सत्यमेव जयते

Central Water Commission

Criteria for Risk Indexing of Glacial Lakes in Indian Himalayan Region

केंद्रीय जल आयोग
CENTRAL WATER COMMISSION
आपो ज्योति रसोऽमृतम

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अध्यक्ष, केंद्रीय जल आयोग एवं
पदेन सचिव, भारत सरकार

सेवा भवन, नई दिल्ली-110066

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Chairman, Central Water
Commission & Ex-officio Secretary
to Government of India

Sewa Bhawan, New Delhi-110066

Foreword

As glaciers retreat, the lakes they leave behind grow larger, while the unstable moraine dams that hold them in place remain vulnerable to collapse. This poses a significant threat for downstream communities and ecosystems, where a sudden breach could result in catastrophic flooding. The Indian Himalayan region, with its densely populated valleys and crucial infrastructure, faces unique risks from these outbursts, making it vital to prioritize mitigation efforts and disaster preparedness. The need for "Criteria for Risk Indexing of Glacial Lakes in Indian Himalayan Region" arises from the increasing threat posed by Glacial Lake Outburst Floods (GLOFs), a consequence of climate change accelerating the melting of glaciers and expanding Glacial Lakes.

Different agencies have adopted various approaches to identify critical Glacial Lakes. There is a need to establish a common set of criteria for identifying these critical Glacial Lakes. In response, CWC has taken the initiative to bring together agencies such as National Remote Sensing Center (NRSC), Centre for Development of Advanced Computing (C-DAC), Defence Geoinformatics Research Establishment (DGRE), India Meteorological Department (IMD), Central Water and Power Research Station (CWPRS), Central Soil and Materials Research Station (CSMRS), Geological Survey of India (GSI), National Dam Safety Authority (NDSA), Wadia Institute of Himalayan Geology (WIHG), Central Electricity Authority of India (CEA), National Institute of Hydrology (NIH), National Disaster Management Authority (NDMA) and State Disaster Management Authority (SDMA) to collaborate on developing a unified framework for rapid risk assessment in the Indian Himalayan region.

The criteria for Risk Indexing of Glacial Lakes offer a structured approach to identifying and ranking Glacial Lakes based on their likelihood of failure and the potential damage they could cause. By evaluating key factors such as the Glacial Lake's Size, Change in Size of GL, Stability of Side Slope, Proximity to other Glacial Lakes as well as considering Downstream vulnerabilities like Habitation, Infrastructures like Dams, Bridges etc, Authorities can allocate resources efficiently for Monitoring, Early Warning Systems (EWS), and Mitigation measures. This method enhances decision-making and provide a guideline to allocate resources where they are most needed, reducing the overall risk of GLOF-related disasters in the region. I hope that use of this unified risk index by all agencies shall help in GLOF mitigation efforts in a long way.

(Kushvinder Vohra)

सदस्य (नदी प्रबंधन), केंद्रीय जल आयोग & पदेन अपर सचिव, भारत सरकार

सेवा भवन, नई दिल्ली-110066

सत्यमेव जयते

Member (River Management),
Central Water Commission &
Ex-officio Additional Secretary to
Government of India

Sewa Bhawan, New Delhi-110066

Preface

The Himalayan Mountain region, often referred to as the "third pole," is home to a vast number of glaciers and Glacial Lakes. One significant concern in this region is the rapid accumulation of water in Glacial Lakes, particularly in those situated near retreating glaciers. When this happens, there is a higher risk of the unstable moraine dams that contain these lakes suddenly breaching. Such breaches can result in extremely high flood known as Glacial Lake Outburst Flood (GLOF), which can have devastating consequences for the areas downstream. Understanding these Glacial Lakes is therefore crucial for effective disaster risk management, as well as for assessing the impacts of climate change.

This criteria for Risk indexing is designed to provide a comprehensive methodology for identifying and categorizing Glacial Lakes based on factors such as Glacial Lake size, Glacial Lake type, Side slope, Snout distance from GL etc and the potential socio-economic impacts of an outburst. By developing this method, we aim to support policymakers, disaster management agencies, and scientists in their efforts to safeguard both lives and livelihoods. The purpose of this document is to facilitate informed decision-making and strategic planning in the face of a growing environmental challenge, ensuring that mitigation efforts are directed toward the most risky lakes within the Indian Himalayas regions.

(Ashok S. Goel)

मुख्य अभियंता (योजना एवं विकास),
केंद्रीय जल आयोग
पश्चिम खंड-2, नई दिल्ली-110066

सत्यमेव जयते

Chief Engineer (Planning & Development),
Central Water Commission
West Block-2, New Delhi-110066

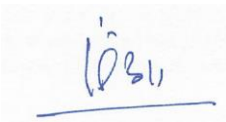
Acknowledgement

Advent of an appropriate Criteria for Risk Indexing of Glacial Lakes has been an issue requiring not only broad basing the diverse and interdisciplinary input but also on boarding practical consideration in respect of monitorable destabilising factors. Accordingly efforts in this direction were initiated to assimilate views of various stockholders while also not losing the sight of present day limitation posed due to reasons of such Glacial Lakes being placed in inhospitable, high altitude remote location.

The Criteria for Risk Indexing of Glacial Lakes in Indian Himalayan Region has been arrived through the collaborative efforts of multiple agencies. Valuable Suggestions from organizations such as the National Remote Sensing Centre ,Centre for Development of Advanced Computing Defence Geoinformatics Research Establishment, India Meteorological Department ,Central Water and Power Research Station, Central Soil and Materials Research Station, Geological Survey of India, National Dam Safety Authority, Wadia Institute of Himalayan Geology, Central Electricity Authority of India , National Institute of Hydrology, National Disaster Management Authority and State Disaster Management Authority of Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Ladakh, Sikkim, Uttarakhand were helpful in formulation of criteria of Risk Indexing. A common set of criteria has now been formulated with the support of all the involved agencies, and their active participation is highly acknowledged and greatly appreciated.

The project team gratefully acknowledges the profuse guidance and continuous encouragement provided by Shri Kushvinder Vohra, Chairman, Central Water Commission & Ex-officio Secretary to the Government of India and Shri Ashok S. Goel, Member (River Management), Central Water Commission & Ex-officio Additional Secretary to Government of India. Shri Vishnu Deo Roy, in his earlier capacity as Director, Morphology & Climate Change Dte, CWC has been a key contributor of various ideas and concepts which crystalized in shape of these criteria. Furthermore, the valuable suggestions from Shri Sameer Kumar Shukla, Director, CWC, greatly enhanced the document. These contributions are sincerely appreciated.

We also extend our sincere thanks to our project team Shri Piyush Kumar, Director, Shri Piyush Kumar, Deputy Director; and Shri Rohit Kumar Yadav, Assistant Director, CWC, for their creative thinking with continuous effort. The team also expresses heartfelt gratitude to the colleagues of the Morphology & Climate Change Directorate for their cooperation and assistance.



(D.P. Mathuria)

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Executive Summary

Central Water Commission (CWC) acts as the nodal agency for Glacial Studies in India, playing a pivotal role in guiding states on critical aspects related to glacial hazards. As a leading organization, CWC provides expertise in monitoring Glacial Lakes, conceptualizing and installing Early Warning Systems and conducting hazard risk mapping.

In order to conduct a rapid risk assessment of Glacial Lakes, CWC has initiated collaboration among concerned stakeholders to develop a unified framework for risk assessment in the Indian Himalayan region. Through multiple meetings and discussions with stakeholders, it has been identified that criteria for Glacial Lake assessments should prioritize those that can be monitored through remote sensing due to the inaccessibility of many lakes and the substantial resources required for conducting physical studies on each one.

There are 12 criteria identified for the risk assessment of which 4 are for Glacial Lake itself, 3 for upstream of Glacial Lake, 3 for downstream of Glacial Lake and 2 for others. Out of total 100 marks, 45 is allocated to the Glacial Lake itself, upstream 15, downstream 30 and other 10. The weightage for these criteria ranges between 5 and 15 marks. Among the criteria, Glacial Lake size, Changes in Glacial Lake size, and Proximity to the nearest dam are particularly emphasized due to their potential severity, each receiving a maximum of 15 marks.

This methodology has been applied to assess 100 Glacial Lakes spread across four States (Arunachal Pradesh, Himachal Pradesh, Sikkim and Uttarakhand) and two Union Territories (Jammu & Kashmir and Ladakh) in the Indian Himalayan Region, at elevations ranging from 3,000 to 6,000 meters. These lakes include moraine-dammed lakes, ice dammed lake and Glacial erosion lakes, with moraine-dammed lakes considered most vulnerable in Indian Himalayan Region.

The assessment categorizes Glacial Lakes into four risk categories, with Category 1 (Score above 70) indicating the highest risk, and Category 4 (Score below 50) representing the lowest risk. Generally, Glacial Lakes classified under Category 1 are deemed the most risky, while those in Category 4 pose the least risk. However, it is possible that a single parameter with a lower weightage could still significantly influence the overall risk of a Glacial Lake, potentially outweighing other factors in the assessment.

The physical monitoring of each glacial lake in the Indian Himalayan Region (IHR) demands considerable financial and logistical resources, making it impractical to assess all glacial lakes comprehensively. Criteria for Risk Indexing of Glacial Lakes in Indian Himalayan Region will act as a crucial guide for stakeholders and the academic community, helping to prioritize monitoring efforts and interventions where they are most needed. By streamlining the assessment process, it supports more effective resource allocation and disaster preparedness.

