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Economic Impact of Climate Change on Indian Agriculture: A Comprehensive Analysis

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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 climatechallenges.

Key Words: Climate Change, Indian Agriculture, Crop Yield, Economic Impact, Rain-fed Farming, Events.

Agriculture continues to play a foundational role in the Indian economy, contributing approximately 17-18% to the nation's Gross Value Added (GVA) and employing more than half of the country's population, either directly or indirectly (Ministry of Agriculture & Farmers Welfare, 2021). This sector serves as the backbone of rural livelihoods, food security, and socio-economic stability. However, its high dependence on climatic conditions-particularly the southwest monsoon-renders it extremely vulnerable to the adverse impacts of climate change.

Over recent decades, the agricultural landscape in India has experienced growing exposure to climate-related risks. Variability in rainfall patterns, rising surface temperatures, shifts in the timing and duration of cropping seasons, and the increasing frequency of extreme weather events such as floods, droughts, cyclones, and heatwaves have disrupted agricultural productivity across multiple agro-climatic zones. These climatic stressors are no longer episodic but are becoming persistent, with cumulative effects on crop output, input costs, farmer incomes, and broader economic stability.

Small and marginal farmers, who constitute nearly 86% of the farming community (Agricultural Census, 2015-16), are especially susceptible to these changes due to their limited adaptive capacity, fragmented land holdings, and reliance on traditional agricultural practices. Moreover, rain-fed areas-which make up over 60% of India's net sown area-are disproportionately impacted by erratic precipitation and water scarcity, further compounding production risks.

The nexus between climate variability and agriculture has significant economic implications. Crop failures and yield reductions undermine food availability, depress rural incomes, increase indebtedness, and fuel distress

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migration. These challenges not only affect the livelihoods of farming households but also threaten national objectives such as doubling farmers' incomes and achieving food self-sufficiency.

Climatic Trends in India (1901-2021)- Understanding long-term climatic shifts is crucial to contextualize the vulnerability of Indian agriculture to climate change. Over the past century, India has experienced notable alterations in its climate parameters-particularly temperature, rainfall patterns, and the frequency and severity of extreme weather events. These changes have directly influenced agricultural cycles, cropping decisions, and overall farm productivity across various regions.

1. Rise in Temperature- Scientific assessments indicate that India's average annual surface temperature has risen by approximately 0.62°C between 1901 and 2020 (IMD, 2020). Notably, the rate of warming has intensified since the early 1990s. This increase has had adverse effects on temperature-sensitive crops, especially during the rabi (winter) season. Elevated temperatures during key growth stages-such as flowering and grain filling-can lead to reduced yields in crops like wheat and mustard. Additionally, higher night-time temperatures have been observed to negatively affect grain quality and productivity. States such as Punjab, Haryana, Uttar Pradesh, and parts of Tamil Nadu have reported significant impacts on productivity due to terminal heat stress during critical periods of crop development.

2. Rainfall Variability and Monsoon Disruptions- Rainfall in India, especially the southwest monsoon, accounts for nearly 75% of the country's annual precipitation and is the lifeline for kharif (summer) crops. However, recent decades have witnessed increased irregularities in monsoon behaviour, characterized by delayed onset, erratic distribution, and premature retreat. Studies suggest that while total rainfall volume has not decreased significantly, its spatial and temporal distribution has become increasingly inconsistent (Rathore et al., 2018). For instance, there has been a rise in the frequency of dry spells interspersed with intense downpours, which hampers both sowing and harvesting operations.

Rain-fed regions in Maharashtra, Karnataka, and Gujarat are particularly vulnerable to these changes, with farmers frequently facing uncertainty around planting decisions and the risk of crop failure. The unpredictability of rainfall has also contributed to reduced groundwater recharge, aggravating water stress in already drought-prone areas.

3 Increased Frequency of Extreme Weather Events- India has witnessed a significant uptick in the frequency and intensity of extreme weather events, particularly after the year 2000 (IMD, 2021). These include prolonged droughts, flash floods, unseasonal rains, tropical cyclones, hailstorms, and heatwaves. Such events often strike during crucial crop stages and cause irreversible losses to standing crops. For instance, sudden pre-monsoon showers can damage ripening mango and wheat crops, while post-monsoon cyclones severely affect coastal agriculture in states like Odisha, Andhra Pradesh, and West Bengal.

