Sattva Knowledge Institute SKI perspective

ENABLING TECHNOLOGY FOR CLIMATE CHANGE ADAPTATION IN INDIAN AGRICULTURE

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Acknowledgements

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Executive Summary

Several effects of climate change such as droughts, floods, cyclones, erratic and delayed monsoon, depleting groundwater, salinisation, pests and diseases, etc. have been affecting the production and productivity of Indian agriculture, thereby impacting farmer incomes as well as food and nutrition security. In a vicious cycle, agricultural practices also result in emissions of greenhouse gases, contributing to further climate change.

It is imperative to make farmers resilient to the risks of climate change for income and food security. Technology can play a crucial role in climate change mitigation and adaptation. However, the adoption of technologies at the farm level involves either a one-time capital investment or recurring subscription and maintenance costs. Small and marginal farmers, who constitute 86% of Indian farmers, find it uneconomical to invest in technologies that do not have tangible short-term financial benefits.

This perspective details out the challenges of agri-tech companies and startups in development, deployment and scaling up climate-smart technologies and proposes key strategic levers to enable improved adoption of technology for climate change adaptation. These levers are centred around strengthening the incubation ecosystem, developing a platform approach, promoting innovative financing solutions for startups and end-users, convergence with government programmes and leveraging strategic grassroot partnerships.

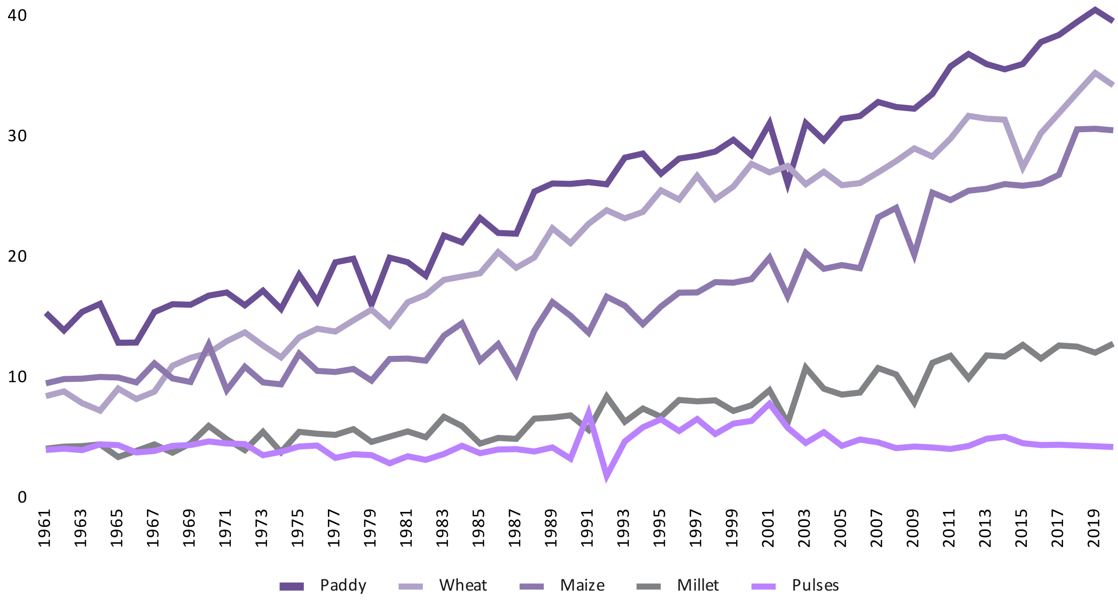
Climate Change: A Meltdown for Indian Agriculture

Impact of climate change on agriculture

In recent years, Indian agriculture has been witnessing various effects of climate change such as irregular, delayed and inadequate rainfall, frequent natural disasters such as floods, cyclones and droughts, increased instances of pests and diseases, depletion of groundwater, soil degradation, increased salinisation in coastal areas, weather aberrations and extreme weather patterns. Allied agricultural activities which rely on riverine, marine, grassland and forest ecosystems have also been impacted. Reduced productivity and increasing crop losses makes farmer livelihoods unsustainable and also threatens food and nutrition security of the population.

