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Technology and knowledge dissemination

Need for scaling impacts in rainfed areas

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Rainfed agriculture in India accounts for 52% of net sown area producing 40% of the food supply and being a primary source of millets, pulses, oilseeds, and cotton. However, this system faces considerable challenges due to variable rainfall, extreme weather, land degradation, and low productivity. In response, agricultural extension has shifted from a public, top-down approach to a more pluralistic, demand-driven model that addresses farmer-specific needs. Scaling up technology and knowledge transfer is critical to support rainfed agriculture, focusing on water management, technology dissemination, and capacity building. ICAR-Central Research Institute for Dryland Agriculture (CRIDA) has pioneered multiple projects, such as Farmer FIRST, Model villages, and National Innovations in Climate Resilient Agriculture (NICRA), which demonstrate climate-resilient practices and adaptive technologies across India's rainfed regions. However, scaling efforts encounter barriers like limited technical options, inadequate resources, and policy support. Digital platforms and collaborative efforts offer potential solutions to these challenges, facilitating wider knowledge dissemination and adoption. This article highlights ICAR-CRIDA's experiences and the role of scaling in enhancing resilience in Indian agriculture

Keywords: Dissemination, Farmer FIRST, Model villages, Scaling up

IN India, rainfed agriculture occupy about 52% of net sown area, practiced in diverse agro-ecologies and contributes 40% of country's food basket and dominant producer of millets, pulses, oilseeds and cotton. Despite the progress made so far, rainfed agriculture in India still encounters multiple risks and constraints relating to biophysical, socio-economic and policy related issues. The rainfed production systems in the country face challenges from the uneven spatial and temporal distribution of rainfall, increased extreme weather events, land degradation, and poor productivity. Additional factors like low input use, limited technology adoption, inadequate fodder availability, low-yielding livestock, resource-poor farmers, and limited credit access further reduce crop and livestock productivity in these regions

Agricultural extension played a pivotal role for realizing the potential of farm sector against the widening demand–supply pressures, and for addressing sustainable, inclusive, and pro-poor development. Agricultural extension system in India, has been constantly scrutinized in the recent time because of the predominance of public sector extension as well as challenges in terms of efficiency and effectiveness in meeting its organizational goals and objectives. The agricultural extension has been delivered by diverse players and transformed from being public to pluralistic, top down to bottom up and being transfer of technology to broad-based and demand driven. In rainfed agriculture scenario, the technology transfer should entail more than just the transfer of inputs equipment and machinery; it also requires the transfer of knowledge and skills and the development of the capacity to use and adapt the technology. In this context, the scaling of information and technology is a suitable strategy to meet the wide range of objectives and target groups. We need techniques, technologies and investments that will increase water-management efficiency and access to irrigation, or find ways to increase their incomes in the face of less secure and more variable water availability.

Information and technology upscaling, typologies and barriers

World Bank has defined upscaling of technologies as the replication and adaptation of techniques, ideas, approaches, and concepts to achieve an increased scale of impact. It aims to direct the socio-economic impact

of the technology to smallholder farmers efficiently and increase in scale of coverage of that technology. For upscaling of technologies, the foremost priority should be given to strengthening the innovation, for which knowledge should be generated, disseminated and adopted at full scale. Upscaling of technologies also refers to reframing the strategies with bridging the gap between research and farming to bring the desirable change in the behaviour of clientele. Upscaling of technology can happen in horizontal, vertical and diagonal direction. Replicating proven technologies or innovation, in newgeographic areas or target clienteles is called horizontal upscaling. While vertical upscaling refers to catalyzing institutional and policy change; diagonal upscaling refers to adding project components, altering the project configuration or changing strategy in response to changing institutional arrangements.

