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Impact of Climate Change on India: The review

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Abstract

India is a country with contrasting topography and weather. India is a peninsular extension of the vast Eurasian landmass, according to geography. India has three distinct climatic regions: tropical, subtropical, and temperate.Despite the fact that its northern region is located in the temperate zone, India is primarily a tropical nation. The Arabian Sea and Bay of Bengal, two branches of the Indian Ocean, wash the southern Indian shores, giving the region a typical tropical monsoon climate.

Keyword: : Tropical, Subtropical and monsoon climate, Location and Latitudinal, Tropical Cyclones, Forest Types, ,Western Disterbance, Agriculture and Food Security

Introduction

India's climate includes a wide variety of weather patterns over a huge geographic area and diverse topography. According to the Köppen system, there are six main climatic subtypes in India, from arid deserts in the west to alpine tundra and glaciers in the north to humid tropical regions with rain forests in the southwest and on the islands. It is one of the countries with the most diverse climates in the world because several of its regions have radically different microclimates. With a few local modifications, the nation's meteorological department observes the four traditional seasons of the world: winter (December to February), summer (March to May), monsoon (rainy) season (June to September), and a post-monsoon period (October and November). India's geography and geology are climatically pivotal: the Thar Desert in the northwest and the Himalayas in the north work in tandem to create a culturally and economically important monsoonal regime. As Earth's highest and most massive mountain range, the Himalayas bar the influx of frigid katabatic winds from the icy Tibetan Plateau and northerly Central Asia. Most of North India is thus kept warm or is only mildly chilly or cold during winter; the same thermal dam keeps most regions in India hot in summer. Climate in South India is generally warmer, and more humid due to its coastlines. The Indian Plate underwent tectonic movement when it passed over the Réunion hotspot, which is today occupied by the volcanic island of Réunion. The Deccan Traps were created as a result of a significant flood basalt event that occurred between 60 and 68 Ma[6][7] near the end of the Cretaceous period. This could have contributed to the Cretaceous-Paleogene extinction event that dramatically decreased solar radiation in India. High sulphur gas concentrations in the atmosphere resulted in the formation of aerosols including sulphur dioxide and sulfuric acid, which precipitated as acid rain. These aerosols are comparable to those found in Venus' atmosphere.

Increased carbon dioxide emissions also played a role in the greenhouse effect, which resulted in warmer temperatures that persisted long after the dust and aerosol cover had dissipated from the atmosphere. Long after India collided with the Laurasian landmass, another round of climatic changes occurred 20 million years ago that were severe enough to drive many endemic Indian species extinct. The Himalayas' formation prevented cold air from Central Asia from reaching India, making India's temperature much warmer and more tropical than it would have been otherwise. The earth's climate system is thought to be changing as a result of the atmospheric buildup of trace gases like carbon dioxide (CO_2) and methane (CH_4), which is mostly the result of anthropogenic activity like the combustion of fossil fuels. "Warming of the climate system is now unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global seal level," the Intergovernmental Panel on Climate Change (IPCC) stated in its fourth assessment report (Soloman et al., 2007). India should be concerned about climate change since a large portion of its population relies on industries that are vulnerable to it, such agriculture, forestry, and fisheries. One of the most significant worldwide environmental issues currently facing humanity is climate change, which has effects on things like freshwater availability, health, natural ecosystems, and food production. The earth's climate system has changed demonstrably from pre-industrial times on a global and regional scale, according to the most recent scientific assessment. Additionally, research indicates that human activities are primarily to blame for

the warming (of 0.1 oC each decade) that has been observed over the past 50 years (IPCC, 2001a and 2001b). Climate change should worry India since it can have a negative effect on the nation. The main "categories" of climate change impacts include those on agriculture, sea level rise that submerges coastal communities, and an increase in the frequency of extreme events that pose serious hazards to India. The impact of climate change on India is extensively covered in the article, with a focus on agriculture, water, health, forests, sea level, and risk events.

FACTORS DETERMINING THE CLIMATE OF INDIA

Location and Latitudinal Extent: The Tropicof Cancer passes through the central part of India in east-west direction. Thus, northern part of India lies in sub-tropical and temper-ate zone and the southern part falls in the tropical zone. The tropical zone being nearerto the equator, experiences high tempera- tures throughout the year with small daily and annual range. Area north to the Tropic of Cancer being away from the equator, experiences extreme climate with high daily and annual range of temperature.

Distance from the Sea: The Indian Peninsula is surrounded by the Arabian Sea and the Bay of Bengal, which moderates the climate in the coastal regions. Areas in India's interior are far from the sea's climate-moderating impact and experience climatic extremes. Because of this, the annual temperature range in Kochi does not surpass 3°C but it can reach 20°C in Delhi.

