

A Study on Threat of Glacial Lakes and Glacial Lake Outburst Floods on the Economy of Himalayan Countries

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Abstract

Climate change is significantly impacting the Himalayan mountain range, causing rapid glacial retreat and the formation of numerous glacial lakes. This study examines the increasing risk of Glacial Lake Outburst Floods (GLOFs) and their socio-economic implications for Himalayan countries, including Bhutan, Nepal, China, India, and Pakistan. Research indicates a regional expansion in both the number and total surface area of glacial lakes, with a higher concentration found in the eastern Himalayas compared to central and western regions. High-risk zones for GLOFs are primarily identified in Bhutan, the Everest region, Sikkim, and Langtang. The primary driver of this phenomenon is accelerated glacial melting, which facilitates the creation and expansion of moraine-dammed lakes. As water inflow increases, these natural dams become increasingly unstable, heightening the probability of sudden, catastrophic releases of water and debris. Such GLOF events cause extensive downstream destruction, ruining crops and damaging critical infrastructure, including buildings, bridges, and hydroelectric stations. Given these escalating risks, the paper underscores the critical need for continuous monitoring of glaciers and reservoirs. Effective water resource management, robust policy frameworks, and international cooperation are essential to mitigate the threats posed by GLOFs and protect the livelihoods of vulnerable mountain communities.

Keywords:

Himalayan countries, Glacial Lakes, Glacial Lake Outburst Floods (GLOFs), Mountains.

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The Hindu Kush Himalayas, which include glaciers, cover many mountain peaks in the Indian subcontinent from the north to the northeast. This region crosses through Pakistan, China (Tibet), India, Nepal, and Bhutan. Glacial lakes are bodies of water that form in front of, on top of, or under a melting glacier. They are usually held back by ice or piles of rock called moraine. When temperatures get warmer, glaciers melt more, which makes these lakes bigger and can weaken the structures holding the water in. These lakes are often found in high areas where glaciers are present. They form when ice, rock piles, or natural dips hold water back. In the last few decades, glacial lakes have been growing at the end of glaciers that are shrinking in the Himalayas. Most of the Himalayan area is on the border between Nepal and India, with Nepal having a larger part of it, covering about two-thirds (Rai and Rai, 2020). Glaciers are like rivers that extend into the land and are used for important purposes like making electricity, moving people and goods, and developing land. When glaciers melt, they create new glacial lakes, which grow bigger and can lead to dangerous outburst events.

The Ngozumpa Glacier is one of the longest glaciers in Nepal. It flows through a rocky valley and is 18 kilometers long, covering an area of 83 square kilometers (Chen et al., 2024). When a glacier moves back, it leaves behind rock and soil at the end, which forms a type of lake known as a moraine. These lakes can hold ice, and as the ice melts, it turns into water, creating glacial lakes (Sarkar, 2024). In some cases, most of the world's glaciers could disappear, which would cause serious problems for water supply. The melting of glaciers is a problem, and studying how ice and the atmosphere interact is a helpful way to understand how ice sheets work (Rasul et al., 2020). A glacial lake is a large lake that forms in, on, or near a glacier because of the melting of the front part of the glacier. As the front of the glacier melts, water collects in a cavity, and over time, this water forms a lake. These lakes can be blocked by glaciers or by dams made of rock and soil. Glacial lakes are found in almost every place where glaciers are present.

A glacial outburst flood (GLOF) happens when a large amount of water and debris is suddenly released from a downstream glacial lake. This can happen when the remnants of old glaciers break apart because of erosion and water getting into the ice, which reduces the lake's ability to hold water. This causes the water to break loose and flood the surrounding area (Bano et al., 2020). People living nearby are affected by these floods. In the past, flooding has caused serious damage to ecosystems, farming, industries, and local communities. While tourism brings in income for many families, damage to infrastructure leads to economic losses and fewer tourists. It is important to diversify the economy to make

more money. Tourism is a seasonal activity and is affected by climate change. To reduce risks, it is necessary to have good community planning, early warning systems, and strong infrastructure (Byers et al., 2020).

Objective

The general objective of the paper is to study the status and the threat of glacial outburst flood on the economy of Himalayan countries. The specific objectives of the study are:

- (a) To study the Glacial Lakes and Glacial Lake Outburst Floods in Himalayan countries as India, Pakistan, Nepal, and Bhutan.
- (b) To examine the impact of Glacial Lakes and Glacial Lake Outburst Floods on society.
- (c) To evaluate the preventive measures for minimizing effects of Glacial Lakes and Glacial Lake Outburst Floods.

Methods and Material

The author used descriptive research in the report. They relied on secondary data for this study. The secondary data was gathered from various international sources like published articles, research papers, and websites such as www.statista.com. A variety of qualitative analysis techniques were applied, including tabulation, content analysis, and textual analysis, to examine glacial lakes, glacial lake outburst floods, and their economic effects in specific areas.

