



SUSTAINABLE FOOD SYSTEMS

AN AGENDA FOR CLIMATE-RISKED TIMES





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Acknowledgements: The research team would also like to thank all experts and stakeholders from government, scientific institutes, civil society and industry, as well as farmers, who have shared their invaluable perspectives and insights.



The Centre for Science and Environment is grateful to Misereor for their support.



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Citation: Amit Khurana, Rajeshwari Sinha, Gauri Arora, Neeraj Kumar, Chhavi Mahaur *et al*, 2025, *Sustainable Food Systems: An Agenda for Climate-risked Times*, Centre for Science and Environment, New Delhi

Published by
Centre for Science and Environment
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OUR FOOD IN THE AGE OF CLIMATE CHANGE

SUNITA NARAIN





Climate change is about greenhouse gas emissions that are generated for fuel and food. These emissions have forced the world's climate to change, leading now to catastrophic events. While we discuss the contribution of the energy system – fossil fuels that emit long-living carbon dioxide – we don't talk enough about the other elephant in the room: agriculture and the food we eat. This is because more than any other economic sector, agriculture creates a divide between the world that emits for survival and the one that emits for luxury.

But food is also about livelihoods, about nutrition and about nature. This is the connection that we need to make as the world begins to rework the paradigm of agriculture so that it is climate-smart and fit for purpose.

In 2018, some 11 per cent of the global greenhouse gas emissions were from food the world produced; of this, the bulk of emissions (roughly 40 per cent) were from enteric fermentation in the digestive systems of ruminant livestock. Food-producing animals emit methane, which is a powerful greenhouse gas. Another 26 per cent of the agriculture-related emissions were nitrous oxide from livestock manure applied in fields or dumped. Synthetic fertilizers used on crops then added 13 per cent nitrous oxide and methane emissions from rice cultivation contributed 10 per cent of the total agriculture-related emissions.

The problem is that there are two distinct agricultural worlds. One, the industrial agriculture model where food is manufactured in factory farms; the size of animal holdings and the amounts of chemical inputs used to produce such food is massive. This intensive food farming system has an ownership pattern, which differs from the subsistence agriculture of the other world.

In this other world, farmers with small landholdings are engaged in growing food for their consumption or for their livelihood. It is the same for livestock – a few cattle or other animals kept in homestead farms. India, for instance, has the distinction of

having the world's largest livestock population which is also in the hands of very small farmers. Livestock contributes 25-50 per cent of an individual farmer's income, according to official data. It is thus crucial for their economic security. That said, the overall emissions of the large numbers of cattle and other ruminants could be significant. According to the "2021 Third Biennial Report" of the Union Ministry of Environment, Forest and Climate Change, methane emissions from enteric fermentation add up to 8 per cent of the country's total greenhouse gas emissions. What then is the answer for controlling methane emissions? And how will it differ from the other world's actions?

This is the same when it comes to rice production in our world; it is grown by small farmers in areas of high rainfall, where the fields are also used for recharging groundwater. This is not to say that rice grown in water-scarce regions of our world, including in states like Punjab and Haryana, is ecologically sound. But we cannot discount the role of rice in nutrition and livelihood for millions in this (our) world.

And remember, as we discuss this, farmers are also the first victims of climate change impacts. In our world, it is a multifold crisis that threatens their very survival. First, the increasing cost of agricultural inputs and the lack of public infrastructure, including for irrigation, hits their livelihood. Second, increasing food costs are unaffordable to most consumers and governments step in to import food from intensive farming systems that are also invariably subsidised. Farmers lose out. Then, third is the fact that farmers are being hit again and again by extreme weather events; their crops are lost to floods, droughts, pest attacks and unseasonal cold and heat.

Methane emissions from enteric fermentation add up to 8 per cent of India's total greenhouse gas emissions. How can the country control these emissions?

REINVENT FOOD SYSTEMS TO SUIT THE FUTURE

There is something fundamentally broken in the world's agricultural system when you see images of rich European farmers and their poorer counterparts in India straddling tractors to block highways to make their anger heard. The fact is that these farmers are enjoined across continents with a serious problem of increased cost of agricultural production in an age of climate risk and losses.

In Europe, the flashpoint ironically was the introduction of the climate regulation, under which farms would be required to halve pesticide use; cut fertilizer use by 20 per cent; double organic production; and leave more land for non-agricultural use for biodiversity conservation. In addition, the Netherlands had proposed to reduce its livestock numbers to cut nitrogen pollution and Germany to slash its subsidy on diesel, a fossil fuel. All this is clearly needed in a world faced with the existential threat of climate change. Agriculture in the EU, as in other parts of the world, contributes significantly to greenhouse gas emissions – one-tenth of its annual emissions. If this cost of abatement is high for rich farmers, what will it do to farmers in our world who are at the margins of survival?

The fact is that the European farming system, which epitomises modern

agriculture as we know it today, has survived because of massive subsidy. Since 1962, the EU's Common Agricultural Policy (CAP) has provided financial support for agriculture – after much criticism, the support was brought down but only marginally. Today it constitutes some 40 per cent of the EU budget and involves direct payments to farmers. Over and above this, there is more investment made to facilitate agriculture to move towards green methods. All in all, huge finances are paid to grow food in these countries.

Over the years, the "nature" of farming has evolved; farms have become larger and more consolidated. Small agriculturists now struggle to survive because of increased input costs, higher standards and bureaucracy. Larger farms are also faced with high debt as costs increase.

In all this, we have to understand what is not working. Today's practice of organic farming is designed to increase the cost of cultivation. Farming has responded by becoming more intensive – more productivity per crop or livestock – and this means more use of chemicals and inputs (or biopesticides and biofertilizers), which combined with environmental conditions,

results in even higher costs. This spiral of costs is then faced with two realities – one, the need to keep consumer prices of food under control and two, growing crop damages because of climate exigencies.

This is the system of intensive agriculture that is feted in the world – it is touted that environmental standards can be built into the system and yet farmers can increase production and make the business work. Clearly, this is not the case. The cost of food is not affordable even in countries of the western world. The environment is not protected.

In India, farmers protesting on the doorstep of Delhi want higher minimum support price (MSP) for their produce. They face the same challenges as their counterparts in rich Europe, but without the massive subsidy to support food cultivation. Then they face a pincer attack – government has to procure food for distribution and so it needs to keep the price under control; consumers (all of us) do not want to be hit by food inflation. So, even as farmers struggle to make ends meet in terms of costs and increased risk because of weather and pest attacks, and every time the food price goes up and they could benefit, the option is to cool down prices through cheaper imports. They lose. They cannot then invest in the

improvement of soil, water or biodiversity. In this system, the only way ahead is to discount the cost of environmental safeguards.

They are now being told that they need to increase productivity to stay profitable. But this comes at a higher cost because of expensive inputs – this food economics makes no sense as the higher costs will not be paid for in a country that needs affordable food. It is clear that the Indian government cannot subsidise individual farmers at the scale of Europe. It is also clear that even this whopping financial support would not be enough in this system of intensive agriculture.

So, we need to discuss how to reduce costs of cultivation and yet put money on the table for farmers. This is where regenerative or natural farming will play a role, but at scale and with great policy and deliberate practice and science to back it. We also need food procurement policies to work at the local level, so that farmers get assured markets for good food. The Odisha government's millet procurement for mid-day meals is one such practice. The fact is, the world has enough food to feed people; the problem is that much of this food is going into feeding livestock or just to waste. This is what needs to be addressed.

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We, therefore, need to discuss agriculture and climate change in the differing contexts of the two worlds. For this we need to confront the beast of intensive food farming systems, which are also linked to the excessive eating of meat in the other world. Today, the vast proportion of food that is grown, is not for humans, but to feed livestock. This takes up land, it takes up water and then chemicals that are used to grow this, end up polluting soils and adding to the greenhouse gas emissions in the atmosphere.

Of course, action is not easy. The Netherlands government learnt this when it decided to cut nitrous oxide emissions, which would require farmers to drastically reduce livestock, convert to green farms or shut down. It led to widespread protests, which then contributed to the fall of the government a few months ago. New Zealand, where cows are highly productive and contribute almost half of the country's greenhouse gas emissions, has proposed a "burp" tax – farmers would have to pay based on the numbers of cattle and feed. But there is opposition as this would invariably lead to lower cattle numbers for farmers. So, the tax has been deferred and the country continues to count its emission reductions without factoring in the agriculture sector's contribution. The meat question is equally touchy. The meat sector interests are as powerful as the fossil fuel industry, if not more so.

The fact is that we cannot go ahead with this model of agriculture in a climate-risked world. The question then is what is the future transition?

This is where farms and food of our world – countries like India – provide answers to the future. We have, as yet, in most parts not moved to a highly input-intensive model of livestock production. Most dairy farmers are still individuals, using combinations of open and stall feeding for their animals. Their farms are based on agro-silvo-pastoral systems.

But this is changing fast. In many crops – including rice, wheat, cotton and many others – farmers use increasingly expensive inputs from fertilizer, seeds and pesticides to grow. This is in turn adding to the debt burden of farmers, making them even more vulnerable to the crop losses, which are now even more frequent because of climate change.

So, what then are the elements of the agricultural model for livelihood-nutrition-nature security in our climate risk world?

First and foremost, it has to be low-input so that it protects the farmer from multiple risks. This will put more money in the hands of farmers, particularly, as we know that the high cost of food is unaffordable for most countries. It is also clear that low-input agriculture is not necessarily lower in productivity. The conventional strategy – even what is being promoted in the name of smart agriculture – depends on high quality and high cost inputs, which add to the cost of cultivation. The argument is that this will lead to higher yields, which will give the farmer higher income. But this only works if the costs do not wipe out the profits. In the case of small-holder farmers, where there is little economy of scale, this is just not possible.

Increasing yields will need working on the health of the soil and in providing irrigation to farmers, when they need it most. This is when it is also clear that climate change will bring new pests for farmers – this makes it all the more important for agriculture to be resilient; but this does not mean increasing the use of pesticides. It can and must mean changes in practices of agriculture as well as the use of non-chemical alternatives. The bottom-line is that resilience requires more ability to cope; recover and this means higher returns in the hands of

Climate change is bringing a whole lot of challenges for farmers, such as new pests. This means that agriculture must become resilient, its practice must change, and it must focus on using non-chemical alternatives



farmers. This also means investing in markets that will provide opportunities to farmers to maximise gains.

Second, agriculture has to be built on the principle of risk minimisation. This would mean promoting multiple-option cropping systems; this cropping system is also one that will promote biodiversity as farmers would grow more than one crop on the field. This is also why livestock economy is integral – it allows for management of risk so that there is income from different sources. Think of it like the diversification of investment portfolios, which bankers would advise you in these times of uncertainty.

Third, is the question of the crop – crops that are both nutritive and compatible with the local environment. In other words, where there is water shortage, farmers should grow crops like millets that are water prudent. But this choice is not in the hands of the farmer. Government must enable policies that will promote growing of these crops – from procurement to price. For instance, more biodiverse and climate-appropriate millets will be grown by farmers where governments have included them in the schemes for mid-day meals (this is one of India's most important programmes as it aims to provide hot-cooked food in every school of the country). Change of cropping patterns towards climate-resilience will need this supportive structure.

Fourth, and, perhaps most critically, choice of food that farmers grow is in the hands of consumers – us. What do we eat? Why we eat it? If we change our diets, it provides signals to the farmer to grow differently. We know that food is medicine; yet we continue to eat wrong; eat junk. We have food on our plates, which has lost the meaning of nutrition. We are in danger of losing the knowledge of good food – what our grandmothers and mothers cooked in different seasons. This is why we must be part of this changed agriculture story. Food cuisines are about culture and biodiversity.

INDIA: AGRICULTURE AND CLIMATE CHANGE

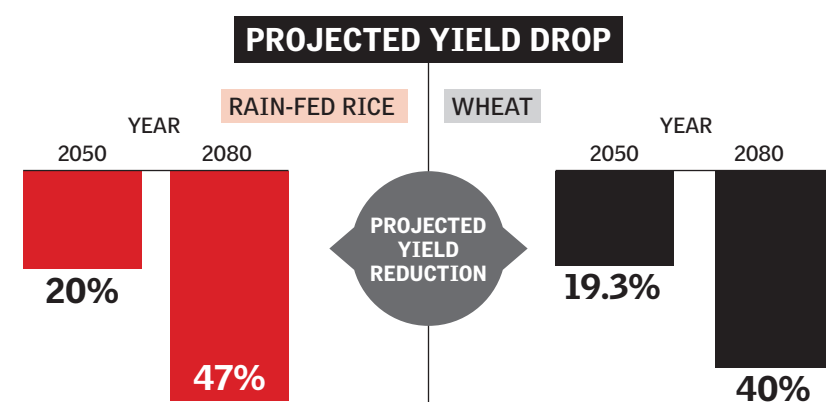
Impact of climate change on India's agriculture

Numerous scientific studies emphasize that climate change poses a severe and quantifiable threat to Indian agriculture, primarily through extreme weather events, rising temperatures, and altered precipitation patterns.

In 2023, in a written reply to Lok Sabha, the Ministry of Agriculture and Farmer Welfare stated that “extensive field and simulation studies were carried out in agriculture by the network centres located in different parts of the country. The climate change impact assessment was carried out using the crop simulation models by incorporating the projected climates of 2050 and 2080. In absence of adoption of adaptation measures, rainfed rice yields in India are projected to reduce by 20 per cent in 2050 and 47 per cent in 2080 scenarios while, irrigated rice yields are projected to reduce by 3.5 per cent in 2050 and 5 per cent in 2080 scenarios”.

The cost on agriculture is increasingly exacerbated because of increased frequency of unseasonal weather. CSE's annual reports, such as the *State of India's Environment*, highlight the escalating frequency of extreme weather events, which are directly responsible for crop damage and economic loss:

- **Frequency of events:** India experienced extreme weather events on 314 out of 365 days in 2022 and 318 days in 2023.



Source: Government of India studies (cited in PIB release, 2023)

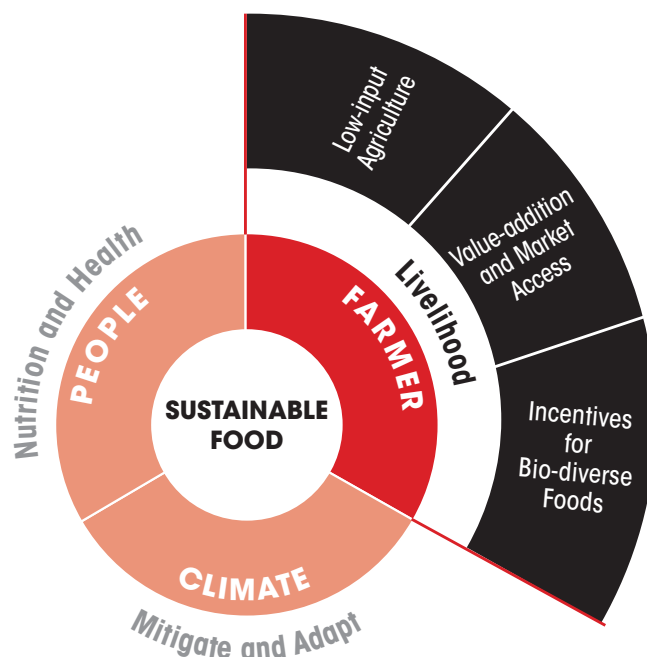
- **Vulnerable districts:** An Indian Council of Agricultural Research (ICAR) assessment, cited by *Down To Earth*, found that 90 per cent of the 573 rural districts assessed face climate risks, with 54 per cent (310 districts) facing “high” or “very high” climate risk.
- **Impact on livelihoods:** This is critical because 55 per cent of the country’s net sown area is rainfed, supporting 60 per cent of the nation’s livestock and 44 per cent of its food requirement.
- **Pests and diseases:** Rising temperatures lead to increased incidence of pests and disease buildup, further reducing crop productivity
- **Water stress:** The total annual rainfall may not have changed dramatically, but its distribution and intensity have. has pointed out that while some semi-arid zones may receive maximum rainfall, central parts of India could face a 10-20 per cent reduction in winter rainfall by the 2050s. Increased water demand and erratic supply are leading to a severe water-supply gap.

Indian farmers are already at the frontline of the climate change impacts. What is also clear is that as temperatures increase, the impact of extreme and unseasonal weather events; rising temperatures, water stress and pest diseases will take a greater toll of their crops and livelihoods. This makes it imperative to understand what needs to be done to make agriculture more resilient to climate change.

AGENDA FOR CLIMATE-RESILIENT AGRICULTURE

Connecting food-climate-farmer-consumer

We know that agriculture is both a contributor of greenhouse gas emissions and also provides the world the opportunity to sequester carbon dioxide. But even as we consider the contribution of agriculture to greenhouse gas emissions, we must put the livelihoods of farmers at the centre. For this we need to rethink what we mean by productivity; and if this comes at the cost of added risk to farmers and to the land and water systems that will be discounted in the need to increase output.



The livelihood connect

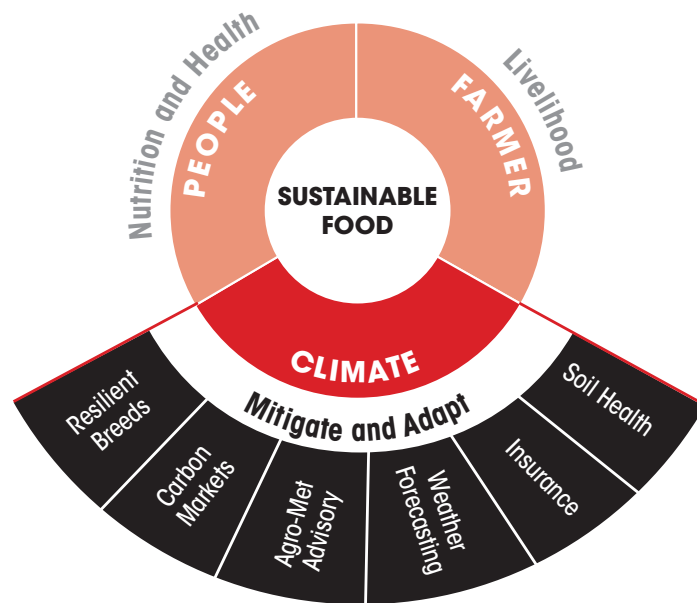
The agenda is to put more money in the hands of farmers. This requires building food systems that will ‘work’ on the best of nature; on the microbes in soils to enhance productivity; on sustainability. We need agro-ecological systems that will build on the strengths of local nature. We need agro-biodiverse systems that will mitigate risks. The goal is production at less cost. The goal is more money in the hands of producers.

Today farmers discount nature; destroy fertility; deplete groundwater; then add costs for chemicals and inputs; this makes them even more vulnerable when the next storm comes. It adds to risks. This is not smart agriculture.

We need systems that invest in nature; are low cost but high value.

This is why we need local, national and global and trade systems that will put more money through value addition in the hands of the producer. If they do not have money, they will not invest in nature for sustainability.

Market access will add to farmer resilience; the farmer producer organisations need to work to build farmer income security and connect to sustainable food.



The climate connect

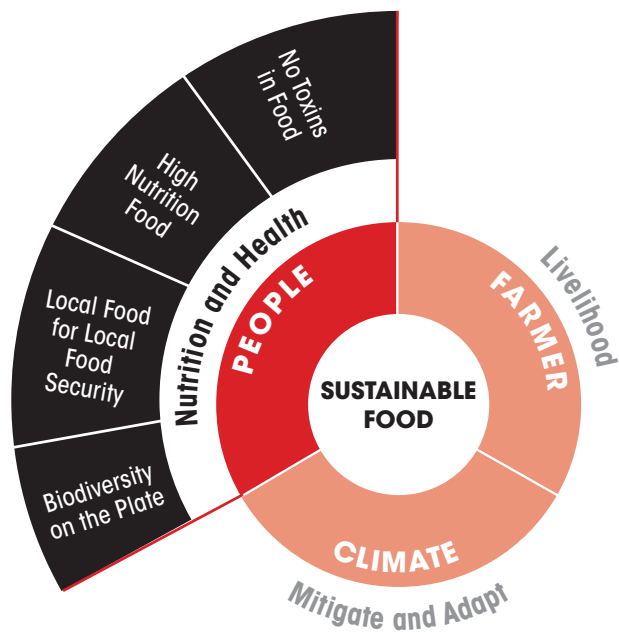
Agriculture is impacted because of climate change but this sector is also a major cause of climate change. We know biodiversity is about resilience – what we grow and what we eat will make nature lose or win and will also add to resilience against extreme heat and weather.

Farmers need safety nets designed for extreme weather and climate impacts. We need insurance systems that will be designed for uncertain times and high risk.

Adaptation will only work if farmers have timely and accurate information about weather anomalies. For this we need weather forecasting and agro-met advisories that are designed for production systems that will work in the ecosystems and at low cost.

Livestock and rice are the two major contributors to greenhouse gas emissions. But the world needs to recognise survival vs luxury emissions; need ways in which these “sources” can be mitigated and this can be paid for through carbon credits. We also know that the more farmers invest in resilient livelihood breeds (in most cases traditional breeds), it will mitigate their risks and help them adapt.

Agriculture is also the biggest opportunity to sequester carbon dioxide and this means investment in soils; we need carbon markets to work for producers and not auditors.

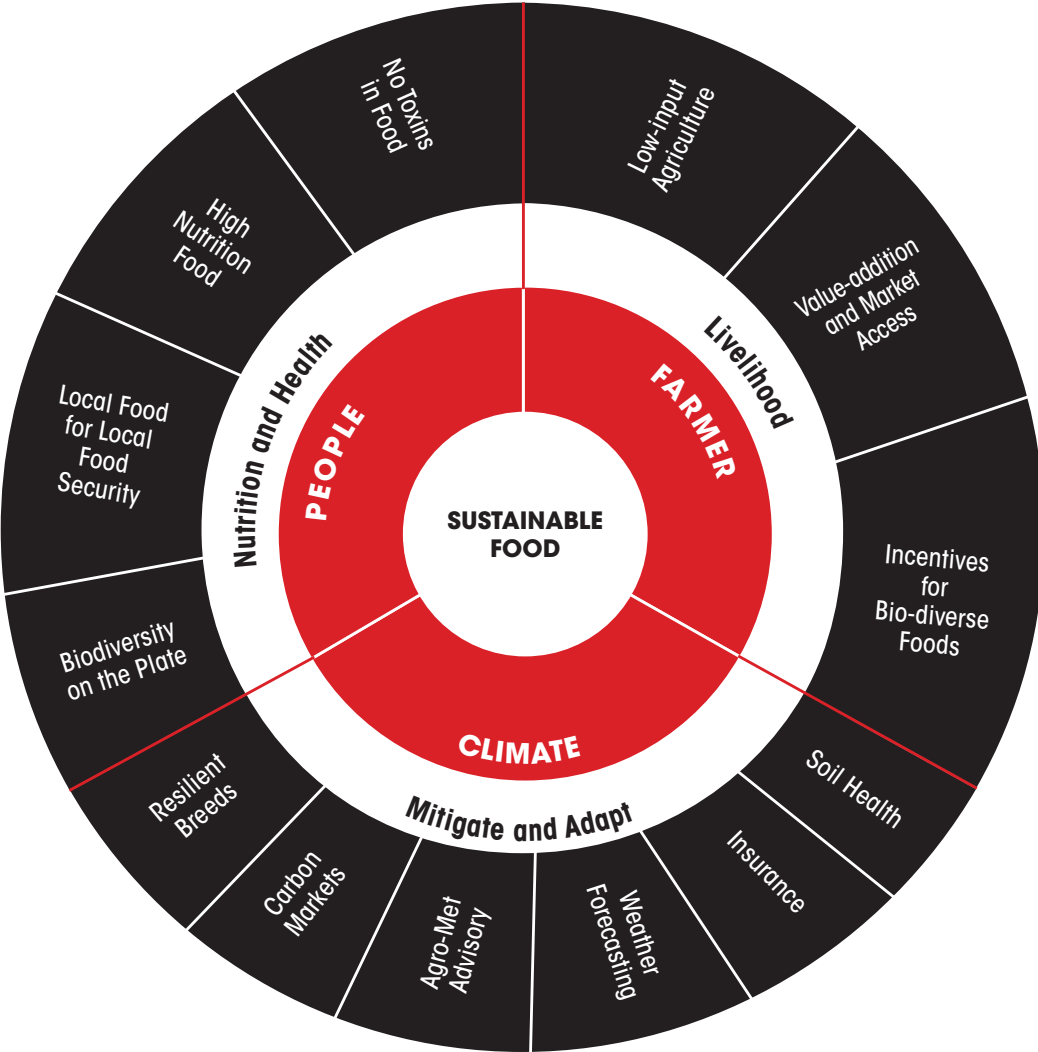


The people connect

What we eat determines our health; food is about nutrition; food is about medicine.

Toxins used for producing food add to our health burden – from pesticides to antibiotics. It is in our health; our bodies interest that the systems of agriculture are redesigned so that there is more money in the hands of producers so that they do not discount our health and nature.

We need not just food; but nutritive food that reaches everyone for food security. Intensive food farming systems may produce cheap food but at what cost? We need the design of local food systems that are nutritive for food security.



AGENDA: SOIL HEALTH AND CARBON CREDIT: IMPROVING PRODUCTIVITY AND FARMERS' INCOMES

SOIL HEALTH

THE STATE OF INDIAN SOILS AND WAYS TO MEASURE AND IMPROVE THEM



IN BRIEF

Soil health is defined as the capacity of soil to maintain the productivity, diversity and environmental services of terrestrial ecosystems. A critical function of healthy soil is its capacity to store carbon, which makes it essential for climate change mitigation; estimates suggest that Indian agricultural soils can sequester up to 6-7 teragram of carbon annually.

CRITICAL DEFICIENCIES AND ASSESSMENT GAPS

The primary mechanism for monitoring soil health in India, the **Soil Health Card (SHC) scheme**, currently assesses only 12 chemical parameters. This approach is criticized by experts because it does not include testing of physical or biological parameters, which are crucial components of overall soil health. International bodies like the FAO's GLOSOLAN and the USDA's NRCS recommend integrating biological indicators (such as microbial biomass, soil respiration and earthworm populations) and physical indicators (like aggregate stability and water holding capacity) for a comprehensive assessment.

Key findings from the SHC scheme of 2023-2025 reveal widespread nutrient depletion:

- **Nitrogen (N) deficiency:** A majority of Indian soils are severely nitrogen-deficient, with 64 per cent of samples testing 'low'. In 18 agriculturally-relevant states, over 50 per cent of the samples had 'low' available nitrogen, with Rajasthan, Tamil Nadu, Kerala, Uttar Pradesh and Uttarakhand showing 'low' levels in almost all samples.
- **Organic carbon (SOC) crisis:** 48.5 per cent of samples tested 'low' for organic carbon. SOC is a crucial yardstick for soil

health, improving structure and microbial abundance. Nine agriculturally-relevant states (including Tamil Nadu, Uttar Pradesh and Rajasthan) had more than 50 per cent samples with 'low' organic carbon.

- **Micronutrient shortages:** Over half of the samples (55.4 per cent) tested 'low' for boron, and 35 per cent tested low for zinc.
- **Climate risk linkages:** Over 43 per cent of the districts identified as being at 'very high' climate risk, had more than 50 per cent of samples with 'low' levels of organic carbon.

LINKAGES WITH CHEMICAL FERTILIZER USAGE

The relationship between increased chemical fertilizer use and soil health status is tenuous, as highlighted by consumption and correlation data:

- **Escalating consumption and subsidy:** Over the last decade (2013-14 to 2023-24), total fertilizer consumption increased by 19.5 per cent. Government expenditure on fertilizer subsidy surged even more dramatically, increasing by 180.5 per cent.
- **Nitrogen imbalance:** Fertilizer consumption is heavily skewed towards urea, which contains about 46 per cent nitrogen by weight and accounted for about 68 per cent of total fertilizer consumption in 2023-24. The high subsidy on urea contributes to imbalanced fertilizer application and overuse of nitrogen.
- **Lack of improvement in soil nutrient levels (key finding):** Statistical correlation between high fertilizer consumption and improved soil status is weak or non-existent:
 - **Nitrogen (N):** There is a moderately positive correlation ($R=0.36$) between average nitrogen fertilizer consumption and samples with 'low' soil nitrogen. This suggests that nitrogen fertilizer consumption does not seem to result in a corresponding improvement in soil nitrogen levels.



Total NPK and SOC: There is also a moderately positive correlation ($R=0.47$) between total (NPK) fertilizer consumption and samples with 'low' soil organic carbon, suggesting that NPK fertilizer consumption does not seem to improve soil organic carbon levels.

Phosphorus (P): There is virtually no correlation ($R=-0.09$) between P consumption and low soil P levels.

IMPROVING SOIL QUALITY: NATURAL INPUTS AND EXPERIMENTAL SUCCESS

Improving soil quality requires shifting away from intensive chemical inputs, which are identified as a key threat to soil health. Several policies and experimental findings support the use of natural and organic amendments:

- **Policy frameworks and non-chemical inputs:** Government schemes promote non-chemical farming methods to enhance soil fertility. These include:
 - ◆ **Paramparagat Krishi Vikas Yojana (PKVY)**, which supports cluster-based organic farming;
 - ◆ **National Mission on Natural Farming (NMNF)**, which promotes natural farming inputs and facilitates the creation of Bio-Input Resource Centres (BRCs) for low-cost, locally produced organic inputs;
 - ◆ **PM-PRANAM scheme**, which provides financial incentives to states that reduce their chemical fertilizer consumption.

Diverse organic and natural amendments such as farmyard manure, compost, vermicompost, green manures, biofertilizers and microbial inoculants are being used to support soil health improvement. Multiple field experiments demonstrate that treatments incorporating organic/natural amendments significantly outperform treatments relying solely on chemical fertilizers in increasing SOC (see *Table 1: Experiments on natural inputs and organic farming*).

Table 1: Experiments on natural inputs and organic farming

Experimental finding	Location/context	Impacts on Soil Organic Carbon (SOC)
Organic vs inorganic	Dehradun Doon University, ICAR-Indian Institute of Soil and Water Conservation and Bhomya Foundation	SOC much higher in organic farm than inorganic farm at two depths tested in Dehradun.
Integrated amendments	Haryana Agricultural University	Treatments combining chemical fertilizers with organic amendments (biogas slurry and vermicompost) resulted in higher SOC, compared to treatments using only chemical fertilizers
Long-term organic farming	ICAR-IARI, New Delhi (since 2009)	All treatments involving organic amendments increased SOC compared to control. Farmyard manure + crop residue treatment resulted in the highest SOC (up to 2.17%)
Natural farming systems	University of Horticultural Sciences, Karnataka	SOC across five crops consistently higher under natural and organic farming practices compared to the package of practice and farmers' practice (which used chemical fertilizers)
Natural farming inputs	Himachal Pradesh Krishi Vishwavidyalaya	Treatments combining natural farming inputs like ghanjeevamrit, jeevamrit and mulching led to higher SOC compared to the control treatment

THE POTENTIAL OF BIOCHAR

Biochar is an emerging soil amendment that is valued for its ability to enhance fertility, retain moisture and serve as a long-term carbon sink by increasing soil organic matter. It is produced through the pyrolysis of biomass.

- **Experimental success:** A pilot project implemented by the India Biochar and Bioresources Network (IBBN) in Karnataka found that the application of biochar increased Soil Organic Carbon (SOC) to 1.05 per cent, compared to 0.72 per cent without biochar application.
- **Addressing challenges:** A major hurdle is ensuring the accessibility and affordability of quality biochar for small and marginal farmers. Pilot attempts are underway using local innovations such as the 'heaping and charring' method and portable biochar kilns (like the 'Holy Mother Biochar Kiln') to



bridge the gap between accurate scientific production and on-farm utility. The National Bamboo Mission has also compiled best practice guidelines for producing biochar from bamboo residues.

POLICY GAPS

Gaps in soil health assessment policy

- **Limited indicator parameters:** The SHC scheme focuses exclusively on testing 12 chemical parameters (macronutrients, micronutrients, pH and electrical conductivity), but does not include any physical or biological soil parameters.
 - ◆ This is considered a gap because internationally recognized bodies like FAO's GLOSOLAN and USDA's NRCS recommend including physical and biological indicators for a holistic assessment of soil health.
 - ◆ A 2017 study by MANAGE also suggested that focusing only on chemical properties did not reflect the overall soil nutrient status and recommended developing a 'soil health index', incorporating physical and micro-biological indicators.
- **Lack of facilities for testing:** The implementation of the SHC scheme faces operational challenges in some states, with reports citing the unavailability of facilities for nitrogen testing.
- **Minimal data update in SHC portal:** Although the SHC portal has begun capturing data for schemes like the National Mission on Natural Farming (NMNF) and PKVY, the updation of testing results is currently minimal, suggesting a gap in comprehensive data integration and monitoring across different soil health initiatives.

Gaps in fertilizer subsidy and application policy

- **Skewed fertilizer consumption:** Government policy, particularly on subsidies, remains heavily skewed towards urea, which contains about 46 per cent nitrogen.

- ◆ The heavy subsidy on urea encourages its overuse and contributes to the imbalance in fertilizer application.
- ◆ Data shows that nitrogen consumption does not result in a corresponding improvement in soil nitrogen levels, indicating that current application practices are inefficient and need corrective policy measures.
- ◆ Similarly, total (NPK) fertilizer consumption is also found to have a moderate, but positive, correlation with low soil organic carbon levels, suggesting that current fertilizer use does not improve soil organic carbon.

Gaps in standards, programme implementation and outreach

- **Non-standardized biochar production:** Although biochar is an emerging soil amendment that can significantly increase soil organic carbon, India has yet to standardize production protocols. This lack of standardization is a policy gap that hinders the widespread adoption of quality biochar by small and marginal farmers, despite pilot projects showing its positive impact.
- **Limited scale of organic farming schemes:** While policies like the Paramparagat Krishi Vikas Yojana (PKVY) and the Mission Organic Value Chain Development for North Eastern Region (MOVCDNER) promote organic farming, the total area under these schemes remains limited (59.75 lakh hectare as of December 2024), indicating a gap in scaling up sustainable practices.

INTRODUCTION

'Soil' is defined as "the natural body consisting of layers (horizons) that are composed of weathered mineral materials, organic material air and water".¹ **Soil health** can be understood as "the ability of the soil to sustain the productivity, diversity, and environmental services of terrestrial ecosystems".²

Functions of a healthy soil include serving as a medium for plant growth, regulating hydrological and nutrient cycles such as those of carbon and nitrogen, and maintaining biological activities.³ Soil health is related to 'soil fertility' which impacts crop productivity. Key threats to soil health include intensive agricultural practices, changes in land use patterns, deforestation and soil erosion.⁴

A healthy soil can reduce the need for external inputs, thereby reducing the cost of cultivation. Soil capacity to store carbon can offset greenhouse gas emissions which makes it critical to climate change mitigation. It is estimated that Indian agricultural soils could sequester up to 6-7 Tg (teragram) of carbon per year.⁵ The soil health status of India thus becomes an imperative discussion within the Indian agricultural sector.

SOIL HEALTH ASSESSMENT

INTEGRATING BIOLOGICAL PARAMETERS IN SOIL HEALTH ASSESSMENT

Soil health measurement can involve the assessment of its physical, chemical and biological parameters. The Soil Health Card (SHC) scheme of India involves testing for 12 chemical parameters: macronutrients – nitrogen, phosphorus, potassium and organic carbon; pH and electrical conductivity; and micronutrients – zinc, copper, iron, boron, sulphur and manganese. It does not include testing of any physical or biological soil parameters. Soil Organic Carbon (SOC), measured under the SHC scheme, is a yardstick for measuring soil health and is known to improve soil structure and microbial abundance.

The Global Soil Laboratory Network (GLOSOLAN) of the Food and Agriculture Organization of the United Nations (FAO) and the Natural Resource Conservation Service (NRCS) of the United States Department of Agriculture (USDA), recommend testing of physical and biological parameters in addition to chemical parameters. The GLOSOLAN recommends testing of chemical parameters over and above those tested in the SHC scheme. The NRCS recommends only a select set of chemical parameters (*see Table 2: Chemical, physical and biological indicators of soil health*).

In 2017, an impact study conducted by the Hyderabad-based National Institute of Agricultural Extension Management (MANAGE) highlighted that the focus of SHC scheme on chemical properties did not reflect the overall soil nutrient status. MANAGE recommended the development of a '**soil health index**' with soil physical properties (such as soil texture, colour and water holding capacity) and micro-biological indicators (such as microbial activity and bacterial content).⁶ Soil microbial community and other soil fauna play a critical role in soil systems through decomposition,

Table 2: Chemical, physical and biological indicators of soil health

Chemical parameters	Physical parameters	Biological parameters
SHC-India Macronutrients: Nitrogen, phosphorus, potassium, organic carbon. Micronutrients: Sulphur, iron, zinc, copper, manganese and boron Electrical conductivity and pH FAO's GLOSOLAN (in addition to SHC-India) Total soluble salt content Microelements: Chlorine molybdenum, nickel USDA's NRCS Reaction carbon, pH, phosphorus, soil nitrate, electrical conductivity	FAO's GLOSOLAN Aggregate stability, coarse fragments, particle-size distribution, water retention curve, porosity, hydraulic conductivity, soil moisture content, soil crusts USDA's NRCS Aggregate stability, slaking, bulk density, soil structures and macropores, available water capacity, infiltration	FAO's GLOSOLAN Soil microbial biomass, soil respiration, enzyme activity, soil mesofauna, earthworm populations USDA's NRCS Particulate organic matter, soil respiration, soil enzymes, potentially mineralizable nitrogen, earthworms

Sources: FAO-GLOSOLAN, 'Standard Operating Procedures'⁷; USDA-NRSC, 'Cropland in Field Soil Health Assessment Guide'⁸; Soil Health Card Scheme Dashboard, Ministry of Agriculture and Farmers Welfare⁹

nutrient cycling, soil mixing and aggregate formation. These include soil microbes such as bacteria, fungi, protozoans, mites, ticks, earthworms, snails, ants, termites, beetles, moles and rodents.

Similarly, a 2019 study by soil scientists from the Y S Parmar University of Horticulture and Forestry in Himachal Pradesh proposed testing of physical indicators such as aggregate stability, bulk density and pore size distribution; and biological indicators such as soil respiration, enzyme activity, nematode and earthworm communities.¹⁰

SOIL HEALTH STATUS AS PER THE SOIL HEALTH CARD SCHEME

Samples tested

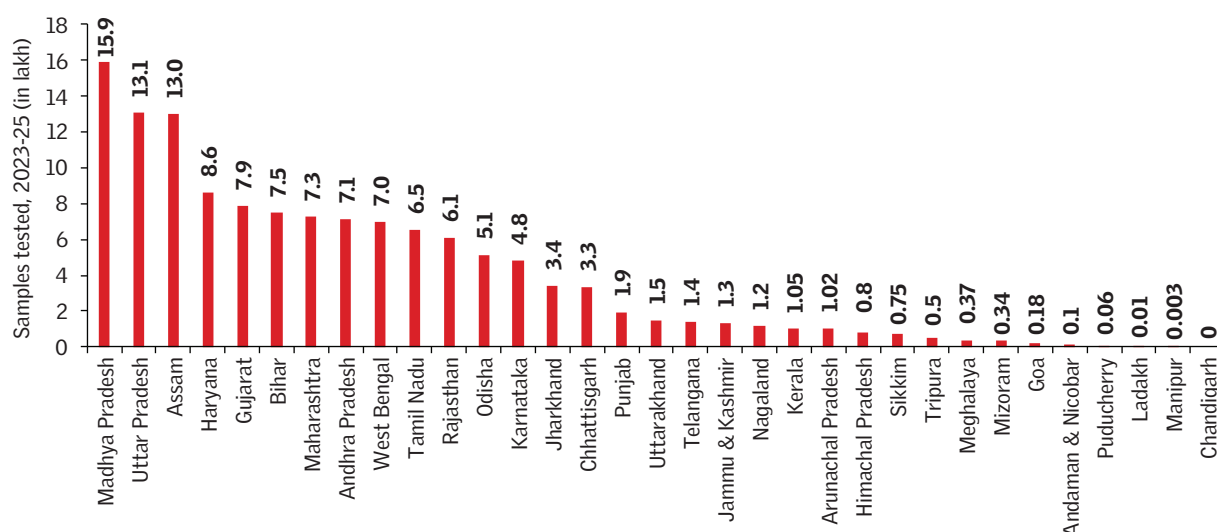
The Soil Health Card (SHC) scheme, launched in January 2015 under the National Mission for Sustainable Agriculture, aims to provide farmers with the soil nutrient status of their agricultural land through soil health cards carrying recommendations on

fertiliser use and amendments required to ensure long-term soil fertility and crop productivity. Until March 2025, about 7.3 crore (73 million) soil samples were tested under the soil health component of the Rashtriya Krishi Vikas Yojana. In 2025 (till October 7), an additional 40.5 lakh (over four million) tests were completed and soil health cards were generated.

As per the Soil Health Card scheme dashboard, during the last two financial years (2023-25), about 1.3 crore (13 million) soil samples were tested for different parameters; for nitrogen, the samples numbered 1.1 crore (11 million), while 1.14 crore (11.4 million) were tested for boron. In a few states, as per the SHC dashboard, facilities for nitrogen testing were not available.

From 2023-25, the highest number of samples tested came from Madhya Pradesh, followed by Uttar Pradesh, Assam, Haryana and Gujarat. Some agriculturally-relevant states with relatively lesser number of samples tested were Chhattisgarh, Punjab, Uttarakhand, Telangana and Himachal Pradesh¹¹ (see *Graph 1: Samples tested across states under the SHC scheme, 2023-25*).

Graph 1: Samples tested across states under the SHC scheme, 2023-25



Source: Soil Health Card Dashboard, Ministry of Agriculture and Farmers Welfare



In a recent development, the Soil Health Card portal has begun capturing soil health testing data segregated according to schemes, such as the National Mission on Natural Farming (NMNF), the Paramparagat Krishi Vikas Yojana (PKVY), and the Mission Organic Value Chain Development for North Eastern Region (MOVCDNER). However, updates on testing results are minimal as of now.

Nutrient status

The results of the Soil Health Card scheme (2023-25) reflect that most Indian soils are deficient in nitrogen and organic carbon. Sixty-four per cent samples tested 'low' for nitrogen and 48.5 per cent tested 'low' for organic carbon (see *Graph 2: Soil Health Status as per the SHC scheme, 2023-25*).

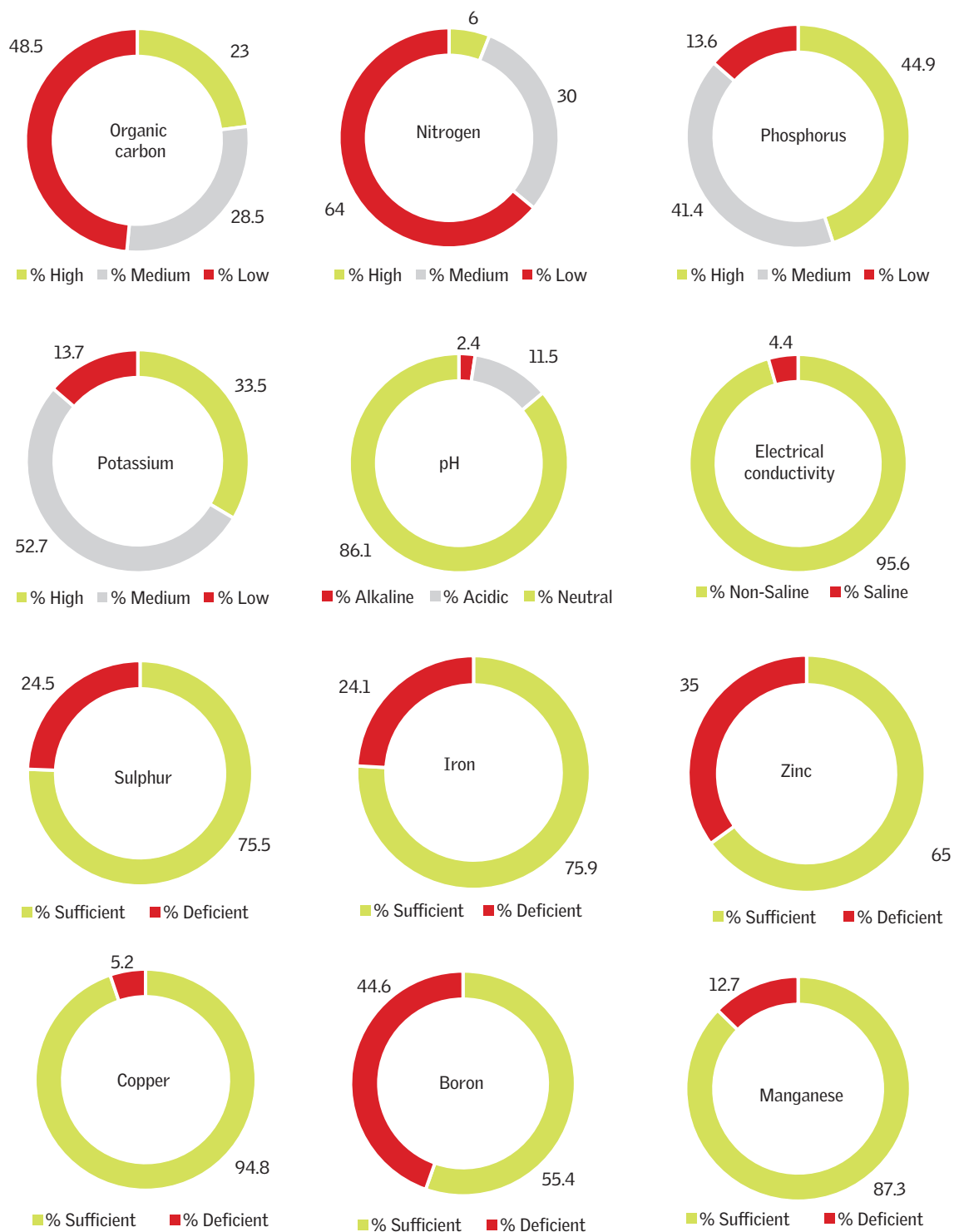
Levels of phosphorus and potassium are relatively better: 13.6 per cent samples tested 'low' for phosphorus and 13.7 per cent were 'low' for potassium. With reference to electrical conductivity, Indian soils are largely 'non-saline': only 4.4 per cent samples were saline. In terms of pH, 86.1 per cent soil samples tested 'neutral', 11.5 per cent were 'acidic' and 2.4 per cent were 'alkaline'. Micronutrients except boron and zinc were found sufficient – 55.4 per cent samples tested 'low' for boron and 35 per cent tested 'low' for zinc.

SOIL NUTRIENT STANDARDS AS PER THE SHC SCHEME

- pH - Acidic: < 6.5; Normal: 6.5-8.2; Alkaline: > 8.2
- EC (dSm/m) - Normal: < 1; Medium: 1-3; Harmful: > 3
- Organic Carbon (per cent) - Low: < 0.5; Medium: 0.5-0.75; High: > 0.75
- Available Nitrogen (kg/ha) - Low: < 240; Medium: 240-480; High: > 480
- Available Phosphorus (kg/ha) - Low: < 28; Medium: 28-56; High: > 56
- Available Potassium (kg/ha) - Low: < 140; Medium: 140-280; High: > 280
- Sulphur (ppm) - Low: < 10; Medium: 10-20; High: > 20
- Magnesium (ppm) - Low: < 1; Medium: 1-2; High: > 2
- Calcium (ppm) - Low: < 1.5; Medium: 1.5-3.0; High: > 3.0
- Zinc (ppm) - Low: < 0.5; Medium: 0.5-1.0; High: > 1.0
- Ferrous (ppm) - Low: < 5; Medium: 5-10; High: > 10
- Manganese (ppm) - Low: < 5; Medium: 5-10; High: > 10
- Copper (ppm) - Low: < 0.2; Medium: 0.2-0.4; High: > 0.4

Source: Soil Health Card (SHC) Scheme: Manual for District-Level Functionaries, (2017).

