

Ecological and Environmental Challenges in the Himalayas with special reference to Sikkim

Birkha Man Subba (Muringla)

Assistant Professor, Department of Limbu
Sanchaman Limboo Government College Gyalshing
nanumabirkha@gmail.com

Abstract

The Himalayas, one of the most fragile and ecologically significant mountain systems in the world, face increasing environmental challenges driven by both natural processes and human interventions. Issues such as deforestation, biodiversity loss, land degradation, glacial retreat, and climate-induced disasters have intensified, threatening both ecosystems and human livelihoods. Within this broader Himalayan context, the state of Sikkim presents a unique case. Despite being recognized as India's first fully organic state and a biodiversity hotspot, Sikkim experiences recurring ecological pressures including landslides, soil erosion, hydropower-induced reverie changes, glacial lake outburst floods, and the adverse impacts of unregulated tourism. Theoretical and analytical perspectives highlight how fragile geology, climate variability, and development pressures converge to create complex environmental vulnerabilities in the region. Understanding these challenges in the Sikkimese context is crucial not only for regional sustainability but also for informing broader strategies of conservation and climate adaptation in the Himalayas.

1. Introduction

The Himalayas, often described as the “Third Pole” and the “water towers of Asia,” are among the world's most ecologically sensitive and environmentally fragile regions (ICIMOD/Scientific assessment, 2022). Stretching across eight countries and sustaining billions of people through their rivers, forests, and biodiversity, the Himalayan ecosystem plays a critical role in global climate regulation and regional livelihoods. However, the region is increasingly threatened by deforestation, unregulated development, biodiversity loss, glacial retreat, and climate-induced disasters such as floods and landslides. These challenges are further compounded by the Himalayas' fragile geology and seismic vulnerability, which make ecological imbalances particularly severe.

Within this larger Himalayan context, the Indian state of Sikkim occupies a special place. Known for its rich biodiversity, cultural heritage, and recognition as India's first fully organic state, Sikkim is part of the Eastern Himalaya—one of the world's global biodiversity hotspots (A Banerjee et al., 2019). Despite its achievements in conservation, Sikkim faces persistent ecological and environmental pressures including soil erosion, hydropower-related ecological risks, glacial lake outburst floods (GLOFs), and the mounting impacts of tourism. Therefore, examining ecological and environmental challenges in the

Himalayas with special reference to Sikkim is crucial for understanding both regional vulnerabilities and pathways toward sustainable mountain development (Biodiversity of Sikkim: Exploring and Conserving a Global/International Centre for Integrated Mountain Development).

The Ecological and Environmental challenge in the Himalayas are

1. Deforestation and Habitat Loss

Large-scale logging, shifting cultivation, and infrastructure development reduce forest cover, threatens biodiversity hotspots and traditional livelihoods.

2. Soil Erosion and Landslides

Steep slopes, deforestation, and road building make the region prone to frequent landslides. Soil fertility decreases, affecting agriculture.

3. Glacial Retreat and Climate Change

Himalayan glaciers, the “water towers of Asia,” are retreating due to global warming, leads to altered river flows, floods, and long-term water insecurity.

4. Biodiversity Threats

The Himalayas host rare species (snow leopard, red panda, and orchids). Habitat fragmentation and climate change push many to endangered status.

5. Overpopulation and Tourism Pressure

Rapid urbanization and unregulated tourism put stress on fragile ecosystems. Waste generation, traffic congestion, and cultural landscape degradation rise.

6. Hydropower Development

Dam construction alters river ecosystems and displaces communities, increases seismic and landslide risks in a geologically fragile zone.

The major problem in Sikkim

1. Landslides and Soil Instability

Frequent due to fragile geology, deforestation, and road construction. Example: NH-10 (Siliguri–Gangtok highway) often disrupted.

2. Glacial Lake Outburst Floods (GLOFs)

Melting glaciers (e.g., South Lhonak Lake) increase risk of sudden floods. 2023 Sikkim flash flood was linked to a GLOF event.

3. Hydropower and River Ecology

Teesta River basin has multiple hydropower projects. Leads to biodiversity loss (aquatic life, riparian forests) and affects livelihoods.

4. Tourism Pressure

Sikkim, a popular eco-tourism destination, faces waste management issues, vehicular pollution, and habitat disturbance. High tourist footfall in places like Gurudongmar Lake and Yumthang Valley disturbs fragile alpine ecology.