Results and Discussion

Glacial lakes are located at high altitudes with harsh climate and rugged terrain. Glacial meltwater not only causes damage but also destroys habitats, roads, fields, forests, bridges and aquatic plants. Ice hazards are associated with high mountain glaciers and glacial lakes and their downstream impacts. Climate change in recent years has had a profound impact on the life cycle of glaciers in the Himalayas. Climate change over the last century has caused an increase in glacial outburst flood events in the Himalayas, causing significant damage to humanity. Numerous glacial lakes have appeared in many mountain regions of the world due to glacier melting and global warming in the last half century. Bolivian Andes have seen large glaciers retreat and expand in recent decades. Glacier retreat is accompanied by the formation of glacial lakes have outburst risk for low-lying communities and infrastructure. Glacial lake sensitivity increases the risk of associated floods. Furthermore, combining high-

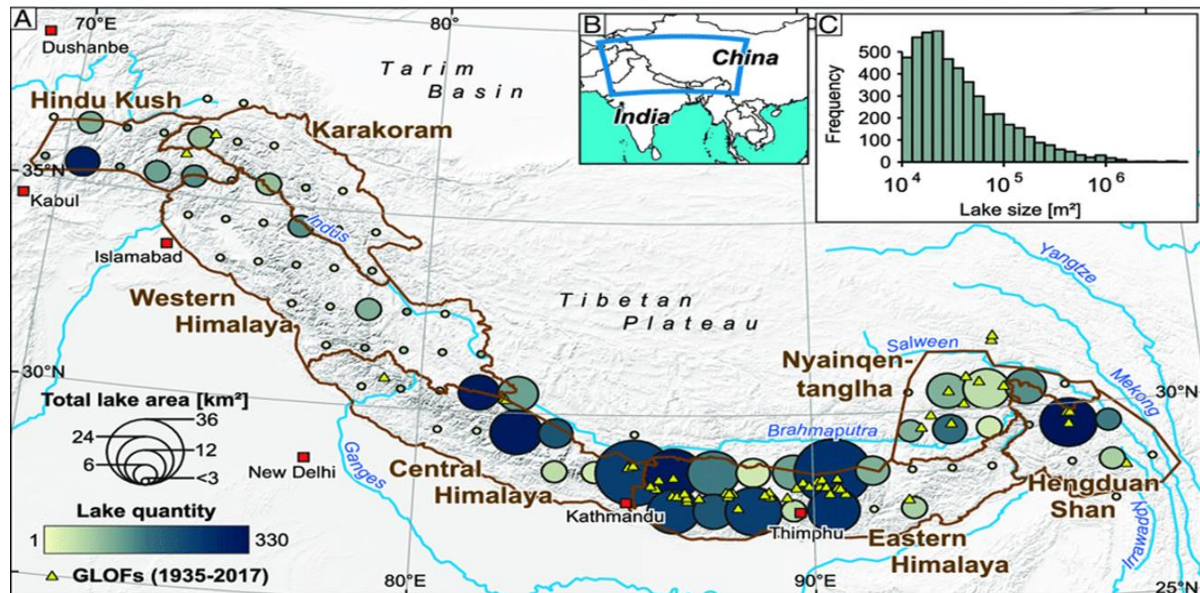
resolution data with robust methodologies and regional studies will help improve glacial outburst flood sensitivity assessments.

Glacier outburst floods are a major concern when glaciers melt in mountain areas around the world. These floods have become a big topic for scientists and doctors in recent times. There is a strong need to learn more about and deal with the effects of ice melting in Thorthomi Lake to lessen the harm to the environment, economy, and people in the area. The research gives valuable data to help leaders and those involved in managing and planning for disasters. The rapid melting of glaciers in mountains including the Hindu Kush, Himalayas, and Karakoram mountains in northern Pakistan has resulted in the formation of more than 3,000 glacial lakes. The main driver behind the melting of glaciers in over the past few decades is ongoing warming. The decline in glaciers is causing sea levels to rise, freshwater to flow into mountain streams and putting mountain livelihoods at risk. Comprehensive assessment of potential glacial outburst flood hazards in flood-prone lakes in the Ladakh region. Glacial outburst floods induced by the combination of climate change and warming pose a major threat worldwide, especially in the Himalayas. Glacial outburst floods in the Himalayas generally originate from glacial lakes in front of moraine dams and ice-dammed lakes.