Over the years, there has been an overall improvement in productivity for major crops, owing to advances in crop technology and adoption of improved farming practices. However,

Figure 1: Productivity of key agricultural crops in India (in qtl/ha)



(Food and Agriculture Organization [FAO])

the notable sharp decline in crop yields in the years 2001-02, 2004-05, 2008-09, 2014-15 and 2019-20 can be attributed to climate shocks. Crop yields in India are estimated to decrease by 2.6% by 2050, due to climate change impacts (FAO 2018). Continuous exposure of plants to high temperatures or heat stress during the crop growth cycle, rising levels of atmospheric carbon dioxide, wilting and chilling stress due to cold waves, abiotic stress due to waterlogging during floods, soil degradation due to excessive use of chemical inputs and salinisation, erratic rainfall during the crop growth phase, etc. are the key causes for reduced crop yields.

According to an IPCC report, we are losing soil at about ten times the rate of its formation (Hobson 2019). Depletion of nutrients in soils, especially micro nutrients like boron and zinc leads to reduced proportions of these essential nutrients in the crops. This further affects the nutritional security of the population, since these nutrients are derived solely from plants and cannot be substituted through meat.

The sea surface temperatures in the Arabian Sea have been 1.2ºC to 1.4ºC higher than normal. In the past 20 years, there has been a 52% increase in the number of cyclones, and 150% increase in very severe cyclonic storms in the Arabian Sea (Nandi 2021). Farmers in the coastal regions in the South, West and East are at risk of suffering huge crop losses.

Weeds, pests, and fungi thrive under warmer temperatures, wetter climates, and increased CO_2 levels. Crops are prone to more diseases, and the resulting use of pesticides and other crop care chemicals can threaten human health as well. Heat stress also affects animals increasing disease vulnerability, prevalence of pests and disease, and reduction in fertility and milk production. Losses in quantity and quality of fodder, and depletion of natural grasslands further threaten livestock farming.

Erratic rainfall and floods affect the quantity of groundwater, while intrusion of saltwater and chemical residues into aquifers affects their quality. Villages located in critically depleted regions in north-western and central India may lose 68% of their cropped area in the future if access to all groundwater irrigation is lost, resulting in 20% decrease in the cropped area during Rabi season at an all-India level. In the absence of assured irrigation, rainfed crops such as millets, pulses and oilseeds are more vulnerable to climate change, because of the limited options for coping with variability of rainfall and temperature.

Climate change and agriculture – a vicious cycle

Agricultural activities contribute to approximately 30% of total greenhouse gas (GHG) emissions, mainly due to the use of chemical fertilisers, pesticides and animal wastes (Schahczenski & Hill 2009). This proportion is bound to rise further, as a result of an increase in the demand for food by a growing global population, the stronger demand for dairy and meat products, and the intensification of agricultural practices. Soil has the capacity to store about twice as much carbon as the atmosphere. However, degraded soils cannot store carbon, leading to their release in the atmosphere, further contributing to climate change.

Impact of climate change on small and marginal farmers

While climate change impacts all farmers, small, marginal and subsistence farmers with limited production and marketable surplus are the most vulnerable. Decline in agricultural productivity, poor access to assured irrigation, losses due to pests, crop diseases, livestock diseases and poor access to post-harvest storage and processing infrastructure result in high losses, poor economies of scale and high overheads for small and marginal farmers.

