Government of India
Ministry of Jal Shakti
Department of Water Resources,
River Development & Ganga Rejuvenation

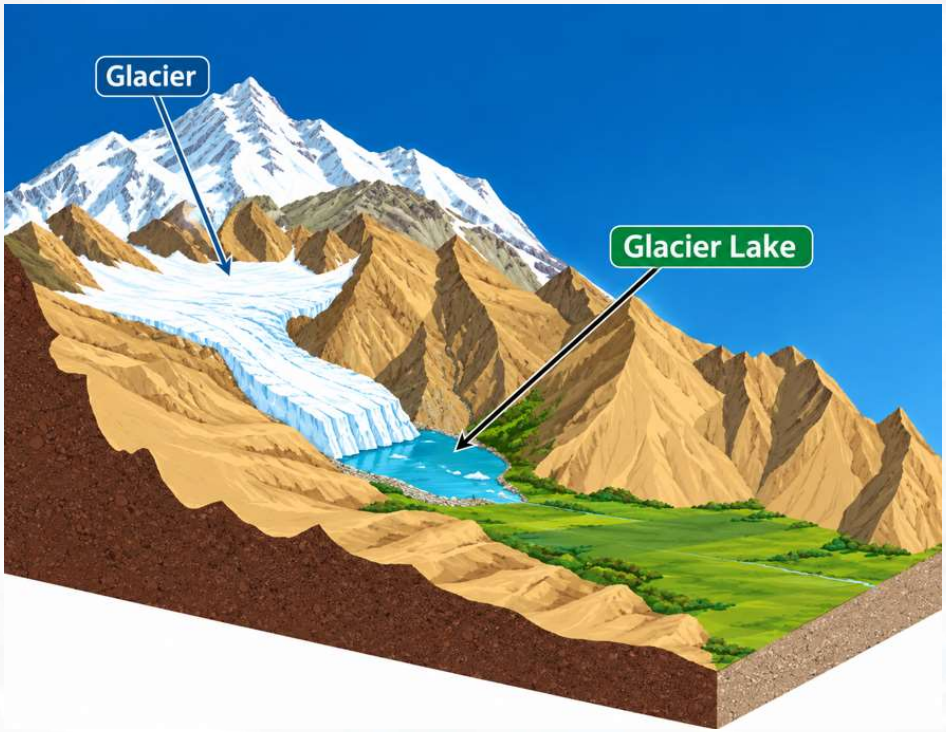
Monitoring of Glacial Lakes of Indian Himalayan Region and Analysis on Water spread area from 2011 to 2025

Central Water Commission

Presented By,
Archa Raj D
Assistant Director, Central Water Commission

- **Monitoring of Glacial Lakes by CWC**
- **Analysis on Waterspread Area of Glacial Lakes based on inventory data**

Glacier Lake



- Glacier erodes the surface before melting and the melt water fills the resulting depression
- Bound by unstable Moraine Structures- loose rocks, gravel, and sediment left behind by moving glaciers
- Unconsolidated, highly fragile & structurally weak
- Tickling time bombs leading to GLOF

Glacial Lake Outburst Flood



- sudden and catastrophic flood caused by failure of natural dam holding a glacial lake
- landslides, avalanche, cloud burst, earthquakes, etc can trigger GLOF

Glacial Lake Mapping of Indian Himalayan Region

Prepared by NRSC



Glacial Lake Inventory 2011, NRSC

Country	Glacial Lakes >10 Ha (Nos.)	Water Bodies >10 Ha (Nos.)	Total >10 Ha (Nos.)
India	60	448	508
Bhutan	77	124	201
Nepal	57	45	102
China	310	903	1213
Myanmar	-	4	4
Total	**504**	**1524**	**2028**

504 GL > 10 Ha

(60 GL located in India)

Glacial Lake Atlas 2023, NRSC

Size (Ha)	No of Glacial Lakes		Total
	India	Transboundary	
0.25-1	3342	9194	12536
1-5	2862	7769	10631
5-10	712	1733	2445
10-50	596	1536	2132
>50	58	241	299
Total	**7570**	**20473**	**28043**

1941 GL > 10 Ha

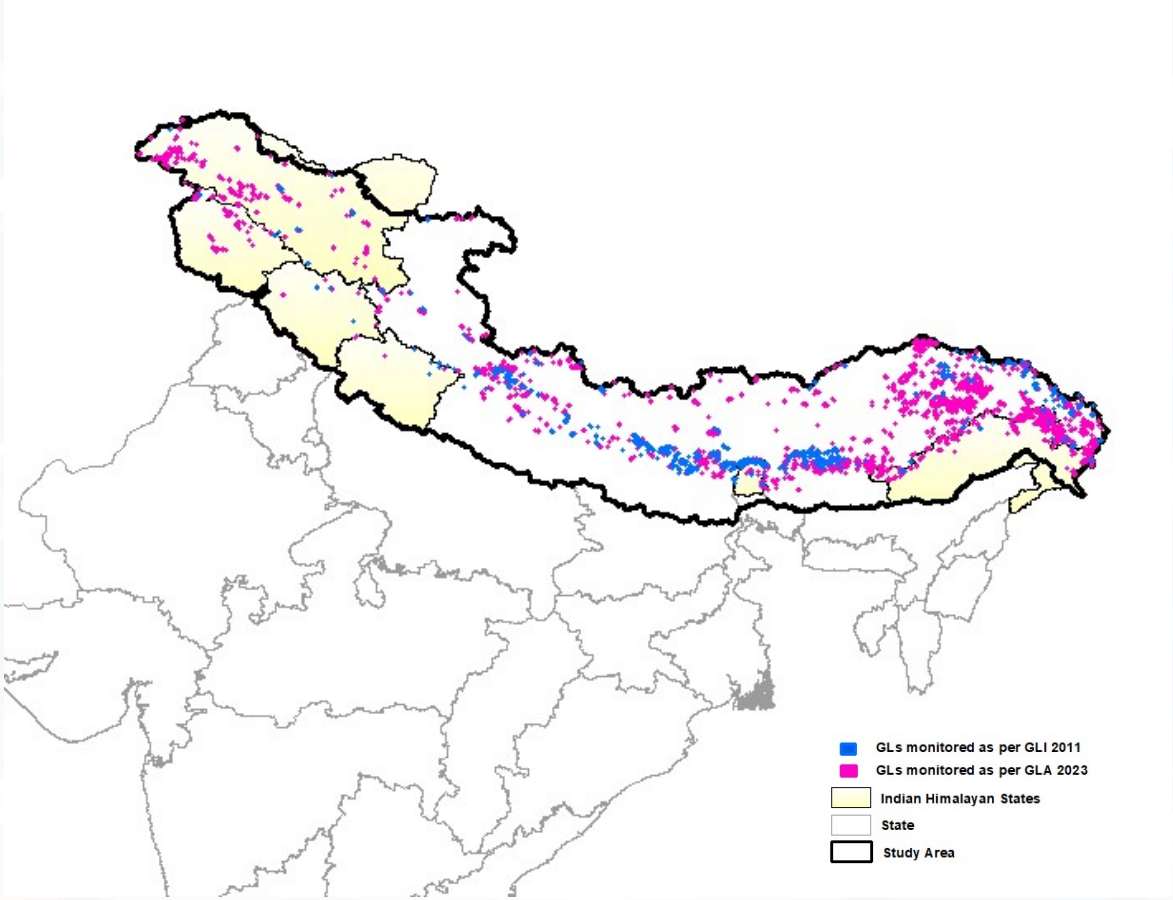
(581 GL located in India)

Glacial Lake Monitoring using Remote Sensing Techniques

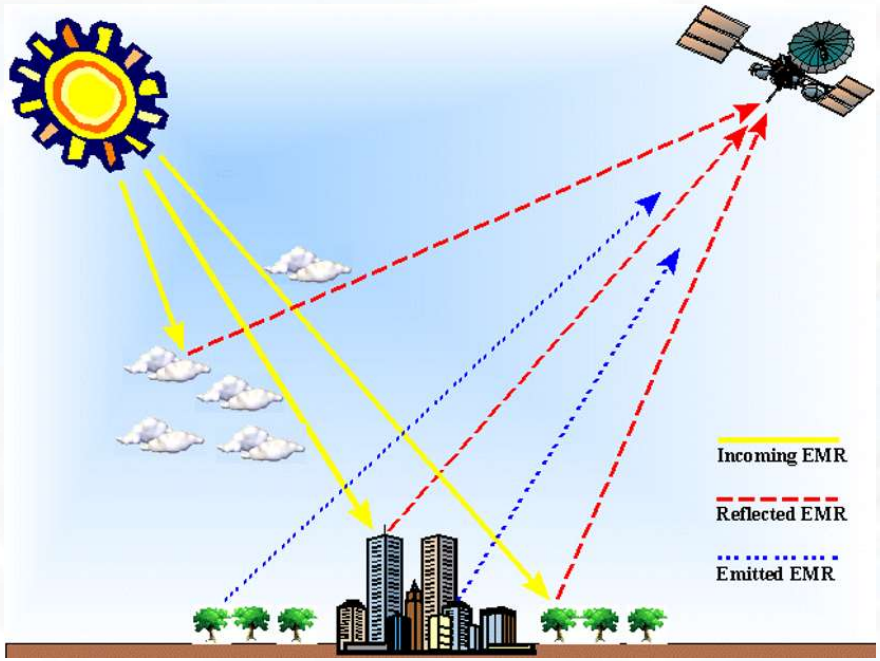
Monitoring of Glacial Lakes

- CWC monitors Glacial Lakes of water spread area greater than 10 Ha of Indian Himalayan Region using Remote Sensing Techniques
- Study Area – India & transboundary region draining to Indian Territory(Nepal, Bhutan and TAR)
- Monthly monitoring - June to October every year
- Google Earth Engine Platform
- Sentinel 1 & Sentinel 2 satellites (10 m resolution)
- Automatic algorithm and manual validation

