

# Effect of Climate Change on Vegetation in India

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## ARTICLE DETAILS

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## ABSTRACT

*A rise in temperatures can lead to droughts, wildfires, and pest outbreaks, resulting in plant species loss. A number of detrimental effects result from this, including: Reduced Productivity: Longer droughts and more heat waves will stress plants, reducing their productivity. The continuing decline in soil moisture can lead to smaller yields and even desertification, with potentially dramatic consequences for food production.*

## Introduction

Any region's climate is its average weather condition over a long period of time. The weather, therefore, is a local variation in the state of the atmosphere over a wide area. In general, climate refers to the weather for a given region over a long period of time. Hence, there cannot be different types of climates in one location, but the climate differs over vast geographical distances. The climate of India is known as monsoon. The term monsoon has Arabic roots and is derived from the word *mausim*.<sup>1</sup>

As a result of the monsoon winds, the majority of the weather is controlled. There are two types of monsoons in India, the south-west monsoon and the north-east monsoon, or the retreating monsoon which occurs between May and December. Hence, India has a monsoon climate. The monsoon climate also has an impact on agriculture, India's main economic activity in terms of the number of people employed. It is not a question of different types of climates in India, but rather a question of different types of vegetation. There is only one type of climate in India, which is the Monsoon climate.<sup>2</sup>

### Indian climate is affected by the following factors:

- Latitude: In mainland India, latitude lies between 804 and 3706 degrees North. The Cancer Tropic divides the mainland into two halves. Since it is near to tropic

regions, it receives high precipitation and has a higher temperature due to the tropical climate, which is a result of the south-facing Cancer Tropic. A region on the northern side of the cancer tropic, on the other hand, experiences extreme weather conditions with wide ranges in both annual and daily temperatures.<sup>3</sup>

- Altitude: It is well known that temperature decreases with height, so places in the mountains are always cooler than plain regions. So, altitude plays an important role in determining the climate.
- Distance from the sea: In regions closer to the sea, the climate is moderate. In regions farther from the sea, the climate is extreme. For instance, Rajasthan, Delhi, and Punjab.

India boasts a very diverse range of plants. Seasonal varieties, as well as those hardy enough to survive all year round, are both abundant; with bushes, cacti and many different kinds of flowers scattered throughout the country. Tall trees like the neem and mango provide shade while low-lying palms fit in seamlessly with their leafless trunks. The Indian climate plays an integral role in ensuring the success of such a wide array of vegetation. There are five types of vegetation in India: tropical evergreen forests, tropical deciduous forests, thorny bushes, mountain vegetation, and mangrove forests. These diverse types of vegetation in India exhibit different ecosystems and, in turn, a wide range of wildlife.<sup>4</sup>

<sup>1</sup> "Rajiv K. Chaturvedi, Ranjith Gopalakrishnan, Mathangi Jayaraman, Govindasamy Bala, N. V. Joshi, Raman Sukumar, and N. H. Ravindranath. 2011. Impact of climate change on Indian forests: a dynamic vegetation modeling approach. *Mitig. Adapt. Strateg. Glob. Chang.* 16, 2 (2011), 119–142. DOI:https://doi.org/10.1007/s11027-010-9257-7"

<sup>2</sup> "Rajiv K. Chaturvedi, Ranjith Gopalakrishnan, Mathangi Jayaraman, Govindasamy Bala, N. V. Joshi, Raman Sukumar, and N. H. Ravindranath. 2011. Impact of climate change on Indian forests: a dynamic vegetation modeling approach. *Mitig. Adapt. Strateg. Glob. Chang.* 16, 2 (2011), 119–142. DOI:https://doi.org/10.1007/s11027-010-9257-7"

<sup>3</sup> "A. Chaitra, S. Uppu, L. D. Bhatta, J. Mathangi, D. S. Anitha, K. Sindhu, Vidya Kumar, N. K. Agrawal, M. S. R. Murthy, F. Qamar, Indu K. Murthy, J. Sharma, R. K. Chaturvedi, G. Bala, and N. H. Ravindranath. 2018. Impact of climate change on vegetation distribution and net primary productivity of forests of Himalayan river basins: Brahmaputra, Koshi and Indus. *Am. J. Clim. Change* 07, 02 (2018), 271–294. DOI:https://doi.org/10.4236/ajcc.2018.72018"

<sup>4</sup> "A. Chaitra, S. Uppu, L. D. Bhatta, J. Mathangi, D. S. Anitha, K. Sindhu, Vidya Kumar, N. K. Agrawal, M. S. R. Murthy, F. Qamar, Indu K. Murthy, J. Sharma, R. K. Chaturvedi, G. Bala, and N. H.

Considering the example of the altitude effect, Indian climate, vegetation, and wildlife are all interconnected. Out of curiosity, I asked how altitude affects vegetation and wildlife. The answer is that altitude affects the climate and temperature, which in turn affects vegetation and wildlife. Temperatures are very low at very high altitudes and relief features are also close to the clouds, causing a large amount of rain and sometimes all year round. As a result, the region has evergreen vegetation resulting in a distinct wildlife. The tropical monsoon region of India is another example of wildlife that is influenced by climate. It is home to monkeys, parrots, lemurs, ocelots, hummingbirds, etc.