1.0 Introduction:

The Indian Himalayan region, an integral part of the world's highest mountain range, is home to thousands of Glaciers that play a vital role in the hydrological cycle and serve as a crucial water source for the region. Glaciers in this region, particularly those located in the upper reaches of river basins such as the Ganges, Brahmaputra, and Indus, store large volumes of freshwater, gradually releasing it to feed rivers and streams. However, in recent decades, glaciers have been rapidly retreating due to global warming, leading to the formation and expansion of Glacial Lakes. These lakes, formed by melt water accumulating behind natural moraine or ice dams, are highly sensitive to climatic changes and pose a growing threat to downstream communities.

A significant concern associated with Glacial Lakes is the potential for sudden and catastrophic events known as Glacial Lake Outburst Floods (GLOFs). These occur when the natural dam holding the lake fails, either due to increased water pressure, seismic activity, landslides, or avalanche into the lake. The resulting floodwaters can cause massive destruction, with devastating impacts on life, property, and infrastructure downstream.

It is crucial to establish a framework for the rapid risk assessment of Glacial Lakes that provides a structured and systematic method for identifying and ranking these lakes. This approach enables authorities to prioritize resources for monitoring, mitigation and reducing the risk of catastrophic Glacial Lake Outburst Floods (GLOFs).

This framework assesses critical factors such as the Glacial Lake size, Changes in Glacial Lake size over time, Stability of side slopes, Proximity to other Glacial Lakes etc. It also considers downstream vulnerabilities, including nearby Habitations and key infrastructures like dams, bridges, roads etc. By evaluating these parameters, authorities can prioritize which lakes pose the greatest threat, ensuring that limited resources are used efficiently for monitoring, Early Warning Systems (EWS), and preventive measures.

1.1 Glacial Lake Outburst Floods (GLOFs):

Glacial Lake Outburst Floods (GLOFs) have occurred in various parts of the world. Indian Himalayan region is also vulnerable due to the presence of a large number of Glacial Lakes and the growing influence of Climate Change. These floods can have significant socio-economic consequences, as many communities in the region depend on the rivers fed by glacial melt water for agriculture, drinking water, and energy generation. Additionally, critical infrastructure, including dams, roads, bridges, and hydropower plants, is often located in the river valleys, putting them at risk from GLOFs.

Several GLOF events in the past have underscored the dangers posed by these floods. Notable GLOF occurrences in the Indian Himalayan region include the 1929 GLOF in the Shyok River basin and the 1985 Dig Tsho outburst in Nepal, which resulted in significant loss of life and property. Recently, the breach of the moraine dam embankment at Chorabari Lake in 2013 triggered by heavy rainfall and South Lhonak Lake in 2023, triggered by a landslide, exemplifies the complex interplay between climate change, glacial dynamics, and extreme weather events. These events have highlighted the urgency of monitoring and managing Glacial Lakes to mitigate the risks associated with GLOFs.

1.2 Importance of Risk Indexing:

The importance of risk indexing for Glacial Lakes lies in its ability to systematically assess and manage the hazards associated with Glacial Lake outburst floods (GLOFs), particularly in regions like the Himalayas where these lakes are becoming increasingly unstable. As glaciers retreat and melt water accumulates in Glacial Lakes held back by fragile moraine or ice dams, the risk of sudden and catastrophic floods grows. Risk indexing provides a method for identifying which Glacial Lakes are most likely to experience such outbursts and prioritizing them for monitoring and intervention.

By evaluating key factors such as the Glacial Lake size, type, Stability of the side slope etc. and its potential impact on downstream habitations and infrastructure, risk indexing assists authorities focus resources on most risky Glacial Lake. This proactive approach is critical for minimizing the loss of life, reducing economic damage, and enhancing preparedness efforts. It also assists the development of Early Warning Systems (EWS) and long-term climate adaptation strategies, making it a crucial tool in mitigating the impacts of Glacial Lake hazards in vulnerable regions.

1.3 Factors for Risk Assessment of Glacial Lake:

Glacial Lakes are situated in high-altitude regions with harsh climatic conditions and challenging terrain, making them generally inaccessible. This inaccessibility is a key factor contributing to the lack of monitoring capabilities for these lakes. Therefore, when considering the wide range of factors influencing Glacial Lakes, it is essential to account for practical constraints. These constraints must be weighed carefully when selecting the factors to be included in any risk assessment framework.

Among the factors influencing the risk associated with Glacial Lakes, some can be measured or monitored, while others cannot. Additionally, some factors are predictable, while others are sudden. This document focuses on factors that are measurable uniformly for remotely located Glacial Lakes and are known in advance. Certain factors that apply equally to all lakes, and thus do not differentiate risk levels, have been excluded from the criteria. For a more detailed risk analysis, additional lake-specific information may be considered for priority lakes. Instantaneous factors can be incorporated into an Early Warning System through systematic and continuous monitoring of high-risk lakes.

The NRSC's Glacial Lake ranking procedure involves a two-step methodology. First, a preliminary screening is conducted using four criteria. Then, six parameters are assigned to the Glacial Lakes, normalized, and weighted. The normalized scores are multiplied by the weights and summed for each Glacial Lake, with the highest total score indicating the most vulnerable Glacial Lake. C-DAC has separately identified 35 criteria with varying weights to assess the risk of glacial lakes in Sikkim. The overall score is determined by adding the points assigned in each category, resulting in a total score where the highest value indicates the most vulnerable lake.

Risk associated with Glacial Lakes is determined by evaluating several key factors that influence the likelihood of a Glacial Lake Outburst Flood (GLOF) and the potential impact on downstream areas. The Glacial Lake size, type, Change in Size, Stability of side slope, Snout to Glacial Lake distance, Snout to Glacial Lake Slope, Glacial Lake in vicinity and connected are some of the important remotely measurable parameters on upstream of Glacial Lake and Glacial Lake itself.

Downstream parameters, including proximity to human settlements and infrastructures like dams, roads and bridges, are crucial for assessing the potential damage if a GLOF occurs. Glacial Lakes closer to infrastructure and populated areas poses a higher risk of catastrophic impacts. Additionally, historical GLOF events and the location of Glacial Lakes in seismic zones further elevate the risk, as past events and seismic activity may destabilize the Glacial Lakes triggering outbursts.

Factors for Risk Assessment of Glacial is divided into four categories which are as follows:

(i) **Glacial Lake:** This category examines factors that directly impact the stability and integrity of the Glacial Lake. Several key factors are considered to assess the potential hazard:

1. **Size of Glacial Lake** – Larger Glacial Lake tend to hold more water, increasing the potential for catastrophic flooding if they burst.
2. **Type of Glacial Lake** – The Glacial Lake's formation (moraine-dammed, ice-dammed, etc.) influences its structural stability.
3. **Change in Size of Glacial Lake over Time** – Rapid expansion of the Glacial Lake indicates growing instability and increased risk of an outburst.
4. **Stability of Lake Side Slope** – The condition of the surrounding slopes is crucial, as unstable slopes can lead to landslides that may trigger a dam breach.

(ii) **Upstream of Glacial Lake:** This section assesses conditions and parameters upstream (u/s) of the lake that could influence its stability and risk level.

1. **Snout to Glacial Lake Distance** – The distance between the glacier's snout and the Glacial Lake helps determine how glacial meltwater might affect the lake.
2. **Snout to Glacial Lake Slope** – The gradient between the glacier and the Glacial Lake can affect water flow dynamics and stability.
3. **Glacial Lakes in the Vicinity and Connected (>1 ha) within 1 Km in same Valley** – The presence of nearby connected Glacial Lake(s) increases the overall water volume and complexity, which can heighten the risk of chain-reaction events.

(iii) **Downstream of Glacial Lake:** This focuses on the parameters downstream (d/s) of the Glacial Lake to assess the potential impact on human life and infrastructure.

1. **Distance from Nearest Habitation likely to be affected** – The Glacial Lake located closer to populated areas poses higher risk to human casualties in the event of an outburst.
2. **Distance from Nearest Dam** – The proximity to critical infrastructure like dams is important, as a GLOF could lead to secondary disasters if the dam fails or opens gates suddenly.
3. **Distance from Nearest Bridge** – Assessing the risk to transportation infrastructure such as bridges helps gauge the potential for widespread disruption.

(iv) **Other Parameters:** Additional factors that can affect the overall risk are considered in this section.

