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# Agricultural Extension for Climate-Resilient Farming

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**Harjeet Singh[1], Dr. Santram[2]**

[1]Ph.D. Scholar, Department of Agricultural Extension Education, Sardar Vallabhbhai Patel University of Agriculture and Technology

[2]Assistant Professor, Department of Agricultural Extension, Chaudhary Charan Singh University, Meerut

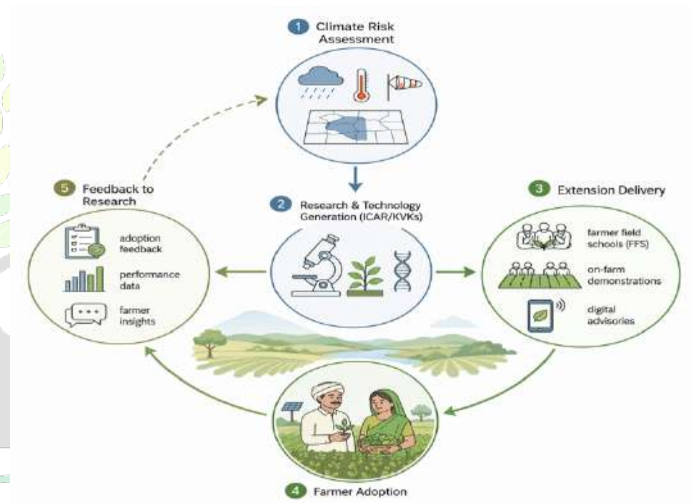
Across the plains of Punjab, the plateaus of Odisha, and the drought-prone tracts of Bundelkhand, farmers are confronting a climate that no longer follows the rhythms their grandparents once trusted. Erratic monsoons, prolonged dry spells, sudden hailstorms, and rising temperatures are steadily eroding the productivity gains built over decades, threatening the food and livelihood security of hundreds of millions of smallholders. Climate-resilient farming has therefore emerged not as an option but as a necessity a way of cultivating crops, livestock, and fisheries that can absorb shocks, recover quickly, and continue to sustain rural communities even as the climate shifts beneath their feet. Yet resilient practices and technologies remain of little use if they stay locked in research stations and policy documents. This is where agricultural extension steps in: as the vital bridge connecting scientific innovation with the everyday decisions of farmers, translating complex climate science into practical, field-ready action.

## 1. Understanding Climate-Resilient Farming

Climate-resilient farming refers to agricultural systems and practices deliberately designed to withstand, adapt to, and recover from climate-induced stresses such as drought, flooding, heat waves, and erratic rainfall, while sustaining productivity and farmer incomes. Its objectives are threefold: reducing vulnerability to climate variability, enhancing adaptive capacity through diversified and efficient resource use, and, where feasible, contributing to mitigation by lowering greenhouse gas emissions from farming operations. The importance of this approach lies in its direct bearing on food security; as India's agri-food systems face rising heat stress and declining soil organic carbon in several regions, climate-resilient agriculture (CRA) initiatives are considered critical for stabilising food supplies and safeguarding nutritional security (Shukla et al., 2025). The guiding principles of CRA include site-specificity, since no single package suits every agro-climatic zone; integration of traditional ecological knowledge with modern science; and a systems approach that links crops, livestock, water, and soil management rather than treating them in isolation. When implemented well, climate-resilient farming does more than protect yields during bad years it strengthens the overall sustainability of the agricultural sector, ensuring that today's productivity does not come at the cost of tomorrow's resources.

## 2. Role of Agricultural Extension

Agricultural extension has traditionally been understood as the set of organisations that help farmers access information, skills, and technologies to improve their livelihoods, and this role becomes even more central under climate uncertainty. Public extension services help farmers survive climate-induced disasters and adapt over the longer term, making them indispensable to both climate action and broader food-system transformation, even though such systems in developing countries often struggle with low budgets and weak technical capacity (FAO & IFPRI, 2023). Extension functions in several complementary ways: through climate advisory services that translate weather and seasonal forecasts into actionable sowing, irrigation, and harvest decisions; through structured farmer education and on-farm demonstrations that let people see a practice before adopting it; and through capacity-building activities that upgrade the skills of both farmers and frontline extension staff. Farmer Field Schools (FFS) remain one of the most evaluated tools in this space: a systematic review of impact evaluations across low- and middle-income countries found that FFS participation was associated with meaningful gains in yields and farmer income, alongside reduced pesticide use (Waddington et al., 2014). Beyond formal training, extension also builds community participation, encourages the dissemination of appropriate technologies, and provides decision-support that helps farmers weigh trade-offs under uncertainty rather than simply following one-size-fits-all recommendations.




## 3. Climate-Smart Agricultural Practices Promoted by Extension

Extension systems actively promote a basket of climate-smart practices tailored to local conditions. Conservation agriculture, built around minimum tillage, residue retention, and crop rotation, helps protect soil structure and moisture. Crop diversification reduces the risk of total crop failure by spreading farmers' exposure across multiple crops and varieties, while drought- and flood-tolerant varieties developed through national research programmes give farmers options suited to increasingly unpredictable seasons. Water conservation and rainwater harvesting structures farm ponds, check dams, and field bunding are widely demonstrated by extension agencies to reduce dependence on erratic rainfall. Soil health management, supported by soil health cards and integrated nutrient management, helps maintain fertility without over-reliance on chemical inputs, while integrated pest management (IPM) reduces both costs and environmental damage. Agroforestry systems that combine trees with crops or livestock add an additional layer of resilience by diversifying income and improving microclimates, and organic and natural farming approaches are gaining extension support as farmers seek to reduce input costs and rebuild soil biology over the long term.