The hazards and distribution of glacial lakes have been studied in many glacial regions of the world, but little attention has been paid to this problem in the Indian Himalayas. Climate change and the resulting retreat of glaciers are causing the formation of new glacial lakes and the expansion of existing ones in the Himalayas. Glacial lake outburst floods are natural disasters that occur when a glacial lake overflows and releases large amounts of water. They are the sudden release of water from a lake formed by melting glaciers onto, in front of, under, or on the surface of a glacier. This can cause serious damage to infrastructure, life, and livelihoods. The draining of glacial lakes due to moraines or glacier collapse, often causing massive flooding downstream, with significant local and economic damage. Flooding from glacial lakes now poses a threat to communities and infrastructure downstream. As glaciers retreated around the world increases in 20th and 21st centuries, the number and area of glacial lakes increased. The volume of water in glacial lakes varies, but can range from millions of cubic meters to hundreds of millions of cubic meters. The United Nations has taken various measures to prevent loss of life and damage in disaster areas. Over the past century, the expansion of glacial lakes has become increasingly important due to population growth and glacial retreat (Lützow et. al., 2023).

Glacial lake and glacial outburst flood events have a long history and have increased in frequency with global warming. Glacial lakes form when glaciers erode the land, melt, and

fill in depressions. Glacial lakes are composed of glacial ice, bedrock, or moraine debris. The largest of the moraine-dammed glacial lakes is around Mount Everest in the central Himalayas. GLOFs have been recorded in many regions, including Bhutan, Nepal, and Sikkim. In Bhutan, GLOF has been recorded since 1960. In Nepal, GLOF occurs in Dudh Koshi Dig Tsho, Tamor Nagma Pokhari and Dudh Koshi Nare (Jacquet et. al., 2017).



Source: <https://www.pnas.org/doi/full/10.1073/pnas.1914898117>

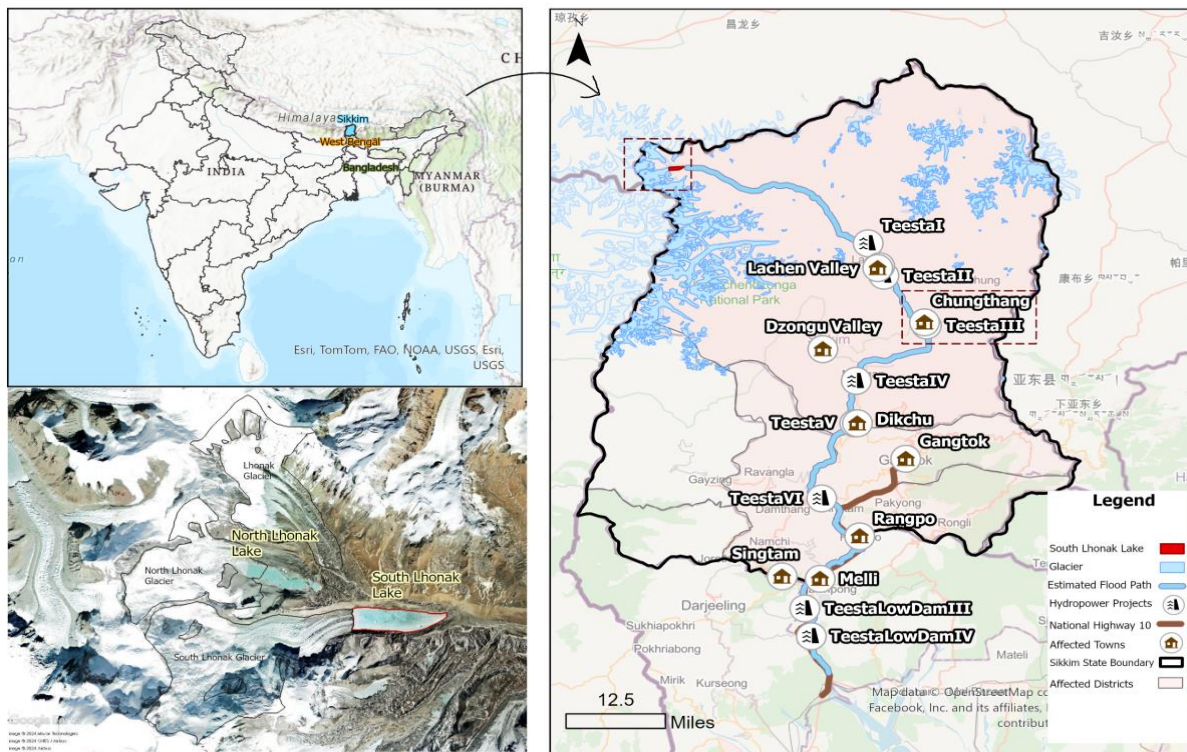
Figure 1: Glacial lakes in Himalayan countries

The melting of glaciers in the Himalayas has resulted in the formation of more than 5,000 glacial lakes, potentially blocked by unstable moraines. Glacial lake erosion has become a symbol of the changes in the cryosphere in the mountain range. The Himalayas are the region most affected by flash floods (Veh et al., 2019). Glacial lake products, which form the lake, are important because they allow non-specialist regional authorities to quickly identify lakes that need more detailed and comprehensive studies (Worni et al. 2013). As the climate warms, ice melts, and new rivers emerge, glacial lakes are rapidly growing. Many dams are unstable and vulnerable to rock/ice avalanches, raising concerns about the increasing number of glacial dams against floods (Veh et al., 2022). Himalayan rivers are often flooded by glacial lakes and failed mudflats; however, the variability and long-term impacts of these floods are still poorly understood (Cook et al. 2011).

