

# Farmer-centric Approach in Agricultural Research: A Need to Unpack the 'Black-box'

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## ABSTRACT

Agricultural systems are increasingly being viewed in terms of complex systems thinking, where rapid transformation or scaling is seen to arise from multiple coinciding influences, events, trends or even shocks. A farmer-centric approach in agricultural research shifts the focus from a 'top-down' model where scientists develop technologies in isolated laboratories-to 'bottom-up' model where farmers are active partners in the research process; where farmers are viewed as innovators and decision makers rather than just passive recipients of new technologies. Research is conducted directly in farmers' field under real world conditions rather than controlled conditions. Scientists and farmers work together to identify problems, select variables for testing, and share insights. This approach integrates formal scientific knowledge with the practical, local expertise and 'informal wisdom' that farmers possess about their specific environments. Successful innovations are spread through farmer-to-farmer learning and research-led networks. Major benefits include higher adoption rate, tailored solutions, sustainability and resilience, and cost effectiveness where farmer-centric extension services often operate on lower budgets by utilising farmers as facilitators within their own communities.

**Keywords:** Farmer-centric approach, Agricultural research, Reforms in farming sector, Sustainability and resilience

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## INTRODUCTION

A "Farmer-centric Approach" in agricultural research means shifting the focus away from researcher-driven agendas to prioritizing the needs, priorities, and knowledge of farmers in the design and implementation of agricultural research projects. This approach recognizes that farmers possess valuable knowledge and experience about their specific environments, challenges, and preferred farming practices. It advocates for actively engaging farmers as co-creators of research, ensuring that the resulting solutions are relevant, feasible, and adopted by them in practice. It emphasizes placing farmers at the core of the research process, recognizing their expertise and knowledge alongside scientific expertise. This approach aims to "unpack the black box" of traditional research by actively involving farmers in identifying problems, designing experiments, and interpreting results, leading to more relevant and effective solutions. It also prioritizes the knowledge, needs, and participation of farmers in the research process. It shifts from a traditional top-down approach where researchers develop technologies and practices that are then disseminated to farmers, to a collaborative approach where farmers are actively involved in identifying problems, designing experiments, and evaluating solutions. This approach aims to create more relevant, effective, and sustainable agricultural solutions by ensuring that research is tailored to the specific contexts and priorities of farming communities. Agriculture is one of the foundational occupations of Man. The challenge to keep up with the increasing population and the ever-growing need to farm animals and provide enough food has led to a growing need for an innovative approach. From medieval

times to modern times, different farm techniques and innovations have been adopted. Across the globe, smallholder farmers are the backbone of the agricultural industry, producing more than 50% of the world's food, they are however often side-lined as innovations are most times made based on assumptions of the problems they face. Most of these innovations end up not being beneficial to farmers, and some are even harmful to farmers and the environment. Farmer-centric research generally involves 'On-Farm Experimentation' and may be better described as 'Farm Action Research', i.e., research conducted at least in part by and for beneficiaries who also farm. The huge uncertainties in farming generally dictate that an appropriate level of confidence in any conclusion from farmer-centric research can only be derived from extensive replication of observations or experimentation across what farmers practice at their farms and/or production cycles. Effective farmer-centric research, therefore, involves a significant element of social cooperation; it is best conducted by groups or networks of farms. On-farm research also commonly merits involvement by experts in research-specific issues such as group facilitation, communications, hypothesis formation, experimental design, statistical analysis, and the biological or other science relevant to each specific research challenge. The potential of farmer-centric research to deliver trustworthy conclusions that address immediate farming challenges has been enhanced by the emergence of many digital tools and communication channels. However, the need for digital infrastructure to support farmer-centric research has hardly been recognised yet.

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### Union Agriculture Minister Shri Shivraj Singh Chouhan's Mantra

There is a need for a fundamental shift in India's agricultural research, emphasising that its direction must now be dictated by the needs of farmers. During the annual conference of Vice Chancellors from state agriculture universities (SAUs) and Directors of Indian Council of Agricultural Research (ICAR) institutes, Chouhan directed the ICAR to set and evaluate 3-4 concrete targets annually, stressing accountability and practical outcomes. Expressing concern over the apparent disconnects between scientists and farmers, the Minister urged agricultural university Vice Chancellors to prioritise practical training for students. He also instructed ICAR to unearth actionable points, categorising them for immediate implementation.

