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Economics of Climate Change in Indian Agriculture

*Deepak Meena[1], Mahesh[2], Mr. Nagesh Vaishnav[3] and Akash Tiwari[4]
[1]Ph.D Scholar, Department of Agricultural Economics and Management, Rajasthan College of Agriculture, MPUAT, Udaipur, India
[2]Ph.D Scholar, Division of Agricultural Meteorology, Chaudhary Charan Singh Haryana Agricultural University, Hisar, India
[3]Field Supervisor, Cost of Cultivation Scheme, DRS IGKV, Raipur Chhattisgarh, Department of Agricultural Economics, Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur, Madhya Pradesh, India
[4]Guest Teacher, Department of Agricultural Economics, Dua Kalyan Singh College of Agriculture, Bhatapara, India
*Corresponding Author's email: dm196140@gmail.com

Agriculture continues to serve as the backbone of the Indian economy, contributing significantly to national income, rural employment, and food security. Despite structural transformation and the growth of the services sector, agriculture still supports nearly half of India's workforce and sustains millions of small and marginal farmers. However, the sector is inherently climate-sensitive, depending heavily on monsoon rainfall, temperature regimes, and seasonal variability. Climate change—manifested through rising average temperatures, erratic rainfall, increased frequency of droughts and floods, and extreme weather events—poses a profound economic challenge to Indian agriculture. The economic implications extend beyond crop losses to farm incomes, rural employment, price stability, food security, and overall macroeconomic stability.

The economics of climate change in Indian agriculture revolves around three core questions. First, what are the measurable economic impacts of climate variability and long-term climate change on crop yields, farm profitability, and rural incomes? Second, how do regional agro-climatic differences influence vulnerability and economic outcomes? Third, what adaptation and policy mechanisms can mitigate risks and enhance resilience? Addressing these questions requires an integration of climate science, agricultural economics, and policy analysis to understand both short-term shocks and long-term structural transformations.

Climate Change and Its Dimensions Relevant to Indian Agriculture

Temperature and Rainfall Trends

India has experienced a consistent rise in average surface temperatures over the past century, with accelerated warming in recent decades. The India Meteorological Department reports increasing frequency of heat waves and higher night-time temperatures, both of which adversely affect crop physiology and yield formation. Even a marginal increase in temperature during critical growth stages such as flowering and grain filling can significantly reduce productivity in crops like wheat and rice. Rainfall variability has also intensified, particularly in the southwest monsoon season. Irregular onset, early withdrawal, and intra-seasonal dry spells disrupt sowing schedules, soil moisture conditions, and irrigation demand. While increased rainfall in certain regions may benefit crops, excessive rainfall often leads to waterlogging, pest outbreaks, and soil nutrient leaching. Thus, temperature and rainfall anomalies have competing and region-specific economic effects, influencing both yield variability and production costs.

Extreme Weather Events

Extreme weather events—including droughts, floods, cyclones, and unseasonal rainfall—have become more frequent and intense. These events directly damage standing crops, livestock, irrigation infrastructure, and rural roads. Economically, such shocks reduce farm incomes, increase indebtedness, and heighten reliance on informal credit. The cumulative economic burden extends beyond individual farmers to local markets and rural supply chains, amplifying vulnerability in agrarian regions.

Economic Impacts of Climate Change on Agriculture

Impact on Crop Yields

Climate change impacts on crop yields are heterogeneous across crops and regions. Simulation studies and projection models under moderate emission scenarios (RCP4.5) suggest substantial yield declines for major staples by mid to late century.

Table 1: Projected Yield Change Under Climate Scenarios (RCP4.5)

Crop	2050 (%) Change	2080 (%) Change
Paddy	-24.23%	-30.48%
Wheat	-6.06%	-7.43%
Maize	-10.09%	-12.51%
Sugarcane	-2.35%	-2.96%
Chickpea	+5.55%	+6.52%

Source: Kumar et al., 2024

The projected decline of nearly 30% in paddy yields by 2080 represents a serious threat to national food security, given rice's central role in India's food system. Wheat, particularly in northern India, is vulnerable to terminal heat stress. Interestingly, certain pulses such as chickpea may benefit marginally from elevated CO_2 levels, though such gains may be offset by moisture stress or pest pressures. These variations highlight the need for region- and crop-specific adaptation strategies.

Income and Livelihood Effects

Beyond yield effects, climate change significantly influences farm income and rural livelihoods. Ricardian analyses—estimating the relationship between climate variables and land values or farm income—demonstrate that higher maximum temperatures tend to reduce net farm income, while adequate rainfall enhances profitability. For example, district-level studies in Tamil Nadu show that a 1% increase in temperature reduced net farm income by approximately 0.45%, indicating strong sensitivity to heat stress. Reduced productivity also lowers agricultural labor demand, affecting landless workers and migrant laborers. Wage fluctuations and seasonal unemployment intensify rural poverty. In regions heavily dependent on rainfed agriculture, income instability becomes chronic, encouraging distress migration and occupational shifts.

