

(A No. 127) Forging the Future: Climate-Resilient Agriculture as the Global Imperative

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Climate change is no longer a distant threat; it is a present reality fundamentally altering the biophysical foundations upon which global food systems rest. With escalating temperatures, erratic precipitation patterns, and the increased frequency and intensity of extreme weather events—from prolonged droughts and flash floods to devastating heatwaves—agriculture, the backbone of human civilization, faces an existential crisis.

The traditional farming models, often reliant on predictable weather cycles, are buckling under this climatic stress. To safeguard **global food security**, protect the livelihoods of the world's 500 million smallholder farmers, and ensure the long-term sustainability of the planet's ecosystems, the global community must urgently pivot towards **Climate-Resilient Agriculture (CRA)**. CRA is an integrated approach that enhances the ability of agricultural systems to anticipate, absorb, adapt to, and recover from climate-related shocks and stresses. It is the roadmap for a future where farming thrives, not just survives, in a volatile climate.



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Defining the Dual Challenge: Adaptation and Mitigation

Climate-Resilient Agriculture (CRA) is distinguished by its twin focus: **Adaptation** and **Mitigation**. It acknowledges that agriculture is both a **victim** of climate change (suffering losses from extreme weather) and a **contributor** (responsible for a significant portion of global greenhouse gas (GHG) emissions, particularly methane and nitrous oxide).

1. Adaptation (Building Resilience)

This involves implementing practices and technologies that increase the agricultural system's capacity to withstand adverse climatic events. Key goals include:

- **Yield Stability:** Maintaining productivity even under stress conditions (e.g., drought, heat).
- **Risk Reduction:** Minimizing crop and livestock losses from floods, pests, and diseases.
- **Resource Efficiency:** Optimizing the use of scarce resources like water and land.

2. Mitigation (Reducing Emissions)

कृषि विज्ञान की मासिक पत्रिका

This involves minimizing agriculture's own contribution to climate change by:

- **Carbon Sequestration:** Enhancing the soil's ability to store atmospheric carbon dioxide.
- **Emissions Reduction:** Decreasing methane (from livestock and paddy fields) and nitrous oxide (from fertilizer use) emissions.

CRA, therefore, is an integrated strategy focused on sustainably increasing productivity and incomes, enhancing resilience, and reducing GHG emissions wherever possible.

The Pillar Technologies of Climate Resilience

The transition to CRA is powered by a diverse toolkit of technologies and time-tested sustainable practices, tailored to specific local conditions.

1. Water Management and Efficiency (More Crop Per Drop)

Water scarcity is the most immediate consequence of climate change for farmers. CRA addresses this through:

- **Micro-Irrigation: Drip and Sprinkler systems** deliver water precisely to the plant root zone, dramatically increasing water use efficiency from the typical 30-40% in flood irrigation to **70-90%**. This is vital for water-stressed regions.
- **Rainwater Harvesting:** Construction of **farm ponds, check dams, and percolation tanks** to capture and store excess surface runoff, recharging groundwater and providing supplemental irrigation during dry spells.
- **Water-Smart Cultivation:** Practices like **Alternate Wetting and Drying (AWD)** in rice cultivation, which significantly reduces water usage without compromising yield.

2. Soil Health and Conservation Agriculture

Healthy soil is the foundation of resilience. Conservation Agriculture focuses on restoring soil fertility and structure.

- **Zero and Reduced Tillage:** Avoiding deep plowing and tilling (Zero-Tillage) reduces soil disturbance, prevents the rapid oxidation of organic matter, and minimizes soil erosion. This saves fuel costs and locks carbon into the soil.
- **Crop Residue Management (Mulching):** Leaving crop residues (stubble) on the field surface. This acts as **mulch**, reducing water evaporation, controlling soil temperature, and slowly adding organic matter back into the soil, thus enhancing its water retention capacity.
- **Cover Crops and Crop Rotation:** Planting non-cash crops (e.g., legumes) during fallow periods to enrich the soil with nitrogen, prevent erosion, and enhance microbial biodiversity.

3. Climate-Resilient Crop Varieties

Biotechnology and modern breeding techniques are crucial for developing crops that can tolerate stress.

- **Stress-Tolerant Cultivars:** Developing **drought-tolerant** varieties of maize and millets, **flood-tolerant** (or submergence-tolerant) rice varieties (like 'Scuba Rice'), and **heat-**

resistant varieties of wheat and pulses. These high-yielding varieties ensure stable harvests even when weather conditions are adverse.