Typologies of scaling

Typology	Description	Strategies
Scaling out	Impacting greater numbers. Based ideas or initiatives never spread to greater numbers or achieve widespread impact.	Deliberate replication: Replicating orspreading programs geographically andto greater numbers while protecting thefidelity and integrity of the innovation. Spreading principles: Disseminateprinciples, but with adaptation to newcontexts via cogeneration of knowledge,leveraging social media and learningplatforms.
Scaling up	Impacting law and policy. Based on the recognition that the roots of social problems transcend particular places, and innovative approaches must be codified in law, policy and institutions.	Policy or legal change efforts: development, partnering, advocacy to advance legal change and redirect institutional resources.

Source: Moore *et al*. (2015)

Key barriers to scaling information and technologies include a lack of tailored technical options and beneficiary awareness, limited resources for capacity building and extension, insufficient funding at all levels, and low private sector investment in smallholders political inaction on issues affecting vulnerable communities, low awareness of climate-smart approaches (e.g., ecosystem services and insurance), insecure land and water access, high adoption risks for certain technologies, and frequent turnover of key advocates also hinder scaling efforts.

Information and technology upscaling: ICAR-CRIDA Experiences

ICAR-CRIDA is upscaling the technologies through its Krishi Vigyan Kendra (KVK) as well as through various outreach programmes such as Farmer FIRST Program (FFP), CRIDA Model Village Project, Scheduled Caste Sub-Plan (SCSP) and Tribal Sub-Plan (TSP). Besides these, through Technology Demonstration Component (TDC) of National Innovations on Climate Resilient Agriculture (NICRA), CRIDA is scaling out climate resilient technologies across the country.

Farmer FIRST Programme (FFP): ICAR-CRIDA has been implementing Farmers FIRST programme on 'Farmer Centric Natural Resource Development for Socio-Economic Empowerment in Rainfed Areas of Southern Telangana Region' in a cluster of villages in Pudur Mandal, Vikarabad district, Telangana. Based on participatory rural appraisal (PRA) and baseline survey information, an action plan and technology package for the area has been implemented. The technology package modules comprised of soil and water conservation, crops and cropping systems, horticulture, livestock, farm mechanization.

Demonstration of manual weeder in FFP village

CRIDA Model village project: CRIDA has developed many dryland agricultural technologies for enhancing the yield, increasing the income and improving the overall livelihood of the farmers. A Model village approach is concerned with holistic packaging, delivery and implementation of demand driven interventions. Model villages serve as miniature self-sufficient, sustainable and equitable units. This project is being implemented by CRIDA in Gaddamallaiahguda village, Yacharam mandal, Ranga Reddy district, Telangana. Intervention of proven dryland technologies in different theme areas viz., soil health and nutrient management, crops and cropping systems, farm energy management, livestock health and nutrient management, knowledge management, training and capacity building etc. were introduced in the Model village.

Scheduled caste sub-plan (SCSP): CRIDA has been implementing Scheduled caste sub-plan in Kotapally

Introduction of improved Yellow Sorghum cv. PYPS-2 in the model village

Demonstration of biofertilizer application in cereals and pulses

mandal of Mancherial district, Telangana and Chincholi Taluka, Kalaburagi district, Karnataka. The dryland technologies viz. rainwater harvesting structures and microirrigation systems, improved varieties of rainfed crops, nutrient management, farm mechanization, plant protection, poultry farming etc in farming system mode were introduced to enhance the livelihood and nutritional security of the small farm holders, further with capacity building of the farmers, women and youth to enhance the knowledge and skills.

Tribal Sub-plan (TSP): CRIDA has been implementing Tribal Sub-Plan (TSP) in the Adilabad district, Telangana in three mandals namely Gudihathnoor, Utnoor, and Indravelli. The dryland technologies including natural resource management, crop management and livelihood activities were demonstrated covering a total of 503 households. The farmers, women and youth were trained on improved dryland technologies including farm mechanization and on various skilling activities.

Digital platforms for knowledge dissemination

Scaling knowledge through digital innovations like mobile technology, e-learning platforms, and social media networks can bridge these gaps. Digital education platforms can enhance understanding of climate-resilient practices. Collaborative approaches, including public-private partnerships and farmer-led innovations, are also vital for scaling impact. Case studies like index-based crop insurance programs and Indian agri-tech start-ups using Artificial Intelligence (AI) for precision farming highlight the potential of these innovations to scale across regions.

