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BEFORE THE NATIONAL GREEN TRIBUNAL,
EASTERN ZONE BENCH,
AT KOLKATA

O.A. No. 171/2023/EZ

IN THE MATTER OF:
IN RE-NEWS ITEM PAPPEARED IN EAST MOJO ON 05.10.2023 TITLED "SIKKIM: HERE'S WHY THE CHAUNGTHANG HYDRO-DAM BREACH IN A BIG DEAL"

...APPLICANT(S)

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Through :

(Ashok Prasad)
Advocate,
Counsel for U.O.I.

Place : KOLKATA
Dated : 03/05/24

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BEFORE THE NATIONAL GREEN TRIBUNAL,
EASTERN ZONE BENCH,
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O.A. No. 171/2023/EZ

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...APPLICANT(S)

COUNTER AFFIDAVIT / REPLY FOR AND ON BEHALF OF THE RESPONDENT NO. 5

MOST RESPECTFULLY SHOWETH:

I, Shashwat Rai, Son of Late Dinesh Chandra Rai, aged about 35 years, employed / appointed as the Executive Engineer, Central Water Commission, Sikkim, functioning / officiating at Sikkim, do hereby solemnly affirm and declare as under:-

1. That I am the authorised signatory in the aforementioned matter. On the basis of records, I am well conversant with the facts of the case and hence, competent to swear this affidavit.

2. That I have read and understood the order dated 28.11.2023 of Hon'ble NGT, Eastern Zone Bench, and filed this Counter Affidavit in compliance of directions under Para 6 of the order dated 28.11.2023.

3. That I have read and understood the contents of the present Affidavit and state that the contents mentioned in the Affidavit are true and correct to the best of my knowledge.

4. That the deponent craves liberty to raise additional submission or file supplementary affidavits in case need arises during the course of arguments.

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BRIEF SUBMISSIONS

5. That the O.A. No. 171/2023/EZ is a case has been filed by the Hon'ble National Green Tribunal to restrain Respondent No. 5 from proceeding any further in the matter of **"Sikkim: Here's why the Chungthang Hydro-dam breach is a BIG DEAL"** news report published in the 'East Mojo' on 05.102023.

6. As per order dated 20.11.2023 in the said earlier O.A. 633/2023/PB, Ld. Tribunal constitute a committee and directed to file a report within 6(six) weeks before the Ld. NGT/EZ.

7. That in the O.A. 171/2023/EZ Ld. Tribunal in the order dated 28.11.2023 impleaded as a respondent no. 5 and directed to file the counter affidavit. And for the compliance of the order dated 28.11.2023 answering respondent prepare a report in the said matter.

   A copy of the Report of Central Water Commission is annexed herewith and marked as Annexure – R-1.

8. In view of the above facts indicated in earlier paras, it is respectfully prayed that this Respondent shall abide by any order or direction, passed by the Hon'ble Tribunal.

DEPONENT

अधिशासी अभियन्ता
Executive Engineer
सिक्किम अन्वेषण मंडल
Sikkim Investigation Division
के०ज०आ०,तादोंग, गंगटोक
CWC, Tadong, Gangtok, Sikkim

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SEAL OF THE OATH COMMISSIONER GANGTOK SIKKIM

VERIFICATION

I, Shashwat Rai, Son of Late Dinesh Chandra Rai, aged about 35 years the above-named deponent, do hereby verify that the contents of above this Counter Affidavit are true and correct on the basis of official record maintained by the answering respondent in the daily course of its business and state that neither any material has been concealed there from nor is any part of it false.

Signed and verified on this 23rd Day of April, 2024 at Kolkata.

Shashwat

DEPONENT

अधिशासी अभियन्ता
Executive Engineer
सिक्किम अन्वेषण मण्डल
Sikkim Investigation Division
केन्द्रीय जल आयोग, तादोंग, गंगटोक, सिक्किम
CWC, Tadong, Gangtok, Sikkim

Identified by Me

TRISHNA CHETTRI (ADVOCATE)
R/o Mamri Colony
Advocate

Ms. Preeti Basnett
Oath Commissioner
High Court of Sikkim
Vide Notification No. 40/HCS/30.09.2023

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Annexure – R-1 (Colly)

Report of Central Water Commission in OA 171/2023 before NGT Principal Bench, New Delhi transferred to Eastern Bench Zone, Kolkata on News item appeared in East Mojo on 05.10.2023 titled "Sikkim: Here's why the Chungthang Hydro-Dam breach is a BIG DEAL"

1. Central Water Commission (CWC) maintains a network of hydro-meteorological sites on all major rivers in India, which are used for hydro-meteorological data collection as well as flood forecasting purposes.

2. On the ensuing night of the GLOF (Glacial Lake Outburst Flood) event i.e. 3rd - 4th October 2023, due to sudden, heavy and unprovoked flow, the three CWC sites at Lachen, Rangma Range and Sangkalang got washed away (viz. River Staff Gauges, Benchmarks, Site Office etc) and network connectivity was completely disrupted, hence the river water level data couldn't be taken.

3. However, as soon as CWC got the information about the disastrous event, the same was communicated to all the concerned stakeholders further downstream viz. NHPC, District Authorities and State Disaster Management Authorities, at around 0130 hrs - 0200 hrs, and also thereafter on 4th October, 2023.

4. The operation and maintenance of hydropower projects in Sikkim and ensuring its safety is the responsibility of the respective Project Authorities such as NHPC and State Government. CWC do not have a direct say in the operation/ regulation of spillway gates in these hydro power projects.

5. Setting up of Early Warning System and taking other appropriate disaster risk mitigation initiatives is the responsibility of the State Disaster Management Authorities.

6. This is to mention that periodically, CWC also issues a Monitoring Report on the status of Glacial Lakes and Water Bodies (of specified size) to all the stakeholders, including the State Government like State of Sikkim, for information and further necessary action (Report attached).

7. Also, CWC, in March, 2015 had also shared an Advisory Report where different possible scenarios in case of breach of South Lhonak Lake in Sikkim and other Glacial Lakes in its vicinity were brought out and resultant quantifiable flood waves anticipated/ projected therein. The said report was shared with all stakeholders including the State Government for information and taking prompt action and also available in CWC Website. (Report attached)

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Annex. Para-C

सत्यमेव जयते

Monthly Monitoring Report

of

Glacial Lakes & Water Bodies in the Himalayan Region of Indian River Basins

(October, 2023)

Morphology & Climate Change Directorate

Central Water Commission

Department of Water Resources, River Development &

Ganga Rejuvenation

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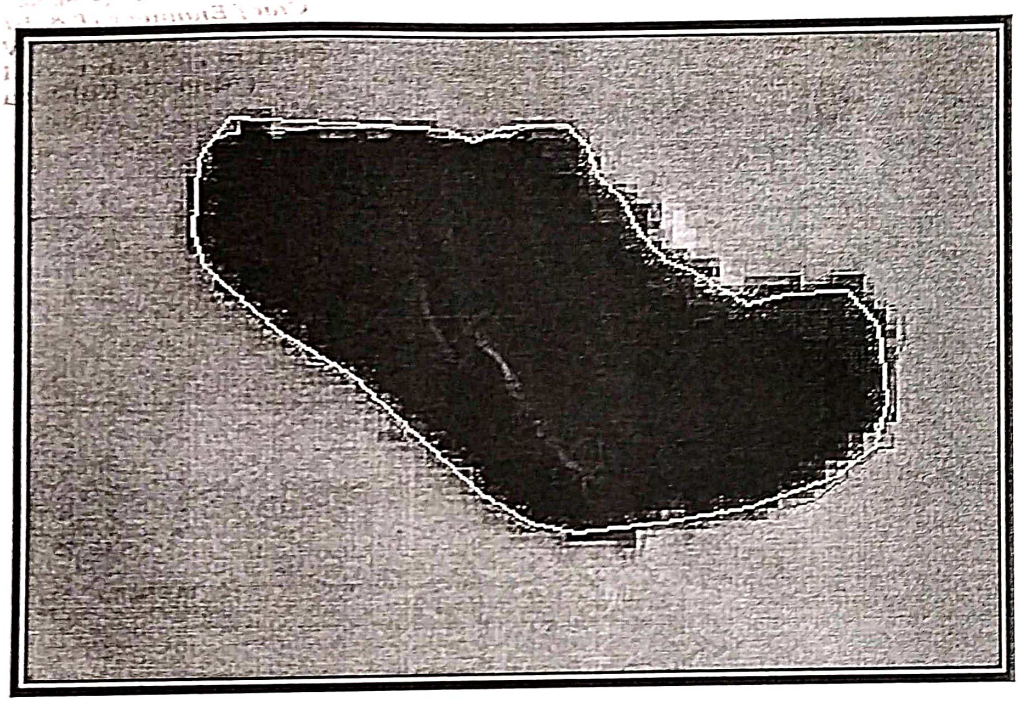
Monthly Monitoring Report of Glacial Lakes & Water Bodies in the Himalayan Region of Indian River Basins

(October, 2023)



Morphology & Climate Change Directorate

Central Water Commission

Department of Water Resources, River Development & Ganga Rejuvenation

Ministry of Jal Shakti, New Delhi

Document Control Sheet

1.	Report / Document Type	Technical report			
2.	Document Control Number	CWC/M&CC/GLWB/ 2023/TR-5			
3.	Title	**Monthly Monitoring Report of Glacial Lakes & Water Bodies in the Himalayan Region of Indian River Basins (October, 2023)**			
4.	Author(s)	Sh. V.D. Roy, Sh. Mohammad Zishan, Smt. Archa Raj D. & Sh. Rohit Kumar Yadav			
5.	Affiliation of authors	Morphology and Climate Change Directorate, CWC, New Delhi			
6.	Project Team	Sh. V.D. Roy, Sh. Mohammad Zishan, Smt. Archa Raj D. & Sh. Rohit Kumar Yadav, Sh. Chiradip Das			
7.	Scrutiny mechanism	Compiled by Smt. Archa Raj D. Assistant Director-II Sh. Mohammad Zishan Deputy Director	Reviewed by Sh. V.D. Roy, Director	Controlled by Sh. D.P.Mathuria, Chief Engineer, (P&DO)	Approved by Sh. P. M. Scott, Member (RM), CWC
8.	Originating unit	P&D organization, CWC, New Delhi			
9.	Date of Publication				
10.	Abstract (with Keywords): This document presents the details on monitoring of Glacial Lakes and water bodies in the Himalayan region and Tibetan region, draining to India. The work has been carried out using remote sensing technique. The adopted methodology is indicated in the report. The change in water spread area for 902 GL&WBs has been worked out. The Glacial Lakes requiring vigorous monitoring have been identified for the month of October, 2023. Keywords: Glacial Lake, Water Bodies, Himalayas, Satellite Images, Remote Sensing				

IP

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ABBREVIATIONS	
AR	Arunachal Pradesh
GEE	Google Earth Engine
GL	Glacial Lake
GLOF	Glacial Lake Outburst Flood
FCC	False Colour Composite
ha	Hectare
HP	Himachal Pradesh
J&K	Jammu & Kashmir
LAT	Latitude
LONG	Longitude
LU/LC	Land Use /Land Cover
NDWI	Normalised Difference Water Index
NDMA	National Disaster Management Authority
NRSC	National Remote Sensing Centre
SAR	Synthetic Aperture Radar
SDC	Swiss Agency for Development and Cooperation
SK	Sikkim
TAR	Tibet Autonomous Region
UID	Unique Identification
UK	Uttarakhand
WB	Water Body

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Executive Summary

The Himalayan Region (HR) is facing important challenges in view of coping with the adverse effects of climate change. Physically, the shrinking of mountain glaciers and expansion of Glacial Lakes are amongst the most recognizable and dynamic impacts of climate warming in this environment. In combination with this altered stability of surrounding rock and ice walls, the potential threat from Glacial Lake Outburst Flood (GLOF) is evolving over time. Therefore, under such changing environment, a close watch on the relative change in water spread area of even smaller lakes has become very crucial in this region.

Remote sensing technique being the most cost effective and reliable approach especially for remote and difficult to access terrain, has been applied for detecting water spread area of such lakes. For analysing and processing large number of remote sensed satellite imageries. Google Earth Engine (GEE), which is an open-source cloud computing platform, has been used. High resolution multi-spectral and microwave (SAR) images at 10m resolution from Sentinel satellite have been analysed. This facilitated in detecting lakes even in cloudy conditions.

The water spread areas for Glacial Lakes and Water Bodies has been calculated in an automatic manner. Manual digitisation, of the lakes was carried out wherever required. The algorithm for automation has been developed in-house in GEE. The detailed methodology is included in this report.

For the month of October, 2023, a total of 902 Glacial Lakes and Water Bodies have been monitored. It includes 477 Glacial Lakes & Water Bodies, with water spread area greater than 50 ha, which are being monitored since 2011. All Glacial Lakes with size of 10 ha and above as per NRSC inventory, 2009 have been monitored. Further, the critical Glacial Lakes as identified by Swiss agency for Development and Cooperation (SDC) for NDMA in their report titled "*Synthesis report on GLOF hazard and risk across the Indian Himalayan Region*" has also been included in monitoring.

The monitoring was based on analysis of 14013 satellite images in the month of October, 2023. From disaster point of view, the base year and average area for last 5 and 10 years, has been considered to determine the maximum change. It was observed that out of 477 GL&WBs with size greater than 50 ha, 26 GL&WBs have shown increase in water spread area greater than 40%, 188 GL&WBs have shown increase in water spread area less than 40%, 28 GL&WBs have shown no change in water spread area, 220 GL&WBs have shown decrease in water spread area, and change detection for remaining GL&WBs could not be performed due to various reasons like frozen condition, dried up condition, cloud cover etc.

Further, for the remaining 425 Glacial Lakes with water spread area of 50 to 10 ha or

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smaller, the area of the GLs for the month of October 2023 was compared with the average area of GL for the year 2022(average of June to October 2022). Out of these, 215 GL have shown an increase in water spread area, 37 GL have shown no change in water spread area, 156 GL have shown decrease in water spread area, and change detection for remaining Glacial Lakes could not be performed.

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1. Introduction

1.1 Background

Glacial retreat due to climate change occurring in most parts of the Hindu Kush Himalaya has given rise to the formation of numerous new Glacial Lakes. The water in these Glacial Lakes accumulates behind loose naturally formed 'glacial/moraine dams' made of ice, sand, pebbles and ice residue as the glaciers melt. Different types of lakes may have different levels of hazard potential depending upon many factors like the nature of the damming materials, the position of the lake, the volume of the water, the nature and position of the associated mother glacier, physical and topographical conditions, and other physical conditions of the surroundings. Interaction between the above-mentioned risk factors and triggering processes like ice avalanches, debris flows, rockfall, earthquake or landslides reaching a lake strongly affect the risk of a lake outburst. For instance, moraine-dammed lakes located at the snout of a glacier have a high probability of breaching with high hazard potential whereas there is a reduced risk of breaching in case of erosion lakes.

Glacial Lake Outburst Flood (GLOF) is created when water dammed by a glacier or a moraine is released suddenly. Some of the Glacial Lakes are unstable and particularly moraine dammed lakes are potentially susceptible to sudden discharge of large volumes of water and debris which causes floods downstream. Climate change is expected to alter and potentially increase the probability of lake outbursts in the future.

1.2 Remote Sensing Technology

Remote sensing is the science of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analysing, and applying that information. Satellite remote sensing (SRS) technology has contributed significantly to the acquisition of Earth's resources, thus helping in their better management. SRS plays a complementary role to other means of spatial data acquisitions i.e., through conventional procedures. Satellite remote sensing offers several unique advantages quick data collection, reliability, more accurate, repetitive collection, geometric integrity and digital storage, which makes it an ideal tool for mapping, inventorying and monitoring the natural resources.

Due to the remote location of Glaciers and Glacial Lakes their access is difficult, owing to tough and difficult terrain. Thus, preparation of inventory of Glacial Lakes using conventional methods requires extensive time and resources together with undergoing hardships in the field. Creating inventories and monitoring of the Glacial Lakes can be done quickly and correctly using satellite images and aerial photographs. Use of these

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images and photographs for the evaluation of physical conditions of the area provides greater accuracy. The multi-stage approach using remotely sensed data and field investigation increases the ability and accuracy of the work. Visual and digital image analysis techniques integrated with techniques of geographic information systems (GIS) are very useful for the study of Glacier and Glacial Lakes.

1.3 Objectives

The broad objectives of the study are

- To monitor the spatial extent in terms of water spread area of the Glacial Lakes & Water Bodies on monthly basis during June to October.
- To detect changes in water spread area of GL&WBs with respect to historical information & base year.
- To detect any sharp change in area of GL&WBs for disaster purpose
- To share the monitoring reports with concerned stakeholders including National Disaster Management Authority / State Disaster Management Authority.

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2. Study Area &Satellite Data Used

2.1 Study Area

The present study area covers the GL& WBs lying in the region of Himalaya and Tibet that drains to India as shown in Figure 2. The study area extends across different countries, namely, India, Nepal, Bhutan and China.

The Glacial Lakes and Water Bodies taken up for the monitoring in the study area are as follows:

- Monitoring of 477 Glacial Lakes and Water Bodies, with water spread area greater than 50 ha which have been included from the inventory of Glacial Lakes & Water Bodies in the Indian Himalayan region using satellite data of the year 2009 prepared by NRSC (Ref: NRSC Report No. NRSC-RS&GISAA-WRG-CWC-Lakes- May2011-TR255).
- Monitoring of 385 Glacial Lakes, with spatial extent greater than 10 ha, which have been taken from the inventory of Glacial Lakes & Water Bodies in the Indian Himalayan region using satellite data of the year 2009 prepared by NRSC (Ref: NRSC Report No. NRSC-RS&GISAA-WRG-CWC-Lakes-May2011-TR255).
- Monitoring of 40 Glacial Lakes, which have been listed as high priority lakes, as per Synthesis report on GLOF hazard and risk across the Indian Himalayan Region prepared by Swiss Agency for Development and Cooperation (SDC) for NDMA.

A total of 902 Glacial Lakes and Water Bodies have been monitored. Of these, 544 are Glacial Lakes and 358 are Water Bodies. All Glacial Lakes of size 10 ha and above as per NRSC 2009 inventory and few Glacial Lakes of size smaller than 10 ha as identified by SDC have also been included for monitoring. The break-up of Glacial Lakes and Water Bodies is shown in Figure 1.

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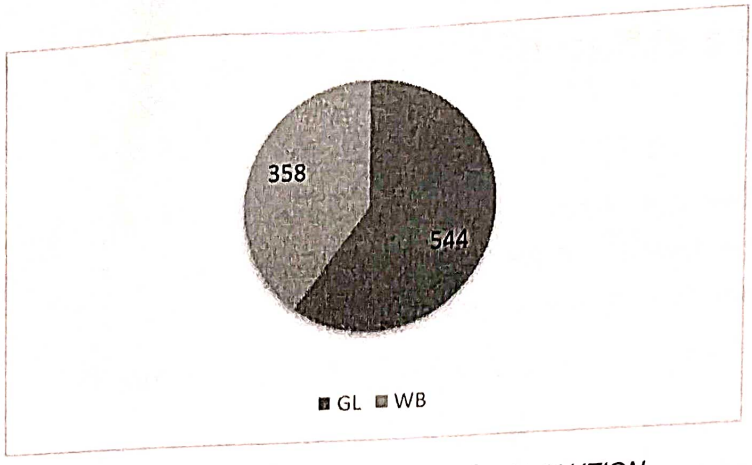

FIGURE 1: LAKE TYPE DISTRIBUTION

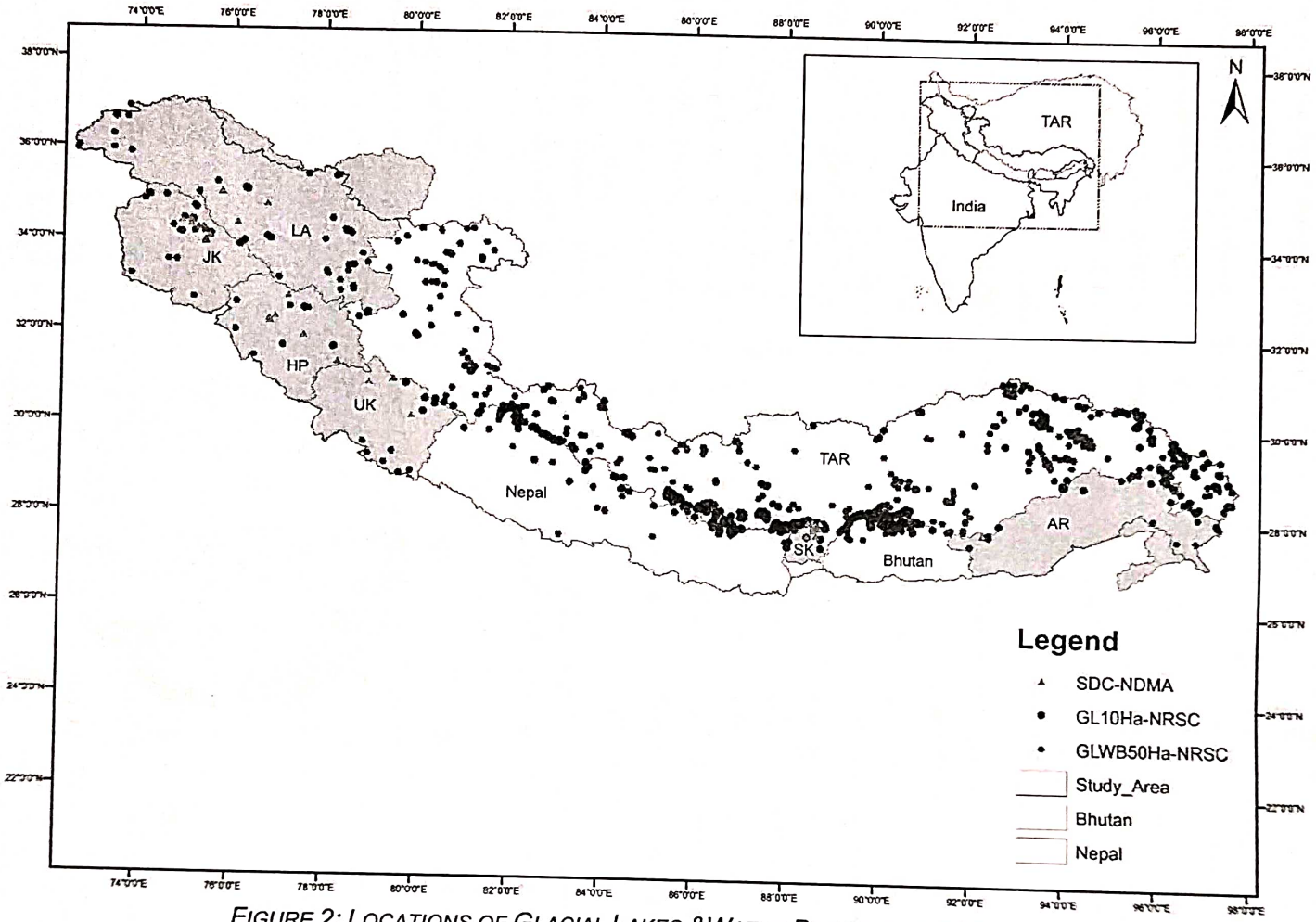

FIGURE 2: LOCATIONS OF GLACIAL LAKES &WATER BODIES IN THE STUDY AREA

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2.2 Satellite Data Used

2.2.1 Sentinel-2 MSI

It is a wide-swath, high-resolution, multi-spectral imaging mission, supporting Copernicus Land Monitoring studies, including the monitoring of vegetation, soil and water cover, as well as observation of inland waterways and coastal areas. The SENTINEL-2 Multispectral Instrument (MSI) samples 13 spectral bands: four bands at 10 metres, six bands at 20 metres and three bands at 60 metres spatial resolution. The revisit frequency of each single SENTINEL-2 satellite is 10 day and the combined constellation revisit is 5 day.