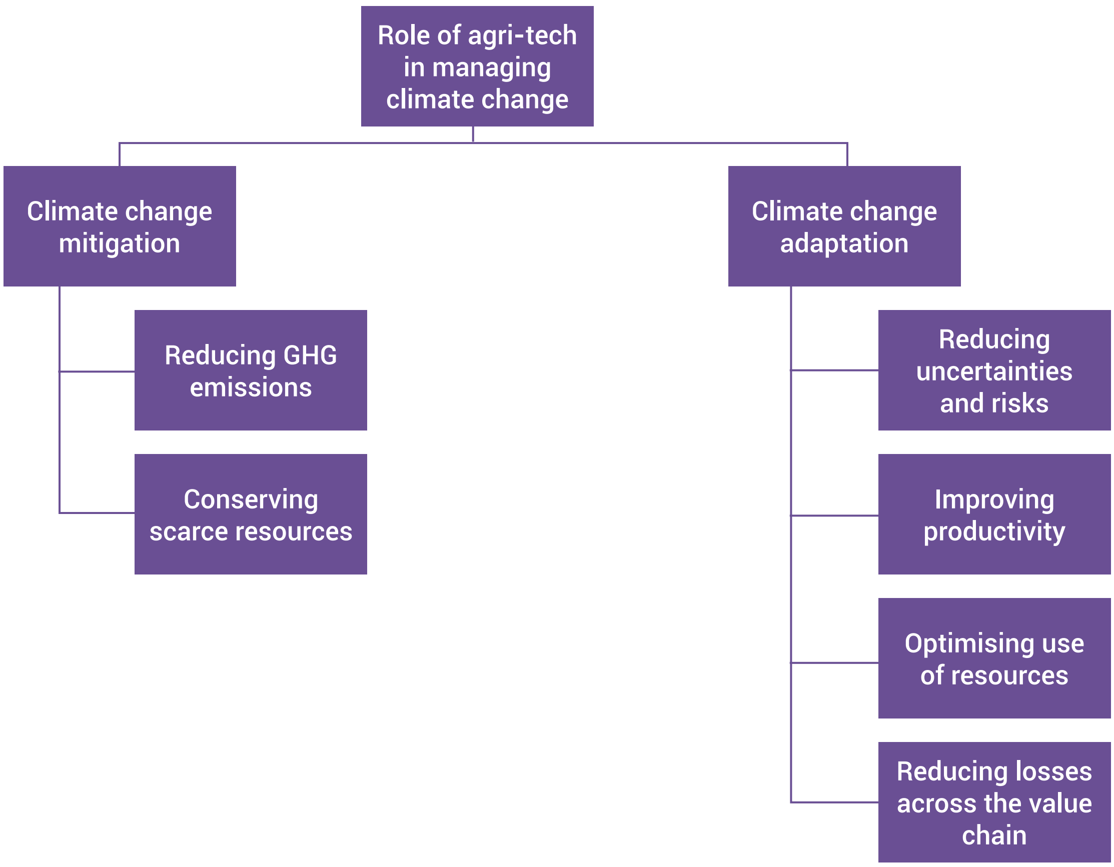
Extreme events like floods, cyclones and droughts can wipe out the entire standing crop, affecting household food stocks and exposing smallholder farmers to hunger, malnutrition and poverty.

Considering the magnitude of the problem and the scale at which solutions need to be implemented, technology emerges as an effective conduit. Addressing climate change requires adoption of sustainable agricultural practices, as well as adoption of resource-efficient, early warning and clean-energy technologies to reduce the risks, losses, and GHG emissions while improving farm productivity and resource-use efficiency.

Role of Technology in Combating the Effects of Climate Change on Agriculture

Climate-smart technologies cover both climate change mitigation and adaptation. The core focus areas within the two broad categories are mapped in the following figure.

Figure 2: Responding to climate change with technology



Climate change mitigation solutions focus on combating climate change by reducing the emission of greenhouse gases and conserving scarce natural resources such as water and soil.