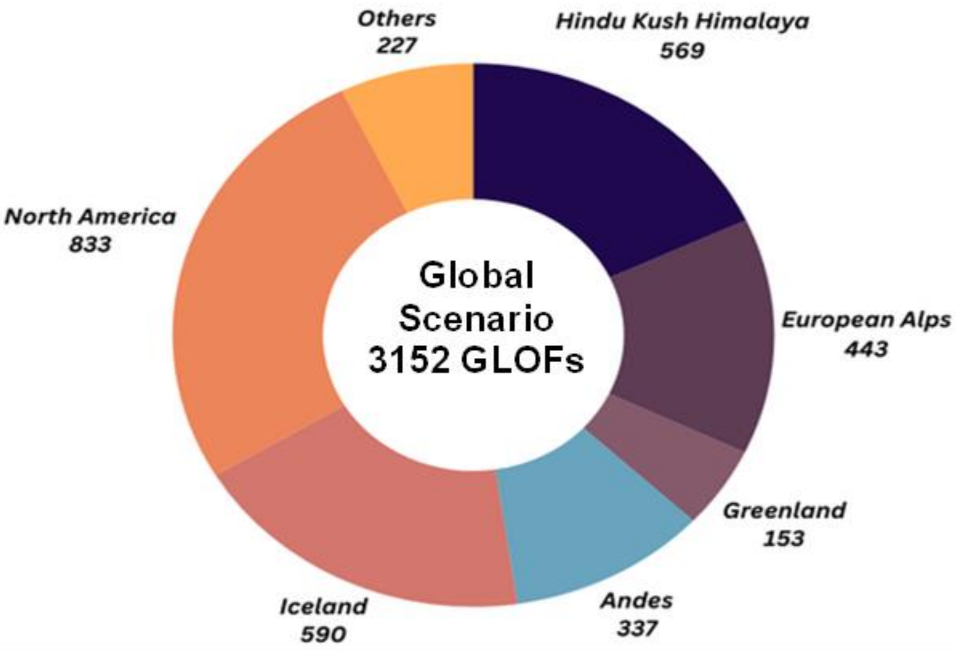
1. **Historical GLOF Events** – Previous GLOFs in the area offer insights into patterns of Glacial Lake instability and potential recurrence.
2. **Seismic Zones** – Glacial Lakes situated in active seismic zones are at higher risk of dam failure due to earthquake-induced destabilization.

2.0 Criteria for Risk assessment through indexing

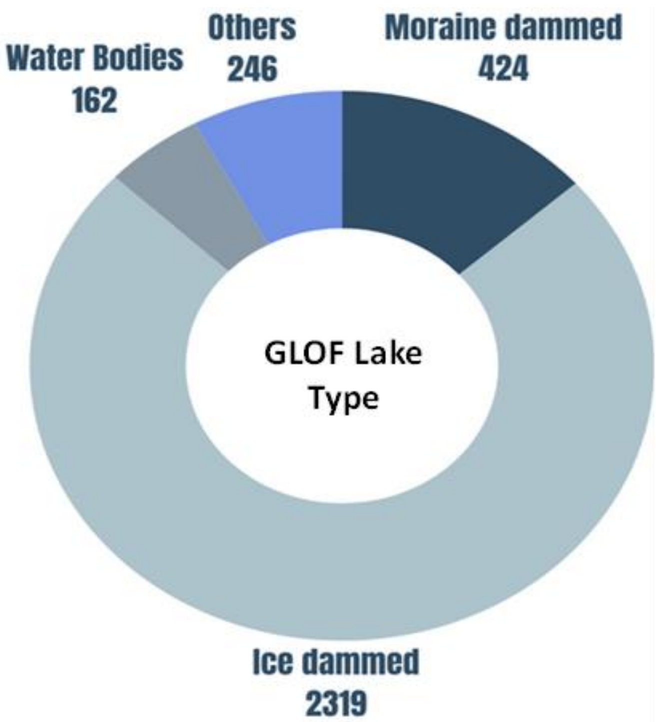
The basic concept behind shortlisting of Index for Risk associated with Glacial Lakes is to prescribe common criteria for studies being/proposed to be taken in this area of concern as mentioned above.

2.1 Background:

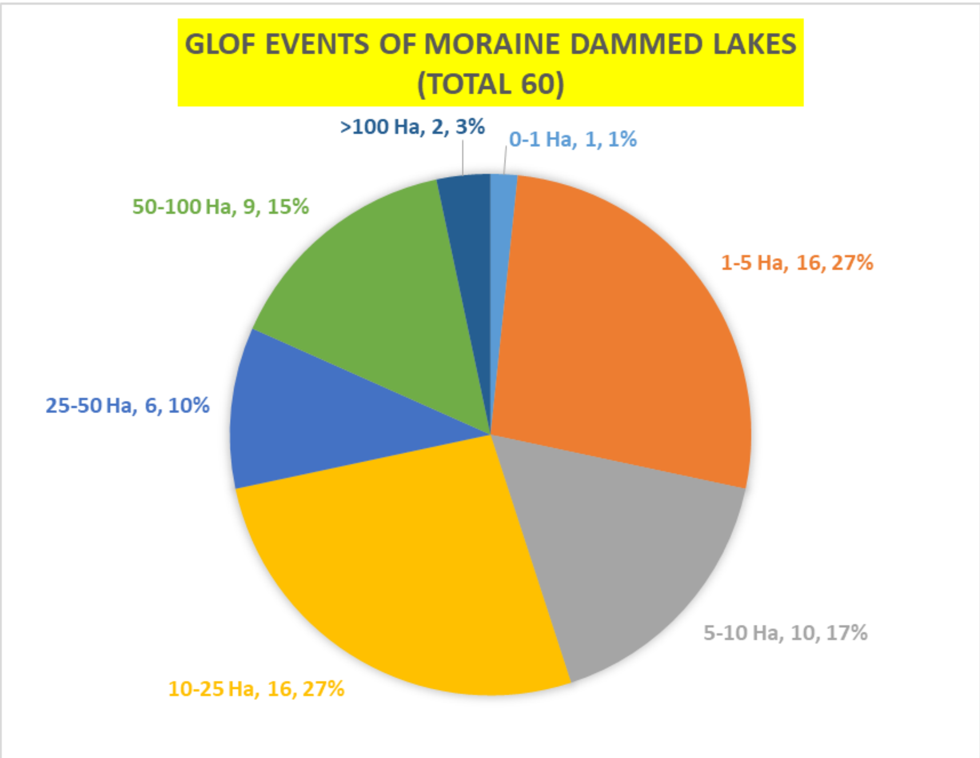
To develop the criteria for risk indexing, it was deemed essential to study the global scenario of Glacial Lake Outburst Floods (GLOFs). A search revealed a historical GLOF events database from a study titled "A Global Database of Historic Glacier Lake Outburst Floods," published on July 12, 2023. This database identified 3,152 GLOF events that occurred across 27 countries from 850 to 2022 CE, with 569 of these events reported in the Hindu Kush Himalaya region. The database includes 2,319 ice-dammed lakes and 424 moraine-dammed lakes. According to the findings, there have been 60 reported failures of moraine-dammed lakes and 394 failures of ice-dammed lakes in the Hindu Kush Himalaya. The size-related details for failures of moraine and ice-dammed lakes are as follows:



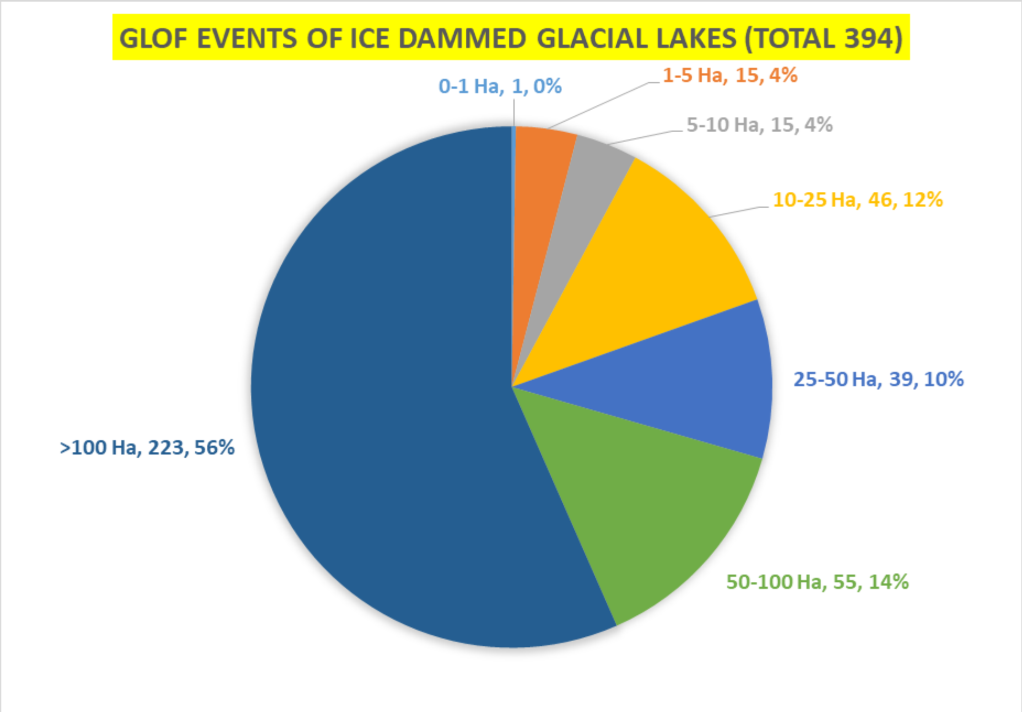
Graph 1: Location-wise past GLOF events



Graph 2: Lake Type GLOF events



Graph 3: GLOF events of Moraine Dammed Lakes (Sizewise)



Graph 4: GLOF events of Ice Dammed Lakes (Sizewise)

Therefore, susceptibility for failure of ice dammed lakes are higher than the moraine dammed lake. Similarly, larger Glacial Lakes are more prone to outburst than small lakes. Glacial Erosion lakes are mostly stable in nature.

However, as per article namely *"Increasing risk of Glacial Lake Outburst Floods from future Third Pole deglaciation"* published in nature climate change by Guoxiong Zheng, most past GLOF sources were related to moraine dammed Glacial Lakes.

