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Impact of climate change on biodiversity of India with special reference to Himalayan region-An overview

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Abstract : India possesses a distinct identity, not only because of its geography, history and culture, but also because of the great diversity of its natural ecosystems. The panorama of Indian biological diversity is much wider, as it comes under the twelve mega biodiverse (Hot-spot) centers of the world. It contains a great wealth of biological diversity in its forests, its wetlands and in its marine areas which are distributed all over the country. This richness is shown in absolute numbers of species and the proportion they represent of the world total. The great Himalayan region has peculiar identity in the perspective of its unique biogeography. It supports a large number of glaciers, lakes, rivers, flora and fauna due to its variable climate. It has a profound effect on the climate of the subcontinent. But due to anthropogenic activities the global climate has changed since last few decades. The climate of the subcontinent has also adversely affected the biological resources of the country along with that of the Himalayan region. The present paper discusses the various causes responsible for melting and shrinkage of glaciers, decreasing water flow in the major rivers, increasing pressure of extinction of the ecological wealth of the country. It also talks about the control measures and various management steps which can be taken, with special reference to the Himalayan region.

Keywords: Biological diversity, Climate change, Himalayan region

INTRODUCTION

The race for modernization between the countries of the world has lead to the excess growth in industrialization, urbanization, transportation that is causing the destruction of the environmental balance through climate change. The major consequences of climate change are green house effect, global warming, ozone depletion and epidemics which directly or indirectly affect the biological resources and life sustaining system of the nature. There is extreme hue and cry on the aspect of climate change all over the globe. The excess exploitation of nature is creating this problem and changing the weather pattern. The increasing concentration of green house gases and deforestation has lead to global warming which disrupts the weather, wind pattern and upper circulation of the atmosphere (Pandey, 2007).

Over the last 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history. A recent summary of the conclusions of Working Group II of the Intergovernmental Panel on Climate Change has predicted that "if current warming rates are maintained, Himalayan glaciers could decay at very rapid rates, shrinking from the present 500,000 square kilometers to 100,000 square kilometers by 2030s". In all these aspects India is also not unaffected from the impact of the climate change. The shrinkage of glaciers, decreasing water flow in perennial rivers continuous rain failure in monsoon period, heavy and un-occasional rain in coastal areas, decreasing winter and increasing the duration of summer season are some important examples of the climate change listed under Indian prospective (Thomas, 2007).

India is the seventh largest country in the world and Asia's second largest nation with an area of 3,287,263 square km. The Indian mainland stretches from 8 4' to 37 6' N latitude and from 68 7' to 97 25' E longitude. The immense variety of the climatic, edaphic and altitudinal variations in India have resulted in a great range of ecological habitats for which Northeast India takes the pride of place. Lying between 22-30° N latitude and 89-97° E longitude, and spreading over 2,62,379 sq. km.. Northeast India represents the transition zone between the Indian, Indo-Malayan and Indo-Chinese biogeographic regions and a meeting place of the Himalayan Mountains and Peninsular India. India contains a great wealth of biological diversity in its forests, its wetlands and in its marine areas.

BIODIVERSITY OF THE SUBCONTINENT

India is rich in its unique flora and fauna and famous world wide for this incredible heritage. It is estimated that about 45,000 species of plants and 65,000 species of

animals are found in India. The flowering plants comprise 15,000 species of which several hundred (5000-7500) species are endemic. Among the animal species diversity more than 50,000 species of insects, 4,000 molluscs, 6,500 other vertebrates, 2,546 fishes, 197 amphibians, 408 reptiles, 1224 birds and 350 species of mammals are found in different habitats Therefore, this great strength of flora and fauna put the country in the list of mega biodiversity centers (Hot-Spot) of the world. The mega biodiversity places of India are Western Ghat and Eastern Himalaya (MoEF, 2000 and Myers *et al.,* 2000).

Table 1. Biological diversity of India and the World.

