



# Climate Change, Agricultural Productivity and Farm Income in India: An Economic Analysis

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## Abstract

Climate change has emerged as an important economic challenge for Indian agriculture because agricultural production remains highly dependent on temperature, rainfall, water availability and other agro-climatic conditions. Changes in temperature, rainfall variability, droughts, floods and extreme weather events can influence crop yields, production costs, market prices and ultimately farm income. The Economic Survey 2025–26 identifies erratic weather, rising temperatures, extreme events and water scarcity as important challenges to agricultural productivity and recommends region-specific climate-resilient interventions. This paper examines the economic relationship between climate change, agricultural productivity and farm income in India using secondary data and evidence from recent empirical studies. The study discusses the channels through which climatic variables affect agricultural production and farm profitability and reviews the role of irrigation, crop diversification, climate-resilient technologies, crop insurance, improved seeds and digital agricultural services. The paper argues for strengthening climate-resilient agricultural investment, irrigation, agricultural research, risk-management mechanisms and income diversification.

**Keywords:** Climate Change, Agricultural Productivity, Farm Income, Rainfall, Temperature, Climate-Smart Agriculture, India, Agricultural Economics

## Introduction

Agriculture occupies a central position in India's rural economy. It provides employment and livelihoods to a large proportion of the population and contributes significantly to national economic activity. However, agricultural production is particularly vulnerable to climatic conditions. Changes in temperature, rainfall patterns, droughts, floods, heat waves and other extreme events can affect crop growth, input requirements and agricultural profitability.

From an agricultural economics perspective, climate change affects farmers through several channels: climate variables influence crop productivity; productivity affects output and production costs; output and market prices determine farm revenue; and revenue relative to cultivation costs determines farm income. Thus, climate change is not merely an environmental issue but also an issue of production economics, income distribution, rural employment, food security and economic development.

## Statement of the Problem

Indian agriculture faces considerable climatic and economic

risks. Small and marginal farmers are particularly exposed because they often have limited access to irrigation, institutional credit, crop insurance, technology and diversified income sources.

Climate variability can reduce agricultural productivity through higher temperatures, irregular monsoon rainfall, droughts and floods, soil-moisture stress, water scarcity, and pest and disease incidence. These changes may increase the cost of cultivation while reducing physical output. Consequently, farm profitability can decline even when agricultural prices increase.

## Objectives of the Study

- To examine the relationship between climate change and agricultural productivity in India.
- To analyse the economic effects of temperature and rainfall variability on agricultural production.
- To suggest policy measures for improving agricultural productivity and farm-income resilience.

### Research Questions

1. How does climate variability affect agricultural productivity in India?
2. What is the relationship between agricultural productivity and farm income?
3. Which climatic factors create major economic risks for farmers?
4. Can climate-smart agricultural practices improve farm income?
5. What policy interventions can reduce farmers' exposure to climate-related economic risks?

### Hypotheses

- H<sub>01</sub>:** Climate change has no significant relationship with agricultural productivity in India.
- H<sub>11</sub>:** Climate change has a significant relationship with agricultural productivity in India.
- H<sub>02</sub>:** Agricultural productivity has no significant relationship with farm income.
- H<sub>12</sub>:** Agricultural productivity has a significant positive relationship with farm income.
- H<sub>03</sub>:** Climate-resilient agricultural practices have no significant effect on farm income.
- H<sub>13</sub>:** Climate-resilient agricultural practices have a significant effect on farm income.

### Review of Literature

Earlier research has established that agricultural productivity is sensitive to climatic conditions, particularly temperature and rainfall. Recent Indian research using long-run annual data has examined the relationship between climate variables and agricultural total factor productivity. Other studies have examined the economic effects of climate change on agricultural income in Karnataka and the effects of climate-smart agricultural practices in semi-arid regions.

The literature broadly indicates that climatic conditions affect agricultural output and farm profitability, while irrigation, insurance, crop diversification, improved varieties and climate-smart technologies can reduce exposure to climatic risks. However, the magnitude of the effect varies across regions, crops and farm characteristics. This creates scope for region-specific empirical analysis.

### Research Methodology

The study is descriptive, analytical and economic in nature. It is based primarily on secondary information from the Economic Survey of India, Ministry of Agriculture and Farmers Welfare, India Meteorological Department (IMD), ICAR, MoSPI/NSO, Agricultural Statistics at a Glance, World Bank and FAOSTAT.

A suitable study period for empirical analysis is 2000–01 to 2024–25, subject to consistency and availability of the selected variables.