5. Biodiversity Conservation Challenges

Sikkim is a recognized biodiversity hotspot (Eastern Himalaya). Despite being an organic state, challenges remain in balancing conservation with development. (Biodiversity, Volume 20, Issue 2-3, 2019)

6. Seismic Vulnerability

Located in a seismically active zone (Natural Hazard, Vol-31, pp. 319-342), increasing risks from dams, urban expansion and fragile mountain slopes. Here's a polished academic-style response that weaves together your points about committees, initiatives, and Sikkim's UNESCO heritage status.

Government Initiatives and Protection Measures in Sikkim:

In recent years, the Government of India and the Government of Sikkim have taken several proactive steps to address the state's growing vulnerability to natural disasters and ecological fragility. Following events such as the 2023 Glacial Lake Outburst Flood (GLOF) in South Lhonak Lake, committees were set up at both the state and central level to study the situation and recommend measures for disaster preparedness, early warning systems, and sustainable development planning in Sikkim. These committees bring together experts in geology, glaciology, hydrology, and disaster management to assess the impact of climate change, fragile mountain geology, and human interventions on the region.

The central Government has also sanctioned two significant amounts for Sikkim's relief efforts following the Glacial Lake Outburst Floods (GLOFs) in 2023.

1. Rs 550 Crore: sanctioned for reconstruction efforts in Sikkim to address damage caused by the devastating GLOFs in October 2023.
2. Rs 44.8 Crore: Released as an advance payment from the State disaster Fund (SDRF) to support immediate relief measures. (Ministry of Home Affairs (2023) . Annual Report 2022-2023. Government of India).

Alongside this, Employees of state Government contributed one day's salary as a gesture of solidarity. Many NGOs, neighboring states, as well as well wisher from the different part of the country also extended their support by contributing generously to the Chief Minister Relief Funds.

Additionally, The Government has taken steps to address the disaster's impact.

3. Evacuations Efforts: Over 2400 people were evacuated from the flood hit areas and more than 7600 people were shifted to relief camps.

Compensation: The State Government announce ex-gratia compensations of Rs 4 Lakh to families of those who died and Rs 2000 to those in relief camps.

4. Reconstruction plans: The Government is rebuilding the Teesta Stage III dam, despite concerns that dams exacerbated flood damage.

The GLOFs occurred on October 4, 2023, when the South Lhonak Glacial Lake in north Sikkim burst, causing massive floods down the Teesta River Valley. The disaster resulted 92 conform deaths, 15 bridges destroyed, Hydroelectric dam damaged, widespread damage to infrastructure and communities.

Sikkim's Tourism Industry has been significantly impacted by the Glacial Lake Outburst Floods (GLOFs) in October 2023, resulting in substantial decline in tourism arrivals and revenue. The state's economy, which heavily relies on tourism, has suffered greatly, with many stake holders, including hoteliers', travel agents, and transporter, experiencing losses.(The Sikkim flood of October 2023)

Break down Tourism Industry

1. Decline in Tourist Arrivals: After the GLOFs tourist movement halted in northern partsof Sikkim, affecting popular destinations like Lachen, Lachung, Yumthang and Yumesamdung.

2. Economic Losses: The tourism industry incurred significantly losses with hotels owner and travel agents force to close business or operate at reduce capacity.
3. Damage to infrastructure: The flood caused extensive damage to roads and bridges, isolating North Sikkim and disrupting tourism activities.

Recovery Efforts

1. Re-opening of North Sikkim: The State tourism Department allows Sikkim after a 14 month hiatus, with the first batches of the tourism reaching destinations like Lachung and Lachen.
2. Surge of Tourist Arrivals: In a positive sign, 4554 tourists visited North Sikkim in just one week after its reopening, indicating a potential rebound in tourism.
3. Government Support: The government is working to restore connectivity and promote sustainable tourism practices to minimize the impact of future disaster.

Challenges Ahead

1. Sustainable Tourism: The surge in tourist arrivals raises concerns about sustainable tourism practices and the need for infrastructural upgrades.
2. Climate Change: Sikkim is vulnerable to climate related disaster like GLOFs, which can have devastating effects on the state's economy and infrastructure.

Regional Corporation: Collaboration with neighboring counties is essential for mitigating the risk associated with GLOFs and promoting regional stability.