Profitability and Commercial Impacts

Climate variability affects not only output but also input costs. Farmers facing erratic rainfall increase irrigation frequency, raising electricity or diesel expenses. Pest outbreaks associated with changing temperatures increase pesticide costs. As a result, production costs rise while yields decline, compressing profit margins. These economic pressures often compel farmers to shift cropping patterns—moving from water-intensive crops like paddy and sugarcane to millets, pulses, or oilseeds. While such shifts may enhance resilience, they may also alter regional market dynamics and supply chains.

Broader Economic Consequences

Food Security

Lower agricultural productivity threatens food availability and affordability. A decline in staple crop yields can increase domestic prices, widen regional disparities in access to food,

and increase dependence on imports. Rising food prices disproportionately affect low-income households, exacerbating nutritional insecurity.

Market and Price Volatility

Climate-induced supply shocks contribute to price volatility in agricultural markets. Uncertain production levels disrupt market expectations, affecting traders, processors, and consumers. Price instability raises transaction risks and reduces investment incentives in agriculture. Therefore, climate change is not only a production issue but also a macroeconomic concern linked to inflation and fiscal stability.

Socio-economic Vulnerability

Small and Marginal Farmers

Smallholders, who constitute the majority of Indian farmers, are particularly vulnerable due to limited access to credit, crop insurance, irrigation facilities, and climate information. Their adaptive capacity is constrained by low savings and high exposure to climatic risks. Economic vulnerability is thus closely tied to institutional and infrastructural deficits.

Regional Variation

Regional disparities shape climate impacts significantly. The Indo-Gangetic Plains, a major wheat-producing belt, face increasing heat stress, while semi-arid regions of central and western India confront recurrent droughts. Coastal regions are exposed to cyclones and salinity intrusion. Such heterogeneity necessitates decentralized planning and agro-climatic zoning in policy formulation.

Adaptation and Economic Policies

Climate-Smart Agriculture (CSA)

Climate-Smart Agriculture (CSA), promoted by the Food and Agriculture Organization, integrates three pillars: enhancing productivity, strengthening resilience, and reducing greenhouse gas emissions. Key CSA strategies in India include:

- Adoption of drought- and heat-tolerant crop varieties
- Micro-irrigation systems such as drip and sprinkler irrigation
- Crop diversification and intercropping systems
- Conservation agriculture and zero tillage

These strategies aim to stabilize yields while reducing production risks.

Extension Education and ICT

Extension services and digital technologies play a critical role in disseminating climate advisories, weather forecasts, and adaptive practices. Mobile-based agro-advisory services, satellite monitoring, and precision agriculture tools improve decision-making efficiency and reduce uncertainty.

Policy Interventions

Government-led policy interventions are essential to build resilience. These include:

- Investment in climate-resilient irrigation infrastructure
- Strengthening crop insurance schemes such as the Pradhan Mantri Fasal Bima Yojana
- Incentivizing sustainable agricultural practices
- Expanding rural credit and weather-based insurance products

Integrated Economic Models

Economists employ various models to estimate long-term climate impacts. Ricardian models evaluate land value responses to climatic variables, while panel data econometric models measure productivity impacts across districts and time periods. Disaggregated analyses reveal that aggregate national estimates often underestimate local-level damages, especially in highly vulnerable regions. Such models provide evidence for targeted interventions and cost-benefit analysis of adaptation investments.

Table 2: Summary of Methodologies in Recent Literature

Study (Year)	Approach Used	Key Findings
Ramanathapuram (2025)	Ricardian Analysis	Temperature rise reduces income; rainfall boosts income
Indo-Gangetic Plains (2024)	Yield Projection Models	Yields decline under RCP4.5 scenario
National Disaggregated (2025)	Econometric Models	Long-term impacts underestimated in aggregate studies
Crop Profitability (2022)	Panel Data Analysis	Profitability declines with temperature rise

Policy Recommendations

1. Strengthen irrigation, water harvesting, and climate-resilient infrastructure.
2. Expand crop insurance and weather-indexed risk management tools.
3. Promote water-efficient and low-carbon technologies.
4. Encourage diversification toward climate-resilient crops such as millets.
5. Enhance climate data systems and localized advisories.

Conclusion

Climate change presents multifaceted economic challenges for Indian agriculture, influencing yields, farm incomes, profitability, food security, and rural livelihoods. The impacts are uneven across regions and farm sizes, with smallholders facing disproportionate risks. While projections indicate significant yield declines for major staples under moderate emission scenarios, adaptive strategies and supportive policies can mitigate economic losses. A combination of climate-smart technologies, institutional reforms, insurance mechanisms, and decentralized planning is essential to ensure long-term sustainability and economic resilience in Indian agriculture. Addressing climate change in agriculture is therefore not merely an environmental necessity but an economic imperative for India's future development trajectory.

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