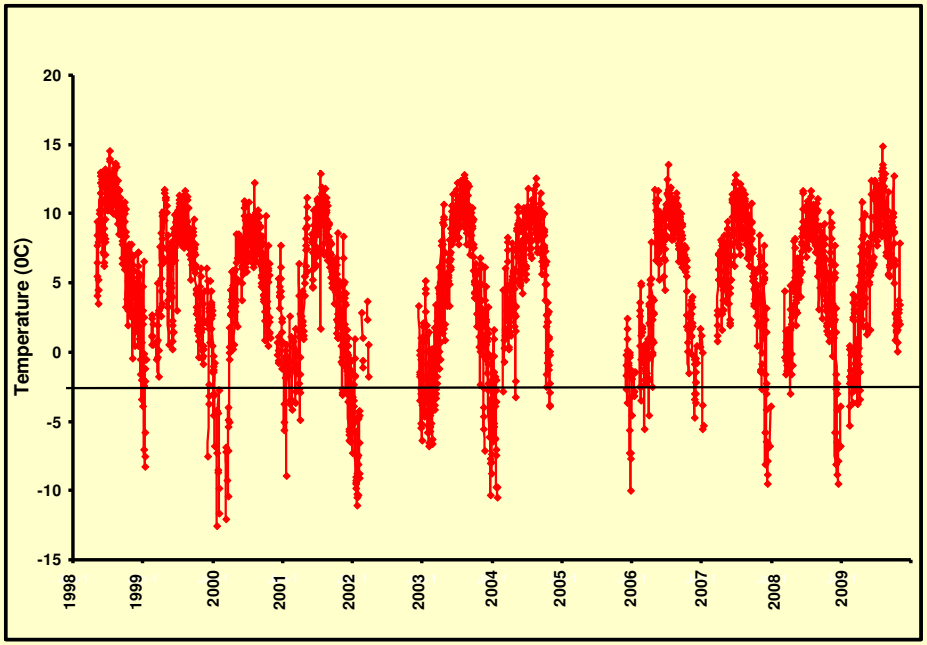
- Solar forcing
- Orbital forcing
- Radiative forcing
- Greenhouse gases, aerosols, dust (Global warming)

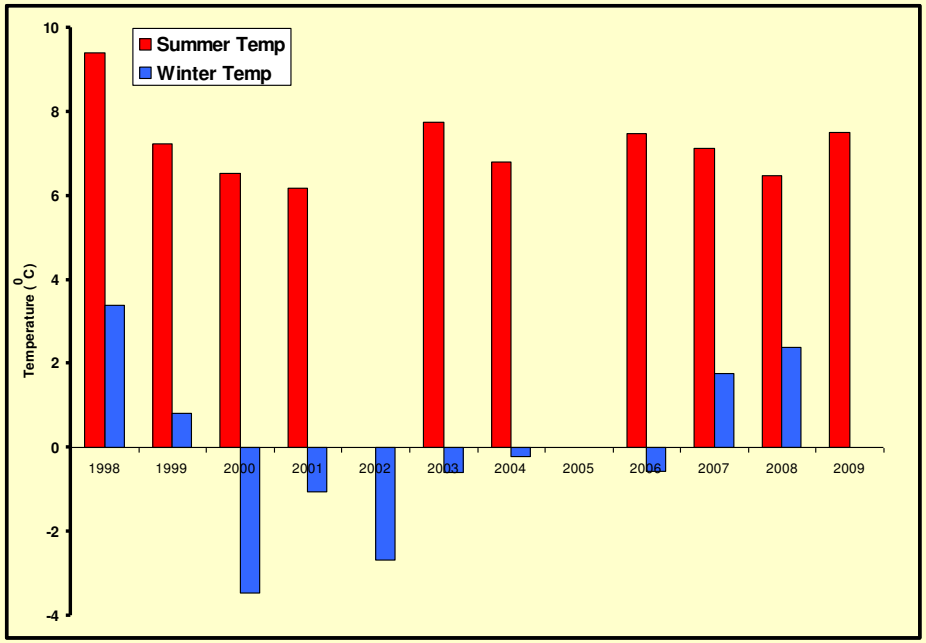
Rapid Change in Global Average Temperature

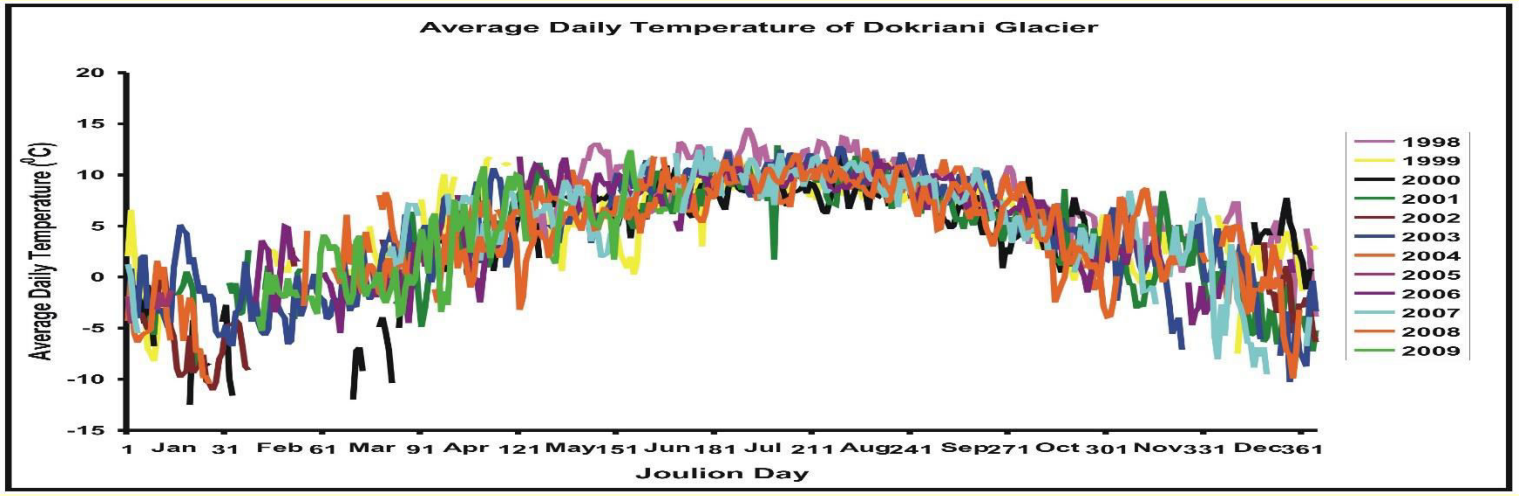




Daily Mean Temperature of Dokriani Glacier (1998-2009)







Temperature scenario in High altitude region : Dokriani Glacier (3900m asl)

