Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 06, Issue: 04 (JULY-AUG, 2026)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

Climate-Smart Farming: A Practical Way to Strengthen Farmers against Climate Change

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Agriculture is among the sectors most vulnerable to climate variability and climate change because crop production depends heavily on the availability and timing of natural resources, particularly rainfall and temperature. In India, increasing climatic uncertainty is being reflected through erratic and uneven rainfall, prolonged dry spells, rising temperatures, heat stress, shifting rainfall patterns and more frequent extreme weather events. These changes can adversely affect crop establishment, flowering, grain and pod development, input-use efficiency and ultimately farm productivity and income. Small and marginal farmers are particularly vulnerable because their capacity to absorb climatic and economic shocks is often limited. Consequently, enhancing farmers' capacity to anticipate, respond to and recover from climate-related stresses has become an important component of sustainable agricultural development.

In this context, Climate-Smart Agriculture (CSA) has emerged as an integrated approach for transforming agricultural systems in response to climate change. CSA seeks to simultaneously enhance agricultural productivity and farm incomes, strengthen resilience and adaptive capacity to climate variability, and, wherever possible, reduce greenhouse-gas emissions and increase carbon sequestration. However, the success of CSA does not depend only on the availability of appropriate technologies. Its effectiveness is closely associated with farmers' knowledge, perceptions, confidence, decision-making capacity and willingness to adopt recommended practices. Therefore, understanding farmers' existing knowledge and perceptions and strengthening their climate resilience are essential prerequisites for successful implementation of climate-smart agricultural interventions.

Dharwad district of Karnataka represents an important agricultural landscape where crops such as green gram, chickpea and groundnut are cultivated under conditions that are increasingly influenced by climatic variability. Against this background, a comprehensive study was undertaken to assess farmers' knowledge and perception of climate-smart agriculture, determine their level of climate resilience and evaluate the effectiveness of different educational technologies for communicating CSA practices.

Understanding Farmers before Promoting Technology

The study was conducted among 180 farmers from four taluks of Dharwad district, covering growers of green gram, chickpea and groundnut. The investigation went beyond simply documenting farmers' awareness of climate-smart technologies. It examined the broader dimensions of knowledge, perception, climate resilience and response to extension interventions. To assess the effectiveness of different approaches for communicating climate-smart technologies, three educational technologies were compared: online lectures delivered by scientists, lectures conducted by progressive farmers, and WhatsApp-based communication incorporating photographs, short videos and concise agricultural advisories.

This comparative approach was particularly relevant because farmers differ not only in their access to information but also in how they understand, trust and use agricultural knowledge.

Farmers' Existing Knowledge of Climate-Smart Agriculture

The findings indicated that the majority of farmers possessed a medium level of knowledge about climate-smart agriculture, suggesting that farmers were familiar with several basic climate-resilient practices but had not yet developed comprehensive knowledge across all dimensions of CSA. Farmers demonstrated relatively better knowledge regarding rainwater harvesting, borewell recharge, integrated nutrient management, integrated pest and disease management, improved crop varieties and appropriate land preparation. These practices are relatively visible, frequently discussed through extension programmes and often encountered in farmers' own production systems. However, important knowledge gaps were observed in soil management, intercropping and scientific seed treatment. These gaps are significant because soil health, crop diversification and quality seed treatment contribute directly to resource-use efficiency, crop establishment and resilience under climatic stress. The findings suggest that farmers' knowledge is influenced strongly by exposure, experience, accessibility of information and practical observability of technologies. Practices that are easily demonstrated or commonly discussed are more readily understood, whereas technically complex practices require repeated explanation, demonstration and hands-on training.

Positive Perception towards Climate-Smart Agriculture

Farmers generally expressed a positive perception towards climate-smart agriculture. A large proportion recognised that climate-smart practices can contribute to environmental protection while maintaining agricultural productivity under changing climatic conditions. Farmers particularly appreciated the importance of water conservation, improved crop management and sustainable use of natural resources. A positive perception is an important foundation for technology adoption because farmers are more likely to consider practices when they perceive them as beneficial, feasible and compatible with their existing farming systems. However, the presence of misconceptions concerning integrated pest and disease management and certain soil-health practices indicates that favourable attitudes alone may not be sufficient. This highlights the importance of extension programmes that move beyond one-way information dissemination and focus on evidence-based learning, practical demonstrations, and problem-solving and continuous farmer–expert interaction.

Climate Resilience: From Awareness to Adaptive Capacity

Climate resilience involves more than awareness of climate change. It encompasses farmers' ability to anticipate climatic risks, prepare for potential disturbances, make timely decisions, modify farm practices, access resources and recover from adverse events. The study revealed that most farmers exhibited a medium level of climate resilience. Farmers were comparatively stronger in preparedness for climate-related contingencies than in self-confidence and independent problem-solving. This indicates an important distinction between *knowing what to do* and *having the confidence and capacity to make the right decision at the right time*. Experience emerged as an important factor in preparedness for climatic uncertainty. Experienced farmers were generally better equipped to respond to climate-related challenges. Nevertheless, the relatively lower confidence of many farmers in making independent management decisions suggests the need for extension interventions that strengthen decision-making skills, experiential learning, risk assessment and adaptive capacity, rather than merely transferring technical information.

Which Extension Technology Worked Best?

One of the important contributions of the study was the comparative evaluation of three educational technologies for communicating climate-smart agricultural information.