The Himalayas: India is shielded from the savagely cold and dry winds of Central Asia throughout the winter by the Himalayan Ranges. Additionally, these ranges serve as a strong physical barrier that prevents rain-producing south-west monsoon winds from entering India's northern frontiers. As a result, the Himalayas serve as a climate barrier separating Central Asia and the Indian Subcontinent.

Physiography: India's physical geography and its climatic conditions are strongly intertwined. Ooty is an example of a higher altitude location with a cool temperature despite being in southern India. Similar to this, despite Agra and Darjeeling being on the same latitude, Agra's January temperature is 16°C while Darjeeling's is only 4°C. The amount and distribution of rainfall as well as the direction and speed of the wind are also influenced by India's physiography. While Assam and the windward portions of the Western Ghats have heavy rainfall from June to September, the southern plateau stays dry because it is situated leeward of the Western Ghats. The funnel-shaped Cherrapunji valley is the wettest location for physiographic reasons**.**

Agriculture and Food Security: The 65% of rainfed Indian agriculture that is highly climate-sensitive, produces approximately 25% of GDP, employs the entire workforce, and accounts for 13.3% of all exports when combined with related businesses (GOI, 2002). Numerous studies suggest that despite a significant increase in the nation's foodgrain output, climate change may cause the yield of some crucial crops, such rice and wheat, to fall significantly (Achanta, 1993).

The rate of CO_2 release into the atmosphere has increased by 30 times in the last 3-4 decades.It is estimated that a 0.5 ^{O}C rise in winter temperature could reduce the wheat yield by 0.45 ton per hectare. A recent World Bank report studied two drought-prone regions in Andhra Pradesh and Maharashtra and one flood-prone region in Orissa on climate change impacts.

Table 1: Summary of Greenhouse Gas Emission in Gg (Thousand Tons from India in 1994 by Sources and Sinks)

Greenhouse Gas Source and Sink Categories	CO_2 (Emissions)	CO_2 (Removals)	CH_4 (Emissions)	N_2O (Emissions)	CO_2 Equivalent (Emissions)
All energy	679,470	–	2,896	11.4	743,820
Industrial process	99,878	–	2	9	102,710
Agriculture	–	–	14,175	151	379,723
Land use, land usechange and forestry	37,675	23,533	6.5	0.04	14,292
Wastes	–	–	1,003	7	23,233

Total national emission (giga gramper year)	817,023	23,533	18,083	178	1,228,540

Source: Subodh Sharma (2006)

Table 2: Trends of GHG Emission in India

Greenhouse Gas Sources and Sink (Gg)	**1990 (CO_2 eq. mt)**	**1994 (CO_2 eq. mt)**	**2000 (CO_2 eq. mt)**	**CAGR in1999-2000**
All energy	622,587	743,820	959,527	4.4
Industrial process	24,510	102,710	168,378	21.3
Agriculture	325,188	344,485	328,080	0.1
Land use, land usechange and forestry	1,467	14,291	–	–
Waste management	14,133	23,233	26,637	7.3
Total emission (Gg)	987,885	1,228,539	1,484,622	4.2
Population	853	914	1,000	–
Per capita emission (tons/capita)	1.2	1.3	1.5	–

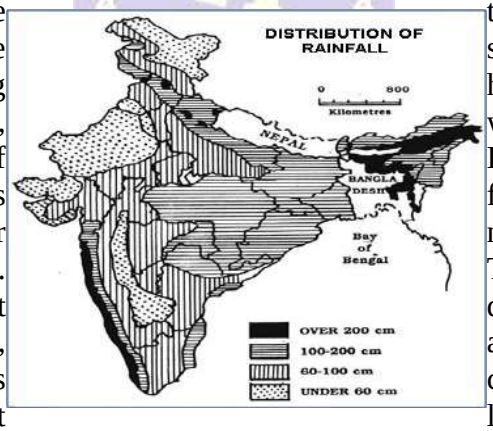
Source: Subodh Sharma (2006); ALGAS (1998); NATCOM (2004)

Tropical Cyclones: Tropical cyclones origi- nate over the Bay of Bengal and the Indian ocean. These tropical cyclones have very high wind velocity and heavy rainfall andhit the Tamil Nadu, Andhra Pradesh andOrissa coast. Most of these cyclones are very destructive due to high wind velocity and torrential rain.