World Glaciers Distribution

13.9%

McKinley

North America

0.51%

Whitney

0.062%

Europe

Blanc

Elbrus

Asia

Middle East

0.77%

Everest

Africa

South America

Kilimanjaro

0.37%

Jaya

Australia/ Oceania

0.15%

Aconcagua

Cook

10% of earth landmass

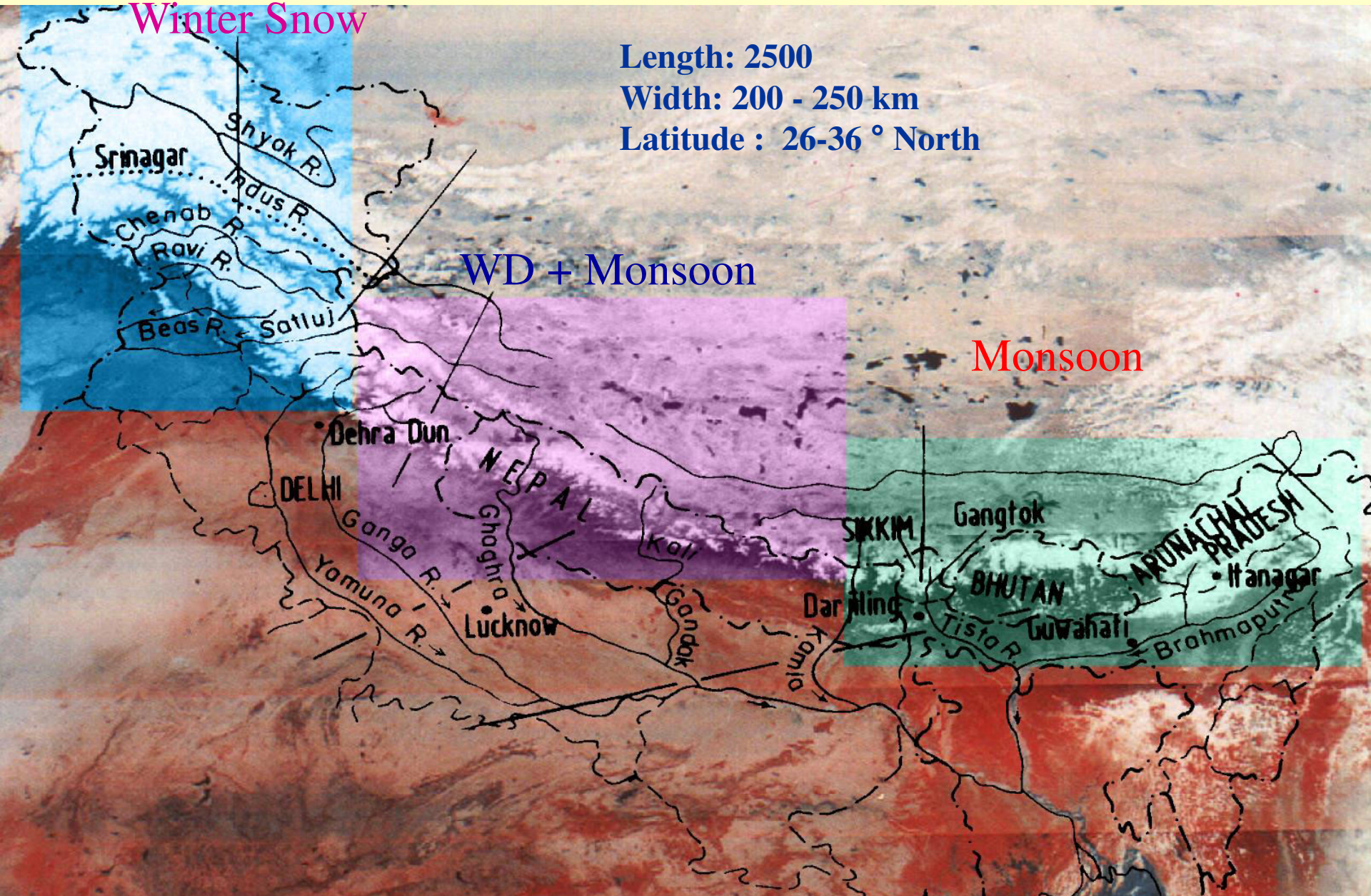
84.16%

Antarctica

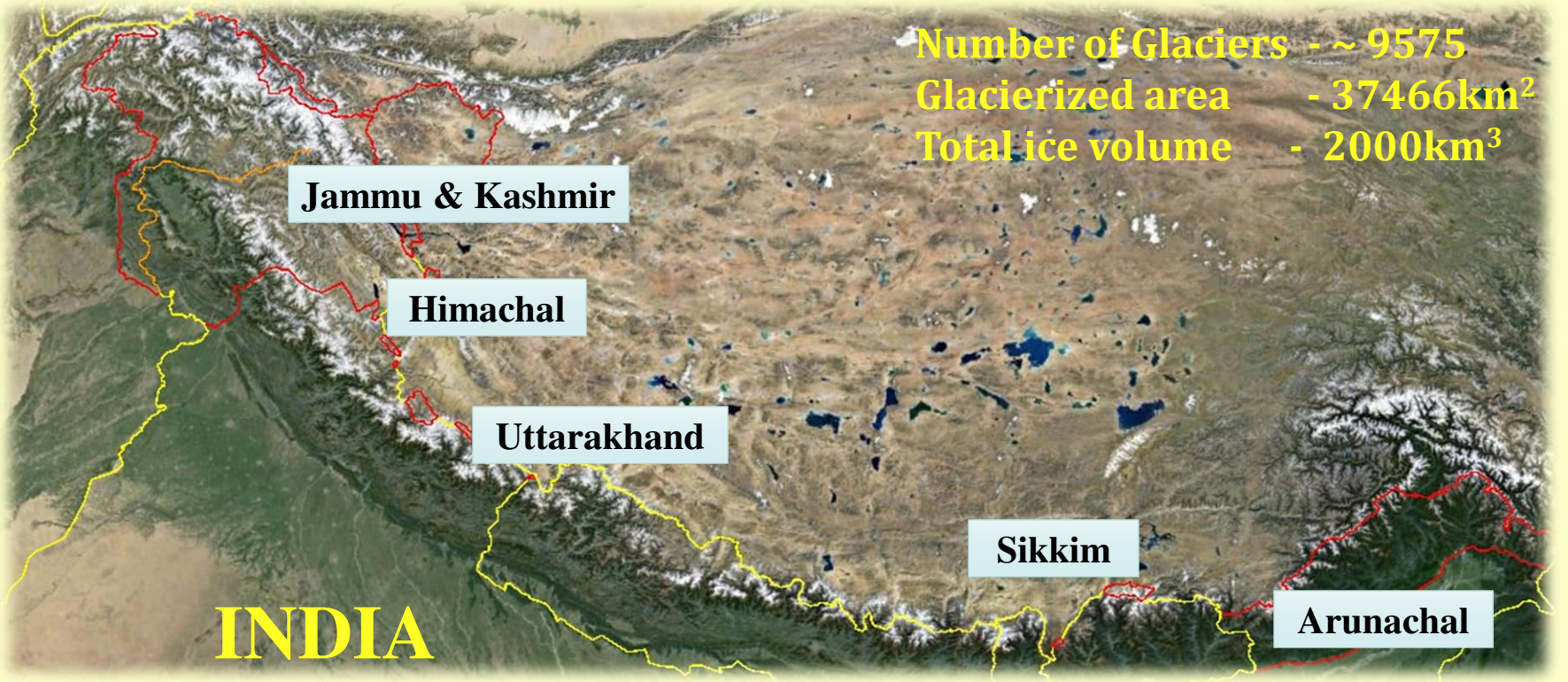
Vinson

Climate zone of the Himalaya

(Moisture sources for glacier development)



