



The Climate Crisis and Resilient in Agriculture

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Agriculture is vital for ensuring food, nutrition, and livelihood security in India, employing nearly two-thirds of the workforce. Its strong linkages with other economic sectors amplify its impact on the country's economy. Despite significant progress in recent years, Indian agriculture now faces numerous challenges. These include stagnant net sown area, plateauing yield levels, deteriorating soil quality, reduced per capita land availability, and the adverse effects of climate change. Furthermore, the growing population is pressuring the agricultural sector to increase food production. This task is highly challenging due to the following factors: 60% of the net cultivated area is rainfed and vulnerable to biotic and abiotic stresses caused by climatic variability and climate change; over 80% of Indian farmers are marginal or small farmers with limited land and poor coping capacity; and Indian farmers are diverse and unorganized. Climate change and its variability will likely exacerbate future food security concerns by impacting agricultural sustainability.

Introduction

Agriculture is vital for ensuring food, nutrition, and livelihood security in India. Despite significant progress in the past, Indian agriculture is currently grappling with several challenges. The major issues include stagnant net sown area, plateauing yield levels, deteriorating soil quality, reduced per capita land availability, and the adverse impacts of climate change. Moreover, the growing population is exerting pressure on the agricultural sector to increase food production. The task is highly challenging due to the following factors: 60% of the net cultivated area is rainfed and vulnerable to biotic and abiotic stresses caused by climatic variability and climate change; over 80% of Indian farmers are marginal and small, with limited land and poor coping capacity; and Indian farmers are diverse and unorganized. Climate change and variability will likely worsen the problem of future food security by impacting agricultural sustainability.

Global climate change presents numerous threats, including glacier melting and diminishment, sea-level rise, and increased greenhouse gas concentrations. Nevertheless, the most paramount environmental issue is global warming, primarily attributable to the escalating levels of atmospheric greenhouse gases (GHGs), namely carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). These GHGs capture the outgoing infrared radiation from the earth's surface, resulting in a rise in atmospheric temperature.

frequency of hot days, hot nights, and heatwaves, as well as more frequent heavy precipitation events, accelerated snowmelt, and sea-level rise. The Intergovernmental Panel on Climate Change (IPCC) reaffirmed in its 2014 Fifth Assessment Report that climate warming is unequivocal. Human activities are demonstrably influencing the climate system through rising atmospheric greenhouse gas concentrations and positive radiative forcing.

Consequently, global climate change has far-reaching impacts on agriculture, including effects on crops, soils, livestock, and pests.

Climate change projections indicate a warmer world within the next five decades, a trend substantiated by empirical evidence. Climate change poses significant threats to agriculture, including increased crop losses, malnutrition, and altered plant disease and insect-pest dynamics. Rainfed regions, which comprise approximately 68% of India's cultivated area and account for 40-45% of total production, experience variable agricultural productivity due to yearly fluctuations. To sustain and enhance rainfed crop production in semi-arid tropics, it is essential to leverage knowledge of climate variability to develop location-specific, innovative cropping patterns and insect-pest and disease management strategies. Current climate change estimates predict a global mean annual temperature increase of 1°C by 2025 and 3°C by 2100. Anticipated changes include increased rainfall variability, intensity, and concentration of greenhouse gases (CO₂ and O₃), leading to enhanced global precipitation.

Impacts of Climate Change on Indian Agriculture

The agriculture sector faces critical challenges in the context of climate change, including:

- Water availability: Changing rainfall patterns, altered stream flow, and increased crop water demand
- Water quality deterioration: Sea water intrusion, transport of salts from deeper soil layers due to over-exploitation of aquifers, and faulty irrigation practices
- Extreme weather events: Increased frequency and intensity of droughts, floods, and cyclones, which will impact production levels more significantly than mean climate changes
- Heat stress: Higher temperatures during critical crop growth stages
- Unpredictable pest and disease dynamics: Changes in pest and disease load, with the possibility of minor pests becoming major pests due to shifting climatic conditions. The classified impacts on crops, water, livestock, fisheries and pest and diseases are presented below (Aggarwal et al. 2009):
 - Crops: While increased ambient CO₂ may enhance photosynthesis in certain crops, such as wheat and rice, and reduce evaporative losses, the overall effect on major cereal crops like wheat is likely to be negative due to decreased crop growth duration, increased respiration, and reduced rainfall/irrigation water supplies resulting from rising atmospheric temperatures.
 - Extreme weather events like floods, droughts, cyclones, and heatwaves will become more frequent and prolonged, adversely affecting agricultural productivity.
 - Rainfed areas will experience reduced yields due to increased crop water demand and changes in rainfall patterns during the monsoon season.
 - The quality of fruits, vegetables, tea, coffee, aromatic, and medicinal plants will decline.
 - Climate change will alter the dynamics of agricultural pests and diseases, leading to increased pathogen and vector development, rapid pathogen transmission, and heightened host susceptibility.
 - Agricultural biodiversity will be threatened by rainfall uncertainty, temperature increases, sea level rise, and increased frequency and severity of droughts, cyclones, and floods.
 - However, a positive effect of climate change is the predicted decrease in cold waves and frost events, leading to reduced yield loss due to frost damage in northern India for crops like mustard and vegetables.

Adaptation of Indian Agriculture to Climate Change

To address the impacts of climate change, potential adaptation strategies include:

1. Developing crop varieties tolerant to heat, salinity, flood, and drought stresses.
2. Modifying crop management practices and improving water management.
3. Adopting resource-conserving technologies (RCTs), crop diversification, and improved pest management.
4. Utilizing better weather forecasts, crop insurance, and harnessing indigenous technical knowledge.

Specific Strategies Include

- Developing new crop varieties with higher yield potential and multiple stress resistance.
- Improving germplasm for heat tolerance.
- Conserving water through efficient use, harvesting, and improving irrigation accessibility and water use efficiency.
- Promoting on-farm water conservation techniques, micro-irrigation systems, and appropriate crop selection.
- Implementing principles of increasing water infiltration, reducing runoff, and soil evaporation.
- Establishing crop insurance schemes to reduce risk.
- Providing micro-finance services to vulnerable farmers.
- Promoting conservation agriculture and RCTs to enhance resource efficiency and provide economic benefits.
- Utilizing weather forecasting to inform crop management decisions.
- Harnessing indigenous knowledge to develop technologies addressing climate vulnerabilities.

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