

## How Climate Change Affects Farming: Challenges for Agriculture

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Agricultural productivity heavily depends on weather, climate, and water availability—any disruption in these can directly harm crop yields. In the past, natural disasters like floods, droughts, and landslides occurred seldom, allowing farmers time to recover. Now, due to climate change, these events strike almost every year—and often multiple times—causing more severe damage. For instance, in 2024, India recorded extreme weather events on 88% of the days, triggering widespread internal displacement and affecting about 5.4 million people. That same year saw 4.07 million hectares of crops damaged, more than double the figure in 2022. Floods alone displaced hundreds of thousands—Assam's monsoon floods impacted 7.7 million people, with over 350,000 evacuated. Moreover, India experienced an unusually early and severe heat wave in 2025, with temperatures hitting 48°C in Rajasthan, causing hundreds of heat-related deaths and widespread agricultural disruption. In light of these escalating threats, it's more urgent than ever to adopt stronger planning, climate-resilient farming methods, and effective support systems for farmers to protect agriculture and ensure India's food security remains intact (Table 1).



**Table: 1. Impact of Climate Change on Agriculture in India.**

Category	Details / Data	Impact on Agriculture & People
Climate Dependence	Agricultural production depends on stable weather, predictable rainfall, and water availability	Disruption in any factor directly reduces crop yield and farm income.
Frequency of Natural Disasters	Previously rare (occasional floods, droughts, landslides).	Now happening almost every year, often multiple times a year.
Extreme Weather Events (2024)	Recorded on 88% of the days in the year (i.e., ~321 days).	Triggered widespread internal displacement; affected 5.4 million people.
Crop Damage (2024)	4.07 million hectares of crops damaged.	Crop loss doubled compared to 2022 figures.
Flood Impact – Assam (2024)	Monsoon floods affected 7.7 million people; over 350,000 evacuated.	Displaced communities; submerged agricultural land.
Heatwave – Early & Intense (2025)	Rajasthan recorded 48°C temperatures unusually early.	Caused hundreds of heat-related deaths; damaged crops in peak growing phase.
Water Stress & Drought Risk	Climate events reduce groundwater recharge; monsoon variability increasing.	Leads to irrigation shortages and crop failure.
Socioeconomic Impact	Small/marginal farmers most affected; internal migration increasing.	Loss of income, rising debt, forced migration to cities.
Proposed Solutions	Climate-resilient crops, better planning, support systems, weather forecasting.	Mitigates damage and ensures long-term sustainability of agriculture.

Source: Down To Earth (2024) and Wikipedia (2024 India floods)

One of the major impacts of climate change in India is the increasing occurrence of floods. Large parts of the country have long suffered from the devastation caused by floods. However, over the past two decades, there have been significant changes in the nature, pattern, and frequency of floods. These changes have had adverse effects on agriculture, health, and livelihoods, with rising losses to life, property, and productivity.

### Climate Change and Drought

Another major impact of climate change in India is the rising frequency and severity of droughts. Due to increasing temperatures and faster evaporation, drought-prone areas have grown from 20% in the early 2000s to over 40% annually, according to the India Meteorological Department. Rainfall patterns have become erratic, with a 6% national deficit during the 2023 monsoon. States like Karnataka and Maharashtra experienced over 20% rainfall shortfalls, severely harming agriculture. Soil's water retention has declined due to deforestation, chemical fertilizers, and unsustainable farming, turning fertile land barren. Emissions inequality is stark—Greenpeace India reports the richest 1% emit 4.5 times more CO<sub>2</sub> than the poorest 38%. Rapid, unchecked urban growth further worsens the crisis. From 1955 to 2000, 2–3 lakh hectares of agricultural land were lost to urban development. ISRO's 2021 report shows a 33% loss in green cover across major cities. This urbanization raises surface temperatures and reduces groundwater recharge. A 1°C temperature rise may cut wheat production by 4–5 million tonnes. Without urgent action, food insecurity, malnutrition, and poverty will worsen—especially for the urban poor.

### Impact of Climate Change on Crops

The effects of climate change on the agricultural sector can primarily be observed in two ways—region-specific and crop-specific. This means that different regions may experience varying impacts on different crops, and even within a single region, different crops may be affected in different ways.

- a. **Impact on Wheat Production:** If the temperature rises by around 2°C, wheat productivity is expected to decline in most areas. Regions with currently high productivity may experience lesser impact, while those with lower productivity will be more severely affected. Additionally, for every 1°C increase in temperature, wheat production may drop by 40 to 50 million tonnes. However, if farmers adjust their sowing schedules appropriately, this decline can potentially be reduced by 1–2 tonnes per hectare.
- b. **Impact on Rice Production:** In India, rice accounts for approximately 42.5% of total crop production. With rising temperatures, rice yields will also begin to decrease. It is estimated that a 2°C rise in temperature may reduce rice production by 0.75 tonnes per hectare. Eastern India, a major rice-producing region, will be particularly affected. Since rice is a rain-fed crop, it is more vulnerable to the effects of climate change, such as increased instances of floods and droughts, making it more susceptible than wheat.

