

(A No. 133) Farming in a New Climate: The Strategy of Climate-Smart Agriculture and Resilient Crops

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The single greatest long-term threat to global food security is **climate change**. Manifesting through unpredictable monsoons, severe droughts, extreme heatwaves, and new pest infestations, climate volatility directly undermines agricultural productivity and farmer livelihoods, particularly in climate-vulnerable regions like the Indian subcontinent. To address this existential crisis, the international community and national governments are rapidly adopting **Climate-Smart Agriculture (CSA)**—an integrated approach designed to future-proof farming systems.

CSA is not a single technology but a management strategy that systematically integrates three interconnected goals, often called the "**Triple Win**": **Productivity, Adaptation (Resilience), and Mitigation**. For India, where agriculture contributes a significant portion of the country's greenhouse gas (GHG) emissions (primarily from paddy fields and livestock) while simultaneously being most susceptible to climatic shocks, the adoption of CSA practices and resilient crop varieties is an **imperative for survival and stability**.

The Three Pillars of Climate-Smart Agriculture (CSA)

The core strength of the CSA approach lies in its holistic nature, ensuring that interventions are tailored to local socio-economic and agro-ecological contexts.

1. Sustainably Increase Productivity and Incomes

The foundational pillar is ensuring that climate actions do not compromise the ability to feed the growing population. Productivity must be maintained or increased, but sustainably, meaning:

- **Efficiency:** Producing more food using fewer resources (water, fertilizer, land).
- **Profitability:** Ensuring that the practices are economically viable for farmers, generating stable incomes, which in turn drives long-term adoption.
- **Nutritional Security:** Promoting crops and livestock systems that deliver balanced nutrition, such as biofortified varieties and nutrient-rich millets.

2. Enhance Adaptation and Resilience (Future-Proofing the Farm)

This is the most critical pillar for exposed smallholder farmers. Adaptation involves strengthening the capacity of agricultural systems to cope with immediate shocks (e.g., flash floods, droughts) and long-term stresses (e.g., rising average temperatures, increasing soil salinity). Key strategies include:

- **Risk Reduction:** Implementing practices like rainwater harvesting, check dams, and micro-irrigation to manage water variability.

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- **Early Warning Systems:** Utilizing **digital weather forecasts (Gramin Krishi Mausam Seva - GKMS in India)** and localized agro-advisories delivered via mobile platforms to inform timely decisions on sowing, harvesting, or protecting crops.
- **Diversification:** Shifting away from monocultures to **mixed cropping, intercropping, and agroforestry**, which hedges against the risk of total crop failure due to a single climate event.

3. Reduce and/or Remove Greenhouse Gas (GHG) Emissions (Mitigation)

Agriculture contributes to climate change through emissions of methane (from paddy fields and livestock) and nitrous oxide (from synthetic fertilizers). Mitigation aims to minimize the farm's carbon footprint:

- **Methane Reduction:** Promoting **Alternate Wetting and Drying (AWD)** irrigation in rice paddies, which significantly reduces methane release without sacrificing yield.
- **Nitrous Oxide Reduction:** Encouraging **Precision Nutrient Management (PNM)** and the use of biofertilizers to reduce the over-application of synthetic nitrogen fertilizers.
- **Carbon Sequestration:** Adopting **Conservation Agriculture (Zero-Tillage and Cover Cropping)** practices that actively sequester atmospheric carbon into the soil (linking directly to Regenerative Agriculture).

The Breeding Revolution: Developing Climate-Resilient Crops

While smart practices are essential, the frontline defence against climate stress is **genetics**. Research institutions globally, led in India by the **Indian Council of Agricultural Research (ICAR)** and its flagship project, the **National Innovations on Climate Resilient Agriculture (NICRA)**, are developing crops specifically engineered to thrive in unpredictable conditions.

1. Drought and Water Stress Tolerance

Drought is the most damaging climatic event for Indian agriculture. Breeding efforts focus on varieties that:

- **Require Less Water:** Cultivating low-water crops like **millets** (e.g., pearl millet, finger millet) and drought-tolerant varieties of staple crops like rice.
- **Maturity Speed:** Developing **extra-short duration** varieties that can escape mid-season or terminal drought stress by completing their growth cycle faster.
- **Example:** ICAR has released hundreds of stress-tolerant crop varieties, including drought-tolerant rice varieties like **CR Dhan 201** suitable for aerobic conditions, and early-maturing pulse varieties (like greengram) that fit into tighter crop windows.

2. Heat and Thermal Stress Resilience

Rising average temperatures, especially during flowering and grain-filling stages, can severely depress yields of major crops like wheat and rice.

- **Breeding for Stability:** Researchers use advanced tools like **precision phenotyping** and **Free Air Temperature Enrichment (FATE)** facilities to screen for traits that maintain grain weight and fertility under high heat.
- **Example:** The development of **heat-tolerant wheat varieties** is crucial for northern India, where early onset of summer can drastically cut yields. ICAR's efforts focus on varieties that perform well even when temperatures spike during the critical physiological phase.

3. Flood and Submergence Tolerance

In Eastern India and coastal regions, prolonged flooding due to extreme rainfall events is a major threat.

- **"Scuba" Genes:** Breakthroughs in genetic engineering and molecular breeding have led to the introduction of genes (like **Sub1**) that allow rice plants to survive for extended periods (up to two weeks) completely submerged underwater, offering a lifeline to farmers in flood-prone areas.

Scaling CSA: Policy and Institutional Support in India

The success of CSA hinges on mass adoption by smallholders, which requires strong institutional backing:

- **National Missions:** Government initiatives like the **National Mission for Sustainable Agriculture (NMSA)** and NICRA provide the policy and funding framework to test and disseminate CSA technologies and stress-tolerant seeds through a network of **Krishi Vigyan Kendras (KVKs)**.
- **Farmer Participation:** The most effective interventions are validated at the local level through a **farmer participatory approach** in climatically vulnerable districts, ensuring that the technology is context-specific and culturally acceptable.
- **Seed System Strengthening:** ICAR and state agricultural universities are actively involved in ramping up **breeder seed production** and establishing seed hubs across the country to ensure timely and affordable access to these new, resilient varieties for farmers.

Conclusion: Adaptation is the New Productivity

Climate-Smart Agriculture and the development of resilient crops are fundamentally changing the definition of agricultural success. It is no longer just about the highest yield in the best year, but about **stable, acceptable yields every year**, despite the worst weather events. By coupling cutting-edge genetic science with intelligent, data-driven farming practices (the CSA triple-win), the sector can navigate the turbulence of a changing climate, securing livelihoods, food supply, and environmental health for generations to come.