

CLIMATE CHANGE AND ITS IMPACT ON INDIA

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ABSTRACT

Climate change is one of the main environmental challenges facing the world today. India is facing several problems. Climate change is associated with various adverse impacts on agriculture, water resources, forest and biodiversity, health, coastal management and increase in temperature. Decline in agricultural productivity is the main impact of climate change on India. A majority of population depends on agriculture directly or indirectly. Climate change would represent additional stress on the ecological and socioeconomic systems that are already facing tremendous pressure due to rapid industrialization, urbanization and economic development. This paper analyzes the impact of climate change and its various aspects in the Indian context.

KEYWORDS: Climate change, Environment, Biodiversity, Impact of Climate Change.**INTRODUCTION**

Climate is one of the most important components of the Earth's environmental system. It is determined by long term interaction among the atmosphere, oceans, land surface, cryosphere and living organism. Natural variations in climate have occurred throughout Earth's history, however the magnitude and rapidity of contemporary climate change are strongly associated with human activities, particularly the increasing concentration of greenhouse gases in the atmosphere. Carbon dioxide, methane, nitrous oxide and other greenhouse gases enhance the natural greenhouse effect and contribute to global warming. Change in temperature are accompanied by alteration in precipitation patterns, melting of glaciers and ice sheets, sea level rise, ocean warming and increasing frequency or intensity of some extreme weather events.

Environmental change is broader than climate change alone. It includes change in land use, soil degradation, water pollution, air pollution, biodiversity loss, habitat fragmentation, deforestation, desertification, chemical contamination and alteration of freshwater and marine ecosystem. These processes are interconnected, for example deforestation can reduce biodiversity and ecosystem services while also releasing stored carbon into the atmosphere. Similarly, climate change can identify droughts, forest, fires, floods, and species range

shifts, which may further accelerate ecosystem degradation. Therefore, nature, climate and environmental change must be examined as an interconnected system rather than as isolated problems.

Biodiversity is particularly important in maintaining the resilience and functioning of ecosystems. Forests, grasslands, wetlands, rivers, mountains, agricultural landscapes, and marine ecosystems support diverse communities of plants, animals and microorganism. Biodiversity contributes to pollution, nutrient cycling, soil formation, water purification, carbon storage and natural pest control.

Accumulation of trace gases such as carbon dioxide (CO₂) and methane (CH₄) in the atmosphere, caused mainly due to anthropogenic activities such as burning of fossil fuels, is believed to be altering the Earth climate system. The Intergovernmental Panel on Climate Change (IPCC) in its fourth assessment report observed that "warming of climate system is now unequivocal, as is now evident from observations of increases in global sea level" (Soloman *et al*, 2007). India has a reason to be concerned about climate change, as a vast population depends on climate sensitive sectors like agriculture, forestry and fishery for their livelihood. The adverse impact of climate change in the form of decline in rainfall and rise in the temperature has resulted in

increased severity of livelihood issues in the country. Climate change would represent additional stress on the ecological and socioeconomic systems that are already under tremendous pressure due to rapid industrialization, urbanization and economic development.

Climate change is one of the most important global environmental challenges facing humanity with implications for food production, natural ecosystems, freshwater supply, health etc. According to the latest scientific assessment, the Earth climate system has demonstrably changed on both global and regional scales since the pre-industrial era. Further evidence shows that most of the warming, observed over the last 50 years, is attributable to human activities (IPCC, 2001).

This unprecedented increase is expected to have severe impact on the global hydrological system, sea level, crop production and related processes. The impact would be particularly severe in the tropical areas, which mainly consist of developing countries, including India (Jayant *et al*, 2006). India is a large developing country with nearly 700 million rural population directly depending on climate sensitive sectors and natural resources such as water, biodiversity, mangroves, coastal zones, and grasslands for their subsistence and livelihood. Further, the adaptive capacity of dry land farmers, forest-dwellers and nomadic shepherds is very low. Despite being symbolically important, Kyoto Protocol is now widely considered as a 'failure' because it neither has initiated emission reduction globally nor it has promised required further cuts in greenhouse gas emission.

