



Litigating Climate Change: Himalayan Glaciers At The Forefront

Navmi Joshi¹

Dr. Monica Kharola²

ABSTRACT

The Third Pole — the Himalayas is an extremely sensitive for the global climate which contains large amounts of glaciers and its location is rather important in terms of the circular motions in the atmosphere. This research focuses on the relationship between climate change and the sustainable development goals in the Himalayas with a specific focus on assessing and improving the legal performances and policies. Diverse objectives are at its core with the ultimate goal being to provide a comprehensive account of the ecological and socio-economic impacts of climate change on this sensitive environment as well as the effectiveness of national and international legal frameworks. The study then forwards tight measures to reinforce these legal frameworks to guarantee that appropriate responses are available for mitigation and adaptation. Particular focus is laid to building harmonized legal framework that captures common environmental issues in the Himalayan region and improve cooperation in governance between the involved countries. As a result, the research advocates for the development of apparatus that set even higher standards of laws meant to enforce environmental legislations as well as the enactment of policies that meet international environmental standards. These legal provisions are imperative to facilitate the proper utilization of resources for the achievement of sustainable development and to achieve requisite targets like the SDG's particularly associated with water and sanitation, healthcare facilities and environmental conservation. Thus, while the legal approach is well deemed a proper instrument, it is stated that there is a serious need for the harmonized approach and strategy in order to accomplish the goal of governing the Himalayan ecosystem and enabling the sustainable development.

Keywords: *Himalayas, Climate Change, Sustainable Development Goals, Glacial Melt, Biodiversity, Socio-economic Impact*

¹Research Scholar, ICFAI Law School, ICFAI University, Dehradun, Uttarakhand

²Associate Dean, ICFAI Law School, ICFAI University, Dehradun, Uttarakhand

For Citation:

Navmi Joshi & Dr. Monica Kharola, ‘Litigating Climate Change: Himalayan Glaciers At The Forefront’, (2024) Special Issue on SDGs, JSS Journal for Legal Studies and Research, 194-212, <https://www.jsslawcollege.in/jsslc-online-journal/>

• Introduction

The Himalayas are popularly known as the “Third Pole” due to their critical importance to the climate system. Located in over five nations—Bhutan, China, India, Nepal, and Pakistan—the Himalayas host some of the world's largest river basins, including the Ganga, Brahmaputra, and Indus. These river systems support over 250 million people in South Asia for domestic, agricultural, and hydropower uses. The glaciers in the region occupy an area of about 33,000 square kilometers, out of which the water from these glaciers is important in sustaining the perennial rivers. However, the Himalayas are one of the most vulnerable societies to climatic change because of more severe temperatures, glacier shrinkage, and more intense weather conditions. The buck does not stop at the regional environments and people but also has impacts on climatic cycles since the Himalayas determine moisture circulation and distribution throughout Asia.

The United Nations SDGs in 2015 set an elaborate agenda on how to meet global challenges such as climate change. The SDGs encompass 17 goals with 169 tentative objectives to reach poverty reduction, sustainable development, and international peace and prosperity by the year 2030. Climate change is directly targeted in goal 13, which is to take immediate action to address climate change urgency. Climate change also impacts this goal and several others, including water and sanitation (SDG 6), health (SDG 3), and life on land (SDG 15). Concerning the Himalayan space, combating climate change is essential to attaining these interconnected aims since the region is both sensitive from an ecological perspective and significant from a socio-economic standpoint.

This research aims to analyze the relationship between climate change and sustainable development goals (SDGs) in the Himalayan area with emphasis on laws and policies. The objectives are threefold: first, the effects of climate change on the biological setting of the Himalayas and consequently the social and economic implications are elucidated; second, the legal and policy measures on combating and responding to climate change at the national and international levels specific to the Himalayas are explored; and third, suggestions for enhancement of all these structures to initiate sustainable development in the Himalayas are proposed. This paper will gather case laws, statutes, and policy documents and present the developing legal performance and framework of Himalayan contextualization and legal approaches to address climate change mitigation and management.

It will be pertinent to mention that the Himalayan region as a whole is an important barometer of global climate feedback given its enormous glacial assets and geographic location. Himalayan glaciers are the primary water storage system for South Asia’s major river systems, which are critical for irrigation and



hydrologic demands in high population density areas. Such glaciers are important for replenishing the stream flows during the dry period, thus avoiding water shortages. Nevertheless, the increasing tendency of the glaciers' speed their melting as a result of climate change endangers the water supply of millions. An IPCC report points out that the Himalayan glaciers are melting faster than the global average, so river flows are likely to decline in the coming decades, leading to further stress on water resources, crops, and energy production.

Besides, the Himalayas affect climate patterns, for instance, the monsoon, which is important for farming in the South Asia region. Due to climate change in the Himalayas, variations in the patterns disrupt weather hitches such as floods, droughts, and landslides. These calamities are not only life- and property-endangering; they are also anti-development forces that plunge vulnerable communities into further poverty. Having indicated how the Himalayas area influences regional as well as global climate systems, the paper established the need to protect such a sensitive area through proper climate change and climate change adaptation measures.

The SDGs are integrated and indivisible and explain the vision of a better and more sustainable future for all people across the world in the next fifteen years. They are related; one deals with poverty issues and the negligence of needed development that has to benefit everybody. Climate change is a cross-cutting problem that cuts through the different Sustainable Development Goals. Specifically, goal 13 is on climate change and calls for countries to step up efforts to integrate climate change risk reduction into the development agenda and enhance the resilience of communities and the favorable progression of natural disasters. This goal revolves around the main idea of mainstreaming climate change in policies, external strategies, and national plans.

In the context of the Himalayas, some of the most vulnerable SDGs are climate change-related ones. For instance, Goal 6 (Clean Water and Sanitation) fits well as the topic because the Himalayan glaciers are the main suppliers of freshwater to millions of people. The melt of these glaciers because of an increase in temperature is a danger to water supply and quality for human and agricultural use. Goal 15 (Life on Land) is also relevant, as the Himalayan area has unique flora and fauna and biodiverse hot spots that are sensitive to climate change. That is why it becomes core to safeguard these ecosystems regarding the well-being of species diversity and the communities living around them.