### Excerpts from an Interview by 'Rural Voice' with Dr ML Jat, Director General ICAR

Based on Indian Government's voice, Dr ML Jat, Director General, Indian Council of Agricultural Research (ICAR) opines that the ICAR would now plan to change its research methods and make the needs of farmers the basis of its research. Along with this, the functioning system of all the institutes working for agricultural research and state agricultural universities (SAUs) is also going to change, while the role of Krishi Vigyan Kendras will also be redefined so that their role in agricultural extension can become more effective. In a way, the concept of 'One ICAR' will be taken forward. Also, the emphasis will be laid on a holistic agri food system approach at the centre of research and methodology. The dream of a developed India (*Viksit Bharat*) by 2047 can only be achieved with developed agriculture. Agriculture is diverse, in terms of land, water, climate, and farmers; and there is need to conduct research and innovation accordingly. A single research or innovation may not work everywhere. That's why it is said that there is nothing absolutely right or wrong in agriculture. Its *mantra* is demand-based and relevant research. There was a time when country lacked food. Hence, during the Green Revolution, ICAR's focus was on increasing production and productivity. Research at that time was designed with a focus on yield. But the situation today is different. Now, overproduction is the problem. The government faces challenges in managing this surplus. Farmers are forced to sell crops at throwaway prices. There is now need to focus on this issue. Recently, there was a discussion that overproduction of rice leads to disposal issues, while on the other hand, we import pulses and oilseeds. There is need of targeted research and technology, which means directing the right solution at the right place (*Problem to Solution*), economically feasible for farmers and sustainable for the environment. For example, extracting water for 10 years to grow paddy in Punjab and then running out of water is not viable, it is a kind of planner's mistake then. We need to design our approach according to specific conditions. Conditions have changed significantly. These are the mega-trends – climate change, land degradation, and biodiversity loss. To address these challenges, our research

design must evolve. We've remained fixated on production, but agricultural output alone is not holistic. There is need to consider pre- and post-production factors also, hence, to go for a comprehensive agri-food systems approach. Without this, farmers won't get market linkage, technology targeting won't happen, and business models won't be built.

For a complete agri-food system, different skills are needed. While KVKs can train Farmer Producer Organizations (FPOs), experts are needed to create business plan. These are new areas; country needs to integrate. It shouldn't be commodity-centric. For instance, suppose a rice variety matures in 145 days but is harvested in 155 days. While this may increase yield by half a ton, it may delay the next crop, causing a loss of one ton. We need to determine what fits best where. One size will not fit at every place. If a farmer has a 70-day window, what can be grown in that period? Growing a 100-day crop in a 70-day window won't work. Accordingly, redesigning is essential. Historically, India has had a robust system of agricultural research, education, and extension, from top to bottom. But as we have become more self-reliant, we started working in silos which now, we can't afford. Every institute doesn't have every kind of expertise, hence sharing of other institute's expertise is necessary which enhances the whole system, and there is need to consolidate these capabilities. There is a need for a system interconnected from bottom to top. Information should flow both ways- from ground-level demand to research, and from research to farmers via extension. For this, we must create/strengthen a strong National Agricultural Research Extension Education System (NAREES). First, the technology is to be developed, then multi-location testing, followed by adaptive trials on farmers' fields. Even within a single field, differences exist due to soil condition and crop management, etc. Therefore, today we need as much socio-economic research as biophysical research – on varieties, water, nutrients. We often say farmers adopt or don't adopt technologies. But why? We must understand the behaviour behind it. No farmer wants low yields, but many decisions are influenced by the community where they live. Researchers talked to farmers about zero tillage, they said it saves water, money, and give good crops. But they don't like how the field looks afterward – a behavioural issue. Agriculture is not always straightforward. There is a need to focus on strengthening social sciences. The scope of biophysical scientists' work is broad and includes other aspects too. We have seen a wide gap between average and actual yields. This shows that while technology exists, adoption is a challenge. We need to understand the reasons behind the yield gap. More than 50% of it is due to knowledge gaps. That means we must improve knowledge dissemination. Krishi Vigyan Kendras, ATMA, and State's line department may help bridge this gap.