Graph 2: Soil Health Status as per the SHC scheme, 2023-25



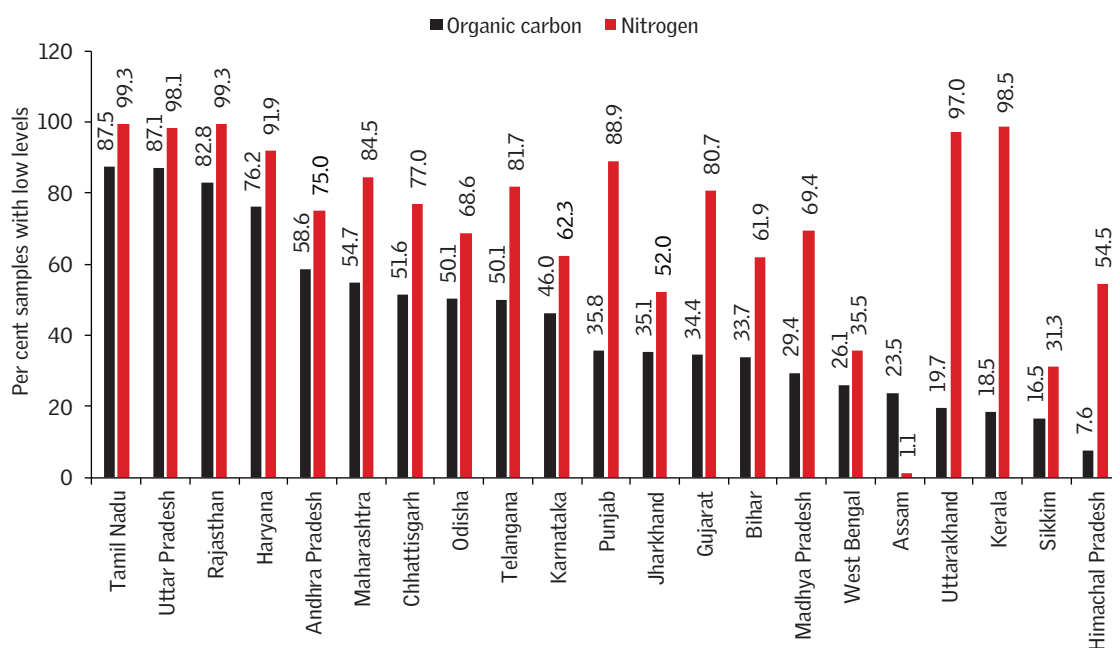
Source: Soil Health Card Nutrient Dashboard, Ministry of Agriculture and Farmers Welfare

ORGANIC CARBON AND NITROGEN STATUS AT THE SUB-NATIONAL LEVEL

SOIL ORGANIC CARBON AND NITROGEN IN AGRICULTURALLY-RELEVANT STATES

Out of the 21 agriculturally-relevant states, nine had more than 50 per cent samples with 'low' organic carbon. These include Tamil Nadu, Uttar Pradesh, Rajasthan, Haryana, Andhra Pradesh, Maharashtra, Chhattisgarh, Odisha and Telangana (see Graph 3: Soil organic carbon and nitrogen in agriculturally-relevant states, 2023-25).

Graph 3: Soil organic carbon and nitrogen in agriculturally-relevant states, 2023-25



Source: Soil Health Card Nutrient Dashboard, Ministry of Agriculture and Farmers Welfare

Soils in some agriculture-intensive states have less organic carbon levels (for instance, Tamil Nadu, Uttar Pradesh, Rajasthan, Haryana etc) than soils in hilly states. There are some agriculture-intensive states which have relatively better levels of soil organic carbon (such as Punjab, Bihar, Gujarat, Madhya Pradesh and West Bengal).

In the case of nitrogen, 18 out of the 21 states had more than 50 per cent samples with 'low' available nitrogen. Almost all samples in Rajasthan, Tamil Nadu, Kerala, Uttar Pradesh and Uttarakhand were found with 'low' nitrogen levels.

SOIL ORGANIC CARBON IN THE DISTRICTS OF DIFFERENT AGRO-ECOLOGICAL ZONES (AEZS)

The Indian Council of Agricultural Research (ICAR) has classified 20 agro-ecological zones (AEZs) based on local topographical conditions.¹² In five of these 20 – covering parts of the states of Punjab, Haryana, Rajasthan, Bihar, Uttar Pradesh, Gujarat, Karnataka and Tamil Nadu – more than 75 per cent samples have tested 'low' in organic carbon in over 50 per cent of their districts.

- AEZ 8 (Eastern Ghats and Tamil Nadu uplands, hot semi-arid) – 68 per cent (32/47 districts)
- AEZ 4 (northern plains and central highlands, hot semi-arid) – 60.9 per cent (67/110 districts)
- AEZ 2 (western plains, Kachchh and Kathiawar peninsula, hot arid) – 55.2 per cent (21/38 districts)
- AEZ 9 (northern plains, hot sub-humid dry) – 50 per cent (32/64 districts)

On the contrary, zones within the Himalayan ecosystem (covering Himachal Pradesh, Uttarakhand, Arunachal Pradesh, Sikkim, Meghalaya, Mizoram, Nagaland and Tripura) and the Western Ghats (Kerala, Goa, coastal Karnataka and Maharashtra) have over 50 per cent districts with more than 75 per cent samples testing 'high' in organic carbon.



- AEZ 14 (western Himalayas, warm sub-humid) – 60 per cent (15/25 districts)
- AEZ 17 (northeastern hills – Purvanchal) – 46 per cent (23/50 districts)
- AEZ 16 (eastern Himalayas, warm per humid) – 33.3 per cent (7/21 districts)
- AEZ 19 (Western Ghats and coastal plains, hot humid) – 32.3 per cent (11/34 districts)

SOIL ORGANIC CARBON AND NITROGEN IN DISTRICTS AT 'VERY-HIGH' CLIMATE RISK

A 2020 risk and vulnerability assessment report by the National Innovations in Climate Resilient Agriculture (NICRA) had identified that out of 573 agriculturally relevant rural districts, 109 districts (19 per cent) are at 'very high' risk.¹³

Over 43 per cent districts (47/109) had more than 50 per cent samples with 'low' levels of organic carbon; Over 83 per cent (85/102) had more than 50 per cent samples with 'low' nitrogen levels.

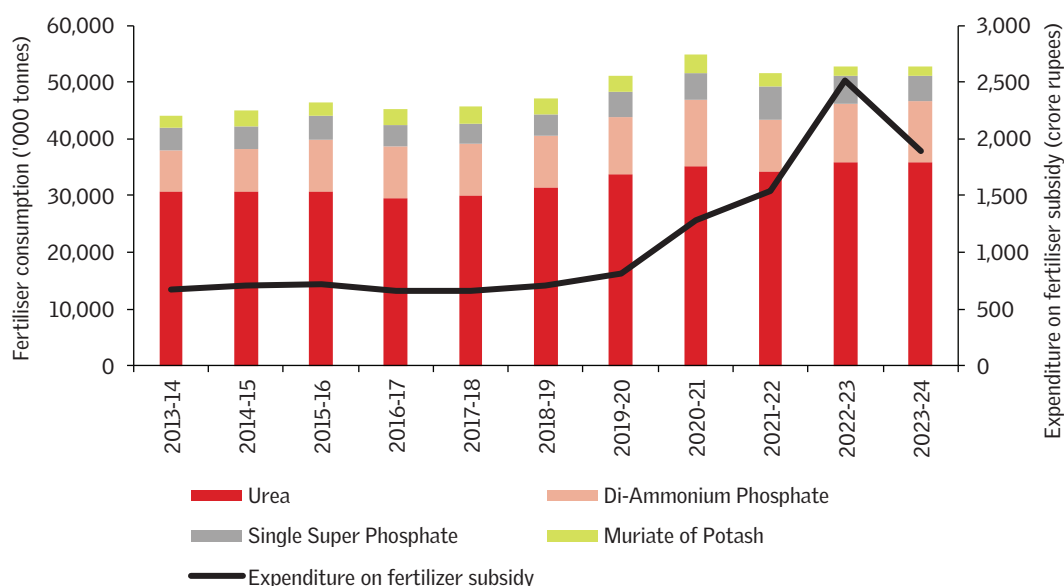
FERTILIZER CONSUMPTION AND SOIL NUTRIENT STATUS

FERTILIZER CONSUMPTION AND SUBSIDY

Over the past decade, fertilizer consumption has increased by 19.5 per cent from 44,135 thousand tonne in 2013-14 to 52,781 thousand tonne in 2023-24. During the same time, government expenditure on this subsidy has increased by 180.5 per cent from about Rs 673 crore to Rs 1,889 crore (about 18.9 lakh crore) (see Graph 4: Average NPK fertilizer consumption and fertilizer subsidy).

Fertilizer consumption in India is heavily skewed towards urea, which contains about 46 per cent nitrogen by weight. In 2023-24,

Graph 4: Average NPK fertilizer consumption and fertilizer subsidy



Source: Fertilizer Statistics, The Fertilizer Association of India (yearly reports 2020-24)



about 68 per cent of the total consumption was of urea. The sale of urea gets the heaviest subsidy, which adds to the imbalance in fertilizer application and the overuse of nitrogen.

To check the growing subsidy on fertilizers and promote sustainable agricultural practices, the Cabinet Committee on Economic Affairs in 2023 approved the PM-PRANAM scheme (PM Programme for Restoration, Awareness Generation, Nourishment, and Amelioration of Mother Earth). The scheme pushes for balanced fertilizer use by providing incentives to states/UTs which will receive a grant equivalent to 50 per cent of their saved fertilizer subsidy, calculated in comparison to previous three years' average fertilizer consumption.

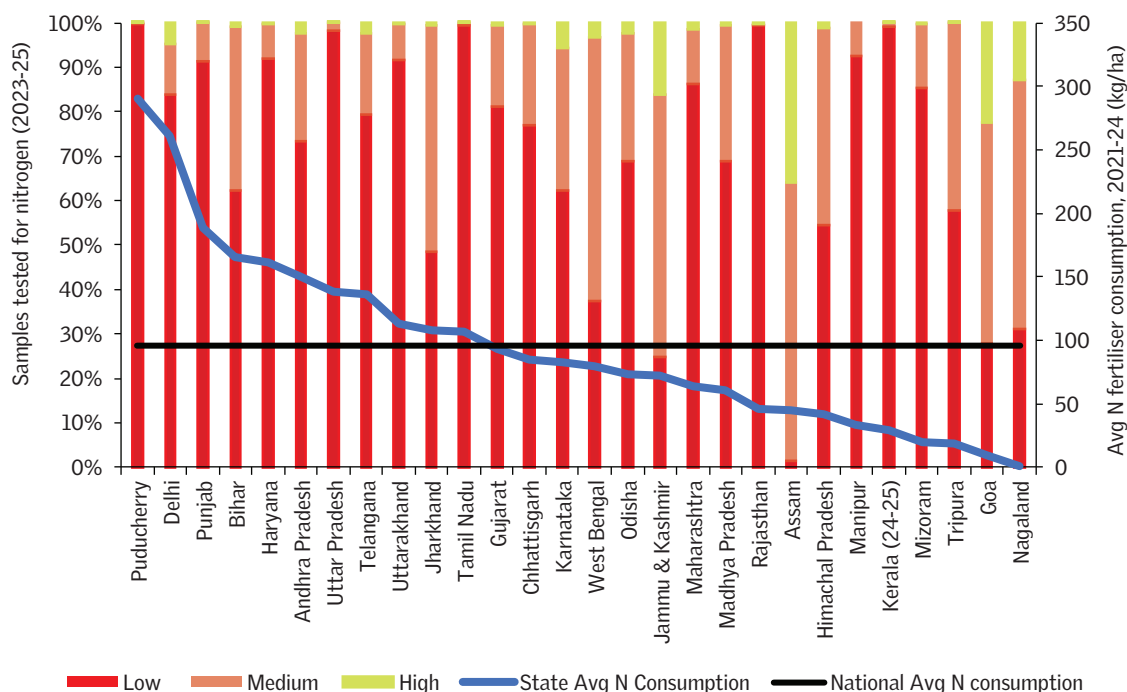
As per a Parliament statement in August 2025, under PM-PRANAM, 14 Indian states collectively reduced their chemical fertilizer consumption by 1.51 million tonne (MT) across urea, DAP, NPK and MOP in 2023-24, relative to their three-year average. Of these, Karnataka contributed about 30 per cent of the total reduction in fertilizer use. Maharashtra, West Bengal and Andhra Pradesh added about 58 per cent out of the remaining reductions.¹⁴

NITROGEN FERTILIZER CONSUMPTION AND SOIL NITROGEN LEVELS

Out of the 12 states/UTs with nitrogen fertilizer consumption which is above the national average – 95.5 kg/ha for 2021-24 – 11 have more than 50 per cent soil samples (tested in 2023-25) with 'low' nitrogen levels. These are agriculturally relevant states like Punjab, Haryana, Uttar Pradesh, Bihar, Andhra Pradesh, Gujarat, Tamil Nadu, Uttarakhand and Jharkhand (*see Graph 5: Nitrogen fertilizer consumption and soil nitrogen levels*).

Out of the 16 states/UTs with below national average nitrogen fertilizer consumption, 11 have more than 50 per cent soil samples with 'low' nitrogen levels.

Graph 5: Nitrogen (N) fertilizer consumption and soil nitrogen levels



Source: Soil Health Card Nutrient Dashboard, Ministry of Agriculture and Farmers Welfare; Fertilizer Statistics, The Fertilizer Association of India (yearly reports 2020-24)

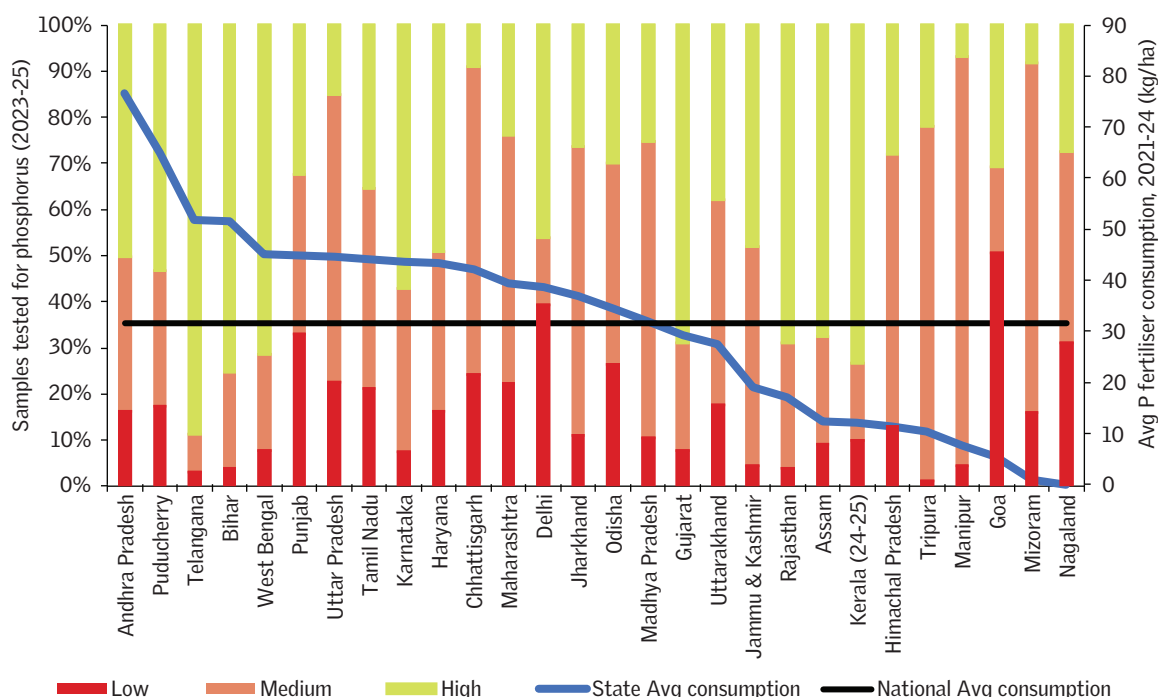
The R value (Pearson's coefficient of correlation) between a state's average nitrogen fertilizer consumption and samples with 'low' soil nitrogen is 0.36, which indicates a moderately positive correlation. **This suggests that nitrogen fertilizer consumption does not seem to result in a corresponding improvement in soil nitrogen levels.**

PHOSPHORUS FERTILIZER CONSUMPTION AND SOIL PHOSPHORUS LEVELS

Out of the 16 states/UTs with above national average phosphorus fertilizer consumption (31.7 kg/ha for 2021-24), none have more than 50 per cent samples with 'low' phosphorus levels.

Out of the 12 states/UTs with below national average phosphorus fertilizer consumption, only Goa has more than 50 per cent samples with 'low' phosphorus levels (see Graph 6: Phosphorus (P) fertilizer consumption and soil phosphorus levels).

Graph 6: Phosphorus (P) fertilizer consumption and soil phosphorus levels



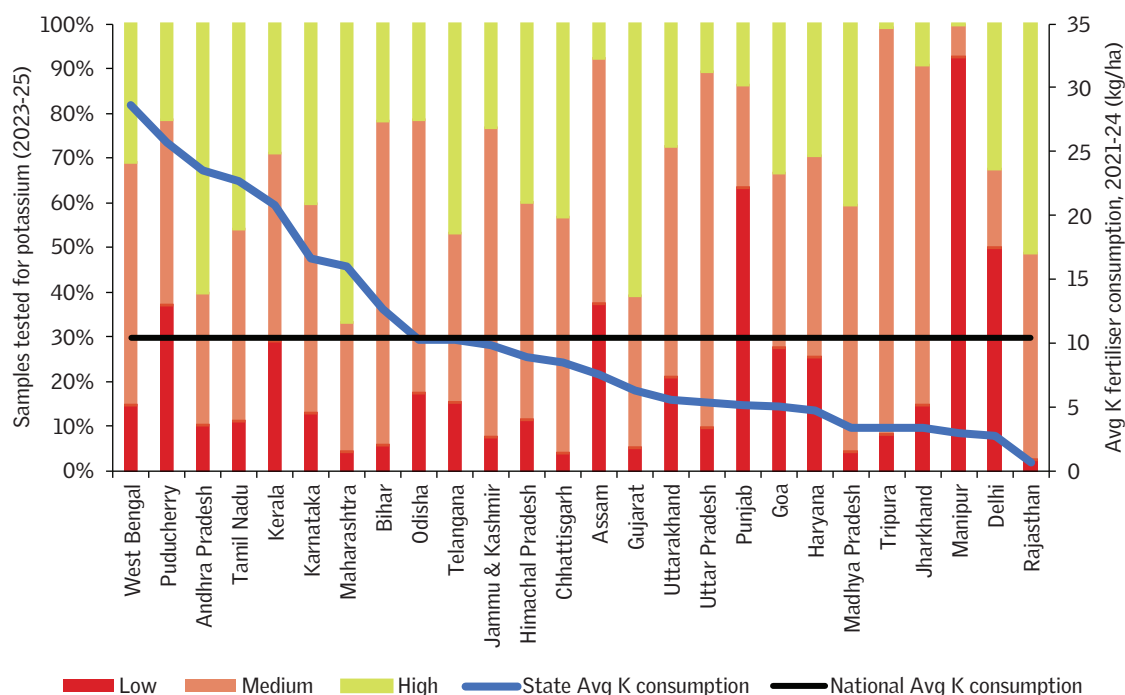
Source: Soil Health Card Nutrient Dashboard, Ministry of Agriculture and Farmers Welfare; Fertilizer Statistics, The Fertilizer Association of India (yearly reports 2020-24)

The R value (Pearson's coefficient of correlation) between a state's average phosphorus fertilizer consumption and samples with 'low' soil phosphorus is (-) 0.09, which indicates no correlation between the two. **This suggests that phosphorus fertilizer consumption does not seem to influence soil phosphorus levels.**

POTASSIUM FERTILIZER CONSUMPTION AND SOIL POTASSIUM LEVELS

Out of the 10 states/UTs with above national average potassium fertilizer consumption (10.4 kg/ha for 2021-24), none have more than 50 per cent samples with 'low' soil potassium levels. Out of the 16 states/UTs with below national average K fertilizer consumption, three (Punjab, Manipur and Delhi) have more than 50 per cent samples with 'low' potassium levels (see *Graph 7: Potassium (K) fertilizer consumption and soil potassium levels*).

Graph 7: Potassium (K) fertilizer consumption and soil potassium levels



Source: Soil Health Card Nutrient Dashboard, Ministry of Agriculture and Farmers Welfare; Fertilizer Statistics, The Fertilizer Association of India (yearly reports 2020-24)

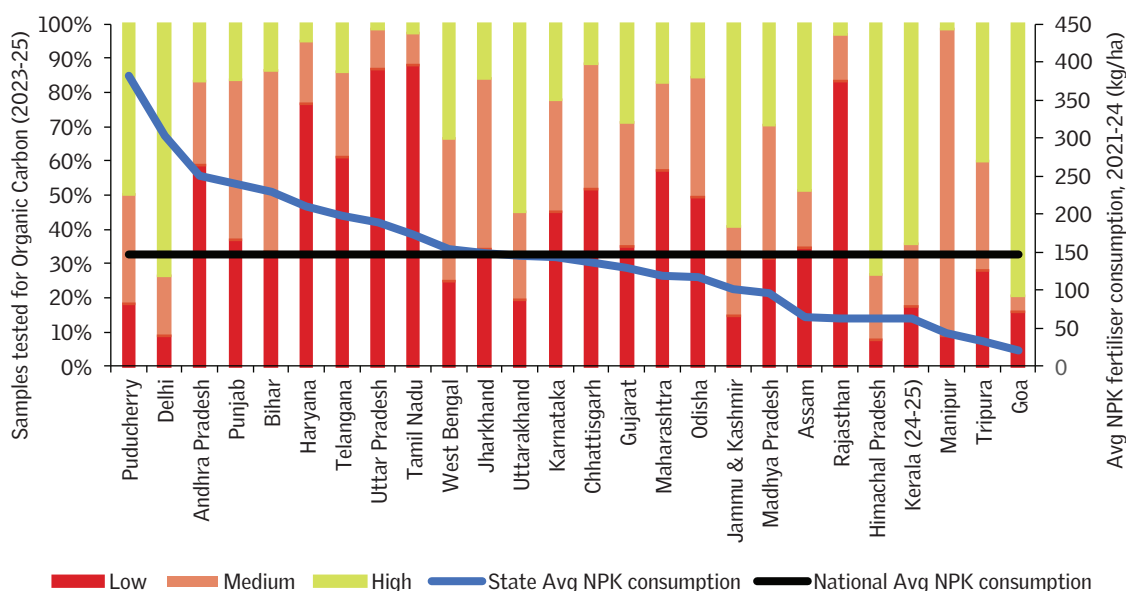
The R value (Pearson's coefficient of correlation) between a state's average potassium fertilizer consumption and samples with 'low' soil potassium is (-) 0.21, which indicates a weak negative correlation. **This suggests that increased potassium fertilizer consumption seems to favorably influence soil potassium levels.**

TOTAL (NPK) FERTILIZER CONSUMPTION AND SOIL ORGANIC CARBON LEVELS

Out of the 12 states/UTs with above national average total (NPK) fertilizer consumption (146.6 kg/ha for 2021-24), five have more than 50 per cent samples with 'low' soil organic carbon. These include agriculturally intensive states like Punjab, Haryana, Bihar, Uttar Pradesh and West Bengal. Two of these 12 states have more than 50 per cent samples with 'high' soil organic carbon (see Graph 8: Total fertilizer (NPK) consumption and soil organic carbon levels).



Graph 8: Total fertilizer (NPK) consumption and soil organic carbon levels



Source: Soil Health Card Nutrient Dashboard, Ministry of Agriculture and Farmers Welfare; Fertilizer Statistics, The Fertilizer Association of India (yearly reports 2020-24)

Out of the 15 states/UTs with below national average total (NPK) consumption, only five have more than 50 per cent samples with 'low' soil organic carbon; four states have more than 50 per cent samples with 'high' soil organic carbon.

The R value (Pearson's coefficient of correlation) between a state's average total (NPK) fertilizer consumption and samples with 'low' soil organic carbon is 0.47, which indicates a moderately positive correlation. **This suggests that total (NPK) fertilizer consumption does not seem to improve soil organic carbon levels.**

IMPROVING SOIL HEALTH: POLICIES AND INPUTS

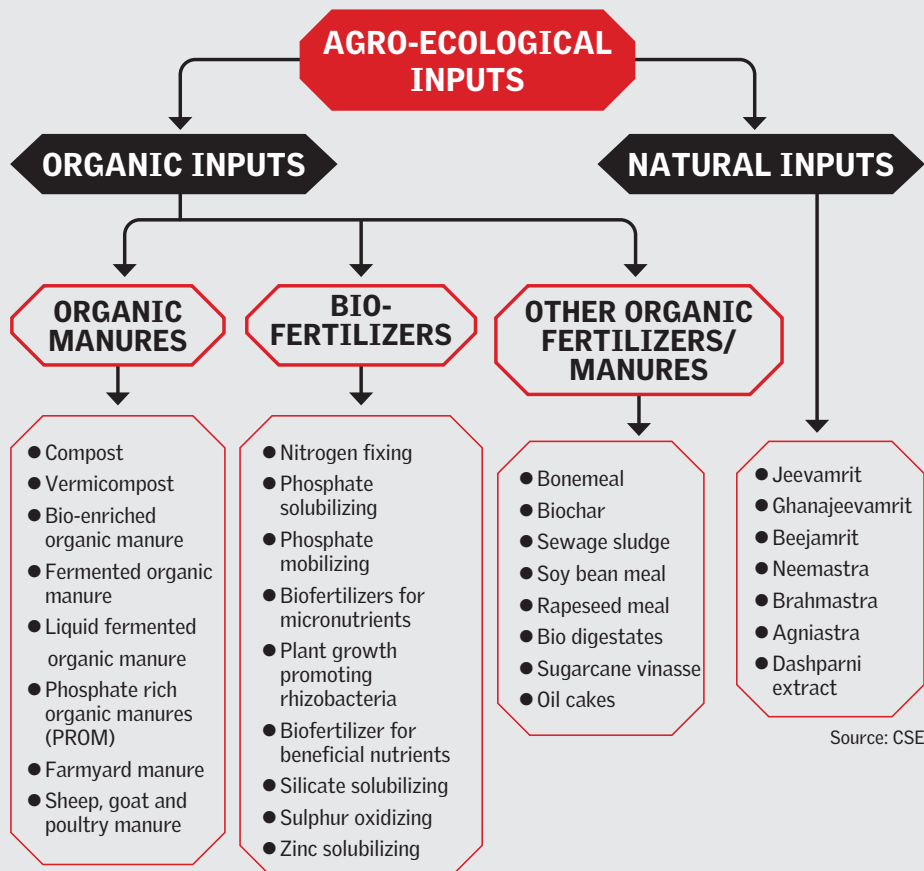
The Soil Health Card scheme under the National Mission on Sustainable Agriculture (NMSA) is the key towards improving soil health. The Paramparagat Krishi Vikas Yojana (PKVY) promotes cluster-based organic farming by supporting states and Union territories financially, while in the northeast, the Mission Organic Value Chain Development for North Eastern Region (MOVCDNER) strengthens soil health management under organic value chains.^{15,16} However, under both these schemes, the total area remains limited – 59.75 lakh hectare (ha) as in December 2024.¹⁷

The National Mission on Natural Farming (NMNF) builds on the earlier Bharatiya Prakritik Krishi Paddhati (BPKP) and promotes natural farming inputs and on-farm preparations that enhance soil fertility.¹⁸ The scheme also facilitates the creation of Bio-Input Resource Centres (BRCs) to ensure farmers' access to low-cost, locally produced organic inputs. As on October 2025, 6.5 lakh ha of land is under natural farming in the country.¹⁹

At the state level, non-chemical input use and region-specific agro-ecological practices are being promoted. For example, the state government of Andhra Pradesh and the not-for-profit Rythu Sadhikara Samstha (RySS) promote 'community-managed natural farming' and aim to bring the entire cropland of the state under natural farming by 2027.

Similarly, the Gujarat Atma Nirbhar package provides financial assistance for the promotion of natural farming, and Himachal Pradesh's Prakritik Kheti Khushhal Kissan (PK3) Yojana focuses on reducing the use of chemical fertilizers.

Figure 1: Agro-ecological inputs for soil health



Soil health improvement is supported by diverse organic and natural amendments. These include farmyard manure, compost, vermicompost, green manures, biofertilizers and microbial inoculants. The standards for production of organic inputs have been revised under the Fertiliser (Inorganic, Organic or Mixed) (Control) Order, 1985^{20,21} (see Figure 1: Agro-ecological inputs for soil health).

BIOCHAR: EMERGING SOIL HEALTH AMENDMENT

Biochar is an emerging soil amendment that increases organic matter in the soil, enhancing its carbon sequestration potential. Produced through the pyrolysis of biomass, biochar is valued for its ability to enhance fertility, retain moisture, and act as a

long-term carbon sink. Although India has yet to standardize production protocols, the National Bamboo Mission has compiled best practice guidelines for biochar production from bamboo residues, highlighting both technical parameters and field-level applications.²²

A major challenge in quality biochar production is its accessibility and affordability for small and marginal farmers. The ICAR-Central Institute of Agricultural Engineering in Bhopal (Madhya Pradesh) experiments with portable biochar kilns (which allow farmers to produce biochar in their fields). Local innovations like the 'heaping and charring' method where agricultural residues are covered with soil and burnt, and the 'Holy Mother Biochar Kiln' are promising pilot attempts to bridge the gap between scientific production accuracy and on-farm challenges.²³

There are examples on impact of biochar use. The India Biochar and Bioresources Network (IBBN) has implemented a pilot project to integrate biochar with sustainable agriculture practices in Kolar, Tumkur and Uttara Kannada in Karnataka and found that soil organic carbon increases with the application of biochar (SOC: 1.05 per cent) compared to without biochar (SOC: 0.72 per cent).

CASE STUDIES

Improvements in soil organic carbon (SOC) through agro-ecological inputs and practices

INFLUENCE OF ORGANIC AND INORGANIC NUTRIENT INPUTS ON SOC AND MICROBIAL ENZYMES

Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana²⁴

The University conducted an experiment under direct seeded rice in a randomized block design with 10 treatments replicated thrice. This was done at the Kaul Farm in the University's College of Agriculture during the 2019 kharif season, and incorporated fertiliser amendments and integrated amendments to vermicompost and biogas slurry.

The results indicate that compared to treatments using chemical fertilizers, soil organic carbon was higher in treatments which had one or the other organic amendments (see Table 3: Results of the study conducted by Haryana Agricultural University). The highest SOC was under integrated treatment, which combined biogas slurry

Table 3: Results of the study conducted by Haryana Agricultural University

Soil treatment	Results: SOC (per cent)
Control (no amendment)	0.55
NPK fertilizer (N75P30K30)	0.57
NPK fertilizer (N37.5P15K15)	0.56
Biogas slurry (4 tonne/ha)	0.61
NPK fertilizer (N37.5P15K15) + biogas slurry (2 tonne/ha)	0.60
NPK fertilizer (N37.5P15K15) + biogas slurry (4 tonne/ha)	0.63
Vermicompost (4 tonne/ha)	0.62
NPK fertilizer (N37.5P15K15) + vermicompost (2 tonne/ha)	0.59
NPK fertiliser (N37.5P15K15) + vermicompost (4 tonne/ha)	0.63
Vermicompost (2 tonne/ha) + biogas slurry (2 tonne/ha)	0.61

and vermicompost with chemical fertilizers. The least increase was under treatment which applied chemical fertilizers only.

ASSESSMENT OF NATURAL INPUTS ON SOC AND NITROGEN UPTAKE IN THE SOILS OF THE TRANS-GANGETIC PLAINS

Indian Council of Agricultural Research-Krishi Vigyan Kendra (ICAR-KVK), Gautam Buddha Nagar, Uttar Pradesh²⁵

This was a three-year (2021-2023) study in a farm in Uttar Pradesh, with a randomized block design and eight treatments on a rice-wheat cropping system ranging from no fertilizers and a recommended dose of fertilizers, to different natural farming and integrated treatments.

The results indicate that over three years, the highest increase in SOC was in natural farming treatments (increased from 0.43 to 0.5 per cent), as compared to fertilizer-based treatment (from 0.4 to 0.46 per cent) and integrated treatment (from 0.43 to 0.49 per cent).

ASSESSMENT OF LONG-TERM ORGANIC FARMING ON SOIL AGGREGATION AND TOTAL ORGANIC CARBON

Indian Council of Agricultural Research-Indian Agricultural Research Institute (ICAR-IARI), New Delhi²⁶

Since 2009, this experiment being conducted in the IARI farm has been set in a strip-plot design with three replications (plot size 7.6 X 7.0 m²). Two cropping systems (rice-wheat and rice-wheat-mung bean) are being used under seven types of nutrient management treatments.

The results indicate that at the two different depths of soil (see *Table 4: Results of study conducted by ICAR-IARI*), all treatments which involved organic amendments had increased the SOC, as compared to the control treatment. SOC was highest under the farmyard manure + crop residue treatment system.

Table 4: Results of the study conducted by ICAR-IARI

Soil treatment	Results: SOC at 0-0.75 cm depth (per cent)	Results: SOC at 7.5-15 cm depth (per cent)
Control (no amendments)	0.4	0.51
Farmyard manure	1.49	1.55
Vermicompost	1.33	1.52
Farmyard manure + crop residue	1.8	2.17
Vermicompost + crop residue	1.56	1.66
Farmyard manure + crop residue + biofertilizer	1.71	2
Vermicompost + crop residue + biofertilizer	1.55	1.69

ASSESSMENT OF IMPACT OF ZERO-BUDGET NATURAL FARMING ON SOC, INFILTRATION RATE AND MICROBIAL ACTIVITY UNDER DIFFERENT CROPPING SYSTEMS

University of Horticultural Sciences, Bagalkot, Karnataka²⁷

Validation trials from 2018 to 2022 at four research stations of the University of Horticultural Sciences in Karnataka compared four treatments: package of practice, farmers' practice, natural farming, and organic farming.

The results indicate that SOC across five crops (guava, sapota, custard apple, mango and cashew) was higher under natural and organic farming practices as compared to the package of practice or the farmers' practice, both of which involved the use of chemical fertilizers (see Table 5: Results of the study conducted by the University of Horticultural Sciences).

Table 5: Results of the study conducted by the University of Horticultural Sciences

Practice	Results: SOC in 2018 (per cent)	Results: SOC in 2022 (per cent)
Package of practice (integrated)	0.48	0.6
Farmers' practice (integrated)	0.47	0.54
Natural farming	0.48	0.65
Organic farming	0.47	0.69

EFFECTS OF NATURAL FARMING ON SOC, NUTRIENT UPTAKE AND MICROBIAL ABUNDANCE

CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur,
Himachal Pradesh²⁸

A field experiment was conducted at Holta, Department of Organic Agriculture and Natural Farming in the CSK Himachal Pradesh Krishi Vishwavidyalaya. This was done during the rabi season in 2019-20 and 2020-21. Wheat was intercropped with chick pea using the HPW 368 and Him Channa 2 varieties, respectively. The experiment was laid out in randomized block design comprising of eight treatments.

The results indicate that all combinations of natural farming led to higher SOC, as compared to the control treatment (*see Table 6: Results of study conducted by HP Krishi Vishwavidyalaya*). The treatment combining ghanjeevamrit, jeevamrit and mulching recorded the highest SOC levels.

Table 6: Results of the study conducted by the HP Krishi Vishwavidyalaya

Treatment and application	Results: SOC in 2019-20 (per cent)	Results: SOC in 2020-21 (per cent)
Ghanjeevamrit before sowing	0.83	0.88
Jeevamrit, foliar application at 21-day interval	0.81	0.85
Mulching	0.85	0.94
Ghanjeevamrit + Jeevamrit	0.87	0.90
Ghanjeevamrit + mulching	0.91	1.03
Jeevamrit + mulching	0.89	1.02
Ghanjeevamrit + Jeevamrit + mulching	0.94	1.08
Control	0.79	0.81

ASSESSMENT OF THE IMPACT OF ORGANIC INPUTS ON SOIL CARBON, MICROBIAL PROPERTIES AND PLANT NUTRIENT STATUS

ICAR-Central Institute for Subtropical Horticulture, Rehmanikhera, Lucknow, Uttar Pradesh²⁹

The experiment in this case consisted of seven treatments laid out in a randomized block design with three replications, conducted on mango trees which are 35 years old.

The study concluded that all combinations of organic treatments led to higher soil organic carbon than treatment with solely chemical fertilizer application (see *Table 7: Results of the study conducted by ICAR-Central Institute for Subtropical Horticulture*). The maximum increase in SOC took place under the application of biodynamic compost + organic fertilizers.

Table 7: Results of the study conducted by ICAR-Central Institute for Subtropical Horticulture

Treatment	Results: SOC (per cent)
Farmyard manure + organic fertilizers	1.02
Biodynamic compost + organic fertilizers	1.2
Neem cake + farmyard manure + organic fertilizers	1.11
Vermicompost + organic fertilizers	1.02
Farmyard manure + amritpani soil application	1.09
Farmyard manure + green manuring + organic fertilizers	1.16
NPK fertilizer application	0.92

IMPACTS OF ORGANIC AND INORGANIC FARMING ON SOIL QUALITY AND CROP PRODUCTIVITY

Doon University, ICAR-Indian Institute of Soil and Water Conservation and Bhomya Foundation, Dehra Dun³⁰

This experiment was carried out in four fields in Dehradun and Jalandhar (one organic and one inorganic in each region). Soil samples were collected during March and April 2023 with a random sampling method at both 0-15 cm and 15-30 cm depths.

In Dehradun, soil organic carbon was higher in the organic farm than in the inorganic farm at both 0-15 cm and 15-30 cm depths, with values of 0.66 per cent and 0.38 per cent, respectively. Similarly, soil organic matter was higher in the organic farm compared to inorganic farm with 1.13 per cent at 0-15 cm depth and 0.66 per cent at 15-30 cm depth.

ALL INDIA NETWORK PROJECT ON ORGANIC FARMING²⁹

ICAR-Indian Institute of Farming Systems Research, Modipuram, Uttar Pradesh³¹

A long-term study (2004 onwards) at multiple centres comparing organic, inorganic and integrated farming systems has found that SOC content steadily increased under organic treatments at six centers:

- **Bajaura:** From 1.3 per cent (2016-17) to 1.49 per cent (2021-22)
- **Bhopal:** From 0.94 per cent (2016-17) to 1.02 per cent (2020-21)
- **Calicut:** From 2.1 per cent (2016-17) to 3.19 per cent (2019-20)
- **Ludhiana:** From 0.59 per cent (2016-17) to 0.62 per cent (2021-22)
- **Ranchi:** From 0.74 per cent (2016-17) to 1.12 per cent (2020-21)
- **Sardar Krushinagar:** From 0.28 per cent (2016-17) to 0.38 per cent (2021-22)

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AGENDA: SOIL HEALTH AND CARBON CREDIT: IMPROVING PRODUCTIVITY AND FARMERS' INCOMES

VOLUNTARY CARBON MARKET FOR AGRICULTURE

SCALE, CONCERNS AND OPPORTUNITIES



IN BRIEF

The Voluntary Carbon Market (VCM) is a critical mechanism designed to monetize the mitigation of greenhouse gases (GHG), where one carbon credit represents one metric tonne of carbon dioxide equivalent (tCO₂e). While the agri-food sector contributes roughly one-third of total global emissions and holds the potential to sequester about 11.5 gigatonnes (Gt) of CO₂ by 2050 through changes in farming practices, agriculture globally accounts for a minimal share – only one per cent of issued VCM credits as of October 2023.

In India, the situation reflects this nascent stage. Out of 1,735 VCM projects listed in major registries (Verra and Gold Standard), only 95 are in the agriculture sector. Crucially, specific high-potential projects focused on sustainable agriculture have zero registered projects and zero credits issued as of August 2025.

THE NATURE OF AGRICULTURAL CARBON CREDITS IN INDIA

Agricultural carbon projects provide monetary incentives for farmers to transition toward practices that reduce emissions, such as methane reduction through Alternate Wetting and Drying (AWD) in rice cultivation, or enhance sequestration, like improving soil organic carbon or utilizing biochar.

- **Financial disparity:** Mainstream agricultural cropland management credits are modestly priced (US \$5–50 per tonne CO₂e), which can make long-duration nature-based projects financially unviable. In contrast, specialized projects like biochar are far more promising, commanding premium prices between US \$100–150 per tonne CO₂e and have already successfully issued credits.

- **The methane challenge:** Projects targeting methane reduction (e.g., wet-dry rice cultivation) rely on complex methodologies. While the closed chamber method for measuring methane is precise, it is described as tedious and expensive. Some project developers instead rely on formulas that calculate emission reduction based on adjusted daily emission factors.

CRITICAL PROBLEMS IN SCALING UP

Scaling Indian agricultural projects is heavily constrained by structural and financial complexities intrinsic to the country's farming demographic:

- **Fragmentation and low yield:** The sector is dominated by small and marginal landholders. A single acre of land typically sequesters enough carbon to generate only one to two credits over a period of time, making individual participation financially challenging.
- **Insufficient farmer incentives:** The initial costs of adoption – including project registration, soil sampling, practice transition, and potential initial drops in yield – often deter farmers. Even when incentives are provided (e.g., Rs 1,920 per hectare (ha) for AWD rice), farmers may find them insufficient because the transition to new methods increases operational costs (e.g., increased herbicide use for weed control in AWD).
- **The “additionality” hurdle:** Current registry standards for baseline activities are stringent and often disregard farmers already practicing sustainable or regenerative agriculture. This prevents them from receiving incentives for their existing management practices, reducing buy-in and perceived fairness.
- **Land rights and consent:** A large volume of farming occurs on leased land, creating persistent challenges in obtaining consent from the landowner and ensuring fair remuneration for the small landholders. Many projects must rely on informal rights recognized only by local authorities, complicating long-term contracts.



KEY OPPORTUNITIES AND POSSIBILITIES FOR FUTURE GROWTH

Despite the barriers, several opportunities exist to catalyze the scaling of agricultural carbon projects:

- **Policy adaptation and inclusion:** There is a critical need to include cropland soil organic carbon (SOC) increase within the government's Green Credit Programme (GCP), which currently focuses only on afforestation.
- **Contextualized MRV development:** To enhance credibility while reducing cost, there is a necessity to develop Measurement, Reporting and Verification (MRV) methods tailored to local Indian climatic and regional contexts, accommodating on-ground sustainable farming practices.
- **Generating robust data:** Policy shifts must be backed by data, requiring efforts to estimate the total SOC stock in different agro-ecological regions of India and calculate the carbon sequestration potential across these zones.
- **Structural aggregation:** Scaling requires creating economies of scale by mobilizing cooperatives and networks of farmers to ensure fairer remuneration and shared operational resources.
- **Focus on proven segments:** The existing success of biochar projects (which have issued credits and command high prices) suggests that focusing on niche, high-value mitigation strategies may offer a faster path to viability than struggling with low-margin cropland management projects.

CARBON CREDITS AND MARKETS

A carbon credit is a representation of a greenhouse gas (GHG) mitigation equaling to one metric tonne of CO₂. The price of one carbon credit can vary based on factors such as the type of market, type of project and the quality of removal.

The history of carbon credits trading goes back to the Kyoto Protocol (1997), which established the Clean Development Mechanism (CDM) for developed countries to fulfil their emission reduction targets by earning Certified Emission Reductions (CERs) from developing countries. This evolved into the carbon markets of today, with Emissions Trading Systems (ETS), certification bodies and various registries. In 2015, the Paris Agreement recognized carbon markets as facilitators of global efforts to reduce GHG emissions.¹

STEPS FOR ISSUANCE AND RETIREMENT OF CARBON CREDITS:

- A project is registered with a certifying platform (a carbon registry)
- The project is developed with a project developer to prepare a Project Design Document (PDD)
- A third party validates and verifies the project
- If successfully validated as per standards, the project becomes eligible for carbon credits issuance
- It is then registered with the standards programme of the registry
- The carbon sequestered/emissions reduced by the project are monitored and reported and verified by an independent third party
- Carbon credits are issued, which can be sold in the carbon market
- Once these credits are purchased by a buyer/company, the credits are retired

Source: The Voluntary Carbon Market in India: Do people and climate benefit?, Centre for Science and Environment (2023)



There are two types of carbon markets, the compliance market – which involves EMS that conduct legally mandated emissions trading, and the Voluntary Carbon Market (VCM) – where companies can voluntarily trade emissions to reduce their carbon impact.²

While the agri-food sector contributes to one-third of total global emissions, agricultural practices can sequester about 11.5 Gt CO₂ by 2050, particularly within soil. The monetary benefits associated with the addition of low emission and carbon sequestering farming practices can offer critical incentives for farmers to transition towards sustainable food systems.³

However, globally, as of October 2023, the agri-food sector comprises a mere one per cent of the credits issued in the VCM.⁴

THE INDIAN CARBON MARKET

The Indian industrial sector has witnessed carbon offsetting efforts through both compliance and voluntary offset projects under the CDM of the Kyoto Protocol. Between 2010 and 2022, India issued 278 million carbon credits in the VCM, accounting for a 17 per cent share in the global supply.⁵ At the same time, regulations for carbon trading in India remain at a nascent stage.

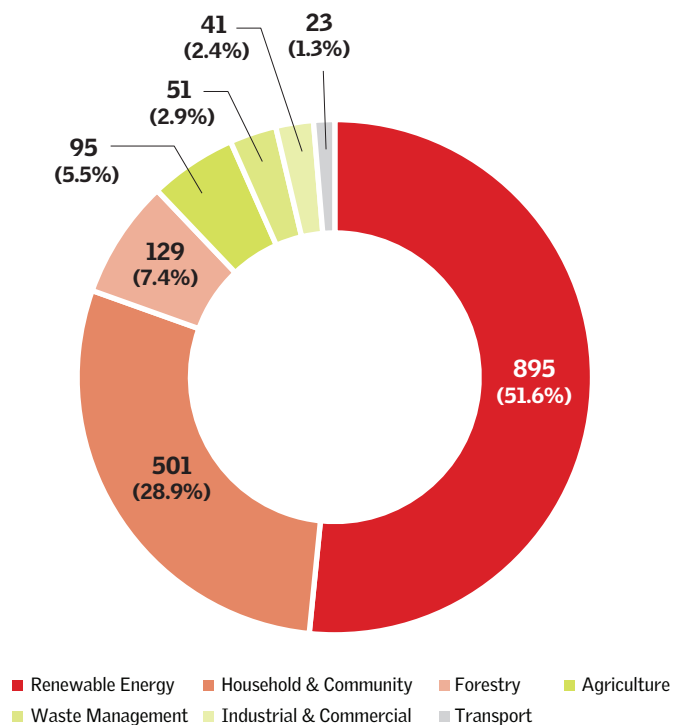
The Central government notified the Carbon Credit Trading Scheme (CCTS) in June 2023 regarding carbon trading activities under the Bureau for Energy Efficiency (BEE) for both compliance and voluntary offset projects. Under the CCTS, the Compliance Mechanism of 2024 details the MRV framework to set standards and requirements for all stakeholders involved in carbon credit trading. Additionally, a National Framework for Indian Carbon Market (ICM) is being developed to create a carbon credit electronic platform at a national scale for both compliance and voluntary markets.⁶

Under the Compliance Mechanism, the agriculture sector is not among the nine sectors identified for transition towards cleaner energy consumption. However, it has been included under Phase I of the voluntary offset mechanism in the CCTS.⁷

In the Indian VCM, there are 1,735 projects listed across different sectors in two major carbon registries – Verra and Gold Standard – as of August 2025 (see *Graph 1: Carbon projects in VCM in India across sectors*).



