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## India: The Impact of Climate Change

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### Abstract

India is both a major greenhouse gas emitter and one of the most vulnerable countries in the world to projected climate change. The country is already experiencing changes in climate and the impacts of climate change, including water stress, heat waves and drought, severe storms and flooding, and associated negative consequences on health and livelihoods. With a 1.2 billion but growing population and dependence on agriculture, India probably will be severely impacted by continuing climate change. Global climate projections, given inherent uncertainties, indicate several changes in India's future climate:

- Global observations of melting glaciers suggest that climate change is well under way in the region, with glaciers receding at an average rate of 10–15 meters per year. If the rate increases, flooding is likely in river valleys fed by these glaciers, followed by diminished flows, resulting in water scarcity for drinking and irrigation.
- All models show a trend of general warming in mean annual temperature as well as decreased range of diurnal temperature and enhanced precipitation over the Indian subcontinent. A warming of 0.5°C is likely over all India by the year 2030 (approximately equal to the warming over the 20th century) and a warming of 2-4 °C by the end of this century, with the maximum increase over northern India. Increased warming is likely to lead to higher levels of tropospheric ozone pollution and other air pollution in the major cities.

**Keywords:** greenhouse gas, health and livelihoods, climate change, general warming

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### Introduction and Background

Global climate projections, given inherent uncertainties, indicate several changes in India's future climate:

Global observations of melting glaciers suggest that climate change is well under way in the region, with glaciers receding at an average rate of 10–15 meters per year.

If the rate of glacial melt increases, flooding is likely in the river valleys fed by these glaciers, followed by a diminished flow, resulting in a scarcity of water for drinking and agricultural irrigation.

All models show a trend of general warming in mean annual temperature as well as decreased range of diurnal temperature and enhanced precipitation over the Indian subcontinent.

A warming of 0.5°C is likely over all India by the year 2030 (approximately equal to the warming over the 20th century) and a

warming of 2-4°C by the end of this century, with the maximum increase over northern India.

Increased precipitation is likely to come in the form of fewer rainy days but more days of extreme rainfall events, with increasing amounts of rain in each event, leading to significant flooding. Fine precipitation (drizzle-type) that replenishes soil moisture is likely to decrease.

Increased warming is likely to lead to higher levels of tropospheric ozone pollution and other air pollution in India's major cities.

Most global models suggest that the Indian summer monsoons will intensify with a warming climate. The timing may also shift, causing a drying during the late summer growing season.

Climate models also predict an earlier snowmelt, which could have significant

adverse effects on agricultural production, both irrigated and non-irrigated.

Growing emissions of aerosols from energy production and other sources may suppress rainfall, leading to drier conditions with more dust and smoke from the burning of drier vegetation, affecting both regional and global hydrological cycles and agricultural production.

#### **Climate Change**

The modern-day climate of India is pretty numerous, beginning from the subfreezing Himalayan winters to the tropical climate of the south. The states of Assam and West Bengal experience extremely damp, moist, and humid situations, at the equal time because the regions of Rajasthan and Gujarat make up part of the arid extraordinary Indian wasteland. Primarily based mostly on precipitation and temperature, India may be divided into six climatic areas: the Himalayas, Assam and West Bengal, the indo-gangetic simple, the Western Ghats and coast, the Deccan (the indoors of the peninsula south of the Narmada river), and the Jap Ghats and coast. The Indian meteorological service divides the year into 4 seasons, two of which are characterized by means of monsoon situations. Wintry weather occurs from December thru February, when situations are normally exceedingly dry and cool. March thru might also is taken into consideration to be summer, as the situations are usually warm and dry. All through these period temperatures at some stage in non-Himalayan India reach the higher 30°C and may attain as high as 48°C for the duration of the day in the pre-monsoon months. The southwest monsoon season occurs from June thru September, while the predominating southwest maritime winds bring rains to maximum of the United States. One branch of the southwest monsoon, referred to as the Arabian sea monsoon, generally breaks at the west coast early within the season and spreads across south Asia by using early July. The other, called the Bay of Bengal monsoon, spreads over Assam for the duration of June and travels alongside the Indo-Gangetic undeniable in the direction of New Delhi, merging with the Arabian