INDIAN MONSOON

Arabic's "MAUSAM," which signifies season, is where the word "monsoon" originates. As a result, mon- soon are seasonal winds that shift direction with the season. In the summer, they flow from the sea to the land, and in the winter, they move the other way. The theories regarding the monsoons are generally divided into following two broad categories:

Classical theory: Halley explainedthe monsoon as resulting fromthermal contrasts between conti- nents and oceans due to their dif- ferential heating. In the summer, the sun shines vertically over the cancer tropic, causing high temperatures and low pressure in central Asia, while the pressure over the Arabian Sea and the Bay of Bengal remains suitably high. As a result, air flows from the sea to land, causing India and her neighbouring countries to experience intense rainfall. The tropic of Capricorn receives vertical sunlight during the winter. The monsoon flow is reversed, and the northwestern region of India becomes colder than the Arabian Sea and the Bay of Bengal. It lacked the physical components necessary to produce the effects of the earth's rotation.



Characteristics of Monsoonal Rainfall

Rainfall from the southwest monsoons is seasonal in character, which occurs between June and September.Monsoonal rainfall is largely governed by relief or topography. For instance the windward side of the Western Ghats registers a rainfall of over 250 cm. The heavy rainfall in the north- eastern states can be attributed to their hill ranges and the Eastern Himalayas.The monsoon rainfall has a declining trend with increasing distance from the sea. Kolkata receives 119 cm dur- ing the southwest monsoon period.

Rainfall Distribution

Areas of very high rainfall (annual rainfall of 200cm and above)

These include the west coast, which stretches from Mumbai in the north to Thiruvananthapuram in the south (Avg. annual rainfall 200 - 400 cm). Nearly all of Assam, Nagaland, Meghalaya, Mizoram, Arunachal Pradesh, Sikkim, portions of Manipur, Tripura, and the northeastern edge of West Bengal also get 200 cm or more of precipitation, with a few isolated pockets getting more than 400 cm. The wettest region of the nation is Meghalaya (The abode of clouds), where Mawsynram and Cherrapunji receive 1221 cm and 1102 cm of rainfall annually, respectively.

Areas of High rainfall (100-200cm annual rainfall) These include eastern slopes of the Western Ghats, major part of the northern plain, Orissa, M.P. Andhra Pradesh, and Tamil Nadu

Areas of Low rainfall (50 - 100 cm annual rainfall) Include large parts of Gujarat, Maharashtra, Western M.P., Andhra Pradesh, Karnataka, eastern Rajasthan, Punjab, Haryana andparts of Uttar Pradesh.

Areas of very Low rainfall (Less than 50cm of annual rainfall) These are desert and semi-deserts areas. They include large parts of Western Rajasthan, Kuchchh, and most of Ladakh region of Jammu and Kashmir.

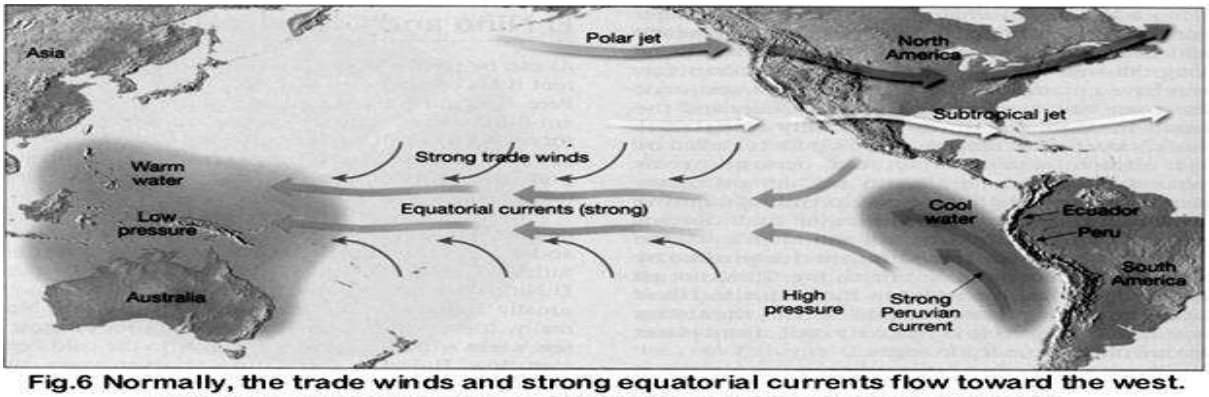


Fig.6 Normally, the trade winds and strong equatorial currents flow toward the west. At the same time, an intense Peruvian current causes upwelling of cold water along the west coast of South America.

WESTERN DISTURBANCES

Due to the polar front's passage south throughout the winter, middle latitude cyclone tracks arrive in the northern section of the Indian subcontinent between October and June. The Indian subcontinent is hardly ever affected by the tracks' significant poleward movement in the other months.The temperate cyclones, often referred to as western disturbances, originate in western Asia and the Mediterranean Sea and travel from west India to the Indian subcontinent in an easterly direction. These turmoils in the West are to blame. snowfall at the highest altitudes of the Himalayas. The rabi crop benefits from rain in the northwest plains. Along with the abrupt drop in temperature, there is also hail.