Digital dissemination of technologies and other extension activities by ICAR-CRIDA

As part of the institute's project, 'Model Village Approach for Assessment and Dissemination of Dryland Technologies,' a WhatsApp group was created, including beneficiaries of the project, to provide agro-advisory services. Through this platform, timely diagnoses of pests and diseases are facilitated by sharing images and videos. Similarly, under the Farmer FIRST Programme (FFP), a WhatsApp group was established for farmers offering advisory services. Social media platforms like Facebook and Twitter are also used to disseminate information about CRIDA outreach programmes to various stakeholders. During 2023-24, ICAR-CRIDA sensitized 504 farmers, 4,138 students, and 44 officials from different states about dryland technologies through video demonstrations. A range of advisories is also provided through phone calls, text messages, and other means to extend support.

Experiences of National Innovations on Climate Resilient Agriculture (NICRA)

NICRA is a network project of the Indian Council of Agricultural Research (ICAR) launched in February, 2011. The NICRA project has successfully introduced various climate-resilient technologies across India to address agricultural challenges posed by climate change which demonstrated the potential for scalability. In Anantapuramu, Andhra Pradesh, the promotion of farm ponds and drip irrigation has sustained groundnut productivity during droughts, and this approach has been effectively replicated in other drought-prone regions. The Integrated Farming System in Coimbatore, Tamil Nadu, encouraged crop diversification, livestock integration, and agroforestry to reduce dependence on rainfall while diversifying farmers' income; this model has been widely adopted in rainfed areas. The project has also promoted conservation agriculture in Ludhiana, Punjab, utilizing zero tillage and crop residue management to improve soil moisture retention and reduce degradation, leading to widespread adoption in Punjab and Haryana. In South 24 Paraganas, West Bengal, brackish water aquaculture with salt-tolerant fish species has increased productivity in coastal areas, offering a scalable model for regions affected by saline intrusion. Overall, the NICRA project exemplifies successful, scalable interventions that enhance climate resilience in Indian agriculture across diverse agro-climatic contexts.

Livestock based technologies and their dissemination

The technologies in the livestock sector that promote climate resilience encompass those pertinent to both adaptation and mitigation efforts. The technologies for adapting livestock encompass various areas viz. breeding technologies; feeding technologies, including balanced feed, total mixed rations, area-specific mineral mixtures, and fodder production and preservation; management technologies, such as shelter, stage-specific management, and body condition scoring; health technologies, which cover deworming, vaccination, and fore-warning; and risk-minimizing technologies, like insurance, agro-advisories, and seasonality analysis. Nonetheless, strategies for mitigation encompass dietary adjustments (such as feed additives like tannins, fats and oils, nitrates, chemical inhibitors, ionophores, seaweeds), enhanced forage species and pasture management, optimized herd management, and advanced livestock farming techniques.

Need for scaling impacts for livestock technologies

Livestock-based technologies are costly and are necessary for specialized knowledge, time constraints, and focus on animals. These technologies can be augmented through the utilization of state animal husbandry programmes and KVKs. An effective strategy

Table 1. Technology case studies from NICRA project which demonstrated the potential of scalability