Graph 1: Carbon projects in VCM in India across sectors



Note: The figures in the graph reflect the absolute number and per cent of carbon projects in respective sectors out of the total VCM projects in India

Source: The Voluntary Carbon Market in India Dashboard, Centre for Science and Environment⁸

AGRICULTURE PROJECTS IN THE INDIAN VCM

Out of 1,735 projects, 95 are in the agriculture sector and five biochar-related projects are also relevant to this sector.⁹

As part of the agriculture sector, sustainable agriculture projects include those related to agricultural land management and regenerative agriculture. Projects on crop emissions involve those related to methane reduction through AWD and low-carbon rice farming. Irrigation-related projects include low-cost irrigation devices and micro-irrigation systems. Manure management projects comprise biogas, vermicompost and organic decomposition-related projects. Biochar projects involve the production of biochar and its usage as a soil amendment (see *Table 1: Status of carbon projects related to agriculture in India*).

Table 1: Status of carbon projects related to agriculture in India

Project type (number)	Under development	Listed (Gold Standard)	Under validation	Registration requested	Registered/ Certified	Late to verify/ Rejected/ Registration request denied/Withdrawn/ Inactive	Credits issued
Sustainable agriculture (51)	24	1	6	13	0	7	0
Crop emissions (22)	0	6	1	0	3	12	0
Irrigation (15)	0	1	5	1	7	1	3,96,504
Manure management (7)	1	0	1	1	2	2	2
Biochar (5)	1	0	1	0	3	0	8,510 (for 2 projects)
Total (100)	26	8	14	15	15	22	4,05,014

Source: The Voluntary Carbon Market in India Dashboard, Centre for Science and Environment¹⁰



VOLUNTARY CARBON MARKET FOR AGRICULTURE

Overall, out of the 100 projects:

- 26 are under development
- Eight are listed under Gold Standard and 14 are under validation (Verra)
- 15 have requested for registration
- 15 are registered
- 22 are either late to verify, rejected, withdrawn or inactive

About four lakh credits have been issued so far for seven irrigation and two biochar projects.

METHODOLOGIES FOR SOIL CARBON SEQUESTRATION

The key methodologies adopted by Verra and Gold Standard registries have standards for baseline, additionality and leakage assessments. *Baseline* indicates the emissions or GHG removals prior to the project. *Additionality* is the GHG emission reduction that occurs after the project is implemented, and the new mitigation practices are carried out. *Leakage* measures the emissions occurring because of the project activities¹¹ (see *Table 2: Key methodologies for soil carbon sequestration*).

Table 2: Key methodologies for soil carbon sequestration

Standard	Methodology/ Framework	Purpose	Eligible activities/Scope	Key features/ Requirements
Verra (Verified Carbon Standard)	VM0017	Original methodology for quantifying SOC sequestration	Sustainable agricultural land management	Status: Inactive; superseded by VM0042
	VM0042 (Improved agricultural land management)	Quantifies comprehensive GHG emission reduction and SOC removals	Reduced tillage, improved fertilizer/water/residue management, changes in cropping and grazing management	Provides a broad framework for multiple practices
	VM0044 (Biochar utilization)	Quantifies CO ₂ removals by converting waste biomass into biochar for stable storage	Production of biochar from waste; application in soils, concrete, and building materials	Mandates investment analysis to prove additionality
Gold Standard	Soil organic carbon framework	Acts as an overarching parent document setting core rules for quantifying SOC and GHG changes	A wide range of agricultural activities	Flexible, modular framework that supports specific activity modules
	SOC activity module for zero tillage	Quantifies SOC benefits, specifically from adopting zero-till or no-till farming practices	Accounts for carbon sequestered in the SOC pool. Excludes other GHG benefits (e.g., from reduced fuel use)	Requires a shift from conservation tillage to no-till practice
	SOC activity module – Biostimulants	Quantifies SOC changes resulting from the application of approved biostimulants	Application of biostimulants to enhance soil microbial activity	Biostimulants must be approved and efficacy is supported by peer-reviewed literature

Source: VM0017 Adoption of Sustainable Agricultural Land Management, v1.0, Verra. (2024); VM0042 Improved Agricultural Land Management, v2.1, Verra. Soil Organic Carbon Framework Methodology, Gold Standard (2020)¹²



AGRICULTURAL CARBON CREDIT PRICES

Accurate information related to prices of carbon credits is not easily available, often indicative, and based on market exchange observations. Prices are influenced by credit demand and shaped by several other factors like risk of failure, robustness of MRV, type of mitigation and SDG benefits (see *Table 3: Carbon credit prices for agriculture projects*).

Mainstream cropland management projects (including nature-based carbon removals) are more modestly priced than projects related to biochar and Enhanced Rock Weathering (ERW). For nature-based carbon removals, the long duration of projects makes the low prices of credits financially unviable despite the ecosystem services they provide.

Low-quality credits are cheap but may have lower environmental credibility, whereas high-quality or specialized projects, such as heritage cacao or biochar, command premium prices due to higher co-benefits and proper MRVs.

Table 3: Carbon credit prices for agriculture projects

Project type	Credit price (per tonne of CO ₂ e)
Agricultural cropland management	US \$5–50
Low-quality agri-food credits	US \$1.80
High-quality agri-food credits (often from smaller projects)	US \$30–80
Nature-based carbon removals	US \$15 onwards
Sustainable agriculture	US \$8–35
Heritage cacao production (Peru)	Up to US \$80
Agriculture (crops and livestock)	US \$6.51
Afforestation/Reforestation (A/R)	US \$15.74
Biochar/ERW projects	US \$100–150

Source: Agrifood systems in the voluntary carbon market: status and prospects. Directions in Investment, No. 14 Rome, FAO, 26-27;¹³ CSE primary research; Note: These prices may not reflect local variations and current prices

PROJECTS IN THE INDIAN AGRICULTURAL VCM

SUSTAINABLE AGRICULTURE PROJECTS¹⁴

Of the 51 projects under sustainable agriculture projects, 24 are under development, one is listed (under Gold Standard), six are under validation, 13 have been requested for registration, and seven are either late to verify, rejected, denied registration, withdrawn or inactive. There are no projects registered, and therefore no credits have been issued as of August 2025 (see *Annexure: Table 1: Sustainable agriculture projects in the Indian VCM*).

The total estimated reduction of these 51 projects was planned to be about 428.24 lakh tCO₂. While the average estimated reduction turns out to be 8.3 lakh tCO₂ per project, the range varies from 100 tCO₂ (a NABARD project) to 53.2 lakh tCO₂ (a project by Grow Indigo).

About 90 per cent of these projects (46 out of 51) are by 25 private sector companies or their CSR initiatives. NABARD is the proponent of the remaining five. Core CarbonX Solutions has six projects, followed by Grow Indigo, NABARD and Value Network Venture Advisory Services, with five projects each. Godrej Group has four projects, whereas Varaha Climate Ag and EKI Energy Services have three projects each. Boomitra and Fair Climate have two projects each, while the rest have one each. Except for one project by Grow Indigo (PRAN), which is listed under Gold Standard, all others are operating under Verra's Verified Carbon Standard.

About 99.9 per cent (428.21 lakh tCO₂) of the total estimated emission reduction is aimed by projects from the private sector or their CSR initiatives. NABARD's five projects aim to reduce only 2,545 tCO₂.

WET AND DRY RICE CULTIVATION

In 2023, the Centre for Science and Environment (CSE) and Down To Earth (DTE) reported on how the voluntary carbon market was functioning in the country. They examined carbon credit projects in wet-dry rice cultivation and found the following — Venkat Reddy, a farmer in Telangana's Nalgonda district, is expecting to receive Rs 6,400 annually for changing the way he cultivates rice. A Hyderabad-based company, Core CarbonX Solutions Pvt. Ltd, a carbon trading, environmental consulting and sustainability advisory firm, had approached him a year and a half ago, introducing him to a new management technique called Alternate Wetting and Drying (AWD). Sometime next year, he and several other farmers in Telangana are expected to be rewarded for collaborating with the company, which has applied for registration with Verra and is hoping to enter the voluntary carbon market in 2024. The project is listed under Verra (VCS 3238).

The conventional method of paddy cultivation accounts for roughly two per cent of the global greenhouse emissions from anthropogenic sources. Typically, paddy is continuously flooded during cultivation to check weed growth. This practice, however, generates methane-emitting bacteria. According to a review paper by International Rice Research Institute¹⁵, fields are alternately flooded and dried under the AWD technique, which experiments in South Asia have shown to reduce methane emissions by an average of 43 per cent and water use by 30 per cent.

The idea is to allow the soil to dry out until fissures appear before re-flooding it. This creates alternating wet and dry cycles for the rice plants. "We keep the fields fully flooded seven days before and after flowering, which happens between 110–120 days," says Niruj Mohanty, Managing Director and CEO of Core Carbon X, who accompanied DTE to meet the farmers.

Core Carbon X has partnered with Swamy Vivekananda Rural Development Society (SVNRDS), a local NGO that provides educational, social development and humanitarian services to the rural population, to recruit farmers in the

district. They also provide training and supply field water tubes to farmers. Measuring 30 centimeters (cm) in length and 15 cm in diameter, the tube is a plastic pipe with drilled holes, sunk into the rice field so that 10 cm of it protrudes above soil surface. When the water level has dropped to about 15 cm below the soil surface, farmers can re-flood the field to a depth of about 5 cm. As of August 11, 2023, when DTE visited Nalgonda, the company claims that 1,50,000 hectare in Telangana had been converted to AWD. This new method of cultivation is being practiced in 17 districts in Telangana, where double cropping occurs, meaning rice is grown both in rabi and kharif seasons. Each village has been allotted a supervisor who monitors progress and conducts surveys.

A similar project is also being prepared for launch in Madhya Pradesh, listed under Verra (VCS3156: Sustainable Rice Cultivation for Marginal Farmers in Madhya Pradesh) and is expected to be registered soon. The project proponent is Value Network Ventures Advisory Services (VNV) based out of Bengaluru, and Shriram Education and Welfare Society (SEWS) based in Seoni, Madhya Pradesh is the project developer. Rameshwar Pardhi, who runs SEWS, explains that under this project, they will form groups of farmers who would collectively own between 60–70 hectare of land. These groups are supervised by appointed individuals responsible for overseeing operations. The groups are trained to conduct the practices, monitor water levels, record observations in monitoring diaries and ensure adherence to the overall practice.

AWD is relatively new in the voluntary carbon market. In India, 13 companies have applied for registration in the Gold Standard and Verra registries. They are all located in three states—Telangana, Madhya Pradesh and Maharashtra.

Rice emission reduction projects currently utilize a CDM methodology called *AMS-III.AU - Methane emission reduction by adjusted water management practices in rice cultivation*.¹⁶ The methodology focuses on reducing anaerobic decomposition of organic matter in rice cropping. Baseline emissions of methane gas are measured

in reference fields using the closed chamber method. This results in a specific emission factor measured in kilogram of methane per hectare per season.

According to Mohanty of Core Carbon X, measuring methane from the field is tedious and expensive. Instead, he uses a formula present in the methodology that allows him to calculate emission reduction by multiplying the adjusted daily emission factor (a coefficient that describes the rate at which a given activity releases GHGs into the atmosphere) with the area of project fields in a year, the cultivation period of rice in a year and the global warming potential of methane. The formula suggests that AWD could result in 52,920 tonnes of CO₂e reduction per year. The project is expected to be active for seven years, resulting in emission reduction of 3,70,440 tCO₂e. Prithvi Ram from Dr Reddy's foundation, who is also hoping to claim carbon credits for AWD projects in Telangana in the future, explains that measuring methane emissions can help check whether theoretical estimates match ground measurements. "It is expensive but doable. The implementation might not be the same everywhere. When you scale up or extrapolate the data, the measurements may look different. So, it's important to validate them" he says.

The methodology also specifies that the shift in practice should not lead to decreased yields. Dhasharata Reddy, a farmer from Urumadla, a village in Chityala mandal in Nalgonda, says he benefited from practicing AWD. "Last Rabi, my yield was 2.9–3 tonnes per acre (roughly 1.2 tonnes per hectare). This is an increase of 0.4–0.5 tonnes", he explains. Muthian Shetty from Wattimarthy village tells DTE that he began following AWD a year ago and has seen no change in yield. However, DTE could not ascertain whether the farmers had increased expenditure in labor and other inputs because of the shift in method.

Core Carbon X has signed an agreement with the farmers stating that the latter has agreed to transfer the rights of carbon rights to the company. A similar agreement has been signed in Madhya Pradesh with VNV Advisory. These agreements outline the farmers' relinquishment of

their carbon rights, their commitment to adhering to specified methods, and their willingness to seek advice for sustainable farming practices.

DTE spoke with a few farmers and found that while they are unaware of carbon credits, they understand that they will receive incentives for following AWD. Mohanty explains that 25 per cent of revenue from the sale of carbon credits will be used by the company and their partner NGO. Farmers are expected to receive 35–45 per cent share, and 30 per cent will go to their investors Carbon Streaming and Vida — Canada-based companies that invest in carbon credit projects. Mohanty told DTE that his company would give the farmers Rs 800 per acre (Rs 1,920 per hectare) per annum. The company expects the value of one credit to be US \$8. Each hectare of land where AWD is practiced generated five to eight carbon credits. If we took an average of 6.5 credits per hectare, then this would fetch the company a carbon revenue of Rs 4,313, of which it plans to share Rs 1,920 per hectare, or roughly 45 per cent, with the farmer.

However, farmers DTE met with said that this incentive is not sufficient. "Because of AWD, we use more herbicides to control weeds and so our costs go up," explains A Ram Reddy from Memmany village.

As for the Madhya Pradesh project, Pardhi shares that each participating group (expected to have 60–65 farmers) will receive financial support of Rs 50,000 annually as an incentive to cover operational expenses — roughly Rs 800 per farmer per year. He estimates that the overall cost per group for the project to his company will be roughly Rs 1 lakh per annum, which includes the cost of registering the project and annual monitoring. This will be secured through the sale of carbon credits.

The big questions that remain in this important mitigation effort are whether the incentives offered to the farmers are sufficient to drive the method change and whether the methodology for estimating the reduction in emissions is robust. The fact is that this change in the cultivation system of a subsistence crop of farmers must be carefully managed so that it benefits both farmers and the planet.



BIOCHAR PROJECTS

Out of the five biochar projects, one is under development, one is under validation and three have been registered, out of which credits have been issued for two. Four of the five projects are by the private sector and one by NABARD (see *Table 4: Biochar projects in the Indian VCM*).

Total estimated reduction of these five projects is 2.8 lakh tCO₂. While the average estimated reduction turns out to be 57,663 tCO₂ per project, the range varies from 1,061 tCO₂ (a NABARD project) to 1.1 lakh tCO₂ (a project by SRCNatura Sure).

Biochar projects are smaller compared to those of sustainable agriculture, but they seem to be promising as credits have already been issued. Presently, biochar projects are in Telangana, Odisha and Maharashtra, but notably absent in Punjab and Haryana, which have acute crop-residue burning issues.

Table 4: Biochar projects in the Indian VCM

Name	Proponent	State	Status	Estimated emission reduction	Credits issued	Credits retired
Biochar project-1 by WeAct	WeAct	Telangana	Registered	22,376	10	0
Project Reignite: Turning farm waste to climate action	SRCNatura Sure	Odisha	Registered	1,10,760	8500	0
Global Biochar Project	EKI Energy Services	Maharashtra	Under validation	37,159	0	0
Project Terre Boost: Biochar for a better tomorrow	SRCNatura Sure	Multiple	Registered	1,16,961	0	0
The potential of plantation-based systems in generating carbon credit through biochar production and application in the West Coast region of India	NABARD	Goa	Under development	1,061	0	0

Source: The Voluntary Carbon Market in India Dashboard, Centre for Science and Environment¹⁷

Additionally, numerous projects are emerging in this sector. Some of the key biochar carbon credit projects and their locations are as follows:

1. Projects by Varaha (multiple locations)

Varaha is a leading developer with a strong focus on utilizing biochar for carbon removal and ecosystem restoration.

Project name/ Focus	Location	Implementation/Objective	Carbon Standard
Banni Biochar Project	Gujarat and Rajasthan (especially the Banni grasslands)	Converts the invasive species <i>Prosopis juliflora</i> (mesquite) into biochar. This restores native grasslands, sequesters carbon and provides economic value to local pastoralists.	Carbon Standard International (Artisan Pro)
Industrial Biochar Facilities	Gujarat	Large-scale facilities, with Google purchasing a significant amount of carbon removal credits. The project uses invasive mesquite biomass.	Puro.earth
Corn Seed Facility 2	Southern India (specific location is broadly referred to as <i>Southern India</i>)	An industrial-scale facility converting agricultural waste, specifically corn shanks, into biochar.	Puro.earth

2. State-supported programme (Himachal Pradesh)

The state government has initiated a first-of-its-kind public-private partnership programme.

Project Name/ Focus	Location	Implementation/Objective	Carbon Credit Goal
State-supported Biochar Programme	Neri, Hamirpur district, Himachal Pradesh	A biochar plant is being established to utilize forest waste like pine needles, lantana, and bamboo. The main goals are to reduce wildfire risks, generate employment for local communities through biomass collection, and earn 28,800 carbon credits over 10 years.	Verra (likely target for credits)

3. Artisanal community-based projects

These projects focus on empowering smallholder farmers to produce biochar using agricultural waste on a local scale.

Project Name/Developer	Location	Implementation/Objective	Carbon Standard
Project Reignite: Turning Farm Waste into Climate Action (Developed by Together for Restoration/SRCNatura Sure Pvt Ltd)	Odisha	Engages 5,000 rural farmers to stop open burning of agricultural waste. They produce biochar for use as a soil amendment on their farms, which generates carbon removal credits.	Verra (first registered biochar project using VM0044 methodology)
Carboneers Biochar Project	Odisha and Assam regions	Trains and equips smallholder farmers with flame curtain pyrolysis techniques to convert agricultural waste (like rice residue) into biochar, creating socio-economic value.	Global C-Sink Registry (Carbon Standards International)



4. Other industrial and upcoming projects

Project Name/ Developer	Location	Implementation/Objective	Status
Varhad Capital & Green Carbon Project	Vidarbha region, Maharashtra	Plans to construct two industrial-scale biochar production facilities to convert over 6,000 tonnes of agricultural residues annually into biochar/biofertilizer for local farmers.	Upcoming (first plant scheduled to start in August 2025)
Tata Steel Biochar Use	Jamshedpur, Jharkhand and Athagarh, Odisha	Not a carbon credit project itself, but a major industrial application. Tata Steel is replacing pulverized coal injection in its blast furnaces with biochar to reduce CO ₂ emissions.	Operational/Scaling up
Biochar for Sustainable Agriculture (BSA)	Punjab and Haryana	Focuses on the production and application of biochar to improve soil health and crop yields, often utilizing crop residues that would otherwise be burned.	Programmatic/ Initiative

CHALLENGES AND POSSIBILITIES

Based on research and stakeholder interaction, the challenges and possibilities in upscaling carbon markets in the agriculture sector are outlined below¹⁸:

CHALLENGES

- India's agricultural sector exhibits vast diversity in social demography for farming, as there are a smaller percentage of large landholders and a higher percentage of small and marginal landholders. For example, one acre of land can sequester enough carbon to generate only one to two credits over a period of time. Moreover, a large percentage of farming is practiced on leased land, and challenges related to remuneration for small landholders and obtaining consent from landowners before availing carbon credits often persist.
- The initial costs of project registration, adopting or transitioning towards a recommended set of practices, soil sampling and a potential initial drop in yield levels often deter farmers from venturing towards sustainable agricultural practices. Besides, there is limited awareness among farmers about the functioning of carbon credits and markets.
- Methodologies provided by registries often have stringent standards to determine baseline activities. These methodologies often disregard farmers who have been practicing sustainable or regenerative agriculture for years, as they are less likely to get incentives for their existing management practices.
- Financial viability in agricultural projects is a hindrance. Projects need carbon credits that sell at good prices and use affordable monitoring methods (MRV) that still ensure credibility. While formal land or carbon rights are ideal for contracts, many projects instead rely on informal rights, often just recognized by local authorities.



POSSIBILITIES

- There is a need to include cropland soil organic carbon increase in the Green Credit Programme (GCP), which currently focuses on afforestation.
- To promote carbon sequestration in Indian croplands, there is a need to generate evidence and data. For example, estimating the total SOC stock in different agro-ecological regions of India to record SOC changes over the years and calculating the carbon sequestration potential of cropland in different agro-ecological zones in India will provide backing for required policy shifts.
- There is a need to develop MRVs that accommodate on-ground sustainable farming practices within local Indian climatic and regional contexts for the issuance of carbon credits.
- There is a need to explore and expand the role of civil society organizations (CSOs) in carbon project implementation. Also, cooperatives and networks of farmers can help create economies of scale in this space to provide fair remuneration to farmers.
- It is important to develop standards for biochar that is to be applied to soils, such as related to (but not limited) level of carbon in the biochar as well as nature and quantum of contaminants (such as heavy metals, if any). This can be done as part of FCO standards or standalone. It would also be important to standardize monitoring mechanisms and measurement methods.

ANNEXURE

Table 1: Sustainable agriculture projects in the Indian VCM

Name	Main proponent	State	Status	Methodology	Estimated Annual Emission Reduction (tCO ₂)
Promoting regenerative agriculture and growth through income generation	Grow Indigo	Multiple	Under development	VM0042	5326066
Regenerative agriculture in the Ganga basin for farmer income and climate impact	Grow Indigo	Multiple	Under validation	VM0042	5048425
Maharashtra and Gujarat initiative for regenerative agriculture and income creation	Grow Indigo	Multiple	Registration requested	VM0042	4861245
Core carbon <i>Sahaja Vyavasayam</i> in Andhra Pradesh	Core CarbonX Solutions	Andhra Pradesh	Under development	VM0017	4830706
Developing carbon finance project for farmers adopting regenerative agriculture practices in the Indo-gangetic plains	Varaha Climate Ag	Multiple	Registration and verification approval requested	VM0042	4796219
Greenshift: Catalyzing regenerative agriculture ecosystem for smallholder farmers in India, through carbon finance	Varaha Climate Ag	Multiple	Under development	VM0042	4505732
Regenerative agriculture in rice-wheat-maize system for income generation	Grow Indigo	Multiple	Registration and verification approval requested	VM0042	4267622
Developing carbon project for farmers adopting regenerative agricultural practices in Gujarat state	Varaha Climate Ag	Gujarat	Registration requested	VM0042	1046945
Sustainable Agricultural Land Management Project by Om Organic Cotton	Om Organic Cotton	Multiple	Under development	VM0017	956199
Core farming in Tamil Nadu	Core CarbonX Solutions	Tamil Nadu	Under development	VM0017	871824
Core farming in Odisha	Core CarbonX Solutions	Odisha	Under development	VM0017	774200
Sustainable agricultural practices for carbon sequestration by organic and natural farming groups	Vedic Green Solutions	Karnataka	Registration and verification approval requested	VM0017	686959
Boomitra carbon farming in south of the Vindhyas	Boomitra	Multiple	Registration requested	VM0042	676391
Incentivizing smallholder farmers to transition to low-emission agriculture and agroforestry	Climeverse	Multiple	Under development	VM0042	463650
Boomitra carbon farming in the Indo-Gangetic plains	Boomitra	Multiple	Under development	VM0042	350000
Core farming in West Bengal	Core CarbonX Solutions	West Bengal	Under development	VM0017	308918

VOLUNTARY CARBON MARKET FOR AGRICULTURE

Name	Main proponent	State	Status	Methodology	Estimated Annual Emission Reduction (tCO ₂)
Core farming in Himachal Pradesh	Core CarbonX Solutions	Himachal Pradesh	Under development	VM0017	291824
Core farming in Jharkhand	Core CarbonX Solutions	Jharkhand	Under development	VM0017	289256
Land management by organic farming practices in India	Qmark Foundation	Uttar Pradesh	Under development	VM0042	275749
Sustainable Agriculture Land Management Project by Suminter India Organics	Suminter India Organics	Multiple	Withdrawn	VM0042	275748
Sustainable Agricultural Land Management Project by Amiha Agro Private Limited	Amiha Agro	Multiple	Withdrawn	VM0017	256116
Sustainable agricultural practices in India	VN Foods & Beverages	Karnataka	Registration and verification approval request denied	VM0017	227272
Transformational Regenerative Integrated Biodiverse Agriculture for Livelihoods (TRIBAL)	Archipel India Foundation	Andhra Pradesh	Registration requested	VM0017	219473
The Nagaland 4 Change REDD+ Project	Envfy Services	Nagaland	Under validation	VM0007	200000
Sustainable Agricultural Land Management Project by Greneity	Greneity Infocom Service	Multiple	Under development	VM0042	173250
Clean air and healthy soil	Fair Climate	Multiple	Registration requested	VM0017	110812
The Biwal Carbon Project	Fair Climate Network	Multiple	Under validation	VM0042	92377
Sustainable Agriculture Project by Arvind in India	Value Network Venture Advisory Services	Gujarat	Registration and verification approval request denied	VM0042	79875
Promoting sustainable agricultural land management practices for climate resilience	Kalpatharu Integrated Rural Development Society	Karnataka	Under development	VM0042	76656
Combating climate change with Sustainable Agriculture and Land Use Management Project by Indian farmers	Himadri Energy International	Multiple	Under validation	VM0042	75794
Sustainable agricultural improvement practices in Punjab	Enen Green Services	Punjab	Under development	VM0017	66175

Name	Main proponent	State	Status	Methodology	Estimated Annual Emission Reduction (tCO ₂)
Improved Agricultural Land Management Grouped Carbon Project in India	RPG Foundation	Maharashtra	Under development	VM0042	65047
Sustainable Cropland Management Project by Phalada Agro Group	Phalada Agro Research Foundations	Multiple	Rejected by administrator	VM0017	44850
Agricultural Land Management Project in Beed District, India implemented by Godrej Properties Ltd	Godrej Group	Maharashtra	Late to verify	VM0017	33764
Agricultural Land Management Project in Telangana, India implemented by Godrej Consumer Products Ltd	Godrej Group	Telangana	Withdrawn	ACM0017; VM0017	33392
Agricultural Land Management Project in Hujgal & Kalari cluster watershed, India implemented by Godrej Agrovet Ltd	Godrej Group	Karnataka	Registration requested	VM0017	30403
Strengthening capacity through regenerative solutions for native sugarcane farmers in Maharashtra, India	Value Network Venture Advisory Services	Maharashtra	Registration requested	VM0017	29250
Sustainable Agriculture Land Management Project by Biowin Agro Research	Biowin Agro Research	Kerala	Under development	VM0042	26639
Agricultural Land Management Project in Barwani district (Madhya Pradesh), India by Godrej Agrovet Ltd	Godrej Group	Madhya Pradesh	Registration requested	VM0017	23154
Sustainable Agriculture Land Management Project by Earthallica Naturals	EKI Energy Services	Chhattisgarh	Under development	VM0017	20000
Leveraging carbon finance for socio-agroforestry in Nandurbar, Maharashtra	Value Network Venture Advisory Services	Maharashtra	Registration requested	VM0017	11700
Incentivizing regenerative cotton farming through carbon finance	Value Network Venture Advisory Services	Multiple	Under validation	VM0017	9250
Incentivizing sustainable maize farming through carbon finance	Value Network Venture Advisory Services	Karnataka	Under validation	VM0017	8500
Sustainable Agricultural Land Management Grouped Project in India	EKI Energy Services	Madhya Pradesh	Under development	VM0017	4099



VOLUNTARY CARBON MARKET FOR AGRICULTURE

Name	Main proponent	State	Status	Methodology	Estimated Annual Emission Reduction (tCO ₂)
Carbon crediting in the rice-wheat system through crop residue management: A farmer participatory approach	NABARD	Punjab	Under development	VM0042	1295
Evaluation of soil organic carbon sequestration under natural farming condition: Enhancing soil quality and capitalizing on carbon markets	NABARD	Gujarat	Under development	VM0042	400
Carbon credit farming through sustainable agriculture approaches in the upper Indo-Gangetic plains	NABARD	Multiple	Under development	VM0042	400
Harnessing the benefits of carbon farming vis-à-vis carbon credit for balancing economic development with climate change adaptation and mitigation	NABARD	Odisha	Under development	VM0042	350
Optimization of the nitrogen fertilizer in India and Thailand by using satellite images analysis	Sagri Co., Ltd.	Tamil Nadu	Inactive	VM0042	100
Reducing GHG emissions in irrigated crops through micro-irrigation in different agroecological regions of India	NABARD	Multiple	Under development	VM0042	100
Promoting Regenerative Agriculture for Nature (PRAN)	Grow Indigo	Multiple	Listed		0

Source: The Voluntary Carbon Market in India Dashboard, Centre for Science and Environment¹⁹

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AGENDA: ADAPTATION THROUGH WEATHER-CROP INFORMATION

WEATHER FORECASTING

TIMELY INFORMATION FOR FARMERS



IN BRIEF

GAPS AND CHALLENGES IN AGRICULTURAL WEATHER FORECASTING AND ADVISORY SYSTEMS

The ability of weather forecasting systems to effectively mitigate the increasing impacts of extreme weather events is limited by significant deficiencies across infrastructure, accuracy and communication.

Infrastructural gaps and maintenance deficiencies

A major challenge is the limited infrastructural capacity, distribution, and maintenance of observational machines.

- **Inadequate coverage:** While block-level forecasts are acknowledged as essential, generating quality forecasts at this level remains difficult due to dependence on existing district-level infrastructure.
- **Insufficient equipment density:** The government infrastructure operates about 1,008 Automatic Weather Stations (AWS). However, to achieve the desired five kilometre radius coverage, India requires an estimated 40,000 AWS.
- **Limited radar network:** India's network of Doppler Weather Radars (DWRs) stood at 39 in 2023, which is significantly less compared to countries like the United States (160) and China (217).
- **Sporadic placement:** The placement of infrastructure is sporadic. For instance, agriculturally active states like Haryana and Punjab share only one DWR, and Karnataka relies on the nearest DWR located in Chennai.

- **Maintenance issues:** There are concerns regarding the lack of appropriate maintenance and upkeep of observational machines. Additionally, KVK (Krishi Vigyan Kendras) scientists reported that since 2021, they have not been able to access the real-time data from the AWS machines installed in their own facilities, making it difficult to monitor irregularities and plan necessary replacements.

Accuracy and modelling limitations

Despite overall improvements, the accuracy of available weather forecasts is still considered far from adequate by stakeholders.

- **Low block-level accuracy:** The accuracy of block-level forecasts is particularly low, ranging between 40–50 per cent.
- **Monsoon variability:** Accuracy is much lower in monsoons, which negatively impacts kharif crops, although accuracy increases significantly in the winter season.
- **Tropical modelling difficulty:** India's tropical nature and varied topography present challenges. For example, convective clouds often form quickly on a small scale (a few kilometers), which is smaller than the typical model grid size (usually 3–12 km). This necessitates parameterizations, adding to the uncertainty of forecasts.
- **Private accountability:** There are concerns regarding the accountability of private players who claim to provide hyper-local weather information.

Dissemination and accessibility failures

Forecast dissemination suffers from gaps in localization, timeliness, and accessibility, limiting the utility of the information for farmers.

- **Lack of hyperlocal dissemination:** While gram panchayat or hyperlocal forecasts are deemed significant, farmers primarily receive district-level forecasts which may be ineffective, particularly in hilly areas with micro-climatic variations.

- **Loss of local advisories:** In a step backward, the India Meteorological Department (IMD) issued a notice in January 2024 to discontinue District Agro-Meteorological Units (DAMUs), which were responsible for issuing block-level advisories which also contain block-level forecasts.
- **Poor communication channels:** The once effective practice of 'warm-blooded dissemination,' through local agrometeorologists in KVKs or village sarpanchs is no longer widely available.
- **Digital divide:** Timely access is challenging due to limited internet connectivity and difficulties faced by tech-challenged farmers, particularly the elderly, for whom accessing information via websites is far less convenient than through WhatsApp or SMS.
- **SMS issues:** Farmers reportedly have not been receiving alerts through the *m-kisan* SMS service since 2021. Furthermore, SMS alerts sent by state disaster management departments are often not area-specific, and their timing varies greatly (from half an hour to one day before the event).
- **Digital platform reliance:** The *Gram Panchayat Level Weather Forecasting* initiative that was launched in October 2024 is criticized because its outputs are primarily accessible only on digital platforms like *e-Gramswaraj* and *Mausamgram*.

WAY AHEAD: POSSIBLE APPROACHES AND FUTURE MISSIONS

To address challenges of accuracy and accessibility, targeted investments, strengthened collaboration, and the development of indigenous technologies are proposed.

Targeted infrastructure scaling

Instead of general expansion, a targeted approach is recommended for increasing infrastructural capacity.

- **Focus on high-risk areas:** Investment should target identified high-risk districts (based on assessments like National Innovations on Climate Resilient Agriculture's (NICRA) 'very highly vulnerable' and 'highly vulnerable' classifications).
- **Prioritize complex regions:** States with higher topographical and micro-climatic variations, such as the Himalayan states (Himachal Pradesh and Uttarakhand) and mountainous regions like the Western Ghats in Karnataka and Maharashtra, should be prioritized for infrastructure development.
- **Mission Mausam goals:** The *Mission Mausam* scheme, launched in 2025, aims to increase the number of DWRs to 126 by 2026.

Enhancing accuracy and timeliness

Specific targets are set for improving model performance and forecast delivery speed.

- **Accuracy improvement:** *Mission Mausam* aims to improve short- to medium-range weather forecast accuracy by five to 10 per cent.
- **Nowcast frequency:** The mission also seeks to increase the nowcast frequency (0–3 hours) from three hours to one hour.

Collaboration and synergy

Exploring collaborative projects is seen as crucial to leveraging the strengths of various sectors for better and timely forecasts.

- **Multi-stakeholder partnerships:** Collaboration should be explored between the government (which owns high-end equipment like supercomputers), private players (who often have a higher number of data collection equipment), civil societies (with dense localized networks), and academic institutions.

- **Quality monitoring:** Such collaborations could also establish mechanisms for monitoring the quality of forecast information shared by private players with farmers, which is currently lacking. The Weather Information and Network Data System (WINDS) project (2023) is noted as an example of collaboration between the government and other entities.

Utilizing indigenous technology

Prioritizing and scaling up investment in Indian-made observation systems is recommended.

- **Addressing maintenance issues:** This approach is intended to overcome difficulties related to the replacement and maintenance of imported equipment, as highlighted by KVK scientists.
- **Cost-effective solutions:** Companies in India are developing and manufacturing their own AWS, which are claimed to be cost-effective compared to imported counterparts and customized for India's climatic conditions.

TIMELY ACCESS TO ACCURATE WEATHER FORECAST FOR INDIAN FARMERS

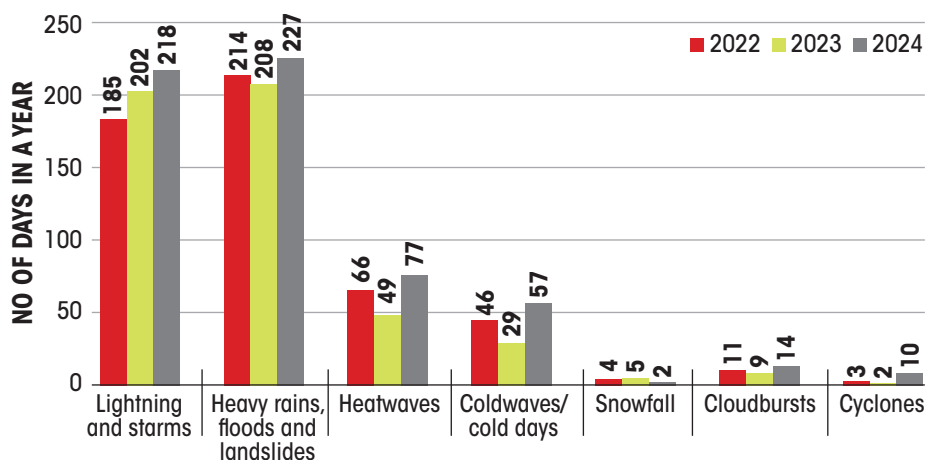
Indian agriculture provides livelihood support to about 42.3 per cent of the country's population.¹ The state of weather can heavily impact agricultural growth and productivity. About 50 per cent of India's net sown area is rainfed which accounts for nearly 40 per cent of the total food production.² About 85 per cent of the operational holdings are small and marginal (holdings of less than two hectares each). The long-term impact of climate change is also estimated to reduce rainfed rice yields by 20 per cent and wheat yield by 19.3 per cent by 2050.^{3, 4}

The frequency of extreme weather events in the country is high and continues to rise.⁵ Over the last three years, extreme events have been occurring almost every other day; in 2024 alone, these occurred on 322 days, in 2023 on 318 days, and in 2022 on 314 days.⁶ Over this period, 'lightning and storms,' and 'heavy rains, floods and landslides' have been the most frequent, followed by 'heatwaves', 'cold waves/cold days', 'cloudbursts', 'snowfall' and 'cyclones' (see *Graph 1: Extreme weather events in India*).

In 2022, 19.60 lakh ha crop area was affected due extreme weather events. This increased to 22.14 lakh ha in 2023 and 40.72 lakh ha in 2024.⁷ Over these three years, the Central region was the most affected, followed by the South Peninsular region, the East and Northeast region, and the Northwest region (see *Graph 2: Crop area affected across regions due to extreme weather events*).

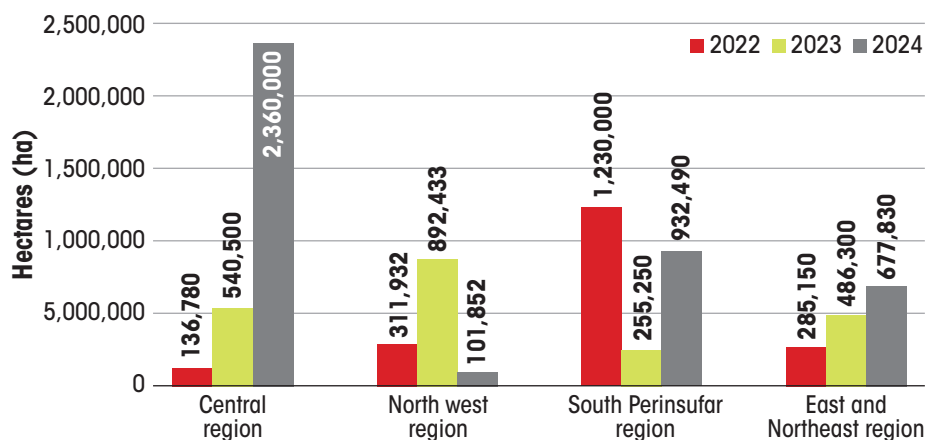
However, the impact of extreme weather on agriculture and livestock can be mitigated to a certain extent if timely and accurate information about such occurrence, location and intensity of such events is made accessible to farmers.⁸

Graph 1: Extreme weather events in India



Source: India's Atlas on Weather Disasters, Down to Earth

Graph 2: Crop area affected across regions due to extreme weather events



Source: India's Atlas on Weather Disasters, Down to Earth

A 2020 study by the National Council of Applied Economic Research (NCAER) concluded that 98 per cent of surveyed farmers (3,965 farmers across 121 districts of 11 Indian states) made modifications to at least one of nine critical agricultural practices based on weather advisories. These practices included rescheduling irrigation, advancing or delaying sowing, and altering the time of schedule of ploughing or land preparation. For farming households that adopted the suggested modifications, the average annual income rose to Rs 3.02 lakh, compared to Rs 1.98 lakh among those who did not make such changes. The study also noted that 55 per

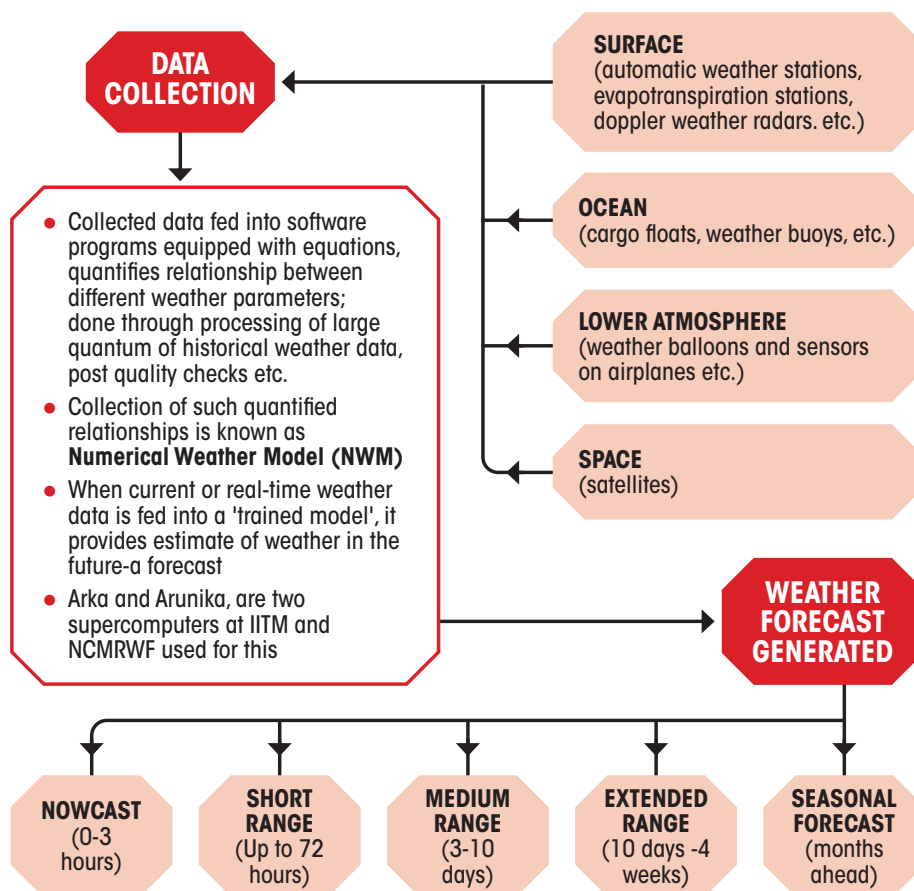
cent of farmers received information on calamities almost every time, and among them, 80 per cent reported a reduction in losses caused by natural disasters.⁹

The information and analysis presented below is based on research and interaction with stakeholders, including those from the government, private sector, civil society, state agricultural universities, Krishi Vikas Kendras (KVKs) and farmers.

WEATHER FORECASTING BY THE GOVERNMENT

As part of the Ministry of Earth Sciences, Government of India, the Indian Meteorological Department (IMD) is the face of weather forecasting, while Indian Institute of Tropical Meteorology (IITM) and National Centre for Medium Range Weather Forecasting (NCMRWF) are also involved in both data collection and modelling, the two key components of weather forecasting (see *Figure 1: Data collection and modelling for weather forecasting in India*).

Figure 1: Data collection and modelling for weather forecasting in India



Source: CSE

Apart from national data, global data is also shared as part of an agreement between different countries of the World Meteorological Organization (WMO). This data helps to get the ‘initial state of atmosphere’.

EQUIPMENT AND FUNCTIONS

Data about weather is collected over land surfaces, oceans, lower atmosphere and from space through different equipment with varying functions (see Table 1: Data collection equipment and functions).

NUMERICAL WEATHER MODELS

Developing a numerical model can take years and at times, countries come together to devise one. A numerical model doesn’t become obsolete; if updated, an existing one can be tuned to local condition. For example, IITM has modified the core physics of a model taken from National Centers for Environmental Prediction (NCEP), United States, which is freely available and is being updated for over a decade. With a large number of modifications, the model can become substantially different from the original one. An example is of the indigenously developed Bharat Forecast System (BharatFS) released recently in 2025.¹⁵

Table 1: Data collection equipments and functions

Equipment	Function
Automatic Weather Stations (AWS)	Measures real-time local weather (temperature, humidity, wind, rainfall) ¹⁰
Agromet observatories	Measures air and soil temperature, humidity, wind speed and direction, rainfall, evaporation, etc. Generally located at sites like KVKs and State Agricultural Universities (SAUs). ¹¹
Doppler Weather Radars (DWRs)	Detects rain, storm movement, wind profiles ^{12,13}
S-Band DWR	Has long range (~300–400 km). Best for heavy rain regions (monsoon, cyclones)
C-Band DWR	Has medium range (~200–250 km)
X-Band DWR	Has short range (~50–100 km) and very high resolution. Good for urban flash floods.
Indian National Satellite (INSAT-3DS)	Records insolation, land surface temperature, evapotranspiration, etc. ¹⁴

Note: These are a few illustrative examples and do not represent the complete set of equipment used

Table 2: Functional numerical models used in India

Model	Resolution	Forecast range	Purpose
Global Forecast System (T1534)	12 km	Up to 10 days	Medium-range deterministic forecasts
NCMRWF Unified Model	12 km	Up to 10 days	High-resolution medium-range forecasts
Multi-Model Ensemble Model	Varies	Up to 5 days	Combined outputs from multiple global models
Weather Research and Forecasting Model (WRF)	3 km	Up to 3 days	High-resolution regional forecasts
Extended WRF	Varies	Extended range	Extended-range regional forecasts
High-Resolution Rapid Refresh	High	Short-term	Rapid-updating high-resolution forecasts

Note: These are examples and do not represent all models used in India

Differentiation of Numerical Weather Model (NWM) is done by their horizontal and vertical resolution, and their lead time. It can therefore be a short, medium, extended range forecast generated¹⁶ (see *Table 2: Functional numerical models used in India*).

Once the forecast is generated, details are shared with regional meteorological centres and can reach farmers through multiple options like the IMD website, advisories generated, *Mausam* app etc. This is facilitated by the Agrimet division of IMD.

WEATHER FORECASTING BY OTHER AGENCIES

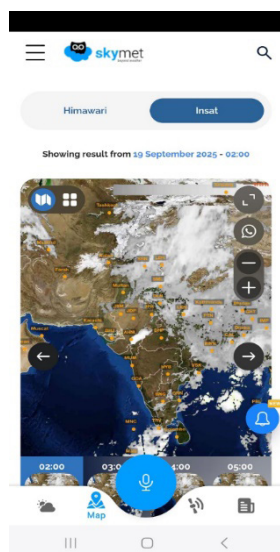
In addition to the Government of India, there are several private, academic and non-government organizations that use different approaches for forecasting and have either localized operations or nation-wide spread.

Skymet Weather Services, a Noida-based company established in 2003, operates through approximately 7,000 Automatic Weather Stations (AWS) spread across 20 states in India.¹⁷ It has its own infrastructure and runs a Numerical Weather Model (NWM) to generate forecasts. These forecasts are sold to crop insurance companies, banks involved in crop insurance, and other related entities. Through its mobile application, farmers and the general public can also access hyperlocal weather forecasting data.

