

Climate-Smart Horticulture: Building Resilient Systems for India's Food & Farm Future

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Horticulture has become a central pillar of India's agricultural growth story. Despite occupying a smaller share of cropped area relative to staples, it contributes disproportionately to agricultural output.

Recent official estimates show:

- Total horticulture production in India reached approximately 355.48 million tonnes in 2022-23, up from ~347 million tonnes in 2021-22.
- Horticultural crops are cultivated on about 28.44 million ha, with modest annual expansion.
- Fruits and vegetables account for nearly 90% of horticulture production.

The value dimension is equally striking: horticulture contributes around 33% of agricultural Gross Value Added (GVA) despite using roughly 13% of gross cropped area. These crops also support employment (especially for women), improved rural incomes, and dietary diversity.

India plays a major role globally, ranking as the second-largest producer of vegetables and fruits in the world after China, although the country's share in global trade remains modest.

Climate Vulnerabilities in Horticulture

Horticultural crops exhibit high sensitivity to climatic conditions at multiple phenological stages flowering, fruiting, maturation making them especially vulnerable to stress.

Key climate risk factors include:

- Temperature increases that impact pollination and fruit set, reducing yields and quality.
- Erratic rainfall and drought, which disrupt soil moisture and irrigation schedules.
- Extreme events (hailstorms, cyclones) that can damage orchards and vegetable crops.
- Pest and disease pressures, which intensify under warmer, more humid conditions.

Assessments also indicate that climate change influences post-harvest physiology and shelf life,

lowering marketable quality and increasing losses if not managed properly.

Globally, fruit and vegetable supply chains waste 15 - 20% of produce due to handling, storage, and climate stresses a figure that also applies in the Indian context.

Principles of Climate-Smart Horticulture

Climate-Smart Horticulture seeks to achieve three interconnected goals:

- Increase productivity to meet rising demand.
- Enhance resilience to weather extremes and climate variability.
- Reduce emissions and environmental impacts from production systems.

CSH is not a single technology but a portfolio of practices integrated across the production post-harvest market continuum.

Smart Production Technologies

Climate-Resilient Varieties

Selecting climate-adapted varieties helps farmers withstand stressors like heat, drought, and variable rainfall. Short-duration vegetable cultivars and drought-tolerant fruit genotypes have shown stabilized yields under challenging conditions.

Breeding efforts by national research institutions aim to expand the portfolio of stress-tolerant cultivars suited to local agro-ecologies.

Water Smart Irrigation

Water scarcity is a climate risk multiplier in horticulture. Smart irrigation technologies reduce water use while improving yields:

- Drip irrigation cuts water use by 40–60% and boosts crop output.
- Sprinkler systems improve water distribution and reduce soil evaporation.
- Fertigation enhances nutrient use efficiency.

These approaches are vital in semi-arid and drought-prone regions where water is the most limiting resource.

Protected Cultivation

Protected structures such as polyhouses and shade nets offer micro-climate control, helping

crops avoid extreme heat, frost, and heavy rains.

Benefits include:

- Extended growing seasons
- Higher quality and uniform produce
- Reduced pest pressure and chemical use

Even low-cost tunnels have proven beneficial for smallholders producing vegetables for local markets.

Sustainable Intensification and Soil Health

Sustainable intensification refers to producing more from less - minimizing inputs while maximizing outputs and ecological benefits.

Key practices include:

- Integrated nutrient management with organic amendments and bio-fertilizers.
- Soil moisture conservation through mulch and crop residues.
- Precision application of water and nutrients using digital decision tools.

These practices improve soil health a foundational climate resilience trait - while reducing reliance on chemical inputs.

Post-Harvest Systems and Loss Reduction

Post-harvest loss remains a significant challenge in horticulture. According to national assessments, losses can range from 10% to 40% depending on the crop, storage, and handling conditions.

Reducing these losses has multiple climate benefits:

- Less food wasted means less embedded water and land use loss.
- Improved cold chain systems stabilize farmer incomes by reducing seasonal gluts.
- Efficient packaging and grading improve marketability.

Investments in cold storage, pre-cooling facilities, and decentralised aggregation centres are central to climate-smart post-harvest systems.

Market Stability and Farmer Incomes

Climate shocks often lead to price volatility for perishable commodities: bumper crops depress prices, while weather-induced shortages drive spikes.

- Climate-smart supply chain interventions include:
- Strengthening Farmer Producer Organisations (FPOs)
- Improved market information systems
- Contract farming and price risk mitigation tools

These tools help farmers plan production and hedge against market risks linked to climatic variability.

Policy & Institutional Framework

India has launched several programmes supporting horticulture growth and climate resilience:

- National Horticulture Mission (NHM) to expand production and enhance farmer incomes.
- Expansion of micro-irrigation subsidies
- Support for cold chains and rural logistics
- Inclusion of horticulture in climate adaptation planning

Public investment, research extension linkages, and climate data services are critical enablers.

Conclusion

Climate-Smart Horticulture offers a pathway for Indian agriculture to balance economic growth with resilience and sustainability. By adopting suited varieties, efficient water systems, soil health practices, better post-harvest infrastructure, and market linkages, growers can improve yields and incomes while mitigating climate risks.

India's success in horticulture depends on integrating technology, policy, and farmer innovation shifting from reactive coping to proactive adaptation.