Location of Glacial Lakes monitored



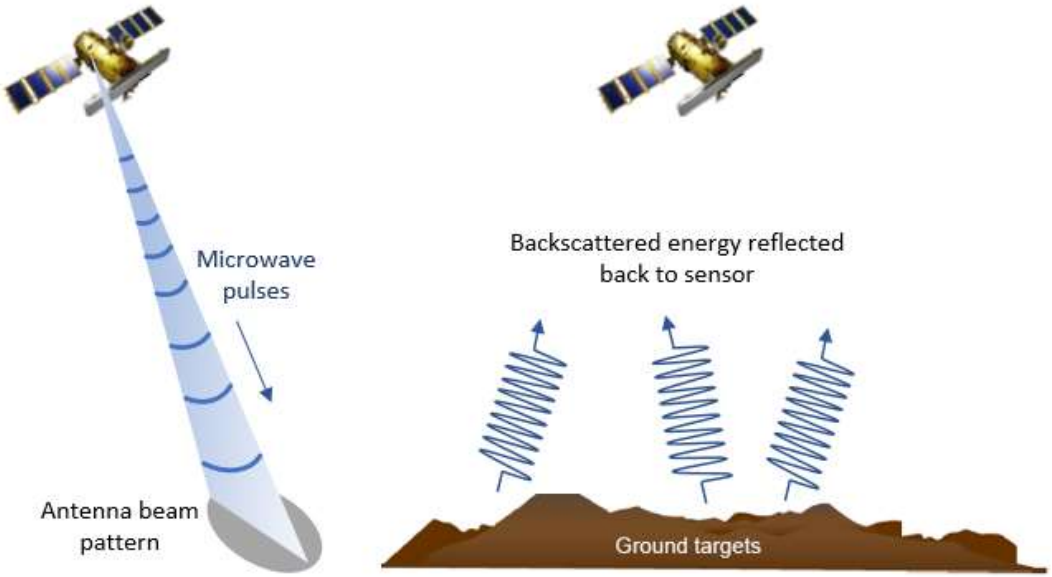
Multi Spectral Imaging



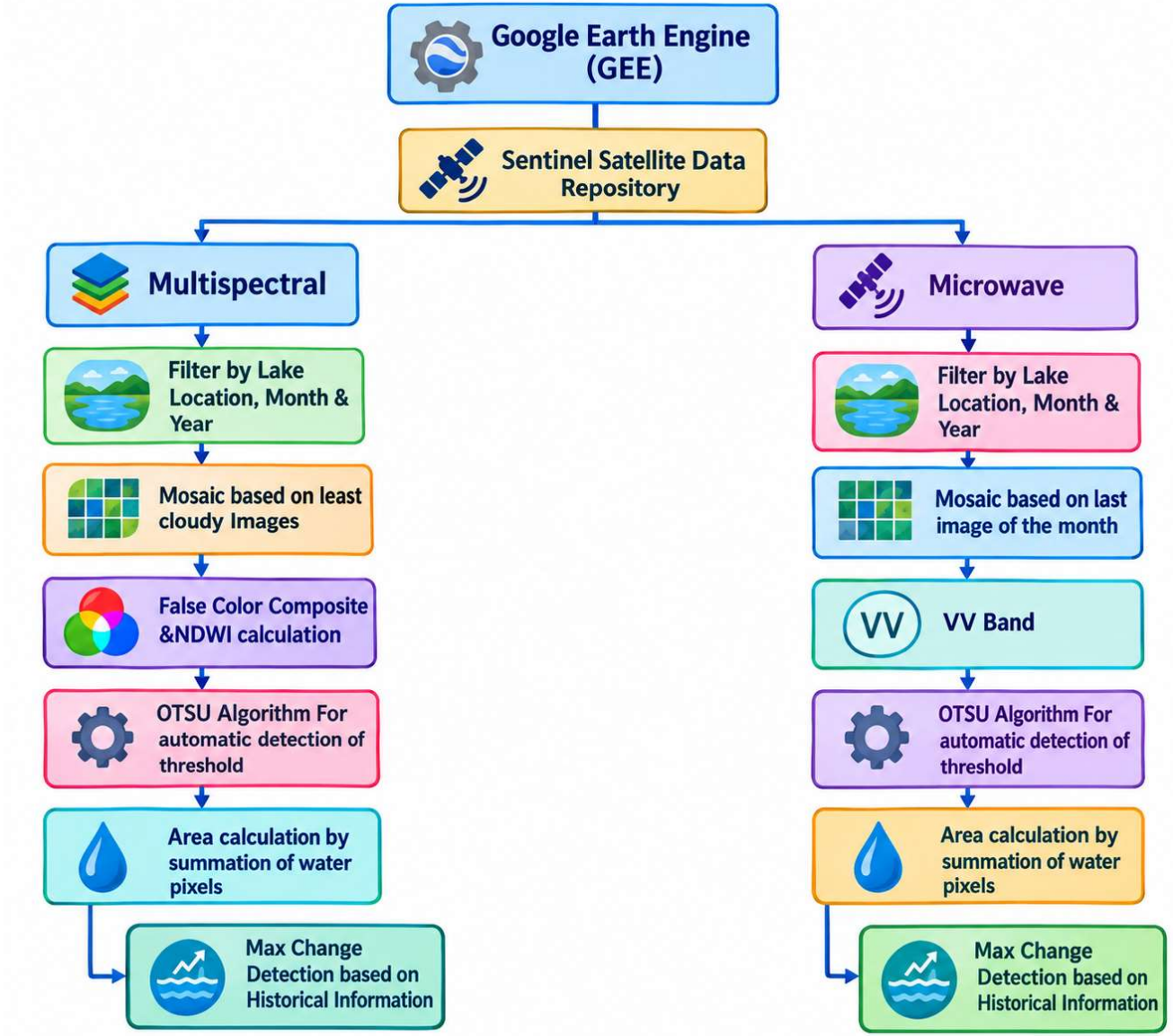
Electromagnetic radiation (EMR)

- Sentinel 2 Multispectral Imagery
- 10 days revisit period (combined revisit-5 days)
- 10 m resolution
- Green, Red & NIR bands utilized

Synthetic Aperture Radar (SAR) Imaging



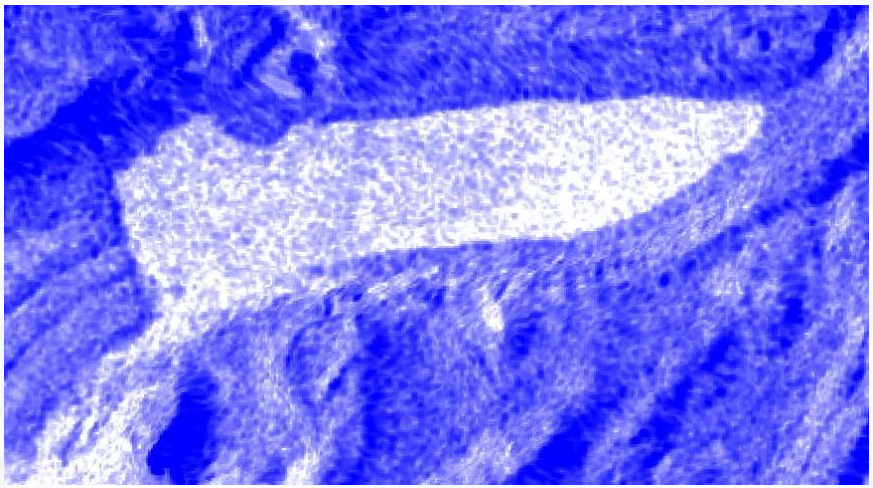
- Sentinel 1 Synthetic Aperture Radar(SAR) Imagery
- 12 days revisit period (combined revisit-6 days)
- upto 5m to 20m resolution
- C Band – VV polarization data is utilized


Google Earth Engine (GEE)
Sentinel Satellite Data Repository
Multispectral
Filter by Lake Location, Month & Year
Mosaic based on least cloudy Images
False Color Composite &NDWI calculation
OTSU Algorithm For automatic detection of threshold
Area calculation by summation of water pixels
Max Change Detection based on Historical Information
Microwave
Filter by Lake Location, Month & Year
Mosaic based on last image of the month
VV
VV Band
OTSU Algorithm For automatic detection of threshold
Area calculation by summation of water pixels
Max Change Detection based on Historical Information

Processed Sentinel Image of South Lhonak Lake, Sikkim October 2025



South Lhonak Lake, Sikkim - processed Sentinel 2 Multi Spectral Image
October 2025

