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GLOF[1]: Natural Disaster or the Revenge of Nature?

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Introduction

The Himalayas, often described as the "water towers" of Asia, support and sustain hundreds of millions of people across South Asia by feeding the major river systems. The glaciers, snow and ice in the Himalayas ensure the supply of water to the downstream populations which indicates their importance not only in terms of environmental security, but also in human security. However, the very same Himalayas that play such crucial role in sustaining the environment and lives on earth, are increasingly being associated with emerging hazards; among which Glacial Lake Outburst Floods (GLOFs) are particularly mentionable due to its frequent occurrence and severely destructive nature. A GLOF generally occurs when a glacial lake, impounded by a moraine, ice or another natural barrier, suddenly releases its stored water following dam failure or overtopping. GLOFs are not a new phenomenon. They have occurred naturally throughout the history of glacierized mountain regions. What makes them worthy of attention now is that the Himalayas are changing and thousands of new glacial lakes have been formed in the Himalayas within the past few decades. Due to natural and man-made reasons, these lakes are in threat to be overflowed and fulminated causing severe landslide and flooding the downstream with its destructive power. Explaining GLOF simply as a natural or human-induced calamity would be an oversimplification. Both the interaction among natural components and human decisions contribute to the emergence and destroying capability of GLOF. The factor that makes this disaster even more significant in terms of human security is that disasters like this does not respect political borders and national boundaries. They can primarily occur in one country and devastatingly affect neighboring countries as well, making them a regional concern. The recent incident of landslide and flash flood in Nepal perfectly illustrates this scenario as the disaster that took place in Nepal also impacted Tibbet and China, although the casualties in Nepal were much intense and precarious. Therefore, taking precautionary steps to minimize the occurrence and casualty of GLOF is not only a national concern anymore, it is a regional and global responsibility.

[1] Glacial Lake Outburst Flood (GLOF) is a natural disaster that occurs when water stored in a glacial lake is suddenly released because of the natural barrier containing the lake fails or is overtopped.

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Understanding GLOFs: From a Glacier to a Flood

A Glacial Lake Outburst Flood (GLOF) occurs when water stored in a glacial lake is suddenly released because of the natural barrier containing the lake fails or is overtopped. Retreat of glaciers is the predominant reason behind the formation of these lakes, and with the withdrawal of glaciers, meltwater can accumulate in depressions behind the terminal or lateral moraine- the deposits of rock and sediment left behind by the glacier. However, the formation of lakes automatically does not indicate the probability or occurrence of GLOF. The transition of a stable glacier snout into a catastrophic GLOF generally involves a series of cascading physical process chains[3]. The risk of glacial lake outburst flood depends on the interaction of multiple natural components and events. The size and geometry of the lake, the features of the dam, the presence of ice within the moraine, the surrounding slope stability and the nature of potential triggers- all influence whether an outburst is possible. Several natural processes can also play role in the outburst. A large displacement wave can be generated by a landslide or rock avalanche entering a lake, causing water to overtop the dam; a similar effect can be produced by an ice avalanche, and these are described as dynamic failures. Heavy rainfall may increase the inflow of the lake and progressively weaken the moraine dam by creating internal erosion or "piping", while destabilizing surrounding slopes, which is described as internal failure. Earthquake or any kind of seismic activity can create a sharp jolt in the lake and trigger the overflow of water by destabilizing the lake barrier. Thus, a GLOF can take place due to a chain of interaction among various physical processes; in the contrary, one natural event may also be adequate to contribute to the occurrence of a GLOF.

What makes GLOF different from a regular flood is its contingency. Conventional flood generally occurs through heavy and prolonged rainfall; whereas, a glacial lake outburst flood develops predominantly due to an abrupt natural event, like- snowmelt, avalanche, glacier retreat, landslide or breaking of dam, which causes water to overflow and rush downstream with high elevation. Therefore, the flood arrives rapidly, carrying substantial sediment and debris. In steep Himalayan valleys, gravitational forces and narrow channels can further increase the speed and erosive capacity of the flow. Nevertheless, the extent of destruction does not only depend on the flood's natural features, but also on how it interacts with populations, infrastructure and livelihoods.

