

Impact of climate change on Biodiversity of Northeast India: An overview

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Abstract

Biodiversity plays an important role in climate regulation. Biodiversity conservation will lead to the strengthening of ecosystem resilience and will improve the ability of an ecosystem to provide important services during increasing climate pressures. But due to anthropogenic activities, the global climate has changed over the last few decades. Because of its geo-ecological fragility, strategic location in relation to the eastern Himalayan landscape and international borders, transboundary river basins, and inherent socio-economic instabilities, the Northeastern Region of India is expected to be not only negatively affected by India's biological resources, but also highly vulnerable to the effects of climate change. Biodiversity and the security and sustainability of the region are and will be greatly challenged by these impacts. The region falls under a high rainfall zone with a subtropical type of climate. Still, under influence of global climate change even high rainfall areas are facing drought-like situations in the current years. Droughts and floods are the adverse climatic conditions arising out of deficit and excess rainfall, respectively. The increasing deforestation in Northeast Himalayas is a great concern for the region. This article discusses the importance of biodiversity, the consequences faced by the plants, animals, humans, and ecosystem owing to climate change, and also control measures or strategies should be taken for the conservation of biodiversity which can protect the earth from the consequence of climate change.

Biodiversity is the 'Full variety of Life on Earth' that includes diversity within species, between species, and of an ecosystem. The term biodiversity is generally used for the natural environment and its conservation. According to UNCED (United Nations Conference on the Environmental and Development), 'Biodiversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.' In the simplest sense, biodiversity may be defined as the total of species richness, *i.e.* the number of species

of plants, animals, and microorganisms occurring in a given region, country, continent, or the entire globe. Broadly speaking, the term biodiversity includes genetic diversity (Diversity of genes within a species), species diversity (Diversity among species), ecosystem diversity (Diversity at the level of community/ecosystem), and habitat diversity. Genetic diversity acts as a buffer for biodiversity²¹. Biodiversity is the very basis of human survival and economic development. It helps in maintaining the ecological balance. There is a necessity for ecological balance for widespread biodiversity²². It plays an important role in the function of an ecosystem by providing many services like nutrients and water cycling, soil formation and retention, resistance against invasive species, pollination of plants, regulation of climate, as well as pests and pollution. Biodiversity is also the source of non-material benefits like spiritual and aesthetic values, knowledge systems, cultural diversity, and spiritual inspiration. Everyone should understand the levels and values of biodiversity²⁰, for the larger interest of the world. It is a source of inspiration to musicians, painters, writers, and other artists¹⁶.

India is one of the 12 mega biodiversity countries in the world and is divided into 10 biogeographic regions. Our country accounts for two hotspots out of the 35 global biodiversity hotspots: the Indo-Malayam which includes the Eastern Himalayas, North-east India, the Andaman Islands, and the Western Ghats. Biogeographically, India is situated at the trijunction of three realms: Afro-tropical, Indo-Malayan, and Paleo-Arctic realms, and therefore, has characteristic elements from each of them. This assemblage of three distinct

realms makes the country rich and unique in biological diversity. It has a great wealth of biological diversity in its forests, wetlands, and in its marine areas.

Study site :

The Northeast region of India is consisting of eight states covering a geographic area of 26.2 million hectares (Fig. 1). It covers an area of total 262,179 km². The Brahmaputra and Barak are the two main river basins of the region. Northeast India has diverse vegetation types encompassing tropical, subtropical, temperate, sub-montane, montane, subalpine to alpine. The local tribal populations are highly dependent on forest resources, which provide a livelihood to more than 225 tribal groups native to the region. The timber trade, tourism and wildlife resorts, and shifting cultivation in the hills are closely woven with the region's forest wealth. The total forest cover was 54 % of the total area in 1993 and increased to 66 % in 2005, although doubts have been expressed over official data. Official reports state that forest cover varies from 80.9% (of the total geographical area) in Arunachal Pradesh to 35 % in Assam, with the other states placed from 76 % in Manipur to 88.6 % in Mizoram. The region is characterized by diverse climatic regimes and is highly dependent on the southwest monsoon. It has two globally recognized biodiversity hotspots and an eco-region renowned for its high species diversity and endemism. According to biodiversity records, Northeast India supports nearly 50 % of the total flowering plants recorded in India, out of which 31.58 % are endemic. It is also recognized as one of the 'centers of origin of cultivated plants.' It is the original location of over 50 important

tropical and subtropical fruits, cereals, and rice (Vavilov 1926; Dhawan 1964; Hore 2005). In addition, out of an estimated 800 species used for food in India, about 300 species occur in Northeast India alone (Rao and Murti 1990). The natural resources of the region are subjected to degradation and loss due to deforestation, unsustainable shifting cultivation practices, fragmentation, and degradation which ultimately impact the biodiversity (Ravindranath et al. 2011). In this article, an attempt has been made to address the impact of climate change in biodiversity in Northeast India, a region distinguished globally for its rich biodiversity and variable climatic conditions.

