Impact of Climate Change on Indian Agriculture: Smart Technologies, Challenges and Sustainable Development

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Abstract

Climate change has become a significant problem for farm production in India. Increases in temperature, inconsistent rainfall, droughts, floods, heat waves, and other severe weather conditions negatively affect crop yields, water availability, soil health, and farmers' livelihoods. Smart Agriculture offers crucial approach to enhancing agricultural output while bolstering resilience to climate uncertainties. This encompasses the use of climate-resilient crop strains, precision farming techniques, micro-irrigation systems, weather-responsive advisory services, artificial intelligence applications, digital farming methods, soil management practices, and integrated agricultural systems. India's policy measures, such as the National Innovations in Climate Resilient Agriculture (NICRA) and various sustainable farming initiatives, advocate for technologies and adaptation methods tailored to specific locations. In 2026, the government disclosed that assessments of climate risks were conducted in 651 mainly agricultural districts, identifying 310 of those as at risk. This research analyses how climate change influences agricultural output in India and explores the contribution of smart agriculture towards achieving sustainable yields, food security, and enhanced farmer incomes.

Keywords: Climate Change, Smart Agriculture, Agricultural Production, Precision Farming, Sustainable Agriculture, Food Security

Introduction

Agriculture is significantly influenced by weather conditions, especially temperature, precipitation, and the supply of water. India faces considerable risk as many farmers rely on

small-scale farms that depend on rain. Variability in the climate can result in failed crops, reduced harvests, pest invasions, disease occurrences, and unpredictable income for farmers. Studies on rain-dependent farming illustrate the specific susceptibility of Indian farmers to inconsistent rainfall, drought situations, flooding, and temperature-related stress. Smart Agriculture integrates innovative technology with eco-friendly farming methods. The primary goal is to enhance food production efficiency while protecting natural resources and making agriculture resilient to climate change.

Objectives of the Study

1. To investigate how climate change affects farming output in India.
2. To explore the idea and significance of Smart Agriculture.
3. To recognize key smart farming technologies utilized to mitigate climate risks.
4. To review governmental efforts those encourage climate-resilient agriculture.
5. To recommend approaches for enhancing sustainable farming practices in India.

Methodology

The current research mainly relies on secondary data. This data was gathered from a variety of sources, including books, academic journals, reports from government entities, and online platforms.

Review of Literature

Prajapati, et al (2010) study examined the Greenhouse gas emissions grow every day within the surroundings from many sources, which includes business activities, crop production, and fossil fuel combustion. These are the principal sources of climate change. The international will increase in global carbon dioxide awareness are due, by and large, to fossil fuel use and land use change, whilst those of methane and nitrous oxide are by and large because of agriculture. Currently available well-known stream models (GCMs) suggest that the area-averaged annual warming might be approximately 3°C within the decade of the 2050s and approximately 5°C within the decade of the 2080s over the land areas of Asia due to destiny will increase in atmospheric concentrations of greenhouse gases.

Mohanty (2017) the take a look at defined that the biggest recognised financial effects of climate change is on agriculture due to the sector's length and sensitivity. Climate change ought to have an effect on agriculture in numerous ways, together with the amount and quality of vegetation in terms of productivity, growth rates, photosynthesis and transpiration rates, moisture availability, etc. The effects of agriculture's contribution to climate change, and of weather extremes' bad effect on agriculture, are intense and are projected to have a huge effect on food production, doubtlessly threatening food security and livelihoods, and consequently requiring unique agricultural measures to address.

Vaid and Thakkar (2026) study explained that the Climate-Smart Agriculture (CSA) has emerged as an integrated technique to concurrently deal with those complicated demanding situations via way of means of improving productivity, constructing resilience, and mitigating greenhouse gas emissions anywhere feasible. In India, CSA includes a combination of conventional expertise and present day clinical improvements tailor-made to the numerous agro-climatic regions. Practices which include conservation agriculture, agro forestry, climate-resilient crop varieties, integrated farming systems, and green water control strategies are gaining growing popularity. Initiatives just like the National Innovations on Climate Resilient Agriculture (NICRA), the National Mission for Sustainable Agriculture (NMSA), and state-led packages underscore India's strategic attention on climate-resilient farming. However, in spite of proactive policies, the transition closer to CSA faces tremendous hurdles. Socio-financial constraints, small landholdings, confined get entry to finance, technological gaps, and gender disparities continue to obstruct widespread adoption, specifically amongst smallholder and marginal farmers who form the spine of Indian agriculture.