2.2.2 Sentinel-1SAR (Micro)

It has C-band synthetic aperture radar (SAR) active sensor which can observe the Earth's surface at any time of the day or night, regardless of weather and environmental conditions. SAR has the advantage of operating at wavelengths not impeded by cloud cover or lack of illumination. SAR actively transmits microwave signals towards the Earth and receives a portion of transmitted energy as backscatter from the ground. The SAR instrument provides radar backscatter measurements influenced by the terrain structure and surface roughness. Generally, the more roughness or structure on the ground, the greater the backscatter. Rough surfaces will scatter the energy and return a significant amount back to the antenna resulting in a bright feature. The repeat orbit cycle of each Sentinel-1 satellite is 12-day.

The numbers of satellite images processed for the month of October - 2023 were 14013. Of these, 9363 were Multispectral images and 4650 were Microwave images as shown in Figure 3.

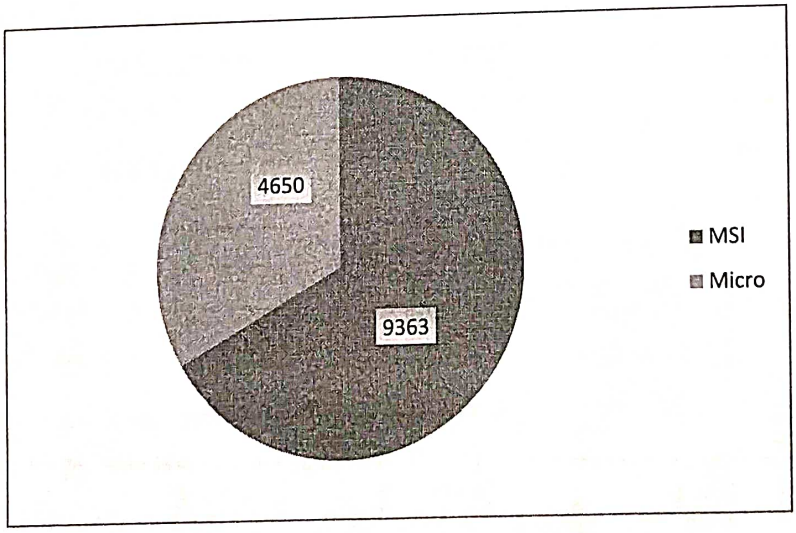

FIGURE 3: ANALYSED SATELLITE IMAGES DISTRIBUTION

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3.Methodology

Google Earth Engine (GEE) being a planetary-scale platform for Earth science data & analysis has been used to process the Multispectral and Microwave Sentinel image data for the monitoring of Glacial Lakes & water bodies. The Microwave and Multispectral Satellite works on different principle, hence separate methodology has been applied to compute the water spread area of GL&WBs in an automatic manner.

Multispectral data consist of visible and infrared bands. The spectral combination of NIR, red & green bands is used to generate false colour composite (FCC). The Normalised Difference Water Index (NDWI) is computed using green and NIR band. The process of calculation of NDWI and FCC is repeated for each GL&WB. The OTSU algorithm is further used to identify the threshold of NDWI for segregating water pixels from other types of features. The detected water pixels are further summed to calculate water spread area in the region of interest.

Microwave data of Sentinel-1 is a phase-preserving dual polarisation SAR system. It can transmit a signal in either horizontal (H) or vertical (V) polarisation, and then receive in both H and V polarisations. The backscatter intensity of vertical transmit vertical receive (X) band has been used to distinguish water pixels from other types of features. The OTSU algorithm is further used to identify the threshold of backscatter intensity for segregation. The water spread area of each lake has been calculated by summation of water pixels in the region of interest.

It has also been observed that some GL&WBs are required to be delineated manually based on the visual interpretation of satellite images. This is due to the fact that region being monitored has rugged terrain with steep mountains and valleys, which may lead to effects like foreshortening, layover, mountain shadows etc in the microwave/SAR data. Also, the cloud cover on many occasions hinders the performance of Multispectral Satellite data. Thus, creating difficulty in interpreting the signal through automatic means.

The change detection in water spread area of Lake has been calculated for following three cases.

- Difference between the current area of lake and base year
- Difference between the current area of lake and Last five years average area
- Difference between the current area of lake and Last ten years average area

The minimum of change observed in three cases has been adopted to identify increase, decrease and no change in water spread area.

The detailed flow-chart of methodology for automatic monitoring of Glacial Lakes and Water Bodies using satellite images is given below in Figure 4.

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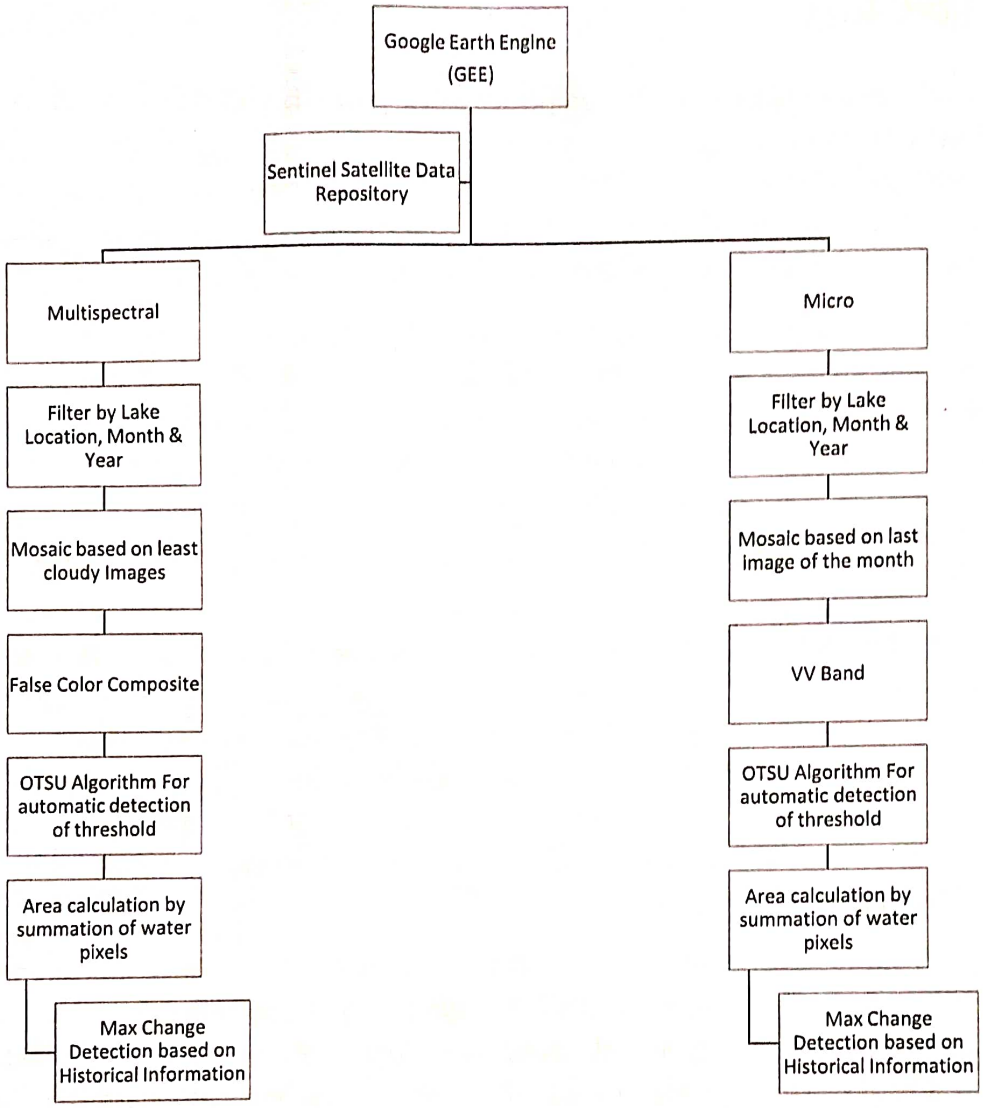

FIGURE 4: METHODOLOGY OF AUTOMATIC MONITORING OF GLACIAL LAKES & WATER BODIES USING SATELLITE IMAGES

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4. Results

The water spread area of 902 Glacial Lakes & Water Bodies was calculated for the month of October 2023 in an automatic manner and manually digitized wherever required using the methodology described above. It includes 477 GL&WBs with water spread area greater than 50ha which are being monitored since the year 2011 and 425 GL&WBs with water spread area 50 ha to 10 ha or smaller being monitored from the year 2022.

For 477 GL & WBs, the water spread area of October, 2023 and maximum detected change in water spread area with respect to base year, last 5 years average area & last 10 years average area is shown in Table 1 to Table 5.

The remaining 425 Glacial Lakes with size up to 10 ha or smaller were monitored from the year 2022. The water spread area for such lakes for the month of October, 2023 and the change detection with respect to average area of the year 2022(June to October 2022) was calculated and is shown Table 6 and Table 7.

It was observed that out of 477 GL&WBs with size greater than 50ha, 26 GL&WBs have shown increase in water spread area greater than 40%, 188 GL&WBs have shown increase in water spread area but less than 40%, 28 GL&WBs have shown no change in water spread area, 220 GL&WBs have shown decrease in water spread area, and change detection for remaining GL&WBs could not be performed due to various reasons like frozen condition, dried up condition, cloud cover etc.

Further, out of 425 Glacial Lakes with size up to 10 ha or smaller, 215 GL have shown an increase in water spread area, 37 GL have shown no change in water spread area, 156 GL have shown decrease in water spread area, and change detection for remaining Glacial Lakes could not be performed.

The same is shown in Figure 5.

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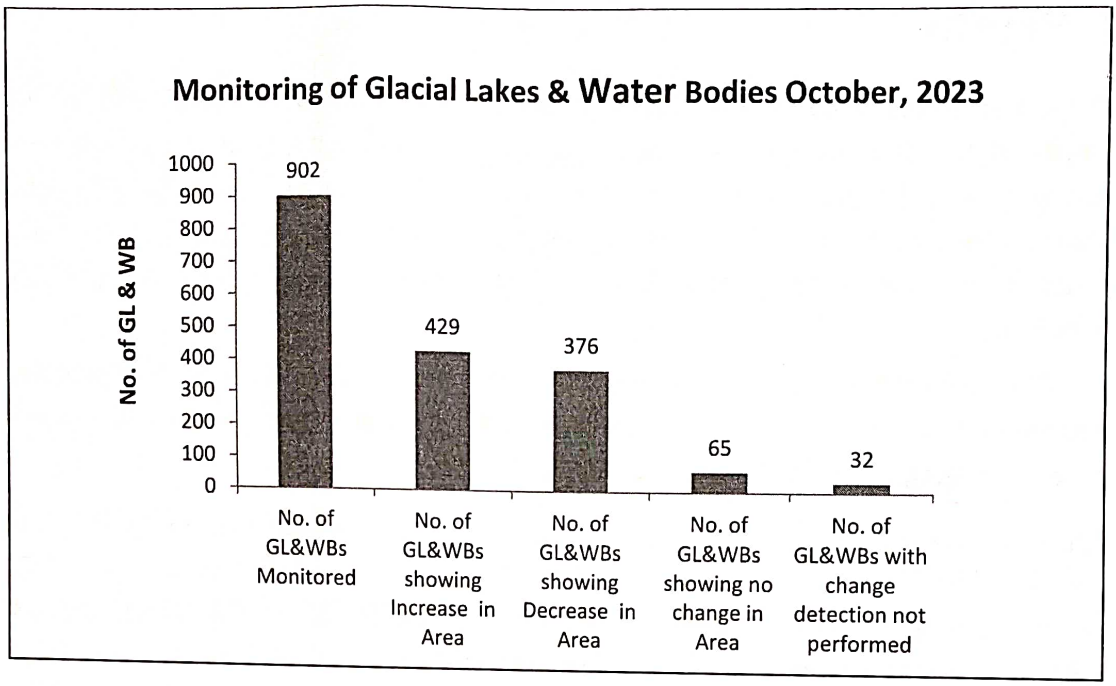

FIGURE 5: OVERALL CHANGES IN WATER SPREAD AREA OF GL&WBS FOR OCTOBER, 2023

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5. Conclusions

- 5 Glacial Lakes and 21 Water Bodies of size greater than 50 ha are required **to be vigorously monitored for disaster purpose**. These Glacial lakes/water bodies have shown increase in water spread area greater than 40%. 4 Glacial lakes and 16 Water Bodies are in China, 1 Water Body is in Bhutan and 1 Glacial Lake & 4 Water Bodies are in India. The Glacial Lake in India is located in Sikkim and Water Bodies in Ladhak(1No.) & Arunachal Pradesh(3 Nos.). The details of these Glacial lake/ water bodies have been highlighted in Table 1.
- 55 Glacial Lakes of size greater than 50 ha have shown marginal increase in water spread area ranging from 1 to 40%, while 5 Glacial Lakes of size greater than 50 ha have shown no change and 51 Glacial Lakes of size greater than 50 ha have shown decrease in water spread area.
- 19 Glacial lakes of size greater than 10 ha (up to 50 Ha) and 4 GL of size less than 10 ha have also shown an increase in water spread area greater than 40% in comparison to the average area of the lakes for the year 2022.
- Google Earth Engine (GEE) has proved to be a very useful and efficient tool in processing large information equivalent to 14013 satellite images in least possible time.
- Automatic algorithm developed in GEE has expedited the process of calculation of water spread area, which has resulted in increase of monitoring of number of lakes from 477 to 902 without any increase in manpower resource and financial implications.
- Use of Microwave satellite image in conjunction with multispectral satellite image (MSI) has overcome short-comings of cloud cover leading to monitoring of all 902 Lakes in all weather conditions. This has increased availability of satellite images at shorter frequency interval. This will further facilitate in reducing the monitoring interval in future.
- The use of Sentinel satellite image has increased the spatial resolution from 56m to10m leading to enhancement of monitoring accuracy. Sentinel images have also aided in improving the temporal resolution.

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6. References

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*TABLE 1: LIST OF GL&WBS WITH WATER SPREAD GREATER THAN 50 HA SHOWING MORE THAN 40% INCREASE IN AREA (**REQUIRING VIGOROUS MONITORING**)*

Sl. No.	Lake ID	Inventory Developed by	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
1	03_82O_047	NRSC	CH_1039	3574	WB	Brahmaputra	Dihang	China	51	-	8	16	219
2	03_91C_074	NRSC	CH_1102	4258	GL	Brahmaputra	Dibang	China	54	-	17	21	157
3	03_91H_017	NRSC	CH_1182	4590	WB	Brahmaputra	Lohit	China	45	-	14	18	150
4	03_82O_044	NRSC	CH_1037	3552	WB	Brahmaputra	Dihang	China	87	-	-	35	149
5	03_78I_085	NRSC	BH_166	4764	WB	Brahmaputra	Puna Tsang Chhu	Bhutan	72	-	12	31	132
6	03_82K_042	NRSC	CH_898	4364	WB	Brahmaputra		China	184	-	35	85	116
7	03_82K_049	NRSC	CH_905	4180	WB	Brahmaputra		China	45	-	18	21	114
8	03_91C_049	NRSC	AP_95	4261	WB	Brahmaputra	Dibang	India	66	-	15	32	106
9	03_82K_040	NRSC	CH_896	4329	WB	Brahmaputra		China	54	-	23	27	100
10	03_91C_070	NRSC	CH_1098	4252	WB	Brahmaputra	Dibang	China	57	-	21	29	97

Sl. No.	Lake ID	Inventory Developed by	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
11	03_91C_005	NRSC	CH_1056	4926	GL	Brahmaputra		China	95	-	16	50	90
12	03_92A_005	NRSC	AP_203	3391	WB	Brahmaputra	Lohit	India	50	-	17	27	85
13	03_91C_078	NRSC	CH_1106	3694	WB	Brahmaputra	Dibang	China	47	-	26	26	81
14	03_82J_024	NRSC	CH_854	4362	WB	Brahmaputra		China	68	-	25	38	79
15	03_82K_007	NRSC	CH_863	4294	WB	Brahmaputra		China	140	-	49	79	77
16	03_82K_103	NRSC	CH_959	3964	WB	Brahmaputra		China	40	-	15	23	74
17	03_78A_021	NRSC	SK_26	5431	GL	Brahmaputra	Teesta	India	94	56	53	50	68
18	03_91D_080	NRSC	CH_1135	4295	WB	Brahmaputra	Lohit	China	41	-	25	20	64
19	03_82J_019	NRSC	CH_849	3944	GL	Brahmaputra		China	104	-	64	52	63
20	03_82F_016	NRSC	CH_741	4632	WB	Brahmaputra		China	48	-	28	31	55
21	03_91C_042	NRSC	AP_89	4531	WB	Brahmaputra	Dibang	India	49	-	19	32	53
22	03_91H_011	NRSC	CH_1176	4494	WB	Brahmaputra	Lohit	China	56	-	37	32	51
23	03_82N_019	NRSC	CH_990	4877	WB	Brahmaputra		China	58	-	39	39	49

24	03_82J_008	NRSC	CH_838	4036	GL	Brahmaputra		China	245	166	167	165	47
Sl. No.	**Lake ID**	**Inventory Developed by**	**UID**	**Elevation (m) (m)**	**Lake Type**	**Basin**	**River**	**Country**	**Area of October-2023 (ha)**	**Area of Base Year of 2011 (ha)**	**Area of Last 5 Years (ha)**	**Area of Last 10 years (ha)**	**Max Change in Area (%)**
25	03_82K_045	NRSC	CH_901	4572	WB	Brahmaputra		China	41	-	28	25	46
26	01_52I_004	NRSC	JK_196	5141	WB	Indus	Shyok	India	91	-	63	62	44

G stands for Ganga, I for Indus and B for Brahmaputra under the rank of vulnerability
-Unobservable (as per NRSC), Ø indicates small rivulet/first order stream

TABLE 2: GL&WBS WITH WATER SPREAD GREATER THAN 50 HA THAT HAVE SHOWN INCREASE IN WATER SPREAD AREA

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
1	03_77L_010	NRSC		CH_526	4457	WB	Brahmaputra		China	56	-	40	37	40
2	03_82G_060	NRSC		CH_821	4577	WB	Brahmaputra		China	61	-	34	44	39
3	03_82N_004	NRSC		CH_975	4290	GL	Brahmaputra		China	145	106	71	75	37
4	03_91C_059	NRSC		CH_1089	4303	WB	Brahmaputra	Dibang	China	104	-	76	72	37
5	02_62J_003	NRSC	254G	NP_19	4854	WB	Ganga	Karnal	Nepal	61	-	45	42	36
6	03_82K_002	NRSC		CH_858	3998	WB	Brahmaputra		China	77	57	50	44	35
7	03_82O_062	NRSC		AP_55	3612	WB	Brahmaputra	Dibang	India	56	42	9	24	33
8	03_91D_010	NRSC		AP_109	3323	WB	Brahmaputra	Dibang	India	53	-	40	34	33
9	03_91D_009	NRSC		AP_108	4037	WB	Brahmaputra	Dibang	India	49	-	37	30	32
10	03_82J_025	NRSC		CH_855	4038	WB	Brahmaputra		China	78	59	45	41	32
11	03_91H_010	NRSC		CH_1175	4433	WB	Brahmaputra	Lohit	China	95	-	73	66	30
12	03_77L_043	NRSC		CH_552	5200	GL	Brahmaputra	Kuri Chhu	China	242	178	188	189	28
13	03_82L_009	NRSC		CH_971	3893	GL	Brahmaputra		China	76	55	60	54	27

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
14	03_82O_064	NRSC		AP_57	3689	WB	Brahmaputra	Dihang	India	47	-	37	31	27
15	03_77L_014	NRSC		CH_530	5289	WB	Brahmaputra		China	47	-	37	36	27
16	03_92E_001	NRSC		AP_206	4206	WB	Brahmaputra	Lohit	India	54	-	43	30	26
17	03_91C_040	NRSC		AP_87	4450	WB	Brahmaputra	Lohit	India	88	-	71	60	24
18	03_91H_040	NRSC		CH_1205	4324	WB	Brahmaputra	Lohit	China	56	-	45	41	24
19	03_78M_022	NRSC		BH_197	4549	WB	Brahmaputra	Dangme Chhu	Bhutan	69	-	54	56	23
20	01_61C_011	NRSC		CH_39	4494	WB	Indus	Indus	China	661	434	539	472	23
21	03_91C_024	NRSC		CH_1075	3977	GL	Brahmaputra		China	360	287	298	280	21
22	03_78E_029	NRSC		BH_73	4250	WB	Brahmaputra	Puna Tsang Chhu	Bhutan	40	-	33	28	21
23	03_77L_066	NRSC		BH_34	4896	GL	Brahmaputra	Manas Chhu &Mange Chhu	Bhutan	162	134	132	133	21
24	03_82K_074	NRSC		CH_930	4553	WB	Brahmaputra		China	82	-	68	64	21
25	03_78E_023	NRSC		CH_612	5291	GL	Brahmaputra		China	68	-	48	56	21
26	03_78M_010	NRSC		BH_188	4496	WB	Brahmaputra	Dangme Chhu	Bhutan	42	-	35	33	20

