

AGRIFRONTLINE

The Voice of Agriculture

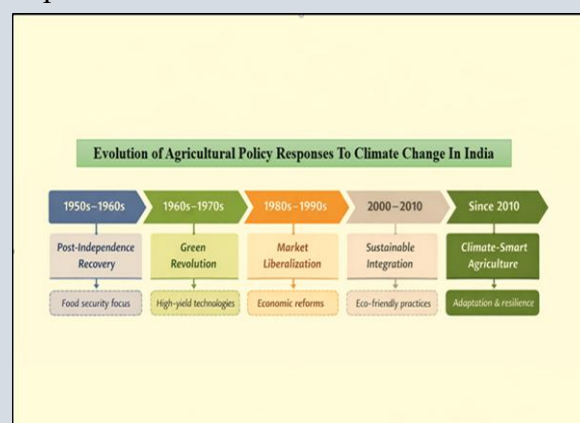
Policy Responses to Climate Change in Indian Agriculture: Gaps, Achievements, and the Way Forward

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1. Introduction: An Agricultural System under Stress

India's agricultural system is presently grappling with a crisis driven by climate change. Recent reports indicate that extreme climatic events have led to the loss of millions of hectares of agricultural land and large numbers of livestock, pushing millions of small and marginal farmers who constitute about 85% of agricultural households into greater vulnerability. These largely monsoon-dependent farmers, constrained by limited resources, face a dual challenge: adapting to the impacts of climate change while simultaneously reducing agriculture's roughly 14% share in national greenhouse gas emissions. Over time, the policy focus has evolved from post-colonial productivity enhancement under the Green Revolution to market-oriented reforms, then to sustainability

concerns. It is now increasingly toward explicit climate resilience.



2. Achievements: Building a Multi-Layered Policy Architecture

2.1 Established Policy Frameworks

India has put in place a comprehensive and multi-layered policy framework to address climate risks in agriculture. The flagship National Innovations in Climate Resilient Agriculture (NICRA) programme, launched in 2011, is currently implemented across 151 climate-vulnerable districts. Its interventions encompass natural resource management, crop and livestock systems, and institutional capacity building. One of NICRA's major contributions is the Atlas

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of Climate Adaptation in Indian Agriculture (ACASA-India), a digital platform that supports evidence-based planning and decision-making. Alongside this, the National Mission on Sustainable Agriculture (NMSA) promotes climate-resilient agricultural practices and the development of rainfed areas, while also fostering state-level institutional innovations such as Odisha's Climate Resilience Cell.

2.2 Financial Safety Nets

The Pradhan Mantri Fasal Bima Yojana (PMFBY) is one of the largest crop insurance programmes in the world. It plays a crucial role in protecting against climate-related crop losses. Ongoing reforms are intended to improve transparency and explore mechanisms to stabilise income. Disaster relief funds, interest subvention schemes, and compensation for livestock losses complement these efforts. Overall financial flows into sustainable agriculture are substantial, averaging around ₹22,393 billion (USD 301 billion) annually. A significant share of this funding, approximately 67%, comes from the private sector, largely driven by the Reserve Bank of India's priority sector lending norms.

2.3 Technological and Digital Push

Significant investments are being made to strengthen digital infrastructure in

agriculture. In addition to ACASA-India, key initiatives include satellite-based crop yield estimation, AI-enabled agrometeorological advisories, and mobile-based weather information services for farmers. The PM-KUSUM scheme supports the adoption of solar-powered irrigation systems, reducing dependence on conventional energy sources. Investments in cold storage infrastructure are also being prioritised to minimise post-harvest losses. Meanwhile, the agri-tech sector continues to expand rapidly, attracting nearly USD 900 million in venture capital and private equity annually. It is projected to reach a market value of USD 34 billion by 2027, offering scalable and innovative solutions across the agricultural value chain.