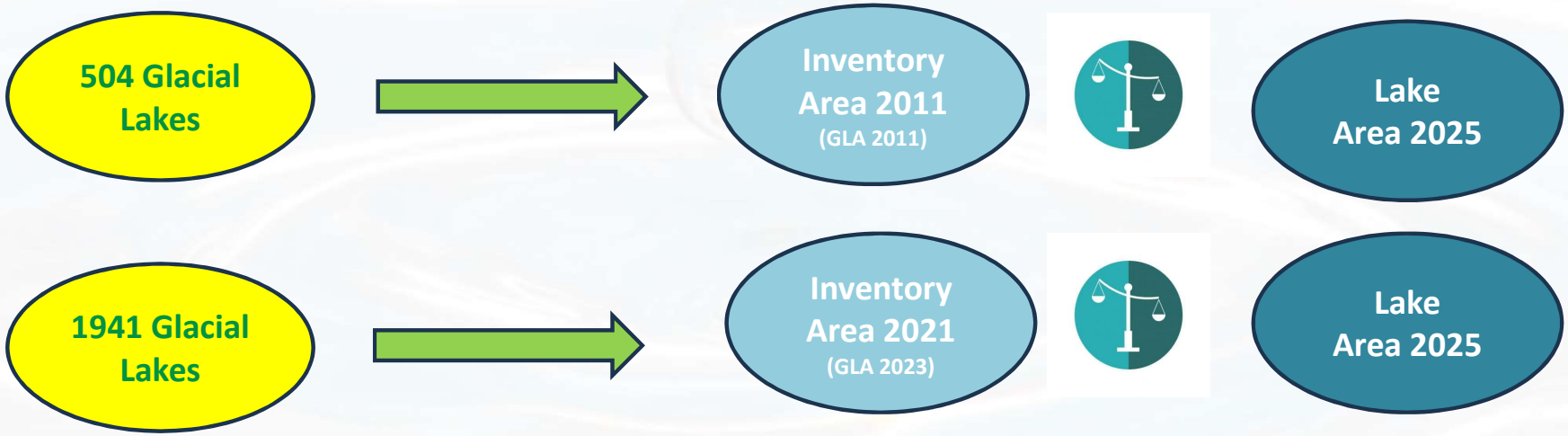


South Lhonak Lake, Sikkim - processed Sentinel 1 Microwave Image
October 2025

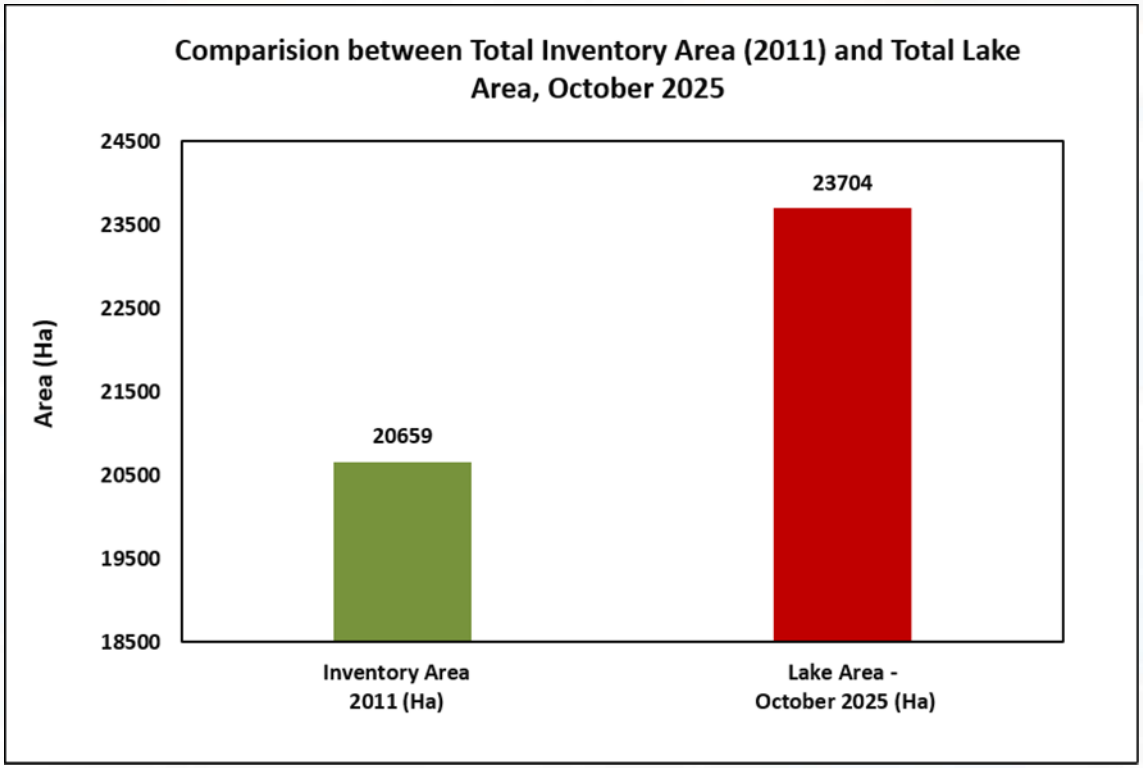


South Lhonak Lake, Sikkim – Google Earth Image
October 2025

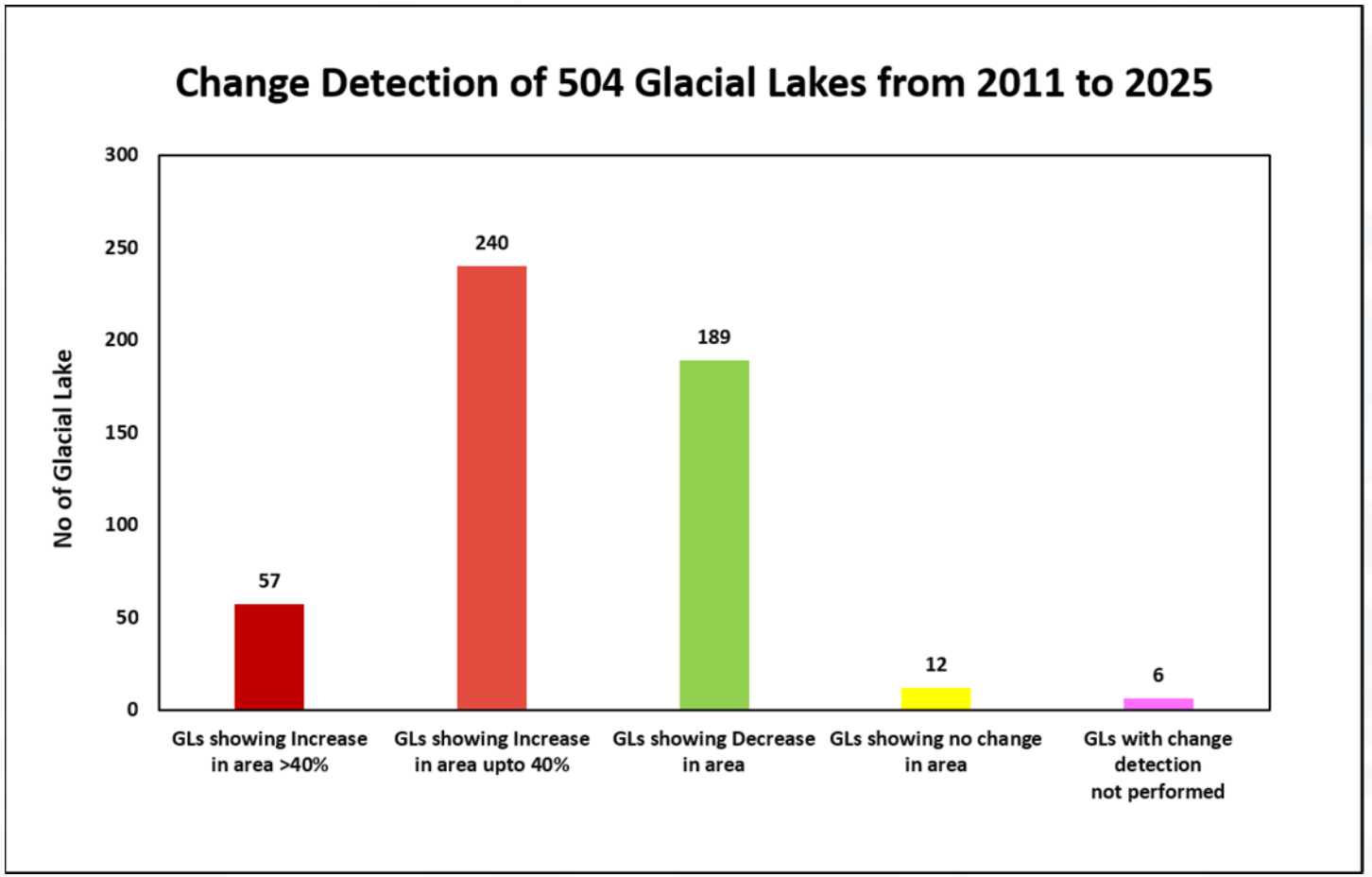
Analysis on Change in Waterspread Area of Glacial Lakes


504 Glacial Lakes
Inventory Area 2011 (GLA 2011)
Lake Area 2025
1941 Glacial Lakes
Inventory Area 2021 (GLA 2023)
Lake Area 2025

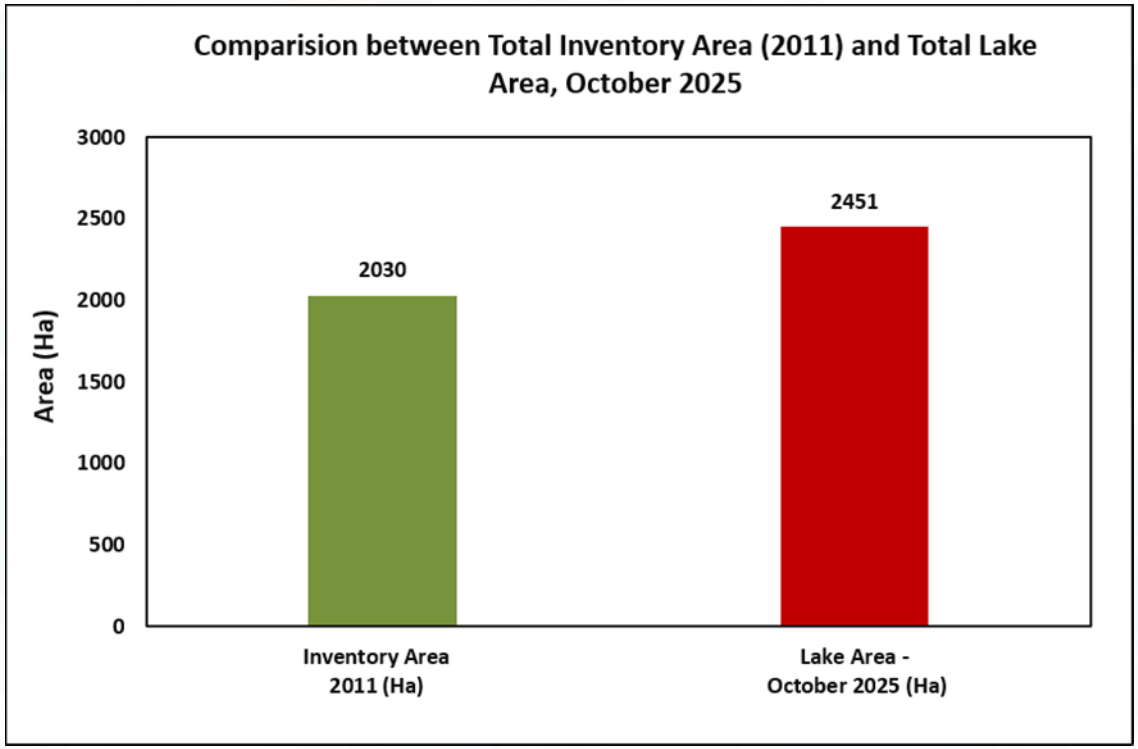
Results of Analysis change in water spread area of 504 Glacial lakes from 2011 to 2025