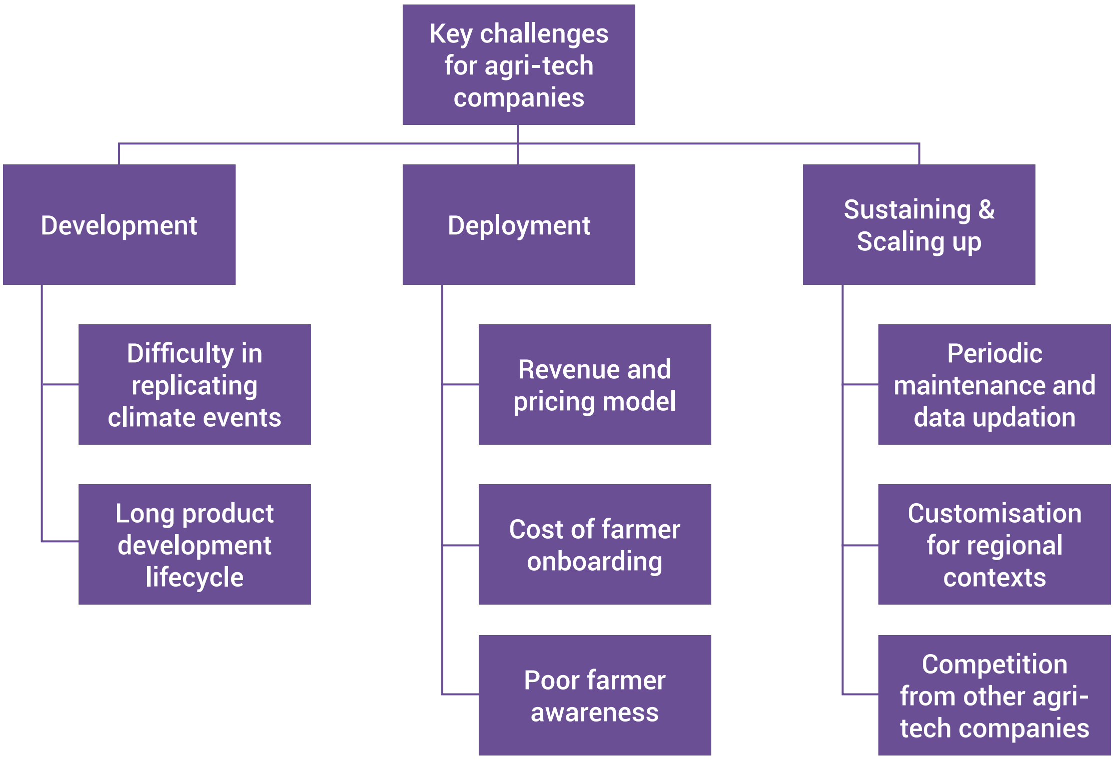
Solutions under climate change adaptation focus on reducing the uncertainties, risks, losses and improving productivity and resource use efficiency across the agricultural value chain. They yield direct economic benefits and hence are comparatively more economically viable and preferred by the farmers.

Figure 3: ~~The crafts sector is important in the pursuit of SDGs~~

Focus Area	Illustrative examples of technology interventions
Reducing GHG emissions	• Use of decentralised renewable energy such as solar, wind, biomass to operate irrigation pumps, cold storages and food processing machinery.
Conserving and optimising use of resources	• AI-enabled sensors can optimise the use of farm inputs such as water, fertilisers and pesticides, leading to optimal use of scarce resources like groundwater and minimising the use of chemical inputs to conserve soil.
Reducing uncertainties and risks	• Early warning systems that leverage satellite technology, remote sensing and automatic weather stations that can predict climate shocks such as floods, cyclones, heavy rains, strong winds, heat waves or cold waves in advance, to enable appropriate and timely decisions and actions. • Technologies such as hydroponics that facilitate controlled production environments that altogether substitute soil for water as a planting medium also reduce the uncertainties and risks of climate change.
Improving productivity	• Precision technologies using AI-enabled sensors aim to maximise yields with minimal inputs. Genetic technologies for producing high-yielding and climate-resilient seed varieties that are also pest-resistant and stress-tolerant help in improving productivity while minimising losses and risks.
Minimising losses in the value chain	• Climate-resilient, stress-tolerant seed varieties and post-harvest infrastructure for storage and processing are some of the technologies focusing on minimising losses across the production and post-harvest value chain.

