

Ecological and Evolutionary Responses to Recent Climate Change in India: A Review

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Abstract

One of the most significant environmental challenges the world faces today is climate change. India faces a multitude of challenges. A rise in temperature, agriculture, water resources, forests and biodiversity, health, and coastal management are all adversely affected by climate change. The objective of the present review is to discuss the impact of climate change on "India", The ecological and evolutionary responses to these changes, and the promotion of sustainable development in the Indian context.

Keyword: Climate, environment, Climate changes, Ecological, Evolutionary, sustainable growth.

Introduction

Changes in atmospheric conditions worldwide, including atmospheric temperature, precipitation, wind speed, carbon dioxide concentrations, groundwater tables, ocean levels, solar ultraviolet rays, and forest cover, are all adverse effects of climate change that have occurred within the last six to seven decades. The physiology of "global population" of microorganisms, plants, animals, and humans is perceptibly altered by these long-term changes, which surpass the threshold magnitude.

It is believed that the accumulation of trace gases in the atmosphere, such as carbon dioxide (CO₂) and methane (CH₄), is altering the climate system of the planet. This accumulation is primarily the result of human activities, such as the combustion of fossil fuels. In its fourth assessment report, the Intergovernmental Panel on Climate Change (IPCC) stated, "Observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and a rising global sea level now unequivocally demonstrate that the climate system is warming". India has just cause for apprehension regarding climate change, given that a substantial portion of its populace relies on climate-sensitive industries for sustenance, including agriculture, forestry, and fishery. Due to the detrimental effects of climate change—a reduction in precipitation and an increase in temperature—the country is currently grappling with a greater array of threats to its means of subsistence. Rapid industrialization, urbanization, and economic development have already placed enormous strains on ecological and socioeconomic systems; climate change would exacerbate these strains. (Giri, 2020).

A. Demographical Features of India

2001 Census of India data revealed that the urban populace comprised 286 million individuals, or 27.80%, of the country's total 1.02 billion inhabitants. It was anticipated that this population will increase to "368 million" by 2012. India's metropolitan populace, residing in 5,161 cities and villages, is confronted with severe sanitation and water shortages.

A "World Bank report" on India's water economy asserts that the country is rapidly depleting its water resources and will face significant strain by 2030. Furthermore, the report projects that by 2050, the demand for water will surpass the supply. In an environment of rapid economic expansion, water demand will inevitably increase. The irreversible release of "millions of tons of carbon dioxide" through the atmosphere, even if it comes primarily from a small number of nations, could cause catastrophic climate change with far-

reaching effects, including the flooding of many islands and coastal areas due to rising sea levels, and changes in cropping patterns and agricultural output due to higher average temperatures. (Borah, 2023)

India, a substantial developing nation, is home to an approximate 700 million rural inhabitants whose livelihoods are directly reliant on natural resources and climate-sensitive sectors, including but not limited to water, grasslands, coastal areas, and biodiversity. Additionally, that of nomadic shepherds, forest-dwellers, and dry-land cultivators is extremely low. Kyoto Protocol is now widely regarded as a "failure" despite its symbolic significance, as it has not initiated global emission reductions and has not committed to further mandatory cuts in "greenhouse gas emissions". Despite the fact that scientists have long cautioned that even complete adherence to the Kyoto Protocol would have little impact on limiting climate change, nearly 15 years have been spent worldwide developing this policy failure. The Kyoto Protocol's near-exclusive emphasis on mitigation is detrimental to the interests of developing nations. The climate crisis is caused by the unsustainable consumption habits of the wealthy industrialized nations. Despite only having 25% of the world's population, these countries are responsible for more than 70% of the world's CO₂ emissions as well as consume 75-80% of many other resources.

B. Impacts of climate change in India

Over the next century, climate change will threaten the availability of safe drinking water, nutritious food, and medical treatment for one billion Indigenous people. The water resources of India are extremely unequal. The harshest regions are located in the northeast and northwest. Over the past few years, India has experienced a diverse range of severe meteorological phenomena. The disastrous 2016 drought adversely affected 330 million individuals across ten states and caused \$100 billion in damages. Climate change's effects on India's water supplies are difficult to generalize about due to the wide diversity among the country's several regions and river basins. As a consequence of climate change, the water resources in India continue to be inadequate to support transdisciplinary integration. Conversely, consequences for health include heightened vulnerability to heat and inadequate air quality, drastic climate fluctuations, and alterations in the transmission of vector-borne illnesses due to influences from socioeconomic, cultural, and biological factors. Rapid environmental change in India poses a risk that climate change will worsen existing health disparities between the sexes. By integrating a gendered perspective into established

policy frameworks for climate change, development, and disaster risk reduction, it is possible to mitigate adverse health impacts and exert control over their proliferation. Reducing climate risks requires multi-sectoral cooperation, better data collecting, monitoring of gender-specific objectives, and equal participation and security for all stakeholders.