The ICAR's focus should be on science-based agricultural transformation. We need new science to solve future challenges. Change should be science-driven; and there is need to keep pace with technological progress. We must

develop a strong data ecosystem. The Ministry is building a Digital Public Infrastructure to map every field. Agriculture relies on data from 7–8 Union Ministries. Without fertilizer or water data, can we farm? A robust AI requires a complete data ecosystem. For small tasks, things may work, but for the big picture, quality data is essential. Extension is much essential. Compared to the past, today's extension is more complex. Now we talk about digital extension that requires skills. Without skills, delivery fails. Hence, we talk about the "science of delivery." We must link the 'science of discovery' with the 'science of delivery'. If these two functions separately, problems will definitely arise. Extension is a science in itself – the science of delivery which requires several elements, like technology-based business models. If business grows through technology, delivery happens. If not, delivery fails. For 70 years, we have followed a linear extension model. We now need a mix of linear and non-linear systems. A new extension ecosystem is emerging. The private sector also has its own network. We aim to converge both public and private systems. If they work in different directions, nothing will be derived and farmers lose. ICAR needs to work towards this convergence.

Researchers always discuss about efficiency of water, fertilizers and nutrient, etc., but forget the time efficiency, which is most critical, especially with climate uncertainty. Without mechanization, we can't ensure time efficiency. There is good progress in mechanization, but many areas still need access – like rainfed or hilly regions. Mechanization isn't just about tractors. Planting, harvesting, inter-cultivation – these are also vital. Mechanization must not deceive farmers. We need multi-utility, multipurpose quality gadgets. A farmer doesn't need 10 planters for 10 crops; instead he needs a planter which should work for all. Mechanization also must be supported by business models. A machine used only for 15 days a year will sit idle for 350 days – that's not viable. We are discussing a national mechanization strategy and how India can feed the world. Our research and agriculture have so much potential that we can feed all of Africa. In terms of quality and affordability, no one can beat us. Public sector doesn't work for profit; but the private sector must for profit. If they don't derive profit, they will collapse, we all should understand that. But they must also consider how they contribute to national goals. CSR (Corporate Social Responsibility) fund of private sector must be properly channelled. They should assess judiciously where they can contribute. Mapping at the district level should be judicious. Everyone has to understand their role and responsibility. Agricultural universities are mushrooming in various places, but there is need to ascertain the mechanism for quality control which is essential to ensure the quality of education and to make it relevant.

**Suggestions from Dr MS Basu, Visiting Scientist, ICRISAT & Former Director, ICAR-Indian Institute of Groundnut Research, Junagarh (Gujarat)**

There is need to reorient ICAR as a Problem-Solving

Enterprise, co-powered by zone-specific intelligence, farmer participation, and real-time impact tracking. There is need to shift from "Lab to Land" to "Problem to Solution". India's agricultural complexity marked by diverse agro-climatic zones, millions of smallholders, and low levels of technology adoption demands a problem-centric, farmer-first research model from ICAR. A shift from purely academic or technology-push approaches to contextual, need-based innovations is critical. In Indian agricultural research, a problem-to-solution approach involves identifying challenges faced by farmers and developing targeted solutions through research and development. This includes addressing issues like low productivity, climate change impacts, inefficient resource management, and market access problems. Solutions often involve technological advancements, sustainable practices, policy interventions, and capacity building. A Way Forward for ICAR to make research truly farmers-centric and problem-driven:

#### **Zone-Specific Problem Diagnostics**

- Conduct Participatory Problem Mapping in each agro-climatic zone.
- Use AI/ML & GIS tools to build an open-access "District-Level Agri Problems Atlas" using CropLocator.

#### **Decentralized, Problem-Centric Research Hubs**

- Establish "Agro-Eco Innovation Labs" in every agro-climatic zone focusing on real problems.
- Strengthen existing KVKs and Zonal Research Stations to become solution hubs.

#### **Farmers as Research Co-Creators**

- Institutionalize Farmer Participatory Research (FPR) models where farmers co-develop and field-test solutions with scientists.
- Promote on-farm trials through farmer clusters and FPOs under "Lab to Land and Back to Lab" framework.

#### **Technology Simplification & Democratization**

- Redesign agri-tech solutions for non-tech-savvy smallholders: voice-enabled apps, vernacular chatbots, etc.
- Partner with AgriTech start-ups to convert complex data into simple advisories.