Challenges and Barriers in Promotion of Climate-resilient Technologies

Figure 4: Challenges and barriers for agritech companies



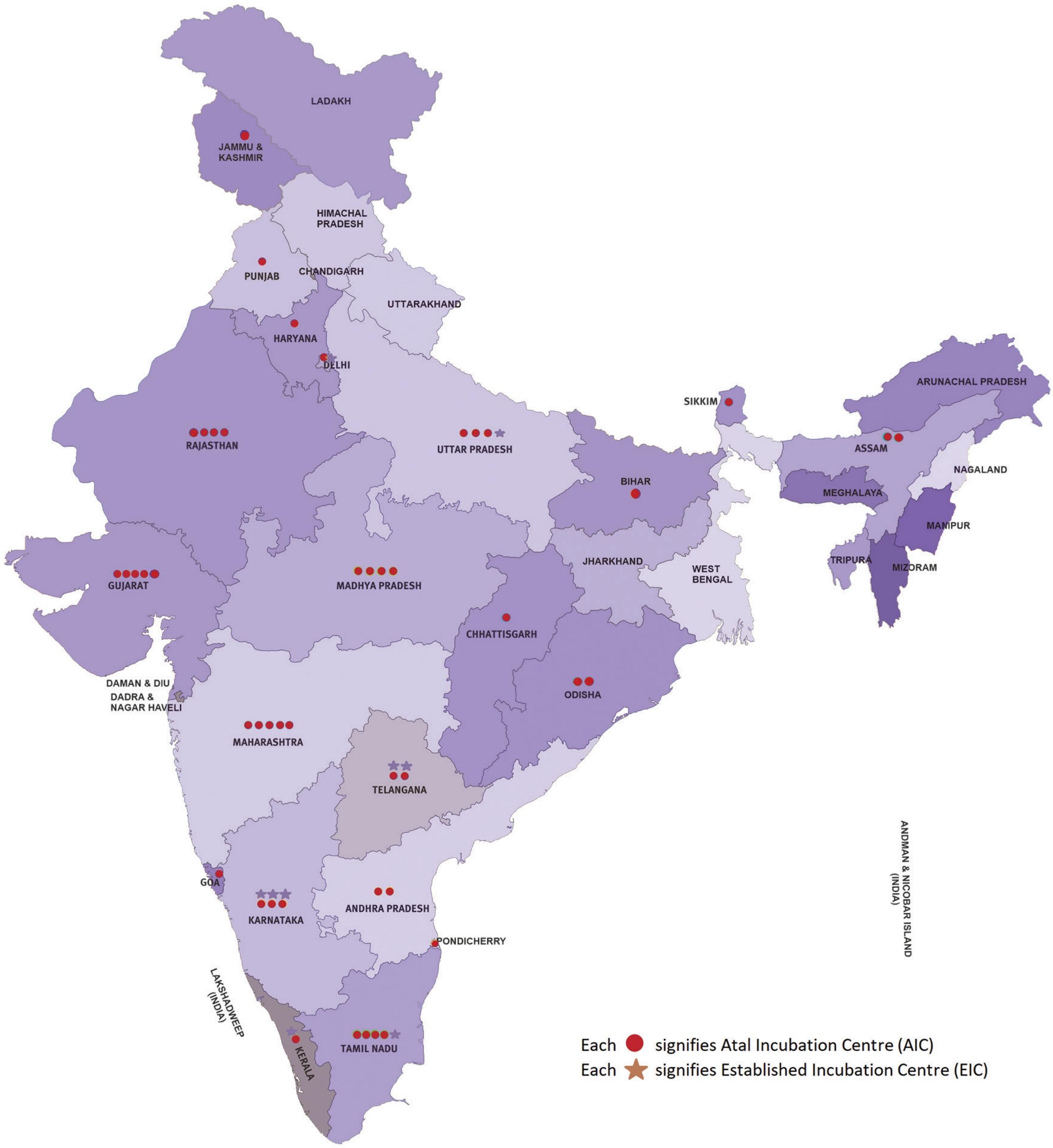
Challenges in development

Climate change impacts agriculture in several ways across various stages - pre-production, production and post-harvest management. Also, the same climate event could have varying implications in different agro-climatic zones. The effects could also vary with seasons, in addition to agro-ecological characteristics such as soil acidity level, topography, soil moisture, wind, rainfall, temperature, and humidity.

With so many variables and the constantly evolving nature of climate change events, it becomes very difficult to replicate climate change events in a controlled environment or a laboratory while designing, testing and prototyping technology solutions to address them. The seasonal nature of agriculture and climate events further pose challenges and delays in the product development lifecycle. The magnitude of the variables associated with the event may even limit the efficacy of the solution.
The long product development lifecycle also increases the cost of product development. Thus agri-tech companies need initial investment in human resources and equipment to sustain in the initial years, before they start generating revenues.

Given the wide range of climate change events and contexts, the available technology solutions may appear fragmented, disaggregated and unevenly concentrated towards certain thematic areas such as precision agriculture and post-harvest management solutions.

Figure 5: Atal Incubation Centres



(Atal Innovation Mission)

Presently, agri-tech incubators and the overall agri-tech ecosystem are also highly skewed in terms of geographical presence and operations, with the startup hubs of Bengaluru, Hyderabad and Gurgaon being preferred by most agri-tech companies. The incubation centres established under the Atal Innovation Mission are also more concentrated in South, West and central India, and there are hardly any centres in the Himalayan, north-eastern and eastern states.

Challenges in deployment

Once the technology solutions (products or services) are developed, agri-tech companies face several barriers in deploying them at scale. While most of the barriers hold true for agri-tech in general, climate-smart technologies face the additional barrier of low prioritisation by farmers – especially climate change mitigation technologies that do not offer any short-term tangible economic benefits to the farmers in terms of improved productivity, reduced losses or reduced costs.