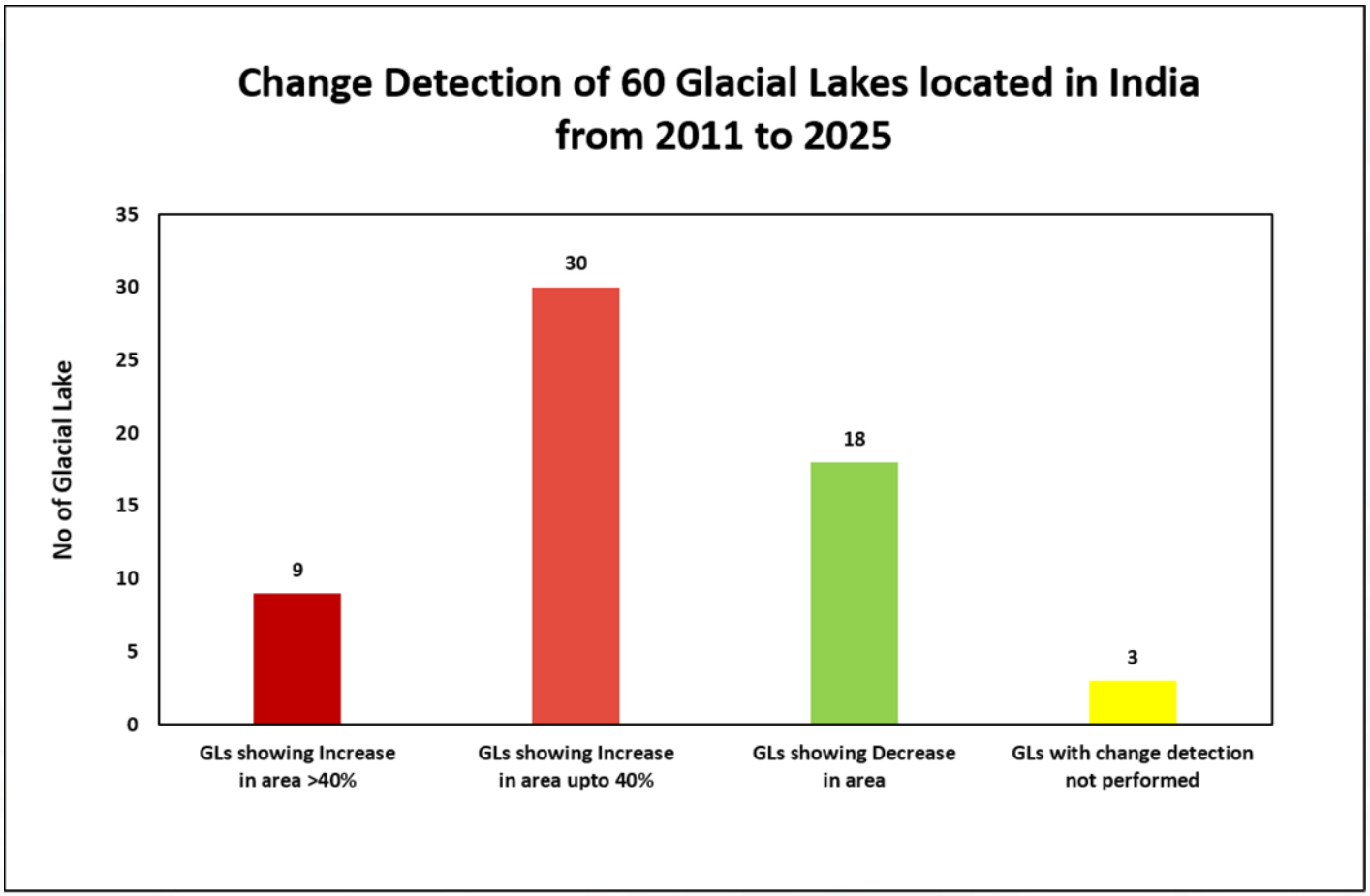
14.7% increase in water spread area


Change Detection of 504 Glacial Lakes from 2011 to 2025
No of Glacial Lake
300
250
200
150
100
50
0
57
240
189
12
6
GLs showing Increase in area >40%
GLs showing Increase in area upto 40%
GLs showing Decrease in area
GLs showing no change in area
GLs with change detection not performed

Results of Analysis change in water spread area of 60 Glacial Lakes located in India from 2011 to 2025



20.7% increase in water spread area(Indian GLs)

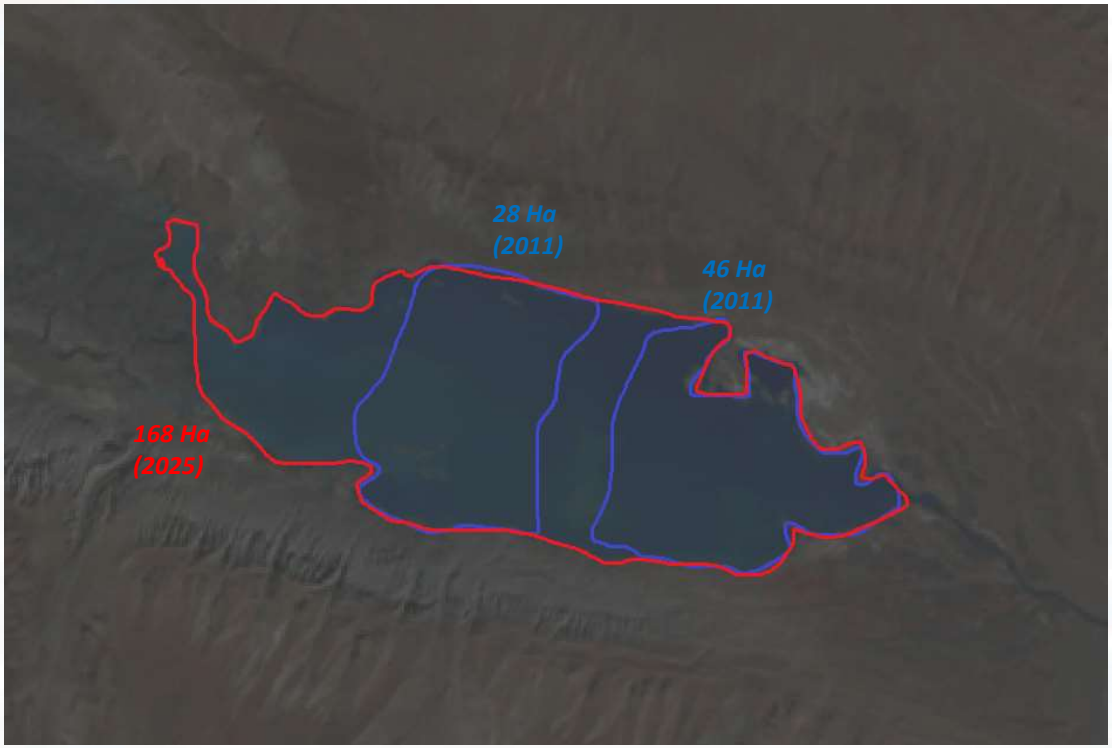

Change Detection of 60 Glacial Lakes located in India from 2011 to 2025
No of Glacial Lake
35
30
25
20
15
10
5
0
9
30
18
3
GLs showing Increase in area >40%
GLs showing Increase in area upto 40%
GLs showing Decrease in area
GLs with change detection not performed

Sanhapo Lake, Arunachal Pradesh – *Lake ID: 03_83A_003-* ***262% increase in area from 2011 to 2025***

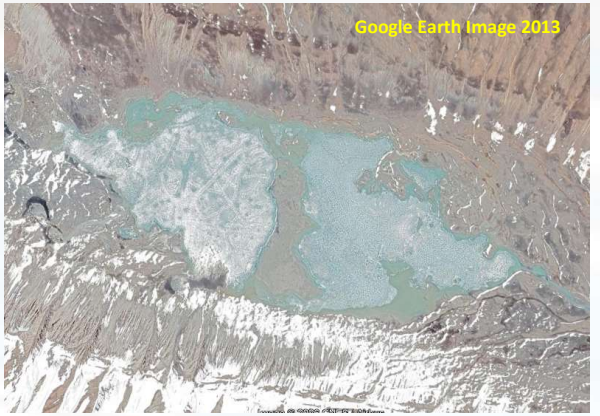


Lat 27°46'12.07"N Long 92°26'14.78"E

Lord Vishnu Lake, Himachal Pradesh – *Lake ID: 01_52H_003 &01_52H_004-**127% increase in area from 2011 to 2025***