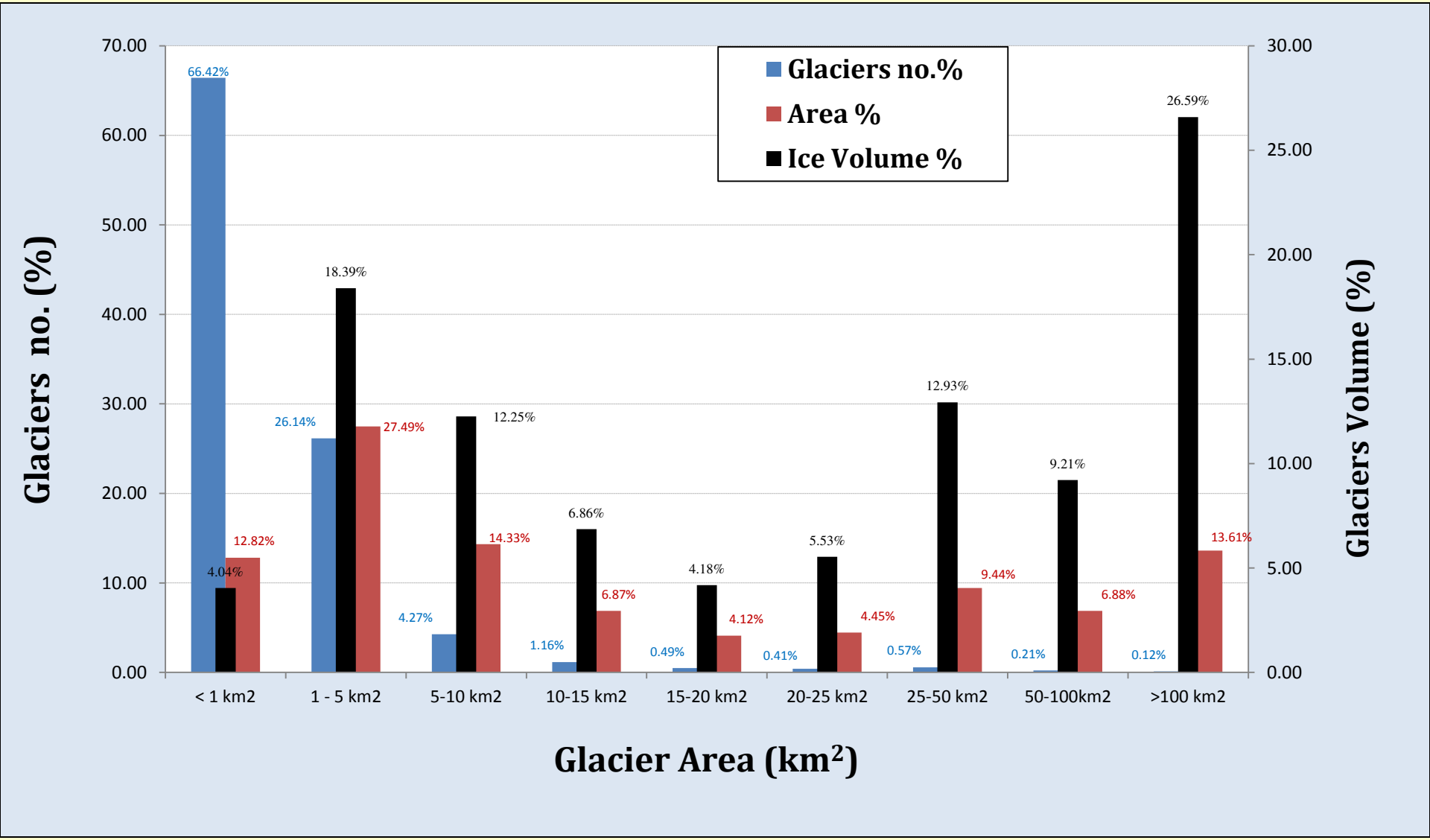
Indian Himalayan Glacier System



State	Glaciers	Area (Km²)	Average Size (Km²)	Glacier (%)
Jammu & Kashmir	5262	29163	10. 24	61.8
Himachal Pradesh	2735	4516	3.35	8.1
Uttarakhand	968	2857	3. 87	18.1
Sikkim	449	706	1.50	8.7
Arunachal Pradesh	162	223	1.40	3.2

(Raina and Srivastava, 2008)

Glaciers number, Ice Volume and Area

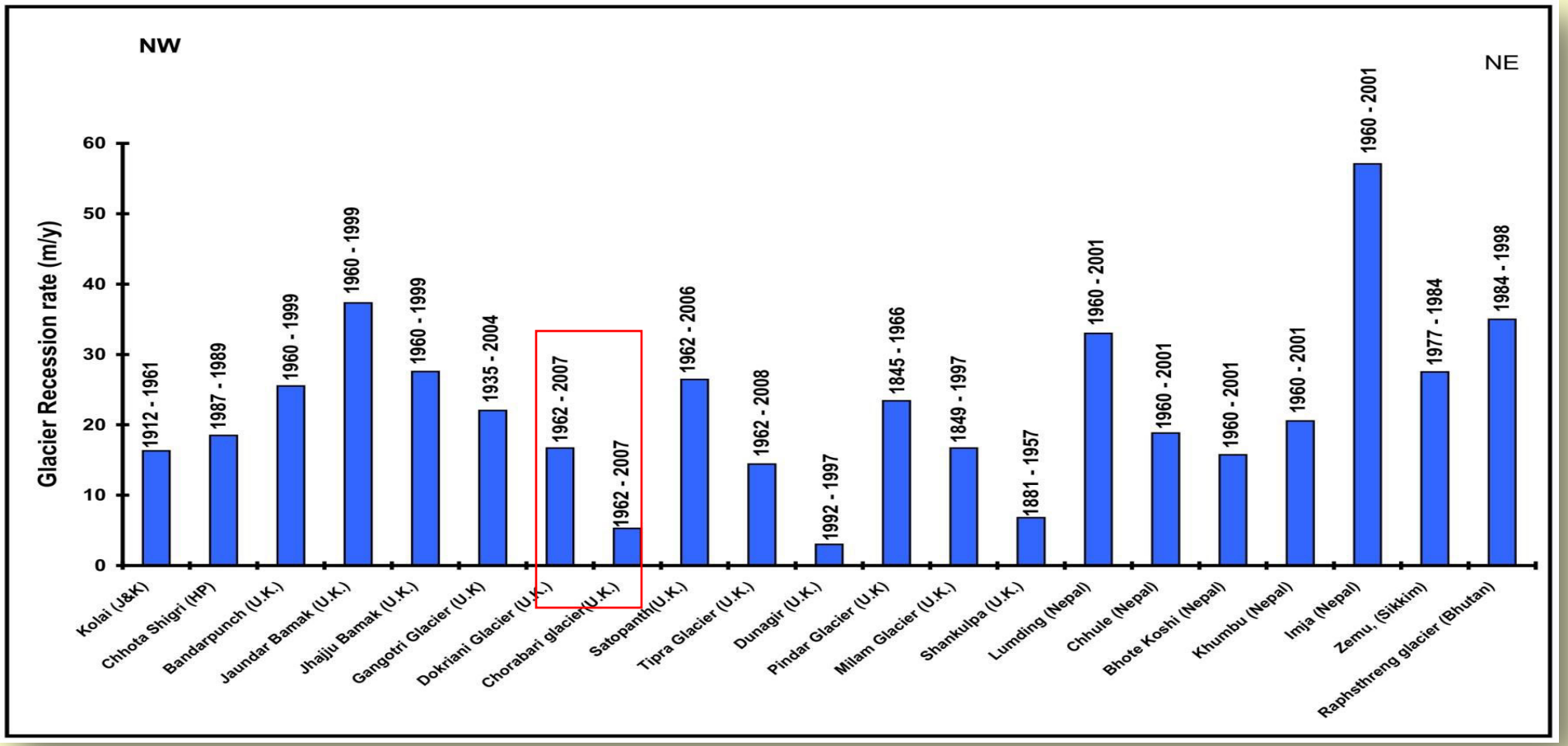


Source; Based on Glacier inventory, GSI,2009

Important Glaciers of the Himalaya

- Siachen : 72
- Biafo : 62
- Hispar : 61
- Baltoro : 58
- Batura : 58
- Rimo : 40
- Choglungma : 39
- Gashbrum : 39
- Gangotri : 30
- Zemu : 26
- Milam : 19
- Kanchenjunga : 16
- Barashigri : 29
- Miyar : 27
- Chhota Shigri : 09
- Satopanth : 13
- Bhagirath Kharak : 17
- Dokriani : 5.5
- Chorabari : 6.0
- Dunagri : 6.0
- Pindari : 5.0
- Nanda Devi : 22