#### **Outcome-Based Research Prioritization**

- Replace "publication metrics" with impact metrics (e.g., % yield increase, reduction in input costs, improved soil health, etc.).
- Link research project approvals to specific farmer-centric goals – not just scientific novelty.

#### **Revamp Extension System**

- Make KVKs digitally smart and accountable for solving local agri problems using evidence-based practices.
- Train a new cadre of "Rural Agri Fellows" (youth from villages) to bridge the tech gap between labs and farmers.

### Main Problems of Indian agriculture

Since 1947 till now, every region of the country has made substantial development. Today India's space program is among the most successful space programs in the world. The Indian Army is one of the most powerful armies in the world and India's economy is one of the five strongest economies in the world. India is regularly writing new development stories in other areas as well. Despite these achievements, there is one area which is still lagging behind in the race of development. The agriculture sector, which plays an important role in areas like food security and rural employment, has still not reached a situation that can be considered satisfactory. The result of this is that crores of people of the country dependent on agriculture are still forced to live in extreme poverty and many times they are not able to fulfil even their basic needs through agriculture.

### Problems

- There is still a lack of irrigation facilities in most parts of India. Only those farmers who have sufficient capital are able to manage irrigation facilities privately because the cost of installing irrigation equipment like tube wells is so much that it is not possible for poor farmers to afford it. In this way, most of the farmers become dependent on monsoon and if there is no timely rain, their crops get spoiled and sometimes they are not able to produce enough for subsistence. Similarly, due to excessive rainfall or various natural disasters, crops get spoiled and the farmer gets trapped in the quagmire of poverty.
- A large population of Indian farmers have only a small amount of cultivable land available. A major reason for this is the increasing population. As a result, agriculture has become a means of subsistence rather than a means of earning profit for the farmers, in which they are somehow able to support themselves and their families. The Indian agriculture sector is also facing the problem of hidden unemployment.
- Farmers often do not get adequate prices for their produce, a major reason for this is that they sell their crops at prices below the Minimum Support Price (MSP) for various reasons such as to repay loans. Due to which they have to face a lot of loss.
- Problems like inability to use modern equipment and techniques in India's agricultural sector, lack of transportation facilities, lack of storage facilities, lack of transportation facilities, lack of other basic facilities and reduction in yield due to poor quality of soil etc. Are included.
- Most of the farmers in India lack/lack the capital to invest in agriculture. Even today, most of the farmers of the country are not able to avail the benefit of institutional credit facilities in practical terms. Many times, farmers do not even have enough capital to arrange for basic things like seeds, fertilizers and irrigation. The result is that farmers are not able to produce crops on time or due to insufficient nutrients the crops are not of adequate quality. Besides this, due to lack of capital, the farmer has to take loans from private individuals at high interest rates, which increases his problems instead of reducing them. In this regard, the *Kisan Samman Nidhi* Scheme launched by the Government of India is proving to be very helpful for the farmers. This helps to a great extent in meeting the basic agricultural needs of the farmers.

### Government's Strategic Initiatives

Point strategic initiative has been launched by the Government of India for infrastructural reforms in the agriculture sector and doubling the income of farmers, which are as follows:

- The Government of India is increasing investment on warehouses and cold storage to prevent agricultural produce from getting destroyed. This will prevent wastage of produce, strengthen the food security situation and the remaining produce can also be exported to international markets.
- Emphasis has been laid by the Central Government on the creation of a National Agricultural Market to provide the farmers the right price for their agricultural produce. This will bring uniformity in the prices of agricultural produce across the country and farmers of all the states of India will be able to get adequate benefits.
- At present in India, emphasis is being laid on using high quality seeds in the agricultural sector and also awareness is being spread to use the same number of fertilizers in the fields as prescribed by the Soil Health Card (SHC) and the soil. It is appropriate to use it according to fertility. This will not only improve the quality of the soil but will also effectively reduce the expenditure on fertilizers. This will also reduce soil and water pollution.
- Per Drop More Crop Strategy – Under this strategy, emphasis is being laid on micro irrigation. This will reduce the amount of water used in agriculture. This will not only conserve water but also reduce the cost of irrigation. This strategy is particularly beneficial in water-scarce areas.
- Emphasis is being laid on using high quality seeds in the agriculture sector. Along with this, awareness is being spread to use the same amount of fertilizers in the fields as is appropriate according to the soil health card. This will improve the quality of the soil and will also effectively reduce the expenditure on fertilizers. This will also reduce soil and water pollution.
- Value addition in the agricultural sector is being promoted through food processing. There is immense potential in the food processing sector in

India.