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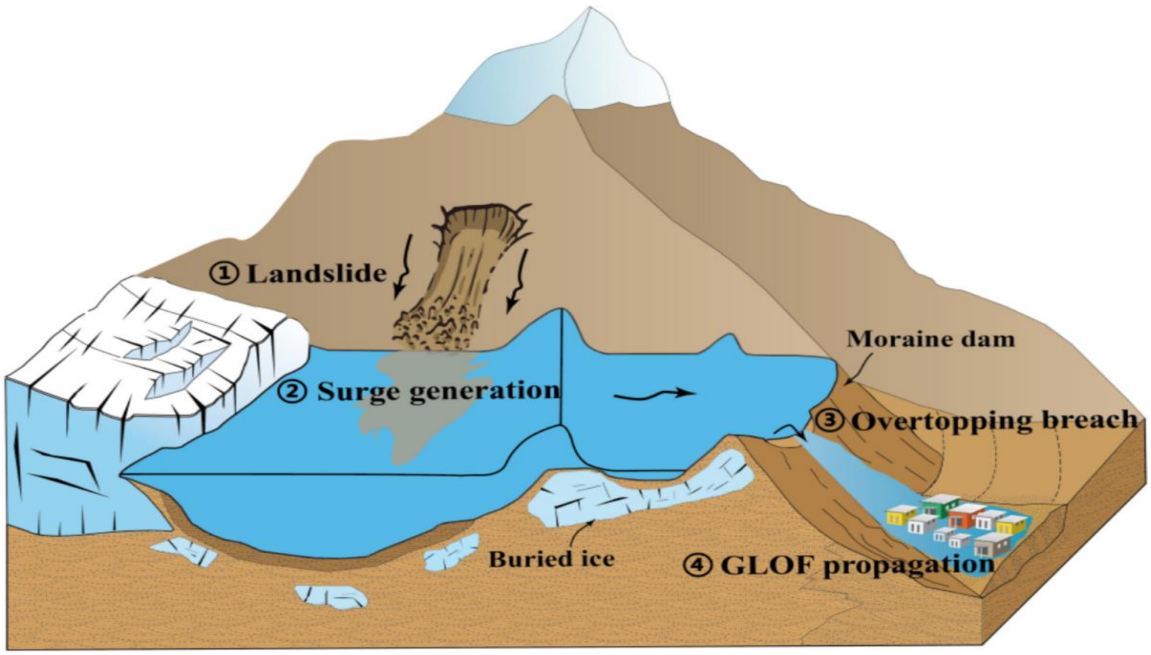
[3] Zheng, Guoxiong., Mergili, Martin., Emmer, Adam., et al. 2021. "The 2020 Glacial Lake Outburst Flood at Jinwuco, Tibet: Causes, Impacts, and Implications for Hazard and Risk Assessment." *The Cryosphere* 15 (7): 3159–80.
https://doi.org/10.5194/tc-15-3159-2021.



Source: Springer Nature

This is important from a disaster-risk perspective. A natural hazard turns into a disaster when it interacts with living things and infrastructure, affecting security and development. The significance of a natural process depends partly on the extent to which human society is exposed to it[4]. So, the existence of a hazardous glacial lake automatically does not, by itself, make a disaster inevitable; what lies downstream influences its potential consequences. This distinction becomes increasingly important in the Himalayas because human activity has expanded into high-mountain environments. Hydropower facilities, roads, highways, bridges, tourism infrastructure and settlements are increasingly present in valleys that can serve as pathways for floodwaters. The relationship between GLOFs and people is, therefore, not simply about a dangerous lake at high altitude; it is about the interaction between hazard, exposure and vulnerability.

The Changing Himalayas and Growing GLOF Risk

The Himalayas are undergoing profound change. Rising temperatures have caused substantial glacier mass loss across much of the region, although the rate and magnitude of change vary considerably between individual glaciers and sub-regions. Nie et al. note that Himalayan glaciers have been experiencing substantial mass loss since the mid-twentieth century and that changing

[4] Hewitt, K. "The International Disaster: Vulnerability and Resilience in Mountain Environments." Mountain Hazards. Routledge. 2000.