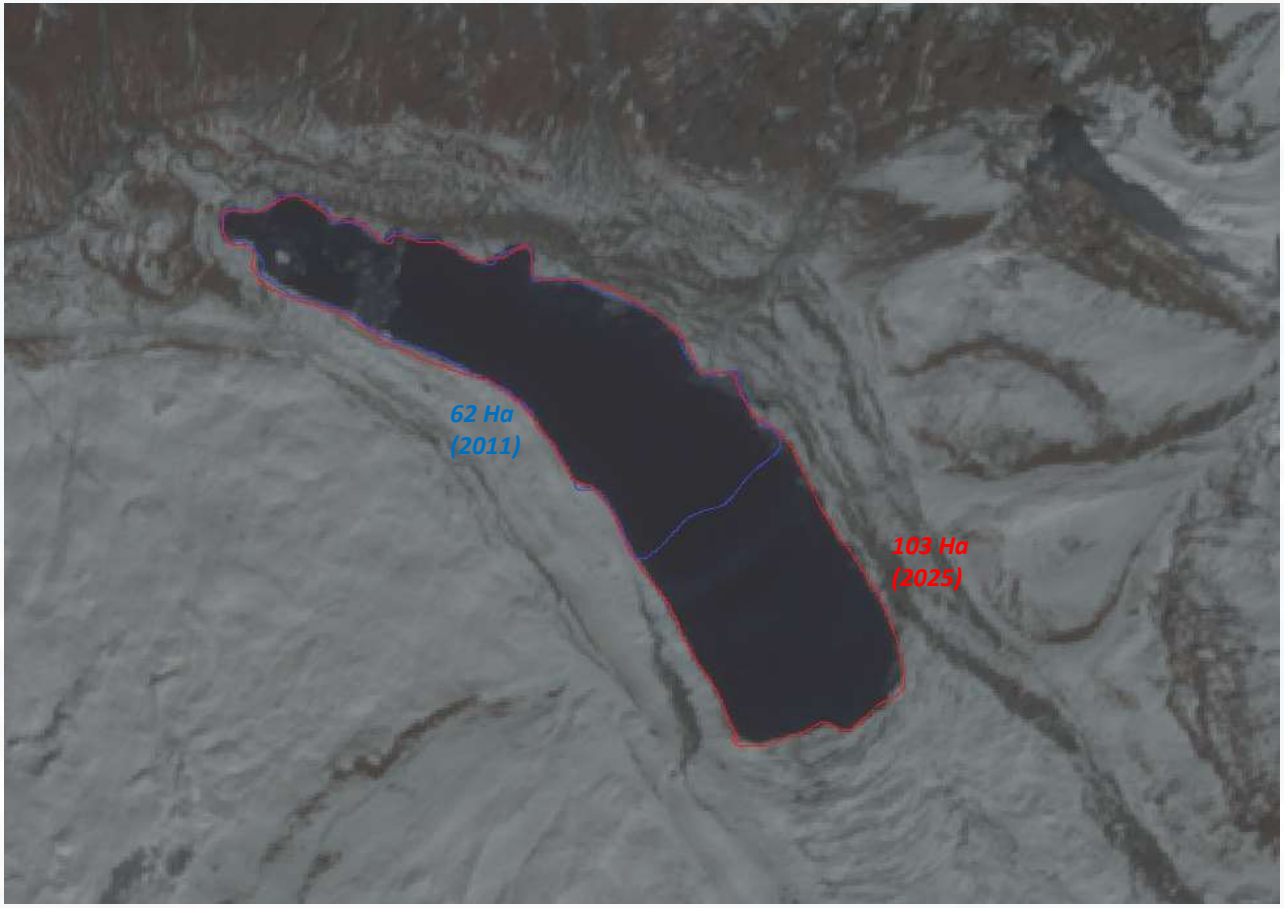


Lat 32°29'54.6"N Long 77°32'37.32"E



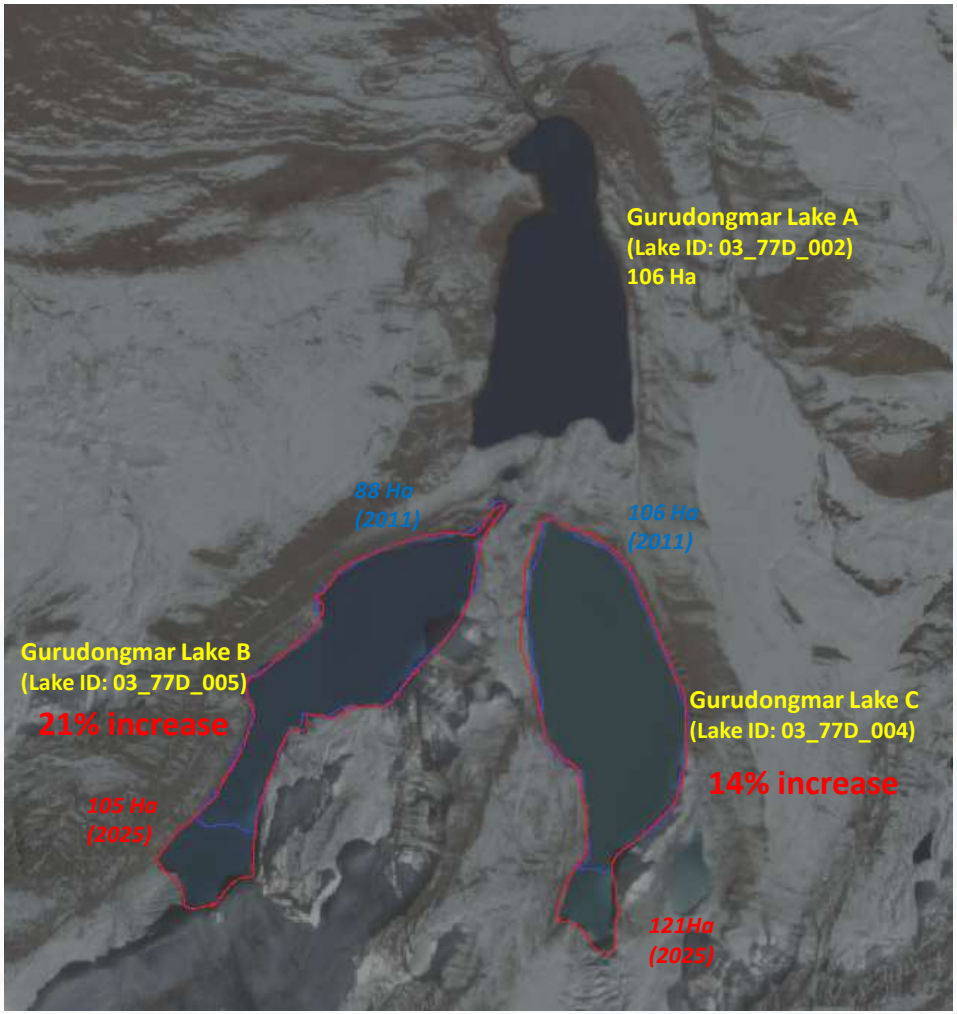


Ghepan Ghat Lake, Himachal Pradesh – *Lake ID: 01_52H_002 -**67% increase in area from 2011 to 2025***



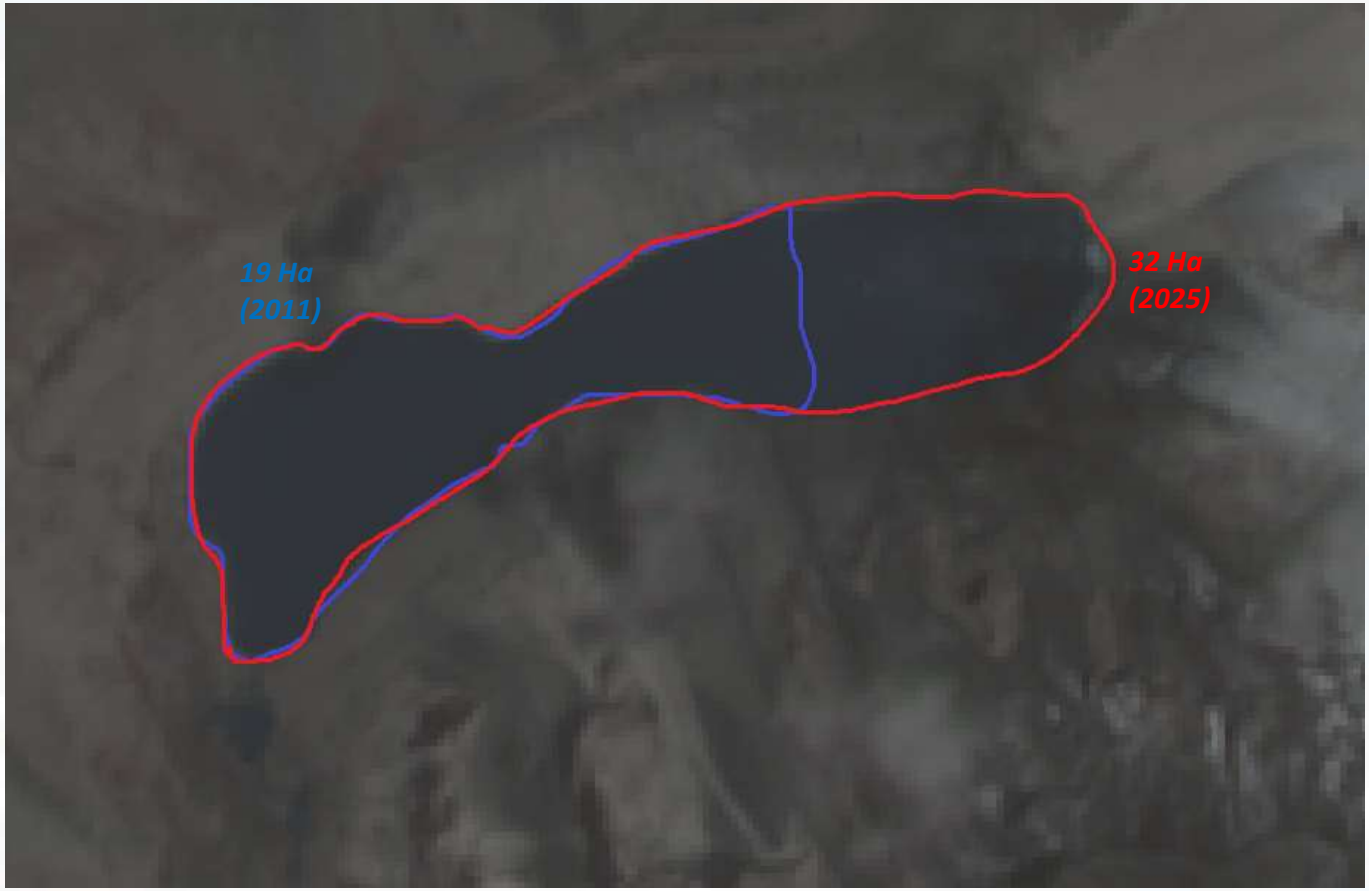
Lat 32°31'28.92"N Long 77°13'5.88"E

Gurudongmar Lake Complex, Sikkim –*approx. 20% increase in area from 2011 to 2025*