An enormous number of individuals are affected annually by drought in India. Due to the monsoon's unpredictability, food security as well as socioeconomic fragility are in jeopardy as one-third of the nation is afflicted by drought. Dry terrain (dry subhumid, arid, and semi-arid) comprises approximately 2,28,106 km² of India. While the incidence of long-term droughts has decreased over the last three decades, the severity of short-term, vegetation-related, and meteorological droughts has risen. The IPCC SRES A2 scenario, which incorporates seventeen global climate models, projects an increased frequency of droughts in the western and central regions of India during the latter half of the 21st century.

The agricultural development and water resources in India, along with the flow and proliferation of glaciers, can be impacted by the Indus, Ganges, as well as Brahmaputra rivers. In Indus, Ganges, as well as Brahmaputra basins, India has a total of 9,040 glaciers covering an area of 18,528 kilometers. With only a few exceptions, long-term mass balance data indicates that the glaciers of the Indian Himalayas have been experiencing mass loss for the past forty years. For instance, between 1960 and 2004, glacial retreat in Indian Himalayan region averaged between 0.2 and 0.7 percent per year across eleven river basins, with a mean extent of 0.32 to 1.4 km². The mass balance of the "Chhota Shigri Glacier" (15.7 km²) in the Chandra River catchment of Himachal Pradesh indicates a net loss of 1,000 meters from 2002 to 2009. In the Western Himalayas, tree ring width data from the "Gangotri Glacier" indicates that significant glacier retreat over the past four centuries has contributed to elevated winter temperatures. Satellite imagery revealed that the Zemu Glacier, situated in "Sikkim Himalayan region", exhibited a diminished snout portion when compared to the toposheet of the same area that was previously studied. In the coming years, certain regions of country are going to be hardest affected by global warming.

C. Ecological and Evolutionary responses

1- Ecological Response

The global climate has experienced two significant periods of warming, from 1976 onwards and between 1910 and

1945. Compared to the first era, the second period has seen the fastest pace of warming in the past thousand years, at around double the previous maximum. However, ecological communities, populations, and organisms do not react to approximations of global averages. A multitude of organisms exhibiting varied geographical distributions have been found to have been impacted by the recent climatic changes, as supported by an abundance of evidence.

Phenology: Monitoring the temporal patterns of seasonal plant and animal behaviors is arguably the most straightforward method for discerning ecological shifts caused by climate change. Particularly, birds, butterflies, and untamed plants comprise species that are well-known and readily distinguishable; as a result, they have garnered considerable public interest. Spring activities often undergo temporal alterations. These include the breeding or initial singing of birds occurring earlier, the arrival of migrant birds earlier, the appearance of butterflies earlier, amphibian choruses and reproduction occurring earlier, and plant shooting and flowering occurring earlier.

Environmental links: Unlike the climatic parameters that influence fall phenology, the climatic signal that governs spring phenology is very well understood: almost every phenophase is correlated with temperatures in the months leading up to spring. Migratory bird populations are sensitive to weather conditions.

Range shifts to keep up with climate change: By influencing species' physiological thresholds for temperature and precipitation tolerance, climatic regimes impact species' ranges, as is well acknowledged. These 'climate envelopes' migrate toward higher altitudes or the poles as a result of trending global warming. It is reasonable to assume that species will adapt to a changing environment by moving their ranges northward in latitude and higher in elevation, provided that dispersion and resource availability permit. When other variables, like light, restrict latitudinal distributions, range shifts in reaction to temperature changes may not take place (for instance, in reef-building corals).

Species interactions in terrestrial systems: Like other ectotherms, amphibians and reptiles are profoundly affected by their environments, which manifests itself in direct climatic impacts on development, geographic distribution, and interactions between species. Their population dynamics and reproductive physiology are both influenced by temperature and humidity.

2- Evolutionary Responses

Adaptation to environmental changes is a critical and virtually ubiquitous component of biotic responses to climate change. Here, we argue that adaptive responses influence the migration rate and persistence of species, as well as forest efficiency. Thus, a more comprehensive understanding of climate-related adaptive responses is required. In addition, fossil records have the potential to serve as empirical laboratories for evolutionary hypotheses, thereby augmenting comprehension of the evolutionary ramifications associated with climate change. Extinction and speciation events pertaining to animal phyla, specifically mammals, have been extensively documented over the last two million years. In contrast, there are very few instances of newly-discovered vascular plant species in the Quaternary fossil record, which lends credence to the idea that evolution is painfully slow for these creatures in particular. Nevertheless, speciation constitutes merely one facet of the process of evolutionary change. The widespread and quick pace of evolutionary change is confirmed by the fact that populations within a species exhibit genetic diversity.