Additionally, eight out of the seventeen goals of sustainable development are impacted by climate change: Goal 3 (good health and well-being): extreme weather and changing climate negatively impact health as vector-borne diseases spread and malnutrition occurs. Climate change mitigation and management hence becomes crucial in realizing the taps outlined above in the Himalayas and other parts of a sustainable world.

• **Geographic and Climatic Significance of the Himalayan Region**

The Himalayan landscape continues from India to Nepal, Bhutan, the Chinese territory of Tibet, and northern Pakistan; this great geological structure plays the climatic and hydrospheric roles of a barrier in South Asian geography. This extensive and highest mountain system in the world with Mount Everest and K2 stretches about 2400 kilometers and is home to diverse habitats ranging from tropical zones at the foothills to arctic conditions up the slopes. This mountain range behaves as a climatic barrier for the monsoon current from the Indian Ocean, where the southern side of the Himalayas receives a good amount of rain as compared to the northern side of it, including the Tibetan plateau, which is basically in a rain shadow zone. It is important to preserve the seasonal conditions in the weather, which is key to the agricultural yields and water supplies in the areas.

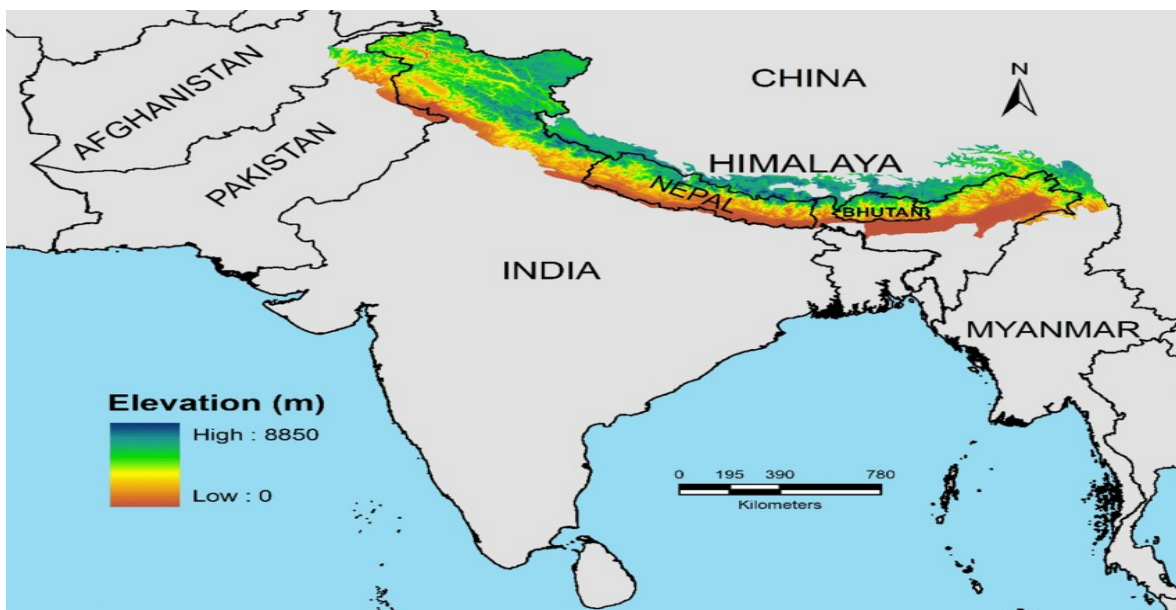


Fig 1. Geographical spread of the Himalayan Mountain system across seven nations, highlighting the elevation gradient from lowlands (green) to high peaks (red). The map includes major geographical features and country borders."

This map illustrates the geographical spread of the Himalayan Mountain System across seven nations: Afghanistan, Pakistan, India, Nepal, Bhutan, China, and Myanmar. The elevation gradient is shown in the form of a color scale, depicting low elevation in green and high elevation in red.

In the Indian context, the Himalayas are also responsible for controlling climate because, while flowing in the territories of India, they impact the movement of atmospheric currents. The climate, which receives heavy rainfall during the monsoon summer season, is largely dependent upon the Himalayan range. It also aids in trapping moisture-laden winds and brings precipitation that assists the agricultural industry, one of the most prominent pillars of the Indian economy. In the absence of the Himalayas, monsoon severity and spatial pattern will be shifted, which will result in the severe intensity of drought for some areas and flooding for others. Likewise, the north-south cover of the Himalayas also shields North India from cold arctic winds

from central Asia and keeps the northern plains of temperate nature.

The Himalayan region itself is a source of worldwide importance because it has tremendous numbers of plant and animal species, including many that can only be found in this region. This biodiversity is attributed to the variety of climatic and ecological belts that range from the tropical forests in the foothills to alpine and permanent snow fields. However, the Eastern Himalayas are identified as one of the 34 global biodiversity hotspots. The Himalayan ecosystems are the life support system of our planet, and these include water supply, filtration and retention, erosion control, and sequestration of carbon, which are critical for the survival of the local people and global sustainable economic development. But this rich treasurization is being messed up by climate change, deforestation, and sometimes unsustainable agriculture practices that interfere with the habitats and make species more vulnerable to extinction.

It is probably overly stated that the Himalayas have a crucial role in controlling the hydrological cycle. Being a part of the largest continuous stretch of ice in the world, the Himalayas belong to major water towers that supply large amounts of freshwater to big river systems of South Asia—the Ganges, Brahmaputra, and the Indus. All these rivers are sources of freshwater supply for millions of people for domestic and industrial use, irrigation, and as sources of hydropower. Since water from glaciers is available all year round, it is adequate throughout the dry period of the year, which is beneficial to farming. Nevertheless, climate change has fast-tracked glacier melt, which poses a question mark on the water availability for the region's inhabitants in the future. The greatest concern is the possibility of reduced glacier mass, threatening the year-round volume of the rivers, and leading to water shortage problems that will affect food and energy production.

The Himalayan ecosystems have cultural and religious significance to the indigenous and local people. Multicultural people have believed that the mountains possess a divine or otherworldly quality; Hinduism, Buddhism, and Jainism. Many arduous journeys and sacred ceremonies are performed across the range, with millions of individuals visiting each year. These cultural practices accompany the conservation of natural resources because many cultures have undergone traditional ecological knowledge, which envisages sustainable use of the environment. However, the next generation's expansion of tourism and modern life has threatened the cultural and environmental balance in Tanzania.