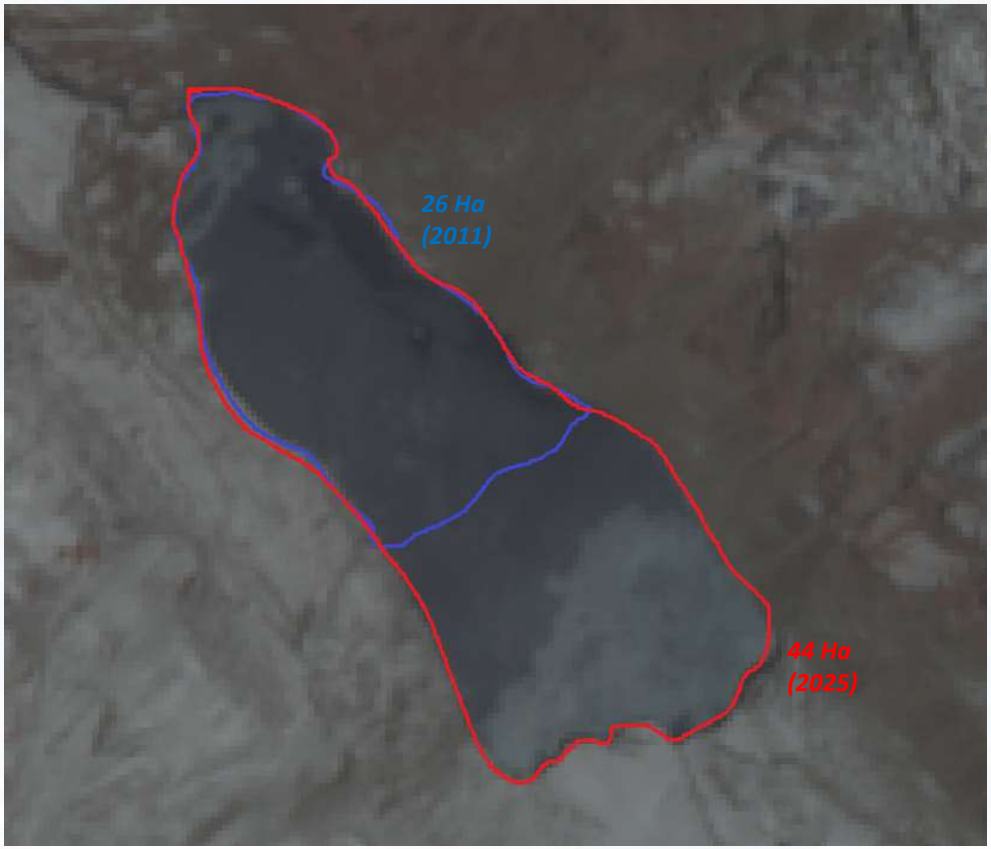
Lat 28°0'25.56"N Long 88°42'46.08"E

Lake ID: 02_62B_004, Uttarakhand - *71% increase in area from 2011 to 2025*



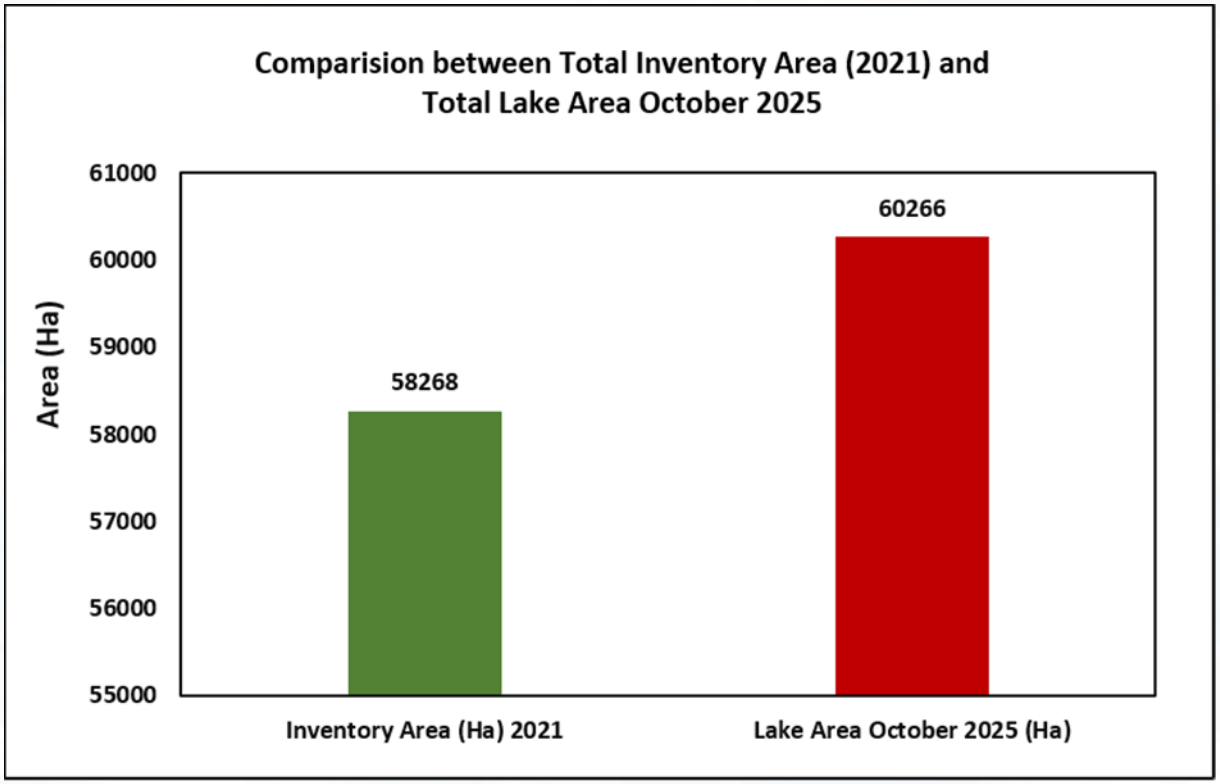
Lat 30°33'52.2"N Long 80°10'41.16"E

Lake ID: 01_52C_002, Jammu & Kashmir - *67% increase in area from 2011 to 2025*

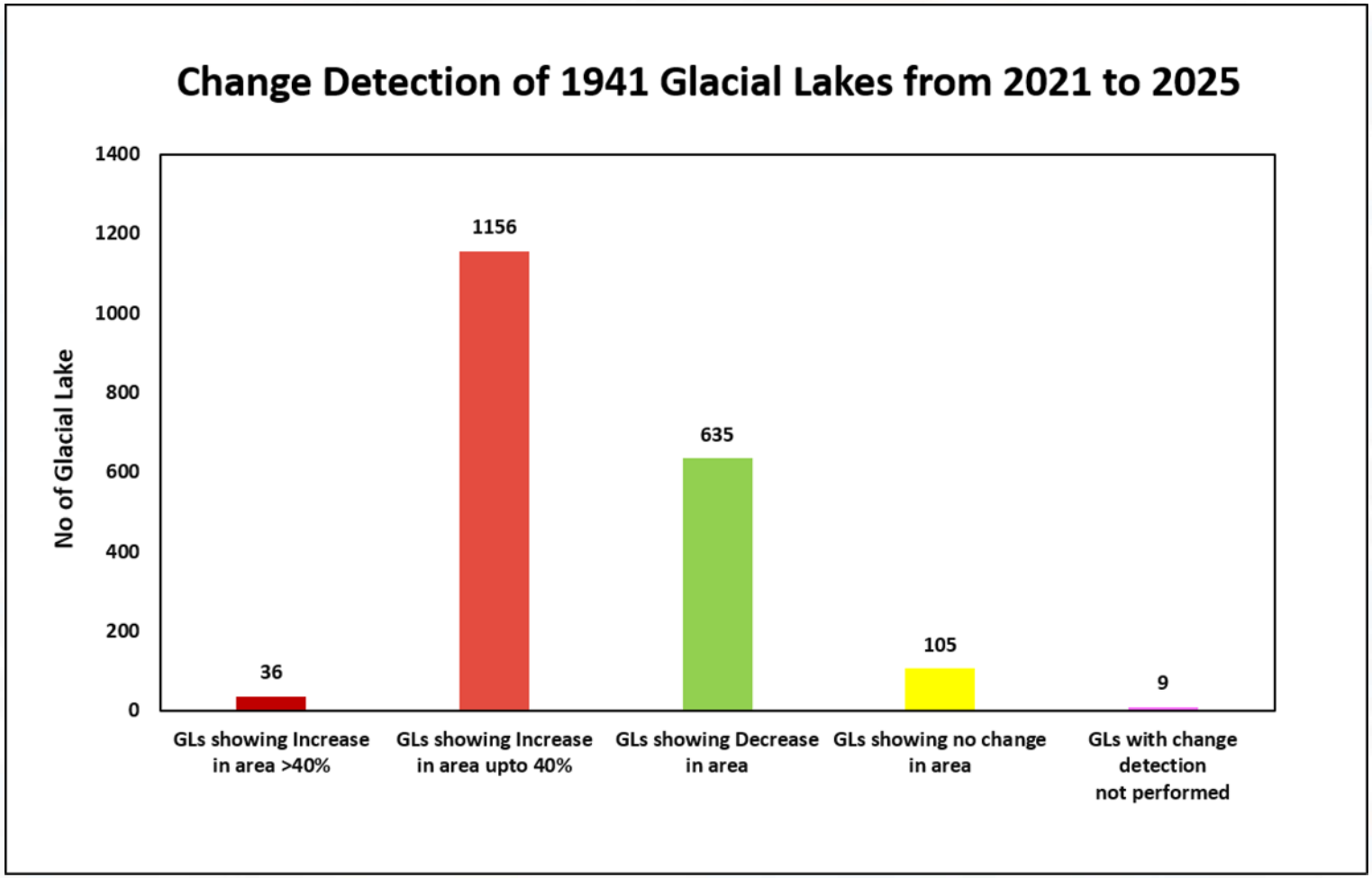


Lat 33°52'10.2"N Long 76°7'9.48"E

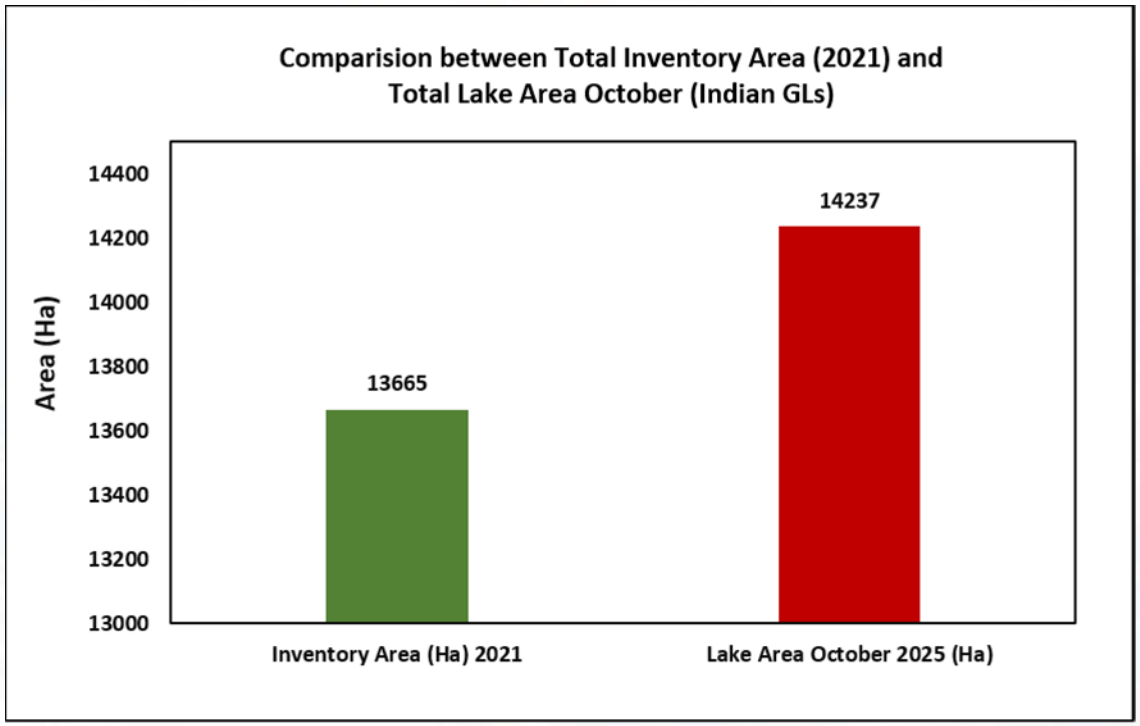
Results of Analysis change in water spread area of 1941 Glacial lakes from 2021 to 2025