India should be connected about the climate change because it might have adverse impact on the country. Not all possible consequences of climate change are yet fully understood, but the main 'categories' of impacts are those on agriculture, rise in sea level leading to submersion of coastal areas and increased frequency of extreme events which pose serious threats to India. The paper discusses elaborately the impact of climate change on India, especially in agriculture, water, health, forest, sea level and risk events.

SCIENTIFIC BASIS OF CLIMATE CHANGE

The Earth's climate system is regulated by interactions among the atmosphere, hydrosphere, lithosphere, biosphere, and cryosphere.

- **Major greenhouse gases include**

Carbon dioxide (CO₂), Methane (CH₄), Nitrous Oxide (N₂O), Water vapour, Ozone, Fluorinated gases.

- **Drivers of climate change**

Burning fossil fuels, Deforestation, Industrial emissions, Agricultural activities, Rapid urbanization, waste generation.

- **Evidence**

Increase in global average temperature, Glacier retreat, Arctic sea ice decline, sea level rise, Increased frequency of extreme weather, Ocean warming and acidification.

- **Nature and Biodiversity**

Biodiversity includes – Genetic diversity, Species diversity, Ecosystem diversity.

- **Healthy biodiversity provides**

Pollination, Soil fertility, water purification, food scarcity, disease regulation.

- **Major threats include**

Habitat destruction, climate change, pollution, Invasive species, Overexploitation.

Climate and scientific research

Scientific research plays a central role in understanding these changes. Environmental science integrates knowledge from ecology, climatology, geology, geography, biology, chemistry, atmospheric science, hydrology and social science. Modern scientific approaches include long term environmental monitoring, satellite, remote sensing, geographic information systems, climate modeling, biodiversity assessment, ecological indicators and analysis of historical environmental records. These methods help researches identify environmental trends, understand their causes, assess ecological and socioeconomic impacts, and develop strategies for adaptation and mitigation.

Environmental changes

Physical changes

Rising temperature, Sea level rise, Desertification, Glacier melting.

Chemical changes

Air pollution, Water pollution, Soil pollution, Ocean acidification.

Biological changes

Species extinction, Habitat fragmentation, Migration of species, Coral bleaching.

Impacts of Climate Change

Climate change refers to long term changes in temperature, rainfall, wind patterns, and other climatic conditions of the Earth. Although climate has changed naturally throughout geological history, the present rate of climate change is largely associated with human activities, particularly the burning of fossil fuels, deforestation, industrialization, transportation, and unsustainable agricultural practices. These activities increase the concentration of greenhouse gases such as carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (NO₂) in the atmosphere, resulting in global warming and changes in the climate system.

Climate change arising due to the increasing concentration of greenhouse gases in the atmosphere since the pre-industrial times has emerged as a serious global environmental issue and poses threats and challenges to mankind. Climate change is increasingly recognized as one of the potential critical factors in sustainable development trajectories and there is an emerging international literature that considers methodological issues and empirical results of studies that explore inter linkages, trade-offs and synergies between the different in India. Similarly, increase in emissions from the waste sector can be attributed to increase in quantity of waste generated due to the large influx of population from villages to cities (Gaikwad *et al* 2004).

Climate change is not limited to an increase in temperature. It affects rainfall patterns, glaciers, oceans, ecosystem, agriculture, biodiversity, human health, water resources, and the economy. Its impacts vary geographically, but vulnerable populations and developing regions are generally more exposed to climate related risks.

Impact on Temperature and Weather Patterns

One of the most direct effects of climate change is the rise in average global temperature. Increasing temperatures contribute to more frequent and intense heat waves. Extreme temperatures can cause heat stress in humans and animals and reduced agricultural productivity. Climate change may experience intense rainfall and flooding, whereas others may face prolonged droughts.

Change in atmospheric conditions can increase the frequency or intensity of certain extreme weather events. Heavy rainfall, storms, floods, droughts and heat waves can cause damage to homes, infrastructure, agricultural land, forests, and ecosystems. Such events also create economic losses and may force people to migrate from affected areas.

Impact on Agriculture and Food Security

Agriculture is highly dependent on temperature, rainfall, soil moisture, and seasonal climatic conditions. Climate change can therefore have serious consequences for crop production. Higher temperature may shorten the growing period of some crops and reduce yields. Irregular rainfall can create water shortages during critical stages of crop growth, while excessive rainfall may cause soil erosion, water logging, and crop damage.