Group	Number of species in the World (SW)	Number of species in India (SI)	% of world species in India
Mammals	4,629	350	7.6
Birds	9,702	1,224	12.6
Reptiles	6,550	408	6.2
Amphibians	4,522	197	4.4
Fishes	21,730	2,546	11.7
Flowering Plants	250,000	15,000	6.0

Source: **(**Myers *et al.,* 2000)

HIMALAYAN REGION- A UNIQUE GIFT OF BIODIVERSITY

The Himalayas, which literally mean the abode of snow, is the youngest and the highest range of Fold Mountains in the world. The Himalayas consist of three parallel ranges, the Greater Himalayas known as the Himadri, the Lesser Himalayas called the Himachal, and the Shivalik hills, which comprise the foothills. It extends between 28^{o} N-36^{o} N latitude and 72^{o} N-96^{o} N longitude run almost without break for about 2500 km. and with a width about 200-400 km. Biogeographically, the Himalayan mountain range straddles a transition zone between the Pale-arctic and Indo-Malayan realms. Species from both realms are represented in the hotspot. In addition, geological, climatic and altitudinal variations in the hotspot, as well as topographic complexity, contribute to the biological diversity of the mountains along their east-west and north-south axes. The flora and fauna of the Himalayas varies with rainfall, altitude, and soils. The climate ranges from tropical at the base of the mountains to permanent ice and snow at the highest elevations. The amount of yearly rainfall increases from west to east along the front of the range. This diversity of altitude, rainfall and soil conditions generates a variety of distinct plant and animal communities, or eco-regions. Besides this the mighty Himalayas are the cradle of nearly 1500 glaciers covering an area of about 33,000 sq km. Snow, ice and glaciers in the region are approximately equivalent to about 1,400 cu.km of ice. These glaciers provide the snow and the glacial-melt waters that keep the major rivers perennial throughout the year (Pachauri, 2007).Phytogeographically, the Eastern Himalayas forms a distinct floral region and comprises Nepal, Bhutan, neighbouring states of east and north-east India, and a contiguous sector Yunnan province in south western China. In the whole of Eastern Himalayas, there are an estimated 9000 plant species, with 3500 (i.e. 39%) of them being endemic. In India's sector of the area, there occur some 5800 plant species, roughly 2000 (i.e. 36%) of them being endemic (MoEF, 2000). Of the estimated 10,000 species of plants in the Himalaya hotspot, about 3,160 are endemic, as are 71 genera, 300 mammals, 977 birds, 176 reptiles, 105 amphibians and 269 fresh water fishes.

Table 2. Biological diversity of Himalayan region.

Taxonomic group	Species	Endemic species	% Endemic of(SI)
Plants	10,000	3,160	31.6
Mammals	300	12	4
Birds	977	15	1.5
Reptiles	176	48	27.3
Amphibians	105	42	40
Fresh water fishes	269	33	12.3

Source: (Myers *et al.,* 2000 and Gadgil, 2008).

They are the sources of water and many river valley projects of the sub-region. The Himalayas are the home of a great biological resources both flora and fauna species along with agricultural plant resources. The mighty Himalayas along with the extension act as an effective climatic barriers as it strikes the cold and chilly winds originated near the arctic circle and blow across the Central and Eastern Asia. So the mountain chain provides an invincible shield to protect the subcontinent from these winds. Thus Himalaya gives the tropical climate to the country. The geology of the region supports many precious metals. Its glaciers, lakes, rivers, the main source of fresh water for the people of the region also provide irrigation sources to agriculture and power generation. The biological resources of the region are much diverse as there are about 35000 species of flora and fauna available over the Himalayan region.

CLIMATE CHANGE AND ITS IMPACT

The word climate refers to the weather variation of any specific area over a period of time. Climate includes the average temperature, amount of precipitation, days of

sunlight, and other variables that might be measured at any given site. However, there are also changes within the Earth's environment that can affect the climate. Climate change refers to change in weather patterns, which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. The increase in annual mean temperatures will cause the biggest problems for plants, animals, and human beings. Climate change is not just about averages, it is also a matter of extremes. Climate change is likely to affect minimum and maximum temperatures and trigger more extreme rainfall events and storms. For the Indian sub-continent, less rainfall in winter and increased precipitation in the summer monsoon are predicted; and in 2050, decreases in winter precipitation by 10-20% and by 30% for the summer have been projected. Climate change and global warming will have a huge impact on the Himalayas. There are more than 5,000 glaciers in the Indian part of Himalayas. They contribute 50-70% of the western Himalayans rivers and slightly less in eastern Himalaya.