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
27	03_82P_010	NRSC		AP_67	1676	WB	Brahmaputra	Dibang	India	97	-	81	68	20
28	03_91C_064	NRSC		AP_100	3972	WB	Brahmaputra	Dibang	India	86	-	72	65	19
29	03_78I_023	NRSC		BH_104	5055	GL	Brahmaputra	Manas Chhu &Mane Chhu	Bhutan	62	52	48	44	19
30	03_91C_038	NRSC		AP_85	4002	WB	Brahmaputra	Dibang	India	100	-	73	85	18
31	01_43K_010	NRSC		JK_111	3946	WB	Indus	Jhelum	India	77	65	60	60	18
32	03_91C_052	NRSC		CH_1085	4591	WB	Brahmaputra	Lohit	China	45	-	34	38	18
33	02_71P_054	NRSC		CH_242	4859		Ganga	Arun Kosi	China	89	-	76	75	17
34	02_71L_010	NRSC	185G	CH_165	5387	GL	Ganga	Sun Kosi	China	62	-	53	46	17
35	03_77H_023	NRSC		CH_492	5313	WB	Brahmaputra		China	48	-	41	33	17
36	02_71P_025	NRSC		CH_213	4807	WB	Ganga	Arun Kosi	China	148	110	127	107	17
37	03_82K_017	NRSC		CH_873	4397	WB	Brahmaputra		China	181	-	146	155	17
38	01_52K_012	NRSC		JK_220	4695	WB	Indus	Indus	India	187	160	159	156	17
39	03_91C_069	NRSC		AP_101	3245	WB	Brahmaputra	Dibang	India	84	72	46	45	17
40	03_78M_019	NRSC		BH_194	4697	WB	Brahmaputra	Dangme Chhu	Bhutan	52	-	45	45	16
41	02_77D_008	NRSC	266G	CH_263	5285	GL	Ganga	Arun Kosi	China	50	-	43	34	16

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Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
42	02_78A_004	NRSC	194G	CH_270	5603	GL	Ganga	Arun Kosi	China	118	85	102	95	16
43	03_77L_017	NRSC		CH_533	5340	WB	Brahmaputra		China	88	76	75	71	16
44	01_52H_005	NRSC		HP_6	4286	WB	Indus	Chenab	India	50	-	43	38	16
45	03_91D_041	NRSC		AP_135	3526	WB	Brahmaputra	Dibang	India	128	110	103	85	16
46	03_78E_028	NRSC		BH_72	2161	WB	Brahmaputra	Puna Tsang Chhu	Bhutan	51	-	44	35	16
47	03_82G_065	NRSC		CH_826	4148	WB	Brahmaputra		China	68	-	55	59	15
48	02_71P_040	NRSC	126G	CH_228	4962	WB	Ganga	Arun Kosi	China	151	131	129	115	15
49	03_77D_003	NRSC		SK_3	5098	WB	Brahmaputra	Teesta	India	112	97	93	91	15
50	03_78M_020	NRSC		BH_195	4157	WB	Brahmaputra	Dangme Chhu	Bhutan	68	59	54	56	15
51	03_82G_055	NRSC		CH_816	4619	WB	Brahmaputra		China	49	-	31	43	14
52	03_78E_002	NRSC		BH_57	5110	GL	Brahmaputra	Puna Tsang Chhu	Bhutan	67	59	35	40	14
53	03_77L_042	NRSC		CH_551	5057	GL	Brahmaputra	Kuri Chhu	China	70	62	61	60	13
54	02_72I_025	NRSC	66G	NP_78	4884	GL	Ganga	Sun Kosi	Nepal	142	102	126	111	13
55	03_82B_028	NRSC		CH_654	4998	WB	Brahmaputra		China	51	-	45	40	13
56	03_71K_003	NRSC		CH_426	4982	WB	Brahmaputra		China	98	73	87	76	13

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October 2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
57	03_82B_021	NRSC		CH_647	5041	WB	Brahmaputra		China	59	52	44	39	13
58	03_78E_026	NRSC		CH_613	5161	GL	Brahmaputra	Amo Chhu	China	48	-	43	43	12
59	03_78E_007	NRSC		BH_60	5008	GL	Brahmaputra	Puna Tsang Chhu	Bhutan	75	67	47	52	12
60	03_82F_022	NRSC		CH_747	4200	GL	Brahmaputra		China	109	98	89	93	11
61	03_62J_026	NRSC		CH_298	5078	GL	Brahmaputra		China	136	115	123	116	11
62	02_71H_029	NRSC	1G	CH_149	5098	GL	Ganga	Sun Kosi	China	538	484	411	452	11
63	03_77K_015	NRSC		CH_517	4455	WB	Brahmaputra		China	120	106	108	106	11
64	02_72I_027	NRSC	41G	NP_80	4977	GL	Ganga	Sun Kosi	Nepal	86	78	73	73	10
65	02_71L_022	NRSC	122G	CH_187	5250	GL	Ganga	Sun Kosi	China	56	51	51	51	10
66	03_73C_011	NRSC		CH_404	4684	WB	Brahmaputra		China	169	127	153	138	10
67	02_73L_004	NRSC	5G	CH_159	5518	GL	Ganga	Arun Kosi	China	125	78	114	92	10
68	03_82G_031	NRSC		CH_812	4735	WB	Brahmaputra		China	46	-	42	35	10
69	03_91H_001	NRSC		CH_1170	4123	WB	Brahmaputra	Lohit	China	66	56	60	46	10
70	03_82J_028	NRSC		CH_853	4315	WB	Brahmaputra		China	113	101	103	99	10
71	01_52J_009	NRSC		JK_205	5576	WB	Indus	Shyok	India	67	61	56	51	10
72	02_72M_016	NRSC	7G	NP_82	4572	GL	Ganga	Arun Kosi	Nepal	217	139	199	163	9

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
73	03_77O_002	NRSC		CH_565	3806	WB	Brahmaputra		China	89	82	80	79	9
74	03_82B_005	NRSC		CH_631	4888	WB	Brahmaputra		China	234	215	211	203	9
75	03_91H_067	NRSC		AP_185	3791	WB	Brahmaputra	Lohit	India	51	-	44	47	9
76	03_91D_022	NRSC		AP_118	3143	WB	Brahmaputra	Dibang	India	39	-	36	30	8
77	01_52H_004	NRSC		HP_5	4155	GL	Indus	Chenab	India	154	-	142	114	8
78	02_72I_004	NRSC	9G	CH_244	5074	GL	Ganga	Sun Kosi	China	218	125	201	174	8
79	03_77L_044	NRSC		BH_19	4385	GL	Brahmaputra	Puna Tsang Chhu	Bhutan	131	121	103	110	8
80	02_77D_006	NRSC		CH_261	4894	GL	Ganga	Arun Kosi	China	105	89	92	97	8
81	01_53A_002	NRSC		HP_10	495	WB	Indus	Satluj	India	13145	12198	11339	11603	8
82	03_82J_014	NRSC		CH_844	3703	WB	Brahmaputra		China	198	183	158	147	8
83	03_77N_004	NRSC		CH_563	3890	WB	Brahmaputra		China	1353	1257	1238	1231	8
84	03_62J_011	NRSC		CH_283	5181	WB	Brahmaputra		China	411	355	380	365	8
85	02_71D_007	NRSC		NP_48	700	WB	Ganga	Trisuli	Nepal	318	294	281	280	8
86	03_62K_012	NRSC		CH_316	5368	GL	Brahmaputra		China	92	78	85	75	8
87	02_62F_019	NRSC	144G	NP_12	5039	WB	Ganga	Karnal	Nepal	69	56	64	59	8
88	03_62O_002	NRSC		CH_347	4587	WB	Brahmaputra		China	53	47	49	42	8

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
89	02_77D_009	NRSC	71G	CH_264	5296	GL	Ganga	Arun Kosi	China	60	56	46	44	7
90	03_91C_014	NRSC		CH_1065	4033	GL	Brahmaputra		China	48	-	45	42	7
91	02_72I_011	NRSC	1G	NP_64	5034	GL	Ganga	Sun Kosi	Nepal	171	103	160	130	7
92	01_52L_002	NRSC		JK_226	4986	WB	Indus	Indus	India	451	406	423	408	7
93	03_77H_018	NRSC		CH_488	4699	WB	Brahmaputra		China	89	75	83	77	7
94	02_71P_047	NRSC	81G	CH_235	5614	GL	Ganga	Arun Kosi	China	92	82	86	72	7
95	03_82B_008	NRSC		CH_634	4928	WB	Brahmaputra		China	280	262	262	254	7
96	01_43N_027	NRSC		JK_154	3683	WB	Indus	Jhelum	India	47	-	44	38	7
97	03_82C_010	NRSC		CH_665	4921	WB	Brahmaputra		China	159	149	120	128	7
98	01_61C_002	NRSC		CH_30	4494	WB	Indus	Indus	China	882	717	822	779	7
99	02_71L_023	NRSC	39G	CH_178	5106	GL	Ganga	Arun Kosi	China	137	124	128	121	7
100	01_52G_001	NRSC		JK_189	5008	WB	Indus	Shyok	India	47	-	44	38	7
101	03_77D_004	NRSC/SDC	/Very High Risk	SK_4	5287	GL	Brahmaputra	Teesta	India	131	113	122	112	7
102	03_77P_020	NRSC		CH_591	4649	WB	Brahmaputra	Kuri Chhu	China	62	58	45	50	7
103	03_78I_048	NRSC		BH_129	4169	WB	Brahmaputra	Manas Chhu &Mange Chhu	Bhutan	55	52	32	38	6

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
104	02_71L_001	NRSC		CH_156	5106	WB	Ganga	Arun Kosi	China	90	81	85	82	6
105	03_71K_007	NRSC		CH_430	4752	WB	Brahmaputra		China	102	96	82	80	6
106	02_62P_003	NRSC	4G	NP_36	4937	GL	Ganga	Trisuli	Nepal	350	330	320	298	6
107	01_43M_003	NRSC		JK_120	2663	WB	Indus	Shigar (Indus)	India	238	198	224	220	6
108	01_61G_002	NRSC		CH_63	4663	WB	Indus	Indus	China	1382	1218	1308	1264	6
109	01_43G_001	NRSC		JK_67	346	WB	Indus	Jhelum	India	24435	22572	22977	22344	6
110	03_77D_005	NRSC/SDC	Very High Risk	SK_5	5249	GL	Brahmaputra	Teesta	India	104	98	94	84	6
111	03_78E_009	NRSC		CH_605	4580	WB	Brahmaputra		China	186	176	168	164	6
112	02_78A_003	NRSC	24G	CH_269	5522	GL	Ganga	Arun Kosi	China	161	131	152	137	6
113	03_71O_006	NRSC		CH_442	4738	WB	Brahmaputra		China	122	104	115	109	6
114	01_62E_005	NRSC		CH_80	5174	WB	Indus	Indus	China	210	193	198	187	6
115	03_82K_077	NRSC		CH_933	4590	WB	Brahmaputra		China	105	-	99	94	6
116	03_82J_004	NRSC		CH_834	3957	GL	Brahmaputra		China	557	378	526	474	6
117	03_82K_009	NRSC		CH_865	4168	WB	Brahmaputra		China	115	109	60	82	6
118	03_71P_001	NRSC		CH_448	5302	WB	Brahmaputra		China	137	130	130	127	5
119	03_77L_041	NRSC		CH_550	5214	GL	Brahmaputra	Kuri Chhu	China	64	-	61	57	5

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
120	03_71G_007	NRSC		CH_416	5153	WB	Brahmaputra		China	198	188	189	187	5
121	03_78A_014	NRSC/SDC	/Very High Risk	SK_20	5234	GL	Brahmaputra	Teesta	India	147	132	140	125	5
122	02_72I_023	NRSC	227G	NP_76	5232	GL	Ganga	Sun Kosi	Nepal	86	82	70	72	5
123	02_72M_009	NRSC	51G	NP_86	4932	GL	Ganga	Tamur Kosi	Nepal	67	-	64	56	5
124	03_91C_044	NRSC		AP_90	4230	WB	Brahmaputra	Lohit	India	67	64	52	52	5
125	01_43J_022	NRSC		JK_100	1583	WB	Indus	Jhelum	India	67	62	64	59	5
126	03_82O_061	NRSC		AP_54	3811	WB	Brahmaputra	Dibang	India	49	47	41	44	4
127	03_91D_107	NRSC		AP_163	3769	WB	Brahmaputra	Lohit	India	56	-	49	54	4
128	03_77L_033	NRSC		BH_13	5176	GL	Brahmaputra		Bhutan	204	186	197	185	4
129	02_71P_043	NRSC	18G	CH_231	5206	GL	Ganga	Arun Kosi	China	80	66	77	64	4
130	03_62O_032	NRSC		CH_377	5012	WB	Brahmaputra		China	57	-	55	45	4
131	01_52H_002	NRSC/SDC	4I/Very High Risk	HP_3	4101	GL	Indus	Chenab	India	101	81	97	83	4
132	02_71L_006	NRSC	3G	CH_161	5365	GL	Ganga	Arun Kosi	China	395	372	380	341	4
133	02_71H_002	NRSC		CH_122	4650	WB	Ganga	Arun Kosi	China	2570	2353	2466	2390	4
134	01_61D_004	NRSC		CH_56	4991	WB	Indus	Indus	China	566	501	546	511	4

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Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
135	03_E2O_045	NRSC		CH_1023	4374	WB	Brahmaputra	Dihang	China	98	94	21	41	4
136	03_E2H_015	NRSC		CH_641	5124	WB	Brahmaputra		China	87	84	78	76	4
137	03_E2O_054	NRSC		CH_1046	3311	WB	Brahmaputra	Dibang	China	53	51	19	33	4
138	03_77L_077	NRSC		BH_45	5136	WB	Brahmaputra	Puna Tsang Chhu	Bhutan	57	55	10	29	4
139	01_62E_015	NRSC		CH_90	5415	WB	Indus	Satluj	China	52	50	49	46	4
140	03_E2G_045	NRSC		CH_806	4523	WB	Brahmaputra		China	77	73	74	69	4
141	03_E2K_020	NRSC		CH_876	4364	WB	Brahmaputra		China	88	85	48	54	4
142	03_77O_001	NRSC		CH_564	3879	WB	Brahmaputra		China	165	153	160	159	3
143	03_62O_042	NRSC		CH_387	4964	WB	Brahmaputra		China	60	58	56	55	3
144	01_45N_030	NRSC		JK_157	3799	WB	Indus	Jhelum	India	90	87	76	77	3
145	01_61I_004	NRSC		CH_61	4814	WB	Indus	Indus	China	40294	37181	39073	38352	3
146	03_62N_017	NRSC		CH_334	5454	WB	Brahmaputra		China	82	79	80	77	3
147	02_72M_007	NRSC	336	CH_253	4950	GL	Ganga	Arun Kosi	China	100	88	97	89	3
148	03_E2E_009	NRSC		CH_635	4963	WB	Brahmaputra		China	181	176	174	166	3
149	01_61C_022	NRSC		CH_50	4339	WB	Indus	Indus	China	1601	1494	1560	1459	3

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
150	02_71H_003	NRSC		CH_123	4649	WB	Ganga	Arun Kosi	China	227	193	220	211	3
151	03_62O_041	NRSC		CH_386	4963	WB	Brahmaputra		China	221	208	214	205	3
152	03_82A_002	NRSC		CH_621	4905	WB	Brahmaputra		China	394	351	382	355	3
153	02_71P_029	NRSC	43G	CH_217	5045	GL	Ganga	Arun Kosi	China	105	76	102	82	3
154	03_71K_009	NRSC		CH_432	4750	WB	Brahmaputra		China	267	258	218	193	3
155	02_71L_028	NRSC	38G	CH_183	5027	GL	Ganga	Sun Kosi	China	100	82	98	91	2
156	03_77L_030	NRSC		BH_12	5305	GL	Brahmaputra		Bhutan	91	89	73	76	2
157	03_77H_008	NRSC		CH_482	4570	WB	Brahmaputra		China	1275	1250	1134	1147	2
158	01_52O_001	NRSC		CH_4	4242	WB	Indus	Shyok	China	69226	66075	67960	66500	2
159	01_61C_001	NRSC		CH_29	4526	WB	Indus	Indus	China	11783	11304	11562	11424	2
160	01_52K_010	NRSC		JK_218	5313	WB	Indus	Shyok	India	151	148	140	136	2
161	01_62E_006	NRSC		CH_81	5055	WB	Indus	Indus	China	531	516	522	506	2
162	03_77L_012	NRSC		CH_528	5014	WB	Brahmaputra		China	29502	28995	29060	28965	2
163	02_71P_028	NRSC		CH_216	4997	GL	Ganga	Arun Kosi	China	62	44	58	61	2
164	01_62A_003	NRSC		CH_69	5142	WB	Indus	Indus	China	1407	1385	1343	1304	2
165	01_62E_013	NRSC		CH_88	5345	WB	Indus	Indus	China	172	169	167	159	2
166	03_82B_010	NRSC		CH_636	4990	WB	Brahmaputra		China	51	50	47	41	2
167	03_82B_020	NRSC		CH_646	4986	WB	Brahmaputra		China	48	-	47	41	2

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
168	01_43N_020	NRSC		JK_147	4112	WB	Indus	Jhelum	India	66	65	61	58	2
169	01_53E_001	NRSC		HP_12	921	WB	Indus	Beas	India	111	70	109	95	2
170	02_62K_010	NRSC		NP_28	2975	WB	Ganga	Karnal	Nepal	1073	1054	1048	1026	2
171	02_71H_015	NRSC		CH_135	5367	GL	Ganga	Arun Kosi	China	551	540	537	524	2
172	02_72I_014	NRSC	6G	NP_67	4574	GL	Ganga	Sun Kosi	Nepal	165	149	164	163	1
173	03_78I_051	NRSC		BH_132	5074	GL	Brahmaputra	Manas Chhu &Mange Chhu	Bhutan	113	112	88	95	1
174	03_77H_003	NRSC		CH_478	4714	WB	Brahmaputra		China	234	231	148	145	1
175	03_62O_040	NRSC		CH_385	4896	WB	Brahmaputra		China	120	112	119	113	1
176	03_71G_001	NRSC		CH_410	5163	WB	Brahmaputra		China	760	741	753	732	1
177	01_62E_003	NRSC		CH_78	5104	WB	Indus	Indus	China	159	148	157	148	1
178	03_77L_051	NRSC		BH_22	4548	GL	Brahmaputra	Puna Tsang Chhu	Bhutan	163	142	162	150	1
179	03_62N_021	NRSC		CH_338	5432	WB	Brahmaputra		China	201	200	185	183	1
180	03_77L_013	NRSC		CH_529	5191	WB	Brahmaputra		China	345	342	327	315	1
181	03_71G_006	NRSC		CH_415	5065	WB	Brahmaputra		China	975	970	955	933	1
182	03_82B_007	NRSC		CH_633	4964	WB	Brahmaputra		China	210	206	207	196	1

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
183	03_82F_004	NRSC		CH_729	4508	WB	Brahmaputra		China	718	713	701	690	1
184	03_78M_016	NRSC		CH_617	4647	WB	Brahmaputra	Dangme Chhu	China	153	151	117	128	1
185	03_77L_068	NRSC		BH_36	4764	WB	Brahmaputra	Kuri Chhu	Bhutan	83	82	69	73	1
186	03_77P_009	NRSC		CH_580	5086	WB	Brahmaputra		China	107	104	106	100	1
187	02_71L_003	NRSC		CH_158	5324	WB	Ganga	Arun Kosi	China	280	276	273	267	1
188	01_62F_010	NRSC	9I	CH_101	5250	GL	Indus	Satluj	China	68	-	67	53	1

G stands for Ganga, I for Indus and B for Brahmaputra under the rank of vulnerability

- Unobservable (as per NRSC) , Ø indicates small rivulet/first order stream

TABLE 3: GL&WBS WITH WATER SPREAD GREATER THAN 50 HA THAT HAVE SHOWN NO CHANGE IN WATER SPREAD AREA

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
1	02_72M_005	NRSC	139G	CH_251	5141	GL	Ganga	Arun Kosi	China	79	79	78	69	0
2	03_62J_032	NRSC		CH_304	4857	GL	Brahmaputra		China	89	89	89	82	0
3	02_72I_003	NRSC	319G	NP_59	4762	GL	Ganga	Sun Kosi	Nepal	42	-	42	36	0
4	01_52K_004	NRSC		JK_212	4293	WB	Indus	Shyok	India	5797	5797	5817	5737	0
5	01_62E_004	NRSC		CH_79	5161	WB	Indus	Indus	China	249	227	248	238	0
6	01_62F_003	NRSC		CH_94	4586	WB	Indus	Satluj	China	41211	40806	41185	41037	0
7	03_62O_039	NRSC		CH_384	4555	WB	Brahmaputra		China	307	306	294	286	0
8	03_62K_009	NRSC		CH_313	5079	GL	Brahmaputra		China	313	265	312	291	0
9	03_82J_005	NRSC		CH_835	4134	GL	Brahmaputra		China	74	74	58	60	0
10	03_82K_080	NRSC		CH_936	4530	WB	Brahmaputra		China	49	-	49	37	0
11	03_62N_001	NRSC		CH_318	5102	WB	Brahmaputra		China	14811	14352	14856	14616	0
12	02_71H_001	NRSC		CH_121	4580	WB	Ganga	Arun Kosi	China	26982	26974	26951	26898	0
13	03_62J_015	NRSC		CH_287	5207	WB	Brahmaputra		China	85	80	85	82	0
14	01_61C_024	NRSC		CH_52	4323	WB	Indus	Indus	China	5120	4733	5107	4842	0
15	01_52N_001	NRSC		CH_3	4964	WB	Indus	Indus	China	12329	11883	12283	12099	0
16	03_71B_002	NRSC		CH_392	5388	WB	Brahmaputra		China	8242	8251	8211	8132	0

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
17	01_62J_001	NRSC		CH_102	4784	WB	Indus	Satluj	China	5761	5525	5774	5583	0
18	01_52K_009	NRSC		JK_217	4921	WB	Indus	Shyok	India	204	205	196	191	0
19	03_82K_037	NRSC		CH_893	4147	WB	Brahmaputra		China	55	55	21	30	0
20	01_61C_016	NRSC		CH_44	4289	WB	Indus	Indus	China	377	377	364	360	0
21	03_82A_004	NRSC		CH_623	5008	WB	Brahmaputra		China	49	-	49	42	0
22	03_78M_003	NRSC		CH_614	4459	WB	Brahmaputra	Dangme Chhu	China	216	215	168	186	0
23	03_62J_001	NRSC		CH_273	5449	WB	Brahmaputra		China	151	151	143	140	0
24	03_82D_003	NRSC		CH_709	4408	WB	Brahmaputra		China	46	46	44	43	0
25	02_53O_001	NRSC		UK_4	1968	WB	Ganga	Ramganga	India	40	-	40	33	0
26	03_82B_002	NRSC		CH_628	4906	WB	Brahmaputra		China	447	449	436	422	0
27	03_82G_019	NRSC		CH_780	4460	WB	Brahmaputra		China	58	58	40	47	0
28	03_62N_009	NRSC		CH_326	5241	WB	Brahmaputra		China	292	289	292	280	0