glacier conditions are already affecting runoff patterns and water-related hazards[5]. The Hindu Kush Himalayan (HKH) region is one of the most sensitive environments to global climate change. Over the past century, a measured warming rate of 1.6 degree Celsius across the north-western Himalayas- far exceeding the global average- has driven unprecedented glacier shrinkage and mass loss[6]. One important consequence of glacier retreat is the formation and expansion of glacial lakes. When ice retreats from a basin, meltwater can accumulate behind moraines or other natural barriers. Continued melting can increase the volume of existing lakes while retreat can expose new depressions capable of storing water. The IPCC reports that continued glacier retreat is expected to produce new lakes in the Himalaya-Karakoram region and that the combination of degrading permafrost, decreasing slope stability and expanding lakes can increase the risk of GLOFs and landslide-related floods in Asian high mountains[7]. However, the relationship between warming and GLOFs is not as simple as "higher temperature equals more floods." Climate change modifies the physical conditions under which GLOFs can occur, but the actual occurrence of an outburst depends on interacting factors. A rapidly expanding lake may remain stable for years, while a smaller lake may experience a destructive outburst if an avalanche or landslide enters it. Recent scientific reviews consequently emphasize the importance of considering lake characteristics, dam stability, surrounding topography, precipitation and potential triggers together.

The risk landscape is nevertheless becoming more complicated. A 2026 review of GLOFs in the Himalayas covering research and satellite observations from 2000-2024 found that increasing temperatures and precipitation anomalies are important factors in GLOF susceptibility and highlighted the growing importance of remote sensing for identifying and monitoring hazardous lakes[8]. A separate 2026 review similarly identifies rapid cryospheric retreat, the formation and expansion of glacial lakes and associated changes in mountain environments as major components of emerging GLOF risk[9]. The result is a changing risk environment in which long-term climate processes and short-term geological events interact. Climate change can create or enlarge the lake and destabilize surrounding environments, while an avalanche, landslide or extreme rainfall event can provide the immediate trigger. This distinction is crucial because it prevents the analysis from reducing a complex hazard to climate change alone.

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[5] Nie, Yong., Pritchard, Hamish., Liu, Qiao., et al. 2021. "Glacial Change and Hydrological Implications in the Himalaya and Karakoram." *Nature Reviews Earth & Environment* 2, 91-106. https://doi.org/10.1038/s43017-020-00124-w.

[6] Allen, S. K., Linsbauer, A., Randhawa, S. S., et al. August 8, 2016. "Glacial Lake Outburst Flood Risk in Himachal Pradesh, India: An Integrative and Anticipatory Approach Considering Current and Future Threats." *Natural Hazards* 84 (3): 1741–63. https://doi.org/10.1007/s11069-016-2511-x.

[7] "IPCC Sixth Assessment Report." 2021. *IPCC*. https://www.ipcc.ch/report/ar6/wg1/chapter/chapter-12/.

[8] Song, Yan., Sun, Hongyan., Jie, Cheng., et al. 2026. "Glacial Lake Changes and Outburst Flood Risk Assessment in the North American Coast Mountains." *Geomorphology* 514 (December): 110530. https://doi.org/10.1016/j.geomorph.2026.110530.

[9] Nie, Yong., Pritchard, Hamish., Liu, Qiao., et al. 2021. "Glacial Change and Hydrological Implications in the Himalaya and Karakoram." *Nature Reviews Earth & Environment* 2, 91-106. https://doi.org/10.1038/s43017-020-00124-w.

Revenge of Nature?