Glacial Lakes and Glacial Lake Outburst Floods- India

Some well-known glacial lakes in India include Vasuki Tal, Nanda Devi East Base Lake, Kedar Tal, Hemkund Lake, Deoria Tal, Roopkund Lake, Gangbal Lake, Rupin Lake,

Suraj Tal, Chandratlal Lake, and Gurudongmar Lake. Most of these are found in the Himalayas and were formed by melting glaciers. These lakes are spread across states like Uttarakhand, Himachal Pradesh, and Sikkim. Deosai National Park in Jammu and Kashmir is also famous for having many glacial lakes. A government report shows that between 2011 and 2024, the number of glacial lakes and other water bodies in the Himalayas increased by 10.81%, which means there is a higher chance of glacial lake outburst floods. The most significant increase has been observed in Ladakh, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh, indicating an increased risk of GLOFs and the need for enhanced monitoring and disaster preparedness. The total area of glacial lakes in India was 1,962 hectares in 2011 and is expected to increase to 2,623 hectares by 2024 [September], an increase of 33.7%. Climate change has led to the formation of many alpine glacial lakes in the Himalayas.



Source: <https://iee.psu.edu/news/blog/glacier-lake-outburst-floods-loss-life-and-infrastructure>

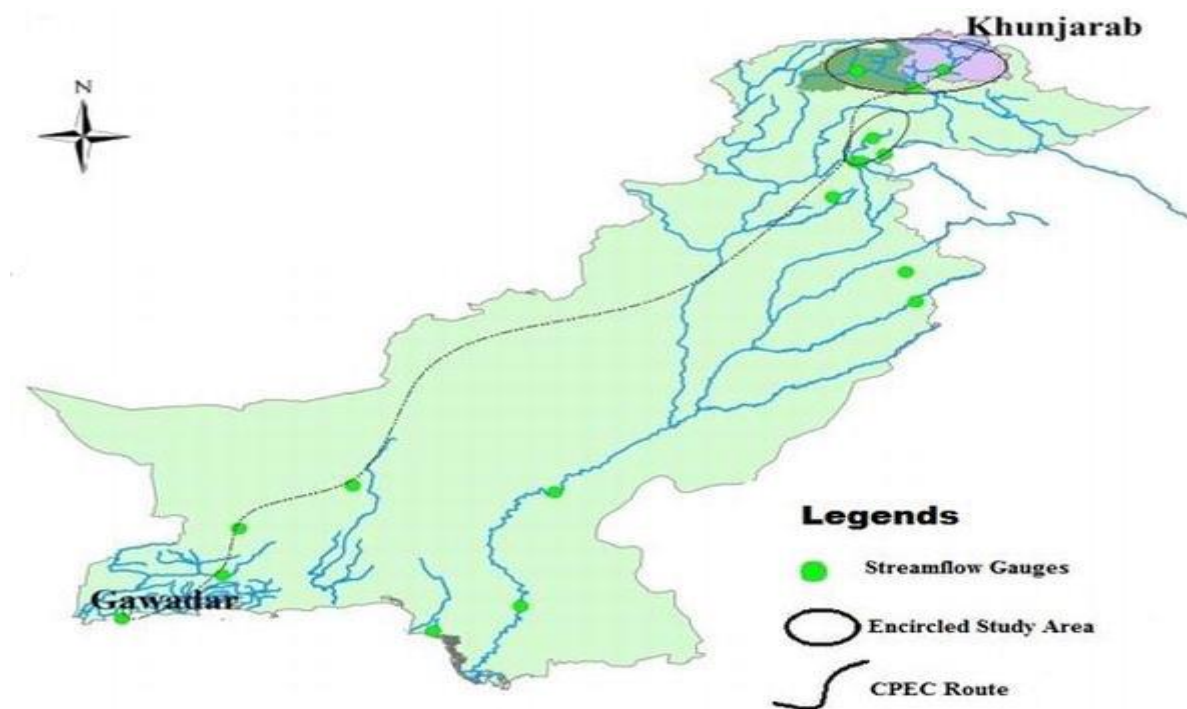
Figure 2: Glacial lakes in Indian state of Sikkim

Safed Lake is one of the largest glacial lakes in the central Himalayas, Uttarakhand, India. The risk of flooding due to glacial lake outbursts in the eastern Himalayas is increasing, further exacerbated by climate change-induced glacier loss, slowdown, and increased infrastructure projects at high altitudes (Sattar et al., 2020). Most of India's vulnerable lakes are located in remote areas, so the lake populations most likely to be affected are those living

far downstream from the lakes. Sikkim is a state in the eastern Himalayas. It has many glacial lakes, including Kecheopali Lake, Somgo Lake, and Gurudongmar Lake. There are over 80 glaciers and 227 alpine lakes in Sikkim. Most of these lakes are fed by glaciers and are considered sacred. The climatic conditions of Sikkim significantly affect its vulnerability to glacial outburst flood, especially monsoon rains, which accelerate the melting of glaciers and increase the amount of water required for glaciers to form. The rise and fall of these natural dams are also affected by changes in time: warmer temperatures cause glaciers to melt faster and cause more frequent flash floods.