Onboarding farmers requires the agri-tech company to have sales staff on the field, thus incurring HR and travel costs. In areas with poor literacy levels, the onboarding process would require more efforts.

With 86% of the farmers in India being small and marginal with limited purchasing power and investment capability, designing a sustainable revenue model for agri-tech solutions becomes a key challenge. Smallholders cannot afford to invest in capital-intensive technologies by paying large amounts upfront. While some technologies are eligible for subsidies by the government, the back-ended nature of most subsidies (requiring farmers to shoulder the expense upfront and submitting proof to avail subsidies after a purchase) and delayed disbursements inhibit farmers from opting for subsidies and adopting the technology solutions. Given that farmers receive their major cash inflows only two or three times in a year after the crop harvest cycle, monthly subscription models or EMI financing options also do not seem attractive from their perspective. While collective ownership models at an FPO or farmer group level can address the affordability issue, they could lead to scheduling conflicts, especially during the peak usage window. Suitable scheduling systems and policies must be designed in order to ensure fair access to the technology solutions.

Challenges in sustaining and scaling up

Digital climate-smart technologies are fully smartphone-based, and most physical or hybrid technologies have a smartphone interface. While smartphone adoption among the rural youth shows an increasing trend, there are several challenges to effective scaling up of these solutions, including

(i) poor literacy levels among farmers,
(ii) multitude of regional languages,
(iii) customisation for specific agro-climatic contexts and
(iv) several agri-tech applications competing for space in the limited phone memory.

Other key barriers are the cost and resources required for periodic updation of farmer-level data for digital applications, and the maintenance of farm machinery and hardware. As a result, agri-tech companies would need to invest in developing robust post-sales service and maintenance network in the rural areas in order to retain their existing users and improve adoption at scale.