The impact of climate change will not be limited to just the quantity of crop production—it will also negatively affect crop quality. Nutritional content, particularly protein levels in grains, is expected to decline. This means that even a balanced diet may not be sufficient to maintain good health, and artificial substitutes may be required to compensate for nutritional losses. In regions along the Ganges River, rising temperatures are likely to result in reduced productivity of most crops.

### Impact of Climate Change on Water Resources

Earth holds about 1,400 billion cubic meters of water, with 97% being saline in the oceans. Only around 136,000 cubic meters of freshwater is accessible for human use. Water exists as liquid (oceans, rivers, aquifers), solid (ice), and gas (water vapor). Despite the total water volume remaining constant, global water consumption doubles every 20 years, driven by urban, agricultural, and industrial needs. Unfortunately, a significant amount is wasted—estimates suggest 40–50% could be saved with better management.

Climate change is intensifying water challenges. Farmers face growing difficulties accessing irrigation water due to irregular rainfall, prolonged droughts, and increased flooding. Semi-arid regions are particularly vulnerable, with reduced river flows, rising salinity, and pollution from urban and industrial sources threatening water supplies near river deltas. Groundwater remains essential for drinking, agriculture, and industry, but growing populations and polluted water sources have made water scarcity a critical issue worldwide. In rural India, traditional water bodies like ponds, lakes, and wells that once supported water tables are vanishing. Rainwater harvesting, historically practiced by farmers to maintain soil moisture and fertility, has declined with the widespread use of electric tube wells and cheap electricity. This shift has further undermined water conservation, exacerbating the crisis and making sustainable water management more urgent than ever.

### Impact of Climate Change on Soil

Like other components of agriculture, soil also suffers under the effects of climate change. The prior depletion of soil's organic carbon due to chemical fertilizers has already weakened its structure. Now, rising temperatures are further reducing soil moisture, adversely affecting its functionality. Soil salinity is increasing, and biodiversity is declining. Falling groundwater levels compound these effects, undermining the soil's fertility. Natural disasters such as floods accelerate soil erosion, while prolonged droughts expand barren land. The diminishing tree cover and lack of biodiversity exacerbate the degradation of fertile soils, ultimately contributing to land becoming infertile.

### Impact of Climate Change on Plant Diseases and Pests

Climate change significantly influences the proliferation of pests and diseases. Changes in temperature, humidity, and atmospheric composition enhance the reproduction of pathogens, fungi, and pests, while disrupting the relationships between pests and their natural enemies. Warm climates facilitate the breeding of insects, and prolonged spring, summer, and autumn seasons allow multiple generations to complete their life cycles. Many survive hidden through the winter in the form of larvae. Wind pattern shifts increase airborne pests, bacteria, and fungi. Controlling these threats may lead to excessive pesticide use, which in turn fosters new diseases. Livestock health will also suffer in similar ways.

### Impact on Biodiversity

Loss of soil fertility due to drought, salinization, or erosion compromises the vitality and regeneration capacity of vegetation. This impacts humans and wildlife that depend on these plants for sustenance and livelihood, triggering crises in food security and pushing vulnerable populations deeper into poverty.

### Reducing Greenhouse Gas Emissions through Agriculture

Embracing organic farming is one of the most effective strategies to lower agricultural greenhouse gas (GHG) emissions. Research consistently shows:

- Organic farming reduces overall GHG emissions.
- It increases carbon sequestration within the soil.

Studies, including long-term field experiments, affirm these results in multiple regions. When compared to modern chemical-intensive agriculture, organic methods generate far fewer emissions. Whether in flood-prone or drought-prone regions, sustainable or organic farming often yields more per hectare. Using traditional seed varieties can further enhance outcomes. Some studies have recorded reductions in soil carbon loss by up to 80%.

- Role of Nitrogen:** In conventional agriculture, chemical fertilizers are the primary source of GHG emissions. In 2005, global consumption of chemical fertilizers reached 908.6 million tonnes, produced using fossil fuels like diesel, significantly contributing to climate change. Organic agriculture, on the other hand, relies on self-sufficient nitrogen sources—such as animal manure, crop residues, nitrogen-fixing legumes, crop rotations, and green manures. These practices substantially reduce emissions of nitrous oxide, a potent greenhouse gas.



- b. **Methane Emissions:** Methane accounts for approximately 14% of total greenhouse gases, two-thirds of which originate from agriculture. Adopting organic and sustainable farming practices can reduce methane output. Indigenous livestock breeds, particularly dairy cows and young animals, emit less methane. Proper valorization of cattle manure also helps curb emissions. In rice fields, using improved crop varieties that require less water—thereby reducing flooding—can further reduce methane release, making low-water rice farming highly advantageous.
- c. **Carbon Dioxide Sequestration:** Organic farming enhances the soil's capacity to absorb and retain carbon. Soil erosion depletes this carbon, directly reducing soil productivity. Practices like using organic manures and crop diversity help maintain optimal carbon levels in the soil.