The Sikkim Government has formed 13 members commission, known as the 'Sikkim Commission on Glacial Hazards, 'to assess glacial across the state, particularly those vulnerable to Glacial Lake Outburst Flood (GLOF), the details about the committee. (Govt. of Sikkim 2024/Sikkim Express Oct 21, 2024).

The Committee Leader: Akhilesh Gupta, former senior advisor in the department of Science and technology of the Indian Government.

Members comprise of 6 they are the expert and educationists including

1. Kalachand Sain
2. A.Ramsoo
3. Mahindra P Lama
4. Piyush Gourav
5. Ashmin Sattar
6. Anil Kumar Gupta

The aim of the commission to evaluate the risks associated with glacial lakes in Sikkim and provides recommendations to mitigate potential damages from the GLOFs.

According to (Geo Journal, 9 April 2025) Including Sikkim University's Geography Department is actively involved in studying Glacial Lakes Outburst Floods (GLOFs), a significant concerned in the Himalayan region.

The research focus on understanding the dynamic of glaciers, glacial lakes and GLOFs. Faculty members and researchers employ geospatial techniques, remote sensing, and field based observation to study glacial lakes bathymetry, moraine-dammed lakes and downstream impact.

Faculty members includes

1. Dr R.B Singh: Known for his work on glacial hydrology and GLOFs
 2. Dr. SK Singh: Expertise in remote sensing and GIS applications for glacial lake mapping
 3. Dr. TC Sharma: Researches glacier dynamics, glacial Lakes, and climate change impacts. Sikkim University's researcher conducted
1. Field Observation: Monitoring glacial lakes, glaciers and downstream areas.
 2. Use remote Sensing: Analyzing satellite data to identify potential GLOFs risk lakes
 3. Geospatial technique: Mapping glacial lakes, stability and modeling potential of flood scenarios.

The government has put emphasis on:

Disaster Risk Reduction (DRR): Strengthening early warning systems for floods and landslides, along with community-based disaster preparedness programs.

Livelihood Protection: Promoting organic farming, eco-tourism, and biodiversity-based livelihoods to ensure economic resilience for mountain communities.

Geological and Ecological Safeguards: Restricting construction in vulnerable zones, monitoring glacial lakes, and regulating hydropower projects in the Teesta basin. Conservation Measures: Expansion of protected areas, strict forest conservation laws, and promotion of sustainable tourism.

Notably, Sikkim is home to the Khangchendzonga National Park, which was inscribed as a UNESCO World Heritage Site in (2016). This recognition underscores Sikkim's global ecological significance as part of the Eastern Himalaya biodiversity hotspot. The park not only protects endangered flora and fauna but also integrates cultural and spiritual values, making it a model of nature-culture conservation.

Through these combined efforts scientific committees, policy interventions, and international conservation recognition—Sikkim is striving to balance development, disaster resilience, and ecological preservation within the fragile environment of the young Himalayas.

Conservation Measures: Expansion of protected areas, strict forest conservation laws, and promotion of sustainable tourism. Notably, Sikkim is home to the Khangchendzonga National Park, which was inscribed as a UNESCO World Heritage Site in 2016. This recognition underscores Sikkim's global ecological significance as part of the Eastern Himalaya biodiversity hotspot. The park not only protects *endangered flora and fauna but also integrates cultural and spiritual values, making it a model of nature-culture conservation. Through these combined efforts—scientific committees, policy interventions, and international conservation recognition—Sikkim is striving to balance development, disaster resilience, and ecological preservation within the fragile environment of the young Himalayas.*

Impact of GLOFs on Heritage Sites and Biodiversity

Glacial Lake Outburst Floods (GLOFs) are one of the most severe climate-induced disasters in the Himalayas, and their impact in Sikkim has raised major concerns for both human settlements and natural heritage sites. When a glacial lake suddenly bursts, *it releases massive volumes of water and debris, causing downstream floods, landslides, and large-scale destruction.*

1. Displacement of Communities

Villages located along river valleys, such as those near the Teesta basin, face forced displacement due to sudden floods. Loss of agricultural land, infrastructure, and livelihood sources forces local populations to migrate, disrupting socio-cultural life.

2. Loss of Endangered Species

The Khangchendzonga National Park, a UNESCO World Heritage Site, harbors rare and endangered species such as *the red panda, snow leopard, Himalayan black bear, and high-altitude flora*. GLOFs damage habitats by uprooting forests, eroding soil, and altering river ecosystems, threatening already vulnerable species (Himalayan white trout fish, toads, black/red Crab, Butterflies and Bee).