The biodiversity of Northeast India has been severely threatened from last few decades due to habitat loss, invasive species, pollution, increasing human population, and overexploitation of natural resources. Another prominent factor for the depletion of biodiversity is rampant poaching. Though stringent laws have been enacted by the government regarding poaching and Wildlife Protection Act (1972) has been passed, which ensures the protection of wildlife and effectively deal with poaching related issues and also many arrests have been made regarding that in recent few years, it is still prevalent and is a cause of concern for the biodiversity and despite the government

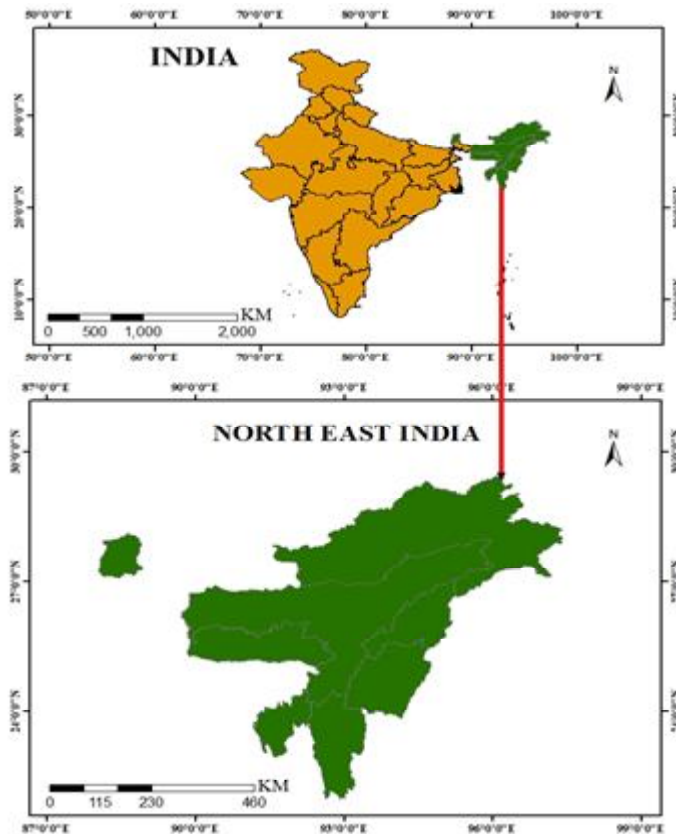


Fig 1: Locational Map of North East India

spending cores on the conservation of animals, the effective implementation of poaching related laws is yet a cause of concern. Similarly, overharvesting of forests also depletes the biodiversity of the region. Another important factor is the conversion of land under forest and grasslands into residential lands and using them for other developmental activities which lead to depletion of biodiversity. Deforestation has a huge impact on biodiversity and clearing of forests for developmental activities leads to reduced forest cover and also contributes to climate changes affecting ecosystems around the globe.

Biodiversity loss has an ecological impact⁹ and its main cause is the changes in the environment. Environmental conditions play a key role in defining the function and distribution of organisms, in combination with other factors. Environmental changes have had enormous impacts on biodiversity patterns in the past and will remain one of the major drivers of biodiversity patterns in the future. Environmental changes are studied under the change in climate or changes due to overpopulation, overexploitation of natural resources, and deforestation.

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 any change in the environment due to human activities or as a result of natural processes.

Climate change refers to significant and long-term changes to a region's climate. These changes can occur over a few decades or millions of years. Climate change alters entire ecosystems along with all of the plants and animals that live there.