Competition from bigger agri-tech companies and consolidation in the ecosystem is another major barrier. Several companies vie for the farmers' limited investment capital. In case of digital solutions, they also have to compete for a share of the limited phone memory. Discussions with farmers revealed the fatigue of using too many applications, which slows down their smartphones. After a point, many farmers uninstall the applications to free up memory and stop using the solutions altogether, which defeats the purpose of the technology.

Many climate-resilient technologies also offer crop advisories based on early warning systems and sensors to mitigate climate risks. In the absence of farm automation to implement the advisories at the farm level, the onus of implementation falls on the farmer. Ineffective or delayed follow-up actions by farmers could affect the risk mitigation activities and still lead to crop loss, rendering the early warning system ineffective with zero return on investment. In such cases, many farmers may blame the technology and be dissatisfied with it. Hence, proper integration and training on technology usage is essential to ensure effective results.

Pathways to Promote Climate-resilient Technologies in Agriculture

While everyone understands the need and urgency for climate action, making it a hot topic for discussion in any forum, the intent has not yet translated into action due to lack of a clear strategy. Some key strategic levers to drive the adoption of climate-smart technology and help farmers better adapt to climate change are:

Strengthening the incubation ecosystem for climate-smart agri-tech startups

In 2021, there were more than 40 incubation centres for agri-business, food technology and agri-tech startups across the country within universities and private institutions affiliated to the Department of Science and Technology, in addition to 68 Atal Incubation Centers and 12 operational Atal Community Innovation Centers empanelled by the Atal Innovation Mission. Startups working on climate-smart technologies, especially the ones in sectors that are currently underserved, must be further incentivised through grants, soft loans, marketing support, compliance support, and strategic partnerships.

Collaborations between agri-tech startups, agricultural universities, research stations and Krishi Vigyan Kendras (KVK) must be improved to enable startups to quickly prototype and deploy their solutions. High potential incubators must be developed further as centres of excellence for climate resilience, by offering incubation support for the initial five years. Some of the big bets, according to leading agri-business incubators and agri-tech think tanks are:

- Water use efficiency.
- Leveraging satellite technology at scale.
- Decentralised, modular and energy-efficient solutions.
- Minimising post-harvest losses and increasing shelf life of perishable commodities.
- Automation in dairy, livestock and fisheries.
- Improving nutrition in food and fodder.
- Leveraging real-time data to lower risk and cost of finance and insurance.

Platform approach for seamless integration of climate-smart technologies with other technology solutions, financial, insurance and extension services

A dedicated and integrated climate-smart technology platform on the lines of the Agri-stack platform, as proposed under the Government's Digital Agriculture Mission, and other private multi-stakeholder platforms and directories like Samunnati's Agri Elevate, FPOnEXT, Samarambh, etc. will facilitate better discovery of climate-smart technology solutions. It would also improve the interoperability between different essential technology applications across digital, physical and hybrid modes.

A platform approach will prove critical to scale up agri-tech innovations (Mathur 2019). Reduced redundancies and cost for different agri-tech companies in engaging with the same set of farmers is one primary benefit. Another advantage is the platform's potential to act as a single and uniform interface for farmers to access services offered by multiple agri-tech companies across the value chain, including financial, insurance and extension services. Such a platform will also ensure easy, timely and integrated action to mitigate climate change effects based on early warning systems. For example, a notification from the automatic weather station could trigger the automated irrigation controller to take appropriate action.