2.2. Measurable factors and their priority:

GLOF is the primary hazard associated with the Glacial Lake. It's the potential for a sudden and catastrophic release of water from a Glacial Lake, causing widespread destruction downstream. The following criteria proposed/identified for Glacial Lakes:

2.2.1 Size of Glacial Lake: The size of a Glacial Lake provide fundamental insights into its water storage capacity. In the event of a GLOF, this characteristic becomes a critical factor. Normally, larger Glacial Lakes have a greater potential for catastrophic outbursts compared to smaller ones due to the volume of water they contain. However, the smaller Glacial Lakes can also pose risks. Lakes with larger sizes should be given higher priority.

2.2.2 Type of Glacial Lake: The diversity of Glacial Lakes necessitates a differentiated approach to risk assessment. Different types of Glacial Lakes exhibit distinct characteristics, formation processes, and potential hazards. Broadly Glacial Lakes are divided into four major types as per NRSC inventory:

i. **Moraine-dammed lake:** When glaciers melt, the water in these Glacial Lakes accumulates behind loose naturally formed glacial/moraine dams made of ice, sand, pebbles and ice residue. This is the another most common type of outburst due to failure of unstructured end moraine material on account of spillage due to flood surge or heavy inflow into the lake /seepage due to high hydraulic head or disappearance of permafrost condition with rise in temperature.

ii. **Ice-dammed lake:** An Ice-dammed Lake is created when a glacier blocks the flow of a river or stream, forming a lake behind the ice. Outburst of such glaciers are the most common due to melting of ice with rise in temperature in addition to other factors like sudden fall of ice/rock/moraine material in the lake.

iii. **Glacier Erosion lake:** These are the water bodies formed in a depression after the glacier has retreated in a form of cirque or trough valley, might be isolated and far away from the present glaciated area, and mostly stable in nature.

iv. **Other Glacial Lake**

2.2.3 Change in Size of Glacial Lake: The change in size of a Glacial Lake refers to increase or decrease in the lake's surface area and volume over time. A lake that rapidly increases in size is often a sign of accelerated glacier melting or instability in the surrounding terrain. This rapid growth can exert immense pressure on the natural or artificial dams containing the lake, increasing the risk of breach. Changes in lake size will be determined by analysing data from the preceding five years/ available data from monitoring reports or base year data from inventory reports. Lakes size increasing at higher rates needs more attention and therefore higher weightage.

2.2.4 Stability of Glacial Lake side slope (surrounding topography): The Glacial Lake side slopes influences erosion, landslides, avalanche and other forms of mass movement. Steeper slopes are more prone to failure and vice versa. Factors such as slope angle, material composition, vegetation cover and water content are important for assessment of surrounding topography of Glacial Lakes. Landslide susceptibility maps of lake’s surroundings as available or to be prepared by GSI may be of use for scoring. Avalanche prone maps or similar database, as available with DGRE for the lakes area may also be of use in this context. Pending availability of desired information from GSI & DGRE, average slope of the surrounding area of the lake derived from publicly available DEM generated from remote sensing data may be used for analysis.

2.2.5 Glacial Lake inlet to snout distance: The snout of a glacier refers to its lower, terminal end where the glacier meets its surrounding environment. A shorter distance between the Glacial Lake inlet and the glacier snout implies a shorter pathway for melt water to reach the lake. This can lead to rapid lake level rise and increased pressure on the lake's dam, enhancing the risk of a GLOF whereas a longer distance can provide a buffer zone, allowing for some attenuation of the water flow before it reaches the lake. Therefore, longer distances between the lake inlet and glacier snout may indicate a lower risks and vice versa. Such data can be derived from publicly available DEM generated from remote sensing data.

2.2.6 Glacial Lake inlet to snout slope: The "Glacier Lake Inlet to Snout slope" refers to the gradient or incline from where a glacier feeds into a lake (the inlet) down to the glacier's terminus (snout). For risk assessment of Glacier Lake Outburst Floods (GLOFs), analysing this slope is crucial. A steep glacier slope accelerates the flow of melt water towards the lake, increasing the rate of lake level rise and pressure on the dam. A gentler slope reduces the velocity of melt water, allowing for more gradual lake level rise and potentially reducing the risk of a sudden outburst. Therefore, gentle slopes may indicate a lower risk and vice versa. Such data can be derived from publicly available DEM generated from remote sensing data.

2.2.7 Glacial Lake in the vicinity and connected (>1 ha) within 1 Km: The Indian Himalayan region is characterized by a high density of Glacial Lakes, many of which are in close proximity to each other. This clustering increases the risk of cascading failures. Global warming has accelerated the formation of new Glacial Lakes in recent years, exacerbating the situation. Interconnected lakes within this region pose a significant threat as the breach of one can trigger a chain reaction, leading to catastrophic GLOFs. Such information can be derived from analysing the inventory of Glacial Lakes in any GIS platform along with DEM and drainage network of the area.

2.2.8 Nearest downstream Habitation Distance (likely to be affected): The assessment of proximity of human settlements to the Glacial Lakes means distance of population and their livelihood in the path of the floodwaters from the lake. The floodwaters from a GLOF can carry debris, boulders, and ice, further increasing the destructive power of the flood. Settlements that are closer to the Glacial Lake are more likely to experience severe and immediate consequences, while those farther away may be less affected or have more time to respond. As first estimate, such data can be generated from Google Earth along with draining network of the area covering lakes. Subsequently, such data can be refined in consultation with local authority or any other source.

2.2.9 Distance to nearest downstream Dam: Downstream dams are particularly vulnerable to the destructive force of a GLOF. These massive surges of water, often carrying significant sediment loads, can overwhelm dam structures, leading to catastrophic consequences. Closer distances between the Glacial Lake and Dam indicates floodwaters will reach the dam more quickly, reducing the time available for early warning & response and vice versa. Such data can be generated from Goole Earth or GIS along with drainage network covering the lake in GIS environment.

2.2.10 Distance to nearest downstream Bridge: Bridges are crucial components of transportation infrastructure, acting as vital lifelines connecting communities and facilitating the movement of people, goods, and emergency services. It plays a significant role in emergency response in the event of GLOF. Bridges located close to Glacial Lakes are at a higher risk of damage or destruction from GLOFs and vice versa. As first estimate, such data can be generated from Google Earth along with draining network of the area covering lakes. Subsequently, such data can be refined in consultation with local authority or any other source.

2.2.11 Historical GLOF events: Historical GLOF events are crucial for understanding the potential magnitude, frequency, and impacts of the hazards. Past occurrences where Glacial Lakes have burst, leading to sudden and catastrophic flooding. Evaluating the frequency of past GLOF events in the region helps identify trends and recurring risks. *Initially, such information may be taken from the historical database from a study titled "A global database of historic glacier lake outburst floods" published on 12th July 2023 identified 3151 GLOF events occurred in 27 countries between 850 and 2022 CE. Subsequently, the same can be refined in consultation with local authority of literatures.*

2.2.12 Seismic Zones: Seismic zones are categorized based on the likelihood and intensity of earthquakes occurring in a specific area. These classifications are crucial for understanding the seismic hazards in regions prone to earthquakes. Identifying and mapping these zones allows for the assessment of risks associated with natural disasters, such as GLOFs. Higher magnitude earthquake in the vicinity of the lakes may cause outburst of frontal dams releasing water from lakes or landslide of surrounding slopes resulting fall of mass into the lake leading to spilling of water or avalanche leading to fall of ice mass into the lake. It is to be noted that Indian Himalayan Region (IHR) includes four states—Himachal Pradesh, Uttarakhand, Sikkim, and Arunachal Pradesh and two Union Territories, Jammu & Kashmir and Ladakh, which fall under Seismic Zones IV and V.

Based on the above identified criteria, a matrix for risk identification has been prepared and placed at **Annexure-I.**

3.0 Criteria classification:
The score for classification of the risky Glacial Lakes is as under (**Table 1**):

Table 1: Risk Score Classification

Risk Score Classification			Remarks
Sl No	**Score (S)**	**Category**	In general, Category 1 lakes are considered to be the most risky and category 4 is the least risky
1	**S>70**	**Category-1**	
2	**60<S<=70**	**Category-2**	
3	**50<S<=60**	**Category-3**	
4	**S<=50**	**Category-4**	

However, the identification of different categories is not intended to suggest that Category-1 lakes, being the most at risk, will necessarily fail, while Category-4 lakes will not. Categorization is meant as a tool for assessment of risk associated with a Glacial Lake only. The failure of a Glacial Lake depends on the interaction of various factors, which can trigger such events depending on the intensity of destabilizing forces.