Plants and animals are sensitive to fluctuations in temperature and climate. Evidence of organic evolution indicated that rapid climate changes have been associated with a mass extinction of plants and animals. Rapid climatic changes could lead to increased diseases, landslides, forest fires which destroy animals and plants. All organisms are adapted to a particular range of climatic conditions. Change in the climatic condition has a danger of extinction of several plants and animals species. Although all species are not directly influenced by changes in environmental conditions but also indirectly influence through their interactions with other species. Indirect impacts are equally important in determining the response of plants to climate change. A species whose distribution changes as a direct result of climate change may 'invade' the range of another species, for example, introducing a new competitive relationship. Thus 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 summer by 30% have been projected⁸. Climate change results due to both; natural and anthropogenic drivers.

Impact of climate change in Northeast India perspective :

Changing pattern of Temperature and Rainfall :

Rainfall patterns over the region in the last century have considerably changed, resulting in its overall drying up. An aspect of warming that influences rainfall is the drying of the land, which increases the frequency and intensity of dry periods and droughts. An increase in moisture and the drying up together change the rainfall patterns in unpredictable ways. The Union Ministry of Environment, Forests, and Climate Change has projected that temperatures in the region will rise by 1.8-2.1 degrees Celsius by the end of 2030. Annual mean rainfall can rise by 0.3-3 percent in the same period (Down ToEarth, 2021). The *Global and Planetary Change* paper forecasts that the annual mean surface temperature will rise by 0.64°C between 2011 and 2040 and 5.15°C by the end of the century. Rainfall may increase by 0.09 millimeters/day amounting to an annual increase of 33 mm. In Assam, the Indian state most vulnerable to climate change, models predict an increase in temperature of 1.7-2.0 degrees Celsius between 2021-2050. The scenario is much more uniform in other states. “Annual rainfall predicted to decrease by 5-15 percent in the 2050s as compared to the baseline and increase by 25-35 percent towards 2080s,” stated Arunachal Pradesh’s state action plan on climate change. Manipur’s climate action plan projects an increase in temperature of 1.7°C by the mid-2030s; it estimates an increase in rainfall of 15-19 percent by the same time. In Nagaland, the temperature may rise by 1.6-1.8 °C and rainfall by 15-20 percent between 2020 and 2050, especially in Wokha and Tuensang

districts. Districts such as Phek, Tuensang, and Kohima are going to witness more extreme rainfall days (DownToEarth 2021).

Water resources :

Climate change affects the water resources through increased evaporation rate. Increased evaporation rates are expected to reduce water supplies in many regions. The greatest deficits are expected to occur in the summer leading to be decreased soil moisture levels and more frequent and severe agriculture drought. More frequent and severe droughts arising from climate change will have serious management implications for water resource users. Such droughts also impose costs in terms of wildfires both in control costs and lost timber and related resources. For example, in 2016 study by researchers from the Central Agricultural University, Imphal found that between 1975 and 2007, there were 18 years of mild drought and one year of moderate drought in 1979. In 2009, Manipur faced a severe drought. Nearly 46 percent of the country faced moderate-severe drought then after a highly deficient monsoon. In 2019, Manipur experienced a humongous rain deficit of 56 percent. Four districts had large deficient rainfall (deficit greater than 60 percent below LPA) for the season with a high of 82 percent deficit in Chandel district (DownToEarth 2021).

Snowfall :

The increased snowfall in the Eurasian region also impacts monsoon rainfall in North East India. Excessive snowfall in Eurasia causes cooling of the atmosphere of the region, which triggers events eventually leading to a

weak summer monsoon season there. The impacts of ongoing climate changes have already been experienced by the communities of Northeast India. During a verbal discussion, a few people from Shillong and people from Mechuka, West Siang District, Arunachal Pradesh, informed us that since the last few years (12–15 years) they have been experiencing a change in the snowfall pattern and intensity. Earlier snowfall started in late October and reached up to their homes. Now snowfall starts only during December and rarely reaches near their homes. Now snowfall is restricted to the top of the mountains only. but now the fruits taste sour. Earlier apples used to flower only once a year during February. Now they flower twice a year, in late March and September. In the past, snowfall used to start in early November and end by February. Now it starts in December and continues till early April.

Impact of climate change on Biodiversity:

Only a small change in the pattern of climate has a severe impact on biodiversity, altering the habitats of the species and presenting a threat to their survival, making them vulnerable to extinction. Millennium Ecosystem Assessment (MEA) predicts climate change to be the principal threat to biological diversity¹. Due to the increase in temperature several plant species like *Berberis sciatica*, *Taraxacum officinale*, *Jasminum officinale*, etc. have shifted towards higher altitude in Nainital. Teak-dominated forests are predicted to replace the Sal trees in central India and also the conifers may be replaced by the deciduous types. According to Gates⁶, 3°C increase in temperature may lead to the forest movement of 2.50 km/ year which is ten times the rate of natural forest

movement. Anonymous² reported that climate changes affect the normal life cycle of the plant. He also reported that invasive species (*Lantana*, *Parthenium*, and *Ageratum conyzoides*) are a threat to native species being more tolerant to climatic variations. Variation in temperature and precipitation patterns can result in more frequent droughts and droughts and floods making indigenous plants more vulnerable to pests and diseases¹⁹.