• **Impact of Climate Change on the Himalayan Region**

Climate change indicators suggest that the Himalayan region is undergoing a transformation owing to climate change. Some of the noticeable signs revealed include an increase in temperatures. This study has revealed that over the last century, this Himalayan region has warmed more than three times faster than the world average. Available research presented temperatures at the higher altitudes of the Himalayan Range as having increased by about 1.5 degrees centigrade since the middle of the twentieth century. This warming has also hastened the melting of glaciers, which are so important to the hydrology of this area. Retention of glaciers is the reflection of global warming, where glaciers are known to melt at a very rapid pace. The

Gangotri Glacier through which the Ganges River originates has retreated more than 1,500 meters in the past 70 years. That loss holds dangers for the future of water for millions of people who depend on it for irrigation, drinking, and for use in hydroelectric power stations.

The following chart illustrates the temperature increase over time in the Himalayan region, highlighting both historical data and future projections:

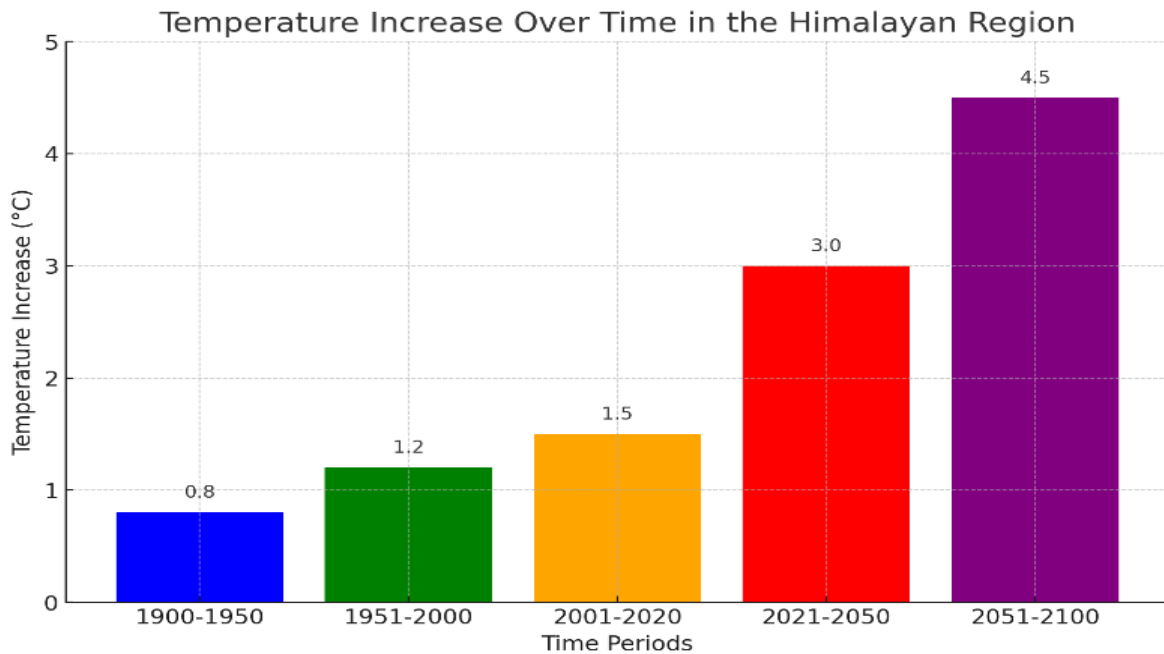


Fig2. Temperature Increase Over Time in the Himalayan Region. The chart illustrates the historical and projected temperature increases in the Himalayan region, highlighting significant warming trends from 1900 to 2100.

- Glacial Retreat in the Himalayan Region

Gangotri Glacier in the Himalayas is one of the huge glaciers, and the main problem in this glacier is the retreating issue from the mid-twentieth century. The following chart illustrates the proportional retreat of the Gangotri Glacier over different periods:

Proportional Retreat of Gangotri Glacier Over Time

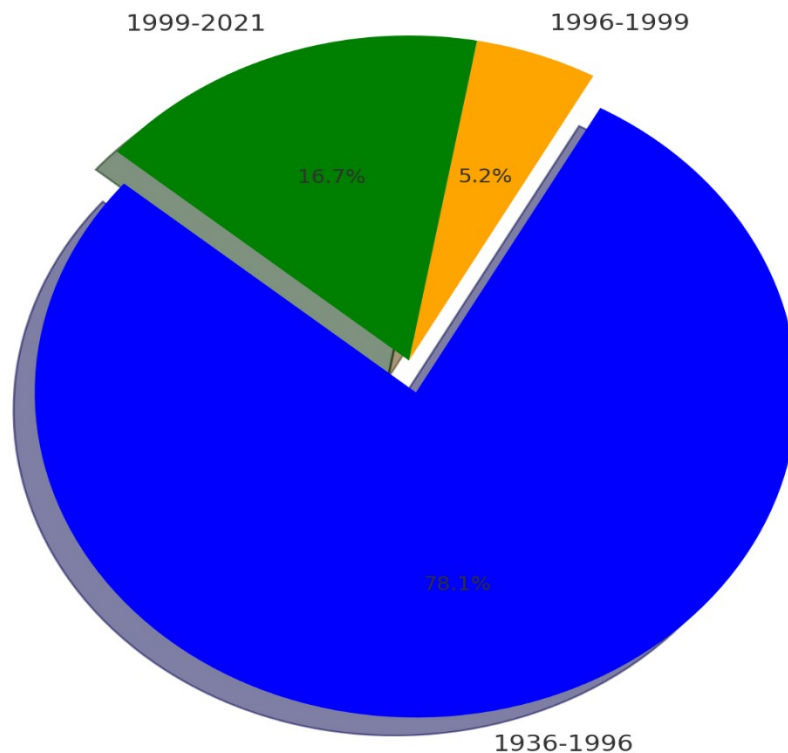


Fig 3. Proportional Retreat of Gangotri Glacier Over Time. The pie chart shows the percentage of glacier retreat during different periods, highlighting the significant increase in retreat rates in recent decades.