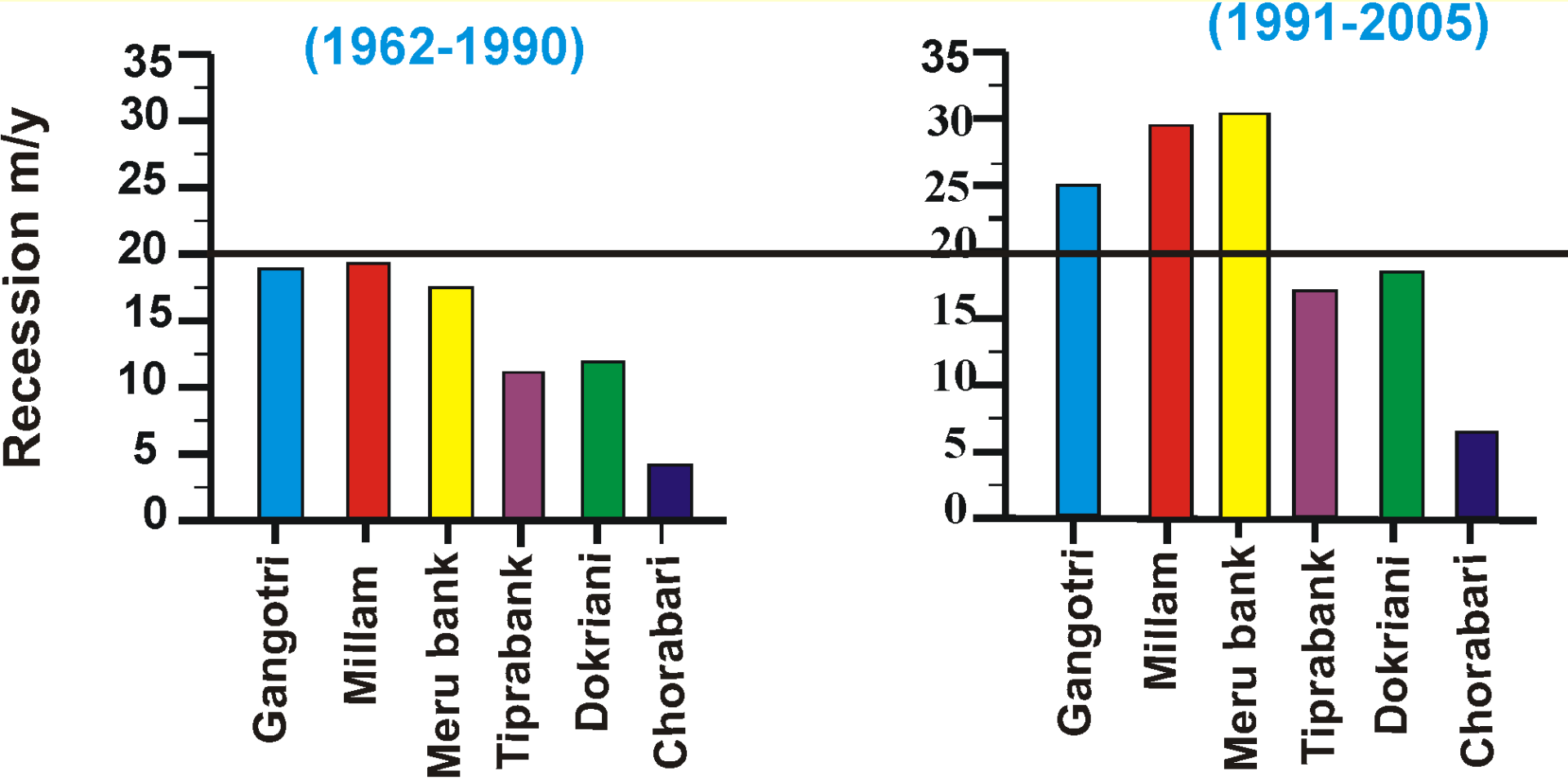
Recession trends of Glaciers in Himalaya (NW- NE)



Rates of glacier retreat vary considerably; between <5 to 20 m/year.

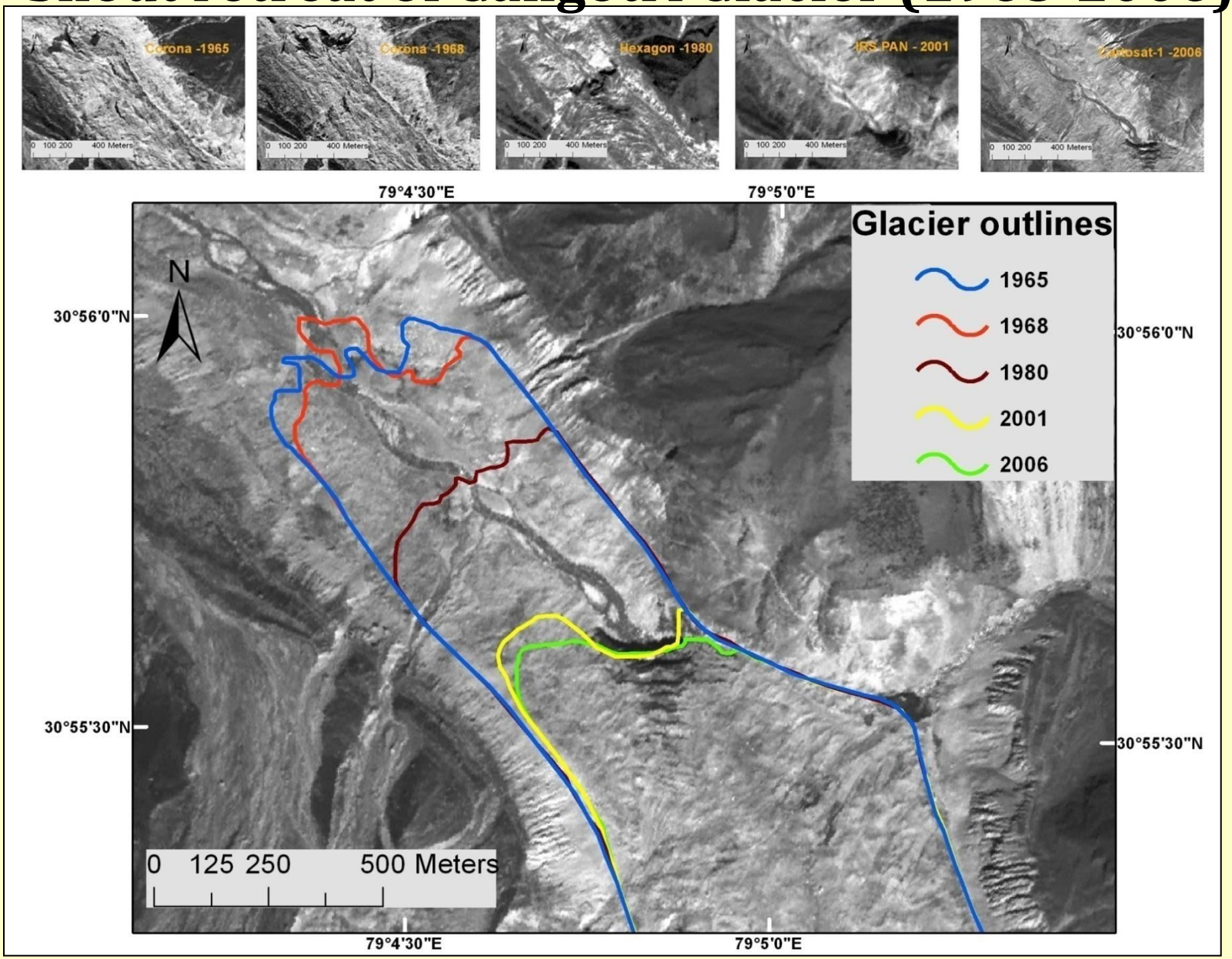
(Source: GSI, WIHG & ICIMOD)