A slight change in climatic conditions leads to the extinction of animal species. For example, climate change has resulted in the extinction of animals like a golden toad and Monteverde Sadguru Prakash and Seema Srivastava 63 harlequin frog¹². Polar bears are in danger due to a reduction in Arctic ice cover; North Atlantic whales may become extinct, as planktons which are its main food have shown declination due to climate change. Though the exact impact of climate change on India's natural resources is yet to be studied in detail, pioneering studies show that endemic mammals like the Nilgiri tahr face an increased risk of extinction¹⁷. Further, there are indicative reports of certain species *e.g.*, Black-and rufous flycatcher (*Mikania micrantha*) shifting their lower limits of distribution to higher reaches, and sporadic dying of patches of Shola forests with the rise in ambient surface temperatures.

Impact of climate change on Ecosystem:

Himalayan ecosystem: Temperatures in the Himalayan ecosystem are increasing at a rate of 0.9°C annually, which is considerably higher than the global average of 0.7°C per decade. Due to these changes mosquitoes are

seeing the first time in Lhasa and Tibet cities, located 3490 meters above sea level. There are similar reports of flies at Mount Everest base camp in Nepal. The presence of these insects suggests the possible spread of vectorborne diseases, such as malaria and dengue fever, to areas where cooler temperatures previously protected people from these threats⁵.

Inland water : It includes a lotic and lentic freshwater ecosystem and comprises 0.8% of the earth's surface, but supports 6% of the total species. They are a rich source of food, income, employment, and biodiversity. Changing climatic conditions like rainfall and temperature lead to changes in the phenology, physiology, and migration trends of some organisms like migratory fishes and birds.

Forest: One-third of the earth's surface is covered by forest and it is the home place of two-thirds of all terrestrial species. They are also rich biodiversity hotspots. But half of the original forest has been cleared up till now. The greenhouse effect has led to an increase in the growth of some forests, migration of tree species towards high altitudes, increased attack of pests, invasive species, and wildfires, hence modifying the composition of the forest. According to FAO⁴, due to these changes many animals, primates, and 9% of all known plant species are on verge of extinction.

Agriculture: The decreasing rainfall trends in the state of the Northeast region have affected agriculture productivity, especially cultivation of paddy as well as pisciculture. Climate change leads to variability in rainfall patterns, heat stress, the spread of pests and

diseases shortening the crop cycle, and affecting plant growth and production. It affects both sustainable and unsustainable agriculture. Unsustainable agriculture has multiple effects²³ and disturbs the ecological balance²⁴ and biodiversity structure. Biodiversity loss has impacted the fishing and hunting practices by indigenous people posing an implication on their only source of food. By the middle of the century, crop yields could decrease by 30% in Central and South Asia, while by 20% in East and Southeast Asia. Drylands and grassland: They have localized species (Wild ass, Kutch, etc.) and have varied crops and livestock. The risk of wildfire is increasing which could change the species' biodiversity.

Impact of climate change on Humans :

Climate change leads to an increase in temperature, melting of the ice, increased natural events like floods, droughts, and cyclones that displace humans from their homes. The hot climate makes insect pests in general and vectors and pathogens, in particular, spread over a wider range and enhance their survival rate. An increase of 1°C in surface temperature is estimated to correspond 10% increase in the incidence of insects as pests and insurgence of many diseases like cholera, typhoid, etc.; spread of tropical and vector-borne diseases like malaria, dengue, etc. and rodent-borne diseases like plague. These diseases have shown a persistent increase in the past 50 years.

Thus global climate changes have major implications on human health. Effect on the ecosystem will change the distribution and burden of vector-borne infectious diseases

including bacterial diseases. Changes in epidemiology may already be underway, complex biological changes are associated with a change in an ecosystem. Water and food-borne pathogens create havoc in developing countries that too when conditions are conducive for the spread of pathogens and compromise with hygiene conditions. Greenhouse gases play their role by increasing the carbon emission, due to which the disease curve is increasing faster. Carbon emission is increasing to a dangerous level, making animal lives vulnerable to pathogens and diseases. The increasing sea level rise has already submerged many islands and will soon leave millions of refugees for the world to provide shelter. The sea salinity ingress in the freshwater sources has made land barren and will soon be a threat to food security.