Glacial Lakes and Glacial Lake Outburst Floods- Pakistan

Pakistan has many glacial lakes in the Hindu Kush, Himalayas and Karakoram ranges. These lakes are formed when glaciers melt due to rising temperatures. Some of these lakes are vulnerable to glacial lake outburst floods, which can cause serious damage to property, infrastructure and lives. In northern Pakistan, glaciers in the Hindu Kush, Karakoram and Himalayas have melted due to rising temperatures, forming 3,044 glacial lakes in the federally administered Gilgit-Baltistan and Khyber Pakhtunkhwa provinces. Around 33 of these glacial lakes are estimated to be hazardous and susceptible to glacial lake outburst floods. These floods can spill millions of cubic meters of water and debris in a matter of hours, causing serious damage to lives, property and infrastructure, and livelihoods in some of the most remote areas of Pakistan.



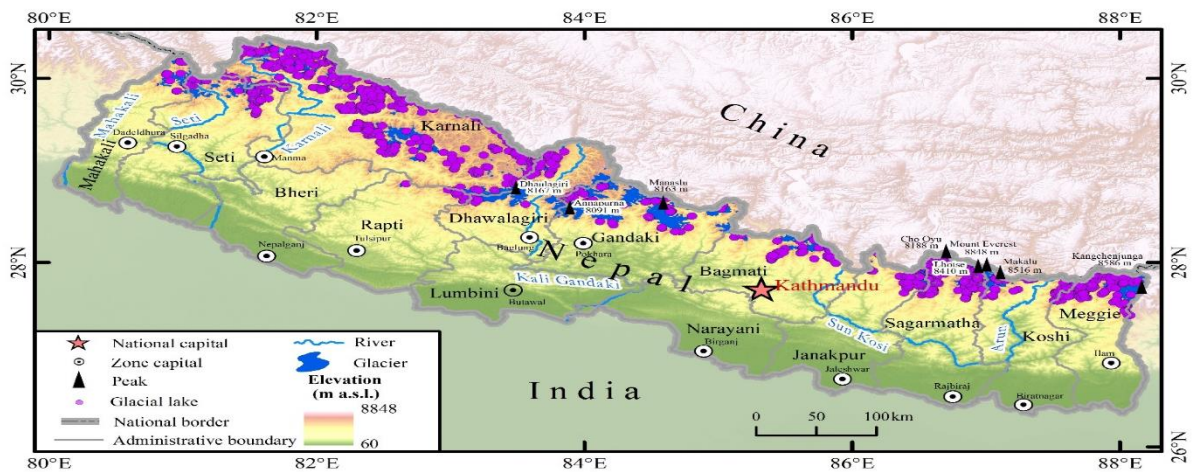
Source: <https://www.intechopen.com/chapters/73124>

Table 3: Glacial lakes in Hindu Kush, Himalayas and Karakoram ranges of Pakistan

Climate change suggests that glaciers may advance and retreat, which could herald a period when dam failure floods could occur again. Flood risks arise from summer monsoon storm conditions (Ashraf et al., 2012). Glacial lake outburst floods have become a serious phenomenon in the Karakoram, Himalaya, and Hindu Kush mountain ranges of northern Pakistan. Record heatwaves and rapidly melting glaciers have led to devastating floods. As global temperatures rise, glacial lakes are not only forming faster, they are also growing in size. Floods from glacial lake outbursts are a growing threat to communities living in the highlands of northern Pakistan and the valleys below, depriving them of reliable access to water. A report by the Intergovernmental Panel on Climate Change warns that unless the world dramatically reduces emissions, glaciers in the Hindu Kush Himalayas will continue to retreat, triggering a chain reaction of floods, landslides and ice sheet explosions.