Climate change may also influence the distribution and abundance of agricultural pests and diseases. Warmer conditions can allow some pests and diseases causing organisms to survive and spread into areas where they were previously uncommon. Livestock are also affected by heat stress, water scarcity, change in fodder availability, and the spread of diseases.

These changes can threaten food, security, particularly for communities that depend heavily on rain-fed agriculture. Adaptation measures such as drought resistant crop diversification, improved soil management, and climate resilient agricultural practices can help reduce these risks.

Impact on Water Resources

Climate change has significant effects on freshwater resources. Increasing temperatures accelerate evaporation, while changes in rainfall influence the availability of surface and groundwater. Melting glaciers and changes in snow cover can alter river flows, particularly in region dependent on glacier-fed rivers.

Droughts can reduce water availability for drinking, irrigation and industrial activities. On the other hand, intense rainfall can cause flooding, soil erosion and contamination of water supplies. Therefore, climate change can create both water scarcity and excess-water problems.

Impact on Biodiversity and Ecosystems

Climate change is a major threat to biodiversity. Plants and animals have specific temperature and environmental requirements. Rapid climatic changes can make existing habitats unsuitable for many species. Species may respond by changing their geographical distribution, seasonal activities, migration patterns or reproductive cycles.

Changes in temperature and rainfall can affect, grasslands, wetlands, rivers and other ecosystems. Some species may adapt, but species with limited mobility or specialized habitat requirements may face a higher risk of population decline or extinction.

Climate change can also disturb ecological relationships such as predator-prey interactions, pollination and food availability. Changes in flowering and fruiting seasons may create a mismatch between plants and the animals that depend on them.

Impact on Forests and Wildlife

Forests are particularly sensitive to changes in temperature and rainfall. Increased temperature, drought and changing precipitation can increase the risk of forest fires and forest degradation. Changes in vegetation can affect the availability of food, water and shelter for wild animals.

Wildlife may be forced to move toward more suitable habitats, increasing competition for resources and potentially bringing animals into greater contact with human settlements. Climate related habitat changes can therefore contribute to human wildlife conflicts.

Forest ecosystems are also important carbon sinks. Their destruction releases stored carbon dioxide into the

atmosphere and further contributes to climate change, creating a feedback cycle.

Impact on Oceans and Coastal Areas

The Oceans absorb a substantial amount of the excess heat associated with global warming. Increasing ocean temperatures can cause coral bleaching and affect marine organisms. Rising atmospheric carbon dioxide also contributes to ocean acidification, which can negatively affect organisms that form shells or skeletons.

Sea-level rise is another important consequence of climate change. Thermal expansion of freshwater and melting glaciers and ice sheets contribute to rising sea levels. Coastal communities may face increased flooding, coastal erosion and saltwater intrusion into freshwater resources and agricultural land.

Impact on Human Health

Climate change can directly and indirectly affect human health. Heat waves increase the risk of heat exhaustion, heat stroke and other heat-related illnesses. Floods and extreme weather events can cause injuries, deaths and displacement.

Changes in temperature and rainfall can influence the distribution of disease vectors such as mosquitoes and other organisms. Climate-related water shortages may also affect sanitation and hygiene. In addition, climate-related disasters, displacement and loss of livelihoods can create psychological and social stress.

Socio-Economic Impacts

The effects of climate change extend to the economy and society. Extreme weather events can damage roads, bridges, houses, electricity networks, communication systems and agricultural infrastructure. Governments and communities may need to spend large amounts on disaster management, rehabilitation and reconstruction.

People whose livelihoods depend directly on natural resources, such as farmers, fishers and forest-dependent communities, can be especially vulnerable, water scarcity and environmental degradation may contribute to poverty, migration and social inequality.

Impact on Ecosystem Services

Natural ecosystems provide important services such as food production, pollination, water purification, soil formation, carbon storage and climate regulation. Climate change can reduce the capacity of ecosystems to provide these services.

Mitigation and Adaptation

Addressing climate change requires both mitigation and adaptation. Mitigation involves reducing greenhouse-gas emissions and increasing carbon absorption. Important measures include renewable energy, energy efficiency, afforestation, sustainable transport, improved waste management and climate-friendly agriculture practices.

