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Economic Impact of Climate Change on Indian Agriculture: A Comprehensive Analysis up to 2020-21

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Abstract: Climate change poses a serious and complex challenge to Indian agriculture, a sector crucial to the national economy and supporting the livelihoods of over half the population. Given the sector's heavy dependence on the monsoon and sensitivity to climatic fluctuations, rising temperatures, irregular rainfall patterns, altered growing seasons, and more frequent extreme weather events have caused significant disruptions. These climatic changes have contributed to decreased crop productivity, lower yields, and heightened economic risks for millions of farmers, particularly those relying on marginal and rain-fed lands.

This study presents an in-depth exploration of the economic repercussions of climate change on Indian agriculture up to the year 2020-21. Drawing from a broad spectrum of academic research, government datasets, climate modeling, and policy reports, the paper highlights regional variations in climate impacts, the vulnerability of specific crops, and associated socio-economic effects, such as declining farmer incomes, increased indebtedness, and rural-to-urban migration.

The research further assesses the effectiveness of adaptation and mitigation efforts initiated by governmental and non-governmental bodies. These measures include policy programs like the National Mission for Sustainable Agriculture (NMSA), insurance schemes such as the Pradhan Mantri Fasal Bima Yojana (PMFBY), and community-led innovations promoting climate-resilient farming practices. The study concludes by offering evidence-based policy recommendations to enhance the resilience of Indian agriculture in the face of ongoing climate challenges.

Key Words: Indian agriculture, national economy, population, dependence, sensitivity, climatic fluctuations.

Agriculture in India contributes approximately 17-18% to the national Gross Value Added (GVA) and provides livelihoods for over half the country's population (Ministry of Agriculture & Farmers Welfare, 2021). However, the sector's heavy reliance on climatic conditions-especially the monsoon-makes it particularly vulnerable to climate-induced stresses such as irregular rainfall, temperature increases, and extreme weather occurrences (IPCC, 2019).

Climatic Trends in India: 1901-2021-**Table 1: Summary of Climatic Trends in India (1901-2020)**

Parameter	Observed Trend	Key Affected States
Temperature	Rise of approximately +0.62°C	Punjab, Haryana, Uttar Pradesh, Tamil Nadu
Rainfall	Increased variability and fewer rainy days	Maharashtra, Karnataka, Gujarat
Extreme Events	Frequency of intense rainfall and drought doubled	Odisha, Bihar, Assam

Temperature Trends- Data from the Indian Meteorological Department (IMD, 2020) shows an average surface temperature increase of around 0.62°C between 1901 and 2020, with a more rapid rise observed since the 1990s. This warming trend has notably affected rabi (winter) crop production.

Rainfall Variability- Monsoon rainfall has become increasingly unpredictable, exhibiting delayed onset, uneven distribution, and premature withdrawal. These disruptions have resulted in frequent interruptions to agricultural activities (Rathore et al., 2018).

Extreme Weather Events- There has been a marked rise in the occurrence and intensity of droughts, cyclones, and unseasonal rainfall events post-2000 (IMD, 2021), exacerbating the sector's vulnerabilities.

Impact on Crop Yields-**Figure 1: Projected Declines in Crop Yields per 1°C Increase in Temperature-**

- * Rice: 4-6% reduction (IARI, 2017)
- * Wheat: 3-5% reduction (ICAR, 2020)
- * Maize: Up to 50% reduction (NIAP, 2019)

Major Cereals- Yields of wheat and rice are strongly negatively correlated with rising temperatures and declining water availability, especially irrigation.



Other Crops- Oilseeds and pulses, mainly cultivated in rain-fed regions, display high year-to-year yield variability.

Regional Impacts-

- * Punjab and Haryana have experienced wheat yield declines due to terminal heat stress.
- * Maharashtra has witnessed pulse crop failures driven by prolonged droughts.
- * Bihar's rice crops have suffered frequent losses due to flooding events.

Economic Implications- Farmer Incomes- Across India, farmer incomes are projected to decline by 15-18%, with rain-fed areas potentially seeing reductions as high as 25% (Economic Survey, 2017).

Contribution to GDP- A 10% reduction in crop yields can reduce overall GDP growth by approximately 1% (World Bank, 2020).

Employment and Migration- Climate-induced stresses have increased rural-to-urban migration and caused labor shortages during critical agricultural periods such as sowing and harvesting.

Disaster Costs- From 1991 to 2020, India incurred losses exceeding ₹9 lakh crore due to climate-related disasters (NITI Aayog, 2021).

Regional Case Studies-

Table 2: Regional Climate Risks and Agricultural Outcomes

Region	Climate Event	Impact
Maharashtra	Drought	Crop failures, increased farmer suicides
Assam	Flooding	Land submergence, population displacement
Tamil Nadu	Heatwave	Irrigation system failures, crop losses

Adaptation and Mitigation Strategies- Policy Interventions-

- * National Mission for Sustainable Agriculture (NMSA): Focuses on supporting rain-fed agriculture and enhancing soil health (MoEFCC, 2020).
- * Pradhan Mantri Fasal Bima Yojana (PMFBY): Despite being a flagship crop insurance scheme, it suffers from low farmer enrollment and delayed claim settlements (CAG Report, 2021).

Technological Innovations-

- * Development of climate-resilient crop varieties by ICAR.
- * Expansion of weather-based advisory services through Kisan Call Centres.

Community Models- Implementation of watershed management and self-help group (SHG)-based planning has improved resilience in semi-arid regions.

Policy Recommendations-

- * Expand investments in micro-irrigation and solar-powered pumping solutions.
- * Enhance digitization and accessibility of crop insurance schemes.
- * Promote cultivation of climate-resilient millets and legumes.
- * Increase funding for climate-focused agricultural research and development.
- * Strengthen Panchayati Raj Institutions to lead localized climate adaptation planning.

Conclusion- Climate change has imposed profound and accelerating economic challenges on Indian agriculture. Building resilience requires integrated, science-driven, and community-engaged strategies. Sustained policy support, innovation, and grassroots participation are vital to ensuring food security and securing the livelihoods of millions dependent on agriculture.

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