### Effect of Climate Change on Vegetation

The Indian Institute of Technology (IIT), Kharagpur, has discovered that most Indian forests are exceptionally resilient to climate change-induced large variations in rainfall and short droughts. To deduce resilience, researchers used canopy cover and rainfall changes. They found that forests in wetter regions and scrubs in drier regions would be more resilient. For predicting the impact of global climate change on Earth's ecosystems, scientists use climate and vegetation models. In this case, the IIT study compared long-term trends in spatial distribution of Indian forests with corresponding rainfall records. According to this study, forests have remained resilient to changing rainfall patterns despite changing precipitation patterns between 2000 and 2017.<sup>5</sup>

This novel research has yielded a “forest cover resilience map” that could be utilized to formulate consistent, more effective climate-adaptive preservation and administration measures in India. Notably, the study incorporates a “precipitation threshold” of forest cover resilience – which assists researchers determine the point after which forest recovery could prove difficult. It is postulated that forest cover would continue to be strong at precipitation levels above 1400 mm yearly.<sup>6</sup>

In Uttarakhand, for instance, up to 80% of forest has been shown to be vulnerable to climate change in previous studies both at the national and regional levels.

“This is a very significant result, but it is drawn by considering only one factor, that is precipitation, of several factors such as temperature, soil, and anthropogenic influences

that greatly influence forest existence and sustainability,” observes Jagmohan Sharma, additional principal chief conservator of forests, Bengaluru.

The team from IIT studied the survival probability of forests and other vegetation types in a changing climate regime. For mapping forest, scrubland, grassland and treeless areas in India, open-source data on tree canopy cover percentages were used, and long-term annual rainfall was assessed as a factor. Forests were found in areas with 340–8650 mm rainfall, scrubland in areas with 196–1018 mm rainfall, grassland in areas with 167–995 mm rainfall, and treeless areas with 34–965 mm rainfall.<sup>7</sup>

According to the findings reported in Biodiversity and Conservation, 0.02% of forest in the dry regions of Trans-Himalaya were classified as “least resilient”, whereas in wetter areas like Western Ghats, Western Himalayas, Eastern Ghats and Northeast India it was predicted to be “highly resilient”. It is quite clear that the majority of India's forest cover tends to be really durable when encountering modifications in precipitation levels and shorter drought periods. On the other hand, scrubland proved to be tough in drier regions and feeble in wetter areas.

According to the scientists, the “forest cover resilience curve saturates about 1400 mm precipitation”, meaning that forests are resilient at rainfall levels over 1400 mm but scrubs are not.

It may not change a forest regime's resilience much if rainfall decreases or increases by 500 mm, for example, if it receives 3000 mm on average. The same change in rainfall of 500 mm would impact resilience “significantly” in another regime receiving 1500 mm, Pulakesh Das, one of the study authors, explained to Mongabay-India.

Consequently, forests in the drier landscapes may experience alterations due to climate change. While the seasonal dry tropical forests in the Deccan Peninsular region can tolerate dry periods and droughts to a certain extent, they are particularly vulnerable to large climate changes, he added.<sup>8</sup>

Das mentioned that his study gives several fresh perspectives. For example, the possible precipitation limits that sustain different vegetation stages “are seldom documented when it comes to regime shift,” he commented. Additionally, the association of vegetation and precipitation generated from global records did not coincide with real conditions in Indian woods. His research aided in refining the procedures applied in

Ravindranath. 2018. Impact of climate change on vegetation distribution and net primary productivity of forests of Himalayan river basins: Brahmaputra, Koshi and Indus. *Am. J. Clim. Change* 07, 02 (2018), 271–294. DOI:<https://doi.org/10.4236/ajcc.2018.72018>

<sup>5</sup> “Aditi Tandon. 2019. Indian forests may be able to withstand climate change better than feared. Mongabay-India. Retrieved January 11, 2023 from <https://india.mongabay.com/2019/05/indian-forests-resilient-to-climate-change/>”

<sup>6</sup> “Aditi Tandon. 2019. Indian forests may be able to withstand climate change better than feared. Mongabay-India. Retrieved January 11, 2023 from <https://india.mongabay.com/2019/05/indian-forests-resilient-to-climate-change/>”

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<sup>8</sup> “Bikash Ranjan Parida, Arvind Chandra Pandey, and N. R. Patel. 2020. Greening and browning trends of vegetation in India and their responses to climatic and non-climatic drivers. *Climate* 8, 8 (2020), 92. DOI:<https://doi.org/10.3390/cli808092>”

global analyses, by taking out human actions for comprehending forest cover and including land use alteration and forestry maps; these generated new conclusions and interpretations.<sup>9</sup>

Scientists from IISc, Bengaluru, prepared a vulnerability index for Indian forested grid points based on previous research. According to their 2011 study, vulnerable forests are concentrated in the upper Himalayas, central India, and northern parts of the Western and Eastern Ghats. On the other hand, northern India, southern Western Ghats and eastern India were found to have the least vulnerable forests. The vulnerability of forested grids in Uttarakhand, in the western Himalayas, has recently been measured by a team led by Manoj Kumar, scientist in charge of the Geographical Information Services (GIS) unit at Forest Research Institute, Dehradun. Using net primary productivity (NPP), scientists assessed vulnerability.