3. Impact on Heritage Environment

As a mixed natural and cultural heritage site, the park's sacred landscapes and biodiversity-rich ecosystems are at risk. Changes in river courses, glacial retreat, and habitat destruction undermine both ecological integrity and the cultural significance of the site.

The displacement of people and the loss of endangered species during GLOFs demonstrate how climate change-driven disasters can have long-term consequences on both human well-being and globally recognized heritage sites. Protecting areas like Khangchendzonga National Park requires integrated disaster management, strict conservation strategies, and community-based adaptation measures to safeguard Sikkim's fragile environments.

Conclusion:

The Himalayas and Sikkim in particular, face interlinked ecological and environmental challenges arising from climate change, fragile geology, human pressures, and development projects. While Sikkim has pioneered conservation initiatives such as becoming India's first 100% organic state and protecting forest cover—sustainable development and disaster preparedness remain crucial to safeguarding its unique ecological heritage. The Himalayas, with their fragile ecosystems and vital role as the “water towers of Asia,” are under growing ecological and environmental stress. Deforestation, climate change, biodiversity loss, and unsustainable development threaten both ecological balance and human livelihoods across the region. In the case of Sikkim, these challenges are particularly pronounced due to its steep terrain, seismic vulnerability, dependence on hydropower, and exposure to climate-induced disasters such as landslides and glacial lake outburst floods.

Yet, Sikkim also stands as a model of resilience, with progressive initiatives such as becoming India's first fully organic state and adopting strong biodiversity conservation measures. The state's policies reflect an awareness that sustainable development must align with ecological preservation.

In sum, while ecological vulnerabilities remain pressing, Sikkim demonstrates that careful planning, community participation, and climate-sensitive policies can balance development with conservation. Addressing these challenges is not only essential for the well-being of Sikkim but also critical for ensuring the long-term sustainability of the entire Himalayan region.

The Forest, Environment & Wildlife Department of Sikkim is primarily administrative in function, and does not house specialized experts in GIS, Remote Sensing, Hydrology, or an advance data analytics. Therefore, for scientific investigation such as glacial lake outburst floods (GLOFs), The Government of Sikkim collaborates with Universities, national research institute, and specialized agencies (ISRO/NESAC/GSI/CWC) to carry out technical studies and hazard mapping.

References

1. ICIMOD (International Centre for Integrated Mountain Development). (2019). *The Hindu Kush Himalaya Assessment: Mountains, Climate Change, Sustainability and People*. Springer Nature. Comprehensive study on ecological and climate challenges across the Himalayas.
2. Arrawatia, M.L., & Tambe, S. (2011). *Biodiversity of Sikkim: Exploring and Conserving a Global Hotspot*. Information and Public Relations Department, Government of Sikkim. Focuses specifically on biodiversity and conservation challenges in Sikkim.
3. Tambe, S., & Arrawatia, M.L. (2009). Climate Change in the Eastern Himalayas: The Case of Sikkim State, India. *Indian Journal of Environmental Sciences*, 13(2), 223–236. Examines climate change impacts on Sikkim's ecology.
4. Chettri, N., Sharma, E., Shakya, B., & Bajracharya, B. (2008). Biodiversity in the Eastern Himalayas: Status, Trends and Vulnerability to Climate Change. ICIMOD. Highlights ecological fragility and environmental pressures in Sikkim and the Eastern Himalayas.
5. Mandal, R., & Hussain, Z. (2018). "Environmental Issues and Challenges in Himalayan States of India with Special Reference to Sikkim." *International Journal of Research in Social Sciences*, 8(7), 559–570. Academic article focusing directly on Sikkim's environmental challenges.
6. Sharma, E., & Chettri, N. (2005). "Sustainable Mountain Development in the Eastern Himalaya: Policy, Practices, and Future Directions." *Journal of Mountain Science*, 2(4), 336–344. Discusses policies and practices relevant to sustainable development in Himalayan regions including Sikkim.
7. Government of Sikkim. (2016). *Sikkim State Action Plan on Climate Change (SSAPCC)*. Department of Forest, Environment & Wildlife Management
8. Ministry of Home Affairs. (2023). *Annual Report 2022-2023*. Government of India.