India is a unique country in their physiographic, land escape, climatic regime and biodiversity. The country has diverse climatic conditions because of the sharp variations in temperature and precipitation reactions from place to place and season to season. While the mercury touches 55°C in the Great Indian Desert, it drops to – 45°C in winter around Leh in Jammu and Kashmir. Mausinram (Meghalaya) a place in India has the world's highest average rainfall (11,873 mm), while in Jasselmer in Rajasthan has minimum rainfall of 10-25mm only. The climatic variation in the country provides a wide range of biological resources in their natural habitat. There is a long list of flora and fauna in the account of the subcontinent due to the favorable climatic conditions. It supports a wide range of biological diversity. One of the mega biodiversity centers in the country is in Himalayan region as eastern Himalayas. There are a large number of national parks, sanctuaries, biosphere reserves and other protected areas which exist as world heritage sites, support a unique biological diversity. In the Indian sub-continent, temperature could rise between 3.5 and 5.5 °C by 2100. An even greater increase is assumed for the Tibetan Plateau. Rapid melt will accelerate river runoff which will initially reduce the ice reserve below a critical threshold and then causing catastrophic floods (referred to by others as the 'mountain tsunami'), which can sweep away all means of livelihood in a single stroke (Bajracharya *et al.*, 2007).

The anticipated effect on the environment and people's livelihoods in the Himalayan region could be substantial. The changes will certainly be complex and to date they are not fully understood. Therefore, there is an urgent need to study implications of climate and environmental change on people's livelihoods in the Himalayas. It is clear that the foreseen changes will affect the provision of Himalayan water resources (Eriksson, 2006). Due to a large number of anthropogenic activities the global climate has changed since last few decades. The main consequences of climate change are green house effect, global warming and ozone depletion. Global average surface temperature increased 0.6 (0.2) °C in the 20th century and will increase by 1.4 to 5.8 °C by 2100. Over the past 100 years, mean surface temperatures have increased by 0.3-0.8 °C across the region (IPCC, 2007).

The ever increasing demand for the resources of the population put the pressure on the biological resources of the world. Industrialization, urbanization, transportation and deforestation are main anthropogenic activities that change the environment and influence climate (IRC, 2002).Climate change is likely to have a number of impacts on biodiversity from ecosystem to species level. The most obvious impact is the effect that temperature and precipitation have on species, ranges and ecosystem boundaries. Any particular ecosystem consists of an assemblage of species, some of which will be near the edge of their ranges and others of which will not. Those at the edge of their ranges may need to move due to climate change (Lemoine and Böhning-Gaese, 2003).The major proximate causes of species extinction are habitat loss and fragmentation etc, extremely accerelated by climate change through various ways.The cheer pheasants (*Catreus wallichi*), with a range primarily limited to the Jammu and Kashmir regions, are declining due to loss of the habitat (Wikramanayake *et al.*, 1998). The genus *Schizothorax* is represented by at least six endemic species in the high mountain lakes and streams, while two other genera of these snow trout, the genus *Ptychobarbus* and the Ladakh snow-trout (*Gymnocypris biswasi)* is a monotypic genus now thought to be extinct and are also unique to the Himalaya Hotspot (IUCN, 2004).

The biggest factor of present concern is the increase in green house gases mainly CO_2 level which change the climate and weather pattern of the world. In India the situation is as critical as continuous rain failure in the northern plains create the condition of draught in this region. The shrinkage of glaciers, decreasing water flow of the perennial rivers depleting ground water level directly and indirectly affect the biodiversity of the sub-region. Some of the most immediate effects of recent climate change are becoming apparent through affects on biodiversity. The life cycles of many wild plants and animals are closely linked to the passing of the seasons and climate. Many developmental processes of the organisms are dominantly dependent on day length and the other on temperature or precipitation. In principle, at least, this could lead to extinctions or changes in the

distribution and abundance of species. These changes in climatic pattern disrupt the ecological wealth of the subcontinent. By 2000, the region had lost 15 per cent of its forest cover compared with the early 1970s. By 2100, it will have lost almost half its forests. Less than one-third of the dense forest on which many native species depend will survive in the western Himalaya, while less than three-quarters in the eastern Himalaya will remain (NSE, 2006). Climate change during last few decades had a significant impact on the high mountain glacial environment. Glaciers are highly sensitive to minor changes in the atmospheric temperature. Therefore, glaciers are considered as very good indicators that help us to quantify changes in the Earth's climate. It is widely confirmed that climate change is the main factor behind the accelerated glacier retreat observed in the Himalayas. The melting of Shiva Lingam (made with ice naturally) in the holy cave of Amaranth in Jammu and Kashmir is a clear indication of increasing temperature in the Himalayan region (DDNEWS, 2007).It is forecasted that the Himalayan glaciers could shrink to 100,000 square km (38,610 square miles) by the 2030s, from 500,000 square km (193,100 square miles) now, if the current pace of global warming continues (Kireet Kumar, 2005).