Fluctuation of Snout Retreat of Himalayan Glaciers



Dobhal et al, 2014

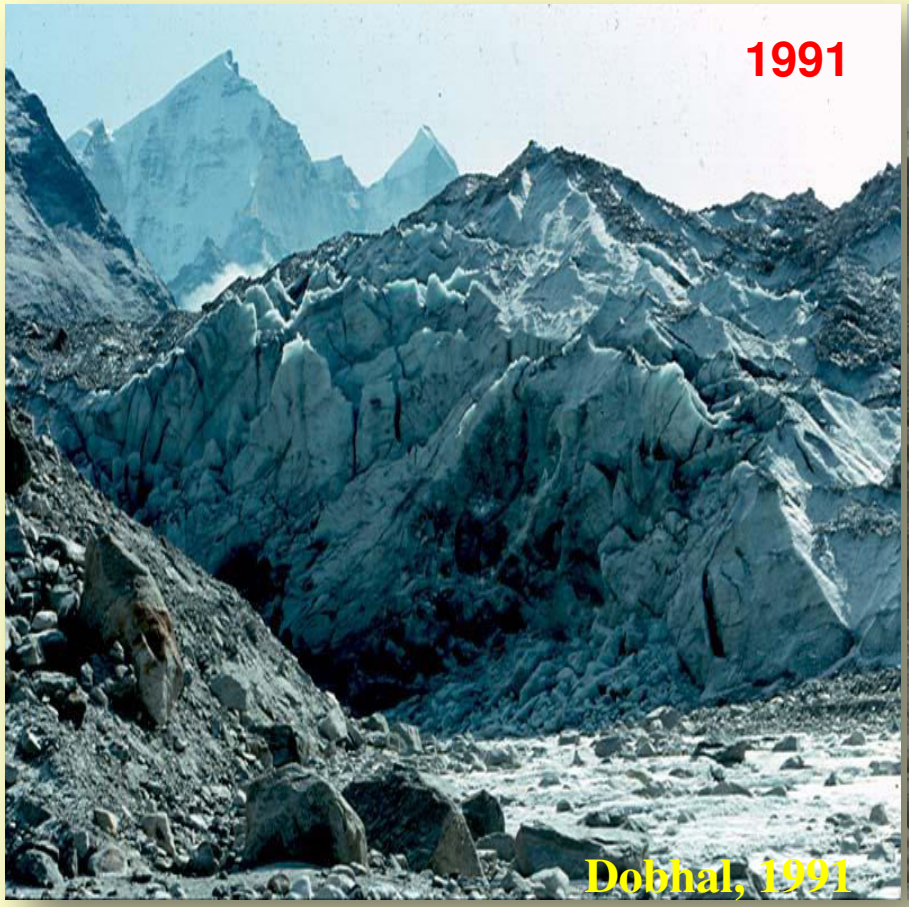
Snout retreat of Gangotri Glacier (1965-2006)



Length reduced 819 ± 14 m and frontal area lost 0.41 ± 0.03 sq. km

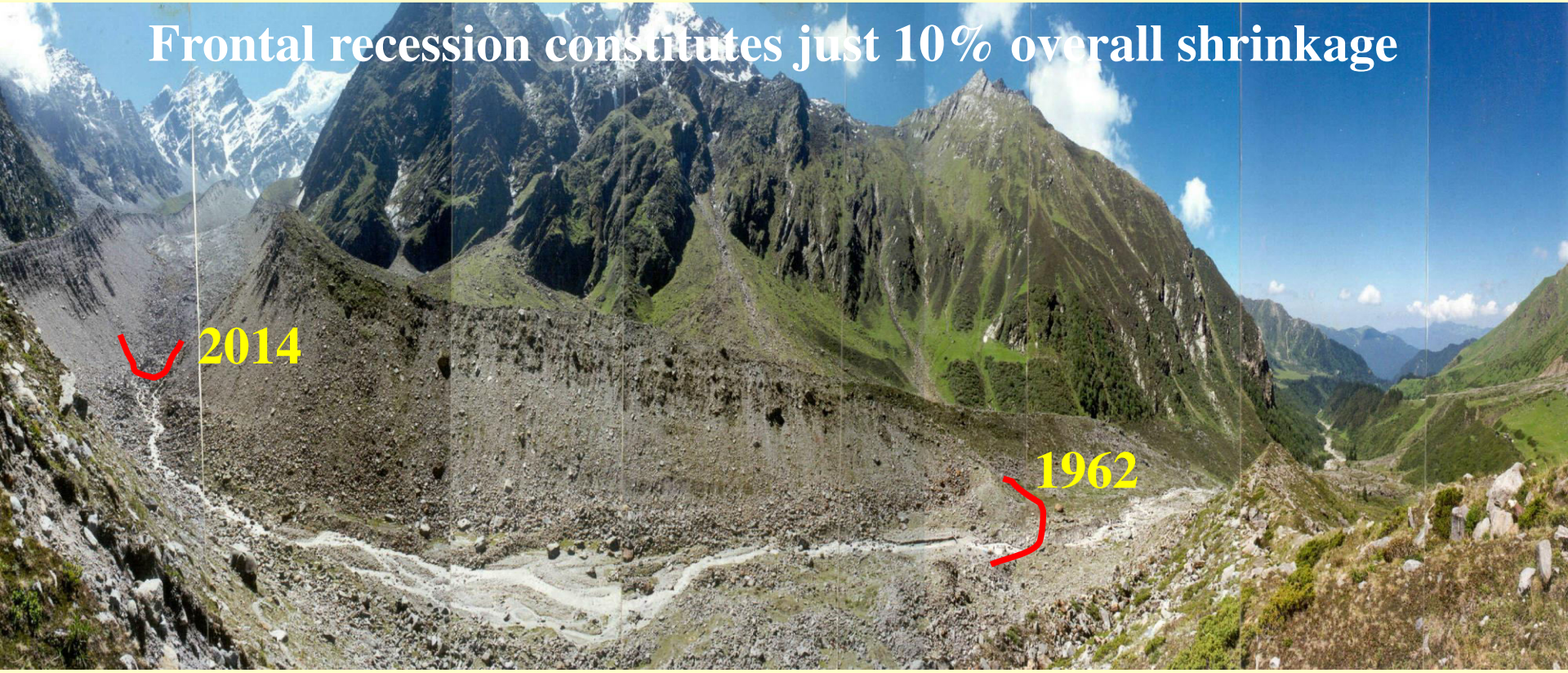
Bhambri el al., 2012, Current Science

Changes in Snout of the Gangotri Glacier



After 20 Years ...

Recession of Dokriani glacier - 1962 to 2014



Total Frontal Retreat 1962 - 2014 = 876 m; 16.8m/yr

Total Frontal Area Loss – 0.78 km^2

Total ice mass loss - ~ 2.45 x 10^6 m^3 w.e.