G stands for Ganga, I for Indus and B for Brahmaputra under the rank of vulnerability

- Unobservable (as per NRSC) , Ø indicates small rivulet/first order stream

TABLE 4: GL&WBS WITH WATER SPREAD GREATER THAN 50 HA THAT HAVE SHOWN DECREASE IN WATER SPREAD AREA

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
1	03_82J_020	NRSC		CH_850	3852	WB	Brahmaputra		China	433	439	348	383	-1
2	03_77L_072	NRSC		BH_40	5201	GL	Brahmaputra	Manas Chhu &Mange Chhu	Bhutan	87	88	79	82	-1
3	01_53A_001	NRSC		HP_9	409	WB	Indus	Beas	India	21814	22072	18290	17771	-1
4	02_71D_004	NRSC	16G	NP_45	4064	GL	Ganga	Trisuli	Nepal	97	75	98	90	-1
5	03_71K_011	NRSC		CH_434	4761	WB	Brahmaputra		China	404	409	399	371	-1
6	03_78I_018	NRSC		BH_99	5083	GL	Brahmaputra	Puna Tsang Chhu	Bhutan	68	69	68	65	-1
7	01_43J_017	NRSC	3I	JK_95	3580	WB	Indus	Jhelum	India	158	160	159	153	-1
8	02_71H_028	NRSC	15G	CH_148	5174	WB	Ganga	Sun Kosi	China	193	194	194	195	-1
9	03_77K_017	NRSC		CH_519	4448	WB	Brahmaputra		China	3757	3807	3760	3734	-1
10	03_82F_030	NRSC		CH_755	3485	WB	Brahmaputra		China	2710	2735	2694	2665	-1
11	03_82J_017	NRSC		CH_847	3829	WB	Brahmaputra		China	284	287	284	279	-1
12	03_62J_012	NRSC		CH_284	4883	WB	Brahmaputra		China	167	164	168	159	-1
13	01_42H_001	NRSC		JK_1	4292	WB	Indus	Gilgit	India	264	264	268	254	-1

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
14	03_82B_014	NRSC		CH_640	4825	WB	Brahmaputra		China	152	155	152	127	-2
15	02_71H_007	NRSC		CH_127	5149	GL	Ganga	Arun Kosi	China	120	122	120	117	-2
16	02_71P_022	NRSC	34G	CH_210	5439	GL	Ganga	Arun Kosi	China	80	82	82	70	-2
17	03_71K_006	NRSC		CH_429	4847	WB	Brahmaputra		China	2140	2173	2088	2036	-2
18	03_77H_030	NRSC		CH_495	4802	WB	Brahmaputra		China	61	62	58	56	-2
19	03_71O_009	NRSC		CH_445	4302	WB	Brahmaputra		China	2174	2111	2210	2129	-2
20	03_77L_001	NRSC		CH_520	4443	WB	Brahmaputra		China	55287	56442	54547	54439	-2
21	03_62O_038	NRSC		CH_383	4893	WB	Brahmaputra		China	133	128	136	130	-2
22	03_62K_001	NRSC		CH_305	4834	WB	Brahmaputra		China	387	396	395	376	-2
23	03_71K_002	NRSC		CH_425	4974	WB	Brahmaputra		China	2324	2369	2288	2280	-2
24	01_52K_011	NRSC		JK_219	5291	WB	Indus	Shyok	India	180	183	175	170	-2
25	02_71L_002	NRSC		CH_157	5261	WB	Ganga	Arun Kosi	China	79	71	81	79	-2
26	02_72M_006	NRSC	349G	CH_252	5188	GL	Ganga	Arun Kosi	China	65	64	66	61	-2
27	03_82K_006	NRSC		CH_862	4523	WB	Brahmaputra		China	47	48	40	44	-2
28	03_77J_003	NRSC		CH_499	5039	WB	Brahmaputra		China	89	91	85	84	-2

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
29	01_52O_005	NRSC		CH_8	4358	WB	Indus	Indus	China	809	829	792	757	-2
30	01_52J_006	NRSC		JK_202	5401	WB	Indus	Shyok	India	104	107	104	100	-3
31	03_62O_027	NRSC		CH_372	4575	WB	Brahmaputra		China	38	-	39	35	-3
32	03_77L_009	NRSC		CH_525	4515	WB	Brahmaputra		China	565	569	584	542	-3
33	03_62J_013	NRSC		CH_285	4934	WB	Brahmaputra		China	910	935	933	911	-3
34	01_61H_001	NRSC		CH_66	4619	WB	Indus	Indus	China	309	317	315	287	-3
35	03_77L_037	NRSC		BH_15	5139	GL	Brahmaputra		Bhutan	579	599	599	578	-3
36	01_43A_001	NRSC		JK_22	3641	WB	Indus	Gilgit	India	201	196	208	194	-3
37	01_43N_001	NRSC		JK_128	4142	WB	Indus	Shingo (Indus)	India	127	131	124	122	-3
38	03_82K_036	NRSC		CH_892	4251	WB	Brahmaputra		China	62	64	38	36	-3
39	03_82K_075	NRSC		CH_931	4511	WB	Brahmaputra		China	116	-	120	102	-3
40	02_71L_013	NRSC	58G	CH_168	5324	GL	Ganga	Sun Kosi	China	57	57	59	56	-3
41	03_82G_050	NRSC		CH_811	4734	WB	Brahmaputra		China	39	-	40	34	-3
42	02_71H_008	NRSC		CH_128	5152	GL	Ganga	Arun Kosi	China	106	99	109	101	-3
43	03_77L_027	NRSC		CH_543	4531	WB	Brahmaputra	Kuri Chhu	China	183	188	173	168	-3
44	02_71D_008	NRSC		NP_49	639	WB	Ganga	Trisuli	Nepal	101	104	102	98	-3
45	02_71L_034	NRSC	89G	CH_188	5095	GL	Ganga	Sun Kosi	China	67	-	69	55	-3

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
46	01_43J_004	NRSC	5I	JK_82	4078	WB	Indus	Jhelum	India	67	70	68	63	-4
47	03_77D_002	NRSC		SK_2	5156	GL	Brahmaputra	Teesta	India	107	112	101	96	-4
48	03_82F_014	NRSC		CH_739	4691	GL	Brahmaputra		China	43	-	45	35	-4
49	03_82D_004	NRSC		CH_710	4481	WB	Brahmaputra		China	368	375	382	372	-4
50	02_53P_001	NRSC		UK_9	210	WB	Ganga	Ganga	India	1773	1855	1621	1567	-4
51	01_62F_001	NRSC		CH_92	4571	WB	Indus	Satluj	China	24525	25680	25164	25241	-4
52	03_91C_045	NRSC		AP_91	3493	WB	Brahmaputra	Dibang	India	107	111	86	96	-4
53	03_82E_003	NRSC		CH_721	5027	WB	Brahmaputra		China	94	98	95	94	-4
54	02_71H_017	NRSC		CH_137	5314	GL	Ganga	Arun Kosi	China	490	512	485	475	-4
55	03_82A_003	NRSC		CH_622	4896	WB	Brahmaputra		China	96	100	92	91	-4
56	02_71L_026	NRSC	73G	CH_181	5057	GL	Ganga	Sun Kosi	China	64	56	67	62	-4
57	02_71L_011	NRSC	61G	CH_166	5439	GL	Ganga	Sun Kosi	China	53	55	54	53	-4
58	01_43N_022	NRSC		JK_149	4243	WB	Indus	Jhelum	India	71	74	72	68	-4
59	01_61C_023	NRSC		CH_51	4350	WB	Indus	Indus	China	644	672	622	599	-4
60	01_43J_020	NRSC		JK_98	1584	WB	Indus	Jhelum	India	177	185	168	164	-4
61	03_78I_056	NRSC		BH_137	4794	WB	Brahmaputra	Manas Chhu &Mange Chhu	Bhutan	81	84	46	57	-4

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Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
62	03_82J_018	NRSC		CH_848	3913	GL	Brahmaputra		China	93	94	97	92	-4
63	01_61C_015	NRSC		CH_43	4280	WB	Indus	Indus	China	797	777	832	770	-4
64	03_78E_012	NRSC		CH_607	4576	WB	Brahmaputra		China	266	274	280	267	-5
65	03_78A_009	NRSC		SK_16	5044	GL	Brahmaputra	Teesta	India	58	61	55	52	-5
66	01_52K_014	NRSC		JK_222	4535	WB	Indus	Indus	India	425	446	413	410	-5
67	02_77D_007	NRSC	244G	CH_262	5215	GL	Ganga	Arun Kosi	China	56	58	59	56	-5
68	03_82F_007	NRSC		CH_732	4801	GL	Brahmaputra		China	114	120	119	113	-5
69	01_52L_001	NRSC		JK_225	4523	WB	Indus	Satluj	India	13702	14351	14180	14105	-5
70	03_91C_029	NRSC		CH_1078	4229	WB	Brahmaputra		China	211	221	218	211	-5
71	02_71P_027	NRSC	82G	CH_215	5389	GL	Ganga	Arun Kosi	China	52	-	55	40	-5
72	03_82F_020	NRSC		CH_745	4110	GL	Brahmaputra		China	70	71	74	68	-5
73	01_43J_007	NRSC	6I	JK_85	3708	WB	Indus	Jhelum	India	97	92	102	92	-5
74	03_91C_046	NRSC		AP_92	3353	WB	Brahmaputra	Dibang	India	57	60	43	46	-5
75	01_52J_005	NRSC		JK_201	5430	WB	Indus	Shyok	India	42	-	44	37	-5
76	02_62K_012	NRSC		NP_30	3653	WB	Ganga	Bheri	Nepal	465	481	494	471	-6
77	03_78A_013	NRSC		SK_19	5470	GL	Brahmaputra	Teesta	India	76	74	81	77	-6

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
78	03_77P_019	NRSC		CH_590	4637	WB	Brahmaputra	Dangme Chhu	China	247	237	263	240	-6
79	01_62E_002	NRSC		CH_77	5139	WB	Indus	Indus	China	163	173	157	149	-6
80	03_82E_002	NRSC		CH_720	5008	WB	Brahmaputra		China	662	675	701	613	-6
81	03_77H_011	NRSC		BH_4	4963	GL	Brahmaputra		Bhutan	151	161	158	142	-6
82	02_71H_027	NRSC	2G	CH_147	5242	GL	Ganga	Sun Kosi	China	449	480	441	437	-6
83	03_77L_067	NRSC		BH_35	5231	GL	Brahmaputra	Manas Chhu &Mange Chhu	Bhutan	82	87	68	71	-6
84	03_62O_024	NRSC		CH_369	4637	WB	Brahmaputra		China	838	740	894	814	-6
85	03_62K_002	NRSC		CH_306	4858	WB	Brahmaputra		China	48	-	51	44	-6
86	03_71C_003	NRSC		CH_396	5412	GL	Brahmaputra		China	49	-	52	45	-6
87	03_78E_006	NRSC		CH_604	4572	WB	Brahmaputra		China	61	65	59	56	-6
88	03_82K_018	NRSC		CH_874	4168	WB	Brahmaputra		China	165	175	65	92	-6
89	02_71H_035	NRSC		CH_155	4366	WB	Ganga	Sun Kosi	China	44	-	47	41	-6
90	03_62J_016	NRSC		CH_288	5303	GL	Brahmaputra		China	51	-	54	44	-6
91	03_78E_019	NRSC		CH_611	5022	GL	Brahmaputra		China	58	60	62	58	-6
92	03_77D_008	NRSC		SK_8	5039	GL	Brahmaputra	Teesta	India	43	-	46	35	-7

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Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
93	01_52J_001	NRSC	8I	JK_197	5311	GL	Indus	Shyok	India	97	104	96	92	-7
94	03_82F_008	NRSC		CH_733	4828	WB	Brahmaputra		China	82	84	88	83	-7
95	01_62E_010	NRSC		CH_85	5233	WB	Indus	Indus	China	152	164	155	146	-7
96	01_61C_012	NRSC		CH_40	4282	WB	Indus	Indus	China	308	317	330	308	-7
97	03_82G_009	NRSC		CH_770	4580	WB	Brahmaputra		China	43	-	46	46	-7
98	03_82O_042	NRSC		AP_49	3093	WB	Brahmaputra	Dibang	India	40	-	43	36	-7
99	01_52O_002	NRSC		CH_5	5262	WB	Indus	Indus	China	106	115	112	102	-8
100	01_62F_004	NRSC		CH_95	5493	WB	Indus	Satluj	China	176	186	191	181	-8
101	03_62J_031	NRSC		CH_303	4897	GL	Brahmaputra		China	201	174	218	192	-8
102	01_52O_003	NRSC		CH_6	4252	WB	Indus	Indus	China	202	220	196	181	-8
103	02_78A_005	NRSC		CH_271	5376	GL	Ganga	Arun Kosi	China	107	91	110	116	-8
104	01_52C_003	NRSC	7I	JK_187	4512	GL	Indus	Indus	India	55	-	60	49	-8
105	01_52K_016	NRSC		JK_224	4675	WB	Indus	Satluj	India	512	555	523	514	-8
106	03_77H_020	NRSC		CH_490	4473	WB	Brahmaputra		China	4560	4976	4525	4594	-8
107	01_43P_002	NRSC		JK_167	669	WB	Indus	Ravi	India	54	58	59	55	-8
108	01_61C_021	NRSC		CH_49	4349	WB	Indus	Indus	China	1100	1147	1195	1071	-8
109	03_83A_012	NRSC		AP_77	4287	WB	Brahmaputra	Dangme Chhu	India	55	60	39	46	-8

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
110	03_77L_011	NRSC		CH_527	4533	WB	Brahmaputra		China	1185	1282	1200	1150	-8
111	03_62O_030	NRSC		CH_375	5013	WB	Brahmaputra		China	101	99	111	101	-9
112	01_52J_002	NRSC		JK_198	5359	WB	Indus	Shyok	India	61	67	61	59	-9
113	01_43A_002	NRSC		JK_23	3790	WB	Indus	Gilgit	India	95	96	104	95	-9
114	03_78E_017	NRSC		CH_609	5253	GL	Brahmaputra		China	42	-	38	46	-9
115	03_82G_048	NRSC		CH_809	4663	WB	Brahmaputra		China	42	38	46	43	-9
116	03_82B_006	NRSC		CH_632	4837	WB	Brahmaputra		China	114	121	125	120	-9
117	03_92A_006	NRSC		AP_204	1178	WB	Brahmaputra	Lohit	India	75	82	80	78	-9
118	03_82E_007	NRSC		CH_725	5043	WB	Brahmaputra		China	62	68	68	65	-9
119	03_82G_062	NRSC		CH_823	4925	WB	Brahmaputra		China	53	-	58	54	-9
120	01_43E_006	NRSC		JK_30	4186	WB	Indus	Gilgit	India	68	75	66	66	-9
121	03_82C_016	NRSC		CH_671	4679	WB	Brahmaputra		China	49	54	50	52	-9
122	02_71H_021	NRSC	76G	CH_141	4463	GL	Ganga	Trisuli	China	43	-	48	40	-10
123	03_77L_003	NRSC		CH_521	4434	WB	Brahmaputra		China	3699	4113	4016	4022	-10
124	03_91H_025	NRSC		CH_1190	3741	WB	Brahmaputra	Lohit	China	82	85	91	61	-10
125	03_71C_005	NRSC		CH_398	5551	GL	Brahmaputra		China	52	58	56	54	-10

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
126	02_71P_015	NRSC		CH_203	4153	WB	Ganga	Arun Kosi	China	948	1031	1059	950	-10
127	03_77P_017	NRSC		CH_588	4751	WB	Brahmaputra	Dangme Chhu	China	2114	2357	2097	2184	-10
128	01_61D_002	NRSC		CH_54	4313	WB	Indus	Indus	China	1495	1654	1562	1461	-10
129	03_82G_017	NRSC		CH_778	4437	WB	Brahmaputra		China	53	59	51	50	-10
130	01_43E_023	NRSC		JK_47	4155	WB	Indus	Gilgit	India	86	96	83	80	-10
131	02_53K_001	NRSC		UK_1	355	WB	Ganga	Ramganga	India	4965	5557	5371	5332	-11
132	02_62P_004	NRSC		NP_37	807	WB	Ganga	Trisuli	Nepal	350	385	394	389	-11
133	03_82K_039	NRSC		CH_895	4128	WB	Brahmaputra		China	188	211	131	167	-11
134	03_77L_029	NRSC		CH_545	5451	GL	Brahmaputra	Kuri Chhu	China	48	-	54	43	-11
135	03_77B_001	NRSC		CH_452	5039	WB	Brahmaputra		China	51	57	43	44	-11
136	03_82K_068	NRSC		CH_924	4320	WB	Brahmaputra		China	49	55	54	50	-11
137	03_78E_010	NRSC		CH_606	4582	WB	Brahmaputra		China	38	-	43	37	-12
138	03_91C_025	NRSC		CH_1076	4022	GL	Brahmaputra		China	100	107	113	107	-12
139	01_62F_002	NRSC		CH_93	4592	WB	Indus	Satluj	China	295	334	320	316	-12
140	01_61C_014	NRSC		CH_42	4279	WB	Indus	Indus	China	274	305	311	298	-12
141	02_53O_005	NRSC		UK_8	239	WB	Ganga	Ramganga	India	1128	1284	1263	1160	-12

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
142	03_82O_029	NRSC		CH_1032	3345	WB	Brahmaputra	Dihang	China	59	68	44	45	-13
143	01_61C_018	NRSC		CH_46	4291	WB	Indus	Indus	China	1765	1958	2037	1901	-13
144	03_91C_034	NRSC		AP_84	4288	WB	Brahmaputra	Dibang	India	136	157	59	80	-13
145	01_43N_032	NRSC		JK_159	3595	WB	Indus	Jhelum	India	53	-	61	50	-13
146	01_42H_003	NRSC		JK_3	3854	WB	Indus	Gilgit	India	104	119	109	101	-13
147	03_77C_006	NRSC		CH_460	4514	WB	Brahmaputra		China	88	101	93	91	-13
148	03_82G_024	NRSC		CH_785	4647	WB	Brahmaputra		China	94	108	78	76	-13
149	02_71P_035	NRSC		CH_223	5146	WB	Ganga	Arun Kosi	China	94	108	98	98	-13
150	03_82B_004	NRSC		CH_630	4893	WB	Brahmaputra		China	89	98	103	98	-14
151	03_82G_035	NRSC		CH_796	4386	WB	Brahmaputra		China	76	80	88	74	-14
152	03_77L_035	NRSC		BH_14	5486	GL	Brahmaputra		Bhutan	61	71	49	52	-14
153	01_52I_003	NRSC		JK_195	5159	WB	Indus	Shyok	India	181	186	211	169	-14
154	03_77B_002	NRSC		CH_453	5019	WB	Brahmaputra		China	214	248	210	206	-14
155	03_71G_008	NRSC		CH_417	5187	WB	Brahmaputra		China	53	62	60	59	-15
156	03_77H_012	NRSC		CH_483	4723	GL	Brahmaputra		China	69	81	80	76	-15
157	03_77H_013	NRSC		CH_484	4950	GL	Brahmaputra		China	44	-	52	43	-15

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
158	02_72I_002	NRSC	645G	NP_58	4854	GL	Ganga	Sun Kosi	Nepal	55	65	60	59	-15
159	03_71O_010	NRSC		CH_446	4296	WB	Brahmaputra		China	866	850	1017	920	-15
160	03_62N_022	NRSC		CH_339	4599	WB	Brahmaputra		China	165	193	194	187	-15
161	03_78A_001	NRSC/SDC	/High Risk	SK_9	5371	GL	Brahmaputra	Teesta	India	189	162	149	222	-15
162	03_71G_011	NRSC		CH_420	4619	WB	Brahmaputra		China	1248	1236	1461	1318	-15
163	02_53K_002	NRSC		UK_2	260	WB	Ganga	Ramganga	India	1263	1481	1000	918	-15
164	01_43K_014	NRSC		JK_115	3521	WB	Indus	Jhelum	India	116	134	138	126	-16
165	03_91H_029	NRSC		CH_1194	3325	WB	Brahmaputra	Lohit	China	41	-	49	37	-16
166	01_61D_003	NRSC		CH_55	4453	WB	Indus	Indus	China	54	64	62	50	-16
167	03_82N_033	NRSC		CH_1004	4357	GL	Brahmaputra		China	71	86	69	67	-17
168	02_53P_003	NRSC		UK_11	207	WB	Ganga	Ramganga	India	941	1138	842	844	-17
169	03_62O_043	NRSC		CH_388	5285	WB	Brahmaputra		China	69	83	80	73	-17
170	03_77P_021	NRSC		CH_592	4749	GL	Brahmaputra	Dangme Chhu	China	53	64	45	47	-17
171	01_61G_001	NRSC		CH_62	4973	WB	Indus	Indus	China	67	81	71	71	-17
172	01_52G_003	NRSC		JK_191	4533	WB	Indus	Indus	India	1324	1609	1315	1335	-18
173	03_62N_004	NRSC		CH_321	5168	WB	Brahmaputra		China	763	899	925	900	-18

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
174	01_43J_021	NRSC		JK_99	1582	WB	Indus	Jhelum	India	1074	1305	992	1028	-18
175	03_77H_001	NRSC		CH_476	4275	WB	Brahmaputra		China	420	521	353	361	-19
176	03_77K_009	NRSC		CH_511	3937	WB	Brahmaputra		China	56	67	69	67	-19
177	03_77L_007	NRSC		CH_523	4510	WB	Brahmaputra		China	1289	1582	1380	1402	-19
178	03_71G_014	NRSC		CH_423	4606	WB	Brahmaputra		China	179	139	222	181	-19
179	02_71P_016	NRSC		CH_204	4182	WB	Ganga	Arun Kosi	China	122	151	139	124	-19
180	02_72E_001	NRSC		NP_57	1554	WB	Ganga	Baghmati	Nepal	135	165	168	153	-20
181	03_77P_013	NRSC		CH_584	5155	WB	Brahmaputra		China	51	64	52	48	-20
182	03_82K_060	NRSC		CH_916	4316	WB	Brahmaputra		China	78	99	71	68	-21
183	02_72I_007	NRSC	785G	NP_62	4540	GL	Ganga	Sun Kosi	Nepal	55	-	70	67	-21
184	03_77H_004	NRSC		CH_479	4428	WB	Brahmaputra		China	158	205	149	150	-23
185	03_78A_003	NRSC/SDC	/Very High Risk	SK_11	4977	GL	Brahmaputra	Teesta	India	57	-	74	57	-23
186	03_71G_009	NRSC		CH_418	5032	WB	Brahmaputra		China	120	155	156	148	-23
187	03_82G_023	NRSC		CH_784	4377	WB	Brahmaputra		China	58	76	70	65	-24
188	03_91C_033	NRSC		CH_1079	4278	GL	Brahmaputra		China	144	190	177	161	-24

