

A Climate-Smart Management Practice for Dryland Agriculture

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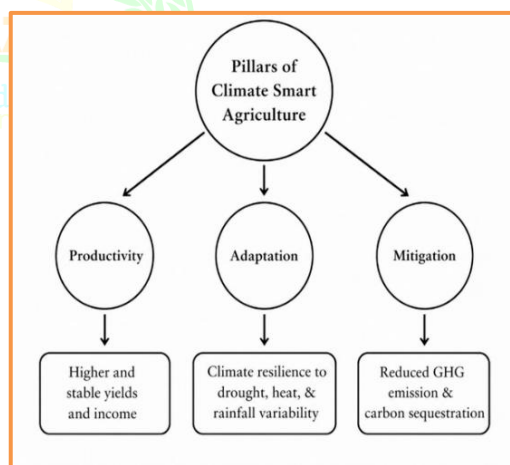
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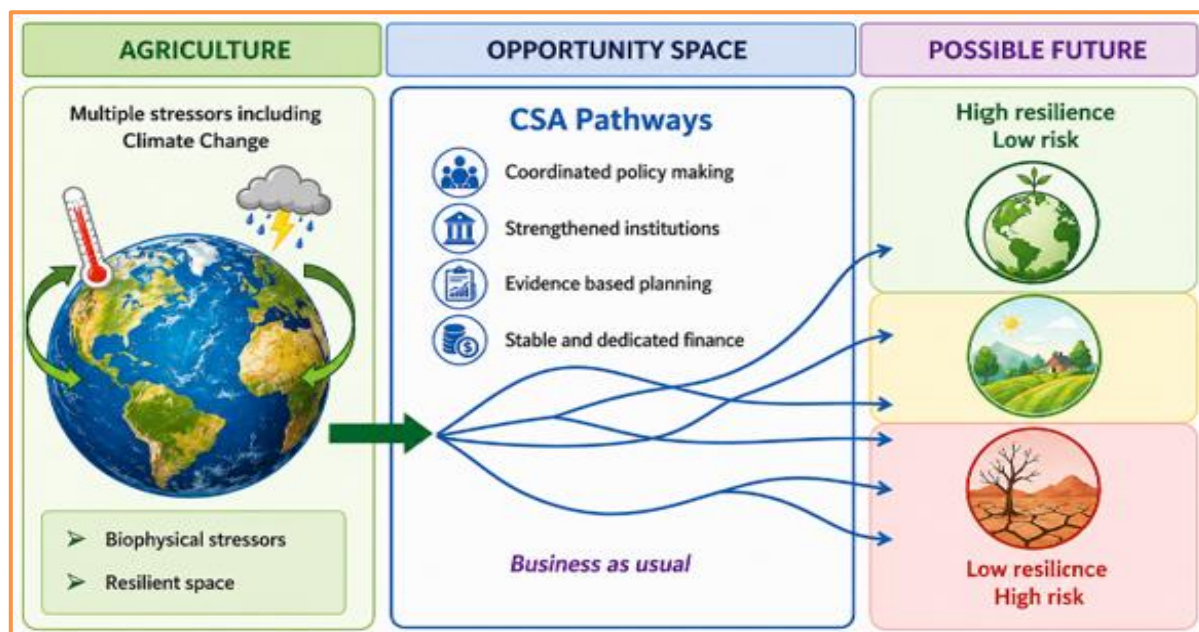
A significant majority of India's rural population depends on agriculture, which remains the foundation of the country's economy. However, a large share of India's agricultural output is produced in dryland and rainfed environments, where farming is heavily reliant on rainfall. Agricultural sustainability is a significant challenge in these areas due to their inherent fragility, limited water availability, degraded soils, and high levels of climatic variability. Nearly 60–65% of India's cultivated land is utilised for dryland agriculture, which sustains a substantial percentage of the country's small and marginal farming community. (Das *et al.*, 2025). The projected increase in droughts, cyclones, extreme precipitation events and heatwaves will result in greater instability in food production. A reduction in the number of rainy days, heavy rainfall events, late onset of the monsoon, mid-season droughts, etc., has been witnessed in recent years, adversely affecting crop production. At the country level, over the last 15 years, 7 years recorded below-normal rainfall, 6 years recorded above-normal rainfall, and 2 years recorded average rainfall (Srinivasa Rao *et al.*, 2015). Climate change has emerged as an additional stressor, intensifying the vulnerabilities of dryland farming systems. Climate variability and climate change have intensified these challenges in recent decades through

- ❖ Increasing the frequency of droughts
- ❖ Increased crop yield uncertainty
- ❖ Increased evapotranspiration losses and rising temperatures.

