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# Climate change trends in Indian states-an analysis

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**Abstract**

India must contend with the challenge of maintaining its rapid economic growth in the face of the world's climate is rapidly altered. The issue has been caused by accumulated greenhouse gas emissions in the atmosphere that humans have caused because of sustained, intensive industrial growth and high-consumption lifestyles in developed nations. India needs a strong national strategy to first adapt to climate change and second, to further improve the ecological sustainability of its development path, even though there is a need to continuously engage the international community to collectively and cooperatively deal with this threat.

To protect the planet and its resources and address the effects of climate change, the Indian government has implemented several technological and policy initiatives. A culture of a greener environment, a well-coordinated environment protection protocol between the government and citizens, and a general passion for protection and conservation also need to be developed. Additionally, there is a need for major national initiatives and grass-roots campaigns to raise awareness at all levels of society. In this essay, the maximum and minimum temperature trends and increases in the various Indian states are analysed.

The findings showed that over the previous six decades, several Indian states had significant state-wide warming in both the highest and lowest temperatures. But not all Indian states have experienced the same changes over the same length of time and geographic area. The rise in both the highest and lowest temperatures was responsible for the increase in spatial coherence and statistically significant warming observed in temperature trends. Even though many states do not have significant rainfall trends, it is alarming to see how consistently rainfall is declining across most of India's states, especially during the monsoon season.

**Key words:** Global climate, economic growth, astronomical cycles, natural resources, environment protection

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Climate change occurs over longer timescales, like decades. Until now, changes in the global climate have occurred naturally, over centuries or millennia, because of volcanic activity, continental drift, various astronomical cycles, changes in the sun's energy output, and other factors. In recent decades, it has become increasingly evident that human activities are changing the makeup of the atmosphere, which is causing global climate change[5].

Increased temperatures are a result of global warming's impact on the earth's climate. As a result, numerous species that depend on the fundamental rules of nature are impacted. Survival becomes a challenge when things change. Humans, plants, and animals are all impacted by a warming earth because it alters rainfall patterns. Greenhouse gas emissions into the atmosphere, such as carbon dioxide, methane, and nitrous oxide, are the main contributor to global warming. The major contributor to too much greenhouse gases is human usage of fossil fuels[4].

Climate change is expected to have an impact on all natural ecosystems as well as socioeconomic systems, according to India's National Communications Report to the United Nations Framework Convention on Climate Change[10].

With the third-largest ice mass in the world, the Great Himalayas, which are located in the north and are 7500 km long, and a densely populated coastline in the south, India is a sizable developing country. Of the one billion people living in the nation, 700 million are rural dwellers who depend on the agriculture, forestry, and fishing industries as well as natural resources like water, biodiversity, mangroves, coastal areas, and grasslands for their livelihoods. Additionally, the adaptability of forest dwellers, fishermen, and nomadic herders is comparatively low[12].

The monsoon plays a significant role in Indian agriculture, therefore its arrival early or late can cause changes in the market for agricultural products and other necessary goods. Rapid economic and population growth have resulted in severe environmental degradation due to climate change that threatens the environmental resource basis on which sustainable development is predicated[3]. Extremes of maximum and minimum temperatures as well as precipitation are expected to increase, particularly over India's west coast and west central region. The Ganges, Brahmaputra, Indus, and other river systems receive a significant amount of meltwater from the Himalayas, which are known for their quick mountain glacier retreat[13].

Human activity has sped up the natural process of climate change brought on by volcanic eruptions, continental drift, and astronomical cycles[6]. Scientists are looking into black carbon's role in climate change because of its ability to absorb solar energy strongly[14].

The main causes of environmental pollution and climate change are deforestation, growing urbanisation, and growing industrialization. For the sake of preserving the earth for future generations, it is imperative that the general population be made aware of the terrible effects that environmental degradation

of climate change has on human health[2].

Menon *et al*.,[9] used a global climate model to examine the impact of aerosols on the climate in China and India. They discovered a relationship between changes in precipitation and temperature and the amount of absorbing black carbon in the aerosols. The air is heated by black carbon aerosols, which changes the stability of the atmosphere and affects the hydrologic cycle and large-scale circulations.

Mumbai is one of the cities most vulnerable to climate change in the world, according to the UN-2010 HABITAT report[8]. Precipitation variations were observed across India over the past century 1901–2019[7].

A few examples of how the effects of climate change on human health include temperature rise, precipitation, more intense and frequent heat waves, floods, droughts, strong winds, and landslides[11]. Extreme heat waves, rising sea levels, changes in precipitation leading to cyclones, earthquakes, flooding, and droughts, powerful hurricanes, and deteriorated air quality are just a few of the environmental effects of climate change that directly and indirectly affect human physical, social, and mental health[1].