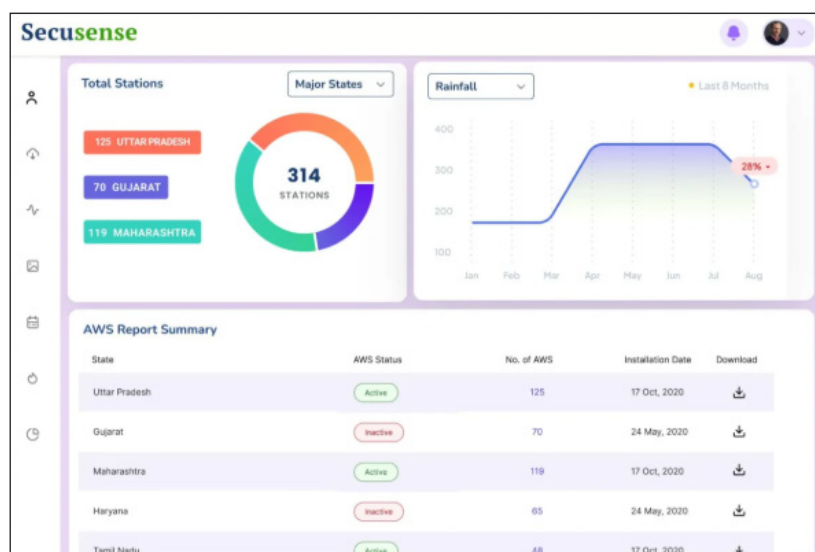
They were recently bought by Reliance Industries as per the company officials. The company now plans to expand their network to 60,000 AWS by 2026 and adopt a new approach for weather forecasting using 'signal attenuation,' utilizing Reliance's cell towers.

WeatherCast Solutions, an incubation project of IIT Bombay is using their own patented model PRAVAH (Physics-driven AI Model for Value-Added Hyperlocal Forecasts) for generating highly precise, hyperlocal weather forecasts. Established in 2022, they have their presence in seven states (largely focussed on the Western region in India). This information is converted into automated weather advisory available in regional languages and shared with farmers in farmer producer organizations via WhatsApp.¹⁸

Weather Risk Management Services Pvt. Ltd. (WRMS) incubated by IIT Kanpur in 2004, currently has operations across 22 states in India selling localized weather data to companies, helping compute weather-based insurance packages for farmers, and calculating risk to crops from weather anomalies. It does this through products like 'SecuSense' that use integrated Numerical Weather Model (NWM) with ground-based weather station data to deliver short and medium-term weather forecasts. 'SecuFarm' does real-time tracking of weather, soil, and crops using Internet of Things (IoT), satellites, and drones.^{19, 20}



Skymet's mobile application



SecuSense dashboard

Cropin Technology Solutions Private Limited, based in Bengaluru connects with multiple data sources, including satellite imagery, IoT devices, drones, and external weather sources to inform their models. The company uses its AI/ML models to process this raw data and generate predictive and prescriptive insights. For example, their Disease Early Warning System (DEWS) model analyzes past and forecasted weather data to predict the probability of a pest or disease outbreak.²¹

Hume Centre for Ecology and Wildlife Biology is working in specific states like Kerala ensuring hyperlocal weather reaches farmers. It has partnered with Cochin University of Science and Technology (CUSAT)'s Advanced Centre for Atmospheric Radar Research to enable localized weather forecasting for Wayanad (through division of district into grids) in order to predict rainfall patterns and intensity. It uses this information to disseminate daily forecast maps among its network of local community and farmers through WhatsApp.²²

Private players prefer installing their own machines as they are involved in selling the data such as to insurance companies. Besides, they focus more on Automatic Weather Stations (AWS), as World Meteorological Organization (WMO) guidelines for Doppler Weather Radars (DWR), which such companies are expected to follow, are stricter.²³

CHALLENGES ASSOCIATED WITH WEATHER FORECASTING AND ACCESSIBILITY

LIMITED INFRASTRUCTURAL CAPACITY, SPREAD AND MAINTENANCE

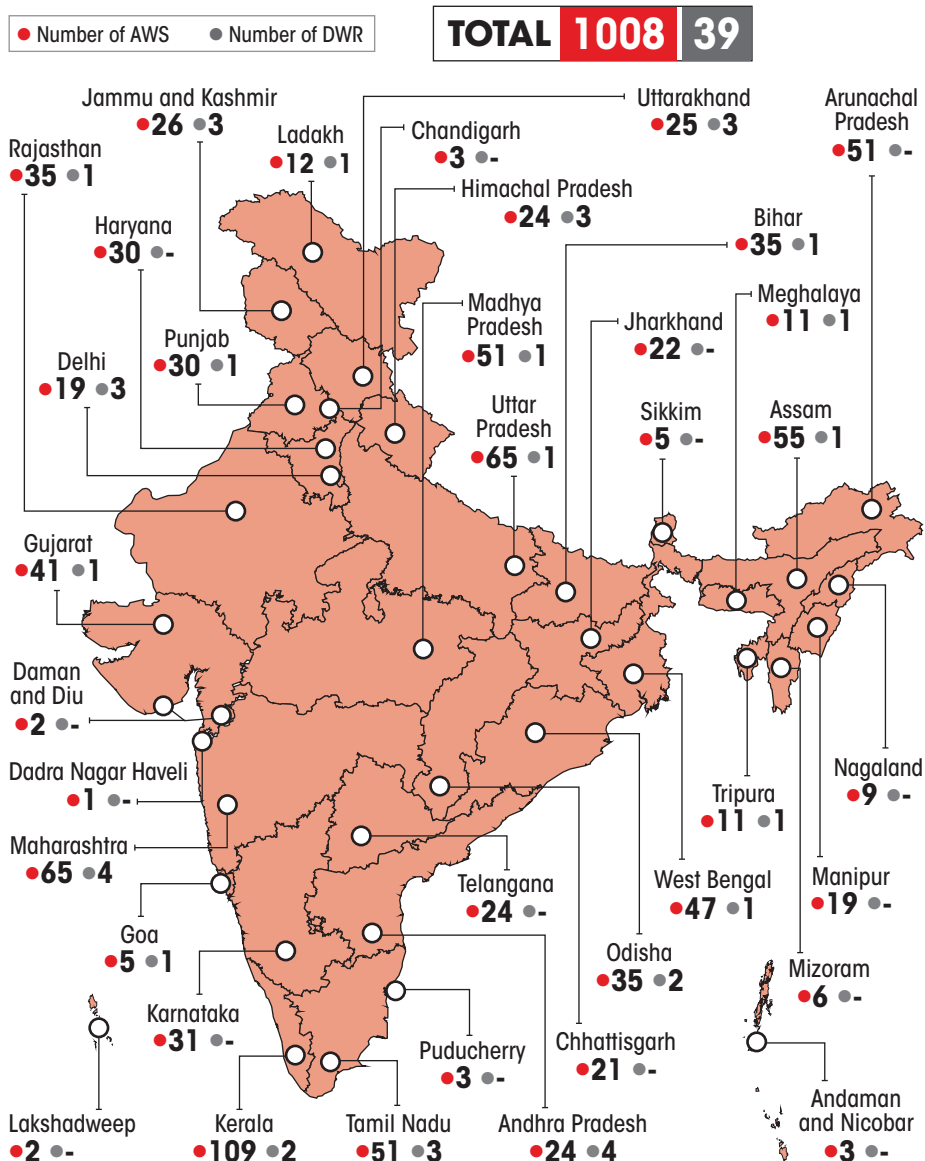
While block-level forecasting is the need of the hour, quality block-level forecasts are hard to generate with district-level infrastructure. It may also lack sufficient level of reliability and adequate lead time.

The government infrastructure under MoES involves about 1,000 AWS, which stakeholders consider insufficient. With an officially stated need for AWS in a five-kilometre radius, India approximately needs 40,000 AWS.²⁴

While advancements in weather forecasting accuracy have been attributed to the expansion of the Doppler Weather Radar (DWR) network from 15 in 2014 to 39 in 2023, the number remains far lower than in countries such as the United States and China, which have 160 and 217 respectively.^{25, 26} India however plans to increase DWRs up to 126 by 2026 as part of *Mission Mausam* launched in 2025.²⁷ On the other hand, the success of 2023 project like the Weather Information and Network Data System (WINDS) aimed at increasing the infrastructural capacity, remains to be seen.²⁸

There are concerns among stakeholders about sporadic placement of the infrastructure. For example, Himachal Pradesh, with an area of 55,658 km², and significant micro-climatic variations and varied topography, has 24 AWS, whereas Kerala with an area of 38,363 km² has a distribution of 109 AWS. Similarly, Haryana and Punjab share one DWR despite both being agriculturally active and climate vulnerable. Karnataka also relies on the nearest DWR in Chennai. Uttar

Map 1: Distribution of AWS and DWR in India



Source: Response to RTI filed with Ministry of Earth Sciences dated 4 July, 2025, Rajya Sabha. Parliament questions February 2024

Pradesh, despite its large area, has only one DWR while Maharashtra has four (see Map 1: Distribution of AWS and DWR in India).

Additional concerns from the ground include, the lack of appropriate maintenance and upkeep, which can impact the oper-

ations of the observational machines. According to scientists at Krishi Vigyan Kendras (KVKs), until 2021, real-time data from all Automatic Weather Stations (AWS) across the country was available on the IMD website and updated every 15 minutes. At present, in the absence of this provision, these scientists cannot access real-time data from the machines installed in their own facilities. This makes it difficult to identify when readings become irregular and which component of the AWS requires replacement.

LIMITED ACCURACY OF THE AVAILABLE FORECAST

Accuracy of the weather forecasting in India has improved over the years with stakeholders mentioning that medium range forecast now achieve around 80 per cent accuracy. As of 2023, IMD reported a 40 per cent improvement in overall forecast accuracy compared to 2014.²⁹ However, despite these improvements, the accuracy of weather forecast currently available is far from adequate as per interactions with farmers and scientists during field visits.

The accuracy is much lesser in monsoons while it increases significantly in the winters. Rain in winters for example, can be predicted two days in advance. This lack of accuracy in monsoons affects the kharif crops.³⁰ Additionally, as per local stakeholders, the accuracy of block level forecast is low and ranges between 40–50 per cent. Accuracy also varies based on the type of forecast. Extended range forecast for example, has a much higher accuracy compared to nowcast or short-range forecast.

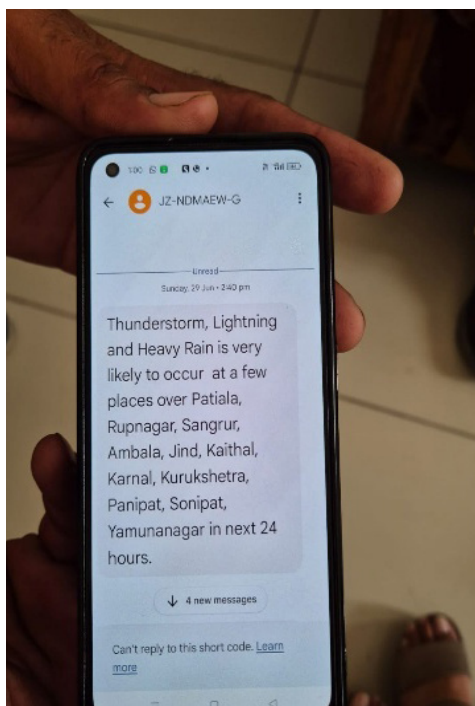
As a tropical country, India faces issues in terms of varied topography and parameters like ‘noise to signal’ [challenge of separating predictable patterns (the signal) from random, unpredictable fluctuations (the noise)].³¹ For instance, in tropical regions, convective clouds develop rapidly, often within a few hours, and are typically small in scale, spanning only a few kilometres, which is much smaller than the model grid size that usually ranges from three to 12 kilometres. As a result, models cannot capture such small structures accurately and must therefore rely on parameterizations, which adds to the uncertainty. In addition, the accuracy of the Numerical Weather Model (NWM) depends on the ‘initial state of

the atmosphere,' which in turn relies on the quality of initial data collection and entry.

Here too, the impact of the most recently launched scheme, *Misson Mausam* is yet to be seen. With a budget of Rs 2,000 crores, it aims to improve short to medium range weather forecast accuracy by five to 10 per cent and improve the nowcast frequency from three hours to one hour.³² There also are concerns about the accountability of private players who claim to provide hyperlocal weather.

POOR DISSEMINATION AND ACCESSIBILITY OF FORECASTS BEYOND THE DISTRICT LEVEL

Firstly, while block-level or hyperlocal forecast, such as the ones at the gram panchayat level, are considered important, in most cases, it is the district-level forecast that is easily available to the farmers, which may not be effective in all situations. For example, in hilly areas due to micro-climatic and topographical variations, district-level forecasts can misinform. Also, forecast during kharif season can vary significantly at a local level. In January 2024, the



SMS from State Disaster Management department



AWS developed by WeatherCast Solutions

IMD issued a notice to discontinue District Agro-Meteorological Units (DAMUs) that were issuing block-level advisories, which also contained block-level forecast.³³

Secondly, timely access to available forecasts is a challenge due to limited internet connectivity, tech-challenged farmers (particularly the elderly) and the overall difficulty of obtaining information from websites compared with easier access through WhatsApp or SMS services. Often, the earlier practice of warm-blooded dissemination, such as through the *sarpanch* or through local-level agrometeorologists in KVKs (District Agro-Meteorological Units or DAMUs), that had once proven effective, is now no longer available.

In October 2024, MoES and Ministry of Panchayati Raj, launched the *Gram Panchayat Level Weather Forecasting* initiative.³⁴ However, there are concerns from stakeholders that these are accessible only on digital platforms such as *e-Gramswaraj*, *Meri Panchayat* and *e-Manchitra* of the Ministry of Panchayati Raj and *Mausamgram* of IMD.^{35, 36}

There are concerns that farmers are not getting alerts through the *m-Kisan* SMS service since 2021. However, in September 2025, the Union Ministry of Agriculture reported that it had sent AI-based monsoon forecasts via SMS (*m-Kisan*) to nearly 3.8 crore farmers across 13 states. These forecasts provided information up to four weeks in advance of the rains.³⁷ Stakeholders from the ground also highlighted that SMS alerts sent by state disaster management departments are often not area-specific and their timing varies from half an hour to one day before the event.

APPROACHES TO ENHANCE ACCESSIBILITY AND ACCURACY OF WEATHER FORECAST

TARGETED APPROACH TO INCREASE INFRASTRUCTURAL CAPACITY

A targeted approach would be most effective for strengthening infrastructural capacity. This could focus on high-risk districts identified in the 2019 assessment by the National Innovations in Climate Resilient Agriculture (NICRA), which classified districts into 'very highly vulnerable' and 'highly vulnerable'.³⁸ Focusing on states with higher topographical and microclimatic variations like Himalayan states (Himachal Pradesh, Uttarakhand) and mountainous regions (Western Ghats in Karnataka and Maharashtra).³⁹

EXPLORING COLLABORATION WITH THE PRIVATE/ NON-GOVERNMENT SECTOR

Collaborative projects can be explored between the government, private players, civil societies and academic institutions for better and timely forecast for farmers. The strengths of each stakeholder can be utilized. For example, the Indian government's possession of high-end equipment like supercomputers, private players with higher number of data collection equipment, and civil societies with their dense localized networks.⁴⁰ An example of such collaboration is the WINDS project launched by the Ministry of Agriculture and Farmers' Welfare in 2023.⁴¹ Collaborations of this kind can also establish systems to monitor the quality of forecast information provided by private agencies to farmers, an oversight that is currently missing.

SCALING UP USE/PROCUREMENT OF EQUIPMENT DEVELOPED IN INDIA

Scientists from KVKs have highlighted issues with the replacement and maintenance of imported equipment, such as AWS, installed at their facilities.

Therefore, investing in observation systems that are made in India and are tailormade for India's climatic conditions can be prioritized and scaled up. While AWS sensors are costly and mostly imported, several Indian companies like Navrithi and WeatherCast Solutions are developing and manufacturing their own AWS.⁴² These are claimed to be more cost-effective than imported systems and offer additional advantages.⁴³

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AGENDA: ADAPTATION THROUGH WEATHER-CROP INFORMATION

AGROMETEOROLOGICAL ADVISORY SERVICES IN INDIA

LINKING WEATHER AND AGRICULTURE



IN BRIEF

The Agrometeorological Advisory Services (AAS) in India represent a critical, evolving system designed to link weather forecasting with agricultural management practices. Their necessity arises from the high and increasing frequency of extreme weather events across the country.

While general weather forecasting began in India around 1945, the specific need for AAS bulletins, which began in the early 1970s, arose because earlier forecasts lacked management guidance regarding field operations. These advisories have proven beneficial: a 2020 study showed that 98 per cent of surveyed farmers modified at least one critical agricultural practice based on the advice.

The creation and dissemination of agrometeorological advisories through the government is a complex process involving collaboration between departments, State Agricultural Universities (SAUs), Krishi Vigyan Kendras (KVKs), etc. In India, private enterprises and civil society organizations are also involved in this sector.

Advisories are operational at the national, state and district levels. District-level advisories are issued bi-weekly (Tuesdays and Fridays) by Agrometeorological Field Units (AMFUs). There are about 130 AMFUs spread across the 128 agro-climatic zones, generally situated at state agricultural universities. To extend reach, the 'Gramin Krishi Mausam Sewa' scheme (2018) established District Agrometeorological Units (DAMUs) in KVKs to cover blocks. However, these services were discontinued in early 2024.

The private sector and civil society also provide AAS, often utilizing their own infrastructure and Numerical Weather Models (NWMs). Examples of such agencies in this sector include BKC WeatherSys Pvt. Ltd., Skymet Weather Services, Wolkus Technology Solutions, and Watershed Organisation Trust (WOTR)

GAPS AND CHALLENGES

The effectiveness and reach of AAS face several critical challenges related to infrastructure, capacity, content and the sudden cessation of key expansion units.

Limited infrastructure and capacity

- **High workload on Agromet Field Unit (AMFU) personnel:** Typically, one agrometeorologist is tasked with issuing bi-weekly advisories for an average of four to five districts. This can be far higher in some regions, such as in the case of Haryana (11 districts per AMFU) or Bihar's Sabour AMFU (17 districts). The capacity challenge has been significantly worsened by the discontinuation of District Agromet Unit (DAMU) services in early 2024.
- **Loss of granularity:** The closure has reduced overall capacity and halted block-level advisories. District-level advisories are often inadequate, especially in regions with varied topography (for instance, in Himachal Pradesh's Kangra district, temperatures can differ by about 10 degrees between hilly and low-lying areas) and diverse cropping patterns.
- **Impossible workload:** If AMFUs were forced to cover all blocks, one agrometeorologist – linked to four-five districts, each with six to eight blocks – would be required to generate 24 to 40 bi-weekly advisories, a task that is quite challenging.
- **Outdated zoning:** The network of AMFUs is based on agro-climatic zones classified in 1971: this classification has not been updated. Climate change has led to significant variations

(such as semi-arid areas becoming arid), potentially impacting the effective placement and number of AMFUs.

Content limitations

The advisory content suffers from issues related to expertise, specificity and format:

- **Lack of local expertise:** Preparing a meaningful advisory requires a skilled, trained agrometeorologist who possesses deep local knowledge regarding the region, the different stages of local crops, and the specific issues faced by farmers. This high level of specialized local experience is sometimes lacking in AMFUs.
- **Non-differentiation:** Advisories generally fail to differentiate between small-, medium- and large-scale farmers. While weather needs are similar, crucial aspects like the financial capacity to purchase agricultural inputs and chemicals vary significantly.
- **Technicality and length:** Advisories can be too technical for small farmers. They are often lengthy (three-four pages) and contain generic information (such as advising farmers to keep animals under sheds during peak summer hours).

Limited reach and dissemination

Despite reaching millions, a substantial coverage gap remains:

- **Incomplete coverage:** India has over 140 million farming households; in all likelihood, a large section of this population is not receiving the service. While the IMD has reported covering 1.768 million farmers via 18,631 WhatsApp groups by early 2025, the total number of farmers with access is not publicly known.
- **Digital divide:** The reliance on Information and Communication Technology (ICT) methods, such as applications (Meghdoot, Damini) and portals, creates hurdles due to inadequate internet connectivity and excludes technologically-challenged elderly farmers.

- **Network loss:** AMFU scientists had relied on the WhatsApp groups for dissemination. The cessation of DAMUs has led to the loss of established, trusted farmer networks built through these WhatsApp groups.
- **Coordination issues:** Another area of concern is the limited coordination between officials of the two core ministries (the Ministry of Earth Sciences and the Ministry of Agriculture).

THE WAY AHEAD: POSSIBLE APPROACHES

These challenges can be addressed through improvements in capacity building, private sector collaboration, and adoption of successful local strategies demonstrated by innovative AMFUs.

It is important to scale up collaborative projects with the private sector and civil society to ensure higher quality, timely and hyperlocal advisories. Ministries realise that they need to partner with public, private and non-government organizations (NGOs) in farm extension activities, leveraging innovative technologies offered by the private sector.

Other options include collaborating with the National Disaster Management Authority (NDMA) to make its existing SMS alerts area-specific for erratic events, and including State Agricultural Officers in the 'panel of experts' to leverage their widespread network for advisory percolation.

AMFUs across states have developed unique, context-specific approaches to enhance the quality, specificity and reach of their advisories, thereby demonstrating scalable solutions. Some examples have been provided in *Table 1 (AMFU initiatives and their impacts)*.

Table 1: AMFU initiatives and their impacts

State	AMFU initiative	Focus and impact
Maharashtra (Parbhani)	Automated, need-based advisories	Has been automating advisory generation since 2019. Advisories are generated when biotic or abiotic stress occurs, moving beyond the strict bi-weekly schedule.
	Content and format-focussed; use of social media	Focuses on a succinct, single-page advisory format. Active YouTube presence with three-minute videos.
Maharashtra (Rahuri)	Physical dissemination network	Involves officers of the state agricultural department, zila parishads and gram sevaks at the panchayat level to maximize dissemination, either physically or by including them in WhatsApp groups.
Uttarakhand (Roorkee)	'Mausam Mitra' network; KVK officials involved in developing advisories	Gives the title of 'Mausam Mitra' (Weather Friend) to vigilant villagers to help disseminate advisories. KVK officials are included in the advisory board to link preparation directly.
Himachal Pradesh (Palampur)	Granular coverage innovation	Previously issued block-level advisories by clubbing blocks that had similar topography and crops to optimize the workload and provide more tailored advice.
Himachal Pradesh (Solan)	Alternative dissemination	Releases regular 'press notes' and involves home-schooled IGNOU students in their respective villages to disseminate the advisory. The state also uses the cadre system of 'Pashu Sakhi' and 'Krishi Sakhi'.
Haryana (Hissar)	Mass media reach; leveraging the DAMU network	Developed the E-Mausam application and a website portal, and maintains a high social media presence (five-six lakh YouTube followers). Also broadcasts on local news channels and newspapers through prominent, trusted academics. Most DAMUs still functional.
Punjab (Ludhiana)	Trust building and language	Publishes a weekly newsletter called 'Kheti Sandesh' in the Punjabi language (since 2017). This newsletter, shared as a PDF on WhatsApp groups, helps gain farmer trust by including the agro-weather advisory alongside relevant KVK package of practice and news.
Karnataka (Bengaluru)	Use of print media and call centre support	Prioritizes using print media for regular and impact-based forecasts. It involves <i>gram panchayats</i> to fax advisories to be printed and displayed in common places (milk dairy, schools). Also utilizes 24x7 call centre services, providing registered farmers with agro-weather information.
	Spatial optimization	Through an ongoing project (REWARD), AMFU is attempting to give advisory at a watershed level instead of simply according to area.

THE NEED FOR AGROMETEOROLOGICAL ADVISORY SERVICES IN INDIA

The frequency of extreme weather events is very high and increasing in India.¹ The debilitating impact of such events on agriculture and livestock can be mitigated to a certain extent by providing timely access to weather information, which can be interpreted by farmers for their operations.² These 'advisories', if disseminated well in advance, especially during critical crop stages, are a crucial service rendered to the farming community.

Sharing of weather forecasts with farmers has been in practice in India since 1945. But those forecasts did not provide any information on the effects of weather parameters or the management of field operations – the need for an advisory, therefore, was sorely felt. The Agrometeorological Advisory Services (AAS) bulletin was launched in the early 1970s as a result.³

Over the years, the advisories have shown a favourable impact. A study in 2020 by the New Delhi-based National Council of Applied Economic Research (NCAER) concluded that 98 per cent of surveyed farmers (3,965 farmers across 121 districts of 11 states of India) made modifications to at least one of the nine critical agricultural practices based on weather advisories.⁴ These related to changes in scheduled irrigation; early or delayed sowing; and changes in the schedules of ploughing or land preparation.

For farming households which adopted the modifications, the average annual income increased by up to Rs 3.02 lakh from Rs 1.98 lakh. The study report said that 55 per cent of the surveyed farmers received information on extreme weather almost every time; 80



per cent reported to have reduced their losses occurring due to natural calamities because of advance access to this information.

Till 2021, 43.37 million farmers in about 700 districts across the country were receiving the Agromet Advisories directly through SMS.⁵

The information and analysis presented in this chapter is based on CSE's own research and its interactions with stakeholders, including those from the government, private sector, civil society, State Agricultural Universities, Krishi Vikas Kendras (KVKs) and farmers.

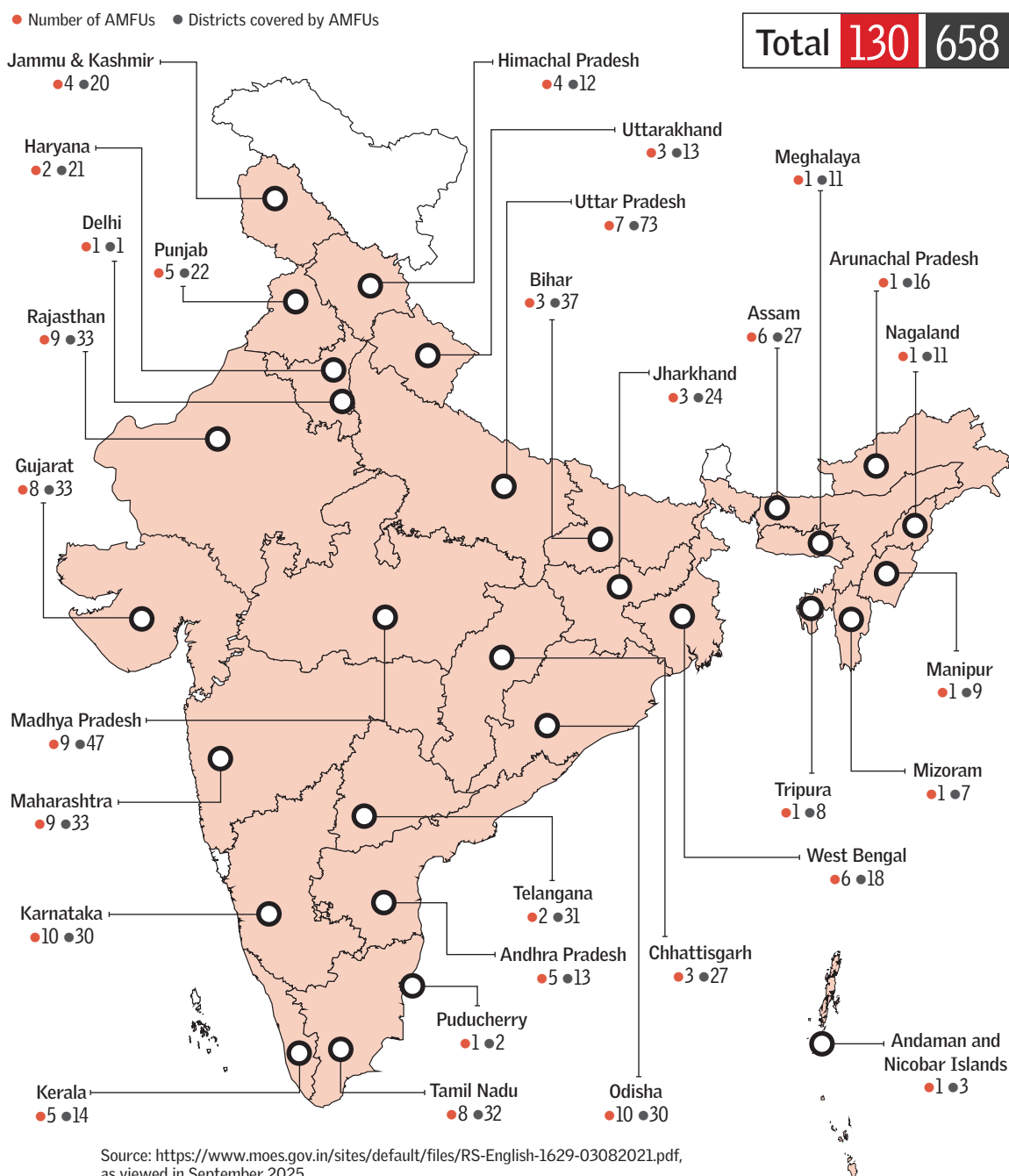
AGROMETEOROLOGICAL ADVISORY SERVICES OFFERED BY THE INDIAN GOVERNMENT

Once a weather forecast is generated by the India Meteorological Department (IMD), agricultural inputs are added to it – the final compiled form of this is an advisory. Advisories have gone through decades of evolution and are currently operational at the state, national and district levels.⁶ The national Agro Advisory Service (AAS) bulletins, based on Extended Range Forecast (ERF), are issued on a weekly basis, while district-level advisories are issued bi-weekly (Tuesdays and Fridays) by Agrometeorological Field Units (AMFUs).

These Units – generally positioned at state agricultural universities – include an agricultural scientist who receives the downscaled forecast for eight parameters: rainfall, temperature (maximum and minimum), relative humidity RH-I (per cent), relative humidity RH-II (per cent), wind speed, wind direction and cloud coverage. The forecast is then used to prepare specific agricultural advisories for the area under the AMFU. About 130 AMFUs are strategically spread out in the 128 agro-climatic zones in the country^{7,8} (see *Map 1: Distribution of AMFUs in India and the districts covered*).

In order to take the advisory to the block level, the Integrated Agro Advisory Services was extended as 'Gramin Krishi Mausam Sewa' scheme in 2018. A pilot project was planned for 100 blocks, under which advisories were to be issued collectively by 25 AMFUs; District Agrometeorological Units (DAMUs) were to be set up in the premises of Krishi Vigyan Kendras (KVKs) under the network of Indian Council of Agricultural Research (ICAR).

Map 1: Distribution of AMFUs in India and the districts covered



To encourage maximum coverage, these DAMUs were established mainly in the districts which did not have AMFUs. The government had aimed to establish 530 DAMUs across districts. Until early 2024, agromet advisories were being prepared by 130 AMFUs and

199 DAMUs bi-weekly, for all the agriculturally important districts (increased from 598 in 2013 to 700 in 2023) and around 3,100 blocks in the country (India currently has around 7,000 blocks).

Until 2021, no template was followed for the preparation of advisories. However, with the development of the 'Agromet-DSS' portal, specific templates were introduced and scientists were required to upload the advisory (district or block level) on the portal using these templates (see *Box: Creation of weather advisory by the government*).

In early 2024, as per instructions of the Ministry of Finance, and based on inputs from the NITI Aayog, the services of DAMUs were discontinued.¹¹ Many DAMU officials had put up a case against this decision in the Central Administrative Tribunal court.

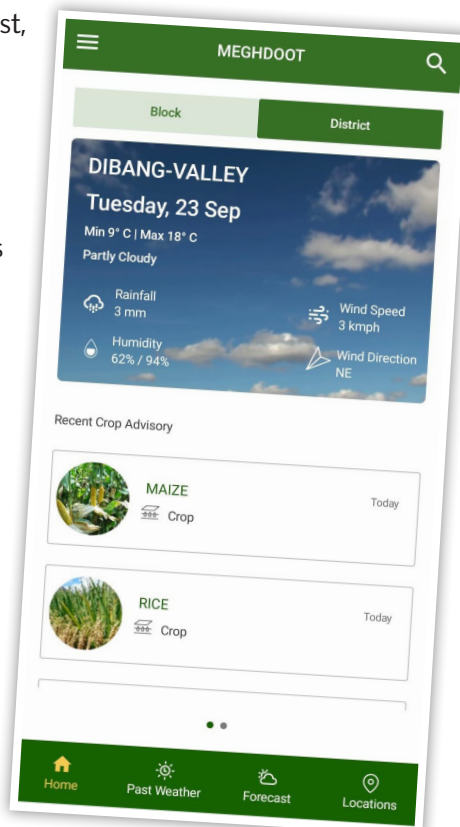
An All India Coordinated Research Project on Agrometeorology (AICRPAM), started 1983 to help the agromet advisory sector, has its coordinating unit at the Central Research Institute for Dryland Agriculture, Hyderabad.¹² Currently, 15-16 projects are functional under 30 state agricultural universities, mostly in rain-fed areas.

CREATION OF WEATHER ADVISORY BY THE GOVERNMENT

The agromet field unit, comprising of one agrometeorologist, makes the advisory; a met observer assists with the observatory. Agrometeorologists log into the Agromet DSS portal — district level weather is updated on the portal on Tuesdays and Fridays.

Based on a consultation with a 'panel' of expert scientists (from the fields of entomology, horticulture, livestock health etc), the agrometeorologist fills crop-wise data in the drop-down options. An additional box for impact-based forecast for erratic/extreme weather events is also filled in.

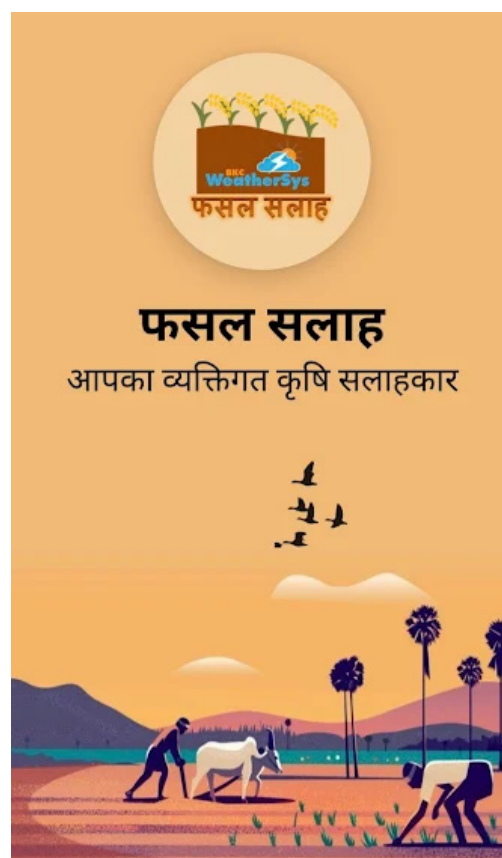
The advisory is generated as a pdf document and uploaded on the DSS portal in English and regional languages; it is accessible only to the agromet unit or those with login details. This advisory is also displayed on IMD's Agrimet website for citizens, and shared with farmers via WhatsApp groups, local news, radio, applications (like Meghdoot, Damini), social media etc.



DISTRICT-HARIDWAR									
Weather Forecast of HARIDWAR District in Uttarakhand - Issued On: 2025-07-30 (Valid Till 08:30 IST of the next 5 days)									
Date (yyyy-mm-dd)	Rainfall (mm)	Temp Max (°C)	Temp Min (°C)	Humidity I (%)	Humidity II (%)	Wind Speed (kmph)	Wind Direction (Degree)	Cloud Cover (Octa)	Warnings
2025-07-30	12.5	29.4	25.8	90	65	6	130	7	Thunderstorms & Lightning, Squall etc.
2025-07-31	6.7	33.0	26.0	90	50	4	140	6	Thunderstorms & Lightning, Squall etc.
2025-08-01	6.7	33.0	26.0	90	50	5	140	5	Thunderstorms & Lightning, Squall etc.
2025-08-02	10.4	33.0	26.2	85	55	5	130	5	Thunderstorms & Lightning, Squall etc.
2025-08-03	24.5	32.8	26.1	85	60	3	130	7	Thunderstorms & Lightning, Squall etc.
Forecast Summary of HARIDWAR District									
*Note: Please Insert in English Language only.									
*Note: Please Insert in Regional Language only.									
Weather Warnings (Valid Till 08:30 IST of next day)									
*Note: Please Insert in English Language only.									
*Note: Please Insert in Regional Language only.									

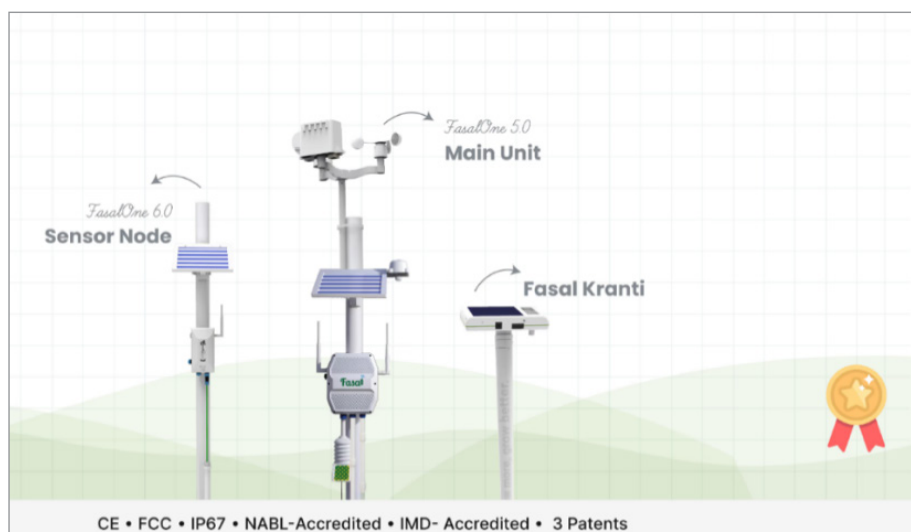
AGROMETEOROLOGICAL ADVISORY SERVICES OFFERED BY THE PRIVATE SECTOR AND CIVIL SOCIETY

BKC WeatherSys Pvt Ltd (based in Noida) is one of India's oldest weather technology companies, with its weather monitoring systems in over 500 sites.¹³ Through its 'Fasal Salah' mobile application, BKC provides real-time personalized crop advisories, based on current and forecasted weather for the next 10 days, at the taluk and village levels.¹⁴ Similarly, **Skymet Weather Services**, another Noida-based company established in 2003, operates approximately 7,000 Automatic Weather Stations (AWS) across 20 states; it provides agricultural advisory in certain states where it has ongoing projects.¹⁵ Both companies generate weather forecast by utilising their own infrastructure, using Numerical Weather Models (NWMs) and open-source information.



Fasal Salah Application

Wolkus Technology Solutions Pvt Ltd, a Bengaluru-based firm, has a 'Fasal' project under which it has developed sensors to monitor soil conditions and basic weather parameters; the company is providing real-time suggestions to those farmers who have installed these devices¹⁶. The cost of these products ranges from Rs 14,000-50,000.



Sensors under the Fasal project



WOTR's 'FarmPrecise' application

The Pune-headquartered **Watershed Organisation Trust (WOTR)** has its presence in around 10 states in India. It has developed multiple portals and applications to automate the process of issuing advisories. One example is the 'AGRIMET-DSS' application to automate weather advisories for the block level. This application, however, was handed over to the IMD a few years ago.

Currently, WOTR has a mobile-based application, the FarmPrecise, which generates dynamic weather-based crop management advisories that are tailored to match crop- and farm-specific conditions.¹⁷ It utilises research done by ICAR scientists such as soil test crop response (STCR) etc, which are fed into the application. The farmer can enter her/his information on region, area cropped etc, and the application can generate the advisory as and when required.

ADAPT, a partnership between Gates Foundation, the government of Odisha, and a consulting firm Samagra, aims to help the Odisha state government make data-informed policy decisions related to agriculture, by providing pest and weather advisory services.¹⁸ It archives this through a dashboard and a mobile application called 'SAFAL'.

The **Village Development Society** in Haridwar is not involved in creating advisories; instead, it disseminates those made by AMFUs operating from the Indian Institute of Technology in Roorkee, among a small number of rural farmers; it uses their networks or awareness programmes to do this.

GROUND-LEVEL CHALLENGES

LIMITED INFRASTRUCTURE AND CAPACITY

Typically, AMFUs are expected to have one agrometeorologist to issue bi-weekly advisories for four-five districts, on an average. This, however, is not the case in certain states. For example, in Haryana, each AMFU issues bi-weekly advisories for 11 districts, while in Bihar, the Sabour AMFU issues advisories for 17.¹⁹

This has meant AMFUs have to struggle to cover all blocks across districts, as every AMFU is linked to four-five districts that have – on an average – six-eight blocks each. This has also meant that about 24-40 advisories will have to be generated bi-weekly by one agrometeorologist – a formidable task.

An effort was made to address this challenge with the establishment of DAMUs. However, apart from reducing the capacity significantly, the discontinuation of DAMUs has led to bigger problems in issuing advisories at the district level: in some states, the DAMUs in KVKs were issuing not just block-level, but also district-level advisories.

Block-level advisories (not issued any more) had a significant impact on the decisions of farmers as district-level forecasts and advisories were good only for a limited part of a district. For example, in Himachal Pradesh, Kangra district has a varied topography; a difference in maximum temperature of around 10°C can be observed between its hilly and low-lying areas. Additionally, not all crops are grown throughout the district – a block-level advisory, therefore, would be of immense help for the district's farmers.

There is also a felt need to update the agro-climatic zones, which can potentially impact the number and placement of AMFUs.

These zones have been the basis for setting up 130 AMFUs and the initiation of district advisories from 2008.²⁰ Agro-climatic zones in India were classified five decades ago in 1971²¹ and have not been updated since, despite variations caused due to climate change; for example, semi-arid districts have become arid, while states like Rajasthan now face high rainfall.

LIMITATIONS OF CONTENT

The correlation created with the weather forecast and the inputs given in the advisory holds great significance. It requires a skilled and trained agrometeorologist with a good knowledge of the region, the different stages of the crops grown, and issues faced by farmers; s/he should be able to act as the link between the weather forecast, agricultural inputs and the farmers. At times, AMFUs do not have an adequately high level of local experience and knowledge: this can lead to insufficient advisories issued to farmers.

Another concern is advisories do not differentiate between small, medium and large-scale farmers. Though weather forecasts and irrigation requirements would be common for all, aspects such as a farmer's capacity to buy agricultural inputs or chemicals could vary.

Advisories can also prove to be too technical for a small farmer. They are not always succinct and brief. In many cases, they are three-four pages long and tend to contain generic information like *"animals should be kept under shed during peak hours in summer"*, etc.

LIMITED REACH

According to the Union Ministry of Earth Sciences, in 2021, about 43.37 million farmers were receiving agromet advisories through SMS. Farmers claim that these SMS-based alerts are no longer reaching them. A January 2025 study by the IMD says about 1.76 million farmers in about 0.135 million villages from 4,015 blocks are being covered through 18,631 WhatsApp groups.²² Experts are of the opinion that about 30 million farmers might be receiving the advisory. The data on how many are actually receiving the advisories is sketchy. But a bigger concern is that with over 140



million farming households in the country, a large part of this population may not be having access to such advisories in all likelihood.

While the focus is on ICT methods through applications (Meghdoot, Damini) and websites/portals (IMD, Agrimet), this has its own set of challenges, such as internet connectivity or technologically-challenged elderly farmers. AMFU scientists have also highlighted the high dependence on WhatsApp groups for dissemination of advisories. With the closure of DAMUs, the established networks of farmers created through such groups has been lost.

Added to these problems is the limited coordination among officials of the two key ministries involved (the Ministry of Earth Sciences and the Ministry of Agriculture and Farmers' Welfare). Physical review meetings of AMFU officials are rarely held.

OPPORTUNITIES AND POSSIBILITIES FOR IMPROVEMENT

Was the lack of trained personnel the reason for discontinuation of DAMUs? We do not know. But the country does have agrometeorologists passing out every year from its many agricultural universities – the skills of this community can be tapped potentially. Experts are of the opinion that about Rs 60 crore would be needed every year to pay salaries for the 660 DAMUs/AMFUs (at Rs 75,000 per month for each).²³

Another opportunity lies in scaling up collaborative projects with private sector and the civil society to ensure higher quality hyper-local advisories that reach farmers on time. The stakeholder ministries have recognised that they cannot reach all farmers and have emphasised the need to take on board the private sector and its innovative technologies. The ministries believe that public, private and non-government organisations need to work together in farm extension activities.²⁴

Other potential options include collaboration with the National Disaster Management Authority, as SMS services/alerts by these agencies in the case of erratic weather events are already functional. If these services are made area-specific, they can prove to be beneficial for farmers. Utilising the knowledge of state agricultural officers while devising an advisory by including them in the panel of experts, and using their widespread network for percolation of the advisory, are possibilities which can be explored.

AMFUs have their own unique ways of reaching out to farmers (ranging from social media platforms like YouTube to using the networks of other departments in a state): these initiatives need to be recognised, scaled up and shared between different states.



CASE STUDIES: AMFU INITIATIVES TO STRENGTHEN QUALITY AND REACH OF ADVISORIES

HIMACHAL PRADESH

State agro-profile

- About 80 per cent cultivated area is rain-fed. The state's hilly terrain leads to a mixed farming approach, with agro-pastoral, silvi-pastoral, and agro-horticultural systems prevalent.²⁵
- The major kharif crops are maize, paddy, millets and pulses; the rabi crops include wheat, barley, gram, pulses and vegetables.²⁶

Table 2: AMFUs in Himachal Pradesh

AMFU	Districts under the AMFU	State agricultural universities with the AMFU
Kukumsheri	Kinnaur, Lahaul and Spiti	Ch Sarwan Kumar Himachal Pradesh Krishi Viswavidyalaya
Palampur	Una, Hamirpur, Kangra, Chamba	
Seobagh	Kullu, Mandi	Dr Yaswant Singh Parmar University of Horticulture and Forestry, Solan
Nauni (Solan)	Solan, Shimla, Bilaspur, Sirmaur	

Initiatives and impacts

- Between 2018 and 2024, AMFU Solan had been issuing block-level advisories, which were discontinued. It is now exploring the option of mentioning block-level forecasts in the district-level advisories.
- 'Press notes' are issued regularly; students of the India Gandhi National Open University have been roped in to disseminate the

advisories. These students are already based in their respective villages, and hence can be approached.

- AMFU Palampur had begun issuing block-level advisories in 2015-16. With 15 blocks under it, an innovation was tried: blocks that had similar topography and crops were clubbed together and limited block-level advisories issued.
- At the state level, services of 'Pashu Sakhi' and 'Krishi Sakhi' are used to increase the reach of agro-weather advisories. Block-level cadre groups have been created on WhatsApp.
- In Chamba, the KVK which has an ongoing NICRA project, has adopted 18 villages (a whole panchayat) and is in constant touch with the farmers for almost 10 years through WhatsApp groups.
- In response to a timely warning of hailstorm by the Solan AMFU earlier in 2025, farmers were able to use anti-hail methods such as putting dry hay on top of their cucumber crop. In Mashobra, farmers used hail nets and were able to save their crops from damage.