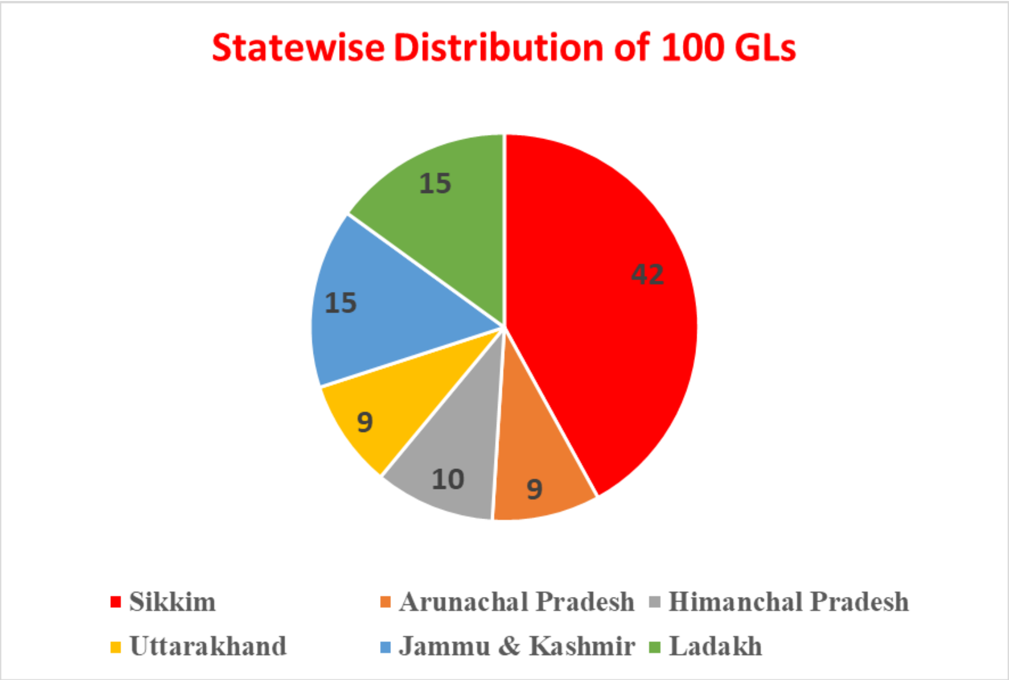
4.0 Result of application of criteria on 100 Glacial Lakes in India

4.1 Statewise Distribution of 100 Glacial Lakes:

The above criteria has been applied on 100 GLs in 4 States and 2 UTs of India in the Indian Himalayan Region. List of these 100 lakes is attached at **Annexure-II**. The details may be seen as per the following **Table 2**.

Table 2: Statewise Distribution of Glacial Lakes

State	No of GLs
Sikkim	42
Arunachal Pradesh	9
Himanchal Pradesh	10
Uttarakhand	9
Jammu & Kashmir	15
Ladakh	15
Total	**100**

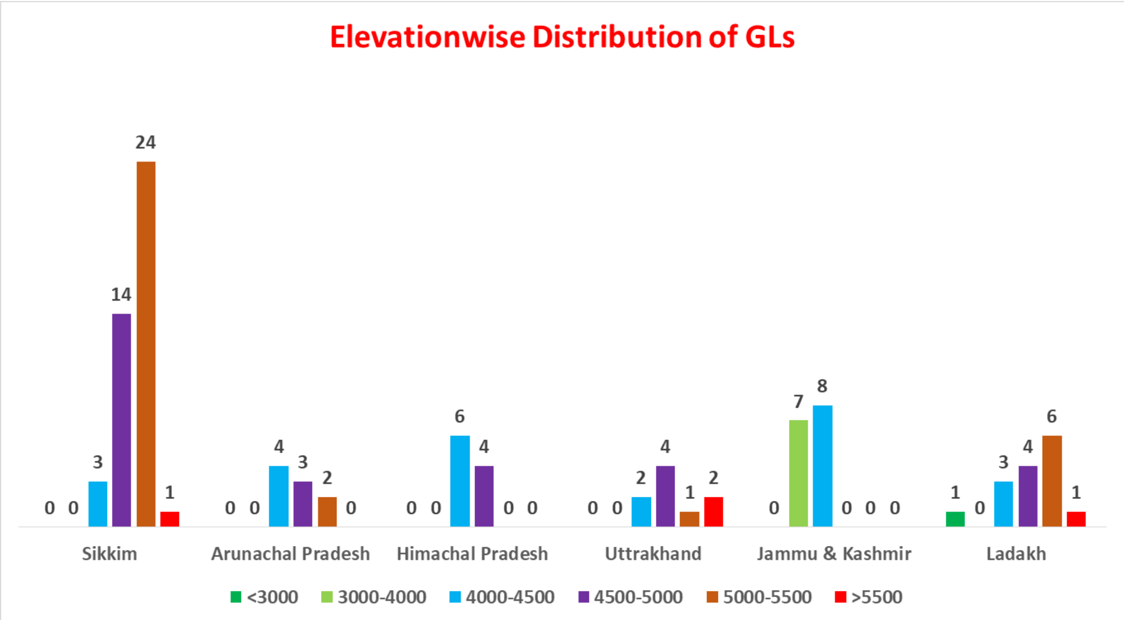


Graph 5: Statewise Distribution of Glacial Lakes

4.2 Elevationwise Distribution of 100 Glacial Lakes:

Table 3: Elevationwise Distribution of Glacial Lakes

Elevation (m)	Sikkim	Arunachal Pradesh	Himachal Pradesh	Uttrakhand	Jammu & Kashmir	Ladakh	Total
<3000	0	0	0	0	0	1	**1**
3000-4000	0	0	0	0	7	0	**7**
4000-4500	3	4	6	2	8	3	**26**
4500-5000	14	3	4	4	0	4	**29**
5000-5500	24	2	0	1	0	6	**33**
>5500	1	0	0	2	0	1	**4**
Total	**42**	**9**	**10**	**9**	**15**	**15**	**100**

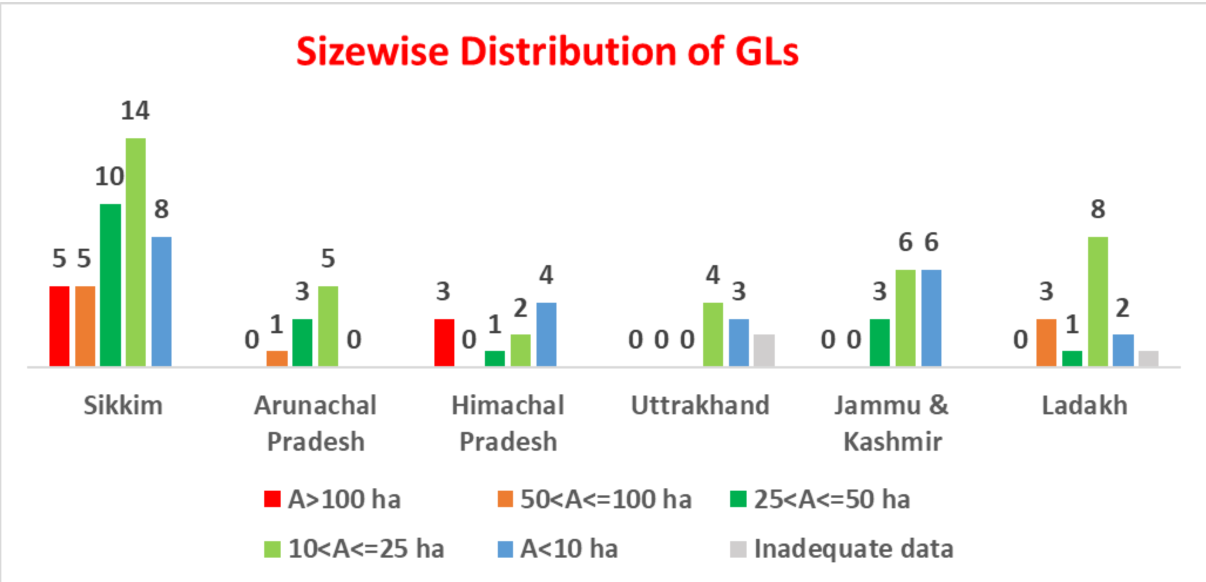


Graph 6: Elevationwise Distribution of Glacial Lakes

4.3 Water Spread area (Size) wise Distribution of 100 Glacial Lakes:

Table 4: Sizewise Distribution of Glacial Lakes

Glacial Lakes Size Distribution							
Area (Ha)	Sikkim	Arunachal Pradesh	Himachal Pradesh	Uttrakhand	Jammu & Kashmir	Ladakh	Total
A>100 ha	5	0	3	0	0	0	8
50<A<=100 ha	5	1	0	0	0	3	9
25<A<=50 ha	10	3	1	0	3	1	18
10<A<=25 ha	14	5	2	4	6	8	39
A<10 ha	8	0	4	3	6	2	23
Inadequate data	0	0	0	2	0	1	3
Total	**42**	**9**	**10**	**9**	**15**	**15**	**100**