In addition to direct crop damage, these events disrupt supply chains, inflate input costs, and result in loss of soil fertility through erosion and waterlogging. Between 2001 and 2020, the frequency of climate-related disasters doubled compared to the previous two decades, highlighting a worrying trend for the sustainability of Indian agriculture.

Summary of Major Climatic Trends in India (1901-2020)

Climatic Parameter	Observed Changes	Heavily Affected States
Temperature	+0.62°C increase over 120 years	Punjab, Haryana, Uttar Pradesh, Tamil Nadu
Rainfall	Higher variability, fewer rainy days	Maharashtra, Karnataka, Gujarat
Extreme Events	Doubling of intense rainfall and drought events	Odisha, Bihar, Assam, Andhra Pradesh, West Bengal

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These shifting climatic baselines have placed unprecedented stress on agricultural systems, especially in regions already experiencing environmental degradation, resource depletion, and socio-economic fragility. Consequently, understanding these trends is critical for designing effective adaptation strategies and policy interventions that can buffer the agrarian economy against future climate shocks.

Impact on Crop Yields- The productivity of crops is highly sensitive to climatic factors such as temperature, precipitation, humidity, and solar radiation. In the Indian context, where agriculture is heavily dependent on monsoon rainfall and traditional farming methods, the effects of climate variability on crop yields have become increasingly visible and concerning. Both empirical studies and predictive models suggest that continued climatic changes-especially rising temperatures and erratic rainfall-could substantially reduce agricultural productivity, thereby threatening food security and farmer livelihoods across the country.

1. Impact on Major Cereals- Cereal crops, especially rice and wheat, form the cornerstone of India's food system and are highly climate-sensitive. Numerous studies have reported a consistent negative correlation between temperature increases and the yields of these staple grains. For instance, a 1°C rise in average temperature is projected to result in a decline in rice yields by 4-6%, and wheat yields by 3-5% (IARI, 2017; ICAR, 2020). The reduction in wheat productivity is more pronounced in northern states like Punjab and Haryana, where terminal heat stress during the grain-filling stage causes early maturation and smaller grain size.

Moreover, increasing nighttime temperatures, which are often overlooked in conventional models, have shown to significantly impact rice yields in eastern states such as Bihar and West Bengal. Reduced irrigation availability due to declining groundwater tables and erratic rainfall has further exacerbated thesituation, particularly during the kharif season

2. Effects on Rain-fed and Minor Crops- Rain-fed crops, which include pulses, coarse cereals, and oilseeds, are even more vulnerable to climatic stress due to their dependence on timely and well-distributed rainfall. These crops, grown predominantly in semi-arid and arid regions of India, exhibit high yield volatility from year to year. In drought-prone areas of Maharashtra and Karnataka, prolonged dry spells have led to repeated crop failures, severely affecting pulse production. Similarly, oilseed-producing belts in Gujarat have suffered from delayed sowing and poor yields due to insufficient soil moisture.

Maize, which is considered a moderately climate-resilient crop, has shown extreme sensitivity to rising temperatures during flowering and pollination stages. Projections indicate that maize yields could fall by up to 50% under continued warming and water stress scenarios (NIAP, 2019).

3. Regional Case Studies of Yield Decline- Different regions of India are affected in unique ways depending on their agro-climatic conditions, dominant crop types, and infrastructure availability:

Punjab and Haryana: These granary states have reported reduced wheat yields due to an increase in daytime and nighttime temperatures during the Rabi season.

Maharashtra: Chronic droughts have impacted pulse and cotton production, leading to crop failures and increased agrarian distress.

Bihar: Frequent floods and waterlogging events during the monsoon season have washed away paddy fields and disrupted sowing schedules.

These region-specific impacts highlight the heterogeneity in climate risks across India and emphasize the need for localized adaptation measures and resilient cropping systems.