Changes in glacier surface morphology

June 1995

June 2008

Surface lowering (Volume loss) in Dokriani glacier during a period of 13 years

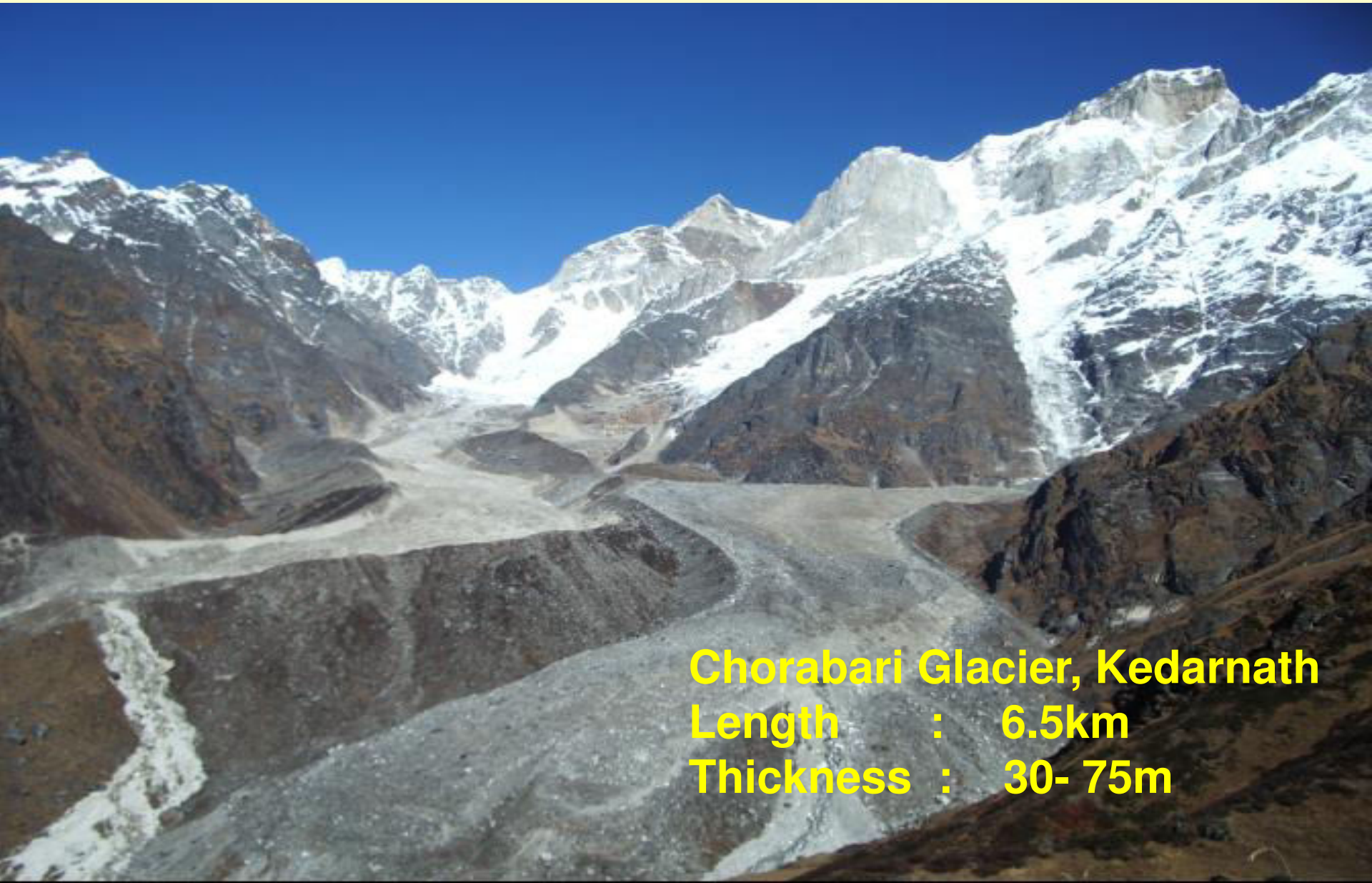
i) Rapid surface thinning
ii) Decrease of snow cover (transition snowline)
iii) Increase of debris cover in lower ablation area

(Dobhal & Mehta ,2009)

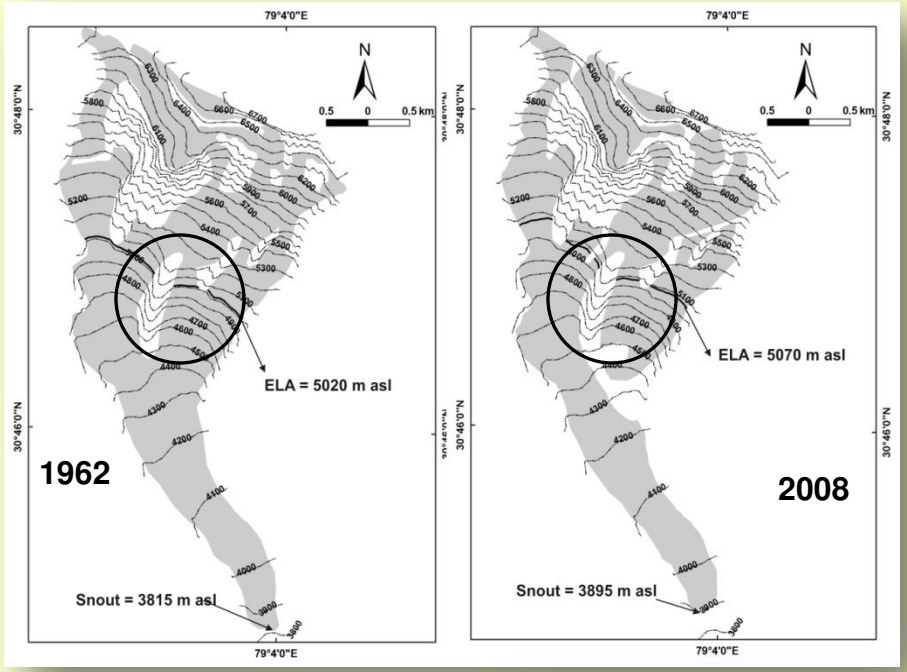
Change in Chorabari Glacier, Kedarnath

After 128 Years ...