Himalaya is the water tower of the South Asian region, providing direct freshwater supply to millions of people living in Indo Gangetic Plains through the perennial river systems. The region's agricultural productivity and power generation are greatly dependent on the freshwater supply of the discharge from Himalayan glaciers. Himalayas are home to some of the world's largest river systems like Ganga, Yamuna, Indus, Brahmaputra, etc. and contribute major water supply systems for agricultural, industrial, commercial and domestic usage in non-peninsular parts of the country. In the current scenario, a critical change is taking place in this "water-rich" Himalayan region that not only reveals the myths about adequate availability of water in the region, but also endorses the critical need of sustainable water management measures in the region.

Due to the human induced climate change and the increasing temperature regime the glacial system in the Himalayan region are undergoing major changes leading to a more vulnerable future to inhabitants and to the water security of the region. In northern India, a region already facing severe water scarcity and power supply problems. It is estimated about 500 million people depend on the tributaries of the glacier-fed Indus and Ganges rivers for irrigation and drinking water. But as the Himalayas melt, these rivers are expected to initially swell and then fall to dangerously low levels, particularly in summer. The melting of glaciers because of global warming has left the scientific community worried. The glaciers in the Himalayas are melting at a very rapid rate which has major implications for water supply in the northern part of the Indian subcontinent (Pachauri, 2007).

Beginning with the industrial revolution in the 1850s and accelerating ever since, the human consumption of fossil fuels has increased CO_2 levels from a concentration of 280 ppm to more than 380 ppm today. These increases are projected to reach more than 560 ppm before the end of the 21st century. It is known that carbon dioxide levels are substantially higher now than at any time in the last eight lakh years. Along with rising methane levels, these changes are anticipated to cause an increase of 1.4–5.6 ^{o}C between 1990 and 2100 (Lonergan, 1998).

Some of the most immediate effects of recent climate change are becoming apparent through affects on biodiversity. The life cycles of many wild and domestic plants and animals are closely linked to the passing of the seasons and climatic changes. The decreasing water budget in these rivers year after year, coupled with the ever increasing incoming sediment load, has 'choked' the minor drainages and is continuously silting up, at an alarming rate, even the major river system. The summer discharge in the mighty Ganga river has shown a sharp decline in recent years. In mountain region climate change can prove disastrous. Flash floods, droughts and change in seasonal cycle have become very common. All river valleys have become disaster prone and maintaining the level of crop production has become very uncertain. The problem of water quality may be exacerbated by climate change. The possible increase in differences between wet and dry seasons may imply wetter wet seasons and drier dry seasons. Already access to safe water is limited throughout the Himalaya. Change in climate will also affect infectious diseases transmitted by insects, i.e., vector-borne diseases: examples are malaria, yellow fever, and schistosomiases. Agriculture and horticulture and age-old traditional food crops have become prone to disease (Eriksson, 2006). Increase in atmospheric temperature can accelerate crop growth and consequently shorten the growth period. In cereal crops for example, such changes can lead to poor vernalization (e.g., hastened flowering) and reduced yield. The fruit orchards of the region have been shifted at higher new areas. Losses are also indicated for the major food grain producing regions of Punjab, Haryana, and Western Uttar Pradesh (IPCC, 2007).

The impact of climate change in the Himalayan region and adjoining plains of major rivers are increasing extinction rate of floral and faunal species, changing the rainfall pattern, changing the duration of vegetative growth and maturity period and overall growth of crop plants. Climate change could cause irreversible damage to unique forest ecosystems and biodiversity, rendering several species extinct. Forests ecosystems require a long response time to adapt to climate change. Climate is projected to change at a faster rate than the capacity of

the forest ecosystems and plant species to adapt. Thus, it is necessary to develop and implement technologies and strategies to reduce the vulnerability of the forest ecosystems to changing climate, but there has been little research on this front. Warming in the Himalayan region indicate moderate to large-scale shifts in vegetation types, with implications for forest dieback and biodiversity (Ravindranath and Sukumar, 1998).