Major Impacts of Climate Change on Indian Agriculture

- Unsteady and erratic precipitation patterns.
- Greater occurrence of floods and dry spells.
- Elevated temperatures and heightened heat stress.
- Reduced agricultural yield in susceptible areas.
- Shortage of water and exhaustion of groundwater sources.
- Degradation of soil quality and decrease in soil nutrients.

- Higher rates of pests and disease outbreaks.
- Uncertainty in farm income and rural living standards.

Smart Agriculture Technologies for India

1. Climate-Resilient Crop Varieties

Creating and implementing crop varieties that are resistant to drought, tolerant of flooding and adaptable to high temperatures can help minimize losses in production.

2. Precision Agriculture

Technologies like satellite data, drones, GPS, and sensors assist agricultural producers in improving their choices about irrigation, fertilizers, and managing crops.

3. Micro-Irrigation

Drip and sprinkler irrigation enhance the efficiency of water usage and diminish water loss. Initiatives by the government, like Per Drop More Crop, support the adoption of these methods.

4. Weather-Based Advisory Services

Online weather updates and agricultural weather recommendations assist farmers in making prompt choices regarding planting, watering, and gathering crops.

5. Artificial Intelligence and Digital Agriculture

Artificial intelligence, remote observation, and satellite systems can aid in monitoring crops, assessing yields, and quickly recognizing climate-associated risks.

6. Soil Health Management

Assessing soil quality, managing nutrients in a holistic way and using organic materials can enhance the health of the soil and boost agricultural output in the long run.

7. Crop Diversification

Transitioning from crops that use a lot of water to grow, like pulses, oilseeds, millets, and other appropriate choices, can help lessen risks related to climate and water.

8. Integrated Farming Systems

Integrating various agricultural elements such as crops, livestock, fisheries, and related endeavours can broaden the revenue streams for farms and lessen reliance on one sole production source.

Government Initiatives in India

National Innovations in Climate Resilient Agriculture (NICRA)

NICRA, executed via the Indian Council of Agricultural Research, emphasizes evaluating climate-related risks, creating robust technologies, showcasing technological advancements, and enhancing skills. Moreover, India has established District Agriculture Contingency Plans for 651 mainly agricultural regions.

National Mission for Sustainable Agriculture

The goal encourages environmentally friendly farming methods and enhances the ability of agriculture to withstand changes in climate.

Per Drop More Crop

This initiative supports effective water management by promoting the use of micro-irrigation technologies.

Soil Health Management

The programme promotes the balanced and efficient application of nutrients while enhancing soil productivity.

Challenges in Adopting Smart Agriculture

- Significant upfront costs for contemporary technology.
- Insufficient knowledge among small and marginal agricultural producers.
- Gaps in digital skills.
- Restricted access to financial resources.
- Lack of sufficient technical education.
- Disparities in access to internet and digital resources.
- Restricted access to timely weather-related information.

Studies conducted in India indicate that having access to farming information, extension services, training, and institutional assistance can greatly affect the implementation of climate-smart strategies.

Suggestions

a. Offer financial support and low-interest loans for advancements in agricultural technology.
b. Enhance farmer education and agricultural support programs.
c. Broaden digital services and weather information for rural communities.
d. Encourage the use of seeds that can withstand climate challenges and promote a variety of crops.
e. Boost funding for irrigation systems and initiatives for water preservation.
f. Support the use of artificial intelligence, satellite technology, and precision farming techniques.
g. Formulate climate adaptation plans tailored to specific locations.
h. Reinforce collaborative research efforts involving universities, ICAR institutions, and farmers.
i. Encourage farming practices that are both integrated and sustainable.
j. Enhance opportunities for market entry and insurance support for farmers affected by climate issues.

Conclusion

Climate change poses a significant threat to the viability and efficiency of agriculture in India. Relying solely on conventional agricultural methods may not be adequate to cope with the growing unpredictability of the climate. Smart Agriculture offers a viable answer by integrating advanced technology, methods that can withstand climate challenges, and sustainable management of resources. Techniques like precision agriculture, micro-irrigation, developing climate-adaptive crops, providing digital guidance, diversifying crops, and adopting integrated farming can enhance output and bolster the resilience of farmers. Thus, promoting the broader implementation of Smart Agriculture, backed by suitable government initiatives, funding, research efforts, and enhancing farmers' skills, is crucial for attaining sustainable agricultural output, ensuring food security, and fostering climate resilience in India.

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