- Every year in India, crops are adversely affected due to natural disasters like drought, fire, cyclone, heavy rain, hailstorm etc. in different areas. To mitigate these risks, crop insurance has been made available at affordable prices. However, its actual benefits have not yet reached enough farmers. The Government of India should take measures at the central level to ensure that its benefits reach most of the people/farmers.

### Government's Reforms in Farmers' Sector

To bring about reforms in the agricultural sector in India and to solve the problems of Indian farmers, there is a need to bring about radical changes in the agricultural markets. Along with this, new direction can be provided to Indian agriculture and the condition of Indian farmers through the several initiatives by the governments to: i) expand the scope of the Minimum Price Support (MSP) system, ii) break the web of Agricultural Produce Marketing Committees (APMCs) and eliminate brokers and middlemen, iii) develop supply-chains to take the agricultural products of farmers to the markets, and better linkages between consumers, farmers and markets, iv) improve the negotiable warehouse receipt system, v) amend the Essential Commodities Act, 1955 in India, vi) simplifying laws related to land and consolidation etc., vii) promote contract farming, viii) create a simple and favourable environment for increasing agricultural exports of Indian farmers, ix) develop food processing facilities, and x) in the present situation of Indian farmers, it has been seen that with the passage of time, instead of improving, the condition of Indian farmers has become worse. The measures taken from time to time by the country's policy makers at the government level to satisfy the farmers provide immediate relief. Under these measures, steps are taken to woo the farmers, whereas what is needed is such structural measures which are long term and can solve the problems of the farmers permanently. Like running a scheme like Universal Basic Income. This will ensure a fixed income every month and farmers will not be forced to sell their produce at throwaway prices. But the reality is that we are not succeeding in solving the common problems of the farmers like electricity, water, fertilizers, agricultural infrastructure, marketing and ability to face risks etc.

### Issue of Loan Waiver of Farmers

The loan waiver scheme of farmers in India has not proved to be a permanent solution to the problems of farmers, because only 20 to 30 percent of the farmers in India get its benefit. Due to this limited reach of the government, the widespread grievances and problems of Indian farmers cannot be resolved. Because in reality, interim measures like loan waiver do not solve the real problem of continuously decreasing income from agriculture.

Today, when technology is being used in every field of human activities all over the world, most of the Indian agriculture is

still dependent on age-old patterns and traditional methods. Till date no special technology is being used in Indian agriculture. Bt cotton started being used 15 years ago, but after that no such experiment has been done in the agriculture sector. Today humans have various types of technologies available, such as biotechnology, information and communication technology, satellite technology, nuclear agriculture technology and nanotechnology for food processing. All these cannot be used in the Indian agricultural sector. A radical change can be brought about in the Indian agricultural sector by adopting the following 6-point plan to improve the agricultural sector in India. Which can have a positive impact in the interest of Indian farmers by: i) strengthening the input delivery system, ii) rapid expansion of irrigation facilities, iii) using diverse technologies in the Indian agriculture sector, iv) investing in the rural infrastructure sector, v) making maximum use of ICT (Information and Communication Technology) in the Indian agriculture sector, and vi) develop capacity building of Indian farmers.

### Key Problems and Probable Potential Solutions

#### Low Agricultural Productivity

- **Problem:** India's agricultural output per unit of land is often lower than in other countries. This is due to factors like small landholdings, poor irrigation, soil degradation, and inadequate access to quality seeds and fertilizers.
- **Solution:** Research into high-yielding crop varieties, precision farming techniques, water-efficient irrigation methods, and sustainable soil management practices can help increase productivity.

#### Climate Change Impacts

- **Problem:** Changing weather patterns, droughts, floods, and extreme temperatures pose significant threats to crop yields and livestock production.
- **Solution:** Developing climate-resilient crops, promoting drought-resistant varieties, improving water management strategies, and implementing early warning systems for extreme weather events are crucial.