This presentation increased the time for the freeze of the glacier, which is a great threat to the water supply for millions of people whose water sources are provided by the glacier water supply rivers. The higher rate of retreat also unfavorably impacts agriculture as well as other hydraulic power generation downstream.

- Frequency of Extreme Weather Events

Floods and landslides are on the rise in the Himalayan zone, as analyzed from the previous decades. The following bar graph illustrates the number of these events recorded per decade:

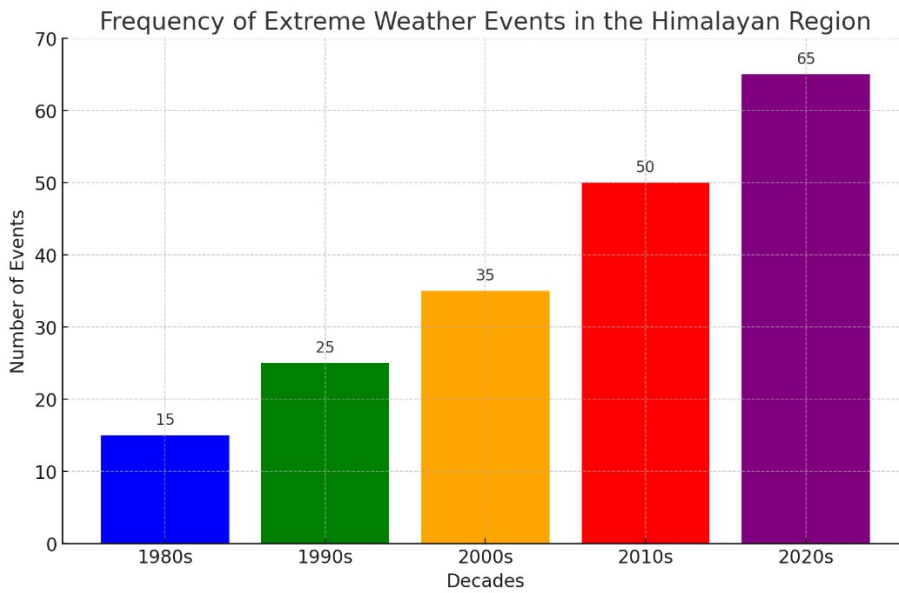


Fig 4. Frequency of Extreme Weather Events in the Himalayan Region. The bar graph shows the increase in the number of extreme weather events over the past five decades.

▪ Impact on River Flows

When analyzing the actual as well as expected future river yields from Himalayan rivers, it was observed that climate change impacts have caused decremented river yields. The following line graph compares these flows:

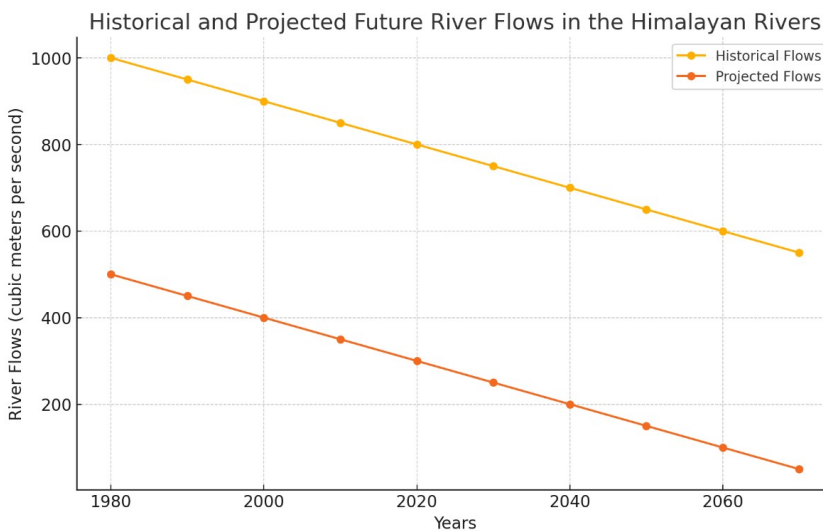


Fig 5. Historical and Projected Future River Flows in the Himalayan Rivers. The line graph compares the historical data with future projections, indicating a severe decline in river flows.

▪ Socio-Economic Impacts of Climate Change

The observed and anticipated river yields of Himalayan rivers depict that climatic change impacts have resulted in declines in rivers' yields. The following line graph compares these flows:

Distribution of Socio-Economic Impacts of Climate Change

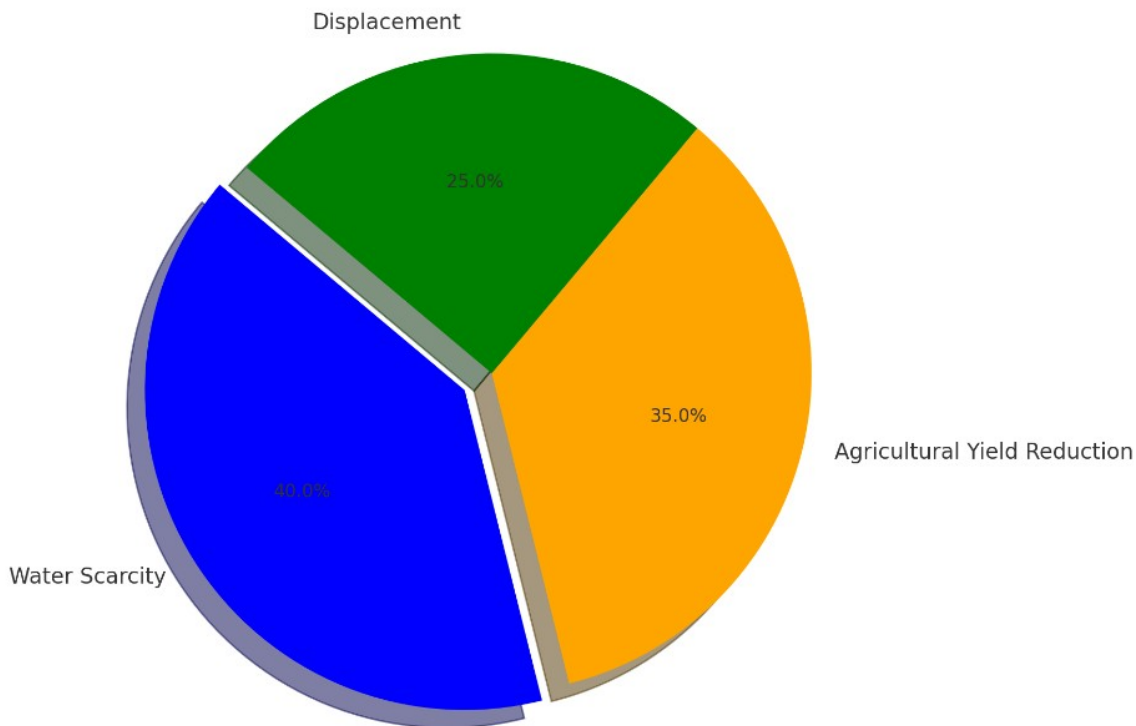


Fig 6. Distribution of Socio-Economic Impacts of Climate Change. The pie chart shows the percentage distribution of different socio-economic impacts caused by climate change.