Climate change's fluctuations in temperature and precipitation, which can cause extreme heat, extreme cold, and unpredictable rain, all contribute to malnutrition, water and airborne infections, vector-borne diseases, the prevalence of diarrheal diseases, and heat-related morbidity and mortality. The maximum and minimum temperatures in Indian states are trended and analysed in this paper.

**Objectives**

1) Studying the maximum temperature trends in Indian states between 1951 and 2010 is one of the study's goals.
2) To evaluate the minimum temperature trends in the Indian states from 1951 to 2010.

Empirical data is the foundation of this study. To analyse the trend and growth of the maximum and minimum temperature trends in Indian states for the period 1951–2010, percentage techniques, linear trends, and compound growth rates were used. Among other sources, secondary data was gathered from the internet, books, newspapers, journals, and brochures.

*Maximum temperature trends in Indian states :*

Table 1 lists the stations that were used to create state-level temperature and rainfall time series for the years 1951 to 2010.

Based on information from 282 surface meteorological stations, Table-1 displays trends in annual and seasonal mean maximum temperatures at the state level for the years 1951 to 2010. In their state-level averaged annual mean maximum temperature time series, most Indian states have shown increasing trends, except Bihar, Chhattisgarh, Delhi, Haryana, Jammu and Kashmir, Meghalaya, Punjab, Tripura, and Uttar Pradesh. There were notable increases in the Andaman and Nicobar Islands, Andhra Pradesh, Arunachal Pradesh, Assam, Goa, Gujarat, Himachal Pradesh, Jharkhand, Kerala, Lakshadweep, Madhya Pradesh, Maharashtra, Manipur,

Table-1
Maximum Temperature Trends In Indian States

| State | Mean Maximum Temperature Trends in °C per year | | | | |
|---|---|---|---|---|---|
| | Annual | Winter | Summer | Monsoon | Post monsoon |
| Andaman &Nicobar | +0.02* | +0.02* | +0.01* | +0.02* | +0.02* |
| Andhra Pradesh | +0.01* | +0.02* | +0.01* | +0.01* | +0.02* |
| Arunachal Pradesh | +0.02* | +0.02* | No trend | No trend | +0.02* |
| Assam | +0.02* | +0.01 | No trend | +0.01* | +0.02* |
| Bihar | No trend | -0.01* | -0.02* | +0.01* | +0.01* |
| Chhattisgarh | No trend | No trend | No trend | No trend | +0.01 |
| Delhi | No trend | -0.01 | +0.01 | No trend | +0.01 |
| Goa | +0.04* | +0.05* | +0.04* | +0.03* | +0.05* |
| Gujarat | +0.01* | +0.01 | No trend | +0.01* | +0.01* |
| Haryana | -0.02* | -0.03* | -0.01 | -0.01* | No trend |
| Himachal Pradesh | +0.06* | +0.06* | +0.06* | +0.06* | +0.07* |
| Jammu & Kashmir | -0.01 | +0.01 | -0.01 | -0.04* | -0.01 |
| Jharkhand | +0.01* | +0.01* | No trend | No trend | +0.03* |
| Karnataka | +0.02* | +0.02* | +0.02* | +0.02* | +0.02* |
| Kerala | +0.01* | +0.01* | +0.01* | +0.02* | +0.01* |
| Lakshadweep | +0.02* | +0.02* | +0.02* | +0.02* | +0.02* |
| Madhya Pradesh | +0.01* | No trend | +0.01 | +0.01* | +0.02* |
| Maharashtra | +0.01* | +0.01* | +0.02* | +0.01* | +0.02* |
| Manipur | +0.03* | +0.04* | +0.01 | +0.03* | +0.03* |
| Meghalaya | No trend | No trend | No trend | +0.01 | +0.01* |
| Mizoram | +0.03* | +0.04* | +0.01* | +0.05* | +0.05* |
| Orissa | +0.01* | +0.01 | +0.01 | No trend | +0.02* |
| Punjab | -0.01* | -0.02* | No trend | -0.02* | No trend |
| Rajasthan | +0.01* | No trend | +0.02* | +0.01 | +0.01 |
| Sikkim | +0.02* | +0.02 | +0.03* | +0.03* | +0.01 |
| Tamil Nadu | +0.03* | +0.04* | +0.03* | +0.03* | +0.02* |
| Tripura | No trend | -0.01 | -0.02* | +0.02* | +0.02* |
| Uttar Pradesh | No trend | -0.01 | -0.01 | No trend | No trend |
| Uttarakhand | +0.02* | +0.02* | No trend | +0.01 | +0.03* |
| West Bengal | +0.01 | No trend | -0.01* | +0.02* | +0.02* |

Source: India Meteorological Department, Ministry of Earth Sciences, Government of India, 2013

Mizoram, Orissa, Rajasthan, Sikkim, Tamil Nadu, and Uttarakhand regions.