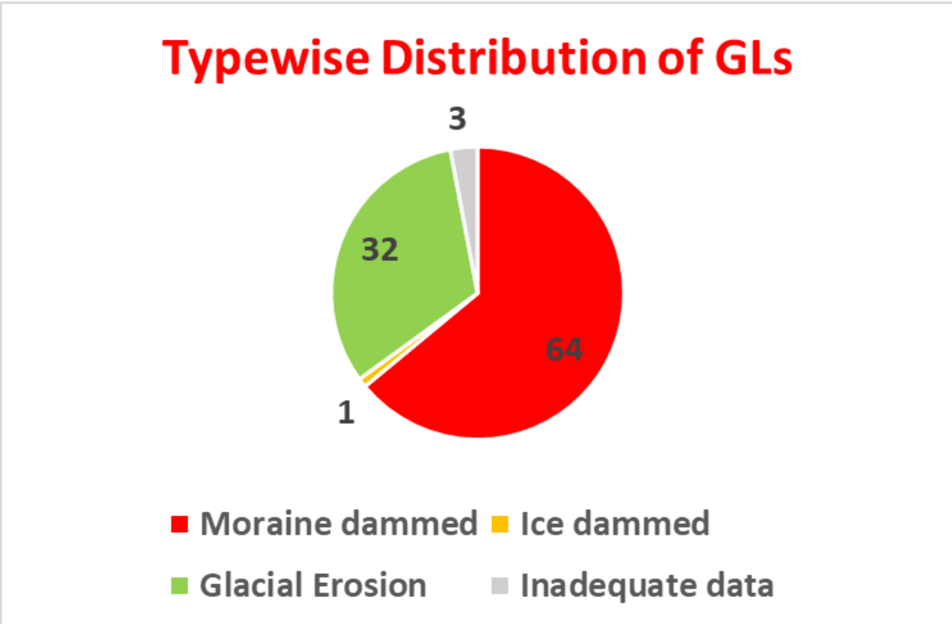


Graph 7: Sizewise Distribution of Glacial Lakes

4.4 Typeswise Distribution of 100 Glacial Lakes:

Table 5: Typewise Distribution of Glacial Lakes

Type of GL	No of GLs
Moraine dammed	64
Ice dammed	1
Glacial Erosion	32
Inadequate data	3
Total	**100**

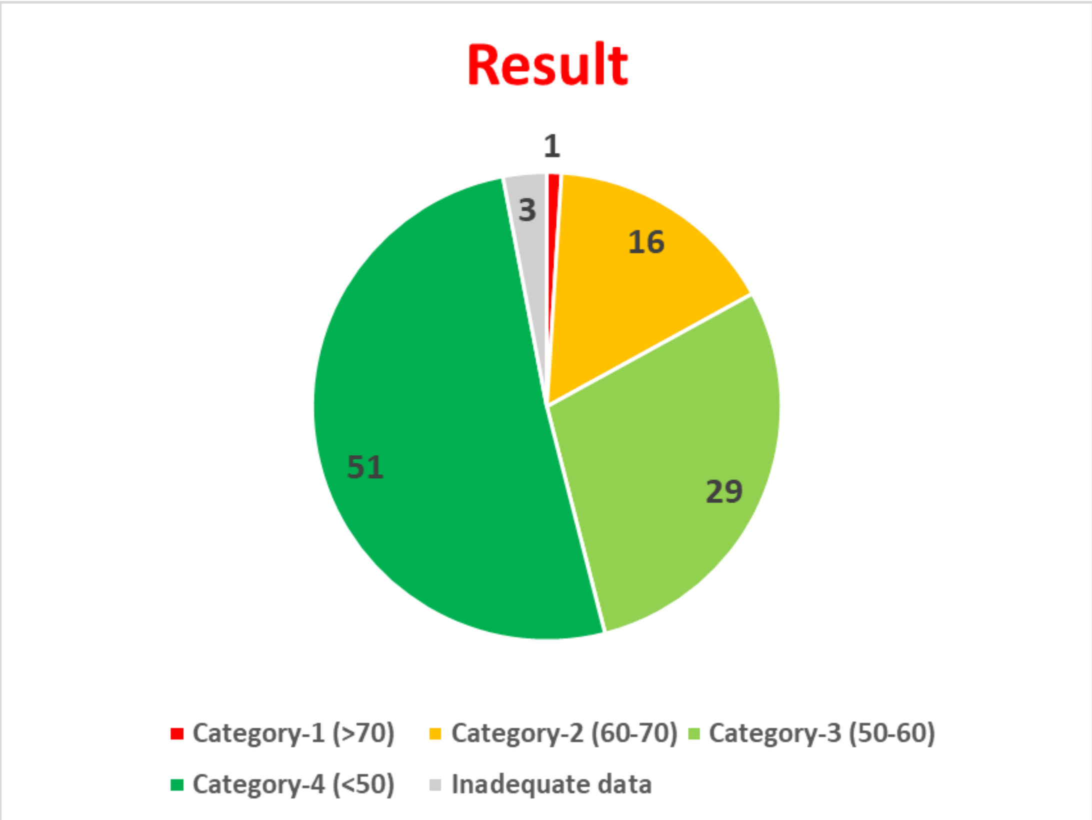


Graph 8: Typewise Distribution of Glacial Lakes

4.5 Result of Criteria application for 100 Glacial Lakes:

Table 6: Result of criteria on 100 GLs in India

Result of criteria on 100 GLs in India			
Category	**Score (S)**	**No of GLs**	**State-wise break up**
Category-1	S>70	1	SK-1
Category-2	60<S<=70	16	SK-12,HP-4
Category-3	50<S<=60	29	SK-11, AP-1, HP-4, UK-3, J&K-8, Ladakh-2
Category-4	S<=50	51	SK-18, AP-8, HP-2, UK-4, J&K-7, Ladakh-12
Inadequate Data	-	3	UK-2, Ladakh-1



Graph 9: Result of criteria on 100 GLs in India

5.0 Limitations and Assumptions:

1. **Data Dependency:** Glacial Lakes are situated in remote, high-altitude regions with challenging terrain and harsh climatic conditions which makes physical monitoring infrequent. Therefore, the risk assessment criteria rely heavily on remote sensing data, which may not capture all relevant parameters with the required precision.
2. **Field Verification Requirement:** Some parameters cannot be measured remotely and require on-the-ground verification, which may be time-consuming and resource-intensive.
3. **Interdependence of Criteria:** Some of the factors are independent and other are dependent. Attempts has been made to consider measurable independent factors only to keep minimum no of factors.
4. **Potential for Criteria Overpowering:** The proposed criteria is for rapid risk assessment assigning certain score to each factor. However, on ground, factors with low score may play more important role in certain condition. This needs to be considered whenever felt necessary as special cases.
5. **Evolving Criteria:** The criteria are indicative and may need revision as new technologies or environmental conditions emerge, potentially altering risk assessments.
6. **Uniform Impact of Criteria:** It is assumed that all criteria have been appropriately weighted, and their impact on the overall risk score is proportionate and balanced.
7. **Stable Environmental Conditions:** The criteria assume relatively stable environmental conditions, though future changes may require reassessmen

6.0 Conclusion:

The finalization of the criteria for assessing Glacial Lakes involved extensive input from various stakeholders, ensuring that the criteria are both comprehensive and effective in addressing the relevant challenges. The risk assessment criteria were systematically applied to evaluate 100 Glacial Lakes across the Indian Himalayan region, which encompasses four states and two Union Territories, each exhibiting diverse elevations and topographical features. This comprehensive assessment leveraged remote sensing technology to gather vital data, given the challenging accessibility of many of these lakes.

The finalized criteria for Glacial Lake risk assessment are based on easily measurable, independent parameters, and are intended to be updated as new technologies or conditions emerge. While the criteria prioritize risk across multiple factors, certain parameters may disproportionately influence the overall score, requiring adjustments. These criteria enable rapid risk assessments to identify high-risk lakes, helping agencies allocate resources efficiently and initiate appropriate monitoring. This process is crucial for planning and implementing Early Warning Systems and mitigation measures for Glacial Lakes identified as having higher risk.

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Annexure I

Risk Index Criteria for Glacial Lakes																								
	Glacial lake (45)								U/s of GL (15)						D/s of GL (30)						Other (10)			
1	2		3		4		5		6		7		8		9		10		11		12		13	
Parameters	Size (ha) of GL		Type of GL		Change in size (in last 5 years/available data)		Stability of lake side Slope (Degree)		Snout to GL distance (Km)		Snout to GL slope (Degree)		Glacial Lake in the vicinity and connected (>1 ha) within 1 Km in same valley		Distance from nearest Habitation likely to be affected (Km)		Distance from nearest Dam (Km)		Distance from nearest Bridge(RCC/Bailey/Rope) (Km)		Historical GLOF events		Seismic Zones	
Total Score	15		5		15		10		5		5		5		10		15		5		5		5	
Score break-up	Size (ha)	Score	Type	Score	Status	Score	Side Slope	Score	Distance	Score	Slope	Score	Draining	Score	Distance	Score	Distance	Score	Distance	Score	Yes/No	Score	Zone	Score
	A>100	15	Moraine dammed	5	Increasing (>25%)	15	S>30	10	D<=0.5	5	S>30	5	Yes	5	D<=25	10	D<=25	15	D<=10	5	Yes	5	V	5
	50<A<=100	12	Ice dammed	3	Increasing (20-25%)	12	20<S<=30	7	0.5<D<=1	3	20<S<=30	3	No	0	25<D<=50	8	25<D<=50	12	10<D<=25	4	No	0	IV	3
	25<A<=50	8	Glacial Erosion	2	Increasing (15-20%)	9	10<S<=20	5	1<D<=2	2	10<S<=20	2			D>50	5	50<D<=100	8	25<D<=50	3				
	10<A<=25	5	Other	1	Increasing (10-15%)	7	S<=10	2	D>2	1	S<= 10	1					D>100	5	D>50	0				
	A<=10	3			Change(within +/- 10%)	3											No Dam	0						
					Decrease (>10%)	0																		

Risk Score Classification		
Sl No	Score (S)	Classification
1	S>70	Category-1
2	60<S<=70	Category-2
3	50<S<=60	Category-3
4	S<=50	Category-4