Technology	Location	Component(s)	Impact	Scalability
Heat tolerant wheat	Hisar, Haryana	Heat-tolerant wheat varieties, zero-tillage	Helped farmers maintain wheat yields in rising temperatures	Scaled across Haryana and can be expanded to other wheat-growing areas facing heat stress
Water harvesting and drought management	Anantapur, Andhra Pradesh	Farm ponds, drip irrigation, soil moisture conservation	Maintained crop productivity (especially groundnut) during drought conditions	Replicated in drought-affected regions of Andhra Pradesh and Karnataka
Integrated farming system	Coimbatore, Tamil Nadu	Crop diversification, livestock integration, agroforestry	Reduced dependence on rainfall and diversified income for smallholder farmers	Adopted widely across rainfed areas in Tamil Nadu and South India
Flood tolerant rice	Barpeta, Assam	Submergence-tolerant rice varieties, raised bed planting	Reduced crop losses due to floods with flood-tolerant rice varieties	Scaled in flood-prone areas of Assam and Bihar
Pest and disease management	Akola, Maharashtra	Pest forecasting models, integrated pest management (IPM)	Helped prevent pest outbreaks and reduced losses for cotton farmers	Adopted by cotton-growing regions in Maharashtra
Climate-resilient horticulture	Navsari, Gujarat	Shade nets, low-cost polyhouses, efficient irrigation systems	Enabled horticulture in arid regions, increasing crop yield and water efficiency	Adopted widely across Gujarat and has potential in other arid regions
Livestock and dairy resilience	Jodhpur, Rajasthan	Drought-tolerant fodder, silage, livestock insurance	Ensured year-round fodder supply and financial protection for livestock farmers during droughts	Implemented across Rajasthan and scaling in other arid and semi-arid regions
Conservation agriculture	Ludhiana, Punjab	Zero tillage, crop residue management, laser levelling	Improved soil moisture retention and reduced environmental degradation from crop burning	Widely adopted in Punjab and Haryana, scalable in regions with soil degradation and water scarcity
Climate-resilient fisheries	South 24 Parganas, West Bengal	Brackish water aquaculture, salt-tolerant fish species	Increased fish productivity and provided sustainable livelihoods for coastal communities	Adopted across coastal West Bengal and Odisha, scalable in other saline-intrusion-prone coastal areas

for optimal coverage and rapid adoption of livestock technologies encompasses the promotion of livestock-based equipment in custom hiring centers, capacity building of trainers, a watershed-based livelihoods approach, field demonstrations, provision of para-veterinarians and *charamitras*, and the development of agri-preneurship in animal husbandry. Nutritional innovations require focused attention for scaling up, as they can decrease production costs and improve animal health and well-being.

Strategies for scaling

The core philosophy of scaling information and technology lies in rethinking purpose and adopting a systems approach. This begins with community-level initiatives led by each institution involved in technology and information dissemination. As organizations and their partners advance scaling strategies, they may need to redefine their objectives, recognizing that scaling often differs from routine activities. Scaling can be achieved in two key ways viz. by deliberately prioritizing scale and impact, and by addressing root causes through systems thinking to clarify the innovation's purpose.

Once scaling becomes an intentional focus, organizations can use various strategies tailored to their foundational strengths, available resources, partnerships, and context, including emerging political, cultural, and social opportunities. Effective scaling also requires stronger partnerships, stakeholder engagement, institutional support, and capacity building. For example, in early stages, knowledge-sharing can effectively spread Climate Smart Agriculture (CSA) practices. Later, well-evidenced interventions may be embedded in government policies, and market-based strategies developed to sustain impacts over the long term.

SUMMARY

Rainfed agriculture in India is a critical sector, covering half of the country's cultivated area and contributing significantly to food production. However, it is highly vulnerable to climate variability, land degradation, and low productivity. Scaling up technology and knowledge dissemination is crucial for building resilience in these regions, addressing water management challenges, and enhancing productivity. ICAR-CRIDA's initiatives, including Farmer FIRST, Model Village projects, and NICRA, demonstrate effective methods for introducing climate-resilient practices and improving livelihoods. Yet, barriers like inadequate technical options, insufficient funding, and limited private sector engagement persist, often slowing the adoption of essential innovations.To overcome these challenges, a multi-dimensional strategy is needed. This includes enhancing digital platforms for knowledge sharing, fostering public-private partnerships, and developing community-focused interventions. Stronger institutional support, targeted capacity building, and community involvement can drive broader adoption and sustainability of these solutions. By reframing objectives to prioritize resilience and inclusive growth, scaling efforts can support long-term productivity and stability for rainfed farmers in India's diverse agro-ecological landscapes.

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