Glacial Lakes and Glacial Lake Outburst Floods- Nepal

Nepal is very at risk from Glacial Lake Outburst Floods (GLOFs) because of the fast melting of glaciers caused by climate change. This danger puts people and buildings in danger. These floods happen when melting glaciers create lakes that are not stable and are held back by natural barriers like moraine or ice. When these barriers break, a lot of water rushes down quickly, causing serious damage. The nation is adversely affected by climate change but contributes little to global carbon emissions. Many scientists are concerned that the freezing of Himalayan glaciers and lakes could lead to extreme temperatures in Nepalese mountains, posing environmental and health risks. Glaciers are an important source of drinking water in Nepal, storing water at high altitudes during summer and winter and carrying runoff to lower altitudes during the dry season (Gautam, 2014). In Nepal, climate change could cause glaciers to melt, lakes to form, and rivers to weaken, leading to glacial outburst floods. These floods can cause property damage and loss of life. Scientists warn that climate change is causing most of the glaciers in the Himalayas to melt at an alarming rate. These lakes are supported by moraine plains (Lala et al. 2018).

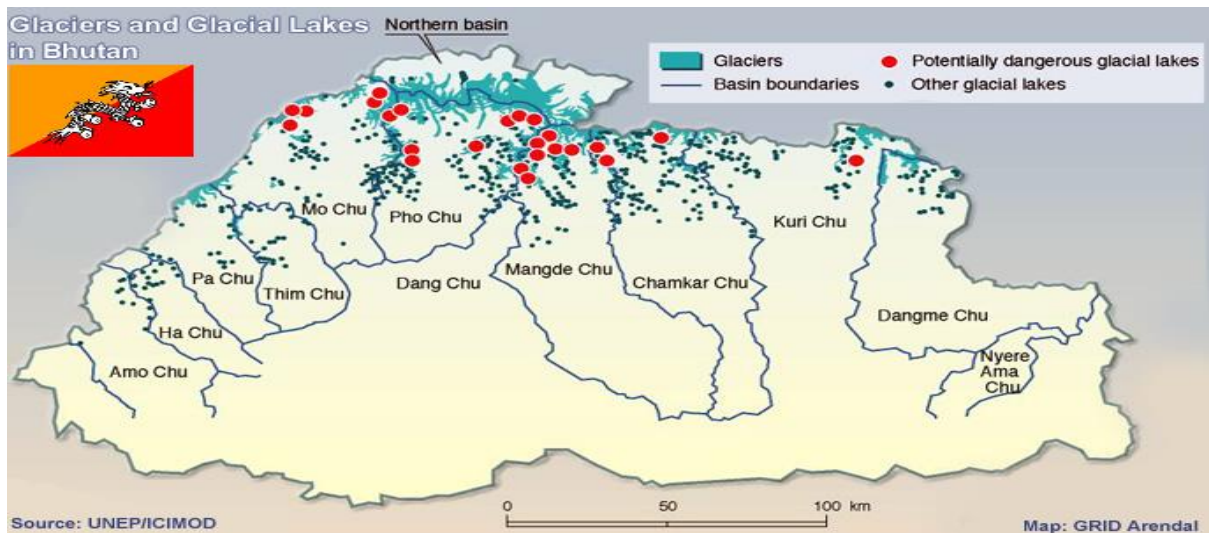


Source: <https://www.mdpi.com/2072-4292/14/19/5034>

The Hindu Kush Himalayas are sometimes called the "Three Pillars" because they have the most snow and ice in the world. But because of climate change, glaciers are melting very quickly. In Nepal, glaciers have lost about a third of their area since 1977, and this trend is likely to keep going as the weather gets warmer. As glaciers melt, more glacial lakes are forming, and their number and size have grown by about 50% since 1990. More than 1,500 of these lakes are in Tibet. It has been a challenge for developing countries, especially Nepal, to protect these lakes from causing floods. Many people, villages, roads, bridges, and important buildings are in danger from flooding. Also, many dams have stopped making electricity because of the risk of big flood events.

Glacial Lakes and Glacial Lake Outburst Floods- Bhutan

Bhutan is at high risk of Glacial Lake Outburst Floods (GLOFs) due to its position in the Himalayas and the effects of climate change, which are causing glaciers to melt, forming high-altitude glacial lakes. These lakes, often blocked by moraine or glacier ice, can burst due to avalanches, earthquakes, or rising water pressure, leading to catastrophic floods that endanger lives, homes, and buildings. Bhutan's lakes include glacial lakes and natural lakes. There are approximately 2,674 glacial lakes in Bhutan. Some glacial lakes, such as Lake Thorthormi in Lunana Gewog, are not single bodies of water but supraglacial lakes. Most of the glacial lakes in the Manas and Punazang (Sangkosh) river systems in north-central Bhutan are considered potentially hazardous.



Source: https://www.raonline.ch/pages/story/bt/btbg_glacier01c.html

Bhutan's glaciers cover about 3% of the country's total land area and provide water for all the rivers except the Amochu and Nyir Amachu. It's amazing to see how tall, snowy mountains turn into rocky land. As the world's climate problem gets worse, glaciers are getting thinner, which is now a real issue in Bhutan and many other places. With more unpredictable rain and changing temperatures, Bhutan's mountainous areas are facing bigger problems. The country is especially vulnerable to floods, which often cause damage. When glaciers melt faster because of higher temperatures, it affects the creation and growth of glacial lakes, which connects climate change directly to the risk of sudden glacier bursts (Dorji, 2021). Lunana is a heavily glaciated region in the north-western part of Bhutan. The Lunana region has three beautiful lakes with depths of up to 140 metres and moraine-dammed glacial lakes.