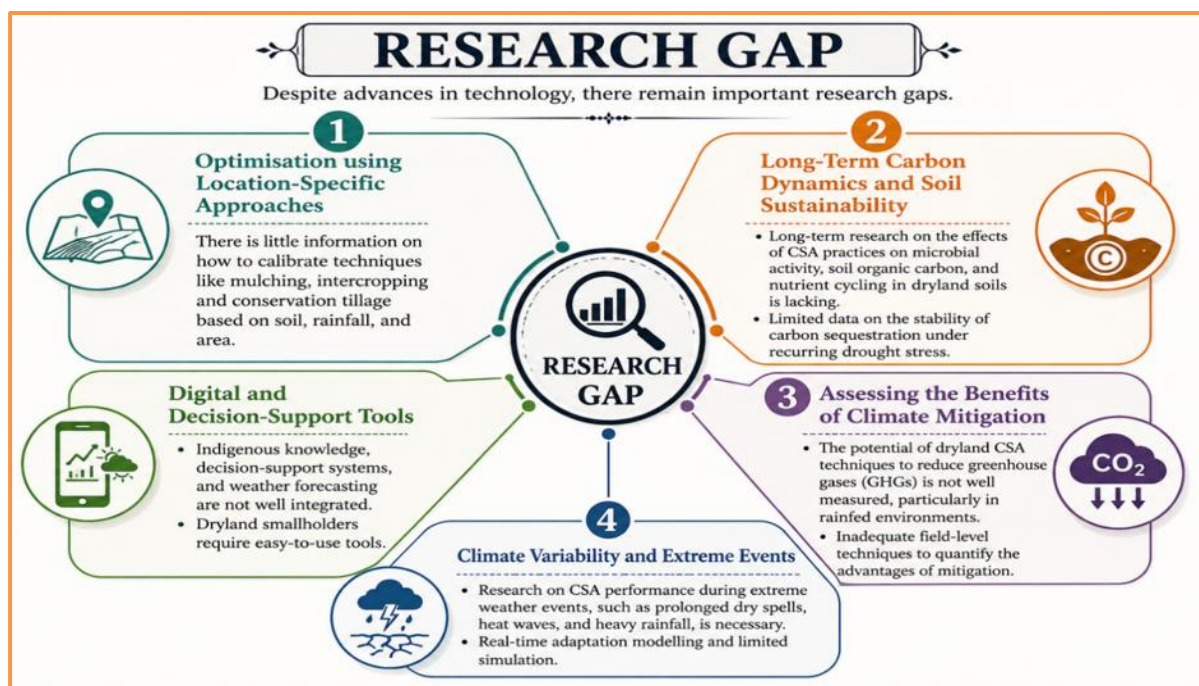
In dryland areas, conventional agricultural practices are no longer adequate to ensure productivity, sustainability, and livelihood security. Climate-smart agriculture (CSA) has become widely recognised worldwide as a promising approach to tackle these challenges. CSA places strong emphasis on integrating approaches to productivity growth, mitigation, and adaptation tailored to the area's agroclimatic characteristics. Climate-smart management techniques have the potential to significantly reduce climate risks, increase resource efficiency, and strengthen farming systems' resilience in dryland areas.



CSA calls for a set of actions by decision-makers at the farm, national, and global levels to enhance the resilience of agricultural systems and livelihoods and reduce the risk of food insecurity in the present and future. An IPCC graphic on climate-resilient transformation pathways, tailored to the specific context of agriculture, can be utilised to illustrate the idea.