#### Resource Management Issues

- **Problem:** Water scarcity, soil degradation, and inefficient use of fertilizers and pesticides are major concerns.
- **Solution:** Research into water-saving irrigation technologies, integrated nutrient management practices, and integrated pest management strategies can help improve resource use efficiency.

#### Market Access and Infrastructure

- **Problem:** Farmers often face challenges in accessing markets due to inadequate storage facilities, poor transportation infrastructure, and exploitative middlemen.
- **Solution:** Investing in cold storage facilities,

improving rural road networks, promoting farmer producer organizations, and developing transparent and efficient market systems are essential.

#### Socio-Economic Challenges

- **Problem:** Rural poverty, lack of access to credit and insurance and limited access to information and technology affect farmers' livelihoods.
- **Solution:** Promoting rural entrepreneurship, providing access to microfinance and crop insurance, and strengthening agricultural extension services can empower farmers and improve their socio-economic conditions.

#### Lack of Skilled Manpower and Technology Adoption

- **Problem:** A gap exists between agricultural research and practical implementation on farms due to a lack of skilled manpower and slow adoption of new technologies.
- **Solution:** Strengthening agricultural education and training programs, promoting farmer field schools, and fostering collaboration between researchers and farmers can facilitate technology transfer.

#### Policy and Institutional Support

- **Problem:** Inconsistent government policies, inadequate funding for agricultural research and bureaucratic inefficiencies can hinder progress.
- **Solution:** Streamlining policies, increasing investment in agricultural research, and strengthening institutional capacity are crucial for supporting sustainable agricultural development.

By addressing these problems through targeted research and development efforts, India can enhance agricultural productivity, improve farmers' livelihoods, and ensure food security for its growing population. This requires a holistic approach that integrates technological advancements, sustainable practices, policy reforms, and capacity building initiatives.

#### Key Aspects of Farmer-centric Research

**Farmer Participation:** Farmers are not just recipients of research findings but active participants in the research process, contributing their knowledge and experience. Research focuses on addressing the specific problems and needs identified by farmers, ensuring relevance and practical application. Farmers are involved in designing experiments, selecting treatments, and interpreting results, fostering a sense of ownership and engagement.

**Key Research Approaches:** On-Farm Experimentation (OFE) involves conducting experiments on farmers' fields, allowing for the evaluation of technologies and practices under real-world conditions. Participatory Action Research (PAR) approach combines research with action, empowering farmers to identify problems, develop solutions, and implement changes. Farmer-Centred Agroecology Research

(FCAR) focuses on refining agroecological farming practices, addressing issues related to land management, marketing, and crop production.

**Benefits of Farmer-Centric Research:** Increased adoption of technologies, when farmers are involved in the research process, they are more likely to adopt new technologies and practices that are relevant to their needs and contexts. Farmer-centric research can lead to more sustainable agricultural practices by incorporating local knowledge and addressing environmental concerns. By addressing the specific challenges faced by farmers, this approach can contribute to improved farm productivity, profitability, and overall livelihoods. Farmer-centric research helps to translate research findings into practical solutions that can be implemented on farms.

**Digital Tools and Technologies:** Digital tools can facilitate data collection, analysis, and sharing, enhancing the efficiency and effectiveness of farmer-centric research. Technologies like drones and satellite imagery can be used to monitor crop health and identify potential problems, providing valuable information for farmers. Digital tools can provide farmers with personalized recommendations based on data analysis, helping them to make informed decisions about their farming practices.

#### Farmer-centric Approach

In a farmer-centric approach, the farmers' knowledge, needs, and innovations play a central role in shaping agricultural development. Imagine a world where farmers have access to the latest and greatest agricultural innovations, and where these innovations are tailored to their specific needs. This is a world where farmers can produce more food with fewer resources, and where they can thrive even in the face of challenges such as climate change and pests and diseases. This is the world that we can create by taking a farmer-centric approach to agricultural innovation. Farmer-centric innovation means putting farmers at the centre of the research and development process and developing innovations that meet their specific needs and priorities. The benefits of a farmer-centric approach to agricultural innovation include:

- **Increased adoption:** Farmers are more likely to adopt innovations that they have helped to develop and that meet their specific needs.
- **Improved impact:** Innovations that are developed with farmers in mind are more likely to have a positive impact on farmers' livelihoods and the environment.
- **More sustainable food system:** A farmer-centric approach to agricultural innovation can help to create a more sustainable food system that is more resilient to shocks and stresses.