- **WhatsApp-based communication recorded the highest improvement in farmers' knowledge.** The effectiveness of this approach can be attributed to the flexibility and accessibility of digital communication. Farmers could access information repeatedly at

their convenience, while photographs, short videos and concise advisories helped translate technical concepts into easily understandable visual messages. The asynchronous nature of WhatsApp communication also allows farmers to revisit information when making actual farm-management decisions.

- **Lectures delivered by progressive farmers recorded the highest symbolic adoption.** The influence of progressive farmers may be explained by peer credibility, social proximity and the visibility of successful farming experiences. Farmers are often more willing to consider a technology when it is demonstrated by another farmer operating under similar agro-ecological and socio-economic conditions. Thus, progressive farmers can function as important local knowledge intermediaries and climate-smart agriculture ambassadors.
- **Online lectures by scientists also contributed to improved knowledge by providing technically sound and scientifically validated information.** However, their relative impact was lower than that of WhatsApp-based communication for knowledge improvement and progressive-farmer interaction for symbolic adoption. This indicates that scientific credibility needs to be complemented by accessibility, repeated exposure, local relevance and social trust.

From Information Transfer to Behavioural Change

The findings demonstrate that agricultural extension is undergoing a transition from conventional one-way technology transfer towards a more participatory and digitally enabled model of knowledge exchange. Climate-smart agriculture requires farmers not only to receive information but also to interpret climatic risks, evaluate alternatives and make timely decisions. No single extension method can adequately address all these requirements. Digital communication is highly effective for rapid dissemination, repetition and visual learning; scientists provide technical credibility and evidence-based recommendations; and progressive farmers provide social validation, local adaptation and peer-to-peer learning. Therefore, the most effective strategy is likely to be a blended extension model in which digital platforms, scientists, field demonstrations and farmer-to-farmer communication complement each other. Such integration can create a continuous learning system in which farmers receive information, observe technologies, discuss practical experiences and develop the confidence required for adoption.

Why These Findings Matter

The findings have important implications for strengthening climate resilience in Indian agriculture. Climate change is not simply a technical challenge that can be addressed by introducing individual technologies. It is also a knowledge, behavioural and institutional challenge. Farmers need timely climate information, locally relevant recommendations, access to appropriate technologies and the confidence to make decisions under uncertainty. The results suggest that future agricultural extension programmes should therefore focus on knowledge + skills + confidence + timely information + social learning, rather than knowledge dissemination alone. Particular attention should be given to technically demanding practices where farmers exhibited knowledge gaps. The integration of digital tools with conventional extension can also increase the reach and continuity of advisory services. Instead of treating WhatsApp, online lectures and farmer networks as independent alternatives, they can be strategically integrated into a multi-channel Climate-Smart Extension System.

Recommendations

Based on the findings, the following measures are recommended:

- ❖ **Establish village-level WhatsApp climate advisory groups** managed or technically supported by agricultural experts to provide timely, concise and locally relevant advisories.

- **Develop progressive farmers as Climate-Smart Agriculture ambassadors** who can demonstrate successful practices and facilitate farmer-to-farmer learning.
- **Strengthen practical training** on soil-health management, integrated nutrient management, integrated pest and disease management, intercropping and scientific seed treatment.
- **Provide stage-specific climate advisories** before sowing and during critical crop growth stages so that farmers can make timely decisions regarding sowing, irrigation, nutrient application and pest and disease management.
- **Use visual communication technologies**, including photographs, short videos, demonstrations and locally understandable infographics, to improve comprehension and retention of technical information.
- **Strengthen farmers' decision-making and confidence** through participatory learning, problem-solving exercises, field demonstrations and climate-risk planning.
- **Integrate scientists, extension personnel and progressive farmers** into a coordinated extension network to combine scientific credibility with local experience and social trust.
- **Promote water conservation and efficient irrigation technologies**, particularly rainwater harvesting, groundwater recharge and improved water-use efficiency, as core components of climate resilience.
- **Adopt a blended extension approach** combining digital communication, face-to-face training, field demonstrations, farmer-to-farmer learning and expert interaction rather than relying on a single communication channel.

Conclusion

Climate-Smart Agriculture is not merely a collection of improved agricultural technologies; it represents a pathway towards productive, resilient, resource-efficient and sustainable farming systems under a changing climate. The Dharwad study demonstrates that farmers possess a foundation of knowledge and generally favourable perceptions towards climate-smart practices, but important gaps remain in technical knowledge, adaptive capacity, confidence and independent decision-making. The comparative evaluation of educational technologies further demonstrates that the mode of communication matters as much as the message itself. WhatsApp-based communication was particularly effective in improving knowledge through repeated and visually supported learning, while progressive-farmer lectures strengthened symbolic adoption through peer credibility and social influence. Scientific online lectures contributed technical knowledge and credibility but were more effective when complemented by accessible and locally relevant communication.

The central implication is therefore clear: the future of climate-smart agriculture depends not only on developing better technologies but also on developing smarter systems for delivering knowledge and building farmers' adaptive capacity. A blended extension model that combines digital platforms, scientific expertise, progressive-farmer leadership, practical demonstrations and timely climate advisories can bridge the gap between scientific knowledge and field-level decision-making. Strengthening farmers' knowledge, confidence and capacity to respond to climatic uncertainty today will contribute to more productive farms, stable livelihoods, efficient resource use and greater resilience of Indian agriculture in the future.