Climate-resilient transformation pathways for agriculture



Climate Change-Induced Challenges to Food Production

Climate change is emerging as a major constraint to sustainable food production, particularly in dryland and rainfed agroecosystems that are highly dependent on the timing, amount, and distribution of precipitation. Rising temperatures enhance atmospheric evaporative demand and evapotranspiration, thereby intensifying soil moisture deficits and increasing crop water requirements. Concurrently, alterations in rainfall regimes, including delayed monsoon onset, reduced rainy days, prolonged dry spells, and recurrent droughts, can disrupt crop establishment, phenological development, and biomass accumulation, ultimately leading to yield instability. (IPCC, 2022 & Lipper et al., 2014) In contrast, high-intensity rainfall events may exceed the soil's infiltration capacity, resulting in increased surface runoff, soil erosion, nutrient losses, and temporary waterlogging. These interacting climatic stresses can accelerate soil degradation, reduce water- and nutrient-use efficiency, and increase uncertainty in agricultural productivity. Consequently, climate change poses a multidimensional threat to food production by affecting crop growth, soil and water resources, and the overall resilience of farming systems. Developing climate-smart

management strategies that improve resource-use efficiency, conserve soil moisture, manage excess rainfall, and enhance the adaptive capacity of agroecosystems is therefore essential for sustaining food production under a changing climate

Major Climate-Smart Management Practices

1. Water Management Practices

Water scarcity is the most critical constraint in dryland agriculture. Efficient water management plays a key role in climate adaptation.

- **Rainwater harvesting** through farm ponds, contour bunding, and check dams
- **In-situ moisture conservation** using contour ploughing and ridge–furrow systems
- **Micro-irrigation techniques** such as drip and sprinkler irrigation

These practices improve water-use efficiency and ensure crop survival during dry spells.

2. Soil Health Management

Maintaining soil fertility and structure is essential for sustainable dryland farming.

- **Conservation tillage** reduces soil disturbance and moisture loss
- **Mulching** helps in reducing evaporation and controlling weeds
- Addition of conservation agriculture, residue management, organic amendments, biochar, cover crops, and soil organic carbon from organic matter improves **Soil Organic Carbon**, enhancing soil structure, nutrient availability, and water-holding capacity

Healthy soils are more resilient to climate stress and support better crop growth.

3. Crop Diversification and Improved Varieties

The selection of suitable crops and varieties reduces climate risks.

- Use of **drought-tolerant and short-duration varieties**
- Promotion of **millets, pulses, and oilseeds**, which are well adapted to dry conditions
- Crop diversification to spread risk and improve soil health

These strategies enhance resilience and ensure stable yields under variable climatic conditions.

4. Integrated Farming Systems (IFS)

Integrated farming systems combine crops, livestock, and other enterprises to optimize resource use.

- Crop–livestock integration
- “Inclusion of agroforestry systems such as agrisilviculture, agrihorticulture, and silvopastoral systems.”
- Recycling of farm wastes

IFS provides multiple income sources, reduces risk, and improves sustainability.

5. Climate Information and Advisory Services

Access to timely and accurate weather information helps farmers make better decisions.

- Use of weather forecasts from agencies like the **Indian Meteorological Department**
- Agro-advisory services for sowing, irrigation, and pest management
- Mobile-based information systems

These services enable farmers to adapt their practices according to changing weather conditions.

6. Nutrient Management

Efficient nutrient management enhances crop productivity and reduces environmental impact.

- Integrated nutrient management (INM)
- Use of organic manures and biofertilizers
- Balanced application of fertilizers based on soil testing

This improves nutrient-use efficiency and reduces greenhouse gas emissions.

Conclusion

Dryland agriculture is increasingly vulnerable to climate change due to rising temperatures, erratic rainfall, droughts, prolonged dry spells, and extreme precipitation events. Climate-smart management practices offer an integrated approach to improving the resilience and sustainability of dryland farming systems. Efficient water and soil management, crop

diversification, integrated farming, balanced nutrient management, and climate information services can enhance resource-use efficiency, reduce production risks, and sustain crop productivity under variable climatic conditions. Integrating traditional knowledge with modern scientific approaches and digital technologies can further strengthen farmers' adaptive capacity. Therefore, the adoption of location-specific and resource-efficient climate-smart practices is essential for building resilient dryland agricultural systems, conserving natural resources, and ensuring long-term food and livelihood security.

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