Floods in southern Bhutan are caused by heavy rainfall over a short period of time. Current flooding can damage property, land and infrastructure. Unprecedented rainfall patterns and sudden, heavy rainfall increase the risk of flooding. Flooding can damage buildings, roads, land, water systems and sewers. The current climate can also cause earthquakes. Floods and inundations, which are among the most common flooding problems in Bhutan, are usually caused by heavy rainfall, the collapse of natural or artificial dams. Bhutan is frequently affected by earthquakes, floods, forest fires, landslides, glacial meltwater events and cyclones. Glacial lakes overflow as a result of erosion of moraines. Floods and inundations, which are among the common flooding problems in Bhutan, are usually caused by heavy rainfall, the collapse of natural or artificial dams (Sarkar, 2025).

Impact of Glacial Lakes and Glacial Lake Outburst Floods

Glacial Lake Outburst Floods are disasters that happen when water from glacial lakes is released quickly. This happens when the natural barriers holding the water together break, often because of landslides, earthquakes, or ice collapses. It also harms people's ways of making a living, especially those who depend on farming and raising animals. Glacial lake bed collapse is extremely destructive and often occurs without warning, causing extensive damage to buildings, structures and land, and causing mass displacement of people. The melting of glaciers and the expansion of glacial lakes due to climate change are major global disasters that must be taken seriously. Glacial lake floods are events that occur when large amounts of water are released in a short period of time, causing rapid and violent flooding and destroying structures along the coast such as bridges, buildings and power lines. Sudden increases in water levels can damage habitats such as homes, farms and critical infrastructures downstream of glacial lakes, as well as causing significant loss of life and death. Glacial lake breakup can cause significant damage to the ecosystem by altering water flow, eroding riverbeds and destroying vegetation in the affected area. Communities displaced by flooding may face challenges in regaining their health and accessing basic services, which can lead to significant economic losses.

Table 1 Incidences of GLOF and the distance to downstream sites

Name of Lake	Country	Peak discharge(m³/s)	Date of outburst
Luggye Tsho	Bhutan	> 2500	7 October 1994
Tam Pokhari	Nepal	10,000	3 September 1988
Dig Tsho	Nepal	1600–2000	4 August 1985
Nare	Nepal	830–1100	3 September 1977
Ganxico	China	1270	14 July 1988
Zhangzangbo	China	15,920	11 July 1981
Gelhaipuco	China	4500	September 1964
Longdaco	China	1000	August 1964
Damenhai-Cho	China	2000	26 September 1964
Sangwang-Cho	China	10,000	16 July 1954
Qubixiama-Cho	China	3690	10 June 1940

Source: <https://typeset.io/pdf/lemthang-tsho-glacial-lake-outburst-flood-glof-in-bhutan-4qc2l5zkor.pdf>

Glacial lake outbursts are a serious issue that can cause numerous fatalities. Since the 1990s, the quantity and scale of glacial lakes worldwide have increased rapidly due to rising populations in mountainous regions and reduced economic activity. These outbursts can be very harmful, causing a lot of damage, destroying buildings, losing lives, breaking up communities, and changing the land, especially because of natural dams in rivers. Glacial lakes form when a lot of water is released from glaciers and underground water sources. This

water can erode mountains and create big piles of soil that flow into rivers and oceans, affecting the Earth's sediment and chemical balance. Glacial lake outbursts can hurt people, damage homes and buildings, and harm underwater life. They also have big effects on the economy, society, and environment. Floods from these outbursts can take lives, destroy property, break homes, close places, cause soil to wash away, and lead to landslides. Glacial lake overflows can damage homes, buildings, and land, cause harm to the environment and people, and put human lives at risk.

Preventive measures and Potential efforts

Preventing the formation of glacial lakes in the North Himalayan region requires a combination of monitoring activities, early warning systems, and engineering measures such as controlled drainage and dam building. This is supported by comprehensive risk reduction initiatives, like India's National Glacial Lake Outburst Flood Risk Mitigation Programme. Additional strategies include creating maps that show areas at risk, utilizing satellite technology for up-to-date information, and enhancing the abilities of local communities to better cope with and respond to glacial lake outburst flood events. It is important to address the root causes of glacier melting and reverse it by reducing greenhouse gas emissions. These include mitigating climate change through a global transition to renewable energy, increasing energy efficiency, and implementing policies to reduce carbon emissions across all sectors. Develop and implement early warning systems for monitoring glacial lakes, weather forecasting, and communications to alert high-risk communities. Using engineering measures to stabilize and control glacial lakes can help reduce the risk of glacial lake collapse. This may include engineering structures such as weirs, drains, and dams to control water levels and prevent uncontrolled discharges. These natural solutions can also provide additional benefits such as environmental protection and carbon sequestration.