According to their analysis published in 2018, 80% of this region's forests are climate sensitive. Worryingly, less than half of this forest area was capable of recovering from climate change impacts. As a result, this report recommends evaluating the causes and remedial measures for reducing these forests' sensitivity, along with exploring options for improving adaptive capacity.

As Kumar explained, the research from IIT, Kharagpur offers a new direction since it discusses the resilience of Indian forests and the tipping point under varying precipitation regimes. As a result, Kumar cautioned, "we need to test other climate drivers as precipitation alone may not justify the purpose". Thus, the new study is "an exciting start in the Indian context."<sup>10</sup>

### Impacts of Climate change

Changing climatic variables relevant to the function and distribution of plants include increasing CO<sub>2</sub> concentrations, increasing global temperatures, altered precipitation patterns, and changes in patterns of cyclones, fires, or storms. Different models and variations in bioclimatic changes have resulted in highly variable species distributions.

- **CO<sub>2</sub>'s effects:** CO<sub>2</sub> concentrations have been on the rise for two centuries, and this has had an effect on how plants carry out photosynthesis. As a result of this, the efficiency of the water used by plants has gone up, their photosynthetic capacity has become stronger and their growth has increased. This in turn can alter the plant community structure and function

due to what is known as 'vegetation thickening'. The differential responses that different types of plants show to atmospheric CO<sub>2</sub> levels, such as C<sub>3</sub> and C<sub>4</sub> plants or woody and non-woody species, can cause changes in competition between them. Additionally, CO<sub>2</sub> levels also have an impact on Carbon : Nitrogen ratios of leaves or other aspects of leaf chemistry; this may potentially affect herbivore nutrition. Studies illustrate that doubling CO<sub>2</sub> leads to greater photosynthesis in C<sub>3</sub> species but not in their C<sub>4</sub> counterparts; however, it appears that C<sub>4</sub>s are better able to cope with dry periods compared to C<sub>3</sub>s.<sup>11</sup>

- **Temperature effects:** Temperature is a major factor in regulating many physiological processes, such as photosynthesis in plants, which have an upper limit according to species. Chemical reactions and enzymatic conversion rates double for every 10 °C temperature increase. Yet when temperatures exceed the plant's tolerance level, desiccation can occur rapidly. Several scientists have proposed that the more warm an area is, the more diverse the plants are. In nature, higher plant biodiversity can often be observed at certain latitudes (which correlate with a specific climate). It is predicted that the effects of climate change will be more severe in mountains of northern latitudes, where montane and snowy ecosystems are at greater risk of habitat loss. Emissions continue to climb, and the Earth is now 1.1°C warmer than in the late 1800s – a record high for the past decade (2011-2020). Most people equate climate change with rising temperatures, but this is merely one outcome of a system where all components influence each other. We are already seeing droughts, water shortages, ferocious fires, sea levels on the rise, flooding, melting polar ice, unprecedented storms and an alarming reduction of biodiversity.<sup>12</sup>
- **Water's effects:** As water supply is critical for plant growth, it plays a key role in determining the distribution of plants. Precipitation is predicted to change less consistently than temperature and to be more variable between regions, with some areas predicted to become much drier and some much wetter than expected. Water availability will play a direct role in determining the growth rates and persistence of plant species in a given area. The irregular intensity of rainfalls will affect which resources are available in the soil. Consequently, reduced levels of moisture in the soil can impede plant growth and alter the ecosystem composition. In

<sup>9</sup> "Bikash Ranjan Parida, Arvind Chandra Pandey, and N. R. Patel. 2020. Greening and browning trends of vegetation in India and their responses to climatic and non-climatic drivers. *Climate* 8, 8 (2020), 92. DOI:https://doi.org/10.3390/cli8080092"

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<sup>11</sup> "Shaftel, Holly. Overview: Weather, Global Warming and Climate Change. *Climate Change: Vital Signs of the Planet*. Retrieved 2022-03-31."

<sup>12</sup> "Duraiappah, Anantha K. (2006). *Millennium Ecosystem Assessment: Ecosystems And Human-well Being—biodiversity Synthesis*. Washington, D.C: World Resources Institute. ISBN 978-1-56973-588-6."

addition, drier climatic conditions caused by climate change may make certain plant and tree species more susceptible to wildfires, further decreasing biodiversity.<sup>13</sup>

### **Conclusion**

As a result of climate change, vegetation is expected to suffer from changes in temperature, rainfall, and climate pattern, which will affect nutrient cycles, microbial activities, and plant physiological activities. Precipitation changes can affect moisture regimes, soil erosion, salinity, acidity, and other physical and chemical factors. All of these factors are closely related to vegetation growth.

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