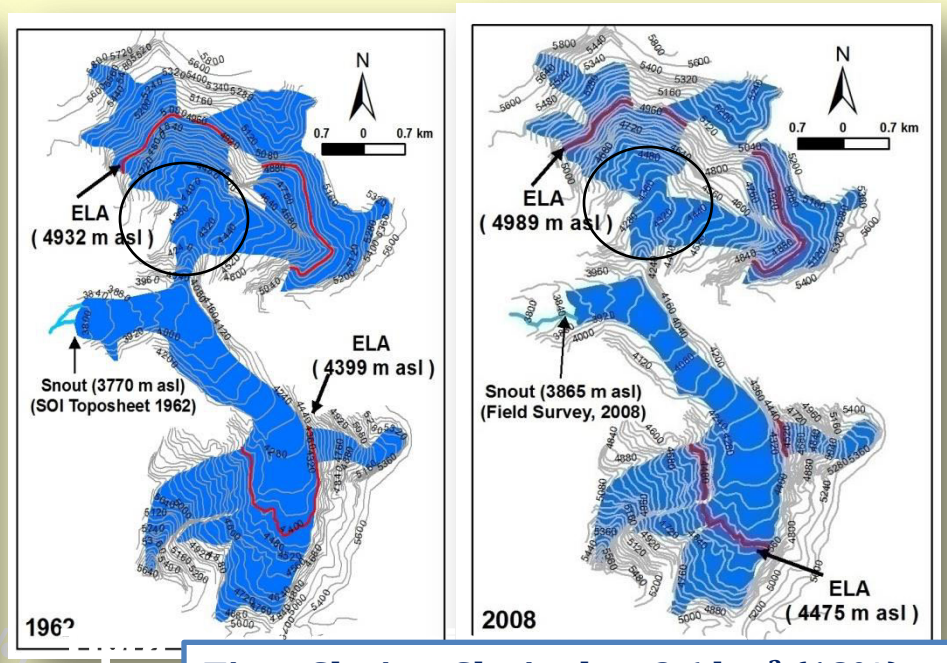
Typical view of Himalayan glacier



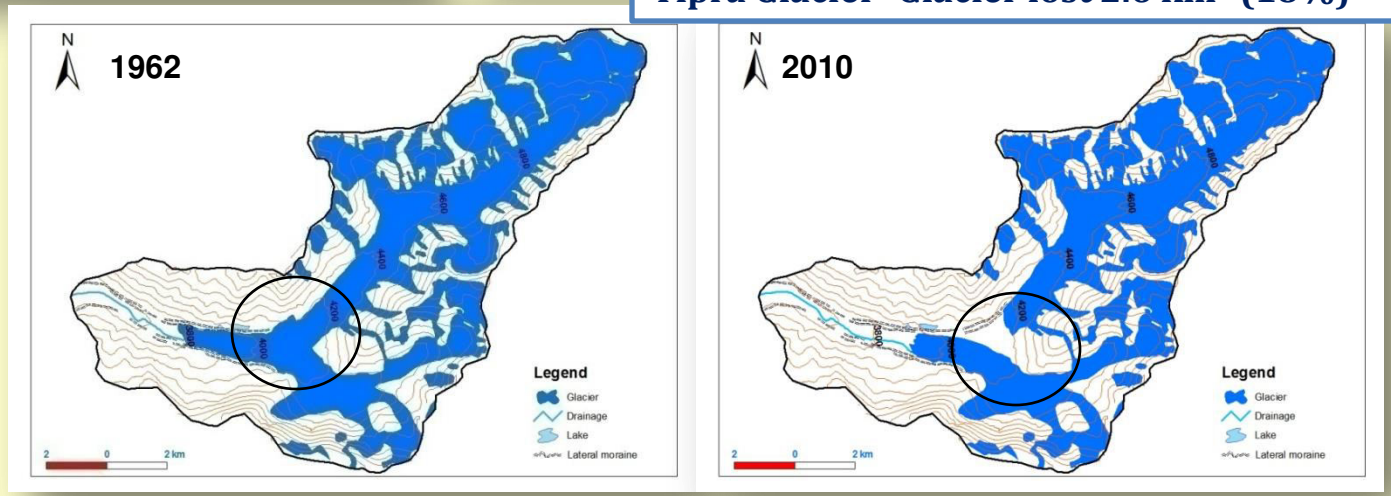
Fragmentation of Larger Glacier



Chorabari Glacier-
Glacier lost 0.71 km^2 (9.6%)



Tipra Glacier- Glacier lost 2.6 km^2 (18%)



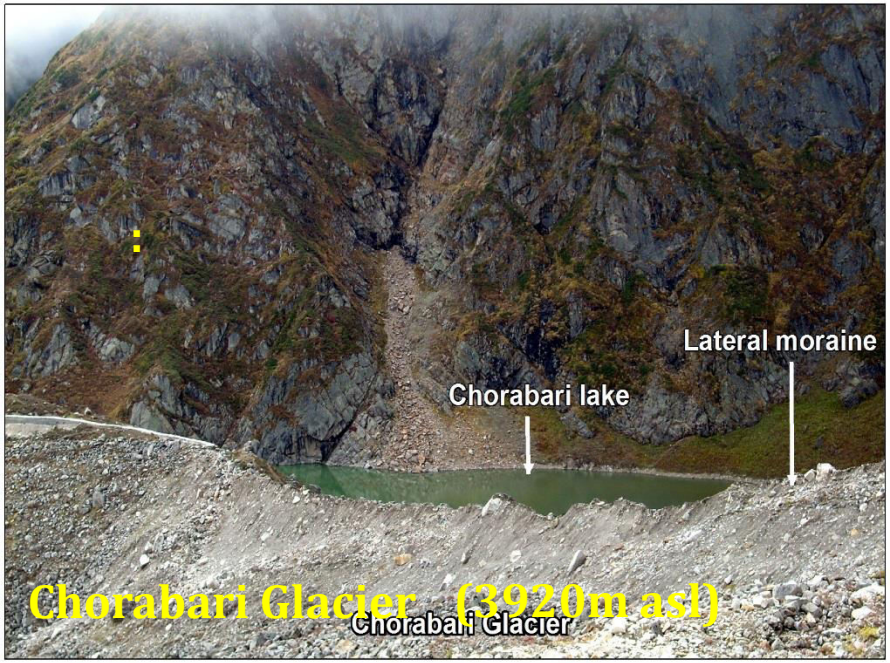
Jaundhar Glacier- Glacier lost 2.68 km^2 (4.7%)