Some of the key problems that smallholder farmers face include:

- **Limited access to credit and financing:** Farmers often have difficulty accessing credit and financing to invest in new technologies and inputs. This can make it difficult for them to adopt innovative agricultural products, which can be expensive upfront.
- **Access to Land:** Limited access to land
- **Limited access to information:** This can make it difficult for them to make informed decisions about whether or not to adopt new products.
- **Lack of training and support:** They often lack the training and support needed to adopt and implement new agricultural technologies and practices. This can make it difficult for them to get the most out of these technologies.

Innovators can address these challenges by developing innovative solutions that are tailored to the needs of smallholder farmers. For example, innovators can develop new financing mechanisms to help smallholder farmers access the credit they need to invest in new technologies. Innovators can also develop new technologies that are affordable and accessible to smallholder farmers. Additionally, innovators can provide training and support to smallholder farmers to help them adopt and implement new agricultural technologies and practices. By getting farmers involved in the research and development process through farmer field trials, participatory design workshops, and other forms of farmer engagement and taking into consideration the need for affordable and accessible to smallholder farmers we encourage farmers to be open to adopting new technology.

#### Farmer Centric Transformation Using Digital Agriculture Technologies-Agronomics

The science of Digital Agriculture has been gaining prominence with the advent of fast-paced progress in technologies that can impact last-mile delivery to smallholder farmers. Digital Agriculture offers a wide range of technology solutions such as smart farming with IoTs, data-driven agronomy and extension systems, market access and financial services. ICRISAT has pioneered research and development in digital agriculture area in early 2016, which was institutionalized through Agri-Tech start up environment at the Innovations Hub (iHub) in Hyderabad. Digitisation of agriculture is not only energising but reversing the generation and flows of knowledge, from top-down to bottom-up, so creating a new crowd-sourced, multi-scale science known as 'agronomics'. Priorities for investment to maximise agricultural progress through agronomics are the creation of: i) an open digital ecosystem for interoperable software services, and ii) a structured network (or 'virtual institute') to lead thinking, research, education and training in agronomics. Of course, agronomics incorporates conventional agricultural science, but it offers to provide far more intensive and extensive quantification, it applies across multiple scales of both time and space, and it has farmers and their supporters as central players, both as exponents and

investigators, unravelling the variation that they, and everyone that depends on them (i.e., everyone!), seek to control. In particular, the new dynamics of measurement and communication enabled by digitisation are offering to supersede conventional rates of progress in agriculture. Digitisation creates a new arena of knowledge generation and offers not only to energise but to reverse knowledge flows in agriculture. If this new science is to progress, the large datasets now routinely being created must be processed: captured, stored, referenced, cleaned, calibrated, analysed, modelled and easily visualised and shared. Exciting current advances in mathematics and computing must be applied to the torrent of new agricultural data. However, experience in science shows the labour required to assemble the opposite data for each impending question, and the labour involved in making sense out of multi-dimensional datasets. The extent of and need for this labour, and its power in knowledge generation, are not widely appreciated outside science, so for decades applied agricultural research has accumulated multiple large, potentially valuable but unanalysed datasets – the AHDB's RL database being just one example. Analytical tools and teams must be developed to undertake 'pump-priming' exercises which demonstrate to farmers and their support organisations the power of big-data analysis, and evolve efficient procedures for this. It must become inherent in new agronomic systems that data providers and analysts see mutual benefits.

#### CONCLUSION

Agriculture in India is a state subject and every state decides its agricultural policies according to its convenience and circumstances. There is a need for the Centre and the States to work together when it comes to the agriculture sector in India. But the bitter and real truth of the present times is that Indian farmers deserve much more than the income they are getting from farming. But it is not possible to increase the income of Indian farmers through short-term measures taken by the Central and State Governments. This will require long-term commitment and systematic solutions, only then can there be any improvement in the economic condition of Indian farmers. The uneven geographical spread of procurement by the Food Corporation of India has also led to unsustainable farming practices in some areas, while farmers in other areas of the country remain perpetually on the brink of poverty. It is proposed that our more conceptual tenets might be addressed by a new structured network or 'Virtual Institute for Agronomics' (VIA) which would lead thinking, research, education and training in agronomics: in particular developing the new science and forging engagement with the knowledge generators – farmers and their advisers. But also, it would seek to reconcile rigour with urgency, develop ways to quantify and report uncertainty, develop farming ontologies, and incorporate social understanding (with appropriate metrics) into more conventional (physical) explanations of agricultural performance. The more procedural tenets above, involving the sharing of data, knowledge and ideas, could be best addressed by developing a new open digital ecosystem