The negative economic effects of climate change in the Himalayan region are clearly manifested in areas such as agriculture and tourism. Both agriculture and water, the majority of which rely on the annual flow of water derived from the glaciers and monsoons, bear the brunt of the impacts caused by climate change and water scarcity. Food crops, including rice, wheat, and maize, on which the population depends, are crops that can be severely affected negatively as far as production is concerned. This not only the food security situation but also the livelihoods of millions of farmers in the country. Besides, climate change impacts the other important source of the region's income, which is the tourism industry, in the Himalayan states. This is because the glaciers are melting and there has been an increase in other environmental triggers like landslides and floods that can be painful for tourists and thus affect the economies. Further, adventure tourism that depends on the natural resources of the region and political stability has a severe inconvenience due to the transformation of the landscape and climatic conditions.

The impacts of climate change have been social too, in the context of the Himalayan region that embraces the following consequences of climate change, such as displacement, health problems, and infringement on the capabilities of community resilience. The cases of flash floods, landslides, and glacial lake outburst floods significantly rise year after year, leading to the newly displaced population. For instance, the Kedarnath flood in 2013 resulted in the loss of several lives and property and affected thousands of people.

Health problems are also growing because people face new threats, such as vectors, with diseases such as malaria and dengue fever, which intensify due to high temperatures. It reveals that malnutrition increases and incidences of waterborne diseases increase with the decline in availability of fresh and clean water and the negative effects of climate change on food production. There is a rising strain in communities because the old coping strategies are no longer useful due to the new climatic shifts. This calls for the improvement of support structures and other related interventions to address the needs of such communities for increased capacity to cope with the impact of disasters.

Cultural losses due to climate change in the Himalayan region include losses of cultural assets and traditional ways of life. The Himalayan is not only a natural geographic beauty but has always been of cultural and religious importance to the local people and all the people of South Asian countries. There are still the native people who have used cultural norms and ceremonies associated with ceremonies to natural phenomena, feasts, and other festivities. For instance, the Char Dham Yatra held each year in Uttarakhand is perhaps one of the largest pilgrimages traveling to the heights of the Himalayas. But climate change brings changes to those landscapes, such as retreating glaciers and more frequent landslides, which are threats to these cultural activities. Vandalism loses believers' cultural icons; violations of estimated cultural sites; and climate change effects on cultures lead to interruption of traditional celebrations and activities, thus reducing the cultural worth, continuity, and belonging of locals.

○ PROTECTION AND MITIGATION STRATEGIES

Increasing effects of climatic change in the region of the Himalayas, therefore, requires enhanced safety and measures that would engage global, countrywide, and regional approaches. Internationally, there are policies and frameworks developed about climate change and sustainability. The Intergovernmental Panel on Climate Change (IPCC) has an important function to evaluate the scientific information on climate change, impact assessment, and proposed measures of adaptation and mitigation. The IPCC provides scientific information to support climate policies and to build legal frameworks, like the one in Paris. The said COP 21 meeting saw the adoption of the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC), where the global community set itself the goal of not allowing the global mean temperature to rise higher than 2 degrees Celsius above pre-industrial levels with the target of maintaining it at 1.5 degrees Celsius. This international framework entails an obligation on states individually and collectively to decrease the emission of greenhouse gases and to build the capacity to adapt to climate change.

The Indian government has framed more than one politically on controlling climate change due to different regions of India, especially in the Himalayan area. These are the National Action Plan on Climate Change (NAPCC) framed in 2008, which consists of eight distinct missions of which NMSHE forms a part. This mission is to cover the achievement of major goals concerning the biological survey of a particular region, consisting of the evaluation of the condition of Himalayan area ecosystems, their conservation, the improvement of effectively utilizing the supply of water, as well as the promotion of sustainable



development in the mentioned region. It also works towards integrating mainstream climate change into the process of development and for capacity building of people. Also, the writer notes that the government of India has stated its policy in its INDC under the Paris Agreement and the country's goal in cutting emission intensity and the proportion of non-fossil fuel energy sources in the mixture.

The measures, probably policies, and action plans of the regional governments are also instrumental in addressing issues originating from the Himalayan states. But today there are also states like Uttarakhand and Himachal Pradesh that have their working plans regarding climate change. The State Action Plan on Climate Change of Uttarakhand also highlights the importance of sectors like agriculture, water, forestry, and disaster. It also contains interventions for climate mitigation like vitamins for enhanced and effective climate-smart agriculture, better water harvesting practices, and measures for strengthening responses to climate-related disasters. Likewise, the present State Strategy and Action Plan on Climate Change of Himachal Pradesh focuses on the need to safeguard natural resources, mitigate GHG emissions through renewable energy and energy efficiency measures, and support measures to conserve biological diversity. Some of the regional initiatives are critical to making climate change interventions more appropriately targeted and sensitive to the particular conditions of the Himalayan area.

Real-life examples from the Himalayan countries explain how the practically implemented different protection and mitigation measures work and how efficient they are. For example, the town of Joshimath in Uttarakhand has suffered from environmental problems contingent on climate change and haphazard expansion. The town is vulnerable to landslides and subsidence, which are caused by increased rainfall and meltwater from the glaciers. As a result, local government authorities have put measures in place that include slope stabilization, afforestation, and construction control to prevent further deterioration of the environment and promote resilience. The use of cartoons may well have been effective in the past in cases such as that of Kedarnath, which was ravaged by the floods in 2013 and yet has stepped up to the task of undertaking reconstruction and learning from the change. The disaster revealed the inadequacies of the early warning systems, woeful infrastructural development, and the lack of adequate community-based disaster management systems. The post-disaster interventions have been directed towards the rehabilitation of the affected natural systems, encouraging sustainable tourism, and building up the resilience of the region in case of subsequent climatic occurrences.