MAHARASHTRA

State agro-profile

- Having 36 districts in nine major agro-climatic zones, the cropping intensity in the state is around 127 per cent.²⁷
- Important crops are sugarcane, cotton, sorghum, pearl millet, chickpea, soybean, sunflower and safflower.²⁸

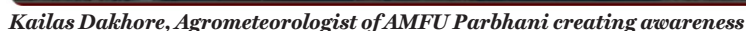
Table 3: AMFUs in Maharashtra

AMFU	Districts under the AMFU	State agricultural universities with AMFUs
Akola	Akola, Amravati, Wardha, Buldana, Washim, Yeotmal	Dr Panjabrao Deshmukh Krishi Vidyapeeth
Shindewahi	Bhandra, Gadchiroli, Chandrapur, Nagpur, Gondia	
Dapoli	Thane, Raigarh, Ratnagiri	Dr Balasaheb Sawant Konkan Krishi Vidyapeeth
Mulde(Kudal)	Sindhudurg	Mahatma Phule Krishi Vidyapeeth
Igatpuri	Nashik	
Kolhapur	Satara, Kolhapur, Sangli	
Pune	Solapur, Pune, Jalgaon	
Rahuri	Dhule, Ahmednagar, Nandurbar	Vasantrao Naik Marathwada Krishi Vidyapeeth
Parbhani	Beed, Osmanabad, Parbhani, Latur, Jalna, Hingole, Aurangabad, Nanded	

NOTES: Some DAMUs are still operational as they are part of an ongoing case in the Central Administrative Tribunal against the closure of DAMUs. Organizations like the Maharashtra State Grape Growers Association are also involved in preparing the agromet advisories.

Initiatives and impacts

- AMFU Parbhani is still issuing block-level advisories in 25 blocks of three districts (Osmanabad, Aurangabad and Parbhani). It had earlier collaborated with the Indian Space Research Organization.
- It has been automating the generation of agromet advisories since 2019 through a collaborative effort, with the focus on cotton, soybean and pigeon pea crops. These advisories can be generated whenever there is a biotic or abiotic stress in the region – instead of twice or thrice a week.
- AMFU Rahuri involves officers of the state agricultural department and zila parishad, as well gram sevaks at panchayat level to maximize dissemination of the advisory. These officers are either included in WhatsApp groups or are asked to physically disseminate the advisories in villages.
- To monitor impact, AMFU Parbhani is issuing projects to university students pursuing Masters or PhD in agrometeorology.
- AMFU Parbhani has an active YouTube channel, and streams short three-minute videos. The AMFU's advisory is an easy-to-read single page document.



Single page advisory by AMFU Parbhani



UTTARAKHAND

State agro-profile

- Major kharif crops are paddy, maize, millets, pulses, oilseeds and sugarcane; major rabi crops include wheat, barley, pulses and mustard.²⁹

Table 4: AMFUs in Uttarakhand

AMFU	Districts under the AMFU	State agricultural universities with the AMFUs
Pantnagar	Udham Singh Nagar, Nainital	G B Pant University of Agriculture and Technology, Pantnagar
Ranichauri	Uttarkashi, Chamoli, Rudrapur, Pithoragarh, Bageshwar, Champawat, Almora, Tehri-Garhwal	VCSG Uttarakhand University of Horticulture and Forestry, Bharsar
Roorkee	Dehradun, Pauri, Haridwar	IIT Roorkee

Initiatives and impacts

- The AMFU in IIT Roorkee has KVK officials in the advisory board, who thus have a say in how the advisories are prepared.
- The met observer takes the data manually from the observatory, which helps authenticate the forecasts.
- Currently, the AMFUs share district-level advisories at the block level as well through WhatsApp groups (in the absence of exclusive block-level advisories).
- Farmers can access block-level forecasts through 'green alerts', an initiative of the IMD. The link to these is shared on WhatsApp groups by the AMFU scientists.³⁰
- AMFU Roorkee gives the title of 'Mausam Mitra' to a vigilant villager to help disseminate the advisories. It has 30 Mausam Mitras so far, who can reach out to 30,000 farmers. The concept of Mausam Mitra was initially designed for farmers who do not have smart phones.

- Scientists are required to do at least five awareness and training programmes in villages and blocks.

HARYANA

State agro-profile

- Known as the 'rice bowl' of India, Haryana's major kharif crops include rice, jowar, bajra, maize, cotton, jute, sugarcane, sesame and groundnut. Rabi crops are wheat, barley, gram, rapeseed and mustard.³¹
- About 83 per cent of the state's area is cultivable. There are two agro-climatic zones.³²

Table 5: AMFUs in Haryana

AMFU	Districts under the AMFUs	State agricultural universities with the AMFUs
Kaul	Panchkula, Ambala, Yamuna Nagar, Kurukshetra, Kaithal, Karnal, Panipat, Sonipat, Gurugram, Faridabad, Jind, Mewat	Chaudhary Charan Singh Haryana Agricultural University, Hisar
Hissar	Palwal, Sirsa, Fatehabad, Hissar, Bhiwani, Mahendragarh, Rewari, Rohtak, Jhajjar	

Initiatives and impacts

- Out of the 13 established DAMUs, 11 are still functional. As a result, the districts which have DAMUs set up in their KVKs also get the block-level advisories. For example, KVK Sonipat is issuing nine advisories bi-weekly, eight for all the blocks and one at the district level. In some cases, DAMUs have been given the additional responsibility of making district-level advisories for neighbouring districts as well. For example, the scientists in KVK Gurugram make district-level advisories for three neighbouring districts.
- AMFU Hissar developed the 'E-Mausam' application (to send SMS to farmers). Its website portal has high social media presence (Facebook and YouTube), with large numbers of

followers (45,000 on FB and five to six lakh on YouTube). The AMFU also broadcasts on local news channels and newspapers through prominent academics whom farmers trust.

- Farmers say that the advisories are helpful. A recent advisory on the use of potash to tackle heat stress has helped. In 2024, a hailstorm warning at the right time saved their mustard harvest.



PUNJAB

State agro-profile

- Punjab's major kharif crops include paddy, maize, cotton and sugarcane; in rabi, the state grows wheat, barley, gram, mustard and vegetables like potato.³³
- The dominance of the wheat-paddy cycle has led to challenges like groundwater depletion and soil degradation.

ਸਾਉਣੀ ਰੁੱਤ ਦੀ ਮੂੰਗੀ ਦੀ ਸਫਲ ਕਾਸ਼ਤ

ਫਲੀਦਾਰ ਫਸਲਾਂ ਮਿੱਟੀ ਦੀ ਸਿਹਤ ਵਿੱਚ ਸੁਧਾਰ ਦੇ ਨਾਲ ਪਾਣੀ ਦੀ ਬਚਤ ਵਿੱਚ ਅਹਿਮ ਯੋਗਦਾਨ ਪਾਉਂਦੀਆਂ ਹਨ। ਸਾਉਣੀ ਦੌਰਾਨ ਮੂੰਗੀ ਦੀ ਬਿਜਾਈ ਜ਼ਿਆਦਾਤਰ ਬਰਾਨੀ ਜਾਂ ਘੱਟ ਪਾਣੀ ਵਾਲੇ ਖੇਤਾਂ ਵਿੱਚ ਕੀਤੀ ਜਾਂਦੀ ਹੈ।

ਕਾਸ਼ਤ ਲਈ ਉੱਨਤ ਕਿਸਮਾਂ :

	ਬੂਟਿਆਂ ਦਾ ਕੋਦ	ਇਕ ਫ਼ਲੀ ਵਿੱਚ ਦਾਣਿਆਂ ਦੀ ਗਿਣਤੀ	ਝਾੜ (ਕੁਇੰਟਲ/ਏਕੜ)	ਪੱਕਣ ਲਈ ਸਮਾਂ	ਰੋਗਾਂ ਦਾ ਟਾਕਰਾ ਕਰਨ ਦੀ ਸਮਰੱਥਾ
ਐਮ ਐਲ 1303 (2021)	71 ਸੈਂਟੀਮੀਟਰ	11-12	4.8	71	ਪੀਲੀ ਚਿੱਤਕਬਰੀ ਅਤੇ ਪੱਤਿਆਂ ਦੇ ਰੋਗਾਂ ਦਾ ਟਾਕਰਾ ਕਰਨ ਦੀ ਸਮਰੱਥਾ ਹੈ
ਐਮ ਐਲ 2056 (2016)	78 ਸੈਂਟੀਮੀਟਰ	11-12	4.6	71	
ਐਮ ਐਲ 818 (2003)	75 ਸੈਂਟੀਮੀਟਰ	10-11	4.2	72	

ਬਿਜਾਈ ਦਾ ਸਮਾਂ: ਮੂੰਗੀ ਦੀ ਬਿਜਾਈ ਜੁਲਾਈ ਦੇ ਦੂਜੇ ਪੰਦਰਵਾਂ ਤੋਂ ਵਿੱਚ ਕਰੋ। ਇਕ ਏਕੜ ਲਈ 8 ਕਿਲੋ ਬੀਜ ਵਰਤੋ ਅਤੇ ਜੀਵਾਣੂ ਖਾਦ (ਰਾਈਜ਼ੋਬੀਅਮ ਕਲਚਰ) ਦੇ ਟੀਕੇ ਨਾਲ ਸੋਧ ਕੇ ਬਿਜਾਈ ਕਰੋ। ਇਸ ਟੀਕੇ ਦੀ ਵਰਤੋਂ ਕਰਨ ਨਾਲ 12-16 ਪ੍ਰਤੀਸ਼ਤ ਝਾੜ ਵਿੱਚ ਵਾਧਾ ਹੁੰਦਾ ਹੈ।

• ਬਿਜਾਈ ਲਈ ਕਤਾਰ ਤੋਂ ਕਤਾਰ ਦਾ ਫਾਸਲਾ 30 ਸੈਂਟੀਮੀਟਰ ਅਤੇ ਬੂਟੇ ਤੋਂ ਬੂਟੇ ਦਾ ਫਾਸਲਾ 10 ਸੈਂਟੀਮੀਟਰ ਰੱਖ ਕੇ ਡਰਿਲ ਕਰੋ। ਵਧੇਰੇ ਝਾੜ ਲੈਣ ਲਈ ਮੂੰਗੀ ਦੀ ਦੋ ਤਰਫਾ ਬਿਜਾਈ ਕੀਤੀ ਜਾ ਸਕਦੀ ਹੈ। ਮੂੰਗੀ ਦੀ ਬਿਜਾਈ ਬਿਨਾਂ ਖੇਤ ਵਾਹੇ ਜ਼ੀਰੋ ਟਿਲ ਡਰਿੱਲ ਨਾਲ ਵੀ ਕੀਤੀ ਜਾ ਸਕਦੀ ਹੈ। ਦਰਮਿਆਨੀਆਂ ਅਤੇ ਭਾਰੀਆਂ ਜ਼ਮੀਨਾਂ ਵਿੱਚ ਮੂੰਗੀ ਦੀ ਬਿਜਾਈ ਕਣਕ ਲਈ ਵਰਤੇ ਜਾਂਦੇ ਬੈਂਡ ਪਲਾਂਟਰ ਨਾਲ 67.5 ਸੈਂਟੀਮੀਟਰ ਵਿੱਚ ਤੇ ਤਿਆਰ ਕੀਤੇ ਬੈਂਡਾਂ (37.5 ਸੈਂਟੀਮੀਟਰ ਬੈਂਡ ਅਤੇ 30 ਸੈਂਟੀਮੀਟਰ ਖਾਲੀ) ਉੱਤੇ ਕਰਨੀ ਚਾਹੀਦੀ ਹੈ। ਮੂੰਗੀ ਦੀਆਂ ਕਤਾਰਾਂ ਪ੍ਰਤੀ ਬੈਂਡ 20 ਸੈਂਟੀਮੀਟਰ ਫਾਸਲੇ ਤੇ ਬੀਜੇ। ਬੈਂਡਾਂ ਉੱਤੇ ਬਿਜਾਈ ਕਰਨ ਨਾਲ ਪਾਣੀ ਦੀ ਬੱਚਤ ਹੁੰਦੀ ਹੈ ਅਤੇ ਫਸਲ ਭਾਰੀ ਮੀਂਹ ਤੋਂ ਹੋਣ ਵਾਲੇ ਨੁਕਸਾਨ ਤੋਂ ਵੀ ਬਚਦੀ ਹੈ।

ਨਦੀਨਾਂ ਦੀ ਰੋਕਥਾਮ: ਮੂੰਗੀ ਵਿੱਚ ਨਦੀਨਾਂ ਦੀ ਰੋਕਥਾਮ ਕਰਨ ਲਈ ਦੋ ਗੋਡੀਆਂ ਕਰੋ, ਪਹਿਲੀ ਗੋਡੀ ਬਿਜਾਈ ਤੋਂ 4 ਹਫ਼ਤੇ ਪਿੱਛੋਂ ਅਤੇ ਦੂਜੀ ਉਸ ਤੋਂ ਦੋ ਹਫ਼ਤਿਆਂ ਬਾਅਦ ਕਰਨੀ ਚਾਹੀਦੀ ਹੈ।

ਖਾਦਾਂ ਅਤੇ ਸਿੰਚਾਈ: ਮੂੰਗੀ ਦੀ ਫਸਲ ਨੂੰ ਖਾਦਾਂ ਅਤੇ ਪਾਣੀ ਦੀ ਬਹੁਤ ਘੱਟ ਲੋੜ ਹੁੰਦੀ ਹੈ। ਬਿਜਾਈ ਸਮੇਂ 11 ਕਿਲੋ ਯੂਰੀਆ ਪ੍ਰਤੀ ਏਕੜ ਅਤੇ 100 ਕਿਲੋ ਸਿੰਗਲ ਸੁਪਰਫਾਸਫੇਟ ਪ੍ਰਤੀ ਏਕੜ ਡਰਿੱਲ ਕਰੋ। ਮੂੰਗੀ ਦੀ ਫਸਲ ਨੂੰ ਜੇਕਰ ਔੜ ਲਗਦੀ ਹੈ ਤਾਂ ਸਿੰਚਾਈ ਕਰਨੀ ਚਾਹੀਦੀ ਹੈ। ਸਾਉਣੀ ਵਿੱਚ ਫੁੱਲ ਅਤੇ ਫਲੀਆਂ ਬਣਨ ਸਮੇਂ ਫਸਲ ਨੂੰ ਸੋਕਾ ਨਹੀਂ ਲੱਗਣਾ ਚਾਹੀਦਾ। ਜੇਕਰ ਮੀਂਹ ਨਾ ਪਵੇ ਤਾਂ ਫਲ ਪੈਣ ਸਮੇਂ ਮੂੰਗੀ ਦੀ ਸਿੰਚਾਈ ਕਰਨੀ ਚਾਹੀਦੀ ਹੈ।

ਵਾੜੀ ਅਤੇ ਗਹਾਈ: ਜਦੋਂ ਮੂੰਗੀ ਦੀ ਫਸਲ ਦੀਆਂ ਤਕਰੀਬਨ 80 ਪ੍ਰਤੀਸ਼ਤ ਫਲੀਆਂ ਪੱਕ ਜਾਂਦੀਆਂ ਹਨ ਤਾਂ ਮੂੰਗੀ ਦੀ ਵਾੜੀ ਕਰ ਲੈਣੀ ਚਾਹੀਦੀ ਹੈ ਅਤੇ ਕਣਕ ਵਾਲਾ ਬਰੈਸਰ ਕੁਝ ਤਬਦੀਲੀਆਂ ਕਰਕੇ ਗਹਾਈ ਲਈ ਵਰਤਿਆ ਜਾ ਸਕਦਾ ਹੈ।

ਪਰਮਿੰਦਰ ਸਿੰਘ ਸੰਧੂ, ਰਮਿੰਦਰ ਸਿੰਘ ਘੁੰਮਣ ਅਤੇ ਪਰਵਿੰਦਰ ਸਿੰਘ, ਫਾਰਮ ਸਲਾਹਕਾਰ ਸੇਵਾ ਕੇਂਦਰ, ਤਰਨ ਤਾਰਨ
ਮੋਬਾਇਲ: 98882-99130

Kheti Sandesh newsletter

Table 6: AMFUs in Punjab

AMFU	Districts under the AMFUs	State agricultural university with the AMFUs
Bhatinda	Moga, Bhatinda, Mansa, Muktsar, Sangrur, Barnala	Punjab Agriculture University
Faridkot	Firozpur, Faridkot, Fazilka	
Gurdaspur	Hoshiarpur, Gurdaspur, Pathankot	
Ludhiana	Amritsar, Kapurthala, Jalandhar, Ludhiana, Fatehgarh Sahib, Tarn Taran, Patiala	
Kandi	Mohali, Rup Nagar, Nawanshahr	

Initiatives and impacts

- With block-level advisories stopped, AMFU Ludhiana is sharing block-level forecasts on existing WhatsApp groups of farmers. There are as many as 400 WhatsApp groups reaching about 10 lakh farmers. University website, portal, PAU Kisan app, e-mails etc are some of the other outreach initiatives.
- Since 2017, a university newsletter called 'Kheti Sandesh' has helped gain the farmers' trust. Published in Punjabi language, this newsletter is shared weekly as a PDF on WhatsApp groups and is made available on the university website. Apart from the agro-weather advisory, the newsletter also contains information on the package of practice for KVKs, news/articles that might be relevant to the farmers, etc.
- KVK Jalandhar has started its own SMS service to farmers.
- Services of private organizations like Skymet and Accuweather are used by farmers to get accurate weather forecasts.

KARNATAKA

State agro-profile

- Crops grown include rice – which more or less is the staple food – maize, pulses and oil seeds. Sugarcane, cashews, cardamom and chillies are also produced on a large scale in the state.³⁴

- Karnataka has the maximum number of operational AMFUs in the country.

Table 7: AMFUs in Karnataka

AMFU	Districts under the AMFUs
Bengaluru	Bengaluru Rural, Bengaluru Urban, Kolar, Chickballapur, Ramnagar
Bidar	Bidar
Vijayapura	Vijayapura, Gadag, Bagalkot
Brahamavar	Udupi, Dakshin Kannada
Dharwad	Dharwad, Belgavi, Haveri
Hiriyur	Chitradurga, Davangere, Tumakuru
Nagahalli	Mysuru, Mandya, Chamrajnagara, Kodagu
Neveli	Shivamogga, Hassan, Chikmangaluru
Raichur	Ballari, Kalaburgi, Koppal, Raichur, Yadgir
Sirsi	Uttar Kannada

Initiatives and impact

- AMFU Bengaluru is trying to give advisories at a watershed level instead of as per area, through an ongoing project: 'Rejuvenating Watersheds for Agricultural Resilience through Innovative Development (REWARD)', being conducted in collaboration with Karnataka State Natural Disaster Monitoring Centre (KSNDMC), Watershed Institute, and the State Agricultural Department.
- AMFU Bengaluru prioritises using warm-blooded channels like print media for regular and impact-based forecasts and involves gram panchayats to fax advisories to local people who print and disseminate the advisory in common places like dairies, schools etc.
- AMFU Bengaluru also uses call centre services (running 24x7) as a part of its ongoing collaboration with KSNDMC. Once a farmer is registered here, s/he also gets the agro-weather information.



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AGENDA: RESILIENCE THROUGH INSURANCE TO COVER RISKS AND LOSSES

CROP INSURANCE IN INDIA

HOW TO DESIGN TO BENEFIT FARMERS IN CLIMATE-RISKED TIMES



IN BRIEF

THE MAGNITUDE OF WEATHER-RELATED RISKS AND THE URGENT NEED FOR PROTECTION

Agriculture, which accounts for approximately 16 per cent of India's GDP and employs about 46 per cent of its workforce, faces increasing vulnerability due to external risks. The growing prevalence of climate shocks and extreme weather events necessitates robust risk protection to secure rural livelihoods.

The severity of these weather risks is starkly evidenced by the rise in agricultural area affected – crop losses due to extreme weather have more than doubled in recent years, escalating from 19.6 lakh hectare (ha) in 2022 to 40.72 lakh ha in 2024. Insurance schemes, dating back to the 1970s, were developed precisely to protect farmers from such yield losses due to non-preventable natural risks. Earlier schemes, however, faltered because of weak infrastructure, limited coverage, delayed processes and unsustainable fiscal liabilities.

EFFECTIVENESS OF PMFBY IN ADDRESSING FARMER RISK AND TRUST

Introduced in 2016, PMFBY aims to provide comprehensive coverage against risks such as drought, floods and hailstorms, incorporating modern technology such as geo-tagging and mobile apps to improve data collection and transparency.

The trust deficit and financial imbalances

While PMFBY has successfully enrolled an increasing number of farmers in the kharif season (up 19.5 per cent between 2018 and 2024), its overall coverage remains limited, representing only a small fraction of over 140 million farming households in the country.

Critically, PMFBY's performance over the last six years shows a severe disparity between collected premiums and claims paid, leading to significant farmer distrust:

- **Massive decline in payouts:** Total claims paid to farmers saw a major decline. Between 2018 and 2024, the payouts dropped by 49.9 per cent in kharif and nearly 78.73 per cent in rabi seasons.
- **Plummeting claim ratios:** The claim ratio (claims paid vs. premium collected) dramatically declined. In kharif, it fell from 90.8 per cent in 2018 to a mere 38.7 per cent in 2024; in rabi, it fell from 105.1 per cent to 22.4 per cent.
- **Insurance company surpluses:** This massive divergence between large premium inflows and relatively low claims outgo resulted in substantial profits for insurance providers. In 2023–2024, the total surplus generated by implementing companies was approximately Rs 13,001 crore. 13 out of 15 companies reported a hefty surplus, with some having claim ratios as low as 17 per cent.
- **Low beneficiary rate:** Consequently, the percentage of enrolled farmers who actually benefited from the scheme plummeted from 33.9 per cent in kharif 2018 to 23.8 per cent in 2024, and in rabi, it fell to a staggering 9.1 per cent.

This situation strengthens the perception among farmers and stakeholders that insurance companies are maximizing profits, leading directly to a loss of confidence in the scheme.

Implementation failures undermining trust

Farmer dissatisfaction stems from critical implementation issues that PMFBY has struggled to overcome:

- **Delayed and inadequate claims:** Farmers frequently report long waiting periods and compensation that does not match their actual losses.



- **Faulty loss assessment:** Trust is eroded by the perceived neglect of micro-climatic variability (localized losses are often ignored) and concerns regarding the non-conduct or inaccurate implementation of Crop Cutting Experiments (CCEs) – the primary method for yield estimation.

Systemic barriers: Farmers face difficulties due to opaque grievance mechanisms, complex digital interfaces, documentation challenges and reported exposure to corruption during claim settlement.

PERFORMANCE OF STATE SCHEMES

Several states have opted out of PMFBY in certain years to implement their own models, often in response to farmer dissatisfaction and to manage the high fiscal burden associated with sharing premium subsidies.

These state schemes – such as the Bihar Rajya Fasal Sahayata Yojana, the Jharkhand Fasal Rahat Yojana, and the Mukhyamantri Kisan Sahay Yojana of Gujarat – typically function as financial relief or compensation schemes, not classic insurance. A key factor in schemes like those implemented by Bihar, Gujarat and West Bengal (the Bangla Shasya Bima) is that they require zero premium payment from farmers, as the government bears the full cost, potentially increasing accessibility and trust.

WHAT NEEDS TO BE DONE

To effectively address farmer risk and rebuild trust, the sources suggest focusing on systemic improvements and exploring alternative models:

- **Improve PMFBY coverage:** There is significant scope to expand PMFBY coverage beyond the current limited penetration.
- **Enhance claim transparency and adequacy:** Addressing the widespread discontent requires solving the problems of delayed or inadequate compensation and establishing transparent, accessible channels for grievance redressal.

- **Modernize loss assessment:** Improving the accuracy and timeliness of claim settlements is paramount. This requires moving away from manual assessment toward complete digitization of crop loss estimation, potentially through tools like YES-TECH.
- **Scale parametric insurance:** Parametric insurance, which uses weather indices (like rainfall or temperature) as triggers for payout rather than manual crop loss assessment, offers a potential solution to uncertainty and lack of transparency. The Restructured Weather Based Crop Insurance Scheme (RWBCIS) is the existing government-subsidized parametric model and represents a good opportunity for expansion, if supported adequately by technological solutions. Although currently not at scale, parametric products are already being offered by private companies and in specific sectors (e.g., heat-index insurance for cattle).

NEED FOR RISK PROTECTION AGAINST EXTREME WEATHER EVENTS

Agriculture and allied sectors contribute approximately 16 per cent to India's Gross Domestic Product (GDP) and employ around 46 per cent of the workforce.¹

Agricultural performance influences food prices, nutritional outcomes and the stability of rural credit systems, making it central to the broader development agenda. However, this dependence on agricultural performance also heightens the vulnerability of a large section of the population. Increasing climate shocks, fluctuating markets and a strained natural resource base expose farming households to risks that extend beyond individual losses, threatening the resilience of rural livelihoods.

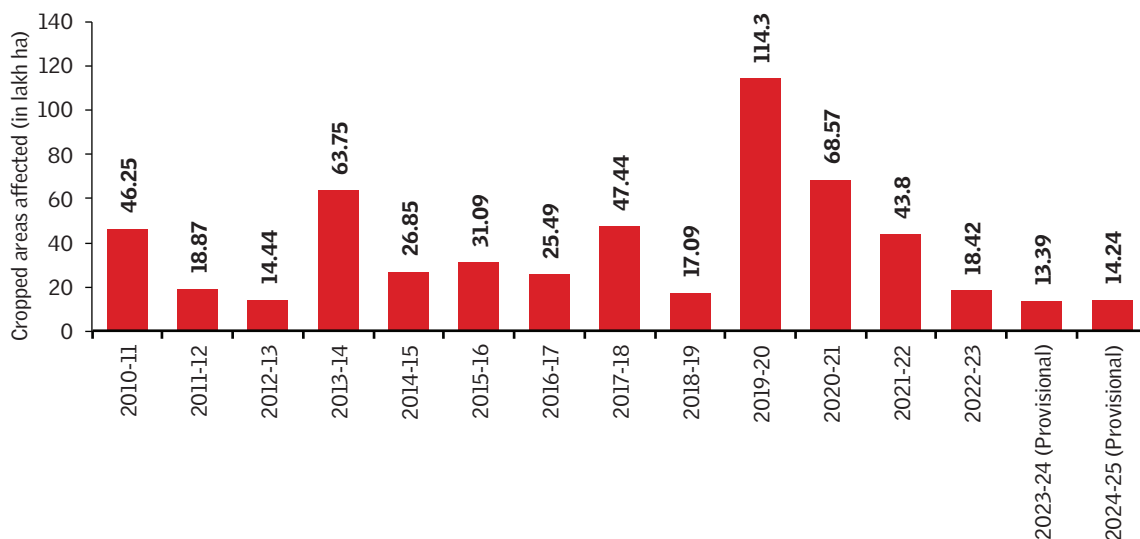
Agricultural losses due to extreme weather events have risen from 19.60 lakh hectare in 2022 to 40.72 lakh hectare in 2024 (see *Table 1: Agricultural losses due to extreme weather events*).

Table 1: Agricultural losses due to extreme weather events

Agricultural losses	2022	2023	2024
Crop area affected (lakh hectare)	19.60	22.14	40.72
Animal deaths	69,899	1,24,813	67,399

Source: India's atlas on weather disasters, Down to Earth²

Graph 1: Crop area affected due to natural extreme events in India



Source: EnviStats India 2025: Environment Statistics³

Also, the Government of India (GOI) publishes data on cropped area affected and cattle lost due to natural extreme events as part of the EnviStats India. According to these reports, there have been several years over the last decade when the cropped area affected was significantly higher (see *Graph 1: Crop area affected due to natural extreme events in India*).

For the years 2023 and 2024, the EnviStats India 2025 reports lower cropped areas affected, likely due to difference in the tenure of calculation (financial year) and the provisional status of the data.

EVOLUTION OF CROP INSURANCE IN INDIA

The idea of crop insurance in India dates back to the 1970s, when the government experimented with schemes to protect farmers from yield losses. The first crop insurance pilot was introduced in 1972, followed by the Comprehensive Crop Insurance Scheme (CCIS) in 1985. CCIS linked insurance with crop loans but had limited coverage and low claim efficiency.⁴



In 1999, the government launched the National Agricultural Insurance Scheme (NAIS), expanding coverage to more crops and farmers. However, NAIS faced criticism for delays in claim settlement due to its dependence on large-scale crop cutting experiments. To address such shortcomings, the Modified NAIS (MNAIS) was introduced in 2010 with improved features, such as actuarial premium rates and better risk coverage.⁵

In parallel, the Weather-Based Crop Insurance Scheme (WBCIS) was introduced in 2007 on a pilot basis, using weather parameters such as rainfall and temperature as proxies for crop yield, enabling quicker claim settlements.

Earlier crop insurance schemes in India faltered due to weak infrastructure, delayed processes, limited risk coverage and unsustainable fiscal liabilities, preventing them from delivering timely or adequate protection to farmers.⁶ A major reform came in 2016 with the Pradhan Mantri Fasal Bima Yojana (PMFBY). It expanded risk coverage and introduced technology for monitoring, among other changes.⁷

PRADHAN MANTRI FASAL BIMA YOJANA (PMFBY)

The Pradhan Mantri Fasal Bima Yojana (PMFBY) is the central crop insurance scheme that protects farmers against the perils of crop loss or failure resulting from non-preventable natural risks. It became voluntary in 2020 for loanee farmers (those who have taken loans under the Kisan Credit Card scheme), while non-loanee farmers have always had the option to enroll voluntarily.⁸

Farmers are expected to pay around two per cent of the premium for kharif crops, and 1.5 per cent for rabi crops, with the rates being set by insurance companies. The remaining premium is paid by the central government. Based on crop losses calculated through manual or technology-enabled CCEs, claims are then paid out to farmers. In all participating states, districts are clubbed together into clusters, based on actuarial and climate risk, determined using historical data.⁹

HOW A CROP CUTTING EXPERIMENT (CCE) IS DONE

CCEs are field-based studies carried out by state governments to estimate the average yield of a crop in a notified unit, usually a Gram Panchayat. Fields are chosen at random, a small plot is marked, the crop is harvested and weighed, and the results are recorded. Data from multiple plots is combined to calculate average yield. This figure is then compared with the **threshold yield** (based on historical data). If the average falls below the threshold, farmers in the unit receive insurance payouts. CCE numbers are set using statistical principles, depending on crop variability and required accuracy, but generally eight-24 per crop per unit are conducted. Across India, more than a million CCEs are done annually.

In recent years PMFBY has introduced mobile apps, geo-tagging and satellite tools to speed up data collection, reduce errors, and make the system transparent.¹¹



State governments release tenders wherein insurance companies bid to implement PMFBY in the respective district(s). Accordingly, the lowest bidder is selected to implement PMFBY.

PMFBY is provided to cover losses in crop yield on an area-based approach, against non-preventable risks like drought, dry spells, flood, inundation, wide-spread pest and disease attack, landslide and natural fire due to lightening, storm, hailstorm and cyclone.¹⁰

Add-on covers are provided to protect against mid-season, post-harvest losses (limited to a maximum period of two weeks after harvesting), as well as losses from localized calamities. States and union territories (UTs) may also opt to provide add-on coverage for crop losses caused by wild animal attacks. Losses arising out of war and nuclear risks, malicious damage and other preventable risks are generally excluded under PMFBY.¹²

APPROACHES OF RISK-SHARING BETWEEN GOVERNMENTS AND INSURANCE COMPANIES

The scheme generally operates on a risk transfer approach, with the risk transferred entirely – or to varying extents – to insurance companies. In Andhra Pradesh, Rajasthan, Tamil Nadu, Puducherry, the Cup & Cap Model (60:130) is followed. Under this model, insurers carry the liability so long as claims fall within 60 to 130 per cent of the premium. If claims exceed the 130 per cent ceiling, the excess is borne by the state and central government. Similarly, if claims fall below 60 per cent, insurers must share the savings with the government.

In states like Karnataka, Madhya Pradesh, Maharashtra and Uttar Pradesh, the Cup & Cap Model (80:110) is followed. In this model, insurers are liable only if claims remain between 80 and 110 per cent of the premium collected. Any losses beyond 110 per cent fall on the state and the centre, while gains below 80 per cent must also be shared back with the state and central governments.

The above two models have replaced the original Profit & Loss Sharing Model, wherein the entire risk – and the profit – of crop insurance used to lie with the insurance companies. But this model largely became unpopular after the first few years of PMFBY's introduction, when insurance companies incurred heavy losses.

RESTRUCTURED WEATHER-BASED CROP INSURANCE SCHEME (RWBCIS)

The Restructured Weather-Based Crop Insurance Scheme (RWBCIS), launched in 2016, works on the principle of weather-based indexing. The scheme is different from indemnity-based PMFBY, wherein crop loss estimation is critical for claims payout. In RWBCIS, the actual payout is not dependent on loss estimation but gets triggered if the values of a select parameter are above or below a pre-determined threshold, often set by the insurer.

The scheme uses parameters such as rainfall, temperature, wind and humidity. It also has a provision for states to provide add-on coverage linked to specific parameters, such as hailstorms or cloudbursts, wherever the risk is perceived to be substantial and identifiable.¹³

As of 2024, the scheme was adopted in eight states, with 13.7 lakh (1.37 million) farmers enrolled – about 73 per cent in kharif and 27 per cent in rabi. Andhra Pradesh tops the list with about 60 per cent of total enrolled farmers, followed by Maharashtra (14.7 per cent), Kerala (7.7 per cent) and Uttarakhand (7.6 per cent). Other states with relatively smaller number of enrolled farmers are Himachal Pradesh (4.9 per cent), Rajasthan (3.7 per cent), Chhattisgarh (0.9 per cent) and Uttar Pradesh (0.4 per cent). In 2024, the total gross premium collected under the scheme was Rs 2,34,665 lakh and the claims paid out was Rs 22,598 lakh.¹⁴

In 2023, the scheme was backed by the Weather Information Network Data System (WINDS), designed to strengthen existing weather data infrastructure in the country and provide high-quality weather datasets from a single digital platform.



WINDS seeks to integrate the existing infrastructure available with India Meteorological Department (IMD), various state governments, and public and private technical organizations.¹⁵

CROP INSURANCE IN STATES

Over the years, states and UTs have shown variation in their participation in PMFBY. While some states like Assam, Chhattisgarh, Haryana, Himachal Pradesh, Madhya Pradesh, Maharashtra, Odisha, Uttar Pradesh and Uttarakhand have participated consistently; Andaman and Nicobar Islands, Andhra Pradesh, Goa, Gujarat, Jharkhand, Jammu and Kashmir, Karnataka, Kerala, Manipur, Meghalaya, Puducherry, Sikkim, Tamil Nadu, Telangana, Tripura and West Bengal have withdrawn from PMFBY in some years. In those years, some of them implemented state crop insurance schemes or other relief models against crop losses. Few states, such as Punjab, have not participated in PMFBY at all (see *Table 2: State/UTs implementing PMFBY scheme: 2018–2024*). In Bihar, the Bihar Rajya Fasal Sahayata Yojana (BRFSY) was launched in 2018 that provides financial relief (not classic insurance) to farmers who incur crop losses due to natural calamities. The scheme is fully funded by the state and farmers are exempted from paying any premium.¹⁶

Jharkhand implemented the Jharkhand Fasal Rahat Yojana when it exited from PMFBY in 2020 before rejoining in 2024. It was a relief and compensation scheme aimed to support farmers in case of crop damage caused by natural calamities. The scheme covers both land-owning and landless farmers in Jharkhand.¹⁷

Similarly, Gujarat launched the Mukhyamantri Kisan Sahay Yojana in 2020. Under this scheme, farmers are not required to pay any premium – the government bears the full cost. All farmers in Gujarat (including small, marginal and tenant farmers) are eligible.¹⁸

Kerala government implemented the Kerala State Crop Insurance Scheme. It provides a safety net for farmers, particularly for a wide range of crops, including plantation crops.¹⁹

Table 2: State/UTs implementing PMFBY scheme: 2018–2024

States/UTs	2018	2019	2020	2021	2022	2023	2024
Andaman & Nicobar Islands							
Andhra Pradesh							
Arunachal Pradesh							
Assam							
Bihar							
Chhattisgarh							
Goa							
Gujarat							
Haryana							
Himachal Pradesh							
Jharkhand							
Jammu & Kashmir							
Karnataka							
Kerala							
Madhya Pradesh							
Maharashtra							
Manipur							
Meghalaya							
Mizoram							
Nagaland							
Odisha							
Punjab							
Puducherry							
Rajasthan							
Sikkim							
Tamil Nadu							
Telangana							
Tripura							
Uttar Pradesh							
Uttarakhand							
West Bengal							

Source: PMFBY dashboard, Ministry of Agriculture and Farmers Welfare

West Bengal has been implementing the Bangla Shasya Bima (BSB) after exiting PMFBY in 2019. It is a voluntary crop insurance scheme, open to all farmers – including landowners, sharecroppers and tenant farmers – cultivating notified crops in specified areas. This scheme also requires zero premium for farmers.²⁰



Punjab government provides financial assistance to farmers on an ad-hoc basis in the event of natural calamities like floods, unseasonal rain or hailstorms. This compensation is typically announced after a disaster and is often a fixed amount per acre for a certain percentage of crop loss.

LIVESTOCK INSURANCE

The National Livestock Mission (NLM) complements crop insurance by providing subsidized livestock insurance and fodder support – together covering India's twin agrarian risks of crop failure and animal loss.

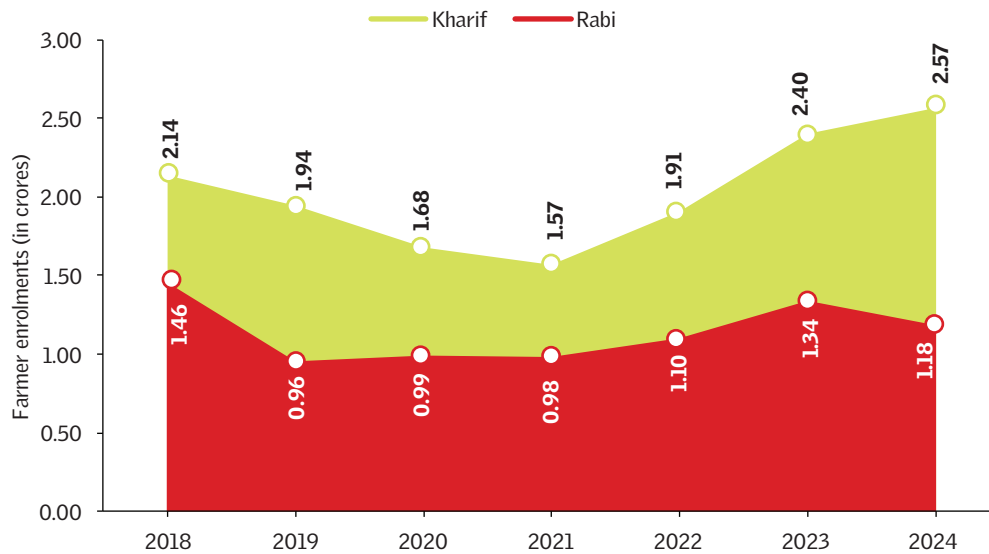
Livestock insurance in India is less uniform than crop insurance. The revised NLM of 2021–2022 provides a premium subsidy for insuring cattle, buffalo, goats, sheep, pigs and poultry, along with fodder and sectoral support, capped at differing premium subsidies and number of units. It is delivered through state agencies and multiple other stakeholders.²¹

PMFBY IMPLEMENTATION STATUS IN NUMBERS

Between 2018 to 2024, for the kharif season, number of enrolled farmers has increased from about 2.14 crore (21.4 million) to about 2.57 crore (25.7 million), or 19.5 per cent, while that of rabi season have seen an overall decline from about 1.46 crore (14.6 million) to about 1.18 crore (11.8 million), or 19.2 per cent (see *Graph 2: Farmer enrollments under PMFBY*).

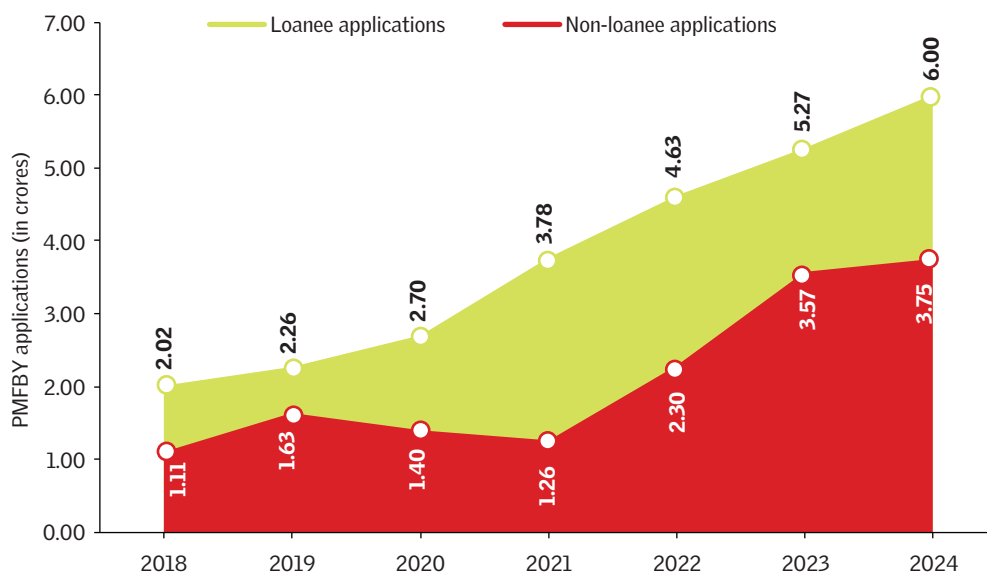
Likewise, the number of PMFBY applications have risen for loanee by 197.6 per cent and non-loanee farmers by 239.1 per cent in kharif season. However, rabi season witnessed minimal rise in non-loanee applications (only about 50 per cent), while loanee applications saw a 193 per cent rise (see *Graph 3: PMFBY applications enrolled under kharif season* and *Graph 4: PMFBY applications enrolled under rabi season*).

Graph 2: Farmer enrollments under PMFBY



Source: PMFBY dashboard, Ministry of Agriculture and Farmers Welfare

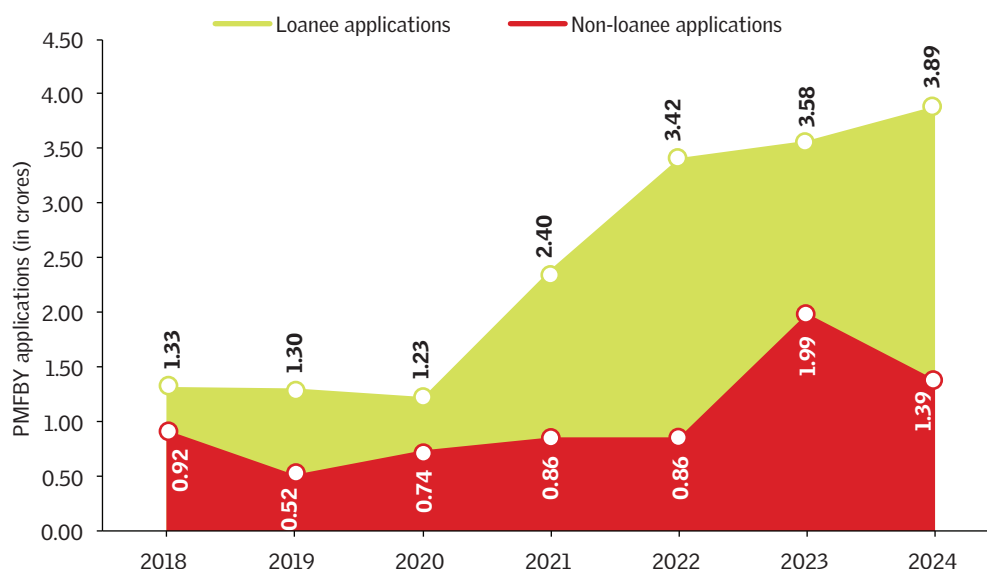
Graph 3: PMFBY applications enrolled under kharif season



Source: PMFBY dashboard, Ministry of Agriculture and Farmers Welfare



Graph 4: PMFBY applications enrolled under rabi season



Source: PMFBY dashboard, Ministry of Agriculture and Farmers Welfare

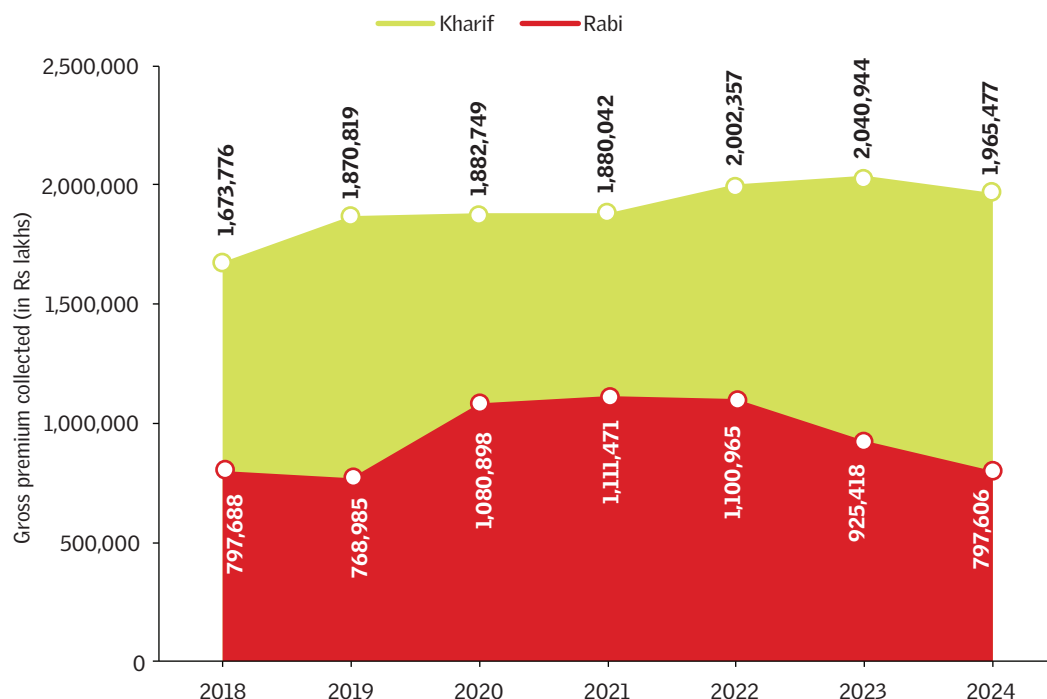
Farmer enrollments indicate the number of individual farmers covered. Application numbers tend to rise faster, as a single farmer can submit multiple applications for different crops sown.

It is clear that number of farmers have increased in the last six years, in both kharif and rabi seasons. However, they still represent a small fraction of the total farmer population of the country, considering there are over 14 crore (140 million) farming households. This indicates that there is a lot of scope to improve the PMFBY coverage.