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
189	03_82N_030	NRSC		CH_1001	4462	GL	Brahmaputra		China	80	-	106	100	-25
190	02_71P_019	NRSC		CH_207	4199	GL	Ganga	Arun Kosi	China	41	-	55	46	-25
191	03_77P_004	NRSC		CH_575	4452	WB	Brahmaputra		China	161	205	216	205	-25
192	03_78A_018	NRSC		CH_598	4880	WB	Brahmaputra	Amo Chhu	China	40	53	17	30	-25
193	03_82A_007	NRSC		CH_626	4911	WB	Brahmaputra		China	69	87	93	88	-26
194	03_77P_006	NRSC		CH_577	4616	WB	Brahmaputra		China	4216	5796	5293	4301	-27
195	03_91D_081	NRSC		CH_1136	3356	WB	Brahmaputra	Lohit	China	320	436	312	247	-27
196	01_52L_003	NRSC		JK_227	4985	WB	Indus	Indus	India	486	680	573	594	-29
197	03_77L_006	NRSC		CH_522	4533	WB	Brahmaputra		China	21	-	30	30	-30
198	01_52D_001	NRSC		HP_1	780	WB	Indus	Ravi	India	586	819	838	768	-30
199	03_82E_004	NRSC		CH_722	5049	WB	Brahmaputra		China	33	48	48	46	-31
200	01_42H_005	NRSC		JK_5	2237	WB	Indus	Gilgit	India	50	72	60	54	-31
201	03_77L_032	NRSC		CH_547	4669	GL	Brahmaputra	Kuri Chhu	China	76	111	80	82	-32
202	02_71P_018	NRSC		CH_206	4199	WB	Ganga	Arun Kosi	China	56	54	82	64	-32
203	02_77D_004	NRSC		CH_259	4378	WB	Ganga	Arun Kosi	China	686	1013	802	740	-32

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
204	03_71G_010	NRSC		CH_419	4491	WB	Brahmaputra		China	204	310	262	259	-34
205	03_77P_018	NRSC		CH_589	4707	WB	Brahmaputra	Dangme Chhu	China	99	153	129	131	-35
206	03_71O_002	NRSC		CH_438	4909	WB	Brahmaputra		China	31	-	49	44	-37
207	02_62B_001	NRSC		CH_106	5216	WB	Ganga	Karnal	China	28	42	45	40	-38
208	02_63M_002	NRSC		NP_41	112	WB	Ganga	Rapti	Nepal	90	148	107	119	-39
209	03_77P_016	NRSC		CH_587	4749	WB	Brahmaputra	Dangme Chhu	China	156	262	224	227	-40
210	03_77P_012	NRSC		CH_583	4975	WB	Brahmaputra		China	44	73	61	56	-40
211	01_62B_001	NRSC		CH_73	4526	WB	Indus	Satluj	China	267	472	301	316	-43
212	03_71G_013	NRSC		CH_422	4543	WB	Brahmaputra		China	156	228	277	250	-44
213	02_77D_001	NRSC		CH_256	4423	WB	Ganga	Arun Kosi	China	2401	4849	3677	3583	-50
214	03_77L_008	NRSC		CH_524	4448	WB	Brahmaputra		China	38	76	80	79	-53
215	02_77D_003	NRSC		CH_258	4364	WB	Ganga	Arun Kosi	China	53	102	82	133	-60
216	03_77H_007	NRSC		CH_481	4424	WB	Brahmaputra		China	310	823	737	670	-62
217	03_82D_010	NRSC		CH_716	5043	WB	Brahmaputra	Dangme Chhu	China	26	70	49	57	-63
218	03_71C_010	NRSC		CH_403	4561	WB	Brahmaputra		China	18	-	54	42	-67

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
219	03_62O_028	NRSC		CH_373	4577	WB	Brahmaputra		China	230	902	644	635	-75
220	03_62N_003	NRSC		CH_320	5208	WB	Brahmaputra		China	6	-	46	44	-87

G stands for Ganga, I for Indus and B for Brahmaputra under the rank of vulnerability
-Unobservable (as per NRSC) , Ø indicates small rivulet/first order stream

TABLE 5: GL&WBS WITH WATER SPREAD GREATER THAN 50 HA WITH NO ANALYSIS OF CHANGE IN WATER SPREAD AREA

Sl. No.	Lake ID	Inventory Developed by	Rank of Vulnerability	UID	Elevation (m) (m)	Lake Type	Basin	River	Country	Area of October-2023 (ha)	Area of Base Year of 2011 (ha)	Area of Last 5 Years (ha)	Area of Last 10 years (ha)	Max Change in Area (%)
1	01_61C_005	NRSC		CH_33	4495	WB	Indus	Indus	China	#	153	384	279	#
2	01_61C_005	NRSC		CH_33	4495	WB	Indus	Indus	China	#	153	384	279	#
3	02_71H_012	NRSC		CH_132	5379	GL	Ganga	Arun Kosi	China	#	-	129	120	#
4	01_61F_003	NRSC		CH_60	5256	WB	Indus	Indus	China	#	565	536	512	#
5	01_61B_003	NRSC		CH_28	5074	WB	Indus	Indus	China	#	218	193	196	#
6	01_61G_003	NRSC		CH_64	4864	WB	Indus	Indus	China	#	80	58	64	#
7	01_52L_008	NRSC		CH_1	3873	WB	Indus	Satluj	China	#	32	101	78	#
8	01_61D_001	NRSC		CH_53	5593	WB	Indus	Indus	China	#	81	76	66	#
9	03_82F_010	NRSC		CH_735	5030	GL	Brahmaputra		China	24	-	-	-	#
10	03_77P_005	NRSC		CH_576	4619	WB	Brahmaputra		China	#	110	95	97	#
11	01_52E_001	NRSC		JK_188	5116	GL	Indus	Shyok	India	#	48	4	19	#
12	01_61C_004	NRSC			4495	WB				#	-	-	-	#
13	03_77P_023	NRSC		CH_593	4235	WB	Brahmaputra	Kuri Chhu	China	#	-	50	43	#
14	01_61C_010	NRSC		CH_38	4495	WB	Indus	Indus	China	#	94	118	121	#
15	01_61F_002	NRSC		CH_59	5279	WB	Indus	Indus	China	#	63	54	50	#

G stands for Ganga, I for Indus and B for Brahmaputra under the rank of vulnerability,
- Unobservable (as per NRSC) , Ø indicates small rivulet/first order stream, # indicates frozen/ dried lakes

TABLE 6: WATER SPREAD AREA OF CRITICAL GLS IDENTIFIED BY NDMA THROUGH SWISS DEVELOPMENT AGENCY (SDC) FOR INDIAN HIMALAYAN REGION

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	State	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
1	98	SDC	High Risk	GL	4103	JK	India	6	#	#
2	976	SDC	High Risk/15I	GL	4314	JK	India	15	#	#
3	2147	SDC	Medium Risk	GL	5688	UK	India	#	0.5	#
4	2299	SDC	Very High Risk	GL	4490	UK	India	#	#	#
5	1805	SDC	Very High Risk/81I	GL	4775	HP	India	5	1.67	*199*
6	958	SDC	Very High Risk	GL	4103	JK	India	8	3.33	*140*
7	295	SDC	Very High Risk	GL	4850	SK	India	9	6	*50*
8	27	SDC	Very High Risk	GL	3775	JK	India	19	13	*46*
9	180	SDC	Very High Risk	GL	4442	JK	India	11	8.33	*32*
10	963	SDC	Medium Risk	GL	3725	JK	India	35	26.67	*31*
11	173	SDC	Medium Risk	GL	5150	JK	India	9	7	*29*
12	298	SDC	Very High Risk	GL	4508	SK	India	6	4.67	*28*
13	515	SDC	Medium Risk	GL	5063	SK	India	10	8	*25*

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	State	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
14	129	SDC	Very High Risk	GL	4895	AP	India	11	9	22
15	931	SDC	Very High Risk	GL	4082	JK	India	22	18.67	18
16	227	SDC	Very High Risk	GL	5176	SK	India	62	53	17
17	237	SDC	Very Low Risk	GL	5322	SK	India	8	7	14
18	599	SDC	Very High Risk	GL	4251	SK	India	9	8	13
19	1360	SDC	Very High Risk	GL	4667	JK	India	10	9	11
20	312	SDC	Medium Risk	GL	5137	SK	India	9	8.33	8
21	260	SDC	Medium Risk	GL	5253	SK	India	42	39.67	6
22	1037	SDC	Medium Risk/271	GL	3603	JK	India	41	39	5
23	1847	SDC	Very High Risk	GL	4570	HP	India	12	12	0
24	1998	SDC	Very High Risk	GL	3857	HP	India	1	1	0
25	1032	SDC	Very High Risk	GL	4007	JK	India	1	1	0
26	2108	SDC	Very High Risk/347G	GL	5587	UK	India	18	18	0

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	State	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
27	1774	SDC	Very High Risk	GL	4593	HP	India	7	7	*0*
28	938	SDC	Very High Risk	GL	3683	JK	India	21	21	*0*
29	293	SDC	Very High Risk	GL	5048	SK	India	2	2	*0*
30	345	SDC	Medium Risk	GL	5108	SK	India	18	18.67	*-4*
31	182	SDC	Very High Risk	GL	4304	JK	India	8	8.5	*-6*
32	569	SDC	Medium Risk	GL	5450	SK	India	30	32	*-6*
33	951	SDC	Very High Risk	GL	3762	JK	India	17	18.33	*-7*
34	256	SDC	High risk	GL	4615	SK	India	14	16.33	*-14*
35	2031	SDC	Very High Risk	GL	4702	HP	India	10	12	*-17*
36	292	SDC	Medium Risk	GL	5577	SK	India	3	3.67	*-18*
37	1014	SDC	Very High Risk	GL	3989	JK	India	3	4.33	*-31*
38	1936	SDC	Very High Risk/321I	GL	4606	HP	India	2	3	*-33*
39	2207	SDC	Very High Risk	GL	4707	UK	India	6	10.33	*-42*
40	993	SDC	Very High Risk	GL	4148	JK	India	5	9	*-44*

G stands for Ganga, I for Indus and B for Brahmaputra under the rank of vulnerability

- Unobservable (as per NRSC) , # indicates frozen/ dried lakes

TABLE 7: WATER SPREAD AREA OF GLS UPTO 10 HA BUT SMALLER THAN 50 HA PREPARED BY NRSC IN 2009

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
1	03_91C_036	NRSC		GL	4298		Brahmaputra	China	55	#	#
2	01_52P_004	NRSC		GL	5470	Indus	Indus	China	0	#	#
3	01_53M_003	NRSC	110I	GL	5511	Indus	Indus	China	13	#	#
4	03_82F_011	NRSC		GL	4720		Brahmaputra	China	12	#	#
5	03_91C_013	NRSC		GL	4925		Brahmaputra	China	14	#	#
6	03_91H_073	NRSC		GL	4481	Lohit	Brahmaputra	India	27	#	#
7	03_91D_096	NRSC		GL	3794	Lohit	Brahmaputra	China	#	#	#
8	03_82O_004	NRSC		GL	4148		Brahmaputra	China	#	#	#
9	03_77L_040	NRSC		GL	4515	Puna Tsang Chhu	Brahmaputra	Bhutan	#	#	#
10	02_62B_007	NRSC		GL	4839	Sarda	Ganga	India	#	0	#
11	03_91C_023	NRSC		GL	4811	Lohit	Brahmaputra	China	#	16.67	#
12	03_82O_003	NRSC		GL	4180		Brahmaputra	China	#	15	#

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m) (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
13	03_82N_018	NRSC		GL	4333		Brahmaputra	China	#	10	#
14	03_77L_054	NRSC		GL	4717	Puna Tsang Chhu	Brahmaputra	Bhutan	5	2	150
15	02_62F_007	NRSC		GL	5179	Karnal	Ganga	Nepal	26	10.67	144
16	03_77L_053	NRSC		GL	4793	Kuri Chhu	Brahmaputra	China	54	27	100
17	03_78I_001	NRSC		GL	5129	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	14	7.33	91
18	03_82N_016	NRSC		GL	5017		Brahmaputra	China	7	3.67	91
19	03_77L_063	NRSC		GL	5183	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	31	18	72
20	02_71D_002	NRSC		GL	4063	Trisuli	Ganga	Nepal	9	5.33	69
21	02_72I_030	NRSC	480G	GL	4624	Sun Kosi	Ganga	Nepal	13	7.67	69
22	03_82F_025	NRSC		GL	4253		Brahmaputra	China	14	8.33	68
23	03_78M_013	NRSC		GL	4232	Kuri Chhu	Brahmaputra	Bhutan	9	5.5	64

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m) (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
24	03_78I_004	NRSC		GL	5194	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	40	26.67	50
25	03_82F_023	NRSC		GL	4354		Brahmaputra	China	12	8	50
26	02_71L_035	NRSC	657G	GL	5091	Sun Kosi	Ganga	Nepal	19	13	46
27	02_62J_002	NRSC		GL	5021	Karnal	Ganga	Nepal	17	11.67	46
28	03_78I_028	NRSC		GL	4792	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	29	20	45
29	03_82G_003	NRSC		GL	4936		Brahmaputra	China	25	17.33	44
30	03_82F_021	NRSC		GL	4487		Brahmaputra	China	11	7.67	43
31	02_72I_024	NRSC	358G	GL	5165	Sun Kosi	Ganga	Nepal	41	28.67	43
32	03_83A_004	NRSC		GL	5109	Dangme Chhu	Brahmaputra	India	23	16.33	41
33	03_77K_003	NRSC		GL	5303		Brahmaputra	China	14	10	40
34	03_82N_015	NRSC		GL	5090		Brahmaputra	China	7	5	40

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m) (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
35	03_91H_015	NRSC		GL	4553	Lohit	Brahmaputra	China	14	10	40
36	03_77L_075	NRSC		GL	4718	Manas Chhu & MangdeChhu	Brahmaputra	Bhutan	25	18	39
37	02_62B_005	NRSC	580G	GL	4314	Sarda	Ganga	India	11	8	38
38	03_78A_035	NRSC		GL	4998	Teesta	Brahmaputra	India	12	8.67	38
39	03_82F_013	NRSC		GL	4761		Brahmaputra	China	12	8.67	38
40	03_82J_003	NRSC		GL	4161		Brahmaputra	China	32	23.33	37
41	01_53M_002	NRSC	142I	GL	5468	Indus	Indus	China	10	7.33	36
42	03_77L_056	NRSC		GL	4963	Kuri Chhu	Brahmaputra	China	19	14	36
43	03_91D_075	NRSC		GL	4274	Dibang	Brahmaputra	India	28	21	33
44	02_71P_001	NRSC		GL	5498	Arun Kosi	Ganga	China	24	18	33
45	03_77H_032	NRSC		GL	5056		Brahmaputra	China	12	9	33
46	02_72I_017	NRSC	49G	GL	5018	Sun Kosi	Ganga	Nepal	11	8.33	32

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m) (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
47	02_71P_033	NRSC		GL	4888	Arun Kosi	Ganga	China	26	19.67	32
48	03_77H_019	NRSC		GL	4804	Puna Tsang Chhu	Brahmaputra	Bhutan	10	7.67	30
49	03_77H_005	NRSC		GL	5113		Brahmaputra	China	27	21	29
50	01_62B_002	NRSC	381I	GL	4998	Satluj	Indus	China	25	19.33	29
51	01_62F_009	NRSC	387I	GL	5712	Satluj	Indus	China	26	20.33	28
52	02_71L_016	NRSC	570G	GL	5345	Sun Kosi	Ganga	China	12	9.5	26
53	03_82J_001	NRSC		GL	4775		Brahmaputra	China	35	27.67	26
54	03_78A_025	NRSC		GL	4888	Amo Chhu	Brahmaputra		12	9.5	26
55	03_71D_003	NRSC		GL	5362		Brahmaputra	China	10	8	25
56	03_78E_001	NRSC		GL	5157	Puna Tsang Chhu	Brahmaputra	Bhutan	36	29	24
57	03_78I_020	NRSC		GL	5331	Manas Chhu & MangdeChhu	Brahmaputra	Bhutan	24	19.33	24
58	01_43J_003	NRSC		GL	3954	Jhelum	Indus	India	17	13.67	24

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m) (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
59	03_78E_011	NRSC		GL	4952	Puna Tsang Chhu	Brahmaputra	Bhutan	24	19.33	24
60	03_82N_034	NRSC		GL	4181		Brahmaputra	China	18	14.5	24
61	03_78I_026	NRSC		GL	5233	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	18	14.67	23
62	03_91D_098	NRSC		GL	4197	Lohit	Brahmaputra	China	14	11.5	22
63	03_77L_020	NRSC		GL	4682	Kuri Chhu	Brahmaputra	China	11	9	22
64	03_91C_008	NRSC		GL	4899		Brahmaputra	China	25	20.5	22
65	03_91G_001	NRSC		GL	5147		Brahmaputra	China	11	9	22
66	03_91H_036	NRSC		GL	4457	Lohit	Brahmaputra	China	26	21.33	22
67	03_78A_027	NRSC/SDC	/Very High Risk	GL	4888	Teesta	Brahmaputra	India	37	30.67	21
68	02_62F_008	NRSC		GL	5620	Karnal	Ganga	Nepal	10	8.33	20
69	02_71H_034	NRSC	320G	GL	4745	Trisuli	Ganga	Nepal	20	16.67	20

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m) (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
70	03_82F_026	NRSC		GL	4607		Brahmaputra	China	12	10	20
71	03_91C_007	NRSC		GL	4817		Brahmaputra	China	12	10	20
72	03_91G_007	NRSC		GL	4785	Lohit	Brahmaputra	China	14	11.67	20
73	03_78I_037	NRSC		GL	5159	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	18	15	20
74	02_71L_029	NRSC	747G	GL	5237	Arun Kosi	Ganga	China	54	45.33	19
75	02_62F_009	NRSC	536G	GL	5586	Karnal	Ganga	China	11	9.33	18
76	03_62O_031	NRSC		GL	5381		Brahmaputra	China	37	31.33	18
77	03_78I_038	NRSC		GL	5143	Puna Tsang Chhu	Brahmaputra	Bhutan	11	9.33	18
78	03_71C_001	NRSC		GL	5543		Brahmaputra	China	9	7.67	17
79	03_82N_008	NRSC		GL	4546		Brahmaputra	China	40	34.33	17
80	02_71P_023	NRSC	124G	GL	5235	Arun Kosi	Ganga	China	22	19	16

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m) (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
81	03_77D_006	NRSC/SDC	/Very High Risk	GL	5084	Teesta	Brahmaputra	India	26	22.33	16
82	03_78E_025	NRSC		GL	4341	Puna Tsang Chhu	Brahmaputra	Bhutan	17	14.67	16
83	03_82K_109	NRSC		GL	4356		Brahmaputra	China	24	20.67	16
84	03_78I_043	NRSC		GL	5000	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	24	20.67	16
85	03_78A_019	NRSC/SDC	/Very High Risk	GL	4809	Teesta	Brahmaputra	India	13	11.33	15
86	03_71C_004	NRSC		GL	5575		Brahmaputra	China	14	12.33	14
87	02_62K_003	NRSC	546G	GL	4571	Karnal	Ganga	Nepal	44	38.67	14
88	03_78A_007	NRSC/SDC	/Very High Risk	GL	4977	Teesta	Brahmaputra	India	19	16.67	14
89	02_71D_001	NRSC		GL	4111	Trisuli	Ganga	Nepal	25	22	14
90	03_78I_072	NRSC		GL	4788	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	14	12.33	14

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m) (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
91	03_91D_099	NRSC		GL	4406	Lohit	Brahmaputra	China	30	26.5	13
92	02_71P_031	NRSC	141G	GL	5395	Arun Kosi	Ganga	China	20	17.67	13
93	03_78I_025	NRSC		GL	5194	Puna Tsang Chhu	Brahmaputra	Bhutan	15	13.33	13
94	03_77L_065	NRSC		GL	5025	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	17	15	13
95	03_91H_008	NRSC		GL	4755	Lohit	Brahmaputra	China	52	46	13
96	03_91H_003	NRSC		GL	4439	Lohit	Brahmaputra	China	15	13.33	13
97	03_71P_002	NRSC		GL	5537		Brahmaputra	China	16	14.33	12
98	03_91C_012	NRSC		GL	4663		Brahmaputra	China	19	17	12
99	03_78E_008	NRSC		GL	5045	Puna Tsang Chhu	Brahmaputra	Bhutan	12	10.67	12
100	03_71D_001	NRSC		GL	5454		Brahmaputra	China	19	17	12

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m) (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
101	02_72I_031	NRSC	14G	GL	4777	Sun Kosi	Ganga	Nepal	31	27.67	12
102	03_78I_058	NRSC		GL	5041	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	29	26	12
103	03_78A_023	NRSC		GL	4547	Teesta	Brahmaputra	India	32	28.67	12
104	03_78I_022	NRSC		GL	5048	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	16	14.33	12
105	03_71C_006	NRSC		GL	5482		Brahmaputra	China	21	19	11
106	01_62E_007	NRSC	437I	GL	5641	Satluj	Indus	China	15	13.5	11
107	03_78A_031	NRSC		GL	4305	Teesta	Brahmaputra	India	13	11.67	11
108	03_91C_019	NRSC		GL	3858		Brahmaputra	China	55	49.67	11
109	03_71C_002	NRSC		GL	5663		Brahmaputra	China	10	9	11
110	02_71P_026	NRSC	322G	GL	5340	Arun Kosi	Ganga	China	15	13.67	10
111	03_62J_009	NRSC		GL	5624		Brahmaputra	China	26	23.67	10

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
112	03_91C_026	NRSC		GL	4305	Dibang	Brahmaputra	India	27	24.5	10
113	03_78I_040	NRSC		GL	5167	Puna Tsang Chhu	Brahmaputra	Bhutan	22	20	10
114	03_77L_022	NRSC		GL	4810	Kuri Chhu	Brahmaputra	China	11	10	10
115	02_71L_008	NRSC	457G	GL	5577	Sun Kosi	Ganga	China	39	35.33	10
116	01_52L_006	NRSC	306I	GL	5727	Indus	Indus	India	11	10	10
117	02_71H_009	NRSC		GL	5448	Arun Kosi	Ganga	China	25	22.67	10
118	01_52B_012	NRSC	129I	GL	5137	Indus	Indus	India	16	14.5	10
119	03_77L_028	NRSC		GL	4632	Kuri Chhu	Brahmaputra	China	14	12.67	10
120	02_72I_005	NRSC	483G	GL	4715	Sun Kosi	Ganga	Nepal	27	24.5	10
121	03_77L_047	NRSC		GL	4364	Puna Tsang Chhu	Brahmaputra	Bhutan	47	42.67	10
122	03_82L_008	NRSC		GL	4342		Brahmaputra	China	11	10	10
123	03_77J_002	NRSC		GL	5254		Brahmaputra	China	11	10	10
124	03_82G_007	NRSC		GL	4994		Brahmaputra	China	12	11	9