Annexure II

State	District	Old Lake ID	New Lake ID	Name	Lat	Long	Type	River	Basin	Elevation (m)	Category
Sikkim	North Sikkim	03_78A_009	07478A050213	Khola Chhobuh	27.9466	88.3316	M(o): Other Moraine Dammed Lake	Khara Chu	Teesta	5034	Category-4
	North Sikkim	03_78A_014	07478A010059	South Lhonak Lake	27.9126	88.1955	M(e): End-moraine Dammed Lake	Gama Chu	Teesta	5194	Category-2
	North Sikkim	03_78A_021	07478A050272	NA	27.8245	88.2492	M(e): End-moraine Dammed Lake	Rhuling Chu	Teesta	5414	Category-3
	North Sikkim	03_77D_005	07477D120030	Lakes of Kangchengyao	28.0075	88.6981	M(e): End-moraine Dammed Lake	Teesta	Teesta	5209	Category-2
	North Sikkim	03_78A_001	07478A130523	Khangchung Tso	27.9902	88.8158	M(e): End-moraine Dammed Lake	Teesta	Teesta	5303	Category-2
	North Sikkim	03_78A_020	07478A050249	NA	27.881	88.2504	M(e): End-moraine Dammed Lake	Gama Chu	Teesta	5198	Category-4

State	District	Old Lake ID	New Lake ID	Name	Lat	Long	Type	River	Basin	Elevation (m)	Category
Sikkim	North Sikkim	03_78A_010	07478A050211	NA	27.9489	88.3052	M(e): End-moraine Dammed Lake	Khara Chu	Teesta	5049	Category-3
	North Sikkim	03_78A_035	07478A050208	Khola Chhamna	27.9513	88.3549	M(o): Other Moraine Dammed Lake	Khara Chu	Teesta	4989	Category-4
	North Sikkim	03_78A_008							Teesta	4989	Category-4
	North Sikkim	03_78A_005	07478A050186	NA	27.9736	88.4224	M(o): Other Moraine Dammed Lake	Nakul Chu	Teesta	5185	Category-4
	North Sikkim	03_78A_006	07478A050193	NA	27.969	88.4296	M(o): Other Moraine Dammed Lake	Nakul Chu	Teesta	4974	Category-3
	North Sikkim	03_78A_002	07478A090358	NA	27.982	88.5084	M(e): End-moraine Dammed Lake	Teesta	Teesta	4917	Category-3
	North Sikkim	227	07478A090355	NA	27.9924	88.5453	M(e): End-moraine Dammed Lake	Teesta	Teesta	5161	Category-2
	North Sikkim	03_77D_006	07477D120025	Lu tso	28.0143	88.5612	E(c): Cirque Erosion Lake	Teesta	Teesta	5073	Category-2
	North Sikkim	03_77D_004	07477D120034	Lakes of Kangchengyao	28.0056	88.7129	M(e): End-moraine Dammed Lake	Teesta	Teesta	5238	Category-3
	North Sikkim	295	07478A090403	Subu Chho	27.9203	88.6723	M(e): End-moraine Dammed Lake	Laehung Chu	Teesta	4827	Category-2

State	District	Old Lake ID	New Lake ID	Name	Lat	Long	Type	River	Basin	Elevation (m)	Category
Sikkim	North Sikkim	237	07478A130519	NA	27.9934	88.8014	M(o): Other Moraine Dammed Lake	Laehung Chu	Teesta	5299	Category-4
	North Sikkim	260	07478A130553	NA	27.8947	88.7614	M(e): End-moraine Dammed Lake	Laehung Chu	Teesta	5232	Category-3
	North Sikkim	03_78A_012	07478A130550	Penbawa Khangse	27.901	88.7819	M(o): Other Moraine Dammed Lake	Penbawa Chu	Teesta	5118	Category-3
	North Sikkim	03_78A_015	07478A130563	NA	27.8731	88.7893	M(e): End-moraine Dammed Lake	Sebozung Chu	Teesta	4962	Category-4
	North Sikkim	515	07478A130576	NA	27.8539	88.8059	E(o): Other Glacial Erosion Lake	Sebozung Chu	Teesta	5051	Category-4
	North Sikkim	312	07478A100485	NA	27.7003	88.5138	E(o): Other Glacial Erosion Lake	Teesta	Teesta	4491	Category-2
	North Sikkim	03_78A_023	07478A100495	Shingo Chho	27.6712	88.5125	E(c): Cirque Erosion Lake	Nathang Chu	Teesta	4525	Category-1
	West Sikkim	03_78A_027	07478A020131	Tikip Chu Lake	27.5331	88.0856	M(e): End-moraine Dammed Lake	Tikip Chu	Teesta	4860	Category-3
	West Sikkim	03_78A_031	07478A030158	Lachmi Pokhari	27.4373	88.0831	E(c): Cirque Erosion Lake	NA	Teesta	4280	Category-3
	West Sikkim	03_78A_026	07478A020123	Bhale Pokhari	27.563	88.1233	M(o): Other Moraine Dammed Lake	Choktsering Chu	Teesta	4710	Category-2

State	District	Old Lake ID	New Lake ID	Name	Lat	Long	Type	River	Basin	Elevation (m)	Category
Sikkim	North Sikkim	599	07478A100486	Chhumzomo Chhokha	27.6951	88.7165	E(o): Other Glacial Erosion Lake	Teesta	Teesta	4207	Category-2
	North Sikkim	03_78A_016	07478A010062	NA	27.8933	88.2123	I(s): Supra-Glacial Lake	Gama Chu	Teesta	5433	Category-4
	North Sikkim	03_78A_003	07478A090361	Gyapu Chho	27.9751	88.6161	M(e): End-moraine Dammed Lake	Lasha Chu	Teesta	4960	Category-3
	North Sikkim	03_78A_017	07478A010063	Green Lake	27.893	88.1909	M(o): Other Moraine Dammed Lake	Gama Chu	Teesta	5496	Category-4
	North Sikkim	03_78A_013	07478A010058	NA	27.9195	88.159	M(e): End-moraine Dammed Lake	Gama Chu	Teesta	5441	Category-4
	North Sikkim	03_77D_008	07477D080005	NA	28.0062	88.4935	M(e): End-moraine Dammed Lake	Nakul Chu	Teesta	5023	Category-4
	North Sikkim	03_77D_007	07477D120032	NA	28.0073	88.5714	M(o): Other Moraine Dammed Lake	Teesta	Teesta	4998	Category-4
	North Sikkim	03_77D_002	07477D120019	Gurudongmar Lake	28.0258	88.7104	M(e): End-moraine Dammed Lake	Teesta	Teesta	5148	Category-3
	North Sikkim	293	07478A090383	NA	27.9509	88.7043	M(o): Other Moraine Dammed Lake	Laehung Chu	Teesta	5030	Category-4
	North Sikkim	298	07478A090425	NA	27.8729	88.6379	M(e): End-moraine Dammed Lake	Kalep Chu	Teesta	5118	Category-2

State	District	Old Lake ID	New Lake ID	Name	Lat	Long	Type	River	Basin	Elevation (m)	Category
Sikkim	North Sikkim	256	07478A090447	NA	27.8156	88.6565	E(o): Other Glacial Erosion Lake	Lako Chu	Teesta	4603	Category-4
	North Sikkim	345	07478A090432	Khangpup Khangse	27.8636	88.7468	M(e): End-moraine Dammed Lake	Khangpup Chu	Teesta	5084	Category-4
	North Sikkim	03_78A_019	07478A130571	NA	27.8645	88.8629	M(e): End-moraine Dammed Lake	Sebozung Chu	Teesta	4781	Category-2
	North Sikkim	292	07477D120035	NA	28.0055	88.6546	M(o): Other Moraine Dammed Lake	Teesta	Teesta	5550	Category-4
	North Sikkim	569	07477D120039	NA	28.0019	88.6391	M(e): End-moraine Dammed Lake	Teesta	Teesta	5424	Category-2
	North Sikkim	03_78A_007	07478A090375	Yulhe khang	27.9609	88.65	M(e): End-moraine Dammed Lake	Lasha Chu	Teesta	4964	Category-4
Arunachal Pradesh	West Kameng	03_83A_004	08683A050830	NA	27.7633	92.4248	M(o): Other Moraine Dammed Lake	Dungma Chu	Manas	5094	Category-4
	Tawang	03_83A_003	08683A050827	NA	27.7706	92.435	M(o): Other Moraine Dammed Lake	Dungma Chu	Dangme Chu	5179	Category-4
	Tawang	03_83A_005	08683A050836	NA	27.7558	92.4011	E(o): Other Glacial Erosion Lake	Dungma Chu	Dangme Chu	4967	Category-4
	Dibang Valley	03_91D_075	10391D060672	NA	28.6078	96.3205	E(c): Cirque Erosion Lake	Thangkung Chu	Dibang	4239	Category-3
	Tawang	129	08683A050825	NA	27.7742	92.3147	E(o): Other Glacial Erosion Lake	Dungma Chu	Dangme Chu	4870	Category-4