PREMIUM AND CLAIMS

Kharif gross premiums increased by about 17.4 per cent, from Rs 16,73,776 lakh in 2018 to Rs 19,65,477 lakh in 2024. The gross premium is the sum total of farmers' premium, state premium and GOI premium. Over the years, farmers' premium has seen a decline of almost 41 per cent in kharif season. In rabi season, the decline was almost 9.3 per cent. In contrast, both the states' and GOI share have witnessed an incremental change in the last few years. There has been a significant 43.1 per cent increase in the state share, and

Graph 5: Gross premium collected under PMFBY



Source: PMFBY dashboard, Ministry of Agriculture and Farmers Welfare

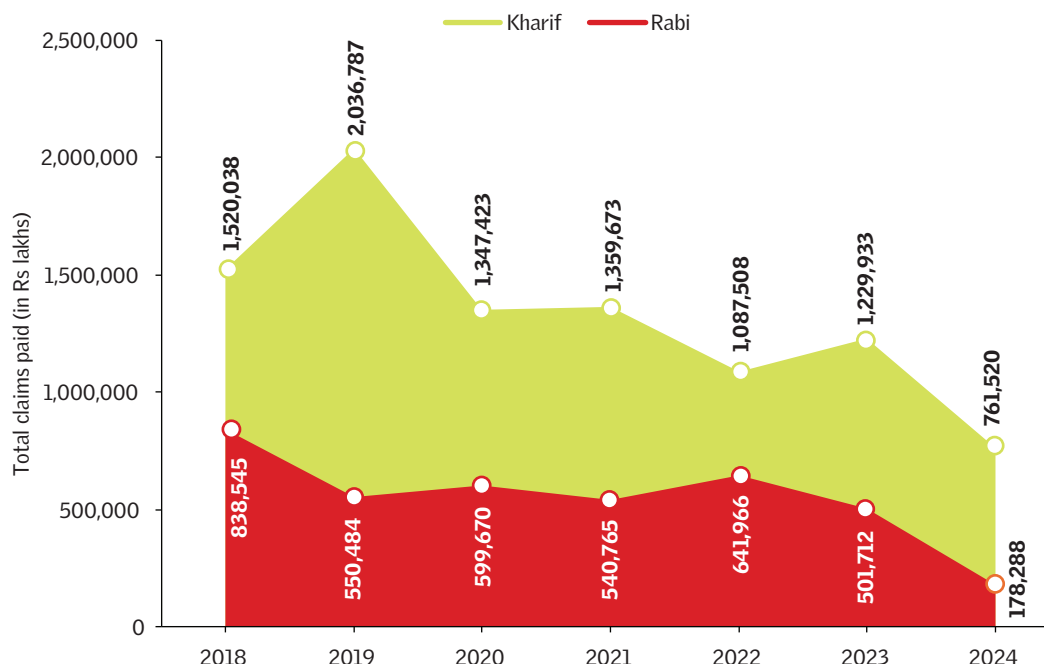
the GOI share increased by 2.3 per cent. The numbers indicate how the burden of premium has shifted to the state government.

Kharif season consistently attracts higher gross premiums than rabi, reflecting the larger cropped area and higher enrollment in the monsoon season. Rabi gross premiums remained almost unchanged, showing a negligible change (see *Graph 5: Gross premium collected under PMFBY*).

On the other hand, claims paid to the farmers against their crop losses have seen a major decline in both kharif and rabi season. Kharif season saw a decline of 49.9 per cent, from Rs 15,20,038 lakh in 2018 to Rs 7,61,520 lakh in 2024, and the claims paid in rabi season dropped by almost 78.73 per cent in the years from 2018–2024 (see *Graph 6: Total claims paid to farmers under PMFBY*).



Graph 6: Total claims paid to farmers under PMFBY

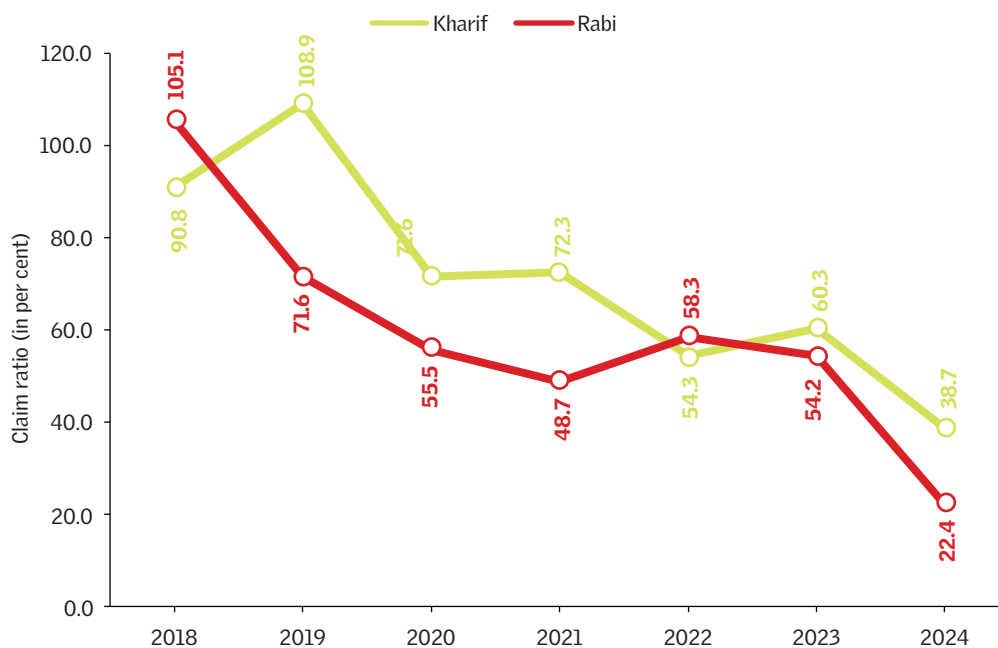


Source: PMFBY dashboard, Ministry of Agriculture and Farmers Welfare

Declining claim ratio

Claim ratio – calculated as $[(\text{Total claims paid} / \text{total premium collected}) \times 100]$ – is an indicator to compare how much insurers pay out in claims versus how much they collect in premiums. Claim ratios have also declined from 2018 to 2024. With 90.8 per cent claim ratio in kharif season, it is clear that the amount of claims paid were nearly the same as the amount of premiums collected. However, in 2024, with claim ratio of 38.7 per cent, the claim paid out was much below the premium inflow. A similar trend was observed in rabi season, with a decline from 105.1 per cent claim ratio in 2018 to 22.4 per cent claim ratio in 2024. (see *Graph 7: Claim ratio of PMFBY*).

Graph 7: Claim ratio of PMFBY



Source: PMFBY dashboard, Ministry of Agriculture and Farmers Welfare

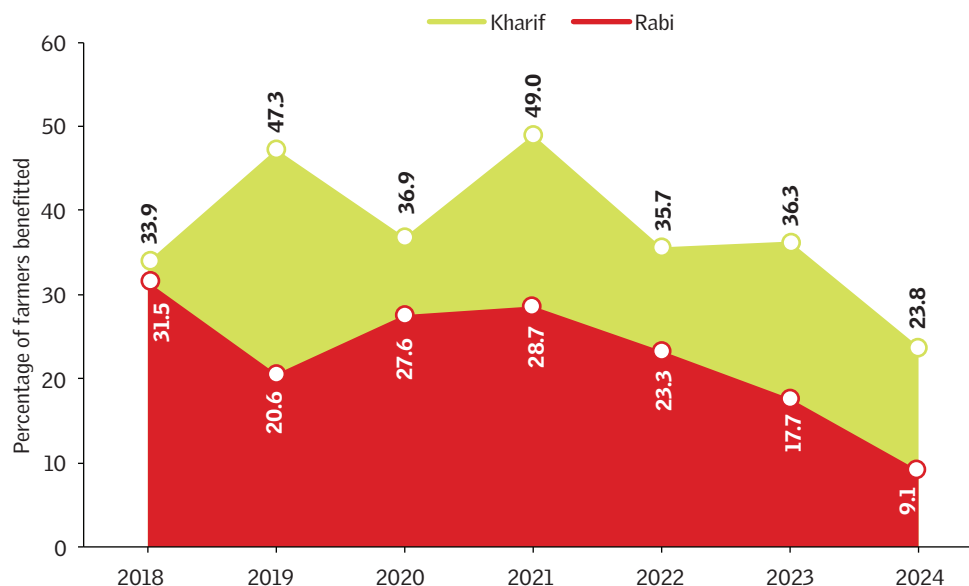
Decline in the number of farmers benefiting from PMFBY

The percentage of farmers benefiting from the scheme declined from 33.9 per cent in 2018 to about 23.8 per cent in 2024 in the kharif season. In rabi season, there was a decline from 31.5 per cent in 2018 to a staggering 9.1 per cent in 2024 (see *Graph 8: Farmers benefited out of total farmers enrolled*).

On one hand, it could indicate improvements in agricultural resilience, with fewer large-scale weather shocks driving claim payouts. On the other hand, it may also reflect a tightening of claim settlements, delays or restrictive loss assessment practices. This interpretation gains weight considering that farmers in several states have expressed dissatisfaction over unpaid or delayed claims during the same period.



Graph 8: Farmers benefited out of total farmers enrolled (per cent)



Source: PMFBY dashboard, Ministry of Agriculture and Farmers Welfare

The divergence between large premium inflows and relatively low claim payouts – coupled with the fact that barely one-fourth of the farmers enrolling in PMFBY reap claim payouts – strengthens perceptions of farmers but and other stakeholders that insurance companies are earning more profits than earlier. This imbalance has contributed to a loss of confidence in the scheme among farmers.

In a positive development on 11 August 2025, the Union Agriculture Minister digitally transferred Rs 3,900 crore worth claims directly to the bank accounts of farmers. According to media reports, the biggest chunks have been pumped into Rajasthan, Madhya Pradesh and Chhattisgarh. However, as per a PIB press release dated 30 June 2025, claims amounting to Rs 6,456.6 crore were still pending for payment.

PMFBY IN STATES

PMFBY ENROLLMENTS CONCENTRATED IN SELECT STATES/UTs

In kharif 2024 season, about 98.4 per cent of the farmer enrollments are from the following 10 states in the given order – Maharashtra, Jharkhand, Rajasthan, Madhya Pradesh, Andhra Pradesh, Odisha, Uttar Pradesh, Chhattisgarh, Assam and Haryana. In rabi season, 96.9 per cent of the farmer enrollments come from the same 10 states except Tamil Nadu, which replaces Jharkhand. The concentration of enrollments is even more prominent, as the top five states make up 73.6 per cent in kharif and 84.9 per cent in rabi season of the total enrollments, respectively. Himachal Pradesh, Tamil Nadu, Meghalaya and Uttarakhand had less than one lakh (0.1 million) farmers enrolled for kharif 2024 season. In rabi season, Jammu and Kashmir, Uttarakhand, Tripura and Puducherry had less than one lakh farmers enrollments.

Tripura, Manipur, Puducherry, Sikkim, Andaman and Nicobar Islands and Goa had less than 10,000 farmer enrollments in kharif season. Goa, Meghalaya, Sikkim, Andaman and Nicobar Islands had a similar situation in rabi season (see *Table 3: State-wise proportion of PMFBY farmer enrollments, kharif and rabi, 2024*).

PMFBY PREMIUMS COLLECTED FAR EXCEED CLAIMS PAID OUT

The top 10 states with enrollments are further analysed for the gross premium collected and claims paid. Clearly, the gross premium collected is much higher than claims paid out. In kharif 2024, the total gross premium collected was about Rs 18,64,004 lakh and the total claim amount paid was Rs 7,37,374 lakh, which is about 39.6 per cent of the gross premium.

Table 3: State-wise proportion of PMFBY farmer enrollments, kharif and rabi, 2024

State/UT	Percentage of farmer enrollments (Kharif 2024)	Actual farmer enrollments* (in lakh) (Kharif 2024)	State/UT	Percentage of farmer enrollment (Rabi 2024)	Actual farmer enrollments* (in lakh) (Rabi 2024)
Maharashtra	30.1	75.40	Maharashtra	24.8	28.46
Jharkhand	12.2	30.54	Rajasthan	19.9	22.89
Rajasthan	12.1	30.28	Madhya Pradesh	17.8	20.46
Madhya Pradesh	9.6	24.06	Uttar Pradesh	13.8	15.87
Andhra Pradesh	9.6	24.05	Tamil Nadu	8.5	9.72
Odisha	9.0	22.42	Haryana	3.1	3.55
Uttar Pradesh	6.1	15.32	Andhra Pradesh	2.5	2.91
Chhattisgarh	5.7	14.27	Assam	2.4	2.73
Assam	2.5	6.25	Chhattisgarh	2.4	2.78
Haryana	1.5	3.74	Odisha	1.6	1.81
Jammu & Kashmir	0.6	1.41	Jharkhand	1.3	1.45
Himachal Pradesh	0.4	0.96	Himachal Pradesh	0.9	1.03
Tamil Nadu	0.3	0.74	Jammu & Kashmir	0.5	0.59
Meghalaya	0.2	0.43	Uttarakhand	0.2	0.27
Uttarakhand	0.1	0.34	Tripura	0.1	0.12
Tripura	<0.1	<0.1	Puducherry	0.1	0.11
Manipur	<0.1	<0.1	Meghalaya	<0.1	<0.1
Puducherry	<0.1	<0.1	Sikkim	<0.1	<0.1
Sikkim	<0.1	<0.1	Andaman & Nicobar Islands	<0.1	<0.1
Andaman & Nicobar Islands	<0.1	<0.1	Goa	<0.1	<0.1
Goa	<0.1	<0.1			

Note: *Values rounded off till two decimal places

Source: PMFBY dashboard, Ministry of Agriculture and Farmers Welfare

The premium collected from Maharashtra was about 41 per cent of the total premium collected from these 10 states. The claims paid by the state were about 59 per cent of the total claims paid out. Along with Maharashtra, Madhya Pradesh, Tamil Nadu and Uttar Pradesh too have a higher proportion of the claims paid out as compared to the proportion of their gross premiums.

However, in actual values, the amount of money collected through premiums in Maharashtra, Uttar Pradesh, and Madhya Pradesh is

Table 4: State-wise proportion of gross premiums and claims for kharif 2024

State/UT	Proportion of total premium (in per cent)	Gross premium (in Rs lakh)*	State/UT	Proportion of total claims (in per cent)	Total claims paid (in Rs lakh)
Maharashtra	40.9	7,63,461	Maharashtra	59.1	4,37,164
Rajasthan	14.9	2,78,102	Madhya Pradesh	15.0	1,11,081
Madhya Pradesh	9.6	1,78,768	Rajasthan	12.7	94,093
Jharkhand	8.6	1,59,993	Haryana	3.9	28,948
Odisha	8.1	1,51,663	Uttar Pradesh	3.7	27,230
Chhattisgarh	7.5	1,39,327	Chhattisgarh	1.6	11,620
Haryana	4.8	89,329	Odisha	1.9	14,280
Uttar Pradesh	2.3	43,039	Tamil Nadu	1.0	7,109
Andhra Pradesh	1.9	35,595	Assam	0.4	2,669
Assam	0.9	16,662	Jammu & Kashmir	0.3	2327
Tamil Nadu	0.1	2,579	Andhra Pradesh	0.1	853
Jammu & Kashmir	0.3	5,486	Jharkhand	0.0	0**
Total	99.9	18,64,004		99.7	7,37,374

Note: *Values rounded off to the nearest whole number

**The value zero may indicate claims paid out not recorded on dashboard

Source: PMFBY dashboard, Ministry of Agriculture and Farmers Welfare

higher than the amount of money given through claims, whereas Tamil Nadu was the only state which paid out more claims than the amount of money collected via premiums.

Rajasthan, Jharkhand, Chhattisgarh, Haryana, Andhra Pradesh, Assam and Odisha account for lower proportion of claims than of premiums. In all these states, the actual amount of money collected through premiums is much higher than claims.

In rabi 2024, the total gross premium collected was about Rs 6,58,047 lakh and the total claim amount paid was Rs 1,77,491 lakh which is about 26.9 per cent of the gross premium.

The premium collected from Rajasthan was almost 30 per cent of the total premium collected from these 10 states. The claims paid by the state had about 34.2 per cent of the total claims paid out. In



Table 5: State-wise proportion of gross premiums and claims for rabi 2024

State/UT	Proportion of total premium (in per cent)	Gross premium (in Rs lakh)*	State/UT	Proportion of total claims (in per cent)	Total claims paid (in Rs lakh)
Rajasthan	29.8	1,97,112	Rajasthan	34.2	60,795
Maharashtra	24.7	1,63,646	Tamil Nadu	29.7	52,844
Madhya Pradesh	14.3	94,793	Madhya Pradesh	9.2	16,414
Tamil Nadu	10.9	72,575	Chhattisgarh	7.8	13,931
Uttar Pradesh	5.8	38,643	Maharashtra	7.7	13,628
Chhattisgarh	4.3	28,466	Uttar Pradesh	7.5	13,409
Andhra Pradesh	2.9	19,371	Haryana	2.0	3,574
Haryana	2.5	16,688	Assam	1.5	2,615
Assam	1.7	11,185	Jammu & Kashmir	0.1	247
Jharkhand	1.1	7,279	Odisha	0.02	34
Odisha	1.1	7,233	Andhra Pradesh	0.00	0**
Jammu & Kashmir	0.2	1,056	Jharkhand	0.00	0**
Total	99.3	6,58,047		99.72	1,77,491

Note: *Values rounded off to the nearest whole number

**The value zero may indicate claims paid out not recorded on dashboard

Source: PMFBY dashboard, Ministry of Agriculture and Farmers Welfare

addition to Rajasthan, Tamil Nadu, Uttar Pradesh and Chhattisgarh have a higher proportion of the claims paid out as compared to the proportion of their gross premiums. However, in actual values, the amount of money collected through premiums is much higher than the amount of money given through claims in these states.

Maharashtra, Madhya Pradesh, Haryana, Assam and Odisha account for lower proportion of claims than of premiums. In all these states, the actual amount of money collected through premiums is much higher than claims (see *Table 5: State-wise proportion of gross premiums and claims for rabi 2024*).

Table 6: State-wise proportion of surpluses: kharif and rabi (2024)

State/UT	Surplus in kharif season (in Rs lakh)	State/UT	Surplus in rabi season (in Rs lakh)
Maharashtra	3,26,297	Maharashtra	1,50,018
Rajasthan	1,84,009	Rajasthan	1,36,317
Jharkhand	1,59,993	Madhya Pradesh	78,379
Odisha	1,37,383	Uttar Pradesh	25,234
Chhattisgarh	1,27,707	Tamil Nadu	19,731
Madhya Pradesh	67,687	Andhra Pradesh	19,371
Haryana	60,381	Chhattisgarh	14,535
Andhra Pradesh	34,742	Haryana	13,114
Uttar Pradesh	15,809	Assam	8,570
Assam	13,993	Jharkhand	7,279
Jammu & Kashmir	3,159	Odisha	7,199
Tamil Nadu	-4,530	Jammu & Kashmir	809
Total	11,26,630	Total	4,80,556

Source: PMFBY dashboard, Ministry of Agriculture and Farmers Welfare

The total premiums collected in these 10 states for both kharif and rabi seasons was Rs 25,22,051 lakh. While the total claims paid out was approximately 36.3 per cent, amounting to Rs 9,14,865 lakh. The total surplus in these 10 states for kharif 2024 was Rs 11,26,630 lakh, and about Rs 4,80,556 lakh for rabi season.

In kharif, the highest surplus was in Maharashtra, followed by Rajasthan, Jharkhand, Chhattisgarh and Odisha. In all these states, the surplus was more than Rs 1,00,000 lakh. In rabi, Maharashtra and Rajasthan had more than Rs 1,00,000 lakh surpluses.



PMFBY: INSURANCE INDUSTRY NUMBERS

Overall, in 2023–2024, there were 15 insurance companies involved in implementing PMFBY across the country, including four public sector companies (Agriculture Insurance Company of India Ltd, National Insurance Company Ltd, Oriental Insurance Company Ltd and United India Insurance Company Ltd) and 11 private companies (Bajaj Allianz General Insurance Company Ltd, Cholamandalam MS General Insurance Company Ltd, Future Generali India Insurance Company Ltd, HDFC-ERGO General Insurance Company Ltd, ICICI Lombard General Insurance Co. Ltd, IFFCO-Tokio General Insurance Company Ltd, Reliance General Insurance Company Ltd, Tata AIG General Insurance Company Ltd, SBI General Insurance Company Ltd, Universal Sompo General Insurance Company Ltd and Kshema General Insurance Ltd).

The total premium collected by these companies was about Rs 29,506 crore, while the total claims paid out were about Rs 16,504 crore, leaving a surplus of about Rs 13,001 crore (see *Table 7: Company-wise proportion of gross premiums and claims for 2023–2024*).

Based on the share in the total premium, Agriculture Insurance Company of India Ltd, Reliance General Insurance Company Ltd, HDFC-ERGO General Insurance Company Ltd, SBI General Insurance Company Ltd and Oriental Insurance Company Ltd were the top five companies with about 72 per cent of the total premium collected. 13 out of these 15 companies had a hefty surplus, which means that the claims paid out were much lesser than the premiums collected. This also indicates that almost all insurance companies potentially made huge profits in 2023–2024 in this sector. Only Oriental Insurance Company and TATA AIG paid out more than what they had collected.

Table 7: Company-wise proportion of gross premiums and claims for 2023–2024

Insurance company	Share in total gross premium for 2023–2024 (in per cent)	Gross premium collected (in Rs crore)*	Share in total claims paid for 2023–2024 (in per cent)	Total claims paid (in Rs crore)	Total surplus (in Rs crore)*
Agriculture Insurance Company of India Ltd	32.2	9,489	33.72	5,564.75	3,924
Reliance General Insurance Company Ltd	12.8	3,784	7.69	1,269.11	2,515
HDFC-ERGO General Insurance Company Ltd	11.1	3,277	3.38	557.29	2,719
SBI General Insurance Company Ltd	9.0	2,641	3.97	655.44	1,986
Oriental Insurance Company Ltd	6.5	1,912	20.35	3,359.44	-1447
Bajaj Allianz General Insurance Company Ltd	5.5	1,609	4.90	809.14	799
Universal Sompo General Insurance Company Ltd	4.6	1,368	4.77	787.96	580
IFFCO-Tokio General Insurance Company Ltd	4.5	1,323	5.33	880.30	443
ICICI Lombard General Insurance Co. Ltd	4.1	1,198	4.66	769.64	428
Kshema General Insurance Limited	3.0	894	2.61	430.96	462
United India Insurance Company Ltd	2.8	838	2.89	477.42	361
Cholamandalam MS General Insurance Company Ltd	1.8	526	2.46	406.08	120
Future Generali India Insurance Company Ltd	1.3	373	1.01	167.01	206
Tata AIG General Insurance Company Ltd	0.9	272	2.24	369.99	-97
National Insurance Company Ltd	0.0003	0.08	-	-	0.08
Total	100	29,506	100	16,504	13,001

Note: *Values rounded off to the nearest whole number

Source: Lok Sabha unstarred question no. 4890, 1st April 2025, Collection of Premium and Payment of Claims Under PMFBY, Ministry of Agriculture and Farmers Welfare

An analysis of these 13 companies clearly shows that the claim ratio $[(\text{Total Claims Paid}/\text{Total Premium Collected}) \times 100]$ ranged between 17 per cent of HDFC-ERGO General Insurance Company Ltd to 77.2 per cent of Cholamandalam MS General Insurance Company Ltd (see *Table 8: Company-wise and year-wise claim ratio (in per cent)*). Companies with less than 50 per cent claim ratio were Future Generali, Kshema General, Reliance General, SBI General and HDFC Ergo. Furthermore, a look at the historical claim ratios of nine out of these 13 companies who were involved in 2019–2020 suggests that their claim ratios have by and large decreased from 2019–2020 to 2023–2024 with some fluctuations in between in certain cases.

Table 8: Company-wise and year-wise claim ratio (in per cent)

Insurance company	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024
Agriculture Insurance Company of India Ltd	101.7	81.9	67.4	68.8	58.6
Bajaj Allianz General Insurance Company Ltd	73.7	44.2	83.0	72.7	50.3
Bharti AXA General Insurance Company Ltd	15.1	23.0	62.0	-	-
Cholamandalam MS General Insurance Company Ltd	-	-	-	-	77.2
Future Generali India Insurance Company Ltd	43.7	32.0	78.0	40.3	44.7
HDFC-ERGO General Insurance Company Ltd	54.4	45.7	63.0	33.6	17.0
ICICI Lombard General Insurance Co. Ltd	-	-	-	66.0	64.2
IFFCO-Tokio General Insurance Company Ltd	85.8	71.5	63.0	15.7	66.5
Kshema General Insurance Ltd	-	-	-	-	48.2
National Insurance Company Ltd	101.2	300.0	118.1	42.6	0.0
New India Assurance Company Ltd	275.3	-	-	-	-
Oriental Insurance Company Ltd	128.3	125.1	-	-	175.7
Reliance General Insurance Company Ltd	54.6	30.5	88.4	61.2	33.5
Royal Sundaram General Insurance Company Ltd	27.0	-	-	-	-
SBI General Insurance Company Ltd	99.2	91.6	62.0	55.4	24.8
Tata AIG General Insurance Company Ltd	-	-	-	-	135.9
United India Insurance Company Ltd	91.0	-	-	77.3	57.0
Universal Sompo General Insurance Company Ltd	28.9	44.9	58.5	44.3	57.6

Note: *Values rounded off to one decimal place

Source: Lok Sabha unstarred question no. 4890, 1st April 2025, Collection of Premium and Payment of Claims Under PMFBY, Ministry of Agriculture and Farmers Welfare

There were some companies (Bharti AXA, New India Assurance Company Ltd, Royal Sundaram General Insurance Company Ltd) who started in 2019-2020, but later exited from PMFBY implementation. There were others who joined PMFBY later, namely, Cholamandalam MS General Insurance Company Ltd, ICICI Lombard General Insurance Co. Ltd, Kshema General Insurance Ltd and Tata AIG General Insurance Company Ltd.

PMFBY IMPLEMENTATION STATUS: PERSPECTIVES FROM THE GROUND

Based on the interaction with multiple stakeholders on the ground the following issues emerged:

FARMERS

- **Delayed claim settlements:** Farmers frequently report prolonged waiting periods before receiving compensation.
- **Inadequate or inaccurate compensation:** Despite regular payment of premiums, many farmers perceive that indemnities do not correspond to their actual losses.
- **Non-conduct of CCEs:** In several cases, mandated CCEs are reported to have not been implemented, leading to gaps in yield estimation.
- **Inaccurate implementation of CCEs:** Where conducted, CCEs are often perceived as methodologically weak or inadequate, especially with increasing extreme weather events and localized losses.
- **Neglect of micro-climatic variability:** Localized weather-induced crop losses are often excluded, as yield estimation depends on area-based averages that overlook individual farm realities.
- **Opaque grievance and feedback mechanisms:** The absence of transparent and accessible channels for grievance redressal or farmer feedback is a prevalent thought among farmers.
- **Barriers in technological access:** For semi-urban and urban farmers, digital interfaces used for enrollment and claims are often complex, inefficient, and user-unfriendly. This becomes especially cumbersome for farmers and landowners not residing in and around their farm lands.
- **Documentation challenges:** Procedural hurdles related to documentation for enrollment and claims persist, contributing to farmer dissatisfaction.
- **High premium burden in select cases:** Although premiums



are subsidized, some farmers still experience higher-than-anticipated rates, particularly for specific crops or regions.

- **Exposure to corruption:** Farmers report encountering corrupt practices at multiple stages, especially in grievance redressal and claim settlement processes.

GOVERNMENT IMPLEMENTERS AND FUNCTIONARIES

- **Privatization-driven market dynamics:** The increasing privatization of the insurance sector has shifted the market towards an industry-driven model, limiting direct government control over scheme implementation.
- **Farmer dissatisfaction:** Persistent farmer discontent, stemming from delayed or inadequate claims and lack of transparency, creates political and administrative challenges for government functionaries.
- **Fiscal burden on states:** State governments face significant financial pressure due to their obligation to share 50 per cent of premium subsidies, which becomes especially burdensome during high-claim years.
- **Mandated targets and governance risks:** Broader coverage and performance targets imposed by higher levels of government often remain unmet in practice. This gap fosters opportunities for corrupt practices at different levels of the scheme implementation system in reporting and execution.
- **Farmer distrust and limited awareness:** Lack of adequate awareness-building efforts has contributed to widespread scepticism among farmers, weakening trust in both the scheme and its implementing agencies.

RURAL BANKS

- **Limited farmer awareness:** A persistent lack of awareness among farmers regarding the provisions, procedures, and requirements of PMFBY increases the challenge for banks to provide continuous guidance and handholding.
- **Administrative and documentation burden:** Financial institutions face a severe workload due to extensive

documentation requirements and the prolonged processes of on-boarding, application handling, and compliance verification.

- **Submission of inaccurate documentation:** False or incorrect documents submitted by farmers complicate the verification process, delay application approvals and increase operational inefficiencies for banks.
- **Mismatch between insured and cultivated crops:** Cases also emerged where stakeholders discussed how farmers cultivate crops that differ from those recorded in their PMFBY applications, resulting in discrepancies that create disputes, complicate claim settlements and undermine institutional credibility.

PARAMETRIC INSURANCE: A POTENTIAL SOLUTION

One of the key challenges of crop insurance schemes is claim settlement. While the crop loss estimation is planned to move towards complete digitization, most of it is being done manually, which has accuracy, certainty and adequacy-related issues. Digitizing crop loss estimation, such as through YES-TECH, is expected to address these issues related to claim settlement to a certain degree.

Parametric insurance can also be another solution, which excludes the need to conduct crop loss assessment. It is an alternative approach that focuses on certain parameters, which act as triggers for the losses and therefore avoids the uncertainty and lack of transparency. In addition to the RWBCIS, which is the most prevalent government subsidized scheme with characteristics of parametric insurance, there are several ongoing schemes and products offering parametric insurance.

The Spices Board of India, provides a weather-based scheme to cardamom growers in Kerala. Implemented through the Agriculture Insurance Company of India (AIC), the scheme protects against losses due to extreme weather events, as per the weather data recorded in the notified Reference Weather Stations (RWS).²² Nagaland, based on its initiative 'Disaster Risk Transfer Parametric Insurance Solution' (DRTPS), has also been reported to replicate the model for agricultural losses in Nagaland and the discussions are ongoing.²³



Parametric insurance products offered by insurance companies include 'Sampoorna Fasal Kawach', which is an index-based approach covering parametric indices (such as rainfall, temperature, etc.) and/or satellite-based indices. It is offered for crops not covered under mainstream government schemes.²⁴

HDFC Ergo provides 'Weather Insurance Policy', an index-based product designed to cover losses due to varying weather conditions, such as temperature, wind speed, rainfall and humidity. This policy is for farmers, banks as well as financial institutions that extend credit to agricultural or non-agricultural operations whose repayments may be affected by weather conditions.²⁵

ICICI Lombard also offers a similar product – 'Weather Insurance: Cover for Losses due to Abnormal Weather' – based on an index by assigning weights to critical periods of crop growth. Deviation between the normal index and the actual index triggers compensation to the insured, on the basis of an agreed upon formula.²⁶

Parametric insurance products are also available for the livestock sector. For example, 'Saral Krishi Bima' is the first heat-index based insurance product for cattle farmers in Kerala. Launched by the Malabar Region of Malabar Regional Cooperative Milk Producers' Union (MILMA-MRCMPU) in six districts – Palakkad, Malappuram, Wayanad, Kozhikode, Kannur and Kasaragod – it is designed to cover economic losses due to heat stress, which can lead to decreased milk production.²⁷

It is clear that parametric insurance is a reality in the agricultural and livestock sector but it has not yet been implemented at scale. This is partly because it is often sold as a product, typically applies to a single crop or product such as milk, or is not subsidized. RWBCIS is the only major parametric insurance cover that is subsidized by the Government of India and state governments, making it a good opportunity – especially if adequately supported by technological solutions.

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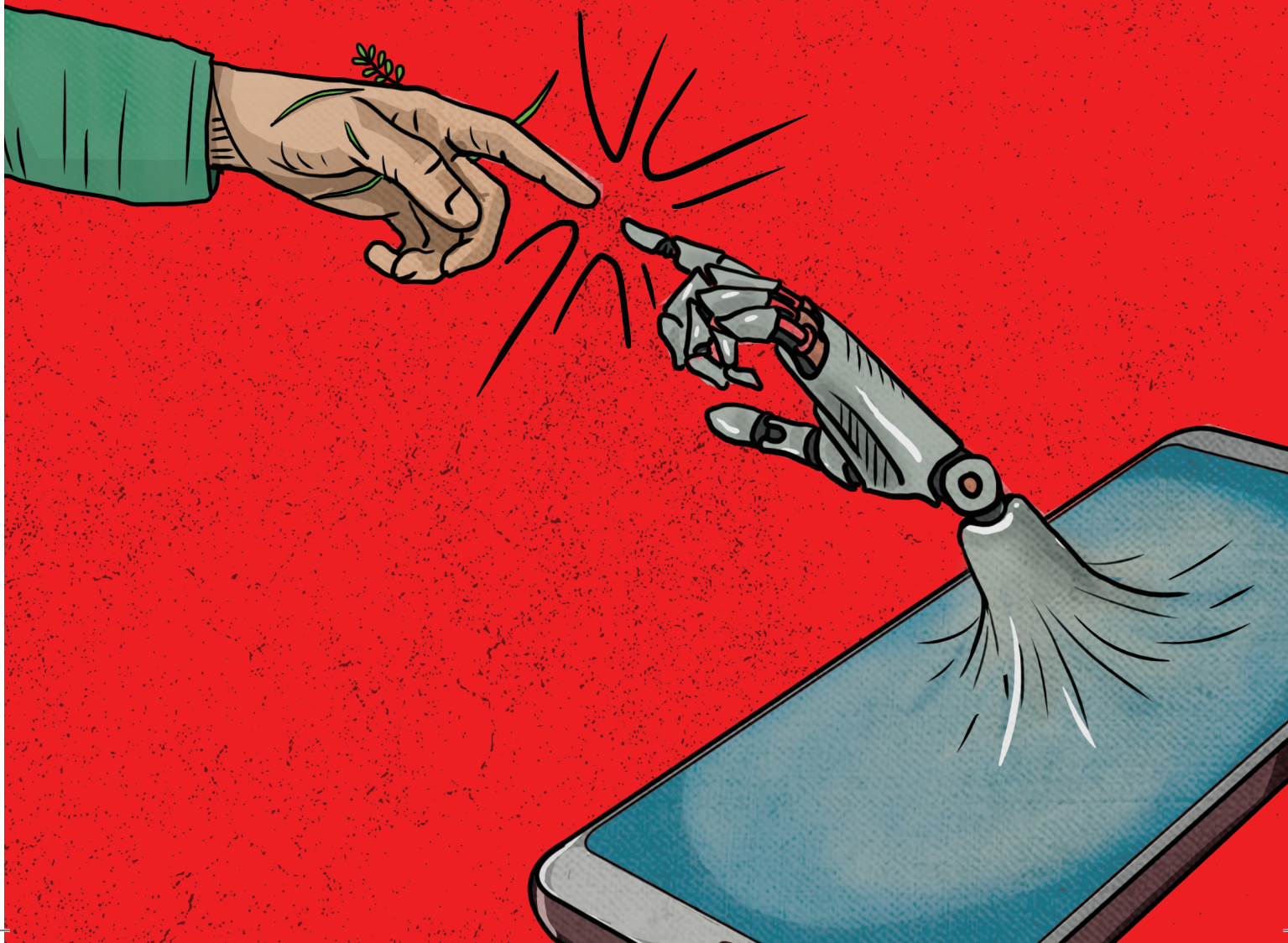


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AGENDA: RESILIENCE THROUGH INSURANCE TO COVER RISKS AND LOSSES

TECHNOLOGY AND AGRICULTURE INSURANCE

**USING NEW-AGE METHODS
TO ESTIMATE LOSSES AND
BENEFIT FARMERS**



IN BRIEF

THE NEED FOR TECHNOLOGY IN CROP INSURANCE

Technology integration became essential to overcome significant shortcomings in India's early nationwide crop insurance programmes. Schemes like the Comprehensive Crop Insurance Scheme (CCIS) and the National Agricultural Insurance Scheme (NAIS) relied on manual Crop Cutting Experiments (CCEs). This process was slow, lacked transparency, and was prone to disputes, leading to fragmented, paper-based data that caused delays and inaccuracies in claim processing. While the Weather Based Crop Insurance Scheme (WBCIS) made an initial attempt to use technology, its effectiveness was limited by the sparse network of weather stations.

The launch of the Pradhan Mantri Fasal Bima Yojana (PMFBY) in 2016 saw a shift in leveraging technology. The thrust to improve technology infrastructure and integration into the scheme has, however, become evident in recent years.

PLATFORMS AND PROCESSES TO ADDRESS IMPLEMENTATION GAPS

Technology is now deployed across several facets of crop insurance, from central management to on-the-ground data collection, including addressing a critical gap, i.e. claims settlement.

Yield and weather data systems

The Yield Estimation System based on Technology (YES-TECH) uses a combination of satellite images, weather data, and mobile apps to estimate crop yields with greater speed and accuracy. Data is collected in parallel from multiple sources, including satellite imagery from Technology Implementing Partners (TIPs), weather data from Weather Information Network Data Systems (WINDS), geo-tagged photos, and drone surveys. This data is then analysed

by artificial intelligence (AI) and machine learning (ML) models. YES-TECH also supports the Smart Sampling Technique (SST), which scientifically selects CCE plots, improving efficiency and accuracy over traditional randomized methods.

To address the need for hyper-local weather data, WINDS was launched. This platform provides granular weather information to support yield estimation models for PMFBY and reduce 'basis risk' for the Revised Weather Based Crop Insurance Scheme (RWBCIS) by providing hyper-local data.

Central management and infrastructure

The National Crop Insurance Portal (NCIP) serves as the central digital platform and master data repository for all stakeholders. It manages core services like enrolment, subsidy release and claim disbursement, and integrates with key government digital infrastructures like Agri-Stack and the Krishi-Decision Support System. NCIP standardizes and integrates data from various sources (satellites, weather stations, etc.) to support automated yield estimation.

GROUND OBSERVATION AND CLAIM PROCESSING

The Collection of Real Time Observations and Photographs of Crops (CROPIC) uses a mobile application to allow farmers and field officials to capture geo-tagged photos of their plots throughout the season. AI/ML algorithms analyse these images to assess crop type, health and damage. Similarly, the CCE Agri App digitizes the manual CCE process, enabling surveyors to upload field data in real time.

For user engagement and claims, the AIDE (Application for Intermediary Enrollment) app allows farmers to enroll online. This app links to SARTHI, a broader ecosystem for agricultural insurance. The Digicclaim module, implemented from kharif 2022, enables direct, paperless and near-instantaneous claim settlements by linking the NCIP with financial systems and insurance company accounts.



SCALE OF ADOPTION

The adoption of these technologies is mandated by PMFBY guidelines and is supported by institutional backing. The government has empaneled TIPs and Mentor Institute for Technology Roll-out (MITRs) to oversee the implementation.

YES-TECH Rollout

YES-TECH was initially recommended for paddy and wheat in 2023, with soybean added in 2024. The initial adoption approach mandates that technology-based estimation be given a 30 per cent weightage in the final blended yield calculation, with manual CCEs still holding a 70 per cent weightage. Madhya Pradesh is the only state to have adopted a 100 per cent weightage for YES-TECH data for its entire yield estimation. Other states like Andhra Pradesh, Haryana, and Maharashtra have also integrated YES-TECH for claim settlements.

WINDS Implementation

WINDS aims to create a vast network of over 200,000 ground stations. As of January 2025, nine states were in the process of implementing the system.

CHALLENGES AND POSSIBILITIES

While technological integration is ambitious and improving, its full impact remains to be seen.

Challenges

- **Complexity of agricultural landscapes and need for robust data:** India's diverse agro-climatic zones, varied cropping practices (intercropping, mixed-cropping), and small farm sizes make it challenging to create a robust and reliable database to train AI models accurately, which is essential for validation.
- **Errors in machinery:** Farmers have reported erroneous data from reference weather stations, which can lead to inaccurate claim under- or over-payments.
- **Farmer awareness:** There is a persistent lack of awareness among farmers regarding the use and benefits of these automated systems, requiring more effort in education and outreach.

Possibilities

- **Reduced basis risk:** WINDS' ability to provide hyper-local weather data for parametric insurance is expected to significantly reduce basis risk, which is the mismatch between the weather index and a farmer's actual loss.
- **Transparency and trust:** Centralized platforms like NCIP and paperless claim settlements via Digicclaim are expected to enhance transparency and build greater trust in the scheme's implementation.
- **Scalability and reach:** Digital tools like AIDE and the Learning Management System (LMS) are poised to improve accessibility for farmers and significantly increase the overall scalability of crop insurance schemes.

INTRODUCTION

The Comprehensive Crop Insurance Scheme (CCIS) introduced in 1985 was India's first nation-wide crop insurance programme. It was an area-based scheme wherein claims were settled based on village-level yield data, collected through manual Crop Cutting Experiments (CCEs). Use of technology was minimal.¹

In 1999, the National Agricultural Insurance Scheme (NAIS) was launched, which still relied on manual CCEs. The process of conducting CCEs was slow, had inadequate transparency, and was prone to disputes. The data generated from CCEs remained fragmented and was managed through paper records and basic digital files, often leading to delayed and/or inaccurate claim processing.²

In 2007, the Weather Based Crop Insurance Scheme (WBCIS) was introduced. It was an attempt to complement yield-based assessments and use weather data from Automatic Weather Stations (AWS) to initiate claims. This was expected to reduce the need for manual CCEs but was still constrained by the sparse network of weather stations.

In 2016, Pradhan Mantri Fasal Bima Yojana (PMFBY) was launched with a focus on, among other things, integrating technology in its design and implementation. It is in recent years, however, that use of technology in PMFBY is gaining traction.

The revised PMFBY guidelines (2023) mandate the integration of various means of technology for the stakeholders involved in its implementation. This is also supported by the Fund for Innovation and Technology (FIAT) (2025), which was approved by the Union Cabinet for research and development (with a corpus of Rs 824.77 crore).³

At a broad level, the integration and/or enhancements in technology and technological processes aim at improving collection and aggregation of data from multiple sources; processing of data; and enabling digital interfaces that are user-friendly.

While the extent of positive impact the technology would have on the crop insurance sector remains to be seen, but there clearly is a huge opportunity to leverage technology and technological processes to make the implementation of existing schemes more transparent, trusted, efficient and scalable.



TECHNOLOGY/ TECHNOLOGICAL PROCESSES FOR DATA COLLECTION AND AGGREGATION

YIELD ESTIMATION SYSTEM BASED ON TECHNOLOGY (YES-TECH)

YES-TECH is a government initiative for technology-based yield estimation. It uses images through satellites, weather data, mobile apps and computer models to estimate crop yields faster and more accurately.⁴

After conducting pilot studies, in 2023, the Department of Agriculture and Farmers Welfare at the Centre rolled out YES-TECH and recommended it initially for paddy and wheat. Soybean was also added from the kharif 2024 season. Kharif 2025 onwards, the central government has introduced coverage of tea under RWBCIS (Revised Weather Based Crop Insurance Scheme) in states like Assam, West Bengal and Kerala.⁵

The 'YES-TECH Manual 2023' suggests a phased approach for adoption of this technology-based yield estimation, which will be given a mandatory 30 per cent weightage in the final blended yield calculation such as of an insurance unit (typically a gram panchayat) for the initial set of recommended crops, while 70 per cent weightage still is to be given to manual CCEs.⁶

States have an option to increase the weightage of this tech-based estimation data and taking a lead, Madhya Pradesh is currently the only state which estimates its entire yield for claim settlement by using YES-TECH. Data collected through YES-TECH therefore gets 100 per cent weightage.⁷

Other states that have adopted YES-TECH include Andhra Pradesh,

Assam, Haryana, Uttar Pradesh, Maharashtra, Odisha, Tamil Nadu and Karnataka. In these states, the claim calculation and settlement through YES-TECH had started kharif 2023 onwards.⁸

West Bengal, which has been implementing its own state-run crop insurance scheme Bangla Shasya Bima Yojana since kharif 2020 season has also integrated remote sensing, satellite imagery, weather data and ground truthing to monitor crop health and claim assessment.⁹

YES-TECH INCLUDES DATA COLLECTION IN PARALLEL THROUGH MULTIPLE COMPONENTS¹⁰

- Satellite imaging of crops and/or farms done by Technology Implementing Partners (TIPs) (private, government and scientific agencies);
- Weather data through Automatic Weather Stations (AWS) and/or Automatic Rain Gauge (ARG) by WINDS (Weather Information Network Data Systems) Implementing Partners
- Crop and/or farm photographs by farmers captured at multiple times during crop cycles;
- Photographs of the manual CCE process by surveyors; and
- Farm situation captured through drones etc.

The National Crop Insurance Portal (NCIP) is the repository of the collected data from all these sources, which is then processed through Artificial Intelligence (AI) and Machine Learning (ML) models.¹¹

There are four different models for yield estimation. These models use different data inputs such as crop health, weather and non-weather indices etc., arrived at from satellites and computer modelling.¹²

These models are outlined as:

- Semi-physical models based on radiation use efficiency;
- AI or ML models—machine learning, deep learning;



YES-TECH Manual with graphic representation of imaging through satellite

- Crop simulation models; and
- Ensemble models (machine learning, crop simulation, semi-physical).

Crop-and season-wise Technology Implementation Partners (TIPs) are empaneled to implement YES-TECH via these approaches. Mentor Institute for Technology Roll-out (MITRs) are also empaneled to oversee and guide the TIPs in implementing YES-TECH.¹³

Both TIPs and MITRs include private companies, government departments and scientific institutes (see *Table 1: YES-TECH Technology Implementation Partners and Mentor Institute for Technology Roll-out*).¹⁴

Table 1: YES-TECH Technology Implementation Partners and Mentor Institute for Technology Roll-out

Technology Implementation Partners (TIPs)	Mentor Institute for Technology Roll-out (MITRs)
• Space Application Centre, Ahmedabad • National Remote Sensing Centre, Hyderabad • National Remote Sensing Centre, Bengaluru • National Remote Sensing Centre, Kolkata • North East Space Application Centre, Shillong • CRIDA-ICAR, Hyderabad • IARI-ICAR, New Delhi • Tamil Nadu State Agriculture University, Tamil Nadu • Odisha University of Agriculture & Technology, Bhubaneswar • Professor Jayashankar Telangana State Agricultural University • Acharya NG Ranga Agricultural University, Hyderabad • Haryana Space Applications Centre, Hisar	• Space Application Centre, Ahmedabad • National Remote Sensing Centre, Hyderabad • National Remote Sensing Centre, Bengaluru • National Remote Sensing Centre, Kolkata • North East Space Application Centre, Shillong • CRIDA-ICAR, Hyderabad • IARI-ICAR, New Delhi • Tamil Nadu State Agriculture University, Tamil Nadu • Odisha University of Agriculture & Technology, Bhubaneswar • Professor Jayashankar Telangana State Agricultural University • Acharya NG Ranga Agricultural University, Hyderabad • Haryana Space Applications Centre, Hisar • Maharashtra Remote Sensing Application Centre, Nagpur • Madhya Pradesh Council of Science and Technology, Bhopal • Andhra Pradesh Space Application Centre, Vijayawada • ICRISAT, Hyderabad • AgroTech Risk Private Limited, Uttar Pradesh • Niruthi Climate & Eco systems Pvt Ltd, Hyderabad • Cropin Technology Solutions Pvt Ltd, Gurugram • WRMS Pvt Ltd, Gurugram • Amnex Infotechnologies Pvt Ltd, Gujarat • RMSI Pvt Ltd, Uttar Pradesh

Source: YES-TECH Manual, 2023

The Government of India has also signed Memorandums of Understanding (MOUs) with other private technology companies. Examples include Pixxel Space India Pvt. Limited, Microsoft India etc.^{15, 16}

Insurance companies also provide technology and other operational solutions for enhanced automated claim settlements.