Table-2 shows that the annual mean maximum temperature increased in Himachal Pradesh by 0.06 degrees Celsius per year, followed by Goa (0.04 degrees per year), Manipur, Mizoram, and Tamil Nadu (0.03 degree Celsius per year each). Significant cooling trends of -0.01 ºC/year and -0.02 ºC/year

were observed in Punjab and Haryana, respectively. But between 1951 and 2010, there were no trends in Bihar, Chhattisgarh, Delhi, Meghalaya, Tripura, or Uttar Pradesh.

Table-2 shows trends in state-level annual and seasonal mean minimum temperature for 1951–2010 based on data from 282 surface meteorological stations.

Table-2
Minimum Temperature Trends In Indian States

| State | Mean Minimum Temperature Trends in °C per year | | | | |
|---|---|---|---|---|---|
| | Annual | Winter | Summer | Monsoon | Post monsoon |
| Andaman & Nicobar | No trend | +0.01 | No trend | No trend | No trend |
| Andhra Pradesh | +0.01* | +0.01 | No trend | +0.01* | +0.01 |
| Arunachal Pradesh | +0.02* | +0.02* | +0.02* | +0.01* | +0.02* |
| Assam | +0.01* | +0.02* | +0.01* | +0.01* | +0.02* |
| Bihar | +0.02* | +0.02* | +0.01* | No trend | +0.02* |
| Chhattisgarh | -0.01* | -0.01* | -0.02* | -0.01* | No trend |
| Delhi | +0.02* | +0.02* | +0.02* | +0.01* | +0.02* |
| Goa | No trend | -0.01* | -0.01* | +0.01* | +0.01* |
| Gujarat | +0.02* | +0.03* | +0.02* | +0.01* | +0.03* |
| Haryana | +0.01* | +0.02* | +0.02* | -0.01 | +0.01 |
| Himachal Pradesh | -0.01 | -0.02 | -0.03* | No trend | -0.03* |
| Jammu & Kashmir | -0.01 | No trend | -0.02 | -0.03* | -0.03* |
| Jharkhand | No trend | No trend | No trend | No trend | +0.01 |
| Karnataka | No trend | -0.01 | -0.01* | No trend | No trend |
| Kerala | +0.01* | +0.01 | No trend | No trend | +0.01* |
| Lakshadweep | +0.01* | +0.02* | +0.01* | No trend | +0.01* |
| Madhya Pradesh | No trend | No trend | No trend | -0.01* | +0.03* |
| Maharashtra | No trend | No trend | -0.01 | No trend | +0.01 |
| Manipur | +0.02* | +0.03* | +0.03* | +0.02* | +0.03* |
| Meghalaya | +0.01* | +0.02* | No trend | +0.01 | +0.02* |
| Mizoram | No trend | No trend | -0.01* | No trend | No trend |
| Orissa | -0.02* | -0.01 | -0.02* | -0.02* | -0.01 |
| Punjab | -0.01* | No trend | No trend | -0.01* | No trend |
| Rajasthan | +0.01* | +0.02* | +0.02* | No trend | +0.03* |
| Sikkim | +0.07* | +0.08* | +0.07* | +0.06* | +0.08* |
| Tamil Nadu | +0.02* | +0.02* | +0.02* | +0.02* | +0.02* |
| Tripura | +0.02* | +0.03* | No trend | +0.01* | +0.03* |
| Uttar Pradesh | No trend | +0.02* | No trend | -0.01* | +0.02* |
| Uttarakhand | -0.03* | No trend | -0.03* | -0.04* | -0.01 |
| West Bengal | No trend | +0.01* | No trend | No trend | +0.01* |

Source: India Meteorological Department, Lodi Road, New Delhi- 3

The past ten years have seen a sharp increase in the state-averaged annual mean minimum temperatures in Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Delhi, Gujarat, Haryana, Kerala, Lakshadweep, Manipur, Meghalaya, Rajasthan, Sikkim, Tamil Nadu, and Tripura. During the research period, Sikkim experienced the largest annual mean minimum temperature increase (+0.07 ºC/ year), followed by Arunachal Pradesh, Bihar, Delhi, Gujarat, Manipur, Tamil Nadu, and Tripura (+0.02 ºC/year each). Annual mean minimum temperature trends are sharply falling over Punjab (-0.01 ºC/year), Uttarakhand (-0.03 ºC/year), Orissa (-0.02 ºC/year), and Chhattisgarh. In Goa, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Mizoram, Uttar Pradesh, or West Bengal, the annual mean lowest temperature has not changed over the past six decades.