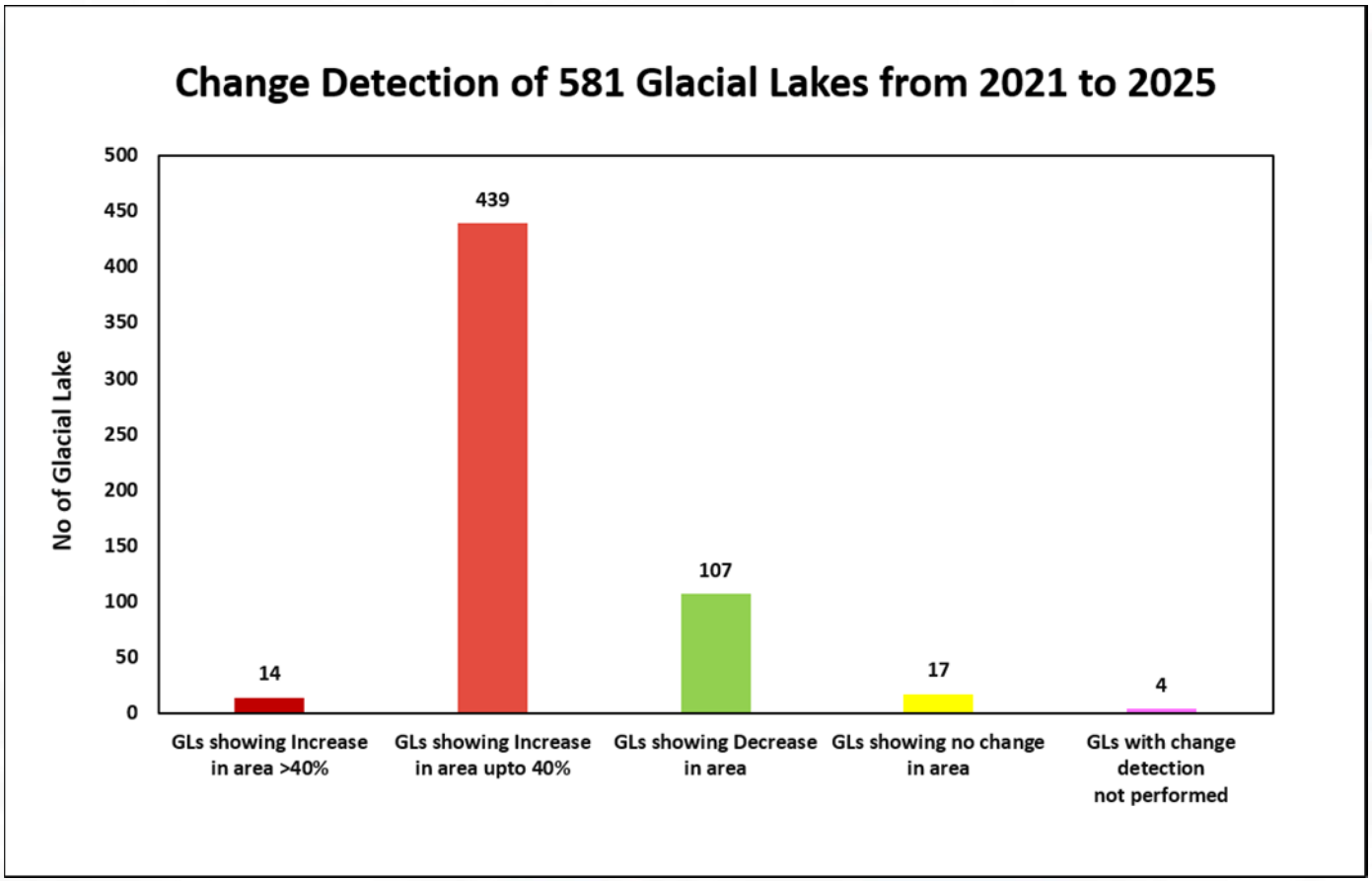
3.43% increase in water spread area


Change Detection of 1941 Glacial Lakes from 2021 to 2025
No of Glacial Lake
1400
1200
1000
800
600
400
200
0
36
1156
635
105
9
GLs showing Increase in area >40%
GLs showing Increase in area upto 40%
GLs showing Decrease in area
GLs showing no change in area
GLs with change detection not performed

Results of Analysis change in water spread area of 581 Glacial lakes located in India from 2021 to 2025



4.18% increase in water spread area(Indian GLs)