Genetic Diversity: Biodiversity systems are facing mounting challenges in the 21st century due to the accelerated climatic change. During the past 500 million years, there have been five major biodiversity crises, each of which has led to the loss of 76% of all living species. Species extinction is only one way in which climate change is affecting biodiversity. Climate change is affecting biodiversity on many different scales, from the genetic to the ecological to the biome level. This includes large life zones like tropical rainforests, savanna and tundras, as well as more frequent and intense extreme weather events and altered precipitation patterns. Additional stressors are imposed on biodiversity as a result. There are several tiers of biodiversity that are affected by climate change. These include functional diversity, gene diversity, species diversity, and ecosystem diversity. Because of how interdependent all the levels are, destroying even a single one would bring down the whole system. The frequency and pool of genes are both impacted by genetic losses. Species diversity is directly impacted by it. Changes in phenology, invasive species, adaptability, migration, and geographic distribution are some of the ways in which climate change affects populations and species.

D. Climate Change and Sustainable Growth

As a result of 1992 "United Nations Conference on Environment and Development" adoption of Agenda 21 and its accompanying conventions, all discussions regarding

global climate change policy have become more environmentally sustainable. It is commonly understood and applied that the Brundtland Commission defines it as "development that satisfies present needs while safeguarding the ability of future generations to provide for their own necessities." Over time, sustainable development has undergone a transformation into a comprehensive notion that incorporates environmental, social, and economic factors. While sustainable development does not preclude the utilization of limited natural resources or assets, it does require that any such utilization be adequately offset. This approach is rejected by developing nations due to its failure to consider their objectives regarding growth and evaluation.

Moreover, robust economic expansion is detrimental to the achievement of sustainable development in developing nations. The achievement of sustainable development necessitates the interplay between environmental preservation, social equity, and economic expansion. Must current economic benefits (such as employment and GNP) be compromised in order to safeguard the environment? Frequently, policymakers in developing countries perceive environmental sustainability and wage growth as reciprocal. Environmental conservation is becoming increasingly apparent to be an obligation rather than a commodity, particularly in developing nations where economic development and growth have been most pronounced over the past several decades. Climate change is anticipated to exacerbate the degradation of natural assets and resources, including wildlife, water, soil, forests, land, and groundwater, within the next 25 to 50 years, as a result of ongoing unsustainable practices.

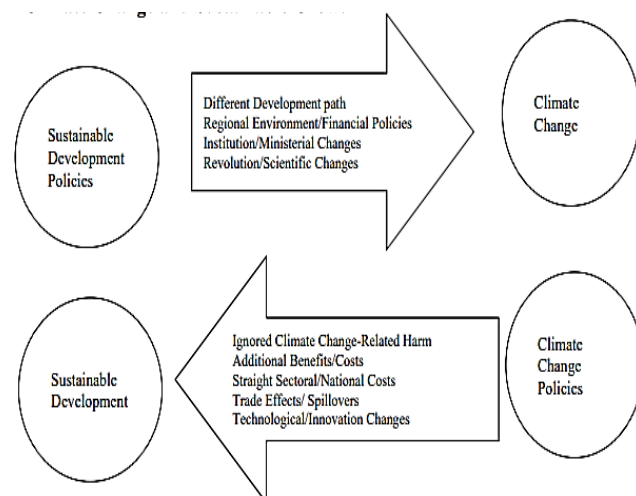


Figure-1 Linkages between sustainable development, climate change, and policies

Already, India is facing serious issues with environmental deterioration and freshwater scarcity. The pursuit of sustainable development strategies that contribute to the control of climate change may be approached in several ways. Some instances are shown below:

- Reduced emissions of greenhouse gases and the use of value energy-efficient technologies in power production, transmission, and allocation may save costs while preserving the environment.
- A better energy supply in the long run and less pollution in the neighborhood are two benefits of switching to renewables, that are often now affordable.
- Conservation of biodiversity, protection of shorelines, creation of local jobs, improvement of incomes for forest dwellers, and augmentation of carbon sinks may all be achieved by jungle management strategies, including afforestation, replanting, and preservation of forests.
- Congestion, pollution, and emissions of greenhouse gases may all be reduced with the aid of public transit systems like metro rails that are fast, reliable, and efficient.
- A long-term plan for rural development may include agricultural, local energy, and forest management to either enhance carbon sinks or decrease emissions of greenhouse gases.
- Reduced carbon emissions are an inevitable byproduct of reasonable energy prices grounded in the long-run marginal-cost concept, which can spur the adoption of renewable energy systems and efficient energy sources, increase utility companies' financial stability, and level the playing field for renewables.

II. Literature Review

(Borah, 2023) Due to its vast size, India is home to a wide variety of climatic zones, from tropical to dry. Climate change affects a large population, which has knock-on effects on human security and sustainable development. Using a narrative review approach, this research seeks to comprehend two main facets of climate-change: environmental problems and human security as they pertain to India. Its ultimate goal is to comprehend the effects of

climate change on long-term advancements and human security.