The analysis's results are presented in Table-3, which shows the pattern and Maximum and Minimum Temperatures in Indian states.

Table-3
Trend and growth of maximum and minimum temperature in Indian states

| Particulars | Trend Coefficients | | $R^2$ | CGR (percentage) |
|---|---|---|---|---|
| | a | b | | |
| Maximum Temperature | 5.89 | 0.049* (6.17) | 0.55 | 4.01 |
| Minimum Temperature | 5.14 | 0.043* (8.01) | 0.63 | 5.83 |

* Significant at 5 per cent level.
Note: CGR = Compound Growth Rate
Figures in parentheses indicate t-values.

In Indian states, the maximum and minimum temperatures have been rising at compounded growth rates of 4.01 percent and 5.83 percent, respectively, according to Table-3. Indicating a positive trend in maximum temperature and minimum temperature in Indian states, the trend coefficients are positive and significant at a 5% level. In Indian states, the maximum temperature trend coefficient is 0.049, and the minimum temperature trend coefficient is 0.043.

The results revealed that many Indian states have experienced significant state-wide warming in both the highest and lowest temperatures over the previous six decades. But not all Indian states have gone through the same changes over the same amount of time and territory. The increase in spatial coherence and statistically significant warming seen in temperature trends was due to increases in both the highest and lowest temperatures. Although many states do not have significant rainfall trends, the spatial consistency of the decrease in rainfall across the majority of Indian states, particularly during

the monsoon season, is concerning.

**Conflicts of Interest**

The author do not have any conflict of interest.

References :


1. Amutha, D. and M. Juliet, Impact of Climate Changes on Human Health in India (November 14, 2017). Available at SSRN: https://ssrn.com/abstract=3071055 or http://dx.doi.org/10.2139/ssrn.3071055
2. Amutha, D., Air Pollution and Its Impact on Human Health (October 19, 2022). Available at SSRN: https://ssrn.com/abstract=4252870 or http://dx.doi.org/10.2139/ssrn.4252870.
3. Amutha, D., Climate Variability and Food Grains Production in India (2012). Available at SSRN: https://ssrn.com/abstract=2119863
4. Amutha, D., Global Warming and Climate Change in Tuticorin District (July 8, 2014). Available at SSRN: https://ssrn.com/abstract=1636164 or http://dx.doi.org/10.2139/ssrn.1636164.
5. Fourth Assessment Report. Geneva: IPCC; (2007). Intergovernmental Panel on Climate Change. Climate Change 2007: Synthesis Report.
6. IPCC (2007). "Summary for policymakers," in Climate change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the IV Assessment Report of the Intergovernmental Panel on Climate. Intergovernmental Panel on Climate Change (IPCC) (Cambridge: Cambridge University Press).
7. Kuttippurath, J., S. Murasingh, P. A. Stott, B. B. Sarojini, M. K. Jha, and P. Kumar, *et al.* (2021). *Environ. Res. Lett. 16:* 024018. doi: 10.1088/1748-9326/abcf78
8. Mehta, L., S. Srivastava, H. N. Adam, S. Bose, U. Ghosh, and V. V. Kumar, (2019). *Region. Environ. Change 19:* 1533–1547. doi: 10.1007/s10113-019-01479-7
9. Menon, S., J. Hansen, L. Nazarenko, and Y. Luo, (2002). *Science 297:* 2250–2253. doi: 10.1126/science.1075159.
10. Ministry of Environment and Forests. New Delhi: 2004. India's Initial National Communications to the United Nations Framework Convention on Climate Change.
11. Orimoloye, I. R., S. P. Mazinyo, A. M. Kalumba, O. Y. Ekundayo, and W. Nel, (2019). *Cities 91:* 213–223. doi: 10.1016/j.cities.2019.01.009.
12. Ravindranath N.H. and J. Sathaye (2002). Climate Change and Developing Countries. Dordrecht, Netherlands: Kluwer Academic Publishers.
13. Smith J.B. (2001) Vulnerability to climate change and reasons for concern: A synthesis. In: McCarthy JJ, editor. Climate change Impacts, adaptation and vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press; pp. 913–67.
14. Surendran, D. E., G. Beig, S. D. Ghude, A. S. Panicker, M. G. Manoj, and D. M. Chate, *et al.*, (2013). *Int. J. Photoenergy* 2013:313652. doi: 10.1155/2013/313652.