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
125	02_62F_013	NRSC	256G	GL	5252	Karnal	Ganga	China	49	45	9
126	03_91C_071	NRSC		GL	4339	Dibang	Brahmaputra	China	37	34	9
127	03_82N_037	NRSC		GL	4691		Brahmaputra	China	12	11	9
128	03_91H_033	NRSC		GL	4389	Lohit	Brahmaputra	China	12	11	9
129	02_71H_004	NRSC		GL	5239	Arun Kosi	Ganga	China	27	24.67	9
130	02_72I_026	NRSC	112G	GL	5188	Sun Kosi	Ganga	Nepal	32	29.33	9
131	02_62F_016	NRSC	591G	GL	5359	Karnal	Ganga	Nepal	16	14.67	9
132	03_78I_014	NRSC		GL	5087	Puna Tsang Chhu	Brahmaputra	Bhutan	21	19.33	9
133	02_71P_030	NRSC	166G	GL	5329	Arun Kosi	Ganga	China	23	21.33	8
134	02_71H_014	NRSC		GL	4458	Trisuli	Ganga	China	9	8.33	8
135	03_77L_073	NRSC		GL	5166	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	13	12	8
136	03_78A_010	NRSC		GL	5078	Teesta	Brahmaputra	India	36	33.33	8

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
137	03_78I_067	NRSC		GL	4918	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	23	21.33	8
138	03_78I_036	NRSC		GL	5028	Puna Tsang Chhu	Brahmaputra	Bhutan	13	12	8
139	03_82L_006	NRSC		GL	4147		Brahmaputra	China	14	13	8
140	02_72I_006	NRSC		GL	4741	Sun Kosi	Ganga	Nepal	19	17.67	8
141	02_72I_013	NRSC	694G	GL	5497	Sun Kosi	Ganga	Nepal	19	17.67	8
142	03_82L_007	NRSC		GL	4163	Ding	Brahmaputra	India	17	15.67	8
143	02_71L_024	NRSC	245G	GL	5263	Sun Kosi	Ganga	China	28	26	8
144	03_83A_005	NRSC		GL	4994	Dangme Chhu	Brahmaputra	India	13	12	8
145	03_77L_057	NRSC		GL	4897	Kuri Chhu	Brahmaputra		48	44.33	8
146	03_78E_016	NRSC		GL	5004		Brahmaputra	China	18	16.67	8
147	02_71H_016	NRSC		GL	5305	Arun Kosi	Ganga	China	27	25.33	7
148	02_71H_032	NRSC		GL	5116	Sun Kosi	Ganga	China	27	25.33	7

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
149	03_71B_001	NRSC		GL	5692		Brahmaputra	China	27	25.33	7
150	03_78I_015	NRSC		GL	5116	Puna Tsang Chhu	Brahmaputra	Bhutan	16	15	7
151	03_77J_001	NRSC		GL	5354		Brahmaputra	China	26	24.33	7
152	03_91C_043	NRSC		GL	4429		Brahmaputra	China	11	10.33	6
153	02_72M_014	NRSC	47G	GL	5217	TamurKosi	Ganga	Nepal	23	21.67	6
154	03_83A_003	NRSC		GL	5188	Dangme Chhu	Brahmaputra	India	87	82	6
155	03_77L_049	NRSC		GL	4716	Puna Tsang Chhu	Brahmaputra	Bhutan	36	34	6
156	03_91H_001	NRSC		GL	4429	Lohit	Brahmaputra	China	18	17	6
157	03_78E_003	NRSC		GL	5152	Puna Tsang Chhu	Brahmaputra	Bhutan	23	22	5
158	02_78A_002	NRSC	668G	GL	5397	Arun Kosi	Ganga	China	14	13.33	5

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
159	03_77L_071	NRSC		GL	5228	Puna Tsang Chhu	Brahmaputra	Bhutan	22	21	5
160	02_71L_009	NRSC	520G	GL	5546	Arun Kosi	Ganga	China	33	31.33	5
161	03_62O_035	NRSC		GL	5256		Brahmaputra	China	33	31.33	5
162	02_72I_015	NRSC	814G	GL	5416	Sun Kosi	Ganga	Nepal	45	42.67	5
163	02_78A_008	NRSC	199G	GL	5032	TamurKosi	Ganga	Nepal	26	24.67	5
164	03_77L_082	NRSC		GL	5019	Puna Tsang Chhu	Brahmaputra	Bhutan	14	13.33	5
165	02_71L_017	NRSC	179G	GL	5211	Sun Kosi	Ganga	China	14	13.33	5
166	02_72M_001	NRSC	737G	GL	5675	Arun Kosi	Ganga	China	7	6.67	5
167	02_71H_030	NRSC	598G	GL	5411	Sun Kosi	Ganga	China	14	13.33	5
168	03_78A_017	NRSC		GL	5545	Teesta	Brahmaputra	India	29	27.5	5
169	03_77L_045	NRSC		GL	5224	Kuri Chhu	Brahmaputra	China	34	32.67	4
170	01_61B_002	NRSC	345I	GL	5722	Indus	Indus	China	27	26	4
171	01_62B_003	NRSC	86I	GL	5288	Satluj	Indus	India	13	12.5	4

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
172	02_71H_005	NRSC		GL	5010	Arun Kosi	Ganga	China	78	75	4
173	02_72I_022	NRSC	287G	GL	5344	Sun Kosi	Ganga	Nepal	32	30.67	4
174	03_78A_030	NRSC		GL	4447	Amo Chhu	Brahmaputra		16	15.33	4
175	02_71H_010	NRSC		GL	5481	Arun Kosi	Ganga	China	26	25	4
176	03_91C_004	NRSC		GL	4137		Brahmaputra	China	19	18.33	4
177	03_77L_061	NRSC		GL	5038	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	18	17.33	4
178	02_71L_030	NRSC	242G	GL	5242	Sun Kosi	Ganga	China	22	21.33	3
179	02_62O_002	NRSC	410G	GL	5495	Kali Gandak	Ganga	Nepal	22	21.33	3
180	03_62K_005	NRSC		GL	4999		Brahmaputra	China	23	22.33	3
181	03_71P_004	NRSC		GL	5637		Brahmaputra	China	11	10.67	3
182	02_71L_007	NRSC	572G	GL	5576	Arun Kosi	Ganga	China	13	12.67	3
183	03_82L_004	NRSC		GL	4441		Brahmaputra	China	12	11.67	3

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
184	02_71H_022	NRSC		GL	5735	Arun Kosi	Ganga	China	20	19.33	3
185	03_77L_036	NRSC		GL	5810	Kuri Chhu	Brahmaputra	China	24	23.33	3
186	02_62K_011	NRSC	612G	GL	4673	Bheri	Ganga	Nepal	30	29	3
187	03_78I_065	NRSC		GL	4668	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	13	12.67	3
188	03_91C_021	NRSC		GL	4093		Brahmaputra	China	31	30	3
189	02_71L_015	NRSC	284G	GL	5261	Sun Kosi	Ganga	China	23	22.33	3
190	03_82J_006	NRSC		GL	3657		Brahmaputra	China	58	56.33	3
191	03_78A_015	NRSC/SDC	/Medium Risk	GL	4970	Teesta	Brahmaputra	India	10	9.67	3
192	03_78I_008	NRSC		GL	5252	Manas Chhu & MangdeChhu	Brahmaputra	Bhutan	13	12.67	3
193	03_78A_005	NRSC		GL	5201	Teesta	Brahmaputra	India	13	12.67	3
194	02_71H_018	NRSC	123G	GL	4787	Trisuli	Ganga	China	32	31.33	2

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Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
195	02_71P_032	NRSC	564G	GL	5190	Arun Kosi	Ganga	China	19	18.67	2
196	03_62J_028	NRSC		GL	5603		Brahmaputra	China	43	42.33	2
197	03_91H_006	NRSC		GL	4620	Lohit	Brahmaputra	China	17	16.67	2
198	02_78A_006	NRSC	676G	GL	5743	Arun Kosi	Ganga	China	17	16.67	2
199	02_71L_025	NRSC	154G	GL	5357	Sun Kosi	Ganga	China	19	18.67	2
200	02_71P_039	NRSC	396G	GL	5489	Arun Kosi	Ganga	China	19	18.67	2
201	02_72M_012	NRSC	69G	GL	4932	TamurKosi	Ganga	Nepal	17	16.67	2
202	03_82C_011	NRSC		GL	5242		Brahmaputra	China	15	14.67	2
203	03_62J_020	NRSC		GL	5603		Brahmaputra	China	15	14.67	2
204	03_77H_025	NRSC		GL	4312	Puna Tsang Chhu	Brahmaputra	Bhutan	24	23.67	1
205	02_72I_016	NRSC	739G	GL	5231	Sun Kosi	Ganga	Nepal	29	28.67	1
206	02_71P_036	NRSC	54G	GL	5121	Arun Kosi	Ganga	China	38	37.67	1
207	02_62F_015	NRSC	59G	GL	5359	Karnal	Ganga	China	29	28.67	1

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
208	03_77L_058	NRSC		GL	5016	Kuri Chhu	Brahmaputra		33	32.67	1
209	03_82O_001	NRSC		GL	4348		Brahmaputra	China	42	41.67	1
210	02_72I_018	NRSC	776G	GL	5370	Sun Kosi	Ganga	Nepal	34	33.67	1
211	02_71L_019	NRSC	323G	GL	5378	Sun Kosi	Ganga	China	12	12	0
212	03_91C_016	NRSC		GL	4813		Brahmaputra	China	13	13	0
213	03_78I_054	NRSC		GL	5138	Manas Chhu & MangdeChhu	Brahmaputra	Bhutan	15	15	0
214	02_71P_041	NRSC	768G	GL	5064	Arun Kosi	Ganga	China	18	18	0
215	03_91C_015	NRSC		GL	4421		Brahmaputra	China	21	21	0
216	02_71L_031	NRSC	52G	GL	4682	Sun Kosi	Ganga	China	30	30	0
217	02_62G_003	NRSC	589G	GL	3603	Karnal	Ganga	Nepal	33	33	0
218	02_72I_010	NRSC	263G	GL	5125	Sun Kosi	Ganga	Nepal	14	14	0
219	03_91C_010	NRSC		GL	4712		Brahmaputra	China	21	21	0
220	03_62J_004	NRSC		GL	5556		Brahmaputra	China	15	15	0

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
221	03_62K_007	NRSC		GL	4911		Brahmaputra	China	29	29	0
222	02_71L_027	NRSC	433G	GL	5234	Sun Kosi	Ganga	China	18	18	0
223	03_77H_009	NRSC		GL	5150		Brahmaputra	China	15	15	0
224	02_72M_003	NRSC	823G	GL	5608	Arun Kosi	Ganga	China	18	18	0
225	02_71P_024	NRSC	576G	GL	5273	Arun Kosi	Ganga	China	22	22	0
226	03_77H_026	NRSC		GL	5233		Brahmaputra	China	10	10	0
227	01_52L_007	NRSC	184I	GL	5498	Indus	Indus	India	33	33	0
228	01_42H_002	NRSC	162I	GL	2763	Gilgit	Indus	India	16	16	0
229	02_78A_007	NRSC	429G	GL	5618	TamurKosi	Ganga	Nepal	15	15	0
230	02_62F_006	NRSC		GL	5444	Karnal	Ganga	Nepal	15	15	0
231	03_77J_005	NRSC		GL	5766		Brahmaputra	China	13	13	0
232	03_91C_006	NRSC		GL	5057		Brahmaputra	China	4	4	0
233	03_78I_046	NRSC		GL	5168	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	22	22	0

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
234	02_71L_021	NRSC	438G	GL	5373	Sun Kosi	Ganga	China	17	17	0
235	02_71L_014	NRSC	240G	GL	5364	Sun Kosi	Ganga	China	16	16	0
236	03_82N_025	NRSC		GL	4764		Brahmaputra	China	24	24	0
237	02_71L_012	NRSC	96G	GL	5570	Sun Kosi	Ganga	China	21	21	0
238	02_72M_013	NRSC	518G	GL	5233	Arun Kosi	Ganga	Nepal	12	12	0
239	02_77D_005	NRSC	499G	GL	5738	Arun Kosi	Ganga	China	7	7	0
240	03_82N_031	NRSC		GL	4409		Brahmaputra	China	16	16	0
241	02_72I_028	NRSC	146G	GL	4408	Sun Kosi	Ganga	Nepal	25	25.33	-1
242	03_77L_039	NRSC		GL	5457	Kuri Chhu	Brahmaputra	China	42	42.33	-1
243	02_77D_011	NRSC	393G	GL	5305	Arun Kosi	Ganga	China	45	45.67	-1
244	03_77L_062	NRSC		GL	5295	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	47	47.33	-1
245	03_62K_011	NRSC		GL	5136		Brahmaputra	China	45	45.33	-1
246	02_77D_010	NRSC	590G	GL	5127	Arun Kosi	Ganga	China	37	37.33	-1

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
247	03_77H_017	NRSC		GL	4537	Puna Tsang Chhu	Brahmaputra	Bhutan	25	25.33	-1
248	03_62J_010	NRSC		GL	5571		Brahmaputra	China	24	24.33	-1
249	03_83A_001	NRSC		GL	5018		Brahmaputra	China	47	47.33	-1
250	03_82N_001	NRSC		GL	5055		Brahmaputra	China	34	34.33	-1
251	03_78A_004	NRSC		GL	5456		Brahmaputra	China	23	23.33	-1
252	02_72I_009	NRSC		GL	5292	Sun Kosi	Ganga	Nepal	17	17.33	-2
253	03_77H_021	NRSC		GL	5135	Puna Tsang Chhu	Brahmaputra	Bhutan	13	13.33	-2
254	03_82F_001	NRSC		GL	4822		Brahmaputra	China	14	14.33	-2
255	03_77L_038	NRSC		GL	5521		Brahmaputra	China	13	13.33	-2
256	02_71P_048	NRSC	283G	GL	5094	Arun Kosi	Ganga	China	18	18.33	-2
257	03_82F_024	NRSC		GL	4197		Brahmaputra	China	19	19.33	-2

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
258	03_62K_006	NRSC		GL	5101		Brahmaputra	China	25	25.5	-2
259	02_71H_020	NRSC		GL	5354	Arun Kosi	Ganga	China	71	72.67	-2
260	03_91C_035	NRSC		GL	4283		Brahmaputra	China	54	55	-2
261	03_77H_022	NRSC		GL	4936		Brahmaputra	China	19	19.33	-2
262	03_82F_012	NRSC		GL	4454		Brahmaputra	China	19	19.33	-2
263	02_71H_036	NRSC	195G	GL	5024	Trisuli	Ganga	Nepal	13	13.33	-2
264	02_71L_005	NRSC	282G	GL	5524	Arun Kosi	Ganga	China	18	18.33	-2
265	03_77L_019	NRSC		GL	5681		Brahmaputra	China	14	14.33	-2
266	02_72M_015	NRSC	115G	GL	4969	TamurKosi	Ganga	Nepal	13	13.33	-2
267	03_78A_006	NRSC		GL	5004	Teesta	Brahmaputra	India	14	14.33	-2
268	03_77H_029	NRSC		GL	5049	Puna Tsang Chhu	Brahmaputra	Bhutan	21	21.67	-3
269	02_71H_013	NRSC	172G	GL	4446	Trisuli	Ganga	China	16	16.5	-3
270	02_71D_003	NRSC	67G	GL	3668	Trisuli	Ganga	Nepal	25	25.67	-3

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Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
271	03_77H_024	NRSC		GL	4369	Puna Tsang Chhu	Brahmaputra	Bhutan	45	46.33	-3
272	01_53I_002	NRSC/SDC	26I/Very High Risk	GL	4273	Satluj	Indus	India	29	30	-3
273	01_52B_010	NRSC/SDC	75I/Medium Risk	GL	5122	Indus	Indus	India	16	16.5	-3
274	03_77L_034	NRSC		GL	5500	Kuri Chhu	Brahmaputra	China	21	21.67	-3
275	03_77L_023	NRSC		GL	5489	Kuri Chhu	Brahmaputra	China	29	30	-3
276	02_72M_004	NRSC	336G	GL	5293	Arun Kosi	Ganga	China	50	51.67	-3
277	03_78A_016	NRSC		GL	5451	Teesta	Brahmaputra	India	11	11.33	-3
278	01_62F_007	NRSC		GL	5344	Satluj	Indus	China	21	21.67	-3
279	03_77D_007	NRSC/SDC	/Very High Risk	GL	5015	Teesta	Brahmaputra	India	24	24.67	-3
280	03_78E_018	NRSC		GL	5164		Brahmaputra	China	18	18.5	-3
281	02_62F_010	NRSC		GL	5502	Karnal	Ganga	Nepal	10	10.33	-3
282	01_52A_002	NRSC		GL	4537	Shyok	Indus	India	20	20.67	-3
283	03_77K_002	NRSC		GL	5154		Brahmaputra	China	36	37.33	-4

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Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
284	01_52H_003	NRSC		GL	4165	Chenab	Indus	India	154	160.67	-4
285	02_62F_011	NRSC	362G	GL	5524	Karnal	Ganga	China	25	26	-4
286	02_72I_012	NRSC	113G	GL	4409	Sun Kosi	Ganga	Nepal	39	40.67	-4
287	03_62K_013	NRSC		GL	5101		Brahmaputra	China	45	47	-4
288	03_78I_019	NRSC		GL	5224	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	23	24	-4
289	03_78E_027	NRSC		GL	4808	Puna Tsang Chhu	Brahmaputra	Bhutan	18	18.67	-4
290	03_78A_008	NRSC		GL	4998	Teesta	Brahmaputra	India	18	18.67	-4
291	02_71L_022	NRSC	715G	GL	5554	Arun Kosi	Ganga	China	26	27	-4
292	03_83A_007	NRSC		GL	5028	Jia Brali	Brahmaputra	India	15	15.67	-4
293	02_71P_046	NRSC	317G	GL	4898	Arun Kosi	Ganga	China	27	28	-4
294	02_71L_018	NRSC	651G	GL	5377	Sun Kosi	Ganga	China	14	14.67	-5
295	03_91H_034	NRSC		GL	4629	Lohit	Brahmaputra	China	13	13.67	-5

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
296	03_78I_064	NRSC		GL	4976	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	19	20	-5
297	03_82O_002	NRSC		GL	4198		Brahmaputra	China	18	19	-5
298	03_62J_024	NRSC		GL	5548		Brahmaputra	China	19	20	-5
299	03_77H_027	NRSC		GL	4927		Brahmaputra	China	21	22	-5
300	01_52C_002	NRSC	46I	GL	4092	Chenab	Indus	India	41	43.33	-5
301	03_82G_004	NRSC		GL	4498		Brahmaputra	China	29	30.67	-5
302	02_71H_006	NRSC		GL	5167	Arun Kosi	Ganga	China	33	34.67	-5
303	03_91G_005	NRSC		GL	5170	Lohit	Brahmaputra	China	10	10.5	-5
304	03_62O_045	NRSC		GL	5566		Brahmaputra	China	9	9.5	-5
305	02_72I_001	NRSC	198G	GL	5333	Sun Kosi	Ganga	Nepal	12	12.67	-5
306	03_77L_078	NRSC		GL	5296	Puna Tsang Chhu	Brahmaputra	Bhutan	14	14.67	-5
307	01_62E_016	NRSC	270I	GL	5528	Satluj	Indus	China	19	20	-5

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
308	03_91G_003	NRSC		GL	5018	Lohit	Brahmaputra	China	19	20	-5
309	03_78A_012	NRSC		GL	5130	Teesta	Brahmaputra	India	28	29.33	-5
310	02_71H_011	NRSC	775G	GL	4509	Trisuli	Ganga	China	27	28.5	-5
311	02_62K_001	NRSC	329G	GL	4404	Karnal	Ganga	Nepal	27	28.33	-5
312	03_82F_005	NRSC		GL	4762		Brahmaputra	China	42	44	-5
313	02_72M_011	NRSC	86G	GL	4865	Arun Kosi	Ganga	Nepal	40	42.5	-6
314	03_78A_011	NRSC		GL	5168	Amo Chhu	Brahmaputra	China	15	16	-6
315	03_78I_005	NRSC		GL	5338	Puna Tsang Chhu	Brahmaputra	Bhutan	42	44.67	-6
316	03_77L_079	NRSC		GL	5386	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	33	35	-6
317	03_62J_003	NRSC		GL	5553		Brahmaputra	China	10	10.67	-6
318	02_72I_019	NRSC	757G	GL	5510	Sun Kosi	Ganga	Nepal	16	17	-6
319	03_82F_018	NRSC		GL	4554		Brahmaputra	China	16	17	-6

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
320	03_77H_015	NRSC		GL	4801		Brahmaputra	China	13	14	-7
321	03_77H_010	NRSC		GL	5518		Brahmaputra	China	13	14	-7
322	03_71D_002	NRSC		GL	5574		Brahmaputra	China	33	35.67	-7
323	03_82F_009	NRSC		GL	4712		Brahmaputra	China	22	23.67	-7
324	02_71L_033	NRSC	408G	GL	5369	Sun Kosi	Ganga	Nepal	14	15	-7
325	02_71P_042	NRSC	654G	GL	5524	Arun Kosi	Ganga	China	19	20.33	-7
326	03_78A_020	NRSC		GL	5219	Teesta	Brahmaputra	India	14	15	-7
327	03_77L_031	NRSC		GL	4698	Kuri Chhu	Brahmaputra	China	17	18.33	-7
328	02_72I_021	NRSC	764G	GL	5276	Sun Kosi	Ganga	Nepal	19	20.33	-7
329	03_71P_003	NRSC		GL	5360		Brahmaputra	China	26	28.33	-8
330	03_62K_008	NRSC		GL	4968		Brahmaputra	China	41	44.33	-8
331	01_52C_001	NRSC	11I	GL	4394	Shingo (Indus)	Indus	India	51	55.33	-8

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
332	03_77L_074	NRSC		GL	5324	Manas Chhu & MangdeChhu	Brahmaputra	Bhutan	16	17.33	-8
333	01_53M_001	NRSC	331	GL	5576	Indus	Indus	China	17	18.5	-8
334	03_91G_009	NRSC		GL	4637	Lohit	Brahmaputra	China	16	17.33	-8
335	02_72I_008	NRSC	99G	GL	5040	Sun Kosi	Ganga		33	36	-8
336	03_78I_009	NRSC		GL	5108	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	24	26	-8
337	02_62P_001	NRSC	258G	GL	4472	Bheri	Ganga	Nepal	41	45	-9
338	02_71H_031	NRSC	78G	GL	5268	Sun Kosi	Ganga	China	25	27.33	-9
339	02_71H_023	NRSC		GL	5595	Arun Kosi	Ganga	China	54	59.33	-9
340	03_78I_057	NRSC		GL	5060	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	40	44.67	-10
341	02_62B_006	NRSC	495G	GL	5106	Karnal	Ganga	China	38	42	-10
342	03_77L_048	NRSC		GL	4792	Kuri Chhu	Brahmaputra	China	23	25.67	-10