(Sharma et al., 2022) In light of global warming and economic growth, India's situation is fascinating. Even though India has a lot of natural resources (forests, solar power, etc.), getting to a zero-carbon economy would be a long process since the country lacks the necessary funding and expertise. Prompt climate change initiatives, such as COP26, are economically taxing and often met with resistance. The Indian economy is now suffering greatly as a result of the inevitable changes in climatic parameters brought about by climate change. But future progress will be impeded if we do not aim for an economy without emissions. Conflicts between energy needs and climate change initiatives are common. As a result of climate change's effects on agriculture, half of India's population is at risk.

(Pandya & Bharad, 2022) To assess the impact on the "Indian economy" and its numerous sectors, a quick study was conducted using several factors, including temperature and precipitation, that have significantly contributed to climate change. By using various analytical techniques, pertinent charts and estimations have been computed and reached in order to comprehend the primary goals of evaluating the effects of this alteration. We have estimated many variables and found their relevance using a regression-based modeling technique. The report's main conclusions demonstrate the substantial impact of climate change on the agriculture industry. Its effects on the service sector are small, but those on secondary sector are substantial, as anticipated.

(Kalakoti, 2021) Warming of the Earth's atmosphere and seas over long periods of time is what's known as global warming. A shift in the Earth's climate that scientists think will last forever. One of the most pressing environmental issues of our day is the threat of climate change and associated global warming. India has a number of issues. A number of sectors, including agriculture, water resources, health, biodiversity, coastal management, and temperature, are vulnerable to the negative effects of climate change. The most noticeable effect of climate change in India is a decrease in agricultural production. Directly or indirectly, agriculture supports the bulk of the people. Rapid industrialization, urbanization, and economic expansion are already putting a great strain on natural and social systems, and climate change will only make matters worse. Using India as a case study, this article examines the effects of climate change from several angles.

(Giri, 2020) One of the most pressing environmental problems in the modern world is climate change. India has a number of issues. A number of sectors, including agriculture, water resources, health, biodiversity, coastal management, and temperature, are vulnerable to the negative effects of climate change. The most noticeable effect of climate change in India is a decrease in agricultural production. Directly or indirectly, agriculture supports the bulk of the people. In a world where industrialization, urbanization, and economic expansion are already putting enormous strain on ecological and social systems, climate change would add to that stress.

(Husain & Javed, 2019) Using a quantitative research approach and secondary data on "climate change variables", GDP, and the population of India from 1980 to 2016, this study analyzes the impact of climate change on the Indian economy during that time. Both data.gov.in and the World Bank database were used to get the information. To analyze the data, researchers used E-views 9.0 and SPSS 22.0. They employed statistical approaches such "Multiple Regression Analysis and Pearson Correlation" to look for patterns in how climatic factors affected India's economic development. The study's results demonstrate that population and climatic change factors (rainfall and temperature) affected India's economic development in tandem, but that neither rainfall nor temperature had a statistically significant effect on economic growth in India on their own.

(Behera et al., 2019) A changing climate is constantly modifying biodiversity. Reorganizations of biological relationships occur as a result of conditions changing at varying rates around the globe. Responses to climate change may be produced by the carbon cycle as well as the water cycle, two of the most crucial large-scale processes for life on Earth, which rely on biodiversity at the genetic, ecological, and species levels. India has also shown in several studies the cause-and-effect relationship between this "feedback mechanism of climate change" & its effects. We have 25 articles in this special edition, written by almost 90 writers from India and throughout the world, that cover a broad range of topics related to biodiversity and climate change.

(Alex & Kumar, 2019) Using scientometric analysis, researchers in India evaluated climate change studies conducted between 1991 and 2018. The data were retrieved from the Science Citation Index, a component of the Web of Science. Researchers tracked the growth of climate change studies across 28 years, from 1991 to 2018. "Climate Change" was the query used to explore the repository. To

get climate change data for India, we narrowed our search to the years 1991–2018, utilized the "Subject" column, and restricted our selection to the nation itself. The total number of records that were found and downloaded is 5,360. We looked at the data to see how the data was distributed by year, by document, by prolific institution or organization, by important research topic, by journal, and by most productive writers in the field of climate change.

III. CONCLUSION

Current public attention is undeniably focused on climate change, which is poised to worsen if no action is taken by humans immediately. The primary objective of this paper was to project the comprehensive effects of climate India after looking at multiple studies it was concluded that the resources has been rapidly depleting along with vast difference in past years reports conducted on population. There were also different responses from ecological and evolutionary parameters which ranged from change in habitat of species to gene losses. With all discussion regarding such big climate change government has come out with several policies one of them being sustainable growth which is also discussed.

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