for interoperable software services. These would automate research processes, facilitate pre-competitive knowledge sharing, generation and recording using newly developed ontologies, design bespoke sensing systems for prioritised metrics, and provide new analytical tools to distil the multiple, new, big, agricultural datasets. To engage in farmer-centered research, researchers need new skills and knowledge, along with respect for farmers' values and trust in their ability to participate meaningfully in research. Involving farmers in the whole research process is one of the guiding principles when convening farmer research networks. The following Way Forward emerged which need to be taken into account:

- Researchers should place farmers at the centre of research, developing the collaborative skills needed to work with producers to better understand the problem, specify practical indicators, and gather meaningful data. Trust between farmers and scientists should grow as the latter shares both research findings and credit for findings with the farmers.
- Farmers will be more willing to work with researchers if they are given upper hand. At the same time, greater numbers of farmers understand the methods and aims of academic research and are adopting and adapting these practices for their own purposes. Farmers who take part in research program tend to actively disseminate findings among their broader networks, especially when these findings are captured in videos in which farmers can see themselves and their environments.
- Seeks to improve public support for farming in the Indian agricultural sector, which is necessary for reasons including national food security. This can be better achieved through broader political consultation and by encouraging beneficiaries of the existing system to diversify production and increase productivity. The mutual interests of political parties at the root of farmers' protests before the Lok Sabha elections cannot be ignored. The agricultural sector needs a new model of public support. It cannot be left at the mercy of the market. The government should lead efforts to build national consensus on this question.
- Most of the country's population is dependent on agriculture. Therefore, poverty eradication, increase in employment, eradication of hunger etc. in the country is possible only when the condition of agriculture and farmers is improved. If the above measures are implemented effectively then the condition of agriculture can definitely improve. This will reduce the despair prevalent in this sector, farmer suicides will stop, and people who have given up farming will start taking interest in this sector again.
- The Government of India is laying emphasis on the development of agricultural supporting sectors like dairy, animal husbandry, beekeeping, poultry, fisheries etc. through various schemes at the central level. Since most of the farmers of the country are already connected with these things. Hence, they can get direct benefit from it. Now there is a need to create awareness among the farmers in India, so that factors like breed improvement of animals can be worked on effectively.
- The Central Government should resolve the grievances of the farmers through talks with the farmers.
- Effort needs to be made to better involve women and young people to ensure an agroecological transition that is just and sustainable. Selecting youth and female participants based on their age and skill can help ensure that the most vulnerable and impoverished youth women farmers benefit from participation.
- Expanding farmer-centric networks across levels and scales requires a systemic understanding of the role agroecology plays in broader social, political, agricultural and ecological systems. Part of this is understanding that farmers need an income.
- Farmer-research networks can contribute to scientific understanding of which indigenous agricultural practices nurture healthy agroecological systems. They could prove useful for agroecological extension work.
- Farmers need to be respected as sources of knowledge. Farmers bring to indigenous knowledge that was handed down from generation to generation over centuries. They are also natural researchers, constantly experimenting and trying new ways to complement the old. The role of researchers is to support this natural ability in whichever way is contextually appropriate. This may involve giving farmers funds so that they can organize themselves to pay for transportation if needed, or providing them with mobile phones to facilitate data-gathering.
- When farmers are meaningfully involved at all stages, and when they can see themselves and their work reflected in the results, they actively share their knowledge and findings, both with their neighbours and with family members in the communities.
- Farmers should receive credit for their contributions, which are often both material (for example, seeds) and practical (for example, data-gathering). Credit does not necessarily refer to financial reward but to recognition of the role they played. Facilitation and negotiation skills are required to find common ground and develop trust-based partnerships with farmers and their broader communities. Trust is built when researchers show a genuine interest in understanding community and farmers' priorities and prioritize these in research activities. The ability to communicate technical

concepts in a way that is timely and resonates with farmers. Farmers actively participate when they understand what is needed of them.

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