### 4. Digital Agricultural Extension

Digital technologies are reshaping how extension reaches farmers, particularly where the ratio of extension workers to farming households remains thin. The Food and Agriculture Organization notes that digital extension and advisory services can substantially widen the accessibility, transparency, and reach of information for smallholder farmers, though this potential remains unevenly realised across regions (FAO, 2023). Mobile advisory services, delivered through apps, SMS, and interactive voice response, now reach farmers directly with weather forecasts, market prices, and crop-specific guidance; in Sri Lanka, for instance, a geo-localised advisory app helped participating rice farmers achieve substantially higher productivity and market prices during a pilot season (FAO, 2025). Artificial intelligence is increasingly layered onto these platforms to personalise recommendations, while the Internet of Things, drones, remote sensing, and Geographic Information Systems (GIS) allow extension agencies to monitor soil moisture, pest outbreaks, and crop stress at scales that human field visits alone cannot match. Social media and digital platforms further extend the reach of extension messaging, allowing farmer-to-farmer learning to spread rapidly across networks that once depended entirely on physical proximity.

### 5. Success Stories

India offers several instructive examples of extension-led climate resilience in action. ICAR's National Innovations in Climate Resilient Agriculture (NICRA), launched in 2011, combines strategic research, on-farm technology demonstration, and capacity building across crops, livestock, and fisheries, and has since developed climate-resilient varieties and hundreds of district-level agricultural contingency plans through its network of Krishi Vigyan Kendras (KVKs) (ICAR, 2011). Globally, the CGIAR-led Climate-Smart Village approach demonstrates how participatory, community-based testing of technological and institutional options can be scaled from local pilots to policy-relevant lessons across Asia, Africa, and Latin America (Aggarwal et al., 2018). In Bihar, Digital Green's video-mediated extension model in which locally produced videos are screened by trained community mediators has been rigorously evaluated through randomised controlled trials; a study layering video content onto face-to-face training on the climate-smart System of Rice Intensification found sizeable, if imprecisely estimated, gains in yields among participating farmers (Baul et al., 2024). Farmer Producer Organisations (FPOs) are also emerging as important vehicles for climate resilience in semi-arid India, helping small and marginal farmers pool resources, access markets, and adopt resilient practices collectively (Nikam & Wester, 2025).

## 6. Challenges

Despite these gains, significant obstacles constrain the reach and effectiveness of extension-led climate resilience. Climate uncertainty itself complicates planning, since even the best advisory systems cannot fully predict localised, short-duration weather extremes. A persistent digital divide means that many smallholders, particularly women and remote or resource-poor farmers, still lack reliable access to smartphones, connectivity, or the digital literacy needed to use advisory apps effectively. Financial limitations at both the farmer and institutional level slow the adoption of resilient technologies, while extension networks in much of the developing world remain understaffed and under-resourced, limiting the frequency and quality of farmer contact (FAO & IFPRI, 2023). Policy constraints, including fragmented coordination between research, extension, and disaster-management agencies, further dilute impact, and limited awareness among farmers about available support schemes or advisory services means that even well-designed interventions can go underused. Finally, technology accessibility issues from patchy rural internet to advisory content not available in local languages continue to limit how evenly the benefits of climate-smart innovation are shared.

## 7. Author's Perspective

In my assessment, the next phase of agricultural extension in India must move decisively from being a one-way channel of information to becoming a genuinely two-way, trust-based partnership with farming communities. Strengthening the human backbone of extension recruiting, training, and retaining sufficient field-level functionaries remains as important as any digital innovation, since evidence consistently shows that technology performs best when it complements, rather than replaces, human-mediated learning (Baul et al., 2024). Equally important is engaging rural youth as extension intermediaries and agripreneurs; young, digitally literate community members can serve as a bridge between formal research systems and older farmers less comfortable with new tools. Finally, building durable partnerships between public research institutions, private agri-tech firms, Farmer Producer Organisations, and civil-society networks such as Digital Green can help pool resources and expertise in ways that no single actor can achieve alone. These are evidence-based reflections offered as one contributor's view on the path ahead, not a claim to definitive answers.

## Conclusion

Climate change is no longer a distant projection for Indian agriculture; it is a lived, daily reality shaping planting dates, input costs, and harvest outcomes. Agricultural extension, in its evolving mix of field demonstrations, Farmer Field Schools, KVK networks, and digital advisory platforms, remains the essential connective tissue between climate science and the millions of decisions farmers make each season.

Strengthening this system through better-resourced institutions, inclusive digital access, and genuine partnership with farming communities is not merely a technical fix but an investment in the resilience of rural livelihoods themselves. If nurtured with foresight, agricultural extension can help ensure that India's farmers do not merely endure a changing climate, but adapt, innovate, and thrive within it.

**Table 1. Traditional Farming versus Climate-Resilient Farming**

| Aspect | Traditional Farming | Climate-Resilient Farming |
|---|---|---|
| Cropping pattern | Mono-cropping; reliance on a few staple varieties | Diversified cropping with stress-tolerant and short-duration varieties |
| Water management | Dependence on unregulated irrigation or rainfall alone | Rainwater harvesting, micro-irrigation, and soil moisture conservation |
| Soil health | Continuous cropping with limited nutrient replenishment | Integrated nutrient management, organic matter enrichment, soil testing |
| Pest management | Calendar-based, often excessive chemical pesticide use | Integrated Pest Management (IPM) guided by field monitoring |
| Information access | Informal, delayed, largely word-of-mouth advice | Real-time mobile, AI, and satellite-based advisories |
| Risk management | Limited crop insurance or contingency planning | District agro-climatic contingency plans and index-based insurance |
| Institutional support | Sporadic, top-down extension contact | Participatory extension via KVKs, FPOs, and Farmer Field Schools |

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