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# Impacts of Climate Change on Hydrology and Biodiversity of Himalayan Region in India

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**ABSTRACT**

*The premise of climate change assumes that the environmental situation today is, and in the future will be, different from what it has been previously. The vast Himalayan region has, in the past, has few resources with which to develop the detailed scientific understanding needed to assess climatological, environmental, and other data; and this means that today there is very little historical information upon which to form a baseline for comparison with the present and from which to anticipate future impacts. The data that are available indicate that there is a moderate warming trend and that temperature increases are more pronounced at higher than at lower elevations. The changes in climate and the consequent changes in the availability of water can be expected to be reflected in the biodiversity of these ecosystems. The ecosystems of the Himalayan region are extremely vulnerable to both growing anthropogenic changes and the consequences of climate change. This paper is concerned with the impacts and the data gaps, in context of hydrology and biodiversity in the Himalayan region which can be used by decision makers and planners in the region to respond to the risks of climate change by devising options for mitigation and adaptation.*

**KEYWORDS : climate change, hydrology, biodiversity, ecosystem.**

## INTRODUCTION

The mountains occupy 24% of the global land surface area (about 25 million km2) and are home to around 12% of the world's population. They have ecological, aesthetic, and socio-economic significance, not only for the people who derive their day-to-day subsistence from mountain resources but also for the estimated 40% of the global population depending indirectly on these resources for water, hydro-electricity, timber, biodiversity, and niche products. The communities who live in mountain areas benefit from these services, but the main beneficiaries of this huge water storage capacity are the multitudes who live in the vast basin areas downstream. The mountains also represent a unique opportunity to detect climatic change and to assess climate-related impacts. The mountains host diverse vegetation and varied microclimatic and ecological conditions, due in part to the extreme heterogeneity and rapid changes in soils and climates, to the rapid elevation changes that give rise to a variety of altitudinal vegetation belts, and to the variable directional orientation with rapid changes in aspect. As a result of the extreme variations in the environment, mountains have abundant high biodiversity, often with sharp transitions in vegetation sequences. The climate change, land use change, and population dynamics are the main drivers of environmental change in the Himalayan region. The sources of these drivers are both internal and external to the region, and they mutually reinforce the effects that they have on human wellbeing and on natural resource availability and use. The increasing demands on ecosystem goods and services from the mountains are putting pressure on the natural resources that they contain. These demand stemming from a burgeoning human population and haphazard infrastructural development, combined with unsustainable use, poor management, and limited investment in conservation, have led to habitat degradation, biodiversity loss, and decreased agricultural productivity.

## CLIMATE AND HYDROLOGY

The extent to which global precipitation changed over the same time period is more variable and uncertain. In the Himalayan region, only scant temperature and precipitation data are available from observational measurements. The marked microclimatic variations with elevation and aspect in the Himalayan region means that a greater density of data sampling sites in needed to capture representative hydro-meteorological data than in areas where the terrain is more uniform. In practice, however, the combination of poor accessibility and low population numbers means that the density of meteorological stations in the Himalayan region is less than elsewhere and that long-term data records are few even from the stations that do exist. In view of the fact that the observational data for the Himalayan region are scanty, climate model simulations can be used to assist planners and decision makers to look ahead and prepare for adaptation to and mitigation of climate change. The models also have a high degree of uncertainty, as they are based on large-scale observations with little possibility for verification and adjustment. The western Himalayan region has the most extensive snow-cover area on average because, in addition to having some of the highest elevations, it is at higher latitudes and is also more subject to the influence of winter westerlies. The increased precipitation in the western region, probably due to climate change, may compensate for a decrease in the meltwater component of rivers such as the Indus that have arid downstream basins but may also lead to greater inter and intra-annual variability. In the monsoon-dominated eastern region, the discharge of rivers such as the Ganges consists predominantly of rainwater; a decrease in glacial meltwater would be noticeable in its upper catchments but would be difficult to detect downstream.