Human activity is changing the probability, intensity or consequences of natural hazards. The catastrophic impacts of GLOFs are not simply natural disasters, they are the direct consequences of human-induced climate change intersecting with expanding exposure and deep-rooted social vulnerability[10]. According to the conceptual climate-risk framework given by the Intergovernmental Panel on Climate Change (IPCC), three overlapping factors determine the level of risk during a natural disaster: hazard, exposure and vulnerability. Firstly, the physical hazard itself has a clear human footprint. While mountain geomorphology is naturally dynamic, warming temperatures driven by anthropogenic greenhouse gas emissions is directly tied to the rapid expansion of glacial lakes over the last 30 years[11]. Globally anthropogenic emissions are considered the primary driver of cumulative glacier mass loss since 1850[12]. Secondly, human exposure to the Himalayas has rapidly increased over the years and expanding physical footprint of human society naturally drives disasters like GLOFs. A mountain valley is not inherently a disaster zone simply because a GLOF could pass through it. Impetuous socioeconomic development- spurred by tourism, agricultural expansion and construction of transport networks- has placed more people and assets in hazardous flood corridors than ever before. In High Mountain Asia, over 1 million people reside within just 10 kilometers of active glacial lakes. This expanding human target, along with changing natural triggers, converts a high-altitude flood into a major disaster. Thirdly, the severity of a GLOF's impact is dictated by social vulnerability- the structural, institutional and demographic factors that determine a community's ability to prepare for, respond to and recover from a disaster. Resilience is drastically undermined by factors, such as- limited access to early warning systems, administrative failure and demographic inequalities. The 2013 Chorabari GLOF in Uttarakhand, India demonstrated how a minuscule outburst in highly vulnerable setting can be devastating. The outburst discharged a minor volume compared to massive high-altitude lakes; yet, due to dense religious tourism, extreme downstream exposure and absence of warning systems, the minor flood claimed over 4,000 lives[13].

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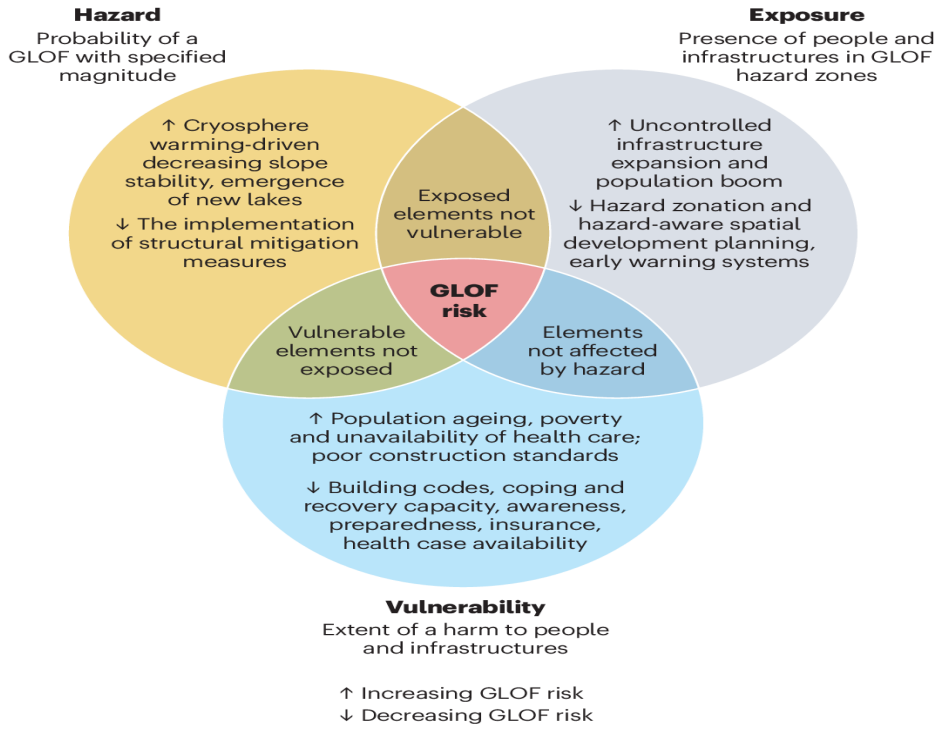
[10] "5 Insights into Understanding Glacial Lake Outburst Floods in a Warming World." United Nations University. 2026. https://unu.edu/ehs/article/5-insights-understanding-glacial-lake-outburst-floods-warming-world.

[11] Taylor, Caroline. "Increasing Risk of Glacial Lake Outburst Floods (GLOFs)." AntarcticGlaciers.Org. February 19, 2025. https://www.antarcticglaciers.org/glaciers-and-climate/glacier-hazards/increasing-risk-of-glacial-lake-outburst-floods/.

[12] Zheng, Guoxiong., Mergili, Martin., Emmer, Adam., et al. 2021. "The 2020 Glacial Lake Outburst Flood at Jinwuco, Tibet: Causes, Impacts, and Implications for Hazard and Risk Assessment." *The Cryosphere* 15 (7): 3159–80. https://doi.org/10.5194/tc-15-3159-2021.