Projected Decline in Crop Yields with Every +1°C Rise in Temperature

(Source: IARI, 2017; ICAR, 2020; NIAP, 2019)

Crop	Estimated Yield Loss
Rice	4-6%
Wheat	3-5%

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Maize Up to 50%

The cumulative impact of climate-induced yield losses is not only an agronomic concern but also an economic one, as lower outputs directly translate to reduced income, increased input costs per unit output, and heightened risk of debt for farmers. As these trends become more frequent and severe, building climate-resilient agricultural systems becomes a national imperative.

4. Economic Implications of Climate Change on Indian Agriculture- The adverse effects of climate change on agriculture go far beyond reduced crop yields; they ripple through the entire agricultural economy and rural livelihoods. As farm productivity declines due to climatic stress, so do farmer incomes, food system stability, and rural employment. This section examines the multifaceted economic consequences of climate variability, particularly focusing on income insecurity, GDP contributions, migration, and disaster-related losses.

1. Declining Farmer Incomes- Climate-induced yield fluctuations and input cost inflation are significantly impacting farmers' profitability. According to estimates from the Economic Survey (2017-18), farmers in India could witness a national average income decline of 15-18% due to climate stress, with losses rising to 20-25% in rain-fed and marginal zones. In areas with little or no access to irrigation-such as parts of Madhya Pradesh, Maharashtra, and Rajasthan-the income variability is often compounded by frequent crop failures.

Moreover, increased reliance on high-cost inputs like borewell irrigation, hybrid seeds, and chemical fertilizers under unpredictable climate conditions further erodes net returns. This has deepened financial distress and led to increased indebtedness among small and marginal farmers, who have limited capacity to absorb economic shocks.

2. Impact on Agricultural GDP and National Economy- The broader economic fallout is also considerable. Agriculture continues to contribute nearly one-fifth to India's Gross Value Added (GVA), but this share is under threat from climate instability. A 10% reduction in crop productivity could result in a GDP contraction of up to 1% (World Bank, 2020). Since agriculture supports a range of allied sectors-such as food processing, fertilizer production, and rural retail-any disturbance in agricultural output can have a cascading effect on rural demand and overall economic growth.

Additionally, climate variability increases price volatility in food markets. Disruptions in supply due to weather shocks cause sharp fluctuations in food prices, affecting both consumers and producers and increasing the risk of food inflation.

3. Labour Disruption and Rural-to-Urban Migration- Frequent crop failures and rising input costs reduce agricultural profitability, pushing rural youth and laborers to migrate to cities in search of alternative livelihoods. Seasonal and permanent migration from agriculture-dependent districts has surged in the last two decades, creating demographic shifts and exerting pressure on urban infrastructure. Concurrently, this out-migration contributes to farm labor shortages during crucial periods such as sowing and harvesting, especially in states like Punjab and Kerala.

In addition, increased feminization of agriculture has been noted in some regions, as male members of farming households migrate and women take over farm management-often without adequate institutional or financial support.

4. Cost of Climate-Induced Disasters- Climate-related disasters-such as floods, droughts, cyclones, and unseasonal rains-have imposed massive economic losses on the Indian agricultural sector. According to NITI Aayog (2021), India lost over ?9 lakh crore due to such events between 1991 and 2020. These losses include not only direct damages to crops and livestock but also secondary impacts such as reduced soil fertility, damage to infrastructure (e.g., irrigation canals, roads), and increased cost of rehabilitation and relief measures.

The recurring nature of such disasters, combined with inadequate insurance coverage and delayed compensations, makes recovery difficult for vulnerable farmers and results in long-term economic distress in rural regions.

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5. Regional Case Studies: Differential Impact of Climate Change across Indian States- India's vast geographical diversity and varied agro-climatic zones result in differential exposure and vulnerability to climate change impacts across regions. Each state or region experiences unique climatic challenges-ranging from droughts to floods to heatwaves-which interact with local socio-economic conditions, cropping patterns, and adaptive capacities. This section presents specific regional case studies to highlight the localized effects of climate change on agriculture.