State	District	Old Lake ID	New Lake ID	Name	Lat	Long	Type	River	Basin	Elevation (m)	Category
Arunachal Pradesh	West Kameng	03_83A_007	09383A060091	NA	27.7276	92.4362	M(l): Lateral Moraine Dammed Lake	Bichom	Jia Bharali	4995	Category-4
	Siang	03_82L_007	09682L050102	NA	28.8374	94.4514	E(o): Other Glacial Erosion Lake	Slke	Siyom	4136	Category-4
	Dibang Valley	03_91C_026	10391C030254	NA	29.3381	96.0821	M(o): Other Moraine Dammed Lake	Jairu Chu	Dibang	4290	Category-4
	Anjaw	03_91H_073	10591H081931	NA	28.0541	97.3296	E(o): Other Glacial Erosion Lake	NA	Lohit	4424	Category-4
Himachal Pradesh	Lahul & Spiti	01_52H_002	0152H0203651	NA	32.5255	77.2197	M(e): End-moraine Dammed Lake	Gepang Gath (Sissu)	Chenab	4069	Category-3
	Lahul & Spiti	01_52H_004	0152H1103771	NA	32.4987	77.5467	M(e): End-moraine Dammed Lake	Chandra	Chenab	4150	Category-4
	Lahul & Spiti	01_52H_003	0152H1103771	NA	32.4987	77.5467	M(e): End-moraine Dammed Lake	Chandra	Chenab	4150	Category-3
	Kangra	1774	0152D1603265	NA	32.2219	76.789	E(o): Other Glacial Erosion Lake	Uhl	Beas	4577	Category-4
	Lahul & Spiti	1805	0152H0103646	NA	32.7623	77.1955	M(e): End-moraine Dammed Lake	Dudha Khol	Chenab	4766	Category-3
	Kangra	1998	0152D1503248	NA	32.32	76.908	M(e): End-moraine Dammed Lake	Ravi	Ravi	4401	Category-2

State	District	Old Lake ID	New Lake ID	Name	Lat	Long	Type	River	Basin	Elevation (m)	Category
Himachal Pradesh	Kangra	1936	0152D1503254	NA	32.2561	76.7778	M(o): Other Moraine Dammed Lake	Thamsar Nala	Ravi	4563	Category-2
	Kullu	1847	0153E0904453	NA	31.9147	77.5258	M(e): End-moraine Dammed Lake	NA	Beas	4462	Category-2
	Kinnaur	01_53I_002	0153I0204530	NA	31.661	78.1677	M(e): End-moraine Dammed Lake	NA	Satluj	4255	Category-3
	Kinnaur	2031	0153I0704552	NA	31.3394	78.2535	M(o): Other Moraine Dammed Lake	Hurba Khad	Satluj	4676	Category-2
Uttarakhand	Pithoragarh	02_62B_005	0262B0700349	NA	30.4458	80.3875	M(e): End-moraine Dammed Lake	NA	Sarda	4306	Category-3
	Chamoli	2108	0253N0500173	NA	30.976	79.4597	M(e): End-moraine Dammed Lake	NA	Alaknanda	5537	Category-4
	Pithoragarh	02_62B_004	0262B0200331	NA	30.5645	80.1785	M(e): End-moraine Dammed Lake	NA	Sarda	4872	Category-4
	Pithoragarh	01_62B_003	0162B1104954	NA	30.4766	80.5923	M(e): End-moraine Dammed Lake	Darma Yankti	Satluj	5263	Inadequate Data
	Uttarkashi	2207	0253J1300055	NA	30.9122	78.9581	M(l): Lateral Moraine Dammed Lake	NA	Bhagirathi	4707	Category-3
	Chamoli	2147	0253N0500169	NA	30.9807	79.4881	M(o): Other Moraine Dammed Lake	NA	Alaknanda	5656	Category-4

State	District	Old Lake ID	New Lake ID	Name	Lat	Long	Type	River	Basin	Elevation (m)	Category
Uttarakhand	Chamoli	02_53N_001	0253N1300271	Basudhara Tal	30.9009	79.7543	M(e): End-moraine Dammed Lake	Dhauli Ganga	Alaknanda	4677	Category-3
	Bageshwar	2299	0253N1600329	Nag Kund	30.1835	79.8757	E(c): Cirque Erosion Lake	NA	Alaknanda	4462	Category-4
	NA	02_62B_007	NA	NA	30.2786	80.1305	NA	NA	NA	4830	Inadequate Data
Jammu & Kashmir	Anantnag	958	0143N0802057	NA	34.1377	75.4167	E(o): Other Glacial Erosion Lake	NA	Jhelum	4083	Category-3
	Muzaffarabad	01_43J_003	0143J0101344	NA	34.9262	74.1555	E(c): Cirque Erosion Lake	NA	Jhelum	3926	Category-4
	Bandipore	27	0143J1501501	NA	34.3796	74.8762	E(o): Other Glacial Erosion Lake	NA	Jhelum	3738	Category-3
	Bandipore	1037	0143N0301929	Gadsar lake	34.4217	75.0578	E(c): Cirque Erosion Lake	Gadsar Nala	Jhelum	3570	Category-3
	Ganderbal	182	0143N0802046	NA	34.2338	75.3248	E(o): Other Glacial Erosion Lake	Durin Nar	Jhelum	4279	Category-4
	Anantnag	963	0143N0802055	NA	34.1389	75.377	E(o): Other Glacial Erosion Lake	Daphhinpar Nar	Jhelum	3709	Category-3
	Anantnag	938	0143O0502269	Sorus Nag	33.9534	75.378	E(o): Other Glacial Erosion Lake	Sorus Nag	Jhelum	3644	Category-3
	Anantnag	931	0143O0502273	NA	33.9287	75.3891	E(c): Cirque Erosion Lake	Lanaihal Nala	Jhelum	4048	Category-4
	Ganderbal	1032	0143N0301938	NA	34.3864	75.0642	E(o): Other Glacial Erosion Lake	NA	Jhelum	4006	Category-4

State	District	Old Lake ID	New Lake ID	Name	Lat	Long	Type	River	Basin	Elevation (m)	Category
Jammu & Kashmir	Bandipore	98	0143N0301935	NA	34.3918	75.0848	E(o): Other Glacial Erosion Lake	Raman Nala	Kishan ganga	4072	Category-3
	Ganderbal	1014	0143N0301959	NA	34.2986	75.0607	E(o): Other Glacial Erosion Lake	NA	Jhelum	3975	Category-4
	Anantnag	993	0143N0401963	Doda Sar	34.2272	75.2223	E(o): Other Glacial Erosion Lake	NA	Jhelum	4137	Category-4
	Anantnag	976	0143N0802050	NA	34.1844	75.3728	E(c): Cirque Erosion Lake	Daphhinpar Nar	Jhelum	4276	Category-4
	Anantnag	951	0143N0802066	NA	34.0668	75.4754	E(o): Other Glacial Erosion Lake	Sonasar Nala	Jhelum	3724	Category-3
	Kishtwar	01_52C_002	0152C0102950	NA	33.8683	76.1208	M(e): End-moraine Dammed Lake	Tanak Nala	Chenab	4071	Category-3
Ladakh	Kargil	01_52C_003	0152C1603156	NA	33.1586	76.9839	M(e): End-moraine Dammed Lake	Katkar Nala	Indus Upper	4479	Category-4
	Kargil	01_52C_001	0152C0102941	NA	33.9453	76.2302	M(e): End-moraine Dammed Lake	Ringdom Sankpo	Indus	4357	Category-4
	Leh	01_52B_012	0152B1602938	NA	34.0056	76.7876	M(e): End-moraine Dammed Lake	Photang	Indus	5126	Category-4
	Leh	01_42H_002	0142H0600150	Ghamu Bar Lake	36.6421	73.4068	M(e): End-moraine Dammed Lake	Darkot Bar	Gilgit	2748	Category-4
	Kargil	180	0152B0302731	NA	34.3513	76.0753	M(e): End-moraine Dammed Lake	Katpachan Lungpa	Indus	4435	Category-3

State	District	Old Lake ID	New Lake ID	Name	Lat	Long	Type	River	Basin	Elevation (m)	Category
Ladakh	Leh	1360	0143M1201790	NA	35.0273	75.7255	E(o): Other Glacial Erosion Lake	Indus	Indus	4647	Category-4
	Leh	01_52A_002	0152A0402408	NA	35.0965	76.2337	E(o): Other Glacial Erosion Lake	Shyok	Indus	4512	Category-4
	Leh	01_52A_003	0152A0802503	NA	35.092	76.2523	M(e): End-moraine Dammed Lake	Shyok	Indus	4533	Category-3
	Leh	01_52A_004	0152A0802509	NA	35.0743	76.2928	E(c): Cirque Erosion Lake	Shyok	Indus	4599	Category-4
	Leh	173	0152B0902855	NA	34.7649	76.7109	E(o): Other Glacial Erosion Lake	Shyok	Indus	5123	Category-4
	Leh	01_52E_001	NA	NA	35.418	77.6046	NA	Shyok	Indus	5122	Inadequate Data
	Leh	01_52J_001	0152J0303811	NA	34.4565	78.1364	M(o): Other Moraine Dammed Lake	Kunzang Lungpa	Shyok	5295	Category-4
	Leh	01_52B_010	0152B1202878	NA	34.0512	76.7178	M(e): End-moraine Dammed Lake	Spang	Indus	5093	Category-4
	Leh	01_52L_006	0152L1504080	NA	32.4406	78.9249	M(e): End-moraine Dammed Lake	Miksadiu	Indus	5680	Category-4
	Leh	01_52L_007	0152L1504092	NA	32.4093	78.8997	M(e): End-moraine Dammed Lake	Nalung	Indus	5468	Category-4

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