- **Millets Revival:** Promoting the cultivation of traditional, nutrient-dense **millets** (sorghum, pearl millet, finger millet) that are inherently resilient to high temperatures and low moisture conditions.

4. Digital Tools and Climate Information Services

The integration of **Agri-Tech** provides farmers with the ability to make data-driven, preemptive decisions.

- **Agromet Advisories:** Delivering weather and climate forecasts (temperature, rainfall, humidity, wind speed) directly to farmers' mobile phones via apps like '**Meghdoot**'. These advisories are critical for timely actions, such as delaying planting, avoiding pesticide spraying before rain, or preparing for cold waves.
- **Precision Agriculture:** Using **drones, IoT sensors, and Artificial Intelligence (AI)** to monitor soil health, crop nutrient requirements, and pest incidence in real-time. This allows for precise and localized application of inputs (fertilizers, water, pesticides), reducing waste and cost.

5. Integrated Farming Systems (IFS)

IFS represents a holistic approach, integrating various farm components to create a synergistic, climate-proof livelihood system.

- **Crop-Livestock-Fishery Integration:** Combining crop cultivation with livestock rearing (dairy, poultry) and, where feasible, aquaculture (fish farming). The waste from one component becomes an input for another (e.g., manure for crops, crop residues for feed). This diversity ensures that if one component fails due to a climate shock (e.g., crop loss due to drought), the farmer still has an income source from livestock or fisheries.

Benefits: A Win for Farmers, Food Security, and the Planet

The large-scale adoption of CRA practices yields transformative benefits that extend far beyond the farm gate.

For Farmers and Livelihoods

- **Increased Income Stability:** Diversified income streams from IFS and reduced production risk lead to more stable and higher net incomes.
- **Lower Input Costs:** Efficient water use (micro-irrigation) and reduced need for synthetic fertilizers (conservation agriculture, organic amendments) drastically lower cultivation expenses.
- **Improved Health:** Reduced reliance on chemical pesticides and fertilizers contributes to better health for farming families and consumers.

For Food Security

- **Stable National Production:** By safeguarding yields from weather variability across millions of hectares, CRA contributes to stable national food production, preventing price volatility and ensuring sustained food access for the entire population.
- **Nutritional Security:** Promoting high-value, nutrient-dense crops like millets and pulses addresses chronic malnutrition issues, particularly in rural areas.

For the Environment

- **Biodiversity Conservation:** Agroforestry and diversified cropping patterns promote biodiversity both above and below the soil surface.
- **Climate Change Mitigation:** Practices like zero-tillage and agroforestry are effective mechanisms for **sequestering carbon** in the soil, turning agricultural land into a carbon sink. Reducing excessive fertilizer use cuts down on the emission of nitrous oxide, a powerful GHG.
- **Ecosystem Health:** Reduced chemical runoff protects water bodies from pollution.

Scaling Up: Policy and Institutional Support

The shift to CRA requires robust support from governments and institutions. Initiatives like India's **National Innovations in Climate Resilient Agriculture (NICRA)**, managed by ICAR, and the **National Mission for Sustainable Agriculture (NMSA)** are critical in demonstrating and deploying these technologies across climatically vulnerable districts.

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Key policy needs include:

1. **Financial Incentives:** Subsidies and credit schemes for installing micro-irrigation and purchasing climate-smart machinery.
2. **Research Prioritization:** Continued public and private investment in developing location-specific, climate-adapted seed varieties and livestock breeds.
3. **Extension Services:** Strengthening KVKs and farmer extension services to effectively transfer complex scientific knowledge to local contexts.
4. **Risk Transfer Mechanisms:** Enhancing crop insurance schemes (like PMFBY) to provide comprehensive and timely payouts against climate risks, incentivizing farmers to adopt newer, yet sometimes perceived as riskier, CRA technologies.

Conclusion

Climate-Resilient Agriculture is the single most important strategy for adapting human civilization to the era of climate change. It is a philosophy that sees the relationship between the farmer, the food, and the environment as intrinsically linked.

By strategically adopting technologies from micro-irrigation and precision farming to age-old wisdom like agroforestry and crop diversification, farmers are transforming their fields into fortified systems capable of absorbing external shocks. The journey to a climate-resilient future is challenging, requiring massive investment and institutional commitment, but the reward is immense: a **secure food supply, thriving rural economies, and a planet healed through responsible stewardship**. CRA is not just an option; it is the **global imperative** to ensure that the next generation inherits a world where the essential act of farming can continue sustainably.