[13] Dubey, Saket., & Goyal Manish, Kumar. "Glacial Lake Outburst Flood Hazard, Downstream Impact, and Risk Over the Indian Himalayas." 2020. *Water Resources Research* 56 (4). https://doi.org/10.1029/2019wr026533.

All three factors- hazard, exposure and vulnerability- deciding the risk level of a natural incident are notably being influenced by human decisions and actions in today's world. Over the years, humans have gotten closer to mountains without maintaining the necessary regulations. Humans have increased the emission of carbon-di-oxide by burning fossil fuels, destroyed the natural setting of mountains to enhance connectivity and utilized the mountain terrains for their entertainment. They have arbitrarily treated the natural environment without conscience and consciousness. The price of neglecting and disrespecting the environment was meant to be paid back by humans as their reckless activities are now triggering the physical geomorphic failures that ultimately leads to the arrival of natural disasters. Human-induced climate change, biodiversity loss, and wreckage of natural systems are contributing to calamities like GLOFs, where not only the causes of disaster are connected to man-made reasons; rather, the effects of the disasters have also become highly related to human activities.



Source: Nature

Natural disasters happen due to natural reasons and they do not represent the "revenge of nature" in literal meaning. However, undoubtedly, human actions increasingly trigger the speed and scale of the natural incidents that may actively contribute to the occurrence of natural calamities like GLOFs. Lack of awareness and precautions makes the effects of the disasters more monstrous and destructive. In this sense, "revenge of nature" is best understood as a metaphor for the consequences of ignoring the physical limits and changing conditions of the mountain environment. Therefore, the nature- in actual meaning- may not want to take revenge from humans;

but the blows humans throw at the nature always find a way back at humans like a boomerang and make them pay the due price.

GLOF as a Regional Security Issue

GLOFs should not be treated solely as environmental or disaster-management concerns. Their implications extend to human security, economic security and regional cooperation. At the human-security level, GLOFs threaten lives, homes, livelihoods and essential services. The 2024 Thame Valley event in Nepal demonstrates the cascading nature of such risks. A rock avalanche into an upstream lake triggered a displacement wave, which contributed to the failure of another glacial lake. The resulting flood travelled roughly 80 kilometers downstream and damaged homes, a school, a health facility, a bridge and hydropower infrastructure. The event displaced 135 people. GLOFs can also produce substantial economic consequences. In the Himalayas, 68% of existing and proposed hydropower plants are located in potential GLOF tracks[14]. Damage to hydropower facilities can affect electricity generation and government revenues, while destruction of roads and bridges can isolate communities and disrupt trade and tourism. Agriculture can also be affected through the destruction of farmland, sediment deposition and river-channel alteration. The regional dimension is particularly important because Himalayan rivers are transboundary systems. The threats posed by GLOFs actively undermine national energy grids, disrupt viral international transport links and pose transnational security challenges across highly sensitive geopolitical borders[15]. The Ganges, Brahmaputra and other major rivers cross national borders and connect countries through shared hydrological systems. The World Bank notes that the Indus, Ganges and Brahmaputra basins are shared by multiple South Asian countries and that cooperation in their management is essential for climate resilience[16].

For Bangladesh, the issue is particularly relevant even though most GLOFs occur far upstream. Bangladesh sits at the downstream end of the Ganges-Brahmaputra-Meghna river system. More than 93 percent of the country's renewable water resources are transboundary, and its major river systems originate beyond its national territory[17]. This does not mean that every Himalayan GLOF will produce a catastrophic flood in Bangladesh. However, recent studies have found substantial

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[14] Dubey, Saket., & Goyal Manish, Kumar. "Glacial Lake Outburst Flood Hazard, Downstream Impact, and Risk Over the Indian Himalayas." 2020. *Water Resources Research* 56 (4). https://doi.org/10.1029/2019wr026533.

[15] Allen, S. K., Linsbauer, A., Randhawa, S. S., et al. August 8, 2016. "Glacial Lake Outburst Flood Risk in Himachal Pradesh, India: An Integrative and Anticipatory Approach Considering Current and Future Threats." *Natural Hazards* 84 (3): 1741–63. https://doi.org/10.1007/s11069-016-2511-x.

[16] World Bank. "Transboundary Water Management in South Asia." World Bank Group. 2021. https://www.worldbank.org/en/news/video/2021/08/04/transboundary-water-management-in-south-asia.