Adaptation involves adjusting human and natural systems to actual or expected climate impacts. Examples include drought-resistant crops, rainwater harvesting, improved irrigation systems, early-warning systems, disaster preparedness, restoration of wetlands and climate-resilient infrastructure.

Agriculture

Reduced crop productivity, pest outbreaks, water scarcity.

Human Health

Heat stress, Malnutrition, Vector borne disease, Respiratory diseases.

Water Resources

Drought, Floods, Groundwater depletion.

Biodiversity

Habitat loss, Species extinction, Forest fires.

Economy

Infrastructure damage, Reduced productivity, increase disaster management costs.

Climate change science

Satellite observations, Weather stations, Climate models, Remote sensing, Geographic information system, Artificial Intelligence, Machine learning, Big data analysis. Atmospheric CO₂ Concentration, Global mean temperature, Sea level, Ice sheet mass, Ocean heat content.

Environmental policies

International Policies

United Nation Framework Convention on Climate change (UNFCCC).

Objective – Stabilize greenhouse gases, Promote sustainable development.

Kyoto Protocol: Legally binding emission reduction targets.

Paris Agreement: Limit warming well below 2⁰C. Pursue efforts to limit warming to 1.5⁰C.

Conservation on Biological Diversity (CBD)

Biodiversity Conservation, Sustainable use, Fair benefits sharing.

Environmental Policies in India

Environmental Protection Act, 1986, Wildlife Protection Act, 1972, Forest Conservation Act, 1980, Biological Diversity Act, 2002, Water Act, 1974, Air Act, 1981.

Government Initiatives

National Action Plan on climate change (NAPCC), Green India Mission, National Solar Mission, National Biodiversity Action Plan, Swachh Bharat Mission, Namami Gange Programme.

Climate change Mitigation Strategies

Mitigation focuses on reducing greenhouse gas emissions strategies, Renewable energy, Energy efficiency, Elective vehicles, Sustainable agriculture, Afforestation, Reforestation, Carbon capture technologies, Green building Water reducing.

Adaptation Strategies

Adaptation helps communities adjust to climate impacts measures include, Climate resilient agriculture, Water conservation, Flood management, Drought resistant crops, Coastal protection, Disaster preparedness, Heat Action Plans, Early warning system.

Nature based solutions(Nbs)

Nature based solutions involve protecting and restoring ecosystems, Like Wetland restoration, Mangrove Conservation, Urban forests, River restoration, Agro forestry, Green infrastructure.

Benefits: Carbon storage, Flood control, Biodiversity, conservation, Livelihood improvement.

Sustainable development

The sustainable development Goals (SDGs) integrated, environmental protection with economic and social development.

SDG6 : Clear water.

SDG7 : Affordable and clean energy.

SDG11: Sustainable cities.

SDG12: Responsible consumption.

SDG13: Climate Action.

SDG14: Life below water.

SDG15: Life on land.

Challenges

Climate change is one of the most serious environmental and a global challenges facing the world today. It affects almost every sector of human life and the natural environment. Agriculture is particularly vulnerable to climate change because crop production depends strongly on temperature, rainfall and soil moisture. Droughts, floods, heat stress and changing pest patterns can reduce crop yields and threaten food security. Climate change is not only an environmental problem but also a social, economic and developmental challenge. Tackling it requires coordinated efforts by governments, scientists, industries, communities and individuals. Sustainable development conservation of natural resources, reduction of greenhouse-gas emissions and strengthening of adaptation strategies are essential for protecting the environment and ensuring a safe and resilient future.

Weak policy implementation, Financial limitations, Lack of environmental awareness, Population growth, Unsustainable resource use, Climate injustice, Technological gaps.

Future Strategies

Carbon neutrality, Circular economy, Green finance, Climate smart agriculture, Sustainable urban planning, Biodiversity conservation, Public participation, International cooperation, Environmental education, Innovation and clean technologies.

CONCLUSION

Nature, climate and environmental system are closely inter connected, Human induced climate change threatens biodiversity, ecosystem, food security, water resources, and human health. Scientific research provides strong evidence for urgent action. Effective environmental policies, International cooperation, technological innovation, and nature based solutions are essential to mitigate climate change and enhance resilience. Governments, researchers, industries, and local communities must work together to achieve sustainable development and safeguard the Earth's natural resources for future generations.

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