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
343	03_78A_002	NRSC/SDC	/Very High Risk	GL	4952	Teesta	Brahmaputra	India	36	40	-10
344	02_71L_020	NRSC	156G	GL	5348	Sun Kosi	Ganga	China	25	27.67	-10
345	03_78I_011	NRSC		GL	5239	Manas Chhu & Mangde Chhu	Brahmaputra	Bhutan	20	22.33	-10
346	02_72M_008	NRSC	376G	GL	4722	TamurKosi	Ganga	Nepal	34	37.67	-10
347	03_91G_006	NRSC		GL	5028	Lohit	Brahmaputra	China	20	22.33	-10
348	02_62F_014	NRSC	236G	GL	5481	Karnal	Ganga	China	6	6.67	-10
349	02_62G_002	NRSC	599G	GL	4822	Karnal	Ganga	Nepal	17	19	-11
350	02_71H_025	NRSC	464G	GL	5303	Trisuli	Ganga	China	17	19	-11
351	03_91H_007	NRSC		GL	4635	Lohit	Brahmaputra	China	28	31.5	-11
352	03_78A_026	NRSC		GL	4736	Teesta	Brahmaputra	India	10	11.33	-12
353	03_62J_027	NRSC		GL	4781		Brahmaputra	China	20	22.67	-12
354	03_77L_025	NRSC		GL	5370	Kuri Chhu	Brahmaputra	China	14	16	-13
355	03_91C_003	NRSC		GL	4703		Brahmaputra	China	27	31	-13

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
356	01_62J_004	NRSC	446I	GL	5504	Satluj	Indus	China	9	10.33	-13
357	02_71H_024	NRSC	155G	GL	4890	Trisuli	Ganga	China	23	26.33	-13
358	03_91D_070	NRSC		GL	4126	Lohit	Brahmaputra	China	14	16	-13
359	02_72I_020	NRSC	763G	GL	5436	Sun Kosi	Ganga	Nepal	18	20.67	-13
360	03_91G_004	NRSC		GL	5262	Lohit	Brahmaputra	China	26	30.33	-14
361	02_78A_001	NRSC	498G	GL	5201	Arun Kosi	Ganga	China	19	22.33	-15
362	03_82N_029	NRSC		GL	4492		Brahmaputra	China	36	42.5	-15
363	02_62O_005	NRSC	609G	GL	5450	Kali Gandak	Ganga	Nepal	11	13	-15
364	02_53N_001	NRSC	250G	GL	4688	Ganga	Ganga	India	19	22.67	-16
365	03_78I_006	NRSC		GL	5158	Puna Tsang Chhu	Brahmaputra	Bhutan	18	21.33	-16
366	02_62J_001	NRSC		GL	5182	Karnal	Ganga	Nepal	5	6	-17
367	02_71P_034	NRSC	726G	GL	5259	Arun Kosi	Ganga	China	19	23	-17
368	03_77H_016	NRSC		GL	4929		Brahmaputra	China	33	40.67	-19
369	02_71P_038	NRSC	586G	GL	5483	Arun Kosi	Ganga	China	22	27	-19

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
370	01_52A_004	NRSC/SDC	/Very High Risk	GL	4619	Shyok	Indus	India	8	10	-20
371	02_62O_004	NRSC	299G	GL	5529	Kali Gandak	Ganga	Nepal	16	20.33	-21
372	02_62B_004	NRSC	232G	GL	4918	Sarda	Ganga	India	16	21.33	-25
373	03_62K_010	NRSC		GL	5181		Brahmaputra	China	51	68.33	-25
374	03_91D_082	NRSC		GL	4550	Lohit	Brahmaputra	China	25	34.67	-28
375	03_62J_025	NRSC		GL	5362		Brahmaputra	China	15	21	-29
376	03_82N_011	NRSC		GL	4997		Brahmaputra	China	15	21	-29
377	01_52A_003	NRSC		GL	4586	Shyok	Indus	India	15	21.33	-30
378	03_82N_035	NRSC		GL	4479		Brahmaputra	China	14	20.5	-32
379	02_62K_006	NRSC	70G	GL	5053	Karnal	Ganga	Nepal	20	30	-33
380	03_91C_002	NRSC		GL	4691		Brahmaputra	China	22	33.5	-34
381	02_71P_017	NRSC		GL	4194	Arun Kosi	Ganga	China	36	60	-40
382	02_71P_020	NRSC		GL	4200	Arun Kosi	Ganga	China	71	118.5	-40
383	02_71H_019	NRSC	92G	GL	4674	Trisuli	Ganga	China	7	15	-53

Sl.No.	Lake ID	Inventory Developed by	Rank of Vulnerability	Lake Type	Elevation (m)	River	Basin	Country	Area of October-2023 (ha)	Base Area (Avg area of year 2022) (ha)	Max Change in Area (%)
384	03_82N_032	NRSC		GL	4384		Brahmaputra	China	17	41	-59
385	02_71P_044	NRSC	557G	GL	5555	Arun Kosi	Ganga	China	0	8.33	-100

G stands for Ganga, I for Indus and B for Brahmaputra under the rank of vulnerability,

- Unobservable (as per NRSC) , Ø indicates small rivulet/first order stream, #indicates frozen/ dried lakes

As per para - 7 207

सत्यमेव जयते

Central Water Commission

Ministry of Water Resources,

River Development & Ganga Rejuvenation

Advisory Sheet

Glacial Lake Outburst Flood –South Lhonak System in Teesta River Basin

Planning and Development Organisation

March 2015

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ABBREVIATIONS:

DEM – Digital Elevation Model
GL – Glacial Lake
GLOF – Glacial Lake Outburst Flood
WB – Water Body

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EXECUTIVE SUMMARY

Glacial lakes (GLs) are common in the higher elevation of glacierised basins in Himalayan region and Water Bodies (WBs) are being formed by obstructions created in the drainage path generally due to massive landslides. GLs are formed when glacial ice or moraines impound water. Incidents of outburst of Glacial Lakes/Water bodies in Himalayan region are increasing which have potential of flooding in downstream areas. Flash floods caused by the outburst of GL/WBs are called as Glacial Lake Outburst Flood (GLOF)/Lake Outburst Flood.

CWC has prepared an inventory of GL/WBs (area > 10 ha.) in the Himalayan Region through NRSC, Hyderabad in June 2011. The GL/WBs are being monitored (area > 50 ha) on monthly basis during monsoon season. The monitoring reports are shared with the related field offices of CWC for considering the information in flood management, as deemed fit.

A study was taken up by CWC to identity habitation or important structures in the downstream of GL/WBs which are vulnerable from flood hazard aspects in the event of GLOF. The size & location of GL/WBs; human habitation; water resources project in the downstream areas were considered for prioritising GL/WBs for taking up the outburst or breach studies, in order to advise the concerned States and stakeholders.

It was reported that South Lhonak Glacial Lake in Sikkim is having very high probability of sudden outburst which may cause floods in downstream areas. CWC conducted a Study up to about 175 km downstream of the lake using information from inventory of GL/WBs, monitoring reports, cross section data @ 1 km interval extracted from CartoDEM ver.2 to analyse flood implications in the downstream villages namely Lachen, Chungthang, Dikchu, Singtam, Manipal, Rangpo & Bara Mungwa and hydropower projects on the river in Sikkim. A highly sophisticated mathematical model MIKE–11 was setup for the study.

It has been observed that four glacial lakes at different locations are discharging in the initial reach of the river. Total Five probable scenarios were analysed for the worst possible situation including a scenario where all four glacial lakes burst at same time but the possibility of that event is very low. The outcome of the study is in the form of likely rise in water level over and above the existing water level in the river due to constant flow of 1000 m^3/s. The rise in water level is varying from 2.0 to 15.24m at various identified locations and is expected to reach in a span of 1.5 hr hr to 6 hr from the time of bursting of the lake(s). The State authorities are advised to inform the local bodies and the Project Authorities of likely consequences of GLOF and to incorporate the information in land use planning, project planning and operation suitably.

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1. INTRODUCTION

Glacial lakes (GLs) are common in the high elevation of glacierised basins in Himalayan region and Water Bodies (WBs) are being formed by obstructions created in the drainage path due to landslides or manmade structures. GLs are formed when glacial ice or moraines impound water. There are varieties of such lakes, ranging from melt water ponds on the surface of glacier to large lakes in side valleys dammed by a glacier in the main valley. These lakes normally drain their water through seepage in front of the retreating glacier. The moraine creates topographic depression in which the melt water is generally accumulated leading to formation of glacial lake. When this lake is watertight, melt waters will accumulate in the basin until seepage or overflow limits the lake level. The impoundment of the lake may be unstable, leading to sudden release of large quantities of stored water. Flash floods caused by the outburst of GL/WBs, called as Glacial Lake Outburst Flood (GLOF)/Lake Outburst Flood, are well known in Himalaya. The shrinkage of Himalayan glaciers has resulted in the formation of more moraine-dammed lakes. Bursting of such lakes lead to flash floods and these floods redistribute sediments and modify the landscape.

The study has been taken up to analyse the impact of GLOF at vulnerable locations including villages, water resources projects etc. in the downstream areas. The analysis has been carried out by developing mathematical model of the system using MIKE-11 software.

2. OBJECTIVE

The objectives of the study are as following:

1. To develop mathematical model for glacial lake outburst study for Teesta River.
2. To study impact of outburst flood at identified vulnerable locations along the river in downstream.

3. STUDY AREA AND DATA

3.1. Study Area

Main study area is upper reaches of the Teesta River which is one of the major tributaries of River Brahmaputra. The river reach, considered for the study starts from origin of critical lake(s) to village Bara Mungwa [Lat: 27° 3'56.13"N Long: 88°25'27.69"E]. There are four lakes whose outburst may cause serious flash flood situation in the downstream areas.

3.2. Data

Water spread area and lake-IDs of the four glacial lakes have been taken from the report "Inventory of Glacial Lakes/Water Bodies in Himalayan Region of Indian River Basin" and monthly monitoring reports. Cross sections of the river reach @ 1 km internal have been extracted using CartoDEM ver.2. In the absence of bed profile of the lakes, due to inaccessibility, the average depth of lakes has been taken as 30 m and also an existing constant flow of 1000 m^3/s has been assumed in the river for the purpose of study.

Fig. 1 below shows Google earth image of glacial lakes and locations of villages and hydro power projects (existing and planned) on the River Teesta and the schematic diagram showing locations and their drainage path are shown in Fig. 2.

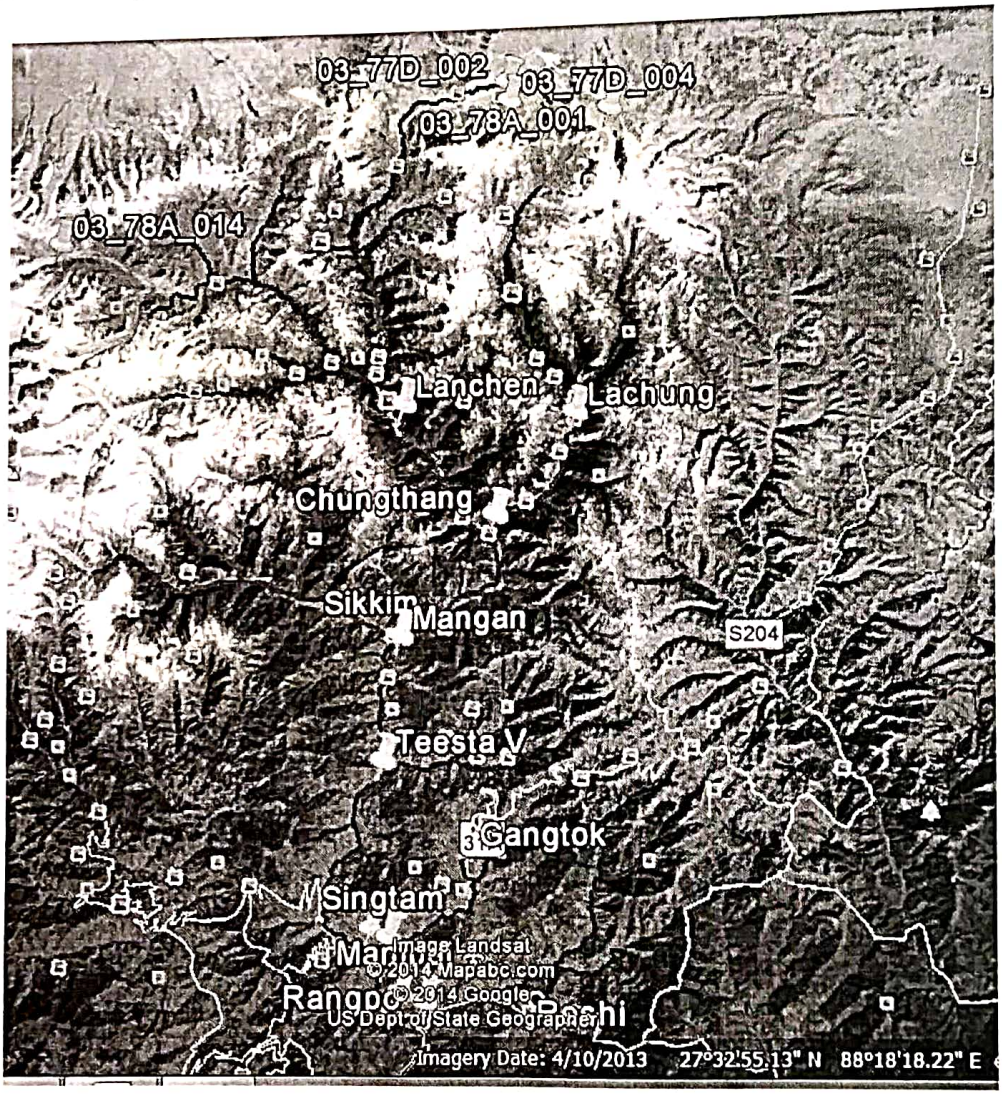

Fig. 1: Google earth image of glacial lakes and locations of villages and hydro power projects (existing and planned) on the River Teesta

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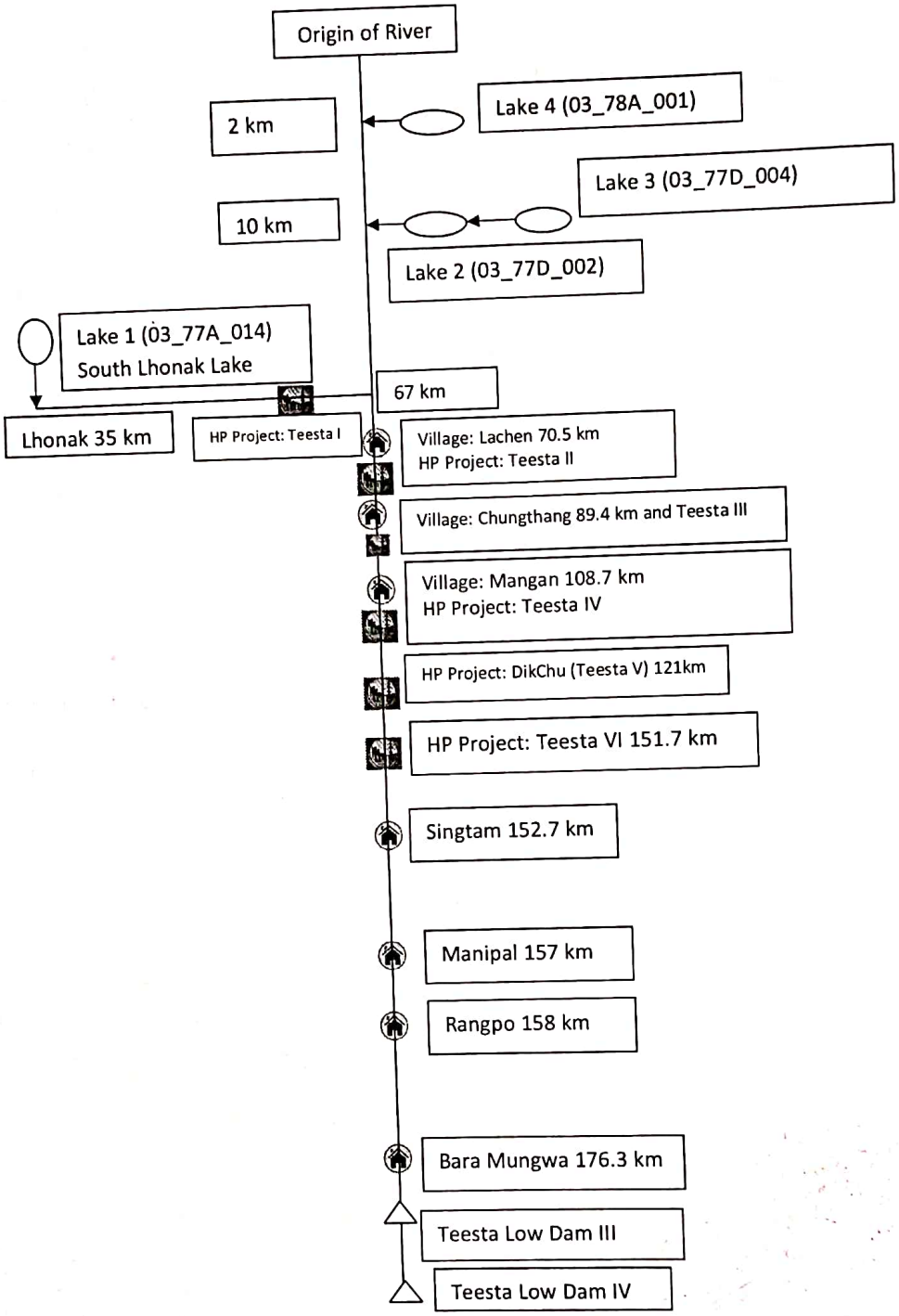

Fig. 2: Line diagram depicting glacial lakes, habitation and hydropower projects along River Teesta

4. VULNERABLE LOCATIONS

Details of the vulnerable locations along Teesta river downstream of the glacial lakes taken for the study as identified in the "Vulnerability Study of

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Glacial Lakes in Himalayan Region within Indian Boundary" prepared by Central Water Commission are given below in Table 1:

Table 1: Details of vulnerable locations downstream of glacial lakes

Name of Human Habitation/ Hydropower Project	*Latitude*	*Longitude*	*Population/ Power generation*
Teesta I	27°46'31.68"N	88°30'24.35"E	Hydro Power Project
Lanchen and Teesta II	27°42'58.99"N	88°33'33.85"E	1000 & Hydro Power Project
Chungthang and Teesta III	27°36'12.47"N	88°38'49.46"E	2800
Mangan and Teesta IV	27°30'1.32"N	88°31'58.37"E	1250 (2001 census) & Hydro Power Project
Teesta V (DikChu)	27°23'14.22"N	88°30'12.50"E	Hydro Power Project
Teesta VI	27°14'32.20"N	88°28'39.58"E	Hydro Power Project
Singtam	27°13'53.61"N	88°29'39.35"E	210
Manipal	27°10'58.06"N	88°30'4.42"E	Educational Hub
Rangpo	27°10'26.41"N	88°31'30.20"E	3724
Bara Mungwa	27° 3'56.13"N	88°25'27.69"E	1297

5. BEHAVIOUR OF GLACIAL LAKES

The water spread area of the identified four glacial lakes as per monthly monitoring reports is given in Table 2 below. It may be noted that the water spread area of the lakes is fluctuating on month-to-month basis but it was the highest in the month of Jun/Jul 2011 during the monitoring period of four years.

Table 2: Water spread area of glacial lakes

	Water Spread Area (ha)			
Lake ID / *Month& Year*	*03_78A_014 (Lake1)*	*03_77D_002 (Lake 2)*	*03_77D_004 (Lake 3)*	*03_78A_001 (Lake4)*
Inventory (2009)	94	105	106	156
Jun-11	**136**	**119**	**123**	cloud
Jul-11	cloud	cloud	cloud	**180**
Aug-11	cloud	cloud	cloud	cloud
Sep-11	134	113	114	162
Oct-11	126	103	101	145
Jun-12	100	96	107	167
Jul-12	Cloud	cloud	118	cloud
Aug-12	Cloud	cloud	cloud	cloud
Sep-12	102	91	103	152
Oct-12	99	99	104	142
Jun-13	117	110	106	161
Jul-13	113	97	101	154
Aug-13	Cloud	Cloud	116	163
Sep-13	115	100	114	164
Oct-13	109	91	105	153
Jun-14	100	106	101	146
Jul-14	Cloud	106	112	Cloud
Aug-14	Cloud	Cloud	108	Cloud
Sep-14	117	Cloud	114	157
Oct-14	128	87	103	144

The variation in water spread area of the identified glacial lakes is shown in graphical form in Fig. 3 below:

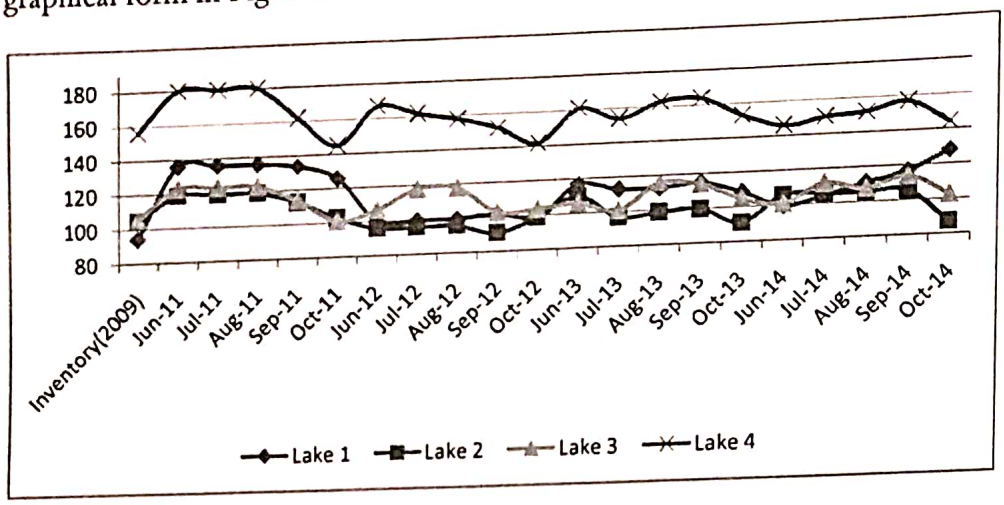

Fig. 3: Graph showing variation in water spread area of four lakes

6. POSSIBLE SCENARIOS FOR STUDY

It may be seen from the Fig. 2 that lake 1 and lake 4 are independent and probability of outburst happening at the same time is very less, whereas lake 2 and lake 3 are interconnected. Lake 3 drains its water into Lake 2 so there can be two possibilities. A worst possible scenario of all lakes getting burst at same time is also considered, but probability of that event happening is really low.