[17] Joseph, George., & Shrestha, Anne. "MONSOONS, RIVERS, AND TIDES: A Water Sector Diagnostic of Bangladesh". 2021. https://documents1.worldbank.org/curated/en/099650012142134358/pdf/P1714520db34b70d2087bf0d6af64015b20.pdf.

increases in the number and area of glacial lakes in the China-Nepal Himalaya between 1992 and 2022. Many research projects have also pointed to continuing lake expansion and growing exposure to GLOF hazards under a changing climate. For countries downstream- like Bangladesh- the risk is not limited to the immediate wreckage caused by the flood; rather, the risks incorporate disruption of connectivity and communication, damage of infrastructures, and destruction of land, settlements and livelihoods[18]. The rising frequency and scale of such hazards also complicate disaster preparedness; especially in countries like Bangladesh that is already prone to natural disasters, and holds minimal institutional and administrative capacity to manage and recover from disasters like glacial lake outburst floods.

Therefore, the concern for Bangladesh is broader: changes in the upstream cryosphere and extreme events can contribute to greater uncertainty in transboundary river flows. Bangladesh is already highly exposed to riverine flooding, and its location downstream makes access to upstream hydrological information particularly important. Bangladesh should strengthen cooperation with other countries and stakeholders on satellite monitoring, early-warning systems, downstream evacuation protocols, river basin data sharing and GLOF risk mapping. Real-time and effective communication between upstream and downstream authorities can assist populations to take necessary precautions and steps before a flood wave arrives[19].

Conclusion

Glacial Lake Outburst Floods challenge the conventional distinction between a "natural" disaster and a "human-made" one. GLOFs are undeniably natural hazards. Glaciers have retreated, lakes have formed and natural dams have failed long before the modern climate crisis. It would, therefore, be scientifically inaccurate to portray every GLOF as a direct product of human activity. At the same time, the context in which these hazards occur is changing. Anthropogenic climate change is contributing to glacier mass loss and the formation and expansion of glacial lakes, while unstable slopes, changing precipitation patterns and other environmental changes can interact with these processes. At the same time, expanding infrastructure and settlements in mountain valleys are increasing human exposure. Scientific research increasingly demonstrates that GLOF risk emerges from the interaction of these factors rather than from a single cause[20].

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[18] Barua, Gautam. "Nepal–China Flash Flood Highlights Growing Risk of Glacial Lake Outburst Floods." The Business Standard. August 29, 2026. https://www.tbsnews.net/thoughts/nepal-china-flash-flood-highlights-growing-risk-glacial-lake-outburst-floods-1527666.

[19] Barua, Gautam. "Nepal–China Flash Flood Highlights Growing Risk of Glacial Lake Outburst Floods." The Business Standard. August 29, 2026. https://www.tbsnews.net/thoughts/nepal-china-flash-flood-highlights-growing-risk-glacial-lake-outburst-floods-1527666.

[20] Nie, Yong., Pritchard, Hamish., Liu, Qiao., et al. 2021. "Glacial Change and Hydrological Implications in the Himalaya and Karakoram." *Nature Reviews Earth & Environment* 2, 91-106. https://doi.org/10.1038/s43017-020-00124-w.

The policy implication is clear: the objective cannot be to eliminate every natural hazard. It is to prevent hazards from becoming catastrophes. This requires better glacier and lake monitoring, satellite-based risk assessment, early-warning systems, resilient infrastructure, responsible land-use planning and community preparedness. Because Himalayan rivers cross national boundaries, it also requires greater regional cooperation in sharing hydrological and hazard information. The recent GLOF incident in Nepal further illustrates the significance of regional cooperation in terms of disaster management and advanced preparedness. For Bangladesh, this cooperation is particularly important. As a downstream country in the Ganges-Brahmaputra-Meghna system, Bangladesh cannot control what happens in the high Himalayas, but it can strengthen its capacity to anticipate and manage changes in upstream river conditions.

Ultimately, the most important lesson of GLOFs is not that nature is fighting back. Rather, it is giving humans the forecasts regarding the calamities that may occur if humans continue to violate the boundaries nature implemented and ignore the warning signs of a rapidly changing mountain environment.