Nepal, another Himalayan country, also offers rich information on cooperation and community-based adaptation programs. A country's National Adaptation Programme of Action (NAPA) covers sectors that should be given priority in adaptation within the country; these include agriculture, water, and climate change disasters. Community-based adaptation initiatives in Nepal have managed to ensure the active participation of the community members in some of the following activities: construction of small water harvesting structures, agricultural practices that respond to climate variability and change, and vegetation stabilization and regeneration. These projects point to the need to support local communities as well as the

basic premise of poverty reduction—applying traditional knowledge in mitigating the impact of climate change, climate proofing, as well as the use of scientific research.

○ SUSTAINABLE DEVELOPMENT GOALS (SDGS) IN THE CONTEXT OF THE HIMALAYAN REGION

The United Nations developed the SDGs in 2015 as the future goals and objectives for the yearly development agendas to cater to all global challenges, including those of climate change. Out of these goals, the concerns of Sustainable Development Goal 13 on Climate Action and Sustainable Development Goal 15 on Life on Land have a definite pointer because the Himalayan region is highly sensitive ecologically and it is vulnerable severely to climate change affecting the milieu and populace of the area. This is the necessity of strategies and actions of the below aims of SDG 13: enhanced resilience and ANC to climate change, integration of PAR into NPA, and education and awareness on CC mitigation adaptation. SDG 15 aims at the protection, restoration, and sustainable use of terrestrial ecosystems, promoting responsible management of forests, reversing desertification, and preventing and minimizing the loss of biological variety. These goals are crucial for the Himalayan area which harbors rich, diverse, and biological and geological formations that are endemic species largely affected by environmental alterations.

Measures that have been employed in the realization of SDG 13 in the Himalayan region include the following strategies and interventions: In enhancing the spread of renewables, disaster preparedness, and improving the adaptive capacity of the communities, the governments and organizations in the region have stepped up efforts. For example, the NAPCC of India, along with the state-wise action plans, included strategies for protecting the Himalayan region from the impacts of climate change. Such plans contain programs aimed at the preservation of the biological yield and water supply and the improvement of the forest programs. Besides, the Indian government has been practicing early warning systems and infrastructure development to minimize disasters like floods and landslides. These activities are in line with the goal and targets of SDG 13 and show an intention to mainstream climate change into other development processes.

Sustainable Development Goal 15 also plays an equally important part in the case of the Himalayan region because this area requires protection of biological variation and the utilization of the environment for developing livelihoods. According to SDG 15, aims and targets have measures carried out in reforestation and afforestation programs, the creation of protected areas, and measures against unlawful sawing and poaching. For instance, the Himalayan states have initiated different species and habitat conservation programs. The RJ Mohny Charitable Trust has many such projects, namely the Snow Leopard Conservation Project in Himachal Pradesh and Uttarakhand, for the conservation of this marvelous and endangered beast through community-led conservation and restoration projects. Promoting the culture of using eco-tourism and sustainable resource utilization not only protects the diversified species on the planet but also assists the lives of the people inhabiting those regions.

However, the attempt towards the accomplishment of the SDGs in the Himalayan region faces the following

challenges: This paper establishes that the region faces major challenges in implementing climate change and conservation-related policies and measures due to geographical and other factors such as socioeconomic attributes of the area. One of the biggest problems is the dearth of data and research material available on the effects of climate change in the Himalayas. This gap impedes the formation of specific and adequate adaptation policies. Also, the social and economic differences between the areas and the fact that many of the inhabitants depend on natural resources for their livelihood make the question of how to achieve the neo-maximization of conservancy while catering to those in the community a challenge. For example, even though reforestation serves as a valuable solution to addressing the issue of land degradation, and an increase in carbon capture, and storage, people's access to forest products such as timber, firewood, and grazing land is limited.

From the deep analysis of the Himalayan region and all its sectors, there are several areas to invest in to advance the SDGs, which include making use of community-based actions and strengthening inter- and intra-regional relations. Local stakeholders know their environment better and should be involved in conservation and climate action programs as a way of reaching success and sustainability. Due to its ability to incorporate indigenous knowledge systems into the development process, community-based adaptation projects have demonstrated the ability to improve the resilience of the communities and their adaptive capacity. Moreover, regional cooperation among the Himalayan countries will increase the rate of knowledge share, resources, and practice. Synovial organizations, including ICIMOD, are involved in action for the enhancement of development cohesion and climate change adaptation across the region by supporting multilateral cooperation and offering a forum for study and discussion.

○ CARBON MANAGEMENT IN THE HIMALAYAN REGION

Carbon management is an equally significant part of climate change mitigation initiatives, more so in regions such as the Himalayas, which are experiencing the effects of global warming. Carbon management is a large complex of measures aimed at minimizing the amounts of greenhouse gases produced and maximizing the rates of carbon capture. Subprocesses within carbon management comprise carbon credits, carbon budgets, and carbon footprints. Carbon credits are issued certificates that can be used to offset one's always carbon allowance or access to emit a certain amount of carbon dioxide or an equivalent of another GHG. A carbon credit is derived from projects that either reduce, avoid, or sequester CO₂ emissions and can be sold in carbon markets as it rewards emission reduction measures. A carbon budget for its part refers to the amount of cumulative carbon dioxide emissions that can be emitted in a given period without exceeding a certain level of global warming. Assigning roles and measures of responsibility, carbon footprint quantifies the total amount of direct and indirect GHG emissions that are associated with the activities of a particular person, organization, event, or product.

The current scenario of carbon management projects speaks of the increasing trends of such projects in the

region due to natural resources and emerging carbon consciousness owing to climate change. Several plans have been carried out to mitigate the carbon emissions in the region through conserving and restoring the region's forests, peatlands, and agriculture. For example, projects of afforestation and reforestation in Himachal Pradesh and Uttarakhand have declared goals of recapturing lost lands and improving carbon stocks. These projects not only enhance carbon storage but also deliver multiple co-products, including benefits to species, soil, and income to local people. The Himachal Pradesh State of India, which has implemented the Himachal Pradesh Reforestation Project that has attracted financial support from the CDM that is under the Kyoto Protocol, can produce carbon credits from the sustainable management of forests. Based on the findings, it can be deemed that this project has captured considerable volumes of carbon dioxide within the surroundings, besides facilitating sustainable utilization of land as well as improving ecosystem stability in the region.