## CLIMATE AND BIODIVERSITY

In mountains, temperatures change with altitude, so that mountain species have opportunities to migrate if 'new temperatures' so not suit them as long as other conditions, such as the availability of soil and water, are similar in the adjacent higher altitudes or more northerly aspect areas. Since the Himalayas have witnessed several warm and cold climate cycles in the geological past, their biota should have experienced several migrations. The growth in the number of protected areas is a noteworthy achievement on the part of the countries of the Himalayan region towards fulfilling their global commitment to conservation. The protected areas provide a unique opportunity not only to conserve but also to study the biodiversity of the region and to look for changes. Although protected areas have been established, the identification and recording of species is still in its early stages, and the constant monitoring to document changes in vegetation and identification and census of indicative species needed to monitor population dynamics as a function of changing climate impacts are still sorely lacking. A certain characteristics enable one species to perform better than another in a rapidly changing climate. Small, highly mobile organisms are likely to fare better than large territorial animals. The species with extensive ranges and large populations are likely to be winners in a changing climate. Since the areas under Himalayan forests in India are projected to experience relatively greater increases in temperature, they should experience bigger changes in forest type.

## IMPACTS OF CLIMATE CHANGE ON HYDROLOGY AND BIODIVERSITY

The increased temperatures will affect the physical, chemical, and biological properties of wetlands, freshwater lakes, and rivers with predominantly adverse impacts on their thermal structures, freshwater species, community composition, and water quality. The increases in the frequency and severity of floods and droughts are projected to have an adverse effect on sustainable development. The potential changes in precipitation will affect soil moisture, groundwater reserves, and the frequency of flood and drought episodes. The climate change is likely to result in an extensive decrease in water storage capacity which could have profound impacts on the hydrological regimes of the ten river basins originating in the Himalayan region. Recent studies show that the extent of permafrost is shrinking, that the thickness of the active layer is increasing, and that this has altered the hydrological cycle, vegetation composition, and carbon dioxide and methane fluxes which appear to be linked to permafrost degradation. The high-altitude wetlands, account for around 16% of the total area of the Himalayan region are under pressure from drainage for agriculture, tourism related pollution, overgrazing, and climate changes. The migratory species are particularly vulnerable as a discrepancy could develop between the timing of migration and the availability of food. The pollination could also be affected when the timing of blooming is no longer synchronised with insect activity. Hence, both the structure and functioning of ecosystems could change. Another mechanism is that dominant species are replaced by pioneer species from the same community that have enhanced capabilities for adaptation.

## CHALLENGES AND OPPORTUNITIES

The valuation of ecosystem services and payment by users for these services is emerging as essential for assessing benefits and designing policies. Conservation in the Himalayan region needs to be proactive in terms of both mitigation and adaptation to the direct impacts of climate change. A scientific understanding of the ecosystem services on multiple scales is essential to map, model, and ultimately value ecosystem services effectively. The projects are now experiencing a paradigm shift which recognises the transboundary nature of both the ecosystems and the issues facing their conservation. Ensuring the meaningful participation of mountain communities is paramount. The land users must be meaningfully engaged in order to understand what incentives will work and how. Defining the links between land use and service provision must be carried out in a way that will ensure incentives target the right land use changes to support specific ecosystem services and ensure that payments do not become a flat subsidy. A comprehensive ecosystem framework is needed to explore holistically the potential and opportunities at the river basin level. An improved understanding of these regional change processes is essential to provide the basis for informed decision making, risk and vulnerability mapping, adaptation and mitigation strategies, and effective biodiversity conservation and management.

## CONCLUSION

The changes wrought by climate change pose practical challenges since they entail consequences for the delivery of the supporting, provisioning, regulating, and cultural services that ecosystems provide to the region and beyond. An improved database would help with many aspects of disaster risk reduction and relief operation and appropriate information from improved databases could also help financial market providers to price the risk adequately and provide services commensurate with this. The research on institutional frameworks and their effectiveness in governance and assessments of good practices with examples of community-led conservation have to be central to formulation of an effective and responsive governance system for protected areas. The strategies to fill data gaps can be divided into two categories: the first set focuses on acquiring new, disaggregated data with an emphasis on obtaining long-term, permanent monitoring; the second set recognises that once data have been acquired they can only be used to their full potential when they are in a form that makes them easy to use and share. The capacity building needs to extend to governments to assist them to put into play policies and laws that honour the communities they have made to global climate-friendly international treaties and conventions.

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