### Crop Rotation and Farm System

Sustainable farming systems rely on key practices such as promoting varietal diversity, integrating perennial trees into crop rotations, using ground-cover crops between rows, and developing self-reliant farming models. Unlike monoculture farming, which often maximizes yield but creates dependency on external inputs like seeds, fertilizers, and pesticides, sustainable systems enhance productivity through natural processes. By drawing nutrients directly from the soil using organic fertilizers, nitrogen-fixing legumes, and agroforestry elements, these systems reduce input costs and create a closed nutrient cycle. This not only improves soil health but also boosts long-term profitability and resilience for farmers.

### Nutrient and Fertilizer Management

Effective nutrient and fertilizer management is essential for sustainable agriculture. Enhancing soil nitrogen levels through native organic inputs and nitrogen-fixing plants improves soil quality and promotes natural nitrogen recycling. Fertilizers should be applied judiciously, timed to match specific crop growth stages to maximize efficiency and minimize excess use. Avoiding over-application of nitrogen is critical to prevent harmful greenhouse gas emissions. Additionally, wise management of tillage and crop residues—such as minimizing or eliminating plowing—helps maintain soil health. Research shows that organic farming not only reduces greenhouse gas emissions by 36% compared to conventional methods but also offers better cost efficiency and lower environmental impact.

### Livestock Management, Pasture, and Feed

Sustainable livestock, especially indigenous animal breeds, play a vital role in reducing methane emissions and ensuring resilient agriculture. Feeding and digestion processes release methane, but through proper management—like limited use of liquid digesters and manure for biofertilizer or biogas—emissions can be reduced. Indigenous breeds generally demonstrate greater resistance to heat, cold, and disease, resulting in better productivity and longevity. Their manure, when managed properly, benefits the soil more effectively than artificial fertilizers.

### Soil Fertility Restoration and Barren Land Rehabilitation

Soil fertility restoration and barren land rehabilitation are vital for sustainable agriculture. Key strategies include enriching the soil with nutrients using indigenous and organic fertilizers and applying soil conservation methods to reduce erosion, carbon loss, and salinization. Techniques such as mulching with crop residues and conserving water help maintain soil moisture and health while promoting the buildup of soil organic carbon. Practices like organic farming, no-till agriculture, agroforestry, and other sustainable methods not only prevent erosion but also transform carbon loss into carbon gains. Consequently, organic farming plays a dual role by reducing greenhouse gas emissions and capturing atmospheric carbon, contributing significantly to climate change mitigation.

## Empowering Farmers through Knowledge-Based Farming

The cornerstone of organic farming is valuing farmers' experiential knowledge, observations, and innovations. This enables farmers to adapt to changing conditions effectively. In contrast, chemically dependent industrial farming alienates farmers' expertise, pushing them into cycles of dependency and loss. By integrating traditional wisdom with modern scientific research, knowledge-based farming fosters resilience and sustainability. It encourages farmers to make informed decisions about crop selection, soil health, pest management, and water use, reducing input costs and environmental harm. Empowering farmers in this way strengthens local food systems and promotes long-term agricultural stability amid climate challenges.

## Measures to Mitigate Climate Change Impacts on Indian Agriculture

To mitigate climate change impacts, Indian agriculture must adopt climate-resilient crop varieties and adjust planting schedules to reduce stress. Water conservation techniques like zero tillage and rainwater harvesting are essential. Promoting integrated farming systems increases resilience and food security. Soil fertility restoration through organic inputs and conservation practices enhances productivity. Lastly, carbon sequestration through sustainable farming helps reduce greenhouse gas emissions (Table 2).

**Table: 2. Key Measures to Mitigate Climate Change Impacts on Indian Agriculture**

Strategy	Description	Benefits
Develop Climate-Resilient Crops	Cultivate varieties tolerant to heat, drought, waterlogging, salinity, and alkalinity. Preserve traditional seeds.	Ensures stable yields under stress, improves adaptability, and maintains genetic diversity.
Adjust Planting Schedules and Farming Methods	Change sowing times; adopt mixed cropping, intercropping, and agroforestry.	Reduces heat stress, improves soil health, diversifies income, and increases resilience.
Water Conservation in Fields	Preserve moisture, capture rainwater; use zero tillage and raised-bed planting techniques.	Cuts water use, reduces costs by ~10%, boosts yields, controls weeds and waterlogging.
Promote Integrated Farming	Combine crops, trees, and livestock in diverse farming systems.	Enhances stability, reduces input dependence, and secures farmer livelihoods during shocks.

## Conclusion

Climate change poses a serious threat to Indian agriculture by disrupting crop production, water availability, and soil health. Increasing floods, droughts, and heatwaves cause significant crop losses, especially for small farmers. Rising temperatures reduce yields of staples like wheat and rice, while erratic rainfall and groundwater depletion worsen irrigation issues. Soil fertility is declining due to erosion, salinization, and chemical overuse. However, adopting climate-resilient practices such as organic farming, water conservation, crop diversification, and traditional seed promotion can mitigate these impacts. With proper support and policies, Indian agriculture can become more resilient, ensuring food security and sustainable rural livelihoods.