2.4 Global Alignment

Domestic agricultural policies are aligned with global commitments, such as the Panchamrit pledges, and integrate renewable energy, agroforestry, and sustainable land management with national development and climate objectives. This alignment positions agriculture not only as a sector for climate change mitigation but also as a key beneficiary of adaptation efforts.

3. Persistent Gaps: Structural and Implementation Challenges

3.1 The Smallholder Paradox

Despite an extensive policy framework, a significant implementation gap remains. Smallholder farmers, who constitute nearly 85–89% of the farming population, often have limited access to climate-resilient technologies and financial resources. Many support mechanisms are geared toward land-owning male farmers, thereby excluding women who contribute substantially to agricultural labour. In addition, fragmented and small landholdings make the adoption of technologies such as drip irrigation difficult. Behavioural factors, including a fatalistic reliance on rainfall, further hinder effective outreach, underscoring the need for interventions informed by social and psychological insights.

3.2 Fragmented Governance and Incentives

Coordination among ministries and implementing agencies remains weak, often resulting in duplication of efforts and policy confusion. While states such as Odisha have established dedicated Climate Resilience Cells, others, including Bihar, lack comparable institutional platforms. In addition, several subsidies, such as those for water and electricity, and minimum support prices for rice and wheat, undermine climate adaptation by discouraging diversification toward more

resilient crops like millets, pulses, and oilseeds. Extension services are also chronically understaffed, and overlapping mandates among Krishi Vigyan Kendras (KVKs) and Agricultural Technology Management Agencies (ATMAs) further dilute their effectiveness at the field level.

3.3 Inadequate and Misaligned Finance

Despite substantial financial flows into agriculture, a significant gap persists in finance specifically targeted toward climate adaptation. Annual sustainable agriculture finance stands at approximately USD 301 billion but has been declining at about 1.1% per year. This contrasts sharply with the estimated adaptation finance requirement of USD 206 billion for the period 2015–2030. Moreover, although the private sector contributes nearly 67% of total flows, this funding is largely debt-based, thereby increasing farmers' financial vulnerability. International climate finance remains marginal, accounting for only about 0.5% of total agricultural funding (around USD 1.5 billion annually). Investment through venture capital and private equity, averaging USD 892 million per year, is largely concentrated on commercial applications, leaving critical public-goods research, such as the development of climate-resilient crop varieties, underfunded.

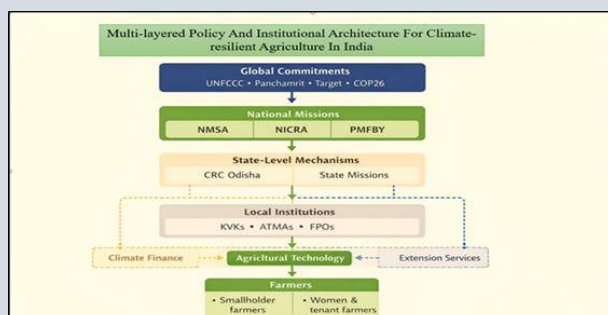


Fig. 2 Multi-layered policy and institutional architecture for climate-resilient agriculture in India, illustrating the linkages between global climate commitments, national missions, state-level mechanisms, local institutions, and farm-level implementation

3.4 Knowledge and Innovation Gaps

A persistent gap exists between formal scientific research and Indigenous Traditional Knowledge (ITK), despite the latter offering valuable insights for climate adaptation. In the absence of strong and effective extension support, farmers often adopt maladaptive practices, such as excessive fertiliser use, which can further degrade agro-ecosystems. Additionally, the agri-tech innovation ecosystem is largely oriented toward commercial applications. At the same time, public goods such as the development of climate-resilient crop varieties suited to vulnerable regions remain relatively neglected.