Also, another indicator shows that further development of the carbon management projects in the area is possible in the Himalayan region. The large cover of the forest, the existing natural systems, and the traditional methods of farming present many options for carbon storage. This paper confirms that agroforestry that involves the inclusion of trees and shrubs in agricultural ecosystems can help increase soil carried-out carbon stocks as well as increase crop productivity and stability when compared to conventional farming. Likewise, the rehabilitation of degraded peatlands, which are first-class carbon reservoirs, contributes greatly to carbon storage objectives. Also, encouraging the use of environmentally friendly tourism practices that help reduce the carbon impact also adds to the region's carbon control measures. Carbon management can therefore provide a critical intervention in the use of climate mitigation and sustainable development in the regions' development planning.

However, it is crucial to have appropriate legal and policy background covering the carbon management activity in the Himalayan region to make such endeavors efficient and sustainable on a larger scale. At the national level, India's climate-related policies and obligations enshrined under international conventions are a strong starting point for carbon data. Based upon the 8 National Missions of NAPCC, such as the Green India Missions, stress the need to increase the carbon stock by way of afforestation, reforestation, and sustainable land management. This is also backed by the Forest (Conservation) Act, 1980, and the National Forest Policy, 1988, on the conservation of forest resources that have a key role in the sequestration of carbon, as 40% of the world's timber resources and 30% of the marketable water resources are found in India. Furthermore, the operations of international carbon markets, such as CDM and more recent articles of the Paris Agreement on Climate Change, generate as well as trade carbon credits that offer financial motivation for proficient carbon management projects, including those in the Indian subcontinent.

At the regional level, the role of state-specific policies and strategies is important to address the issues and prospects in carbon management in haste regions. For instance, Himachal Pradesh has developed carbon management projects, first of all, the first CDM forestry project in India. The actions are backed by the State Himachal Pradesh Forest Sector Policy and Strategy, which is aimed at increasing the forest area and improving forest resources management. Likewise, the State Action Plan of Uttarakhand on Climate Change

(SAPCC) also contains strategies for enhancing forest carbon stocks and promoting sustainable agriculture. It is worth emphasizing that these regional initiatives are important when developing carbon management solutions that are unique to the region and require direct input from communities located within the region.

○ Suggestions

Achieving climate resilience-related development problems in the Himalayan region entails cross-sectoral and multi-disciplinary intervention. In this case, strategies should aim at enhancing measures of adaptive capacity for the natural and human systems in the region. The following measures can be considered:

- Developing a Himalayan-Specific Climate Watch System
 - Devise a Himalayan Climate Watch Program (HCWP) to place islands of high-altitude climate monitoring using automatic weather stations, satellite-based imaging systems, and climate-based computerized synthesized methodologies. Local climatic condition specialized personnel should be posted at sub-centers of this program at each Himalayan state.
 - Example: Obtain satellite data and assess glaciers' monthly changes in mass and compare the results with the river's flow to predict the amount of water and such things as the early alarms of drought or flood.
- Integrating Remote Sensing and Local Data Collection
 - Establish a Himalayan Climate Data Integration Network (HCDIN) university and country agencies, local meteorological agencies, and international organizations. This network must come up with uniform data acquisition procedures and develop dual observing sites for comparing satellite data with ground facts.
 - Example: Drone surveillance of particularly sensitive areas, including the Gangotri Glacier; installing real-time data recorders of temperature, snowfall, and melting rate for enhancing climate model quality.
- Implementing Standards for Climate-Resilient Infrastructure
 - Regulate that any infrastructure projects after a certain height (say 2500 meters) be designed under newly established Himalayan Resilient Infrastructure Standards (HRIS). These standards should include fabrication, structural designs, and particular appendages, such as those against avalanche and landslide features.
 - Example: Employ high-durability materials in construction; for instance, fiber-reinforced concrete for constructing bridges when exposed to rapid changes in temperature. Use self-healing asphalt for roads in extreme climates.
- Mandatory Climate Risk Assessments for Development Projects
 - Insist that EIAs of projects in the Himalayas have a CRM that estimates the climate risk of the

projects. Imposing fines for failure to implement strategies and rewarding overall environmentally safe endeavors are crucial effects of climate solutions.

- Example: Ensure that hydropower projects explain how they will keep the operation capacity functional under varying glacial melt conditions and make them shoulder the responsibility of funding the most efficient solutions to the problem of variable water flow.
- Adopting Watershed-Based Management for River Basins
 - Constitute Himalayan Watershed Management Committees (HWMCs) at major river basin levels, namely Ganga and Brahmaputra. These committees should involve local people, scientists, and policymakers to enforce watershed-based land use planning, which integrates floodplain management, buffer strips, and agroforestry.
 - Example: Use contour trenching on steep slopes to control the excess water flow and soil erosion, and the use of riparian buffer zones since they act as filters detaching pollutants from water that flows in rivers.
- Launching Targeted Ecosystem Restoration Projects
 - Launch a “Himalayan Restoration Initiative” with the target of planting trees in 1 million hectares in the next 10 years, concentrating on regions with high deforestation rates and climate change impacts. Employ the local species to boost the local species population as well as the carbon sinks.
 - Example: The restoration of specific degraded wetlands is proposed for improvement in carbon storage and water retention, especially wet lands near the Kashmir Valley, wherein controlled flooding may be applied and wetland-specific vegetation may be planted to enhance carbon sequestration.
- Promoting Climate-Smart Agriculture Specific to the Himalayas
- Set up climate-smart Himalayan agriculture demonstration centers to educate farmers on suitable climate-smart agriculture. It urged that methods such as greenhouse farming with an altitude to grow plants, crop interchangeability with plants that have a fixing ability of nitrogen, and the use of drought-tolerant seeds should be championed.
- Example: Use water-saving techniques such as farming on slopes with sprinkling systems where water is a real problem in Ladakh and conserve collective seed libraries for locally adapted crop types that perform well under climate change conditions.