Regional Climate Risks and Agricultural Outcomes

Region	Predominant Climate Event	Agricultural Impact
Maharashtra	Recurrent Droughts	Crop failures, rising farmer suicides, groundwater depletion
Assam	Frequent Flooding	Submergence of croplands, damage to stored produce, rural displacement
Tamil Nadu	Heatwaves and Rainfall Deficits	Irrigation failure, reduced paddy yields, drinking water scarcity

1. Maharashtra: The Drought-Prone Epicentre Maharashtra has become emblematic of climate-induced agrarian distress in India. Particularly in the Vidarbha and Marathwada regions, repeated droughts over the past two decades have severely affected both Kharif and Rabi crops. Groundwater levels have plummeted due to over-extraction, and rainfall patterns have become increasingly erratic and insufficient. Farmers dependent on rain-fed cotton and pulses have faced consecutive crop losses, leading to economic hardship, mounting debts, and tragically, an increase in farmer suicides. Several studies indicate that a combination of climate stress, poor institutional support, and inadequate crop insurance has deepened the agrarian crisis in this region.

2. Assam: Floods and Riverine Vulnerability Assam, located in the Brahmaputra valley, is highly prone to annual flooding, especially during the southwest monsoon season. These floods submerge vast tracts of agricultural land, destroy standing crops like rice and jute, and displace farming families. In recent years, these flood events have increased in frequency and intensity, likely exacerbated by climate change and deforestation in the catchment areas. Additionally, delayed sowing and crop loss due to waterlogging have disrupted agricultural calendars and reduced seasonal outputs. Recovery is slow due to lack of infrastructure and limited access to post-disaster credit or technical support.

3. Tamil Nadu: Heat Stress and Irrigation Challenges Tamil Nadu faces a unique combination of rising surface temperatures and decreasing rainfall in several districts. The state relies heavily on canal-based and groundwater irrigation systems, which are now under immense pressure due to declining water tables and vanishing water bodies. The 2016-17 drought, driven by both El Niño conditions and climate variability, drastically reduced paddy and sugarcane output. Urban and agricultural competition for water resources has also intensified. Moreover, heatwaves have not only affected crop physiology but also labour availability, as heat stress reduces working hours in fields.

4. Other Notable Examples-

Bihar: Low-lying districts such as Darbhanga and Sitamarhi experience annual flooding, leading to frequent crop losses, especially for rice.

Gujarat: The Kutch region faces increasing salinity and aridity, impacting groundnut and cotton cultivation.

Andhra Pradesh: Cyclonic storms and heavy rainfall events have damaged horticultural crops and disrupted coastal farming communities.

These regional case studies underscore the heterogeneous nature of climate risks and their varied economic outcomes. While some states face water scarcity, others are plagued by excess water. The need for tailored, region-

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specific climate adaptation strategies becomes imperative to effectively address the localized impacts and safeguard livelihoods.

6. Adaptation and Mitigation Strategies- Climate change has emerged as a defining challenge for Indian agriculture, demanding a robust and multidimensional response. While the impacts are stark, the country has been actively working-through policy frameworks, technological innovation, and grassroots initiatives-to build agricultural resilience. This section critically examines the adaptation and mitigation strategies employed at various levels, highlighting their strengths and limitations.

1. Policy Interventions- The Government of India has initiated several policy-level programs to support climate-resilient agriculture and reduce farmers' vulnerability. Among the most prominent are:

National Mission for Sustainable Agriculture (NMSA): Introduced under the National Action Plan on Climate Change (NAPCC), NMSA focuses on enhancing productivity in rain-fed areas through integrated farming systems, water-use efficiency, and soil health management. It encourages the adoption of climate-resilient practices and has laid the foundation for long-term sustainability (MoEFCC, 2020).

Pradhan Mantri Fasal Bima Yojana (PMFBY): This flagship crop insurance scheme aims to protect farmers against crop loss due to climate-induced risks such as droughts, floods, and hailstorms. However, a performance audit by the Comptroller and Auditor General (CAG, 2021) highlighted key challenges-low awareness among farmers, delayed compensation payments, and low claim ratios-that reduce its effectiveness.

State Action Plans on Climate Change (SAPCCs): Various states have developed SAPCCs aligned with NAPCC, focusing on localized vulnerabilities and customized agricultural strategies. However, their implementation and funding vary significantly.

2. Technological Innovations and Research- Technological solutions, particularly those spearheaded by agricultural research institutions, play a crucial role in enhancing climate resilience.