Major variables include temperature, rainfall, rainfall variability, cropped area, irrigation, crop yield, agricultural total factor productivity, farm income, fertilizer use, labour, mechanisation, crop insurance and agricultural diversification.

### Conceptual Framework

Climate Change → Temperature/Rainfall

Variability/Extreme Events → Crop Yield and Agricultural Productivity → Production Cost and Agricultural Output → Farm Revenue → Farm Income.

At the same time, irrigation, technology, crop diversification, insurance and climate-resilient seeds can reduce climate risk, improve productivity and strengthen income resilience.

### Climate Change and Agricultural Productivity

**Temperature:** Moderate temperature is necessary for crop growth, but excessive heat can affect flowering, grain formation and crop maturity. Increasing temperatures can also increase evapotranspiration and irrigation requirements.

**Rainfall:** Rainfall is particularly important for India's rain-fed agricultural regions. Both insufficient and excessive rainfall can reduce crop productivity.

**Extreme Weather Events:** Droughts, floods and heat waves can generate sudden production losses. These events may simultaneously increase input expenditure and reduce agricultural output, creating a double economic burden for farmers.

### Climate Change and Farm Income

Farm income can be expressed conceptually as:

Farm Income = Gross Farm Revenue – Cost of Cultivation  
 Gross Farm Revenue = Quantity of Output × Market Price

Climate change can affect both output and production costs. A climate shock can reduce yield and output while increasing irrigation, labour and other input expenditure. Therefore, lower revenue combined with higher costs can reduce farm profitability.

### Climate-Resilient Agriculture

Climate-resilient agriculture includes practices and technologies designed to reduce farmers' exposure to climate risks.

1. **Improved and climate-resilient seeds:** Varieties tolerant to drought, heat, pests and diseases can help maintain production under stress.
2. **Micro-irrigation:** Drip and sprinkler irrigation can improve water-use efficiency and reduce dependence on uncertain rainfall.
3. **Crop diversification:** Horticulture, livestock, dairy, fisheries and agroforestry can reduce dependence on a single crop.
4. **Digital agriculture:** Weather forecasting, precision agriculture, remote sensing and digital advisory systems can support decisions on sowing, irrigation and input application.

### Economic Role of Irrigation and Crop Insurance

Climate-risk management requires both physical adaptation and financial risk management. Irrigation reduces dependence on rainfall, crop insurance reduces income risk, climate-resilient seeds stabilise yield, crop diversification reduces crop-specific risk, weather information improves decisions, FPOs can improve market access, storage can reduce post-harvest losses, and agricultural credit can support adaptation investment.

**Major Findings**

1. Climate variability is an important economic risk to Indian agriculture.
2. Temperature and rainfall conditions influence agricultural productivity.
3. Climate-related production shocks can affect farm income through both output and production-cost channels.
4. Rain-fed agriculture is particularly exposed to rainfall variability and water scarcity.
5. Irrigation can reduce farmers' dependence on uncertain rainfall.
6. Crop diversification can provide additional sources of agricultural and allied income.
7. Climate-resilient seeds and technologies can improve production resilience.
8. Crop insurance provides an important mechanism for reducing downside income risk.
9. Digital weather information can improve farmers' production and investment decisions.
10. The economic impact of climate change is heterogeneous across regions, crops and farm sizes; therefore, region-specific adaptation policies are important.

**Policy Implications**

1. Strengthening irrigation through micro-irrigation, rainwater harvesting and efficient water management.
2. Promoting climate-resilient seed varieties through agricultural research and extension.
3. Improving the accessibility, timeliness and effectiveness of crop insurance.
4. Encouraging crop diversification towards horticulture and allied activities where suitable.
5. Expanding localised weather forecasting and digital agricultural advisory services.
6. Increasing investment in agricultural research, development and extension.
7. Strengthening Farmer Producer Organisations to improve aggregation, marketing and bargaining capacity.

**Conclusion**

Climate change represents a significant challenge to the economic sustainability of Indian agriculture. Its effects extend beyond physical crop production to production costs, agricultural prices, farm profitability, employment and rural livelihoods.

The available evidence indicates that temperature and rainfall conditions are economically relevant determinants of agricultural productivity, while climate shocks can influence farm income. Climate-smart agriculture, irrigation, insurance and resilient technologies can strengthen adaptation.

Therefore, the policy focus should move towards climate-resilient agricultural growth through investment in irrigation, agricultural research, improved seeds, digital technologies, crop diversification, insurance and rural infrastructure.

Climate Resilience → Higher Productivity → Lower Risk  
→ Stable Farm Income → Sustainable Rural Development.

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