These refinements give clear further processes that are more straightforward and pertinent to the special queries of the zone of the Himalayas, while the proposal can't be too universal but thorough and pointed.

○ CONCLUSION

The Himalayan region is recognized to be providing profound value to the global climate system as both the



water tower and a climate moderator. Nonetheless, the Government faces serious challenges from the effects of climate change including intensified glacial melt, unusual climate patterns, and increased incidences of weather extremities. All these changes have negative consequences for the local environment and habitats, as well as for the climate of the entire world.

The rising rates of glacier melt in the Himalayas are a severe threat to the water supply of millions of people in South Asia. Glaciers also serve as a water storage and supply source for the Ganges-Brahmaputra and the Indus major systems that are important for drinking water, irrigation, and hydropower. In some regions, the authors described reductions in river flows in the range of 15–35% that can threaten water sources for agriculture and hydropower. This in turn destabilizes and puts in danger not only food security but also the lives of millions of farmers who expect a stable water supply for their crops.

With changes in the cyclone, monsoon, and locations of specific environmental impacts of climate change, precipitation patterns may change—there could be more intense floods or a lack of rainfall, which can cause droughts and landslides. They also dislocate persons, lead to loss of life and property, and most importantly, set back developmental causes, taking vulnerable persons back to the realm of abject poverty. Many of the region's species of fauna and flora are also threatened by loss of habitat and change of climate factor.

At the national level, there are various strategies and action plans framed to address climate change problems, mostly in the Himalayan zone of India. There are missions in NAPCC like the National Mission for Sustaining the Himalayan Ecosystem, which is to provide sustainable measures to look at the Himalayan ecosystems, attempting to improve water availability, and ensuring sustainable development patterns. Also, under the Paris Agreement, India pledged to target emission intensity and the portion of energy from fossil fuels.

Regional policies are equally important. Also, the policies of the regions are important to know. The concerned state governments have come up with National Action Plan on Climate Change like Uttarakhand and Himachal Pradesh response action plans that have aspects of sectors like agriculture, watershed, forest, and disaster. These plans are also comprised of measures for the improvement of climate change adaptation activities, the promotion of climate-smart agriculture, water conservation, and disaster risk reduction measures.

The use of case studies from the region, the Joshimath and Kedarnath in Uttarakhand example, along with the Nepali community-based adaptation projects, shows the success of different protection and mitigation measures. Proper and effective works of this type underline functions of slope stabilization, afforestation, construction regulation, early warning systems, sustainable tourism, and disaster management of different types with the involvement of communities at risk.

The fact that other Himalayan countries are in a similar situation means that there is synergy in the sharing of information, knowledge, and other vital resources. Partnership-based approaches like those espoused by the ICIMOD with the support of other development partners are crucial for enhancing regional cooperation to

enhance sustainable development and climate change vulnerability in the region.

Therefore, the fight against climate change in the Himalayan region is considered the key to achieving sustainable development goals. This can only be approached through the application of scientific, policy, and community interventional approaches that will draw on traditional knowledge and regional collaboration for the sustainability of this important region.

References

- Aziz, F., Jahangir, A., & Khurshid, T. (2023). Early 21st Century Trends of Temperature Extremes over the Northwest Himalayas. *Atmosphere*, 14(3), 454. <https://doi.org/10.3390/atmos14030454>
- Basannagari, B., & Kala, C. P. (2013). Climate change and apple farming in Indian Himalayas: A study of local perceptions and responses. *PLoS One*, 8(10). <https://doi.org/10.1371/journal.pone.0077794>
- Bhutiyani, M. R., Kale, V. S., & Pawar, N. J. (2010). Climate change and the precipitation variations in the northwestern Himalaya: 1866–2006. *International Journal of Climatology*, 30(4), 535–548. <https://doi.org/10.1002/joc.1921>
- Immerzeel, W. W., Van Beek, L. P., & Bierkens, M. F. (2010). Climate change will affect the Asian water towers. *Science*, 328(5984), 1382–1385. <https://doi.org/10.1126/science.1183188>
- Gangotri Glacier. (2023). In Wikipedia. Retrieved from https://en.wikipedia.org/wiki/Gangotri_Glacier
- NASA Earth Observatory. (2004). Retreat of the Gangotri Glacier. Retrieved from <https://earthobservatory.nasa.gov/images/14469/retreat-of-the-gangotri-glacier>
- Aziz, F., Jahangir, A., & Khurshid, T. (2023). Early 21st Century Trends of Temperature Extremes over the Northwest Himalayas. *Atmosphere*, 14(3), 454. <https://doi.org/10.3390/atmos14030454>
- Basannagari, B., & Kala, C. P. (2013). Climate change and apple farming in Indian Himalayas: A study of local perceptions and responses. *PLoS One*, 8(10). <https://doi.org/10.1371/journal.pone.0077794>
- Bhutiyani, M. R., Kale, V. S., & Pawar, N. J. (2010). Climate change and the precipitation variations in the northwestern Himalaya: 1866–2006. *International Journal of Climatology*, 30(4), 535–548. <https://doi.org/10.1002/joc.1921>
- Immerzeel, W. W., Van Beek, L. P., & Bierkens, M. F. (2010). Climate change will affect the Asian water towers. *Science*, 328(5984), 1382–1385. <https://doi.org/10.1126/science.1183188>
- NASA Earth Observatory. (2004). Retreat of the Gangotri Glacier. Retrieved from <https://earthobservatory.nasa.gov/images/14469/retreat-of-the-gangotri-glacier>
- Pandey, K., & Sengupta, R. (2022). *Climate India 2022: An Assessment of Extreme Weather Events*. Centre for Science and Environment.
- Why so many cloudbursts? Experts point to rising temperature. (2019). *Down to Earth*. Retrieved from <https://www.downtoearth.org.in/news/climate-change/why-so-many-cloudbursts-experts-point-to-rising-temperature-65262>



- Adapted from ResearchGate. "Spatial spread of the Himalayan Mountain system across seven nations, elevation gradient from lowlands to high peaks." Available at: https://www.researchgate.net/figure/Spatial-spread-of-the-Himalayan-mountain-system-across-seven-nations-The-elevational_fig1_328790994