Impact of habitat loss, overpopulation, and overexploitation :

Besides climatic change, other human activities are also largely responsible for biodiversity loss. It is estimated that about 27000 species become extinct every year. If this will continue, 30 percent of the world's species may be extinct by the year 2050. The current extinction rate is 100 to 1000 times that of the natural rate of extinction. Other human activities are habitat destruction, invasive species, pollution, population, and overexploitation of natural resources⁷. Climate change will provide new ways for invasive species to encroach on new territory. Natural disasters like storm surges and high winds, which increase in number and severity as the earth warms, spread non-native plants and insects to new territories. Virtually all

ecosystems worldwide have suffered invasion by the main taxonomic groups including India.

The rapidly increasing population has forced the men to cut down the forests to fulfill the requirements of food and shelter. Deforestation has led to the destruction of the habitats of plants and animals. Loss of habitats is the most important cause of the extinction of species. Habitat extinction compels the species to move where they find it difficult to adapt and this may ultimately lead to their extinction. Physically larger species and those living at lower latitudes or in the forests or oceans are more sensitive to reduction in habitat areas³. Human activities like deforestation, pollution, overpopulation are ultimately responsible for habitat destruction. The introduction of exotic species is also responsible for the loss of biological diversity. The endemic and other local species may not be able to compete with the exotic species and are unable to survive. Overexploitation, in the form of hunting of animals and plants for their commercial value, is one of the major reasons for the loss in biodiversity. Illegal wildlife trade is the single largest threat to biodiversity loss. Overpopulation of humans and overconsumption of natural resources is the root cause of all biodiversity loss¹⁶.

Climate change mitigation of Northeast Region :

Several adaptations for conservation of biodiversity have been proposed by several workers, which include assisted colonization, use of invasive species to restore ecosystem services, creation and expansion of protected areas, corridors, and networks, and efficient

use of resources. Provision of affordable energy; keeping air pollution and climate change under control; management of water systems in support of agriculture, industry, and human settlements; increasing agricultural production; protecting soil, groundwater, and surface water quality; and slowing down and eventually halting the further loss of biodiversity are considered as the key elements of sustainable development.

It is evident that the loss in biodiversity is due to the change in the climate. All these changes in the environment, adversely affecting biodiversity, are mainly due to human activities. The increase in greenhouse gases is leading to global warming at a faster rate and impacts biodiversity, ecological balance, and humans. The ecological balance is an indispensable need for human survival²⁵. Every change in the ecosystem process or ecological balance works on the principle of Newton's law of motion (every action has an equal and opposite reaction) which may be damaging or complimentary. Even a small change in the climate can lead to the extinction of some vulnerable and sensitive species. Climate change results in the impact on the biodiversity like change in their distribution pattern, migration of species, invasion of invasive species, change in the phenological behavior like breeding period, migration time, *etc.*, increase in the forest fires and pest attacks¹⁴. To maintain the balance of an ecosystem, the interaction between the plants, animals, and biodiversity needs to be understood, hence promoting its conservation and protection by designating the hotspots as biosphere reserves, increasing afforestation, reforestation, and agroforestry practices. Biodiversity-based

adaptation and mitigation strategies will enhance the resilience of ecosystems and prevent damage to human and natural ecosystems.

Increasing our understanding of the effects of climate change on biodiversity, developing ways of mitigating such effects, and reducing anthropogenic activities are critical to limit such damage. Without conserving biodiversity and minimizing anthropogenic activities, it is almost impossible to get inclusive and sustainable development²⁶. Thus, there is a growing realization among decision-makers that biodiversity is not an optional bonus in human affairs, but the very foundation of our existence. Moreover, biodiversity conservation tailored to changing climatic conditions is not only necessary to help species and habitats to adapt to change, but such action is also likely to mitigate climate change⁵. In terms of agriculture, there is a need for climate-resilient farming systems. Climate literacy should be spread and a cadre of Community Climate Risk Managers should be formed in villages. The calamity of climate change should be converted into an opportunity for developing and spreading climate-resilient farming techniques and systems¹⁸.

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