MANAGEMENT OF CLIMATE CHANGE

Climate change poses a global challenge and India may play a dual role in responding to the challenge as a responsible member of the international community and in its own interest. There are two dimensions in the response to global warming- mitigation and adaptation. Mitigation measures include control on the processes, which are responsible for climate change in the region. The diminution of greenhouse gas emissions can minimize the impact of climate change like warming, melting of the glaciers, flooding of rivers and habitat degradation. Aforestation should be done in the region. Policy instruments could create incentives for producers and consumers to significantly invest in products, technologies and processes which emit less greenhouse gases. Without new mitigation policies, global greenhouse gas emissions will continue to grow over the coming decades and beyond. Rapid world-wide investments and deployment of mitigation technologies, as well as research into new energy sources will be necessary to achieve a stabilization of the concentration of greenhouse gases in the atmosphere. Improved physical infrastructure can afford some protection against phenomenon associated with climate change such as floods, extreme weather events or coastal erosion. A switch to new crops, seeds or agricultural practices can moderate the impacts on agriculture of changes in temperature and water availability. Education, training and rural extension services can facilitate adaptation efforts. Improved weather and flood forecasting and better communications can assist evacuation, relief and rehabilitation.

India's primary effort as a developing country must be in the area of adaptation. Tourism is also an important activity in the region as a number of tourist spots exist here. As a consequence, disturbance in habitats may take place by way of mass heat, dhabas, restaurants, transportation and sport activities. Changing climate requires dynamic forest planning and management strategies. There is a need to incorporate climate change concern in the long-term forest planning and policy making process. The traditional Working Plan approach of managing forests adopted by the Forest Departments, which is not adequate even in a situation of no climate impacts, may need to be improved and made dynamic to incorporate the climate impacts. India has a large diversity of tropical and subtropical forest ecosystems subjected to diverse socio-economic pressures. Climate change will be an additional stress on the complex forest ecosystems. Thus, there is a need for modeling to incorporate the socio-economic and land-use change pressures along with the projected climate change parameters to make a realistic assessment of the implications of climate change on forest ecosystems and biodiversity. Further, the climate impact and vulnerability assessment studies are limited not only by models, but also input data on vegetation parameters, soil and water characteristics, climate variables and socio-economic factors. Other options include improved management of crop and grazing lands (e.g. improved agronomic practices, nutrient use, and tillage and residue management), restoration of organic soils that are drained for crop production, and restoration of degraded lands.

Mitigation measures are required to reduce global greenhouse gas emissions with the intention of eventually stabilizing atmospheric concentrations at some level at which an acceptable dynamic equilibrium could be sustained between climate, ecosystems and human society. On the other hand, due to the inertia of both the climate system and our energy structures, greenhouse gases accumulating in the atmosphere since the pre-industrial era will continue to affect global climate long into the future. Together with the existing exposure of many communities and assets to extremes of weather, adaptive measures become essential in order to enhance the coping abilities of valued ecosystems, vulnerable communities and exposed infrastructures (Rhys *et al.*, 2003)

According to the report of Intergovernmental panel on climate change(IPCC), the main reason of climate changes are some anthropogenic activities such as deforestation, combustion, emission of green house gases, which are frequently released in the atmosphere (Pachauri, 2007). So all these processes should be strictly prohibited. Change in consumption habits can help to address climate change. Mitigation measures to reduce greenhouse gas emissions, certain alternatives of the fossil fuel should be found and invented. A wide variety of policy tools can be applied by governments to create incentives for mitigation action, such as regulation, taxation, tradable permit schemes, subsidies, and voluntary agreements (UNDP, 1998).

Conclusion

Climate change is a major concern in the Himalayas because of its potential impact on the economy, ecology, and environment of the Himalayas and areas downstream. It is the home of so many glaciers, rivers and distinct flora and fauna. A wide range of distinct variety of habitats supports great world's genetic resources of both flora and fauna in their unique ecological province. Habitat

destruction, land-use/cover change, land degradation, forest fire have adversely affected biological resources of the sub-region induced by climatic change. The various altitudinal zones of the regions are witnessing major biodiversity, ecological and geophysical changes. The increasing unpredictability of weather and the natural catastrophes in the region are clear-cut indicators of marked shift in weather patterns in the region. Various control measures and management steps in the form of afforestation, reforestation, landscape management, tourism management, reducing energy consumption, increasing energy efficiency, promoting renewable energy technologies, control on green house emission, prediction model, regular monitoring and more research on related aspects of climate and biodiversity are needed in order to save the Himalayan region from decline of its wealth present in the forms of natural sources.

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