Convergence - Incorporating climate-smart technologies into existing and new government programmes

Schemes like PMKSY (Pradhan Mantri Krishi Sinchayee Yojana) currently provide subsidies for adoption of drip irrigation. However, there is no subsidy for farm automation and installation of sensors for precision irrigation, owing to which precision irrigation companies find it difficult to market their innovations to smallholder farmers. The PM KUSUM (Kisan Urja Suraksha evam Utthaan Mahabhiyan) Yojana focuses on adoption of solar and other renewable energy to reduce carbon emissions in agriculture. These schemes should also emphasise modular and decentralised renewable energy (DRE) solutions.
National Mission for Sustainable Agriculture (NMSA) focuses on water use efficiency', nutrient management and livelihood diversification through the adoption of sustainable practices, environmental friendly technologies, adoption of energy-efficient equipment, conservation of natural resources, and integrated farming, among other measures. There

is good scope for convergence with the Central Government scheme for the promotion of 10,000 FPOs by allocating a budget for FPOs to adopt climate-smart technologies within their value chains. Integration of climate-smart technologies with district agricultural contingency plans can enable real-time decision-making and action to minimise crop losses.

The World Bank-funded Project on Climate Resilient Agriculture (PoCRA) in Maharashtra aims to develop a drought-proofing and climate-resilient strategy for the agriculture sector as a long-term and sustainable measure. It focuses on village-level development plans, based on a comprehensive data-driven microplanning exercise led by the community, and includes measures for optimal utilisation of natural resources, identification of appropriate cropping patterns, adoption of latest technologies, and improved access to markets. Such multilaterally funded programmes need to be replicated in other states and should provide for the adoption of climate-smart technologies.

Public-private partnerships and promotion of sustainable supply chains in the private sector

As part of their sustainability initiatives, agri-business corporate organisations could partially or fully fund the adoption and integration of climate-smart technologies within their existing and new supply chains. Programmes such as PPP-IAD (Public Private Partnerships for Integrated Agriculture Development) and PPP-IHD (Public Private Partnerships for Integrated Horticulture Development) which were successfully undertaken in Karnataka and Maharashtra need to be continued, scaled up and replicated in other states as well, with a stronger focus on climate resilience and climate-smart technologies. Such programmes can improve adoption of otherwise expensive technologies by small and marginal farmers, who are the most vulnerable to climate change effects.

Innovations in climate-finance for startups and end-user financing

Catalytic capital from governments, foundations, CSR, multilateral agencies should be deployed in the form of revolving funds, soft loans, and grant-in-aid to absorb the high product development and deployment costs in the initial years. Climate-smart technologies should be subsidised by the government for small and marginal farmers. Promotion of bridge loans can help address the issues due to delays in release of subsidies, by providing farmers and FPOs with timely working capital to manage their operations.

Innovative climate finance solutions will incentivise both mitigation and adaptation solutions at the farmer level, through a model where incentives are built into financial products, like farm loans with reduced interest rates. In the next five years, the development of carbon markets will further fuel the adoption of climate-smart technologies at the farmer and FPO levels.

Strategic grassroot partnerships for deploying solutions at scale

Prospecting farmers for marketing technology solutions would involve mobilising farmers, conducting village-level meetings, follow-up discussions, awareness programmes and live demonstrations to showcase the tangible and intangible benefits of the technology solution, and establishing a clear value proposition for adopting the solution.

Startups should partner with grassroot NGOs working in agriculture, FPOs, cooperatives and existing farmer groups for these activities, in order to minimise their deployment costs. Leveraging the existing community relationships and trust would also help them to quickly deploy and scale their solutions. They can offer some fixed and variable incentives to the field partners for their support.

Collective asset ownership and service delivery models can also be explored at the FPO or cooperative level. Innovative business models creating shared value among the partners will result in additional revenue streams for the FPO. Moreover, deployment of certain technology solutions can happen at the FPO-level itself, further minimising the deployment costs and time, while also reducing the risk of default on payments.

Conclusion

Enabling agri-tech solutions to facilitate climate change adaptation would require coordinated efforts from all the stakeholders in the agricultural ecosystem. Strengthening the incubation ecosystem, focusing on a platform approach, converging with key government programmes coupled with innovative financing solutions for startups and end-users, and establishing strategic grassroot partnerships are the critical levers that can address the challenges in development, deployment and scaling up of agri-tech innovations to promote climate change adaptation.

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