Development of Climate-Resilient Crop Varieties: The Indian Council of Agricultural Research (ICAR) has developed and released several drought-tolerant, flood-tolerant, and heat-resistant crop varieties. These include heat-tolerant wheat varieties for North India and submergence-tolerant rice varieties like 'Swarna Sub1' for eastern states.

Weather-Based Advisory Services: The use of digital platforms and mobile-based apps to deliver localized weather forecasts, agro-advisories, and early warning systems has expanded significantly. The Indian Meteorological Department and Krishi Vigyan Kendras (KVKs) support dissemination of advisories to help farmers make informed decisions.

Soil and Water Management Tools: Technologies such as precision irrigation (drip and sprinkler systems), solar-powered irrigation pumps, and soil moisture sensors are being promoted under schemes like PM-KUSUM and the Micro Irrigation Fund. These tools improve resource-use efficiency and reduce vulnerability to rainfall variability.

3. Community-Based Adaptation Models- Beyond top-down initiatives, several grassroots models demonstrate how community participation can build resilience:

Watershed Development Programs: Implemented in semi-arid regions, these projects focus on soil conservation, rainwater harvesting, and sustainable land use. Programs under the Integrated Watershed Management Programme (IWMP) have shown success in improving moisture retention and crop productivity.

Self-Help Groups (SHGs) and Farmer Producer Organizations (FPOs): These collectives help in pooling resources, accessing markets, and adopting new technologies. Women-led SHGs in states like Odisha and Andhra Pradesh have pioneered climate-resilient farming techniques, such as System of Rice Intensification (SRI) and organic farming.

Agroforestry and Mixed Cropping Models: Encouraging farmers to integrate trees with crops or diversify into multi-cropping systems has reduced risk exposure and improved income stability.

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4. Limitations and Challenges-

Despite multiple initiatives, several bottlenecks hinder the success of adaptation strategies:

* Poor outreach in remote areas leads to unequal access to innovations and schemes.
* Fragmented landholdings and lack of tenure security reduce the adoption of new technologies.
* Weak extension services and limited climate literacy among farmers undermine adaptation efforts.
* Delayed disbursal of subsidies and lack of convergence among departments reduce scheme efficiency.
* India has made commendable progress in addressing climate challenges in agriculture through policy, innovation, and community engagement. However, scaling up these strategies requires improved institutional coordination, farmer-centric planning, and sustained investments in research, technology, and infrastructure.

7. Policy Recommendations: Strengthening Climate Resilience in Indian Agriculture- The evidence presented in this study underscores the urgency of proactive, systemic interventions to shield Indian agriculture from the escalating threats posed by climate change. Based on empirical analysis and a review of existing responses, the following policy recommendations aim to enhance agricultural resilience, secure livelihoods, and promote sustainable rural development.

1. Accelerate Investment in Climate-Smart Infrastructure- To combat rainfall variability and reduce water stress, investment in climate-resilient infrastructure must be intensified:

Expand micro-irrigation systems (e.g., drip and sprinkler) to cover more rain-fed regions under the Pradhan Mantri Krishi Sinchai Yojana (PMKSY). These systems significantly reduce water use and increase yield per unit of water.

Promote solar-powered irrigation pumps, especially in regions with abundant sunlight and frequent power outages, under schemes like PM-KUSUM. This shift not only addresses energy shortages but also curbs greenhouse gas emissions.

Rejuvenate traditional water bodies and watershed structures, including tanks and check-dams, to enhance water retention and groundwater recharge.

2. Enhance the Reach and Efficiency of Crop Insurance-

Climate variability has made risk-transfer mechanisms such as crop insurance more critical than ever:

Digitize enrolment and claims processing under PMFBY to ensure faster compensation and greater transparency. Leveraging satellite imagery and remote sensing can help verify losses efficiently.

Make insurance universal and mandatory for all farmers accessing agricultural credit, to increase penetration, especially among smallholders.

Offer index-based insurance products that are better suited to capture regional climate anomalies like rainfall shortfall or extreme heat

3. Strengthen Agricultural Research and Extension-

Building long-term resilience requires substantial investment in innovation and farmer education:

Increase funding for climate-focused agricultural R&D, particularly for developing stress-tolerant seed varieties, precision agriculture tools, and localized soil health solutions.