Modern theory:ITCZ; according of FEOHN monsoon is only the normal seasonal migration of planetary winds following the sun. According to him the existenceof Asian monsoon is not due to contrast between land and sea but mainly due to the annual migration of thermally pro- duced planetary winds and pressure belts under continental influence. The southeast trade winds of the southern hemisphere cross the equator and start flowing from southwest to northeast direction under the effect of Coriolis force. These displaced trade winds are called south west monsoon and bring monsoon to the region.

Role of jet streams; M.T.Yin had given this concept stating that the burst of monsoon depends upon the upper air circulation. Two prominent jet streams effect the monsoon winds The sub tropical westerly jet stream, this jet stream dominates in winter time in upper troposphere circulation of thenorthern latitudes. It has a global extent between latitudes 25-32 ° N and can be located over south Asia at an elevationof about 12 km. the jet stream is splitowing to the 0presence of Himalayan mountain system in its path.**Forest:** Global assessment has shown that future climate change is likely to have a significant impact on forest ecosystems. Climate is probably the most important determinant of vegetation patterns globally and has a significant influence on the distribution, structure and ecology of forest (Krischbaum *et al.*, 1996). India is a mega-

biodiversity country where forests account for about 20% (64 million ha) of the geographical area (State Forest Report, 2001).With nearly 200,000 villages classified as forest villages, there is obviously large dependence of communities on forest resources (Ravindranath *et al.*, 2006). Table 5 explains data from FSI which can be used to map the location of various types of forests across India.The major forest types in India (those occupying 0.5% or more of the forested area) are presented in Table 5. Forests in India are extremely diverse and heterogeneous in nature, and it is difficult to classify them into a small number of categories. As a result, the pan- Indian 'Miscellaneous forest' category (with no dominant species) shows the highest (63%) proportion. The miscellaneous forest area occurs under all the forest types. The other two most dominant forests are *Shorea robusta* or sal (12%) in the eastern part of Central India and *Tecton grandis* or teak (9.5%), spread across Central India and the Western Ghats in southern India.

Impact of Climate Change on Forest Types

The size of the projected changes in each of the forest types can be determined by comparing the area that is likely to occur in each under the two future climate scenarios and that under the current climate regime. Using the CRU3 10-min climatology, the BIOME42 model was ran for a total of 10,864 grid points (10 min x 10 min) across the Indian region. Only 10,429 of these grid points could have had vegetation types assigned to them by the model because of gaps in the data on soil parameter values. As previously indicated, we were able to use the data from 35,190 FSI grids by comparing it to the FSI database, which is accessible at a much finer resolution of 2.5 min x 2.5 min. The forest types allocated by FSI and those anticipated by BIOME4 had a respectable degree of agreement. As a result, temperate forests were shown to occur in regions corresponding to fir/spruce/deodar woods, while tropical evergreen forests were seen to occur in the southern Western Ghats and in the northeastern region (Ravindranath et al. 2006).

Increased Temperatures and Extreme Events

The effects of climate change will result in more frequent hot days, heat waves, droughts (declining water tables, crop failures, etc.), and cyclone-related natural disasters. Using data from 40 stations evenly spaced across India for the years 1970–2002, Kothawale (2005) analysed India's temperature extremes and found that circumstances are substantially more common in May than in June, while very few heat waves happened in the months of March and April. Additionally, he mentioned that during the pre-monsoon season, the number of hot days is greatest over the central region of India and the lowest in the west coast. More summer rainfall is anticipated as a result of the warming climate. The prospects for and effectiveness of climate policies will be influenced by the effects of climate variability and change, climate policy responses, and related socioeconomic development. Missions, the rate and magnitude of climate change, climate change impacts, the power to adapt to those changes, and the capacity to counteract those changes will all be significantly impacted by the socioeconomic and technological aspects of various development routes.

Conclusion:

The well-being of people is anticipated to be impacted by climate change in a variety of ways, including capital, ecosystem, disease, and migration. Regardless of how important the issue is, it is unclear how to calculate the value using the condition of the economics. A significant development at the very least entails lowering reliance on agriculture by shifting from an agricultural to a non-agricultural economy. Since the majority of the labour force—roughly 70%—depends on the sector for both employment and a means of subsistence, it will free up the necessary labour and capital for the manufacturing and service sectors when it becomes more productive and ensures food self-sufficiency. It is vital to demonstrate that India is far from being inert in the context of the present discussion about climate change and that significant steps in terms of policies, programmes, and projects are being implemented. Transferring technologies can hasten modernization efforts, while greater funding can hasten government efforts to conserve energy. However, strategies for reducing poverty must be given top attention.

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