Another use of YES-TECH is in smart sampling technique (SST), which helps choose CCE plots based on scientific data—satellite imagery, weather parameters and vegetation indices—to select the most representative fields within each Insurance Unit (IU). It replaces the randomized selection of a plot for a manual CCE.¹⁷

Moreover, space technology is also used for initiatives such as the FASAL project (Forecasting Agricultural output using Space, Agro-meteorology and Land based observations) and Drought Monitoring, which also provide technological support to PMFBY.¹⁸

Weather Information Network Data Systems (WINDS)

To address the concerns related to a sparse network of weather stations and need for granular weather data, the Ministry of Agriculture and Farmers' Welfare launched Weather Information Network Data Systems (WINDS) in July 2023 to support PMFBY and RWBCIS. A centralized digital platform—the WINDS portal—pools and integrates data from multiple sources.¹⁹

WINDS is expected to provide hyper-local, reliable and high-quality weather data (such as precipitation, wind speed, wind direction, air temperature, humidity etc.) to a wide range of stakeholders through the centralized WINDS portal.

It plans to connect and leverage the existing infrastructure of, for instance, private, scientific and public agencies, and set up a network of automatic weather stations (AWSs) at the block/tehsil level and automatic rain gauges (ARGs) at the gram panchayat (village) level. As of 2023, the goal was to set a network of weather stations in line with over 200,000 ground stations (AWS, ARGs).²⁰



In the case of PMFBY, it provides weather indices that feed into modelling to be done for yield estimation. In the case of RWBCIS, which has characteristics of a parametric insurance, it provides hyper-local data, based on which claim disbursement gets initiated without any loss estimation. It is believed to help in reducing the 'basis risk'—the mismatch between the weather index and a farmer's actual crop loss.²¹

Similar to YES-TECH implementation, WINDS Implementation Partners (WIPs) are onboarded via a tender, and Quality Assurance Partners (QAPs) are assigned for quality checks.

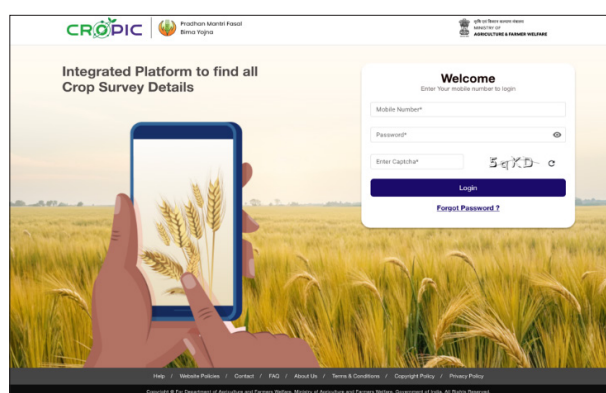
Mahalanobis National Crop Forecast Centre (MNCFC) functions as the secretariat of the WINDS committee which oversees the functioning. An interactive map of ground stations is presented on the WINDS portal for the implementers.²²

As on January 2025, nine states were in the process of implementing WINDS. These were Kerala, Uttar Pradesh, Himachal Pradesh Puducherry, Assam, Odisha, Karnataka, Uttarakhand and Rajasthan.²³

TECHNOLOGY FOR DATA PROCESSING

COLLECTION OF REAL TIME OBSERVATIONS AND PHOTOGRAPHS OF CROPS (CROPIC)

CROPIC leverages mobile technology and Artificial Intelligence (AI) in a multi-step process. A mobile application is used by farmers and field officials to capture geo-tagged photographs of their crop plots at different stages of the crop cycle (typically four to five times per season).^{24, 25}



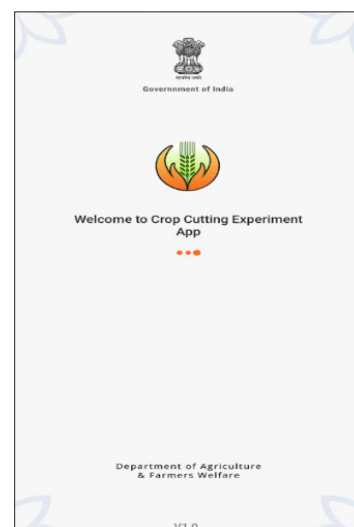
CROPIC website homepage

The photographs, along with meta-data like location and time, are uploaded to a cloud-based platform. AI and ML algorithms analyse these images to identify the type of crop, its health status, growth stages, and any signs of stress, pests, diseases or damage due to natural calamities etc.

The analysed data is displayed on the dashboard of NCIP. This dashboard provides officials and insurers with visual insights and data-driven information to make decisions on crop health and loss assessment.

CCE Agri App

Developed for the purpose of digitizing the process of crop yield estimation and collation of yield data obtained through Crop Cutting Experiments (CCEs). A mobile application has been developed and is being used for capturing the CCE data from the field and for uploading on the server. The CCE Agri app works in both online and offline mode.



CCE Agri app

TECHNOLOGY/ TECHNOLOGICAL PROCESSES ENABLING USER-FRIENDLY DIGITAL INTERFACE

NATIONAL CROP INSURANCE PORTAL (NCIP)

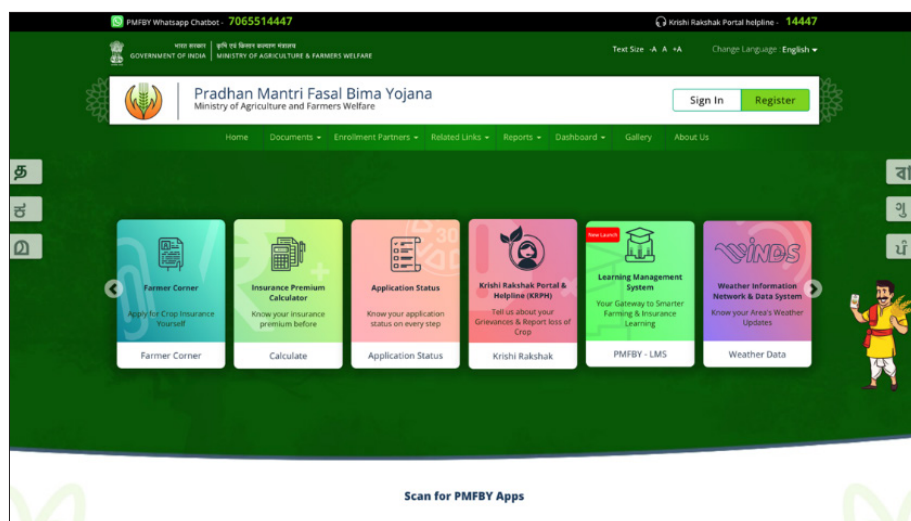


Photo: NCIP homepage with different sub-portals

Since the kharif season 2018 onwards, the National Crop Insurance Portal (NCIP) has been functioning as a centralized digital platform for all stakeholders. NCIP captures the entire data related to insured crops and also serves as the repository for the data relating to the crop insurance scheme.²⁶

NCIP is like a master portal which connects the user with the notification digitization, farmers application enrolment, application management, user management, subsidy release management, claim disbursement etc. thus acting as the central platform for all implementing bodies/stakeholders.

Applications and modules which can be accessed through the NCIP portal include:

AIDE (Application for Intermediary Enrollment)/ Sahayak app

A mobile application, AIDE, was launched for online enrollment in kharif 2024. This allows the farmer to enroll into crop insurance schemes without visiting a physical setting.^{27, 28}

SARTHI (Sandbox for Agricultural & Rural Security, Technology & Insurance Platform)

SARTHI, which serves to offer a comprehensive ecosystem of several insurance products relevant to farming and rural communities, is also linked to NCIP and can be accessed via the AIDE application.^{29, 30}



AIDE/Sahayak mobile application

Digiclaim module

Kharif 2022 onwards, the Digiclaim Module was set up to enable direct, paperless and near-instantaneous claim settlements to farmers' bank accounts. It also integrated NCIP with Public Finance Management System (PFMS) and accounting systems of insurance companies to provide timely and transparent processing of all claims.³¹

Agri-Stack

The NCIP is being integrated with Government of India Digital Public Infrastructures (DPIs), such as Agri-Stack, a nationwide, farmer-centric DPI that incorporates Farmer Registry, Geo-Referenced Village Map Registry and Crop Sown Registry.^{32, 33}

Krishi-Decision Support System

Integrated into NCIP, it works to integrate and standardize geospatial and non-geospatial data, including satellite, weather, soil, crop signatures, reservoir, and groundwater data, along with government scheme information. It offers crop maps, soil maps, automated yield estimation models, drought/flood monitoring systems, etc.³⁴

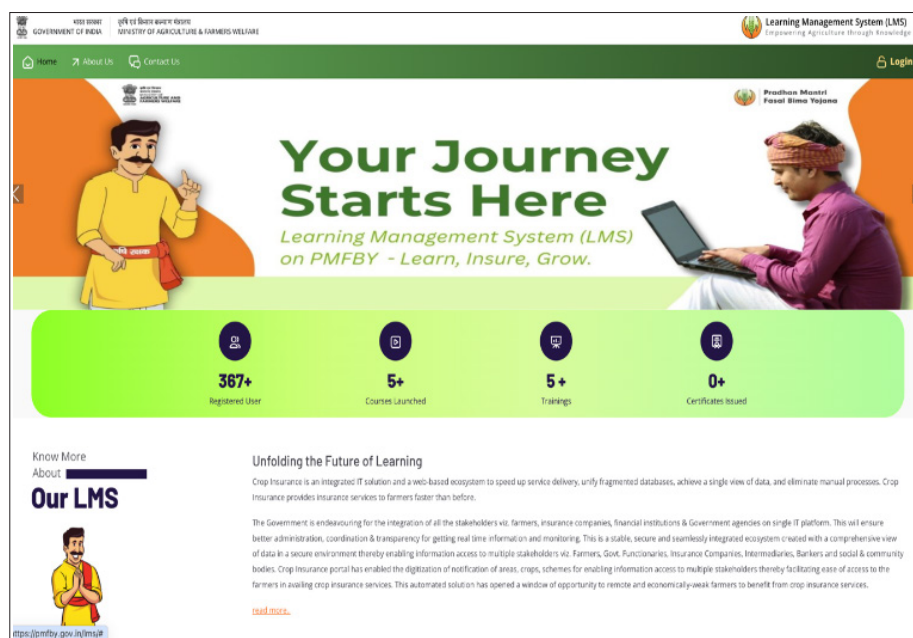
Krishi Rakshak Portal & Helpline (KRPB)

A portal which can be accessed by the farmer and a toll-free helpline number for query resolution and grievance redressal of farmers.

Learning Management System (LMS) Platform

LMS was developed in collaboration with the National E-Governance Division (NeGD) to provide stakeholders, including farmers, insurance companies, Government officials, state government representatives, and participants in the PMFBY, with the essential skills and knowledge needed for efficient crop insurance and agricultural credit.

The LMS aims to facilitate training and knowledge sharing through interactive modules, personalized training programmes, and accessible resources.³⁵



LMS homepage

CHALLENGES

Based on stakeholder interaction, it came out that although the crop insurance schemes have been witnessing a major technological integration, there still are gaps in terms of reach, penetration and conversion into favourable outcomes for farmers.

Reasons cited include, varied agro-climatic zones in India, coupled with difference in crops grown. Intercropping, mixed-cropping and other local variations exist interspersed across diverse farm sizes. The immense variations exacerbate the need for a robust database to better train AI models with the accurate information. Only then, validation becomes increasingly robust.

Moreover, errors in machinery persist. Farmers report erroneous recordings in the cases of reference weather stations, which result in under- or over-pay out of claims.

The farmers experience limited awareness and dependence on automated systems which needs to be further worked upon.



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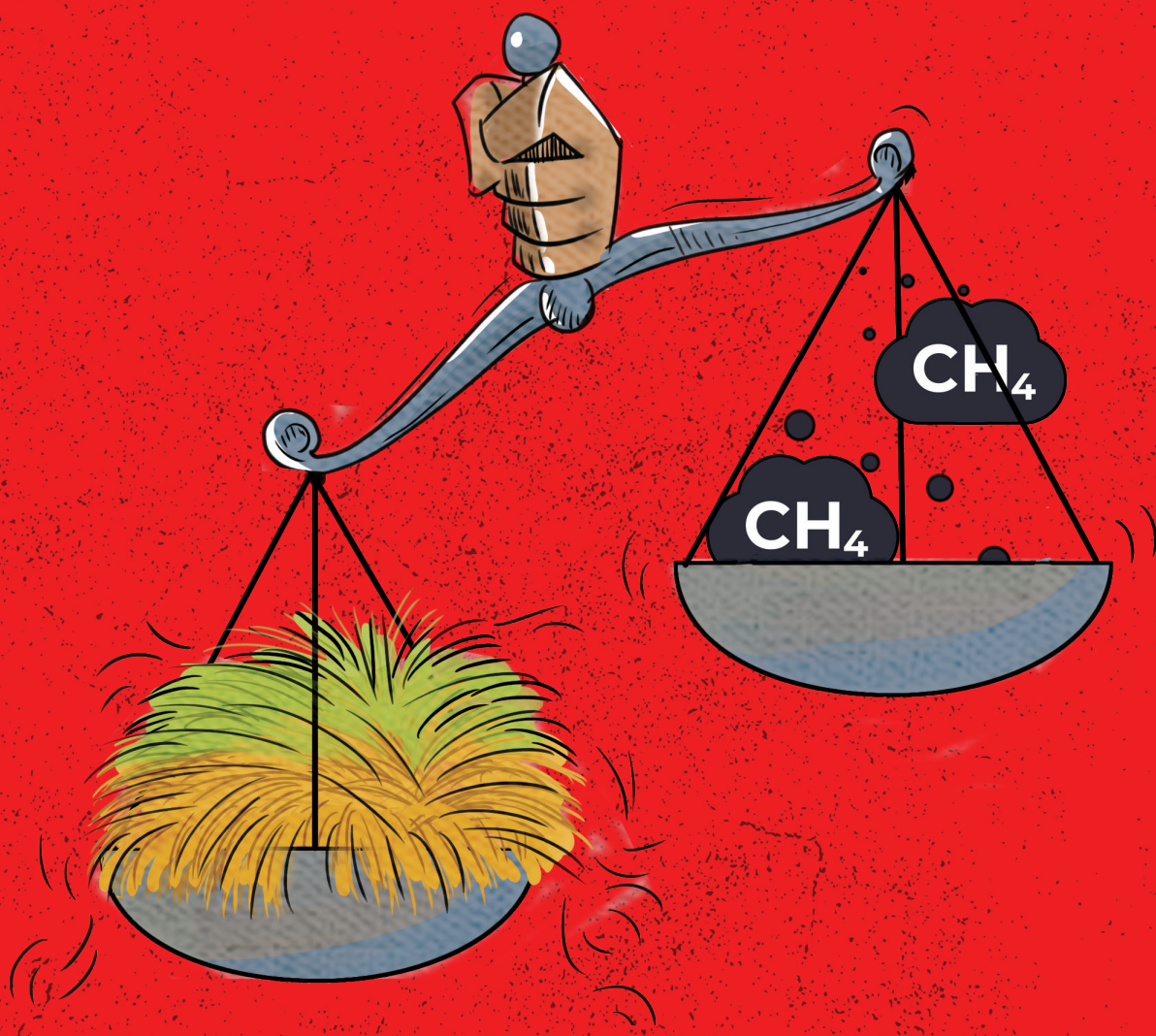


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AGENDA: LIVESTOCK-AN AGENDA FOR MITIGATION AND ADAPTATION

GHG EMISSIONS FROM THE INDIAN LIVESTOCK SECTOR

**SCALE AND POTENTIAL
MITIGATION OPTIONS**



IN BRIEF

STATE OF LIVESTOCK EMISSIONS AND FOCUS ON METHANE

Greenhouse gas (GHG) emissions from the Indian livestock sector involve primarily methane (CH₄) from enteric fermentation in ruminants (key sources: cattle, buffalo, goat, sheep) and methane and nitrous oxide (N₂O) from manure management.

Emission status (2020):

- **Enteric fermentation:** Emissions totalled 222.6 million tonnes of carbon dioxide equivalent (MTCO₂e).
 - ◆ **National share:** Enteric emissions constituted 8 per cent of the country's total emissions (2,959 MTCO₂e) (without Land Use, Land-Use Change, and Forestry [(LULUCF)], making it the third-largest single contributor.
 - ◆ **Share of agriculture:** Within agricultural emissions, enteric fermentation was dominant, accounting for 54.8 per cent.
- **Manure management:** Emissions were 13.07 MTCO₂e, contributing only 2 per cent to agriculture emissions and 0.44 per cent to the national total.

The magnitude of emissions is driven by India's large ruminant population and their reliance on high-fibre, low-digestibility feeds. Between 2011 and 2020, enteric emissions remained stable, growing at 1.6 per cent, compared to the 27 per cent growth in total country emissions.

CONNECTION TO DAIRY SECTOR POPULATION

The dairy sector is intrinsically linked to emissions, as cattle and buffaloes account for about 90 per cent of total enteric emissions.

- **Emission contribution:** 'Mature dairy cattle' and 'mature dairy buffalo' together accounted for nearly half (49.8 per cent) of all enteric emissions. They also emitted over half (54 per cent) of the methane from manure management.
- **Socioeconomic role:** India is the world's largest milk producer (25 per cent global contribution in 2023–24). The sector contributes five per cent to the national economy and employs over eighty million farmers. A crucial factor is that small, marginal, and landless labourers own about 75 per cent of the bovine population.
- **Population shift:** The total bovine population was 303.3 million in 2019. While indigenous/non-descript cattle population decreased by six per cent, the exotic/cross-bred cattle population increased significantly by 29.3 per cent. The milch cattle population of exotic/cross-bred varieties grew by 34.3 per cent, whereas indigenous milch cattle grew by only 0.8 per cent.

MITIGATION OPTIONS: FEED, BREED AND MANURE MANAGEMENT

Mitigation efforts focus on strategies with tangible co-benefits for farmers, addressing financial and resource limitations. These include:

Feed management

- **Ration Balancing Programme (RBP):** Achieved an average 13.7 per cent reduction in enteric methane emissions per kg of milk, alongside co-benefits like reduced feed cost and increased milk yield.
- **Feed additives:** Using bypass protein supplements reduced emissions by 0.417 MTCO₂e (2019–23). Supplements containing tannins and saponins, such as Harit Dhara (17–20 per cent reduction) and RESMI (potential 30 per cent reduction), are being developed.
- **Fodder quality:** Promoting green fodder production and silage making under the National Livestock Mission resulted in a reduction of 1.414 MTCO₂e (2019–24).

Breed improvement

- **Rashtriya Gokul Mission:** Promotes breed improvement through high genetic merit germplasm (AI, IVF, etc.). This strategy reduced emissions by 2.08 MTCO₂e (2019–24).
- **Strategic focus:** Indigenous cattle emit the least methane per head compared to exotic/cross-bred cattle and buffaloes. They offer high resilience and climate adaptation benefits. Experts recommend that mitigation efforts should focus on improving the productivity of indigenous breeds rather than substituting them.

Manure management

- **Biogas and organic fertilizers:** Options include setting up biogas plants at various scales (farmer, community, regional) for energy generation and producing organic fertilizers. NDDDB implements models like the Varanasi Model (large plant supplying steam/power to dairy plants and producing organic fertilizer), Banaskantha Model (producing bio-compressed biogas and organic fertilizer) and Zakariyapura Model (household biogas for cooking energy and organic fertilizer).
- **Government schemes:** Schemes like the GOBARdhan Yojna and the New National Biogas and Organic Manure Programme promote the better utilization of dung and minimizing methane emissions.

TOWARDS SUSTAINABLE LIVESTOCK

Mitigation in the Indian livestock sector is challenged by high costs, lack of awareness and the fact that these are primarily ‘survival emissions’ for the large population of small and marginal farmers (over 80 per cent) whose primary focus is livelihood security.

Required farmer-centric approach: A successful strategy must be carefully considered and phased, promoting solutions that offer simultaneous co-benefits.

- **Design:** Solutions must be farmer-centric, simple and cost-effective.

- **Holistic implementation:** They should be tailored to local contexts, avoid a one-size-fits-all approach, and aim for long-term sustainability and resilience.
- **Circularity and integration:** Practices should embrace circularity (e.g. using animal waste as manure) and must be integrated with adaptation strategies.
- **Strategic focus:** The emission intensity (emissions per kg of milk) perspective is less relevant; instead, the focus should be on improvement in the productivity of indigenous breeds, which are better suited for small farmers and emit less methane.

Mitigation is dependent on overcoming gaps. Its success hinges on overcoming implementation gaps and addressing financial constraints.

- **Incentivization and support:** Policy must incentivize farmers, particularly small and marginal cultivators, for their mitigation efforts. Adequate support is necessary to address gaps in technology, information and implementation.
- **Resource management:** Policies must address constraints such as fodder availability and affordability, as well as the high cost of feed additives, which currently hinder widespread adoption.
- **Strategic direction:** Policy must commit resources strategically to the improvement in the productivity of indigenous breeds.

GREENHOUSE GAS (GHG) EMISSIONS FROM THE INDIAN LIVESTOCK SECTOR

Greenhouses gas emissions from livestock are about the following emissions:

- Emissions from enteric fermentation (methane [CH_4]) in livestock (key sources: ruminant livestock like cattle, buffalo, goat and sheep)
- Emissions from manure management (methane and nitrous oxide [N_2O])

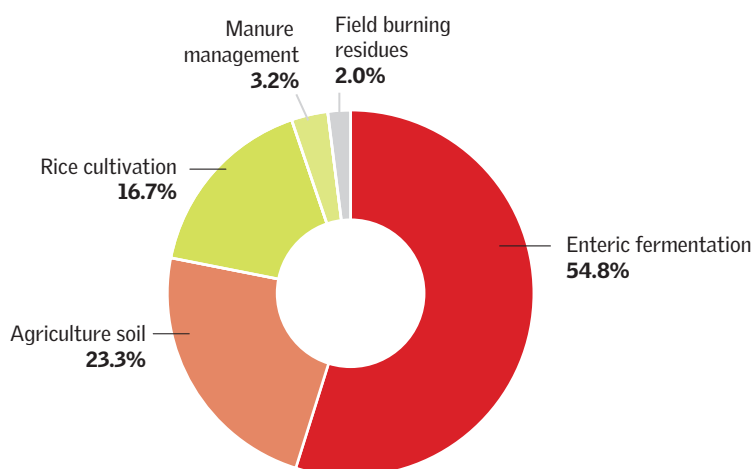
In 2020, emissions from enteric fermentation were 222.6 million tonnes of carbon dioxide equivalent (MTCO_2e) and emissions from manure management were 13.07 MTCO_2e as per the fourth Biennial Update Report (BUR-4) of the Ministry of Environment, Forest and Climate Change, published in December 2024.¹

With 8 per cent contribution in the total emissions of the country (2,959 MTCO_2e without Land Use, Land-Use Change, and Forestry), enteric emissions were the third-largest single contributor. However, emissions from manure management are just a small fraction (0.44 per cent).

Enteric emissions were 54.8 per cent and manure management were only 2 per cent of the agriculture emissions, which also include emissions from rice cultivation, agriculture soils and field burning of agriculture residues (see *Graph. 1: Emissions from enteric fermentation and manure management as part of agriculture emissions*).

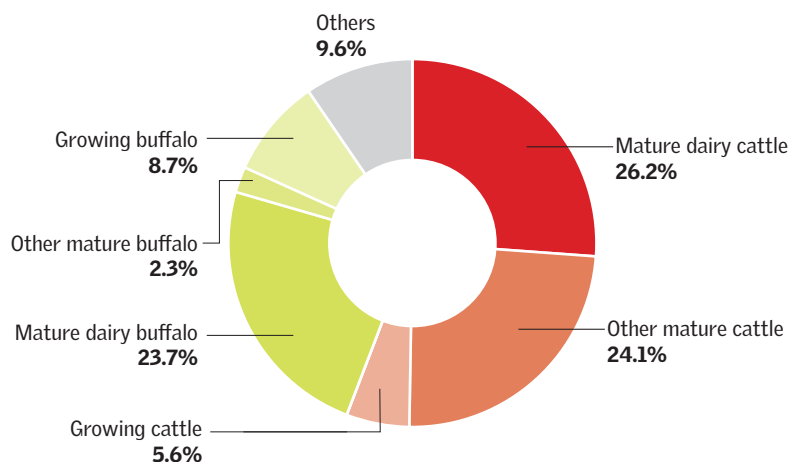
Between 2011 and 2020, the growth rate of emissions suggest that both agriculture (–0.8 per cent) and enteric emissions (1.6 per cent) remained stable, compared to total country emissions (27 per cent). About 90 per cent of the total enteric emissions are from cattle and

Graph 1: Emissions from enteric fermentation and manure management as part of agriculture emissions



Source: BUR-4; Note: BUR-4 reports the use of a global warming potential (100 years) of 21 for methane.

Graph 2: Share of enteric emissions from cattle and buffalo in livestock emissions



Source: BUR-4; Note: BUR-4 reports the use of a global warming potential (100 years) of 21 for methane.

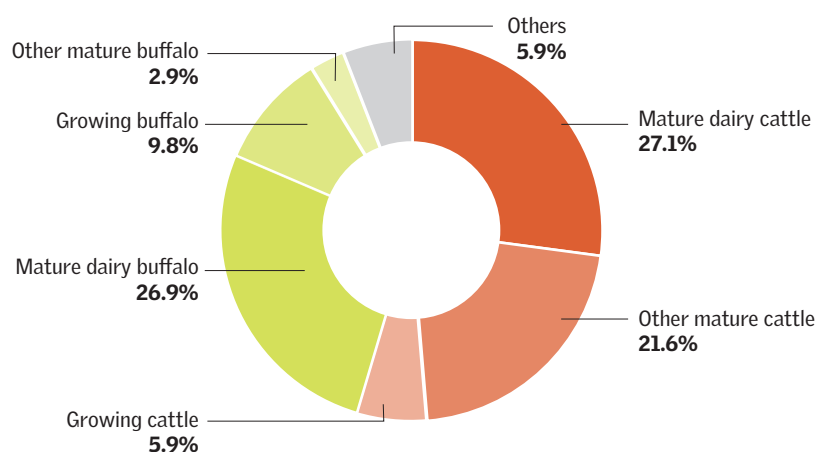
buffaloes, and the remaining 10 per cent are from other livestock species such as sheep, doe, swine, camels, mules and horses. With 55.8 per cent, emissions from cattle were more than buffaloes (34.6 per cent). 'Mature dairy cattle' and 'mature dairy buffalo' together emitted about half (49.8 per cent) of the enteric emissions.² The 'growing cattle' and 'growing buffalo' together emitted 14.3 per cent (see *Graph 2: Share of enteric emissions from cattle and buffalo in livestock emissions*).

EMISSION PHYSIOLOGY FROM ENTERIC FERMENTATION

Methane emission in the livestock sector is primarily linked to enteric fermentation, which involves the digestive process of ruminants that constitute the bulk of India's cattle and buffalo population. In these animals, complex fibrous feeds such as crop residues and grasses are fermented in the rumen by microbes to produce volatile fatty acids that supply energy to the animal. During this fermentation, hydrogen and carbon dioxide are generated as byproducts, which are then converted into methane by methanogenic archaea to maintain rumen stability. The methane formed

is expelled mainly through belching. The scale of this process in India is significant because of the country's large ruminant population and their dependence on high-fibre, low-digestibility feeds. Consequently, enteric fermentation from livestock remains one of the dominant sources of methane emissions in India's agriculture sector, contributing substantially to the country's overall greenhouse gas profile. Ruminant livestock (e.g. cattle, buffalo, goats, and sheep) are key sources, while non-ruminant animals also contribute smaller amounts.

Graph 3: Share of methane emissions from management of cattle and buffalo manure



Source: BUR-4; Note: BUR-4 reports the use of a global warming potential (100 years) of 21 for methane.

About 94 per cent of the total methane emissions from manure management were from cattle and buffaloes (see *Graph 3: Share of methane emissions from management of cattle and buffalo manure*), and the remaining 6 per cent were from others such as sheep, doe, swine, camels, mules and horses. With 54.6 per cent, emissions from manure management of cattle are more than that of buffaloes (39.5 per cent). Manure management of 'mature dairy

cattle' and 'mature dairy buffalo' together emitted over half (54 per cent) of the emissions.³ Manure management of 'growing buffalo' and 'growing cattle' together emitted 15.7 per cent.

Nitrous oxide emissions from manure management—of 'mature dairy cattle'—accounted for 33 per cent, 'mature cattle' for 22 per cent, 'mature dairy buffalo' for 21 per cent, and other species for 24 per cent.

ESTIMATION OF ENTERIC EMISSIONS FROM LIVESTOCK

To assess the methane from enteric fermentation in cattle and buffaloes, India utilizes the Tier 2 method of emission calculations developed by the UN Intergovernmental Panel on Climate Change (IPCC), which represents national circumstances. But the Tier 2 process is complex and requires a substantial amount of data (known as activity data) and needs continued technical capacity building and, in the absence of specific relevant data, relies on expert judgement. Estimating methane emissions from Indian livestock involves identifying and categorizing species and breeds, estimating feed intake and body weights, and calculating total dry matter intake (DMI).

The first step is to categorize and sub-categorize livestock populations based on factors such as species, productivity, age and sex. Cattle and buffaloes are categorized into two main categories: dairy and non-dairy. Dairy cattle are further classified into two sub-categories: low-yielding indigenous and high-yielding crossbred. Non-dairy cattle and buffaloes include calves below the age of one (but over three months because young calves do not have a functioning of rumen and hence do not generate methane), adults beyond

calving age, and those between one and two years in age.

After identifying the population, feed intake is estimated as the number of kg of dry matter per 100 kg of body weight per day. Body weights are determined using published reports, while for non-descript cattle (which lack specific breed descriptions) expert judgement is employed and set at 20 per cent less than that of well-described breeds in the respective region of the country. Subsequently, the total DMI for each subcategory of livestock is calculated as a percentage of their body weight.

Methane emission factors (estimated as kg CH₄ per head per year) are then calculated by multiplying the methane conversion factor (gCH₄ per kg of DMI as published in reports), indicating the average emissions for each livestock type annually. Emission factors vary across categories and sub-categories. Finally, the emission factors are multiplied by the associated animal population and summed up to find the total emissions. Because of several reasons, including the size and diversity of the population and the quality and quantity of the feed intake, livestock emissions are believed to have high uncertainty.

India uses the Tier 1, default method for methane and nitrous oxide emissions from manure management.

THE INDIAN DAIRY SECTOR

Dairy products in India are the single largest agricultural commodity. India ranks first in milk production globally, with 25 per cent contribution in 2023–24. During this year, 239.30 million tonnes of milk was produced, with a per capita availability is 471 grams per day.⁴ In the last five years, milk production has grown by 20.6 per cent.

The dairy sector contributes 5 per cent to the national economy and directly employs more than 80 million farmers.⁵ Most of the milk production happens at the level of small, marginal and landless labourers who own about 75 per cent of bovine population, and are about 85 per cent of total farming community with 45 per cent of the total agricultural land.^{6, 7}

As per 20th Livestock Census of 2019, the total number of cattle and buffaloes were 303.3 million, of which 64 per cent were cattle (193.46 million) while 36 per cent were buffaloes (109.8 million).

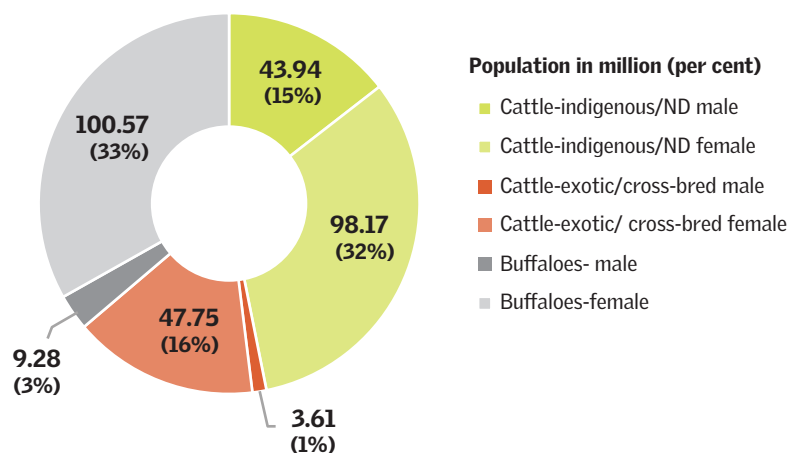
Cattle population grew only by 1.3 per cent from 2012 and the population of buffaloes grew by 1.1 per cent.

Total population of indigenous/non-descript (ND) cattle was 142.1 million and of exotic/cross-bred cattle was 51.4 million. The female cattle population (145.91 million) grew by 18.6 per cent and milch cattle (74.59 million) grew by 10.4 per cent (see *Graph 4: Population of cattle and buffaloes in India, 2019*).

The total indigenous/ND cattle decreased by 6 per cent, while the indigenous female population grew by 10 per cent and indigenous milch cattle grew just by 0.8 per cent.

On the contrary, total exotic/cross-bred cattle increased by 29.3 per cent, while their female population (47.75 million) grew by 41.4 per cent and their milch cattle (26.1 million) grew by 34.3 per cent.

Graph 4: Population of cattle and buffaloes in India, 2019



In case of buffaloes, the female population (100.57 million) grew by 8.6 per cent and milch cattle (51.17 million) grew by 0.2 per cent.

POTENTIAL EMISSION MITIGATION OPTIONS IN DAIRY SECTOR

DIET MANAGEMENT FOR ENTERIC EMISSIONS

As per the BUR-4, between 2019 and 2024, 1.63 lakh animals were covered under the Rational Balancing Programme (RBP), which led to an emission reduction of 0.0205 MTCO₂e. Based on the concept of a balanced diet, the Department of Animal Husbandry and Dairying (DAHD) under the National Dairy Plan I had launched RBP in 2012. Implemented by the National Dairy Development Board (NDDB), the programme covered over 33,000 villages in 18 states, and 28.7 lakh dairy animals of about 21.6 lakh farmers.⁸ An average of 13.7 per cent reduction in enteric methane emissions per kg of milk was achieved, in addition to increase in net daily income of the farmers due to reduction in feed cost, additional milk yield and increased fat content, and increased lactation period in cattle and buffaloes.⁹ A 'Pashu Poshan' app was also developed for milk producers.

BUR-4 reports that between 2019 and 2023, 7.5 lakh cross-bred/exotic cows and buffaloes who were fed with bypass protein supplement led to an emission reduction of 0.417 MTCO₂eq. Studies suggest that diet management through bypass proteins (designed to pass through the rumen of a cow and digest in the abomasum or the stomach), increased usage of green fodder, enriching dry fodder like silage, feed additives like tannins and saponins, feed supplements and mineral mixture supplementations, can achieve a 10–30 per cent reduction in enteric methane emissions (see *Table 1: Feed additives with potential to reduce enteric emissions from livestock*).

The National Livestock Mission, through its sub-mission on feed and fodder development promotes green fodder production, silage making, chaff cutting, and total mixed ration. During 2019–24, according to BUR-4, 35.27 lakh animals were given green fodder and an emission reduction of 1.414 MTCO₂e was achieved. Similarly, over 26,000 buffaloes were fed with silage during the 2021–24, and emission reduction of 0.0019 MTCO₂e was achieved during 2019–24.

Table 1: Feed additives with potential to reduce enteric emissions from livestock

Feed additive/ Supplement	Developer	Details	Advantages
Harit Dhara	ICAR-National Institute of Animal Nutrition and Physiology	An anti-methanogenic feed supplement prepared from tannins and saponins containing natural phytosources	Helps to reduce enteric methane emissions by ~17-20 per cent when included in feed ^{10,11}
GRAND (Gruel Rooted Additive Nourishment Drops)-TANUVAS	Tamil Nadu Veterinary and Animal Sciences University	An aqueous nutritional feed supplement for cattle, especially those on a gruel-based, nitrogen-deficient diet common in small-holder dairy farms	Potential to reduce methane emission per animal by 20 per cent ¹²
Red seaweed-based animal feed additive	CSIR-Central Salt and Marine Chemicals Research Institute	It is linked to the <i>Asparagopsis</i> genus, contains active compound bromoform, a powerful methane inhibitor	Can bring down methane emissions ¹³
Tamarin Plus	ICAR-National Institute of Animal Nutrition and Physiology	Tamarind seed husk (TSH) included in the diet of ruminants, acts as a methane suppressant. It is an anti-methanogenic feed supplement prepared from tannins and saponins containing natural phytosources	Supplementation of TSH at 5 per cent level decreased methane emission by 17 per cent in cattle ^{14, 15}
RESMI-Composite feed additive	ICAR-Central Institute for Research on Buffaloes	Composite feed additive consisting of methane inhibitors and alternate hydrogen sinks	Supplementation can reduce methane emission by 30 per cent, by reducing number of methanogenic archaea in rumen and promoting growth of alternate hydrogen utilizers like sulphate reducing bacteria ¹⁶

BREED IMPROVEMENT FOR ENTERIC EMISSIONS

As per BUR-4, 2.08 MTCO₂e emissions were reduced by producing female calves having high genetic merit germplasm for enhancing milk production and productivity for the period 2019–24.

Understanding the importance of indigenous cattle resources in India's journey towards sustainable and productive livestock, DAHD is promoting breed improvement under the Rashtriya Gokul Mission. Launched in 2014, the mission has several components, such as ensuring availability of germplasm with high genetic merit, accelerated breed improvement through artificial insemination, in vitro fertilization, sex-sorted semen centres, farmer awareness and skill development. The scheme is continued for 2021–26, with an outlay of Rs 2,400 crore.

The scheme has shown some success and there are certain challenges. With 70 per cent of the indigenous cattle as non-descript as per 2019 Livestock Census, India's unique decentralized subsistent dairy agriculture sector required tailored programmes, which may take longer to implement. This also means that scope of improvement is quite high.

Large populations of indigenous cattle is often held responsible as the primary cause of enteric emissions. However, indigenous cattle emits the least methane per head compared to exotic/cross-bred cattle and buffaloes, and therefore is a recognized solution with multiple benefits such as better disease resilience and climate adaptation. Experts suggest that indigenous cattle produce less methane due to their smaller size and efficient metabolism. They also thrive in domestic, smallholder and pastoral systems, reducing their carbon footprint further.

With reference to both breed improved and diet management, financial and resource limitations do pose significant challenges. While stakeholders emphasize the need to incentivize farmers, particularly small and marginal cultivators, for their mitigation efforts, fodder availability and affordability, feed additive costs, lack of high-yielding purebred indigenous cattle and a lack of farmer awareness hinder the widespread adoption of these mitigation measures.

MITIGATION OF EMISSIONS FROM MANURE MANAGEMENT

Mitigation options for emissions from manure management include

- Biogas generation from manure-biogas plants at the farmer, community and regional levels;
- Good manure management practices; converting animal dung to organic fertilizers like vermi compost and other bio-inputs; improved dung handling practices; and
- Promoting organic and natural farming which has multiple co-benefits; encouraging a circular economy approach.

Innovative manure management options include NDDB's Varanasi Model that started in 2021, and involved dung-based large-

capacity biogas plant to suffice steam and power needs of dairy plant and produce organic fertilizer. Another NDDDB initiative known as Banaskantha Model started in 2023 with a dung-based large-capacity biogas plant to produce bio-compressed biogas and organic fertilizer. Its 2019 Zakariyapura Model uses household-level biogas-based manure value chain model sufficing for the cooking energy and organic fertilizer needs of farmers.

Other potential programmes that could be leveraged are 'New National Biogas and Organic Manure Programme' of the Ministry of New and Renewable Energy, which aims to promote setting up of small-scale user-friendly family and community-level biogas plants using cattle manure and other organic waste, for better utilization of cow dung and minimizing methane emission.¹⁷ Better management of dung is also promoted under GOBARdhan (Galvanizing Organic Bio-Agro Resources Dhan) Yojna by the Department of Drinking Water and Sanitation.¹⁸ In 2023–24, 198 plants were set up across the country, including 12 compressed biogas plants and 186 biogas plants, under this scheme.

At the state level, Chhattisgarh's Godhan Nyay Yojana (launched in 2020) and the Maharashtra Methane Mission (launched in 2024) focus on dung management to reduce emissions and boosting rural income.^{19, 20}

NEED FOR FARMER-CENTRIC APPROACH TO REDUCE EMISSIONS

There are several mitigation options but each option has its own set of challenges such as high cost, lack of awareness, capacity-building needs and implementation difficulties. Based on challenges and possibilities, some have received more attention. There are others that have been tested but are no longer implemented or are less lucrative to farmers and do not offer adequate co-benefits. Overall, the scale of adoption of mitigation measures promoted by governments has been low in Indian agriculture.

The fact that agriculture emissions in India are 'survival emissions', or generated from vital activities that ensure livelihoods and food security for a large population, also means that the scope of

reduction is limited compared to 'luxury emissions', or those from activities that are not essential.

For over 80 per cent of farmers who are considered to be small and marginal, adopting measures just to reduce emissions would not be a priority. Their primary focus is on ensuring livelihood security. At the national level, food and nutrition security concerns also influence decisions that determine the degree of efforts and resources allocated to mitigation.

A carefully considered and phased approach would suit the Indian scenario better. Options that can help reduce emissions and offer co-benefits can be more useful. This may include reducing enteric emissions through resilient indigenous breeds and non-chemical approaches like natural and organic farming. Moreover, addressing the gaps in technology, information and implementation along with adequate support to farmers will determine the success of any such programme.

Successful mitigation will happen if the solutions designed and promoted are farmer-centric, simple, and cost-effective, with clear incentives for adoption, especially for small and marginal farmers. The solutions must be holistic and aimed towards long-term sustainability and resilience. These should be tailored to local contexts, involving stakeholders to enhance adoption and community-wide benefits, avoiding a one-size-fits-all approach. These should embrace circularity, like using animal waste as manure instead of chemical fertilizers. India's approach to mitigation must be integrated with adaptation.

It is also important to recognize that the value of livestock for a small farmer in India is not just limited to milk productivity. This means the emission intensity (emissions per kg of milk) based point of view to reduce emissions is less relevant in the Indian context. For example, while India's indigenous breeds are not as productive as cross-breeds, they offer several advantages to small farmers. India's mitigation in the livestock sector therefore is best placed through improvement in the productivity of the indigenous breeds, rather than substituting them with cross-bred cattle, which is not only less-suitable for Indian small-farmer, but also emits much more methane.

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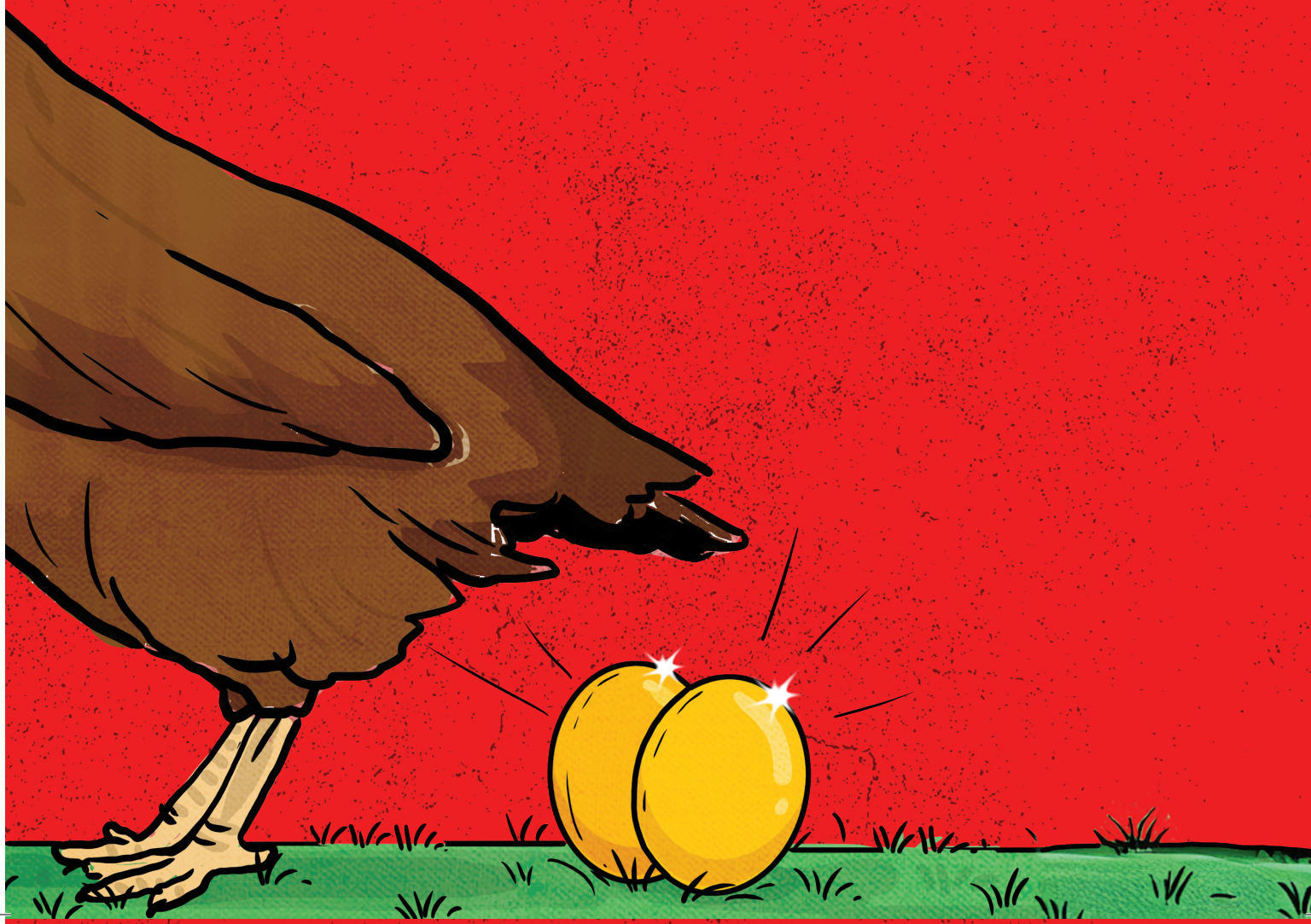
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AGENDA: LIVESTOCK-AN AGENDA FOR MITIGATION AND ADAPTATION

BACKYARD AND RURAL POULTRY SYSTEMS

**HOW RESILIENT BREEDS
CAN LEAD TO IMPROVED
LIVELIHOOD AND
NUTRITION**



IN BRIEF

BACKYARD AND RURAL FARMING SYSTEMS MORE SUSTAINABLE THAN COMMERCIAL MODELS

Rearing systems: Indian poultry production is categorized into three types: backyard (10–15 birds, primarily for family nutrition and small supplementary income), rural (50–100 birds in free-range settings or 500–3,000 birds in sheds, supporting both nutrition and livelihood/income generation), and commercial (intensive, organized rearing of flocks exceeding a lakh).

Scale: In 2019, 37 per cent (317.07 million) of India's total poultry population (851.81 million) was part of backyard poultry (including rural poultry). Backyard poultry contributed over 22 billion eggs in 2023–2024, representing 15.4 per cent of the country's total egg production (142.77 billion).

Health and environmental impact: Backyard and rural poultry systems are more sustainable than intensive, commercial systems as they help reduce the negative impact associated with the latter. Intensive systems, particularly in poultry, are also linked with zoonoses and pandemics.

RESILIENT BREEDS FUNDAMENTAL TO THE SURVIVAL, GROWTH AND SUSTAINABILITY OF BACKYARD AND RURAL POULTRY

Some key advantages of resilient breeds include:

High adaptability and disease resilience (environmental sustainability)

Resilient breeds are naturally suited for extensive, low-impact farming environments reducing the need for intensive resource management.

- **Adaptation to local conditions:** Many resilient breeds, including Indian native poultry, are grown locally and have higher adaptability to local climatic and environmental variations.
- **Disease resilience:** These breeds are characterized by their natural disease resistance, a hardiness that stands in contrast to commercial systems which rely heavily on medication and strict biosecurity. Intensive, commercial systems are also linked with risks such as zoonoses and pandemics.