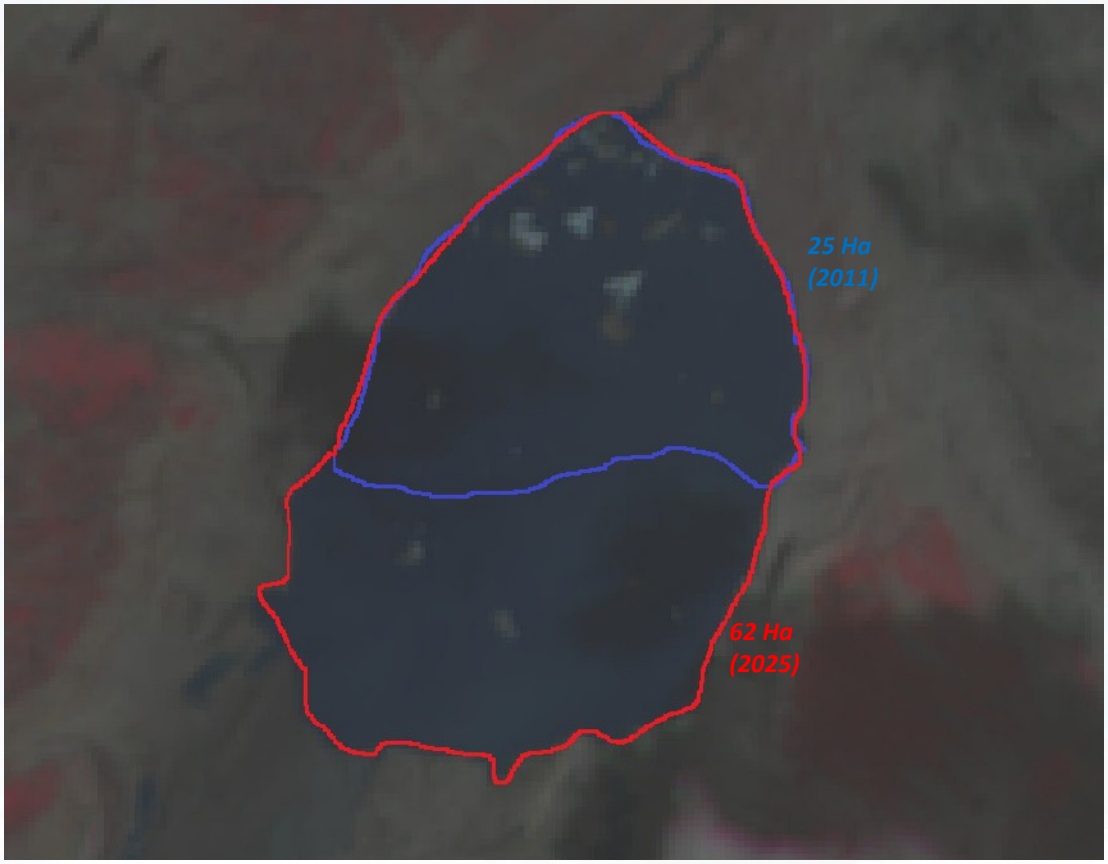

Change Detection of 581 Glacial Lakes from 2021 to 2025
No of Glacial Lake
500
450
400
350
300
250
200
150
100
50
0
14
439
107
17
4
GLs showing Increase in area >40%
GLs showing Increase in area upto 40%
GLs showing Decrease in area
GLs showing no change in area
GLs with change detection not performed

Lake ID: 03477D120008-***Sikkim***–***244% increase in area from 2021 to 2025***



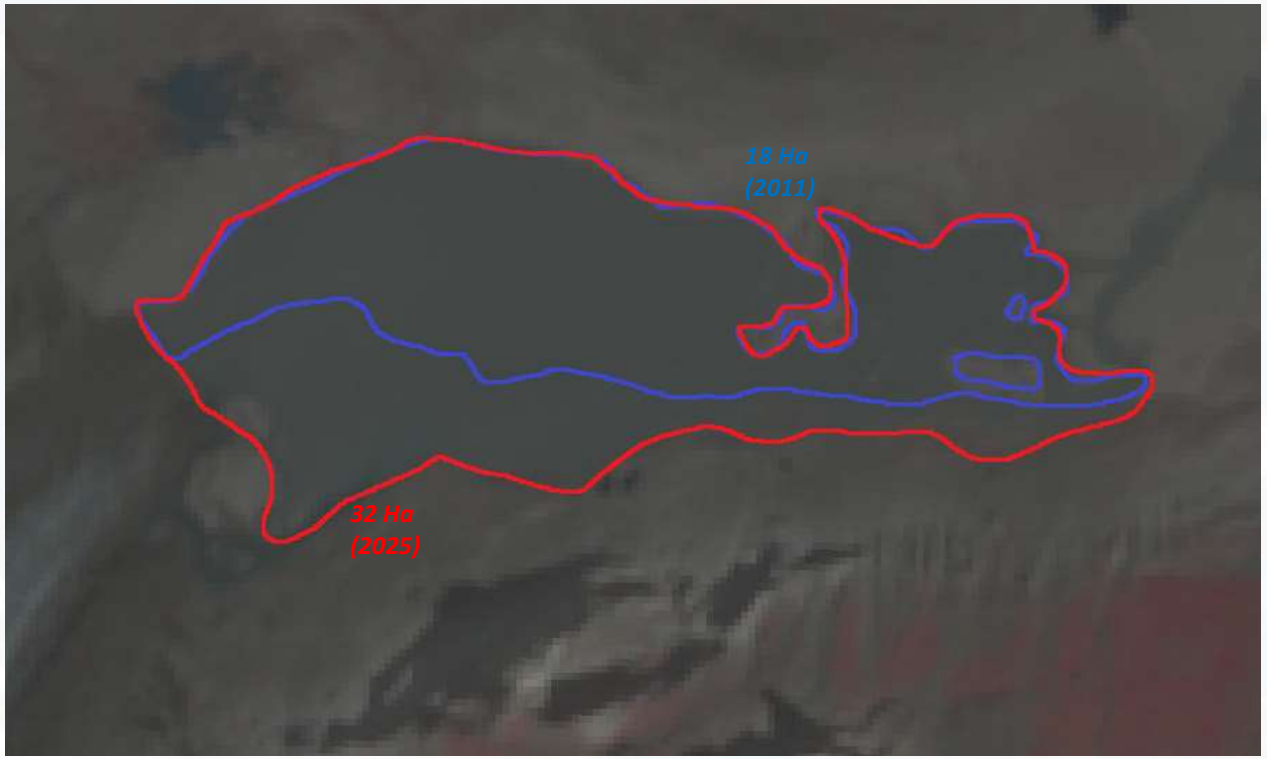
Lat 28° 3' 30.96"N Long 88° 37'52.32"E

Lake ID: 0143N1602259-***Ladakh***–***145% increase in area from 2021 to 2025***



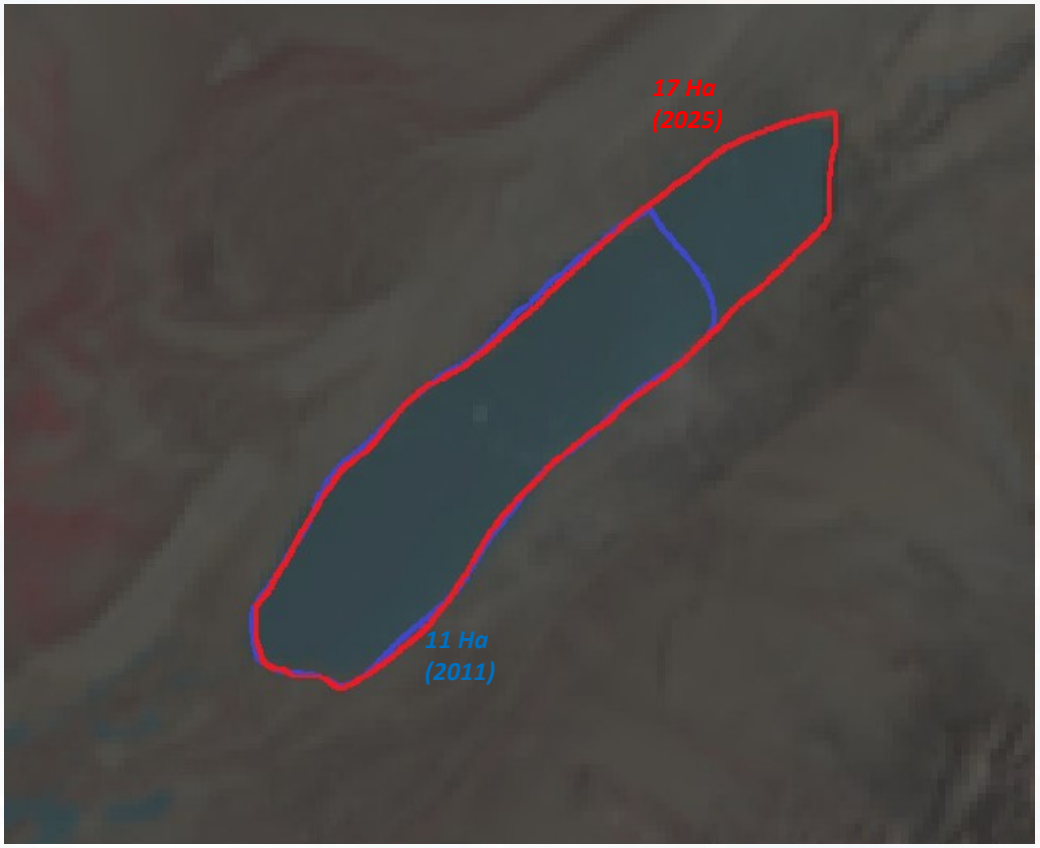
Lat 34° 2' 24.72"N Long 75° 50' 38.76"E

Lake ID: 0152C0503044-***Ladakh***–***73% increase in area from 2021 to 2025***



Lat 33° 50' 36.96"N Long 76° 22' 31.08"E

Lake ID: 0262B1100358-***Uttarakhand***–***52% increase in area from 2021 to 2025***



Lat 30° 23' 30.12"N Long 80° 31' 54.48"E

Discussion

- Increase in area of glacial lake is mostly associated with Glacier snout retreat. Such lakes and the retreating glaciers require close monitoring.
- Moraine strength and lake volume of increasing Glacial lakes needs to be assessed & moraine displacement should be closely watched.
- GLOF mitigation measures comprising structural measure(lowering of lake water level, strengthening of moraine, construction of retention structures) and non-structural measures(installation of early warning systems, capacity building of the downstream community) has to be taken up adequately.

THANK YOU