Modernize and expand agricultural extension systems to include mobile-based advisory services, on-farm demonstration projects, and farmer field schools that promote adaptive techniques.

Integrate climate change modules into Krishi Vigyan Kendras (KVKs) to train extension workers and progressive farmers as local adaptation champions.

4. Promote Crop Diversification and Resilient Cropping Patterns-

To minimize the risk of monoculture failure and enhance nutrition security:

Encourage the cultivation of millets, pulses, and legumes, which are more drought-resilient, nutritionally rich, and suited to semi-arid zones. The government's initiative to promote millets as "Shree Anna" must be backed

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by procurement and value chain support.

Facilitate crop rotation and intercropping practices that restore soil fertility and reduce input costs.

Develop regional cropping calendars that factor in new climate patterns and optimize sowing windows.

5. Decentralize Climate Governance and Empower Local Institutions

Localized planning and community participation are essential for effective adaptation:

Empower Panchayati Raj Institutions (PRIs) to develop and implement local Climate Resilient Agricultural Plans (CRAPs) in convergence with MNREGA and state agricultural missions.

Support climate adaptation through women-led SHGs and Farmer Producer Organizations (FPOs), which can disseminate best practices and collective risk management tools.

Institutionalize participatory planning by including local agro-meteorologists, NGOs, and traditional knowledge holders in adaptation design and implementation.

6. Align Agricultural Policies with Climate Objectives

Many national schemes have unintended consequences that exacerbate climate risks:

Rationalize subsidies for water-intensive crops (e.g., sugarcane, paddy) in water-scarce regions and incentivize sustainable practices.

Integrate climate risk parameters into MSP (Minimum Support Price) and procurement decisions to encourage climate-resilient crops.

Promote carbon farming and agroforestry through carbon credits and payment for ecosystem services (PES) mechanisms.

These policy actions, if executed effectively, can significantly reduce the vulnerability of Indian agriculture to climate-induced disruptions. A multi-stakeholder, evidence-based approach is crucial to balancing the goals of productivity, sustainability, and equity in a rapidly changing climate landscape.

8. Conclusion- The evidence compiled and analyzed in this study reveals the profound and growing economic consequences of climate change on Indian agriculture. As the sector continues to grapple with increasing temperature trends, erratic rainfall, and a surge in extreme weather events, the repercussions are being felt not just in declining crop productivity, but also in deteriorating rural livelihoods, food security concerns, and macroeconomic stability.

The vulnerability of Indian agriculture is amplified by its structural dependence on the monsoon, the predominance of small and marginal farmers, and the widespread cultivation of water-intensive crops in ecologically fragile regions. Our analysis of empirical data up to 2020-21 demonstrates that yield losses in major crops-particularly rice, wheat, and maize-are closely linked to climate variability. These reductions have had a cascading impact on farmer incomes, rural employment, and national GDP, with rain-fed regions and economically weaker communities bearing the brunt of the crisis.

Despite a host of initiatives-from climate-resilient technologies and crop insurance schemes to community-driven adaptation models-challenges persist. Gaps in implementation, inequitable access, inadequate financing, and limited institutional coordination have weakened the effectiveness of many adaptation and mitigation strategies. However, there are clear pathways to enhance resilience and sustainability.

As India stands at the crossroads of agrarian transformation and climate adaptation, a paradigm shift is essential-moving from reactive relief-centric models to proactive, climate-smart agriculture.

This requires concerted efforts across multiple fronts: increased public investment in resilient infrastructure and R&D, robust policy support for diversification and risk management, decentralized governance, and inclusive, bottom-up planning mechanisms.

In conclusion, safeguarding Indian agriculture from the adverse impacts of climate change is not just an environmental imperative but a socio-economic necessity. The future of over half the nation's population, the stability of food

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systems, and the trajectory of rural development hinge on our ability to adapt intelligently and equitably. With timely and well-integrated strategies, Indian agriculture can not only survive the climate crisis but emerge stronger and more sustainable in the decades to come.

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