Low-input requirement (economic sustainability)

Resilient breeds minimize the investment needed for successful rearing, making the systems economically viable for smallholders.

- **Minimal investment:** Their feed, care and housing require less investment than commercial breeds raised in intensive industrial systems.
- **Cost-effectiveness and low-risk:** Rearing these breeds can be cost-effective, carries low risk and they offer good returns on investment.
- **Feed flexibility:** Improved varieties, such as the Kuroiler, are resilient to harsh rural conditions and can thrive on household scraps and waste, requiring minimal shelter.

Foundation for smallholder farming and livelihoods

Resilient breeds (both native and improved varieties) form the backbone of smallholder farming systems in rural settings in India. This reliance on adaptable breeds allows these systems to offer crucial sustainability benefits such as:

- **Dual purpose and nutrition:** Native breeds are often dual-purpose (reared for both meat and eggs). The smallholder rural poultry systems, particularly backyard systems, are sustainable because they offer livelihood and nutrition to rural masses.

- **Improved productivity:** Improved varieties address the productivity concerns of native breeds while retaining resilience, boosting sustainability by ensuring better outputs.

Market value and quality

The products of resilient breeds hold an advantage in quality, contributing to their long-term sustainability:

- **Higher market price:** If market access is achieved, the meat and eggs from these resilient breeds can yield a higher market price because they are often chemical free, high in nutritional value, and rich in taste.

PROMOTION OF BACKYARD AND RURAL FARMING — NEED TO SCALE UP

National Livestock Mission (NLM)

This mission promotes the rearing of low-input technology (LIT) birds. It provides a one-time 50 per cent capital subsidy (up to Rs 25 lakh) to entrepreneurs, self-help groups (SHGs) and Farmer Producer Organizations (FPOs), to establish parent farms, hatcheries, and brooder-cum-mother units.

AICRP on poultry breeding (ICAR)

This project focuses on developing location-specific chicken varieties and conserving native germplasm, distributing about 11.8 lakh chicken germplasm to 16.7 thousand farmers in 2024.

State initiatives

Many states offer programmes for small and marginal farmers, such as West Bengal's programme to distribute 1.5 crore chicks, and Odisha's scheme of providing 100 per cent subsidy for 50 LIT birds to marginalized farmers.

GAPS AND CHALLENGES LIMITING PROMOTION OF BACKYARD OR RURAL POULTRY FARMING SYSTEMS

- **Disease risk and mortality:** Farmers often skip timely vaccination (crucial in the first 6–8 weeks) due to lack of awareness, resources, cost and poor access/availability. This leads to high disease prevalence and mortality.
- **Infrastructure and brooding:** Small farmers lack the necessary resources and facility for adequate brooding and nutrition during the initial six to eight critical weeks, which contributes to high mortality. Proper infrastructure for biosecurity is also lacking.
- **Access to quality stock:** Farmers in remote areas often rely on local middlemen and may not receive healthy, quality stock of the right breed or variety. Stock from government sources is cheaper but sometimes perceived as lower quality than that from private players.
- **Veterinary support:** Distribution centers lack adequate follow-up processes, and there is a limited on-the-ground presence of veterinarians to guide farmers or manage diseases like Ranikhet disease.
- **Market access:** Backyard farmers often struggle to travel to markets to sell small quantities of birds, and there are limited vendors or middlemen to collect stock at a fair price.

POLICY AVENUES AND POSSIBILITIES

Risk reduction via mother units

The most crucial need is to reduce risk and mortality in the first six to eight weeks. This requires establishing and strengthening mother units that can collect day-old chicks (DOCs), provide the necessary brooding, management and vaccination conditions, and keep chicks until they are stable (6–8 weeks) before distributing them to farmers.



Ensuring sustainable supply and availability of resilient breeds

- Public-private partnerships (PPPs) should be explored and encouraged to ensure a continuous supply of locally relevant and resilient breeds, thereby addressing the demand-supply gap that government institutions alone cannot meet.
- Incentives should be given to select farmers to set up their own breeder farms and small incubators, fostering self-sustainability.

Strengthen coordinated support, capacity and veterinary guidance

- State governments should ensure access to at least basic essential vaccines.
- Community Animal Health Workers (CAHWs) or para-vets should be utilized and trained to provide vaccination, basic veterinary treatment, and guidance in areas where professional veterinary supervision is limited.
- Support is needed for the creation of dedicated FPOs and formal structures such as cooperatives for backyard and rural poultry. These organizations would ensure appropriate market access, remunerative pricing, and help farmers source essential inputs like vaccines, feed and subsidized veterinary services.

EXAMPLES OF SUCCESSFUL BACKYARD/ RURAL POULTRY FARMING IMPROVING FARMER LIVELIHOOD AND NUTRITION

Backyard and rural poultry systems, led by resilient breeds, provide crucial livelihood security and nutritional benefits, especially to rural households. These systems also offer nutritional and market value for rural masses. If market access is achieved, the meat and eggs from these resilient breeds can yield a higher market price because they are often chemical-free, nutrient-rich and better tasting. Three distinct models demonstrate effective implementation approaches:

the KeggFarms Kuroiler model, a community-led backyard poultry initiative supported by the Aga Khan Rural Support Programme (India), and mother units supported by the Central Avian Research Institute (CARI) to promote farmer livelihoods.



INTRODUCTION

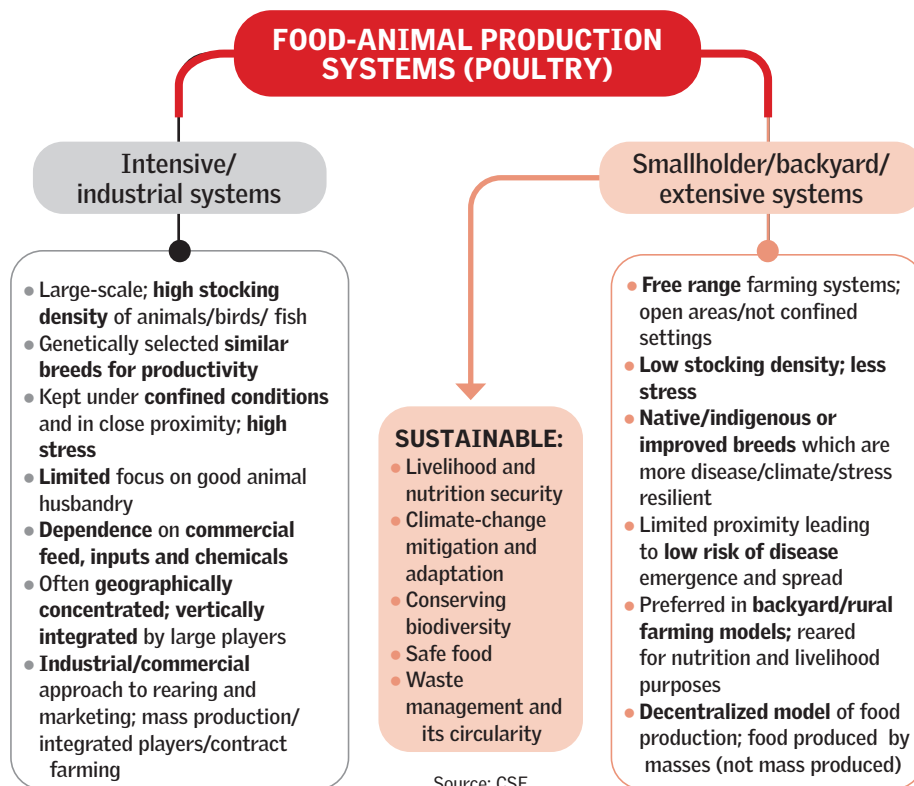
Food-animal production systems such as dairy, poultry and aquaculture can significantly impact environment, ecological health, climate, biodiversity, food safety and food security. Sustainability of such a system depends upon the kind of rearing systems (such as intensive or extensive rearing systems) used to grow food from animals. Each of these system is characterized by different breeds, use of feed, stocking density, management practices and other factors, all of which determine the impact each of these food systems may have.

Resilient breeds play a critical role. Many locally reared varieties, including Indian poultry, show greater adaptability to local climatic and environmental variations. They also require lower investment in feed, care, and housing compared to the high-maintenance commercial breeds preferred in intensive industrial production systems.

Productivity challenges associated with resilient native breeds are being addressed through improved breeds that combine high productivity with adaptability. Together, native and improved breeds form the backbone of smallholder poultry farming systems in rural India.

In addition, such smallholder rural poultry systems, in particular, backyard poultry systems are sustainable compared to commercial intensive systems. They not just offer livelihood and nutrition to rural masses, but help reduce negative impact of commercial intensive food production as mentioned above. Such intensive systems, particularly in poultry, are also linked with zoonoses and pandemics. (see *Figure 1: Sustainability of food systems*)

Figure 1: Sustainability of food systems



INDIAN POULTRY PRODUCTION SYSTEMS

The Indian poultry production systems can be broadly understood as three different types of farming systems—backyard, rural and commercial systems. Backyard farming entails rearing of 10-15 birds in the backyard aimed primarily for family nutrition and small supplementary income. Rural farming involves 50-100 birds in free-range settings for family nutrition and livelihood, as well as 500-3,000 birds reared in sheds primarily for income generation. Commercial farming is about organized, intensive rearing systems with flock size going up to a lakh or more. Each system has distinct characteristics, but rural and backyard poultry stand out for offering both livelihood and nutritional benefits while being more sustainable than commercial models (see *Figure 2: Poultry production systems in India*)

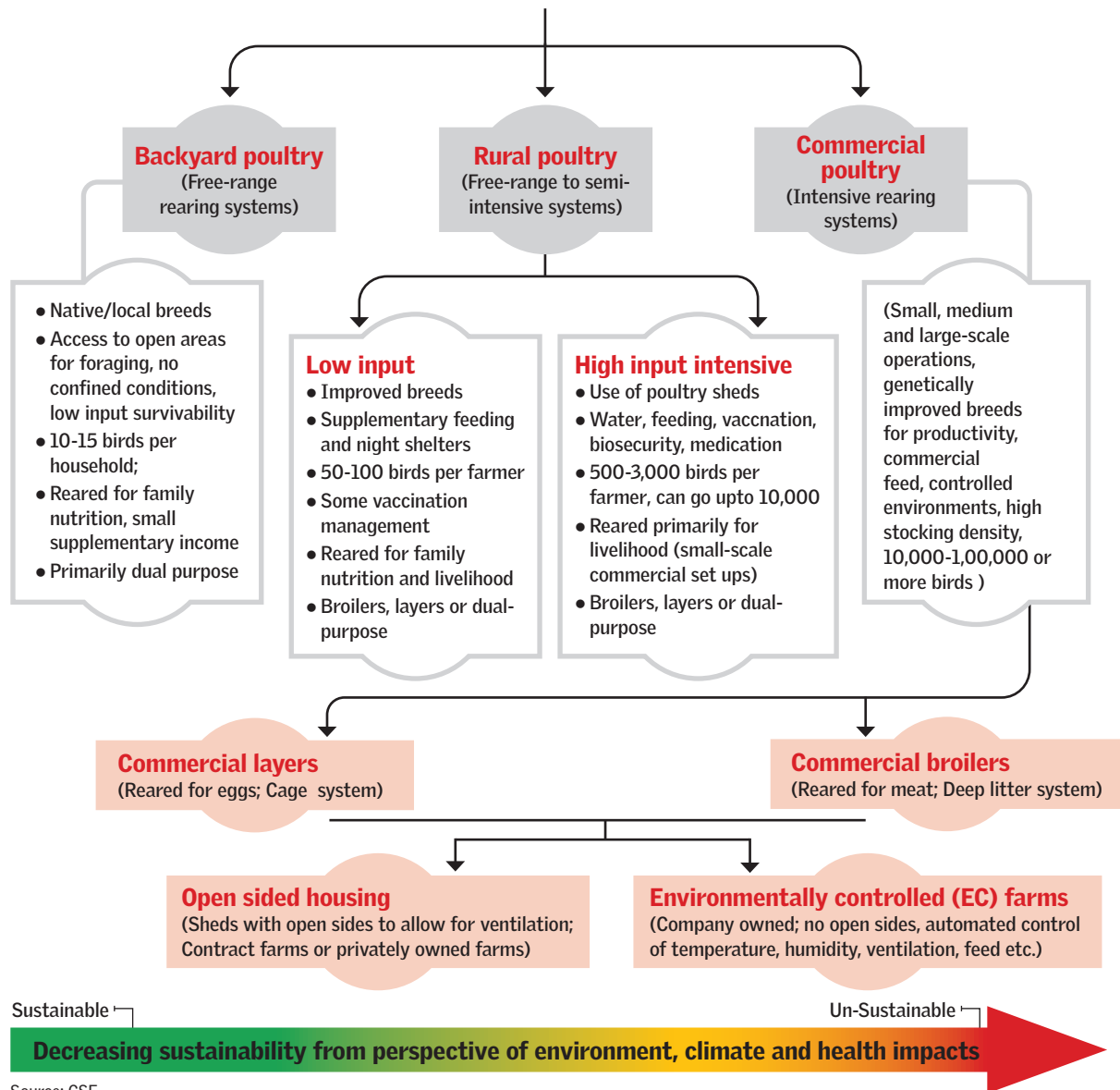
BACKYARD AND RURAL POULTRY IN INDIA

The total poultry population as per the latest Livestock Census of 2019 was 851.81 million, out of which 95 per cent are fowls (cocks, hens and chicks below five months).¹ Thirty-seven per cent (317.07 million) of the total population was part of backyard poultry (including rural poultry), which saw about 46 per cent growth from 2012. The remaining about 535 million are part of commercial poultry systems.

In 2023–2024, over 22 billion eggs were from backyard poultry which is only 15.4 per cent of the total egg production (142.77 billion) in the country.² Ninety three per cent (20.56 billion) of these eggs are from fowls—68 per cent (15 billion) from desi (native) fowls (<100 eggs produced in a year), 25 per cent (5.6 billion) from improved fowls (>100 eggs produced in a year).

The top 10 states collectively producing over 83 per cent of total number of eggs from backyard poultry (fowls) are:

Figure 2: Poultry production systems in India



Source: CSE

- West Bengal [≈7.81 billion (781.49 crores) or 48.1 per cent of its total egg produced]
- Kerala [≈2.18 billion (217.85 crores) or 90.6 per cent of its total egg produced]
- Maharashtra [≈1.52 billion (152.12 crores) or 19.5 per cent of its total egg produced]



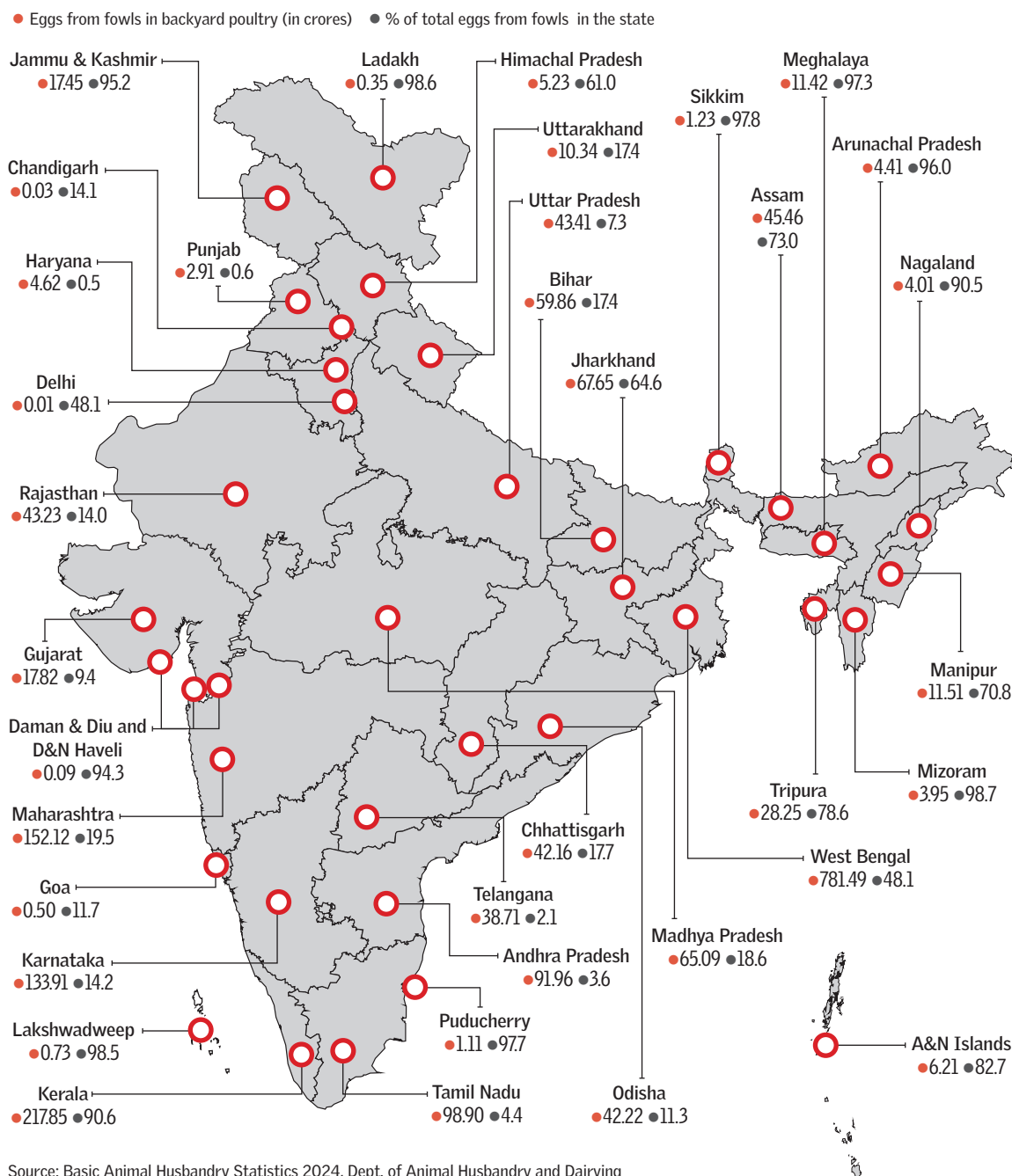
- Karnataka [≈1.34 billion (133.91 crores) or 14.2 per cent of its total egg produced]
- Tamil Nadu [≈0.99 billion (98.90 crores) or 4.4 per cent of its total egg produced]
- Andhra Pradesh [≈0.92 billion (91.96 crores) or 3.6 per cent of its total egg produced]
- Jharkhand [≈0.68 billion (67.65 crores) or 64.6 per cent of its total egg produced]
- Madhya Pradesh [≈0.65 billion (65.09 crores) or 18.6 per cent of its total egg produced]
- Bihar [≈0.60 billion (59.86 crores) or 17.4 per cent of its total egg produced]
- Assam [≈0.46 billion (45.56 crores) or 73 per cent of its total egg produced]

The figures indicate that states such as Tamil Nadu and Andhra Pradesh primarily produce eggs through commercial poultry systems, whereas states like Kerala and Assam derive a significant share of their egg production from backyard poultry (see *Map 1: Egg production from backyard poultry (fowls) in states/UTs*).

Other states/UTs which also produce a high proportion of eggs from backyard poultry (fowls) are Jammu & Kashmir, Meghalaya, Arunachal Pradesh, Nagaland, Mizoram, Sikkim, Puducherry, Lakshwadweep and Ladakh.

Some states produce a large share of their eggs through backyard poultry systems, while in others, these systems contribute only a small proportion, indicating a greater dominance of commercial poultry.

Map 1: Egg production from backyard poultry (fowls) in states/UTs



IMPORTANCE OF RESILIENT BREEDS IN BACKYARD AND RURAL POULTRY PRODUCTION SYSTEMS

Resilient breeds have enabled the survival and growth of backyard and rural poultry production systems, thereby improving livelihood and nutrition of rural households and smallholder farmers. The breeds typically reared in these systems are indigenous/local/*desi* varieties and their improved strains. They are characterized by high adaptability to harsher conditions and local climate, disease resilience and survivability in low-input settings. With market access, eggs and meat from these systems can command higher prices, as they are typically chemical-free, nutrient-rich, and superior in taste. Rearing resilient breeds is also cost-effective, low-risk, and capable of providing strong returns on investment.

NATIVE BREEDS FOR BACKYARD POULTRY

Native/indigenous/*desi* breeds are known to have evolved and adapted to local environmental conditions through many generations. Native to specific regions, these breeds are often dual-purpose, raised for both meat and eggs, and grow more slowly than commercial chicken varieties. These birds are usually reared in small backyard flocks of 10–15. India has 20 such chicken breeds registered with the ICAR–National Bureau of Animal Genetic Resources (NBAGR).³ In addition to these registered varieties, several other indigenous chicken breeds are found across the country (see *Table 1: Native breeds in India registered with NABGR*).

Table 1: Native breeds in India registered with NABGR

Breed	Native location	Breed	Native location	Breed	Native location
Ankaleshwar	Gujarat	Nicobari	Andaman and Nicobar	Aravali	Gujarat
Aseel	Chhattisgarh, Odisha, Andhra Pradesh	Punjab Brown	Punjab, Haryana	Harringhata Black	West Bengal
Busra	Gujarat, Maharashtra	Tellichery	Kerala	Kadaknath	Madhya Pradesh
Chittagong	Meghalaya, Tripura	Mewari	Rajasthan	Kalasthi	Andhra Pradesh
Danki	Andhra Pradesh	Kaunayen	Manipur	Kashmir Favorolla	Jammu and Kashmir
Daothigir	Assam	Hansli	Odisha	Miri	Assam
Ghagus	Andhra Pradesh, Karnataka	Uttara	Uttarakhand		

Source: National Bureau of Animal Genetic Resources; Note: Naked Neck and Frizzle Fowl are other indigenous breeds not registered with NABGR

IMPROVED VARIETIES FOR RURAL POULTRY

To enhance productivity (e.g., weight gain, egg yield) or select specific traits (e.g., better growth rate, heat dissipation) while retaining the native characteristics of parent breeds, improved chicken varieties were developed. This was achieved through either pure-line selection or cross-breeding. These varieties are classified as low-input or low-input technology (LIT) varieties, usually reared in flocks of 50–100 in free-range systems to support nutrition and livelihoods for small farmers, or as high-input intensive varieties, reared in flocks of 500–10,000 birds in poultry sheds for small-scale commercial production. In some cases, LIT varieties are also used in backyard farming.

A large number of improved varieties have been developed by public sector organizations such as ICAR-Central Avian Research Institute, ICAR-Directorate of Poultry Research, Central Poultry Development Organization, state agricultural universities as well as private players (see *Annexure, Table: Improved low-input, high-input and dual-purpose poultry varieties for rural poultry farming*).



Table 2: Productivity of select improved varieties compared to native breeds

Improved variety	Purpose	Native breed used in crossing	No. of eggs produced by native breed	No. of eggs produced by improved variety	Avg body weight of native breed (kg)	Avg. body weight of improved variety (Kg)
Krishibro	Broiler	Punjab Brown	-	-	0.65 (8 wks)	2.0 (7 wks)
Indbro Aseel	Broiler	Aseel	50-60 (annual)	160 (annual)	1.5 (22 wks)	1.7 (maturity; ~20 wks)
Thriveni	Layer	Tellicherry	60-80 (annual)	180-200 (annual)	1.6 (M), 1.2 (F)	-
CARI Nirbheek	Dual	Aseel	50-60 (annual)	198 (annual)	1.2 (20 wks)	1.8 (M), 1.3 (F) (20 wks)
CARI Shyama	Dual	Kadaknath	80 (annual)	210 (annual)	0.9 (20 wks)	1.46 (M), 1.12 (F) (20 wks)
Hitcari	Dual	Naked Neck	75-90 (annual)	200 (annual)	1.0 (20 wks)	1.75 (M), 1.32 (F) (20 wks)
Gramasree	Dual	Naked Neck	75-90 (annual)	180-200 (annual)	1.0 (20 wks)	1.8 (M), 1.4 (F) (16 wks)
Chann	Dual	Naked Neck	75-90 (annual)	150-170 (72wks)	1.0 (20 wks)	2.0-2.2 (20 wks)

Source: CSE research

Improved varieties are a strong alternative to native breeds, offering higher productivity in terms of egg production and weight gain. Their performance is also relatively comparable to commercial poultry breeds, which typically produce around 250–350 eggs per year (see *Table 2: Productivity of select improved varieties compared to native breeds*).

CENTRAL GOVERNMENT PROGRAMMES TO PROMOTE BACKYARD AND RURAL POULTRY

ALL INDIA COORDINATED RESEARCH PROJECT (AICRP) ON POULTRY BREEDING

Led by the ICAR-Directorate of Poultry Research, this national level project aims to develop location-specific chicken breed varieties and disseminate them for village poultry.⁴ It also works towards conservation, improvement, characterization and application of germplasm belonging to local native breeds, among others.

The AICRP on Poultry Breeding currently operates 20 centres across various agricultural and veterinary universities and ICAR institutes in India. Earlier, 12 centres under the Poultry Seed Project, which was designed to increase the availability of rural chicken germplasm in remote areas, were merged with the AICRP.

During 2024, about 11.8 lakh chicken germplasms were distributed to about 16.7 thousand farmers. The number of germplasms offered to farmers by a centre ranged from 14,000 to 1.5 lakhs, benefiting between 23 and 2,306 farmers. The budget utilized was Rs 1,354.73 lakhs and total revenue was Rs 353.45 lakhs.⁵

Farmers are provided germplasm free of cost or at a minimal price after the necessary vaccinations. Among the twenty centres, the highest suppliers of germplasm are Kerala Veterinary and Animal Sciences University (about 1.5 lakh), Karnataka Veterinary Animal and Fisheries Sciences University (about 1.5 lakh) and Bihar Animal Sciences University (about 93,000).⁶



SUB-MISSION ON BREED DEVELOPMENT OF LIVESTOCK AND POULTRY, NATIONAL LIVESTOCK MISSION (NLM)

One of the focus areas of this sub-mission is breed improvement, wherein rearing of low-input technology (LIT) birds in rural areas, and supporting farmer's nutrition and livelihood is popularized.⁷ Through NLM, the central government provides incentives to potential entrepreneurs (e.g., individual farmers, self-help groups, farmer producer organizations or farmers cooperatives) to establish parent farm, rural hatchery, brooder-cum-mother units to produce hatching eggs or chicks, and rearing them for four weeks.

A one-time 50 per cent capital subsidy (up to a maximum of Rs 25 lakh per unit) is provided while the remaining amount is to be arranged by the entrepreneur (e.g., loan, self-financing).

Table 3: Low-input technology birds popularized under National Livestock Mission

TYPE OF STOCK	ORGANIZATION
	Public sector organizations
Cha Bro, Kalinga Brown, Kaveri, Kadaknath	Central Poultry Development Organization
Gramapriya, Vanaraja	Project Directorate on Poultry
CARI-Gold, Nirbheek, Hitcari, CARI-Debendra, Upcari	Central Avian Research Institute
Giriraja, Girirani, Swarnadhara	Karnataka Veterinary, Animal and Fisheries Sciences University
Nandanam 99	Poultry Research Station, Nandnam, Chennai Tamil Nadu
Gramalakshmi, Gramashree, Krishipriya	Kerala Veterinary University, Mannuthy
Rajasri	Sri Venkateshwara Veterinary University, Hyderabad
	Private sector organizations
Satpuda-desi	Dr. Yashvant Agritech Pvt. Ltd, Jalgaon, Maharashtra
Rainbow rooster	Indbro Research and Breeding Farm Pvt. Ltd., Hyderabad
Kuroiler	Kegg Farms, New Delhi
Shipra	Shipra Hatcheries, Patna, Bihar

Source: DAHD; Note: This list can be updated as and when required.

There are 23 identified LIT chicken varieties for supply to farmers (see *Table 3: Low-Input technology birds popularized under National Livestock Mission*).⁸

There are other programmes such as the Rashtriya Krishi Vikas Yojana which are typically associated with establishment of smaller poultry units (10–50 birds) in states. They also coordinate with NLM and other state-level programmes to deliver chicks, vaccination and training.

DEENDAYAL ANTODAYA YOJANA — NATIONAL RURAL LIVELIHOODS MISSION (DAY-NRLM)

Under the Deendayal Antyodaya Yojana – National Rural Livelihoods Mission (DAY-NRLM), the Mahila Kisan Shashaktikaran Pariyojana (MKSP) focuses on promoting backyard poultry as part of the farm livelihoods promotion component implemented through State Rural Livelihood Missions.⁹ The emphasis is on community-led service delivery through self-help groups and capacity building aimed at better nutrition, women's empowerment, and strengthening livelihoods. Both native and improved breeds are promoted under this approach, with backyard poultry models supported in states such as Bihar, Rajasthan, and Jharkhand.

STATE INITIATIVES FOR PROMOTING BACKYARD AND RURAL POULTRY

Several states run their own programmes to promote backyard and rural poultry, encouraging small and marginal farmers to rear LIT birds for greater self-sufficiency (see *Table 4: State programmes to promote backyard and rural poultry*)

Table 4: State programmes to promote backyard and rural poultry

State/Department	Scheme/Programme
Animal Resources Development Department, West Bengal	<i>Special Backyard Poultry Farming Programme through Distribution of Chicks and Ducklings among Individual Beneficiaries under State Plan 2021-2022</i> planned to distribute 1.5 crore 28-day old birds and mother brooding units among 25 lakh beneficiaries during 2023-24.¹⁰
Directorate of Animal Husbandry and Veterinary Services, Odisha	<i>The Livelihood Support to Farmers through Rural Backyard Poultry Rearing under State Plan (2023-24)</i> scheme aims to assist 31,377 individual farmers by providing 50 unsexed LIT poultry birds each, with 100 per cent subsidy support.¹¹ Farmers can be from SC/ST community, transgenders, poor or differently-abled. <i>Establishment of Chick Rearing Unit under the State Plan Scheme (2024-25)</i> aims to chick rearing units (1,000 chick capacity per batch) with seven batches in the year to promote backyard poultry and enhance marketing of LIT birds.¹²
Department of Animal Husbandry, Maharashtra	<i>Integrated Poultry Development Program under District Annual</i> scheme aims for the distribution of 100 day-old-chicks or about 25 pullets to farmers who are below poverty line, landless agricultural labourers, belonging to backward classes, or are marginal land holders. Fifty per cent subsidy for all categories.^{13,14}
Department of Animal Husbandry and Dairying, Haryana	<i>Scheme for the Establishment of Backyard Poultry Units (2025-26)</i> targets setting up 1,500 backyard poultry units. Each beneficiary availing this scheme is to get 50 (10-day old) chicks, free of cost along with two drinkers and two feeders.¹⁵
Karnataka Cooperative Poultry Federation	<i>Scheme on Distribution of Poultry Birds (2023-24)</i> plans to distribute 20 local poultry birds reared for five weeks to each rural farmer women/members of Mahila SHGs.¹⁶
Animal Husbandry Department, Uttar Pradesh	<i>Backyard Poultry Farming Scheme</i> aims to establish poultry units for its beneficiaries, with a price of Rs 3,000 fixed for each. Fifty day-old chicks of LIT birds are given to each beneficiary, particularly SC women. Overall 15,000 beneficiaries were to be benefitted in 2022-23.¹⁷
Directorate of Animal Husbandry and Veterinary, Assam	<i>Rural Backyard Poultry Development (RBPD) Programme</i> provides one-time assistance to strengthen farms w.r.t. hatching, brooding and rearing of birds.¹⁸
Directorate of Animal Husbandry and Veterinary Services, Tamil Nadu	- Scheme for upliftment of 38,700 rural backyard poultry units (2024-2025) which have capacity of 40 Aseel birds. Fifty per cent subsidy is given to the select beneficiary (e.g., poor women, preferably widow, destitute and physically challenged, or belonging to SHGs) who can bear remaining 50 per cent. - Scheme for upliftment of 100 rural farmers through establishment of native chicken poultry farms, with 250 birds per unit. Here also, 50 per cent subsidy will be given to beneficiary for shed construction, equipment purchase, feed cost for four months. Beneficiaries to have at least 625 sq. ft land to construct poultry shed and bear 50 per cent of total cost.

CASE STUDIES: SCALING UP BACKYARD POULTRY FOR IMPROVED LIVELIHOOD AND NUTRITION

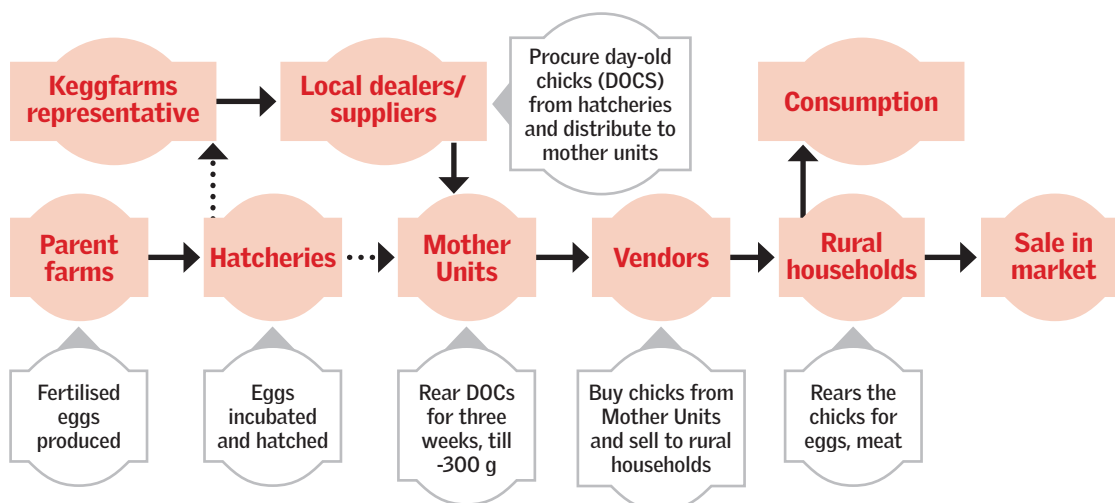
KEGGFARMS KUROILER MODEL

The Kuroiler model aims to improve the nutrition and livelihood status of rural women, as well as create micro-entrepreneurs (e.g., dealers, mother units, vendors) and give them livelihood.

Kuroiler is a dual-purpose chicken variety introduced in 1990 by the KeggFarms Pvt. Ltd., based in Gurugram, Haryana. The variety is resilient to harsh rural conditions, can thrive on household scraps and waste, requires minimal shelter, and is disease-resistant. It has a prolific egg-laying capacity (220–230 eggs over a 12–16-month period) and exhibits rapid growth than native breeds.

The distribution model employed by KeggFarms to reach remote villages is multi-tiered (See *Figure 3: Kuroiler distribution model*).

Figure 3: Kuroiler distribution model



Source: Information from KeggFarms Pvt. Ltd.

Fertilized eggs of Kuroiler from parent farms are transferred to hatcheries. After 24–36 hours of hatching, the day-old chicks (DOCs) are bought at Rs 25 per chick by local dealers and delivered to rural *mother units* at ~Rs 26 per chick. At the mother units, chicks are reared for three weeks with adequate nutrition and necessary vaccination until they attain a weight of 300 grams with a total investment of Rs 45–46 per chick. The mother unit owners then sell the chicks to vendors at about Rs 50 per chick. With a profit of Rs 4–5 on each, a mother unit with 1,000-day-old chicks (DOCs) can earn Rs 4,000–5,000 per month.

Village vendors who buy brooded birds, load baskets with chicks and peddle them on bicycle in small flocks (5–10) to village households making a profit of Rs 10–15 per chick by selling them at Rs 60. Women in village rear the birds, mainly on household and agricultural waste for nearly two months. During this time, there is availability of high-quality nutritional food for household consumption. The bird is typically sold after about two months at Rs 250 per kg. Average supplementary household income from Kuroiler is Rs 300–500 per month.

*Village vendors collecting
chicks from mother units
and transporting them to
villages for selling*





Women buying chicks from village vendors



Kuroiler reared by women in rural household

The model currently serves over 1,500 dealers, 5,000 mother units, and 7,500 village vendors, reaching around 15 lakh rural households. Operating across nearly 20 Indian states, it has helped generate an estimated additional income of over Rs 500 crore and supported the creation of more than 5,000 micro-entrepreneurs. The Kuroiler breed is also distributed under the National Livestock Mission.

A COMMUNITY-LED BACKYARD POULTRY FARMING INITIATIVE SUPPORTED BY AGA KHAN RURAL SUPPORT PROGRAMME (INDIA)

Since 2020, the Aga Khan Rural Support Programme (India) [AGRSP (I)] is working with landless farmers to improve their livelihood and reduce migration through poultry farming. In Khandwa district of Madhya Pradesh, this initiative began by forming a cluster of 10–15 interested and enthusiastic farmers and training them on poultry farming. Currently there are 1,000 farmers in the cluster.

The programme simultaneously built a cadre of around 235 *Pashusakhis* (women animal health workers) by identifying and training them in various aspects of poultry farming such as health management, breed selection, and farm practices. These women now independently provide services to farmers, including vaccination, deworming, shed design, first aid, and azolla-based feed preparation. Each *Pashusakhi* receives a one-time kit containing vaccines, herbal medicines, medical tools, and a manual. They can also seek guidance from the district animal husbandry department when needed.

Two farmer producer organizations (FPOs) in the district operate a hatchery and a feed mill to support farmers seeking chicks or feed for poultry farming. The poultry varieties commonly supplied include CARI Sonali and Vanaraja. In some cases, private companies also supply chicks directly to farmers. AGRSP (I) facilitated direct linkages between the FPOs and vaccine manufacturers to ensure timely vaccine supply based on planned vaccination schedules.

Pashusakhis collect the vaccines from the FPOs and carry out vaccination, maintaining the cold chain throughout the process.

To reduce DOC mortality, the programme supported select well-performing farmers in setting up mother units to rear DOCs, procured from FPOs, for 15–20 days before distributing them to other farmers. AGRSP (I) provides one-time capital and infrastructural support for establishing these units. The cost of rearing a chick for 15 days is around ₹42–45, after which the chicks are sold at ₹50 each, allowing the owner to earn ₹5–8 per chick. The FPOs also help farmers access markets by purchasing mature birds and selling them at pre-decided prices. On average, a farmer can earn ₹25,000–30,000 per year through this model.

Azolla culture in a poultry farmer household



CENTRAL AVIAN RESEARCH INSTITUTE (CARI) SUPPORTED MOTHER UNITS FOR FARMER'S LIVELIHOOD

The development of the Backyard Poultry Hubs Project, implemented by the ICAR–CARI, focuses on developing and promoting climate-resilient backyard poultry varieties to enhance the nutrition and livelihoods of farmers from SC and ST communities. Operational in selected districts of Uttar Pradesh and Uttarakhand, CARI provides farmers with training, day-old chicks (DOCs), and essential poultry equipment such as feeders and waterers.

To address initial challenges of brooding DOCs and the resulting high mortality rates, CARI identified committed and innovative farmers from the community and signed MoUs with them. These farmers received specialized training in brooding and were designated as Mother Unit In-charges.

Initially, each in-charge purchases 2,000–3,000-day-old chicks (DOCs) from CARI at the same rate offered to farmers (around Rs 20–22 per chick) and broods them. After 40 days, CARI buys back the chicks at a pre-decided price of Rs 95–110, based on evaluation criteria such as body weight. The birds are then sold to farmers or the State Animal Husbandry Department directly from the mother unit. Mortality during the brooding period is around five per cent, with a few additional chicks discarded based on quality.

The model also addresses concerns related to limited infrastructure and manpower of CARI for brooding. In addition, the model provides an extra source of income for the mother unit in-charge, who earns a profit of Rs 10–20 per bird along with the assurance of a direct and guaranteed buy-back arrangement. Currently, 11 mother unit in-charges are associated with CARI. Through this system, farmers receive healthy, 40-day-old brooded chicks without having to make any additional effort or investment in brooding.

CHALLENGES AND POSSIBILITIES FOR SCALING UP BACKYARD AND RURAL POULTRY PRODUCTION SYSTEMS

Based on discussions with stakeholders from central and state governments, the scientific community, civil society, the poultry industry, and farmers, the following challenges and opportunities have been identified for scaling up backyard and rural poultry production systems.

CHALLENGES

- **Farmers are often unable to provide necessary vaccines to chicks.** Timely vaccination of chicks during the first six to eight weeks is considered crucial in backyard and rural poultry. However, farmers are unable to provide the required vaccination due to lack of awareness and/or resources. Those who are aware face issues related to vaccine availability, cost and access. As a result, vaccinations are often skipped, leading to disease and higher mortality.
- **Adequate nutrition and brooding infrastructure is not always available.** Small farmers in villages lack the resources and facility to brood day-old chicks (DOCs) and provide the right nutrition, both of which are crucial for at least initial six to eight weeks. Proper infrastructure for biosecurity or waste management is also lacking. This also contributes to high disease prevalence or mortality.
- **New farmers struggle due to dearth of right information and training.** Farmers often lack access to reliable information on where to source chicks, equipment, or support services

needed to start and manage a poultry farm effectively. Training programmes conducted by government agencies are few and often insufficient to address practical aspects such as breed selection, bird handling during transport, housing design, temperature management, nutrition, vaccination, and financial planning. As a result, farmers are left to rely on trial-and-error methods and may lose interest or motivation when their efforts do not succeed.

- **Access to right breeds and good quality chicks is a concern.** Farmers in rural/remote areas rely on local hatcheries/middlemen to obtain chicks or birds of native and improved varieties. However, they may also not always get the right or best quality stock. The birds may be unhealthy, or at times, the breed or variety is unknown. To avoid the difficulty of travelling to urban distribution centres, farmers usually settle for what is locally available, regardless of breed quality. Moreover, birds supplied through government sources are often perceived as cheaper but of lower quality compared to those from private suppliers.
- **Limited veterinary guidance or follow up support from distribution centres.** Follow-up by distribution centres on bird health and related issues is often inadequate. Farmers also struggle to manage diseases such as avian influenza and Ranikhet due to the limited availability of veterinarians in rural areas. This affects bird care and health, leading many farmers to lose confidence and discontinue poultry farming.
- **Access to a formal market and fair pricing is a challenge for the backyard farmer.** In rural village settings, a small backyard farmer will have to travel all the way to the market to sell few reared birds but still may not be able to sell any. There are also limited middlemen or vendors to collect birds at a price from farmer and sell in the market. In case available, their requirements of specific bird related to weight, age etc. may not be met which can reduce farmer's income potential.

POSSIBILITIES

There is a need to create a favorable ecosystem so that backyard and rural poultry production systems are scaled up such as through following possibilities:

Reducing the risk and mortality by effective bird management in first six to eight weeks. This can be done by:

- **Establishing and strengthening mother units,** which can act as a link between distribution centres and farmers. The units could collect fertile eggs or DOCs from the distribution centres, hatch eggs, provide right brooding conditions to DOCs, give necessary vaccines and keep the chicks for about six to eight weeks with proper management. Once the birds have grown and are stable, these can be given to farmers. This will reduce mortality rates.
- **Promoting and incentivizing development of breeder farms at the farm level.** Select small farmers can be encouraged to set up their own breeder farms which can become a sustainable business model for them in the long-term and add to their livelihood and nutrition. When chicks mature, enthusiastic farmers can maintain their own breeding flock. A group of four to five farmers can come together to arrange a small incubator for 100–200 eggs and procure hatching eggs for incubating on their own.

Supporting the developers of LIT birds (such as scientific institute or state agriculture university)

- Public-private partnership models should be explored to ensure continuous availability and supply of locally relevant, resilient breeds to backyard farmers. This will help address the demand-supply gap, in view of the limited extent to which the government institutions can develop and distribute improved varieties to farmers. Private players can include industry, civil society or community (through cooperatives, self-help groups or farmer producer organizations).



- **Strengthening in-house infrastructure and capacity building.**
Greater investments need for infrastructure at the research/distribution centers for rearing chicks until six to eight weeks; and vaccination and for trained resources.

Generating a coordinated responses to challenges faced by backyard farmers. Farmers need to be supported and incentivized by ensuring access to good quality chicks, better vaccines, veterinary guidance and awareness and training. For e.g., state government can help ensure access to at least basic essential vaccines of chicks, while it may not be possible to provide all vaccines. In case of limited veterinary supervision, Community Animal Health Workers (CAHWs) or para-vets can be trained for vaccination, basic veterinary treatment and guidance.

Support creation of markets and dedicated farmer producer organizations and cooperatives for backyard and rural poultry. Such arrangements will not just provide appropriate access to markets and remunerative pricing to rural households and farmers, but also help them source vaccines, feed, and other inputs along with veterinary services at a subsidized rate.

ANNEXURE

Table: Improved low-input, high-input and dual purpose poultry varieties for rural poultry farming

Developer	Low-input broiler and layer varieties for rural poultry	Low-input dual purpose for rural poultry	High-input varieties for small-scale commercial rural poultry
Central Avian Research Institute (CARI)	Broiler: CARIBRO Samrudhi	CARI Debendra, CARI Nirbheek, CARI Shyama, Upkari, Hitcari	Broiler: CARIBRO Vishal, CARIBRO Dhanraja, CARIBRO Mrityunjay, CARIBRO Tropicana Layer: CARI Priya
Directorate of Poultry Research (DPR)	Broiler: Krishibro, Asli Bro Layer: Gramapriya, Swetasri	Vanaraja, Srinidhi, Vanashree, Janapriya	Layer: Krishilayer
Central Poultry Development Organization (CPDO)	Layer: ChaBrown, Kalinga Brown	Chann, Aseel cross, Kadaknath Cross, Kaveri, Chabro	
Tamil Nadu University of Veterinary and Animal Sciences, Tamil Nadu	Broiler: Namdanam chicken III	Nandanam chicken I and IV	
Lala Lajpat Rai University of Veterinary and Animal Sciences, Haryana	Layer: Harlay		
Kerala Veterinary and Animal Sciences University, Kerala	Layer: Grama Lakshmi, Thriveni	Gramasree	Layer: Athulya (ILM 90)
Guru Angad Dev Veterinary and Animal Sciences University, Punjab			Broiler: IBL80
Anand Agricultural University, Gujarat			Layer: Anand
Sri Venkateswara Veterinary University, Andhra Pradesh			Layer: ILR-90
Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Himachal Pradesh		Himsamridhi	
Birsa Agricultural University, Jharkhand		Jharism	
Assam Agricultural University, Assam		Kamrupa	
Nanaji Deshmukh Veterinary Science University, Madhya Pradesh		Narmananidhi	
Maharana Pratap University of Agriculture and Technology, Rajasthan		Pratapdhan	
Karnataka Veterinary Animal and Fisheries Sciences University, karnataka		Giriraja, Swarnadhara	
P.V. Narsimha Rao Telangana Veterinary University, Telangana		Rajasri	
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Madhya Pradesh		Krishna J	
IndBro Research & Breeding Farms Pvt. Ltd*	Broiler: Indbro Aseel	Indbro Rainbow Rooster	Broiler: Indbro Coloured Broiler Layer: Indbro Brown Layer
KeggFarms Pvt. Ltd.*	Layer: Keystone Golden Layer, Saurangi	Kuroiler	

Note: Table is not exhaustive; *Private players



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NOTES

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Our existing food systems — the way we produce, distribute and consume food — are not really working well, either for farmers' livelihoods or consumers' health and nutrition; they are also adding toxicity to the environment and the planet's ecological health. The crisis has become wider and deeper in the present climate-risked times.

The solutions need to be at scale and holistic. The agro-ecological farming movement