A. Lake 2 alone bursts
B. Lake 3 bursts and consecutively Lake 2 also bursts.

Therefore, Five possible scenarios as given below are likely to occur for which simulation studies have been carried out.

Scenario a. Only lake 1 outbursts
Scenario b. Only lake 2 outbursts
Scenario c. Lake 2 and lake 3 outburst at almost same time
Scenario d. Only lake 4 outbursts
Scenario e. All lakes outburst at same time.

7. METHODOLOGY

7.1. Volume of Glacial Lakes

The volume of water contained in the glacial lakes is a key input for the study as tabulated below in Table 3.

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Table 3: Maximum water spread area and volume of glacial lakes

Lake	*Maximum Area (ha)*	*Average depth (m)*	*Volume (m^3)*
Lake 1	136	30	40.8×10^6
Lake 2	119	30	35.7×10^6
Lake 3	123	30	36.9×10^6
Lake 4	180	30	54.0×10^6

7.2. Scheme of the River Network

River network scheme has been digitized using the MIKE-11 GIS application. The river network along with glacial lakes has been schematized and exported as MIKE-11 Network file.

7.3. Cross sections

Extracted cross-sections, at an interval of 1 km, were exported as MIKE-11 cross section files. The cross sections were examined and incompatible cross-sections (which did not follow the profile) were removed. Generated longitudinal profile of the river is shown in Fig. 4.

7.4. Mathematical Model setup

Glacial lakes were represented as separate branch using dummy cross sections and volume of the glacial lakes has been assigned as storage volume of respective cross sections. These branches were hydraulically connected to the main river at the appropriate location.

Cross-sections extracted using DEM were incorporated in the model. Model was run for identified five scenarios as detailed under para 6 above.

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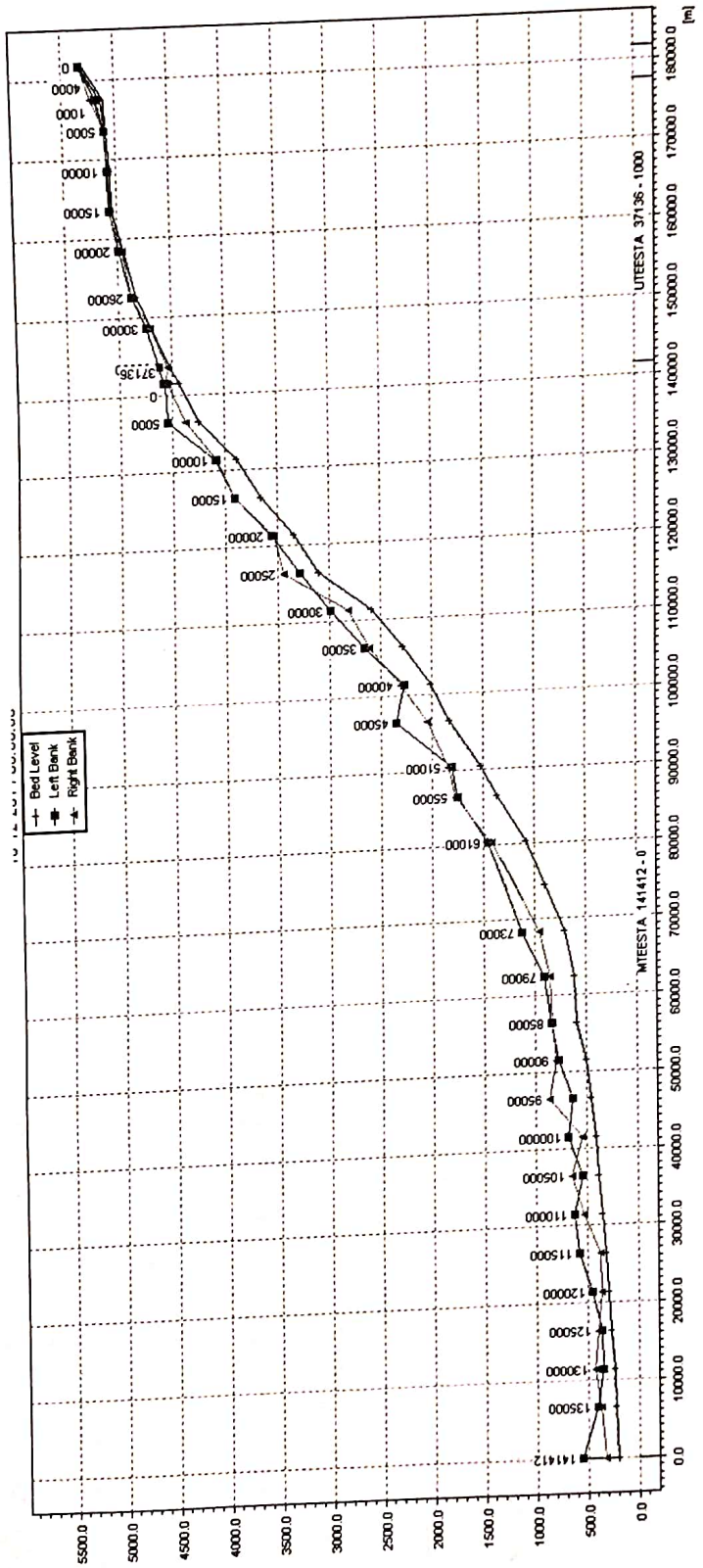

Fig. 4: Longitudinal profile of River Teesta

gis

7.5. Assumptions and Limitations

The following assumptions and limitations have been considered in the study:

- It has been considered that flow is not being modified at hydro power projects.
- A scenario with constant flows of 1000 m^3/s have been considered as existing conditions in the river, though the real case may be different.
- Depth of the glacial lakes is assumed as 30 m as per guidance available in the related literature.
- The cross sections considered are not actual but derived from CartoDEM ver.2 digital elevation model.

8. RESULTS

Increase in water levels and discharges, maximum velocities and time for the peak flood wave to reach at the site due to GLOF at all locations under study were worked out as given below in the tables 4a to 4e for five scenarios. The increase is over and above of existing water level in the river due to a constant flow of 1000 m^3/sec as already explained above. The site of proposed Teesta I project would be affected only in scenario a.

Table 4a: Scenario a

Location	*Increase in water level (m)*	*Discharge (m^3/s)*	*Maximum velocity (m/s)*	*Time to reach at (minutes)*
Teesta I	4.43	6230	14.3	100
Lachen and Teesta II	4.31	6225	14.2	105
Chungthang and Teesta III	4.45	6210	12.45	120
Mangan and Teesta IV	4.71	6200	10.45	125
Dik-Chu (Teesta V)	7	6080	5.9	140
Singtam and Teesta VI	5.4	5846	5.4	192
Manipal	3.96	5788	4.3	210
Rangpo	3.65	5788	4.3	210
Bara Mungwa	2	5650	4	250

Table 4b: Scenario b

Location	*Increase in water level (m)*	*Discharge (m^3/s)*	*Maximum velocity (m/s)*	*Time (minutes)*
Lachen and Teesta II	4.08	5520	13.5	120
Chungthang and Teesta III	3.6	5500	12	140
Mangan and Teesta IV	4.04	5460	9.2	140
Dik-Chu (Teesta V)	5.43	5180	6.3	160
Singtam and Teesta VI	4.84	4935	5.7	220

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Location	*Increase in water level (m)*	*Discharge (m^3/s)*	*Maximum velocity (m/s)*	*Time (minutes)*
Manipal	3.38	4800	4.5	260
Rangpo	3.28	4770	4.1	260
Bara Mungwa	2.37	4640	3.5	280

Table 4c: Scenario c

Location	*Increase in water level (m)*	*Discharge (m^3/s)*	*Maximum velocity (m/s)*	*Time (minutes)*
Lachen and Teesta II	7.51	11810	18.3	120
Chungthang and Teesta III	7.03	11600	16.5	120
Mangan and Teesta IV	7.64	11500	12.2	140
Dik-Chu (Teesta V)	8.87	10800	8.2	160
Singtam and Teesta VI	8.29	10250	7.35	200
Manipal	6.15	9900	5.4	220
Rangpo	5.81	9820	5.2	220
Bara Mungwa	4.21	9080	4.5	260

Table 4d: Scenario d

Location	*Increase in water level (m)*	*Discharge (m^3/s)*	*Maximum velocity (m/s)*	*Time (minutes)*
Lachen and Teesta II	4.4	6090	14.1	180
Chungthang and Teesta III	4.11	6070	12.8	190
Mangan and Teesta IV	4.49	6050	9.5	190
Dik-Chu (Teesta V)	6.04	5900	6.6	220
Singtam and Teesta VI	5.55	5690	6	270
Manipal	3.85	5630	4.4	290
Rangpo	3.78	5600	4.1	290
Bara Mungwa	2.87	5490	3.5	330

Table 4e: Scenario e

Location	*Increase in water level (m)*	*Discharge (m^3/s)*	*Maximum velocity (m/s)*	*Time to reach at (minutes)*
Teesta I	**4.43**	**6230**	**14.3**	100
Lachen and Teesta II	**12.65**	**30520**	**29.64**	115
Chungthang and Teesta III	**12.78**	**30430**	**25.96**	125
Mangan and Teesta IV	**13.25**	**30400**	**21.52**	130
Dik-Chu (Teesta V)	**15.24**	**30110**	**16.20**	135
Singtam and Teesta VI	**13.51**	**28900**	**11.241**	165
Manipal	**13.48**	**28215**	**8.98**	172
Rangpo	**13.45**	**28180**	**8.25**	176
Bara Mungwa	**12.71**	**26149**	**7.2**	195

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Graphs in Fig. 5a to 5e show the discharge and time to reach peak flood wave after the lake the outburst. It may be seen that the maximum levels, discharges and velocities are likely to occur in scenario when lake 2 and lake 3 outburst almost at the same time.

Since the locations Teesta IV and Singtam are close they are represented by a single hydrograph and same is the case with Mangan-Teesta IV and Lachen-Teesta II and Chungthang-Teesta III. The zero hour in simulation is 1200 hrs and the dates are tentative.

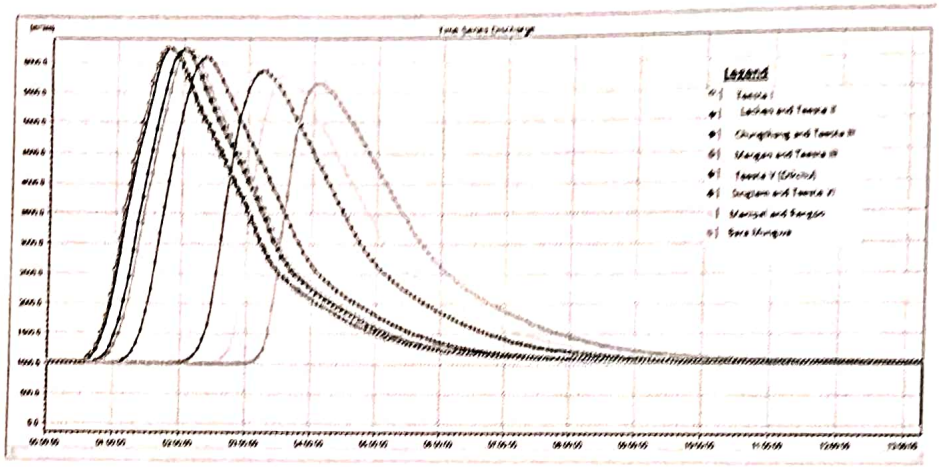

Fig. 5a: Hydrograph at various locations with time lag for scenario a

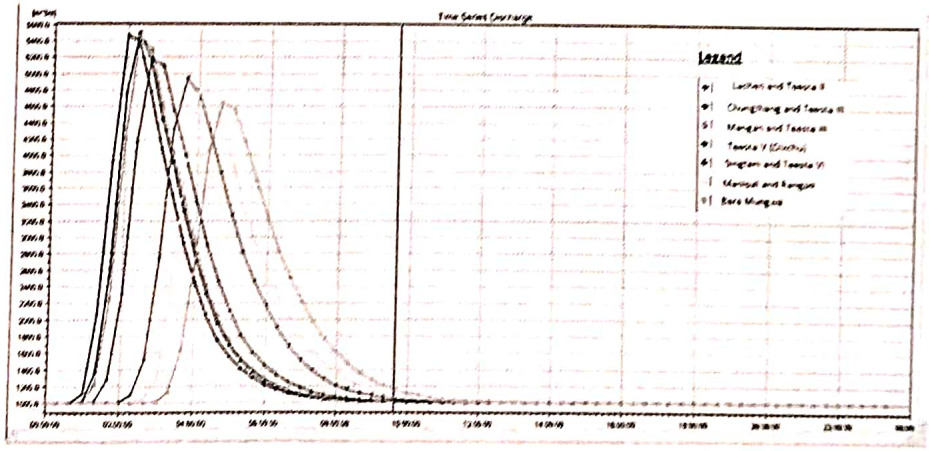

Fig. 5b: Hydrograph at various locations with time lag for scenario b

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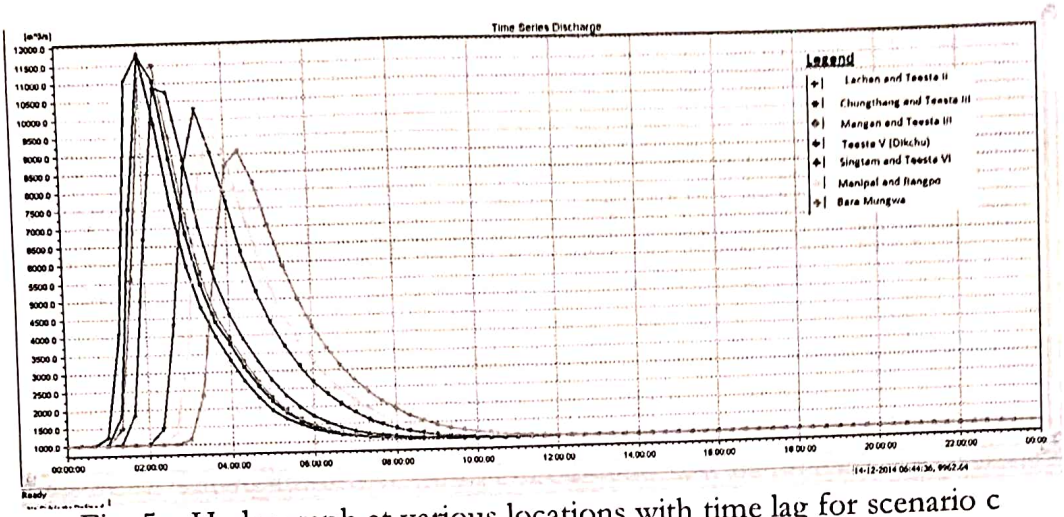

Fig. 5c: Hydrograph at various locations with time lag for scenario c

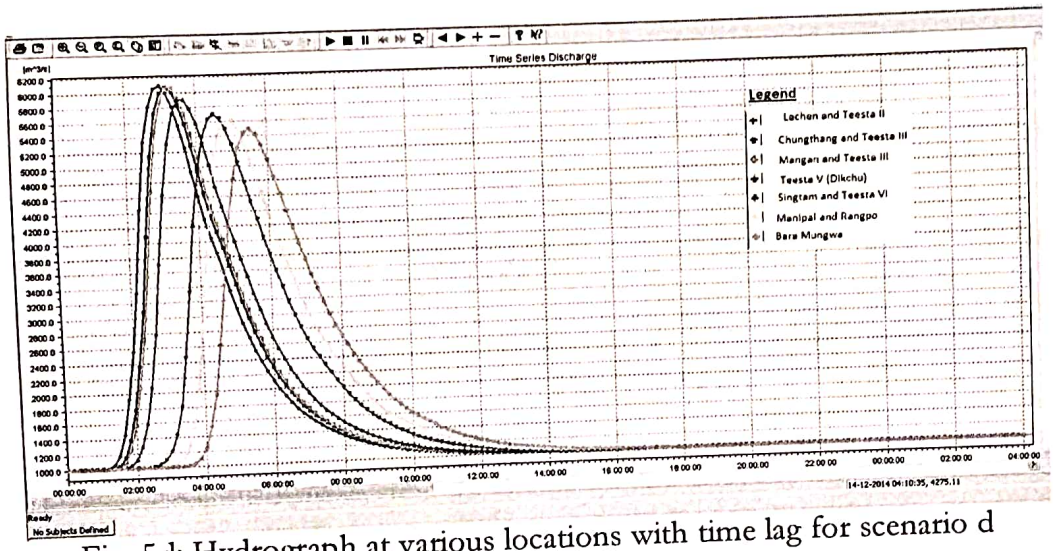

Fig. 5d: Hydrograph at various locations with time lag for scenario d

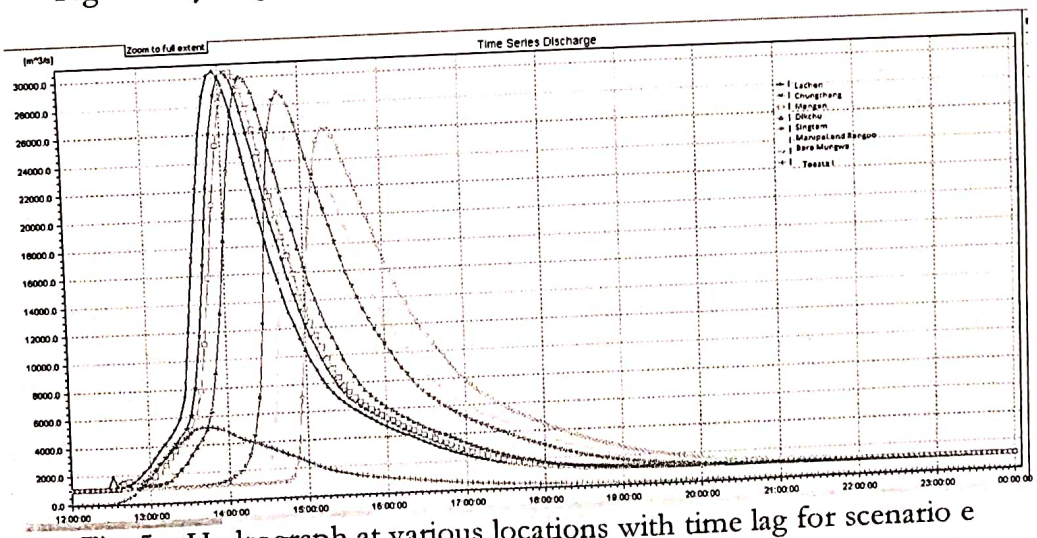

Fig. 5e: Hydrograph at various locations with time lag for scenario e

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9. ADVISORY

Based on the study conducted, the State Authorities are being made aware of the situation, which may arise, in case of outburst of Glacial Lake(s) situated in the upstream of Teesta river. The villages in the downstream are likely to experience a rise in water level to the tune of 2.0 m to 15.24 m varying from place to place, over and above the water level generally attained during flood season at those locations.

The Hydropower project authorities are also advised to consider the findings and develop mechanism for close monitoring of the lakes in order to get very timely warning about abnormal rise-fall in the water level in the lakes and its geological health. Standard Operating Procedures may also be developed to mitigate adverse situations.

The maximum likely water level rise, discharge and velocities at various locations which will be happening in case of breach of all lakes at same time are given in Table 5. However the probability of this event occurring is very low.

Table 5: Water levels, discharge and maximum velocities at various locations (all lakes burst at same time)

Location	*Increase in water level (m)*	*Discharge (m^3/s)*	*Maximum velocity (m/s)*
Teesta I	4.43	6230	14.30
Lachen and Teesta II	12.65	30520	29.64
Chungthang and Teesta III	12.78	30430	25.96
Mangan and Teesta IV	13.25	30400	21.52
Dik-Chu (Teesta V)	15.24	30110	16.20
Singtam and Teesta VI	13.51	28900	11.241
Manipal	13.48	28215	8.98
Rangpo	13.45	28180	8.25
Bara Mungwa	12.71	26149	7.20

Independent and interconnected glacial lakes outburst events have more probability than the above case (i.e. all glacial lakes outburst at same time.). The maximum likely water level rise, discharge and velocities at various locations which will be happening in such case are given in Table 6.

Table 6: Water levels, discharge and maximum velocities at various locations

Location	*Increase in water level (m)*	*Discharge (m^3/s)*	*Maximum velocity (m/s)*	*Remark*
Teesta I	4.43	6230	14.30	Scenario a
Lachen and Teesta II	7.51	11810	18.30	Scenario c
Chungthang and Teesta III	7.03	11600	16.50	Scenario c
Mangan and Teesta IV	7.64	11500	12.20	Scenario c

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Location	Increase in water level (m)	Discharge (m^3/s)	Maximum velocity (m/s)	Remark
Dik-Chu (Teesta V)	8.90	10800	8.20	Scenario c
Singtam and Teesta VI	8.29	10250	7.35	Scenario c
Manipal	6.15	9900	5.40	Scenario c
Rangpo	5.81	9820	5.20	Scenario c
Bara Mungwa	4.21	9080	4.50	Scenario c

Important: In no case, the advisory suggest that the lake(s) are geologically weak or that they are like to breach any time soon. However, appropriate precautions must be taken to ward of any untoward situation.

10. SUCGESTIONS FOR FURTHER WORK

Suggestions for further Improvisations which may be made in the study are listed below; however these improvisations would require additional specific data sets.

1. With the specific warning for heavy rainfall in the catchment, the model can give advance warning regarding the rise in water levels and discharges at all the locations in the river valley.
2. The model can be run incorporating 100 year return period flood as the existing flow in the river, in place of assumed constant flows of 1000 m^3/s.
3. Inundation extent may be analysed.
4. Development of mechanism for installation of sensor based river gauges and high decibel warning in affected area.

11. Acknowledgement

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12. Reference

(i) Inventory of Glacial Lakes/Water Bodies in the Himalayan region of Indian River Basin by CWC in association with NRSC, Hyderabad.
(ii) Monthly Monitoring reports of the Glacial Lakes/Water Bodies in the Himalayan region of Indian River Basin by CWC in association with NRSC, Hyderabad.
(iii) Report on the Prioritization of Glacial Lakes/Water Bodies in the Himalayan region of Indian River Basin prepared by CWC.
(iv) ICIMOD guidelines on depth of glacial lakes in Nepal and Bhutan.

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