branch to bring rains farther north. The southwest monsoon gives almost 80 percentage of the yearly rainfall to maximum of the United States. It is seriously important to agricultural manufacturing. Predictions of its timing are utilized by agronomists and farmers to decide most beneficial dates for plantings. The northeast monsoon takes place in October and November because the southwest monsoon retreats. The states of Tamil Nadu, Karnataka, and Kerala get hold of most of their rainfall from the northeast monsoon throughout November and December. Interannual weather variability is related to a global-scale, evidently going on phenomenon known as the el niño/southern oscillation (enso) cycle. ENSO can explain a number of the interannual rainfall variability over the subcontinent of India and might have an effect on the area and hobby of tropical storms. Analysis of observational statistics indicates a massive correlation among ENSO and tropical movement and precipitation such that there's a tendency for less Indian summer season monsoon rainfall in el niño years and above-normal rainfall in Los Angeles la niña years. However, the impact isn't linear. The capacity correctly predicts the timing and prevalence of the ENSO phenomenon is extraordinarily crucial to agricultural manufacturing.

#### **Climate Observations**

Global observations propose that climate change is well beneath way. At continental, local, and ocean basin scales, numerous lengthy-time period changes in climate had been found, together with sizable adjustments in precipitation amounts; ocean salinity; wind styles; and components of severe climate which includes droughts, heavy precipitation, warmness waves, and the depth of tropical cyclones. Studies of the tropical indo-pacific region show unusual warm temperature inside the 20th century, and lots of isotope records show a fashion in the direction of warmer situations within the tropical Indian Ocean. In maximum multi-centennial coral collection, the late 20th century is shown to be warmer than any time within the beyond 100 to three

hundred years. A few research have recommended that the south Asian (Indian) monsoon, in the drier areas of its have an effect on (northwest India), has these days reversed its millennia-lengthy orbitally pushed, low frequency fashion closer to much less rainfall. This current reversal in monsoon rainfall also appears t°C coincide with a synchronous growth in inferred monsoon winds over the western Arabian Sea, an exchange that would be related to increased summer time heating over and around the Tibetan plateau. Globally, estimates of the capability destructiveness of tropical storms and hurricanes display a vast upward trend for the reason that mid-seventies, with a fashion towards longer typhoon length and greater storm intensity. Hurricane hobby is generally correlated with tropical sea floor temperature. The distributions of global minimal and maximum temperatures have shifted to higher values, steady with average warming. Greater heat extremes imply an elevated frequency of warmth waves. But, bloodless extremes have warmed greater than the warm extremes over the last 50 years. In addition symptoms encompass the discovered trend towards fewer frost days related to the average warming in maximum mid-range areas. A distinguished indication of a exchange in extremes is the proof of will increase in heavy precipitation occasions over the mid-latitudes within the past 50 years, even in places in which imply precipitation amounts are not growing. For extremely heavy precipitation activities, increases are stated as nicely, but effects are available for only a few areas. Latest warming in sea surface temperatures (sst) is strongly obtrusive at all latitudes, although there are inter-hemispheric differences. A good deal of the surface of the Indian Ocean has warmed because 1955, with the major exception of the 5°s to 20°s latitude belt. The southern ocean (south of 35°s) within the Atlantic, Indian, and Pacific sectors has generally warmed. The regions that exhibit cooling are in particular within the shallow equatorial regions and in some high-range regions. Within the Indian Ocean, cooling