4. The Way Forward: Strategic Pathways

4.1 Hyper-Localised Solutions and Institutional Reinvention

Vulnerability assessments and corresponding interventions must be tailored to local conditions using platforms such as ACASA-India. Extension systems should be restructured to become more participatory, recognising farmers as active innovators rather than passive recipients of technology. To promote gender equity, the unit of intervention should shift from the “climate-resilient agriculture (CRA)-adopting farmer” to the “CRA-adopting family.” Strengthening Farmer-Producer Organisations (FPOs) is also essential to help smallholders achieve scale through collective investments in shared resources such as seed banks and custom hiring centres.

4.2 Realigning Economic Incentives

Subsidies and minimum support price (MSP) mechanisms need to be reoriented to encourage the cultivation of climate-resilient crops. Assured procurement of millets, pulses, and oilseeds through the Public Distribution System and nutrition programmes such as Odisha’s Millet Mission can accelerate crop diversification. Financial products should be offered as bundled packages combining seeds, irrigation, credit, and insurance. In addition, innovative instruments such as Payments for Ecosystem Services (PES) and agricultural carbon credits under India’s emerging Carbon Market should be

leveraged to incentivise sustainable agricultural transitions.

4.3 Data-Driven Governance and Digital Integration

India must fully utilise its digital investments to build systems that generate actionable intelligence for policymakers and farmers alike. Integrating ACASA-India with real-time farmer feedback can improve the accuracy and relevance of advisories and early warning systems. Artificial intelligence can be used to deliver hyper-local, language-specific advisories. At the same time, blockchain technologies can enhance transparency in fund disbursement and enable automated insurance payouts based on satellite-derived data. All digital solutions, however, must be designed with farmers' digital literacy and accessibility in mind.

4.4 Innovative Finance Mobilisation

Innovative financing approaches are critical for scaling climate-smart agriculture. Blended finance models that use public funds to reduce risks for private investors can play a key role in mobilising additional capital. At the same time, a clear pipeline of bankable climate adaptation projects needs to be developed to attract sustained investment. Access to finance must also be broadened beyond traditional land-ownership criteria to include group-based

and collective models that cater to tenant farmers and the landless, thereby ensuring more inclusive access to transition finance.

Key Strategic Recommendations:

Governance & Institutions:

- Establish dedicated state-level coordination cells for climate resilience.
- Strengthen Farmer-Producer Organisations (FPOs) to enable collective action and resource sharing.
- Shift the policy focus from the individual farmer to the farming household as the primary unit of intervention.

Finance & Incentives:

- Promote blended finance mechanisms to crowd in private investment.
- Introduce outcome-based incentives, such as Payments for Ecosystem Services (PES), to reward sustainable practices.
- Ensure assured procurement and the development of value chains for climate-resilient crops.

Knowledge & Technology:

- Integrate Indigenous Traditional Knowledge with formal scientific research systems.
- Develop hyper-local, AI-enabled digital advisories in local languages.
- Reorient extension systems toward participatory, farmer-centric approaches.

Monitoring & Evaluation:

- Implement comprehensive climate tagging across all agricultural expenditures.
- Develop credible and robust carbon credit methodologies tailored to agriculture.
- Create real-time feedback mechanisms that link satellite-based data with farmer-reported outcomes.
- **Conclusion: From Ambition to Transformation**

India's response to climate change in agriculture has matured into a

comprehensive and multi-dimensional policy framework. Programmes such as NICRA and PMFBY, along with digital platforms like ACASA-India, demonstrate significant ambition and institutional learning. However, persistent challenges, including the smallholder paradox, fragmented governance, misaligned incentives, and gaps in adaptation finance, continue to constrain meaningful transformation at the farm level. Moving forward, a fundamental shift in approach is required, one that recognises smallholders as co-creators of solutions rather than passive beneficiaries. Policy implementation must emphasise equity, localisation, and integrated systems thinking. As India works toward its vision of a 'Viksit Bharat' by 2047, developing a climate-resilient agricultural sector is not only an environmental necessity but also central to food security, sustainable livelihoods, and inclusive development. The groundwork has been laid; the imperative now is to translate ambition into transformative action.

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