Effective glacier water management requires engaging local communities in risk assessment, planning and decision-making. Building local preparedness capacity, including training in emergency response and evacuation procedures, can assist communities better prepare for GLOFs and other disasters. Because many of the Himalayan glacial lakes are located across international borders, international cooperation is vital for risk management and mitigation. Cooperation between countries sharing the same basin can facilitate information sharing, joint monitoring, and joint problem solving. Global climate change is causing glaciers to expand and thin. Global warming is reducing the flow of mountain glaciers, reducing their volume and area, and causing glacial lakes protected by unstable moraine ridges to form and

expand, posing a threat to human recreation. As Himalayan glaciers thin and retreat, new glacial lakes are formed, and existing lakes are enlarged by the discharge of water from the terminal moraines. These lakes are unstable and can cause serious damage to people and property in the valleys. Glacial lake outbursts are a significant problem in high mountain regions. In the Himalayas, most of the Himalayan glaciers have retreated due to climate warming in recent years, increasing the risk of catastrophic glacier outbursts (Nie et al., 2013). However, effective risk management is still needed, especially considering the impacts of climate change and increased seismic activity.

Important glacial lakes need to be identified and prioritised for in-depth exploration. Since the available data on large glacial lakes are based on topographic maps of the last decade, some of which date back to the 1960s, it is necessary to revisit large glacial lakes and assess the risks associated (Gurung, 2017). India, Nepal, Bhutan, Pakistan, and Afghanistan established the Hindu Kush and Glacier Economic Network in 2018 to promote regional glacier-based cooperation to combat climate change. The Global Security Institute, in partnership with Change Without Borders, conducted extensive research on glacial lake outbursts and climate change in the Hindu Kush. It works to combat climate change, raise awareness of climate change, and promote cooperation on climate change. The Ulaanbaatar Declaration, adopted at the Asian Ministerial Conference on Disaster Reduction in 2018, called for all regions to take measures to reduce climate change risks. China and Nepal also agreed to cooperate on environmental protection, which could be another step in managing transnational risks. (Davis et al., 2021).

Conclusion

Glacial lakes in the Himalayas are growing quickly because of climate change, which makes it more likely for dangerous Glacial Lake Outburst Floods to happen. These floods can cause flash floods, rock slides, and landslides that put communities downstream in danger. These lakes form when glaciers melt and are held back by ice or piles of rocks. If the dam breaks, it can release a huge amount of water. It is very important to keep an eye on these lakes and the areas around them so that early warning systems and ways to reduce damage can be created to keep people and buildings safe. Population growth and economic development have made human activities and infrastructure projects have a bigger effect on mountain areas that are already at risk for disasters. Stable and long-lasting reservoirs can be a good way to get drinking water and treat wastewater. There's some evidence that glacial lakes have become more common and bigger over time, but it's not yet clear if there's a direct link between these

lakes and the dangers they might cause. Global warming is causing mountain glaciers to melt, which raises the risk of glacial meltwater. Glacial floods are sudden, powerful, and wide-reaching natural disasters that often happen with landslides.

Glacial lakes are very sensitive to climate change, and their increase in number, size, and volume around the world is mostly because of global warming. Glacial lake erosion is a big but not well understood threat linked to climate change. It's recommended to regularly check all lakes and glaciers to prevent or reduce future lake-related events in the area. These lakes in lowland areas can change how sediment moves and cause big floods in major rivers. These lakes can overflow and eventually flow into large rivers, so they need to be watched closely because they can damage the environment below. As the ice sheets get thinner and move back, flooding in glacial lakes is possible. Glacial lakes are bodies of water formed by melting glaciers. They are created when glaciers erode the land and then melt, filling in the depressions they made. A good example of a glacial lake is Devtal Glacial Lake in the Garhwal Himalayas, which is the largest glacial lake in India. Glacial lakes are an important source of fresh water. The landscapes around these lakes also encourage tourism and help the local economy. These lakes can provide fresh water to meet the needs of the region and can also be used as potential sources of energy.

Long-standing glacial lakes support a variety of wildlife that comes from nearby water sources or other glacial areas. Glacial lake outbursts are measured based on the volume of floodwater, how much water flows out, how much sediment is moved, and how much fresh water is available. As natural hazards in a changing cryosphere, their role has become more important because of human activities, infrastructure development, melting glaciers, and growing glacial lakes. Glacial lakes are a growing problem but are also part of the natural glacial process. On the other hand, with rising global temperatures and more people living in the area, flooding has also become a bigger concern.

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