happens at subsurface depths focused on 12°s (south equatorial modern) at 150 m depth and within the pacific targeted at the equator and a hundred and fifty m intensity. Within the tropical and Japanese subtropical Indian ocean (north of 10°s), warming within the higher a hundred m is consistent with the big warming of the sea floor from 1900 to 1999. The surface warming fashion all through the 1900 to 1970 period was particularly vulnerable however extended substantially inside the 1970 to 1999 duration, with a few areas exceeding 0.2°C according to decade. Models propose that top-ocean warming inside the south Indian Ocean can be attributed to a discount in the electricity of the southeast exchange winds and related decrease inside the southward shipping of heat from the tropics to the subtropics. Neighborhood and local changes inside the character of precipitation also rely a splendid deal on atmospheric flow patterns decided with the aid of el niño, the north Atlantic oscillation (nao), xxi and other styles of variability. India's rainfall functions display sturdy variability but little in the manner of a century-scale fashion, whilst the linear tendencies of rainfall decreases for 1900 to 2005 were 7.5 percent in western Africa and a comparable lower turned into discovered whilst averaged over the broader southern Asia area as a whole. Over a lot of northwestern India, the 1901 to 2005 duration shows precipitation will increase of greater than 20 percent per century, but the same place shows a robust decrease in annual precipitation within the 1979 to 2005 period. Very dry land regions across the globe have greater than doubled in area for the reason that seventies, an remark that has been related to precipitation decreases associated with ENSO and with subsequent increases in the main due to surface warming. The tendency of the warming to be more pronounced in iciness is a conspicuous feature of the found temperature tendencies over India, one this is probably to hold.

#### **Projections of Future Temperature and Precipitation**

Modern projections of weather alternate from the cutting-edge ipcc assessment recommend increases in temperatures, precipitation quotes, and the depth of tropical storms over the Indian Ocean. Maximum fashions both assume a doubling of co2 and their consequences can be compared the use of this assumption, or the models are run to the 12 months 2100 and the results of the climate projections are assessed for that date. The ipcc has no longer protected numerical version consequences in particular for the year 2030. Kumar et al. have modeled climate adjustments at the Indian subcontinent for intermediate scenarios at 2020 and 2050; however, simplest the consequences for the very last situation for 2080 have been published. An in advance study used eight global fashions to mission temperature and precipitation changes over all India per decade for 3 exclusive emission situations. Even though the tables presented on this reference are useful, the uncertainties, especially within the prediction of precipitation changes, are high-quality. Maximum agcms expect fashionable warming and more desirable rainfall over India, with these changes becoming mainly massive by means of 2040 Kumar et al. Use the version imparting local climates for influences studies (summary), developed by using the Hadley Centre for weather prediction and research, to yield projections for climate exchange at some point of intermediate time scales (every 10 years till 2100); those projections can be averaged over version outcomes to estimate weather trade in 2030. Xxxi the models task an average temperature growth over all India through the 12 months 2030 of ground zero. 5°C, an growth comparable with that that has happened over the globe for the duration of the 20<sup>th</sup> century. The maximum temperature boom (i. E., annual suggest temperature change) is predicted to occur over northern India, with a secondary maximum over the jap peninsula. By using the 12 months 2100, the temperature boom might be on the order of two-4°C, with a maximum growth within the northern vicinity of 4°C. A local

version recently developed on the Indian Institute of Tropical Meteorology (IITM) projected that, averaged over the country; India should face a temperature boom of 4°C by way of 2100. However, the version predicts that, because of the longer time scales for machine-wide adjustments in environment-ocean interactions, a postpone in the boom in monsoon rainfall will occur, ensuing in drought in a few areas.

#### **Agricultural Growing Periods**

Many areas of India already face water shortage. Productive agricultural areas within the north depend on the spring snowmelt to replenish nearby water supplies. Climate models predict an earlier snowmelt, which can have a tremendous effect on agricultural production, especially if the ranges of moisture inside the soils are reduced during the developing season. The retreat of snow and ice cowl in and around the Himalayas is already having a drying effect on these regions. A latest study of the melting naimona'the big apple glacier inside the Himalayas, which offers water to the Indus, and Brahmaputra rivers suggests that the glacier has melted a lot that the exposed surface of the glacier dated to 1944. Decreasing traits in evapotranspiration all through recent a long time are glaring in statistics, even though such statistics are sparse. This is possibly due to decreased sunshine length associated with increases in air pollutants, atmospheric aerosols, and will increase in cloud cover. An accelerating trend in sulfate deposition has been discovered in Himalayan glaciers and is probably due to improved sulfur dioxide emissions from the growing electricity call for all through Asia. The attention of sulfate deposited within the glaciers in the beyond 50 years exceeded that for any prior 50-year duration inside the closing millennium.

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