Mehta et al, 2012

Small glaciers are more prone to melting

Supra-glacial Lakes

Lateral Moraine Dam Lake



End Moraine-dammed lake

South Lhonak Lake, Sikkim Himalaya

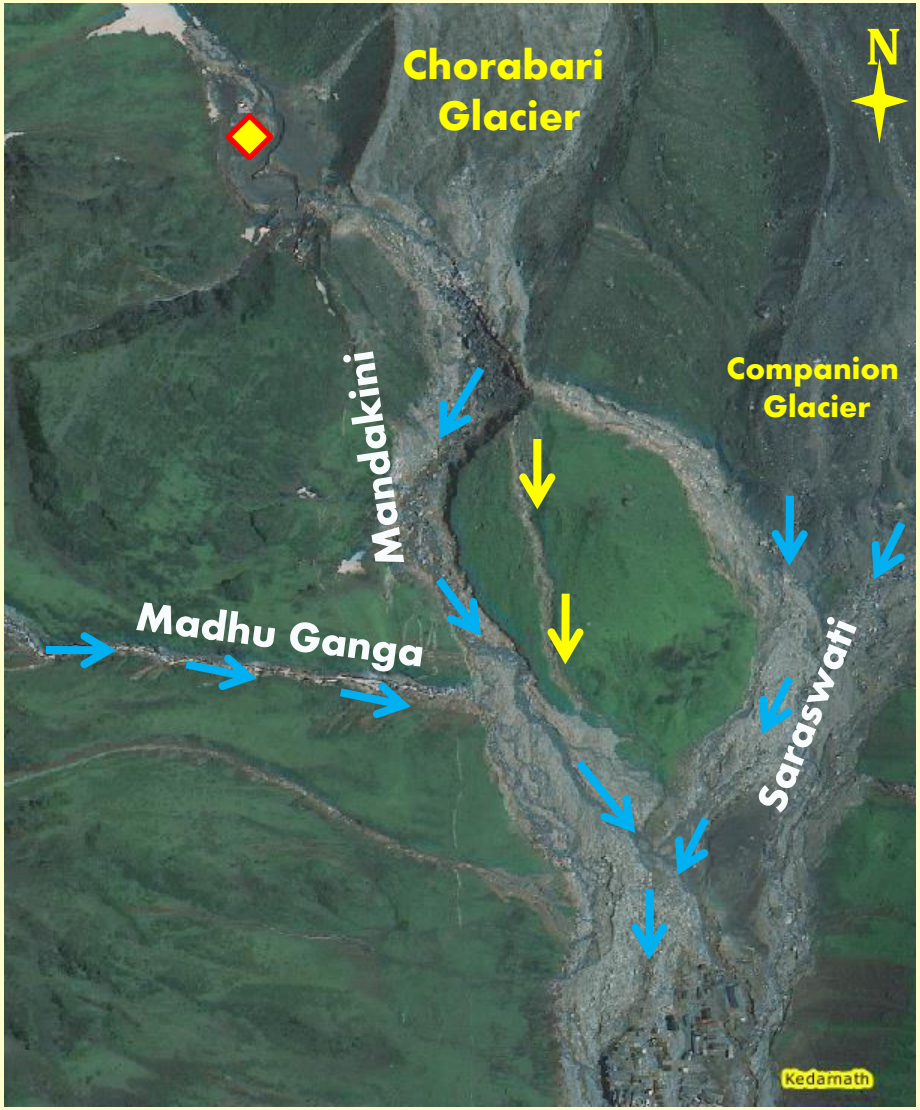
Cirque/ Glacier erosion lake

Hem-kund Lake (4400 m asl),Uttarakhand Himalaya

Chorabari Lake (3905m asl); Uttarakhand Himalaya

Chorabari Lake burst on June 17, 2013

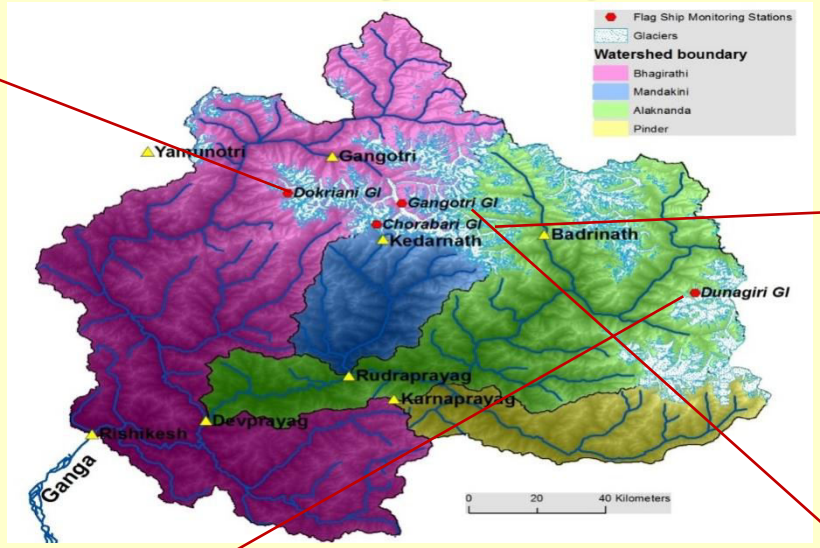
Chorabari Glacier Lake Burst and its impacts 17 June,2013



Glacier Monitoring Stations of Upper Ganga Basin

Centre For Glaciology
Wadia Institute of Himalayan Geology

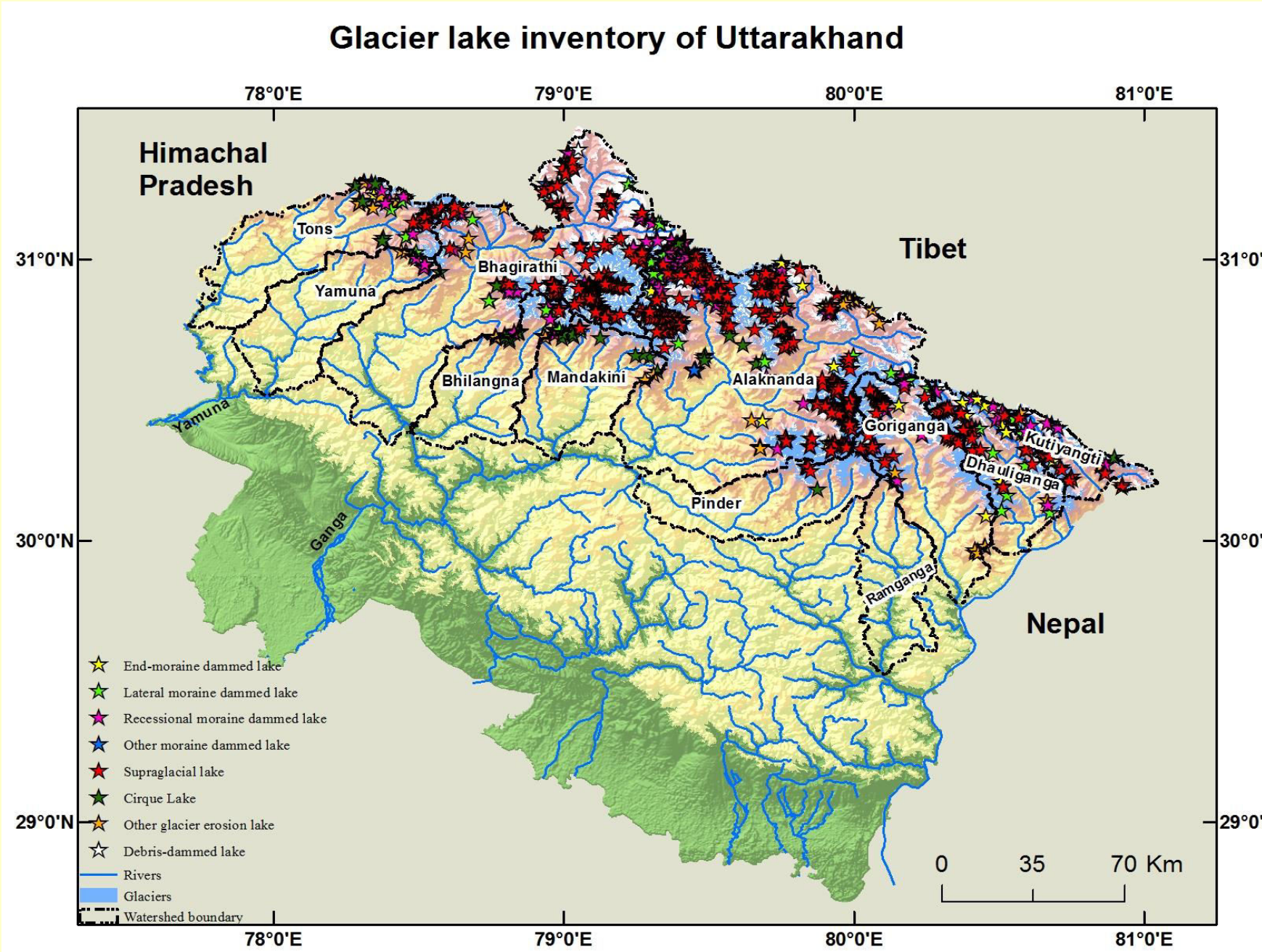
Dokriani



Chorabari

Dunagiri

Gangotri


Glacier lake inventory of Uttarakhand
78°0'E
79°0'E
80°0'E
81°0'E
31°0'N
30°0'N
29°0'N
Himachal Pradesh
Tibet
Nepal
Tons
Yamuna
Bhagirathi
Bhilangna
Mandakini
Alaknanda
Goriganga
Kutiyangti
Dhauliganga
Pinder
Ramganga
Ganga
End-moraine dammed lake
Lateral moraine dammed lake
Recessional moraine dammed lake
Other moraine dammed lake
Supraglacial lake
Cirque Lake
Other glacier erosion lake
Debris-dammed lake
Rivers
Glaciers
Watershed boundary
0
35
70 Km

Glacier lake inventory of Uttarakhand

Main type	Sub type	Total number	%	Total area $(m)^2$	%	Mean area $(m)^2$
Moraine-dammed lake	End moraine-dammed lake	44	3.5	1596367	21.0	36281
	Lateral moraine-dammed lake	67	5.3	652054	8.6	9732
	Recessional moraine-dammed lake	214	16.9	1589375	20.9	7427
	Other moraine-dammed lake	4	0.3	98143	1.3	24536
Ice-dammed lake	Supra-glacial lake	809	63.9	2000524	26.3	2473
Glacier erosion lake	Cirque lake	48	3.8	1174222	15.5	24463
	Other glacial erosion lake	77	6.1	466491	6.1	6058
Other glacial lake	Other glacial lake	3	0.2	17695	0.2	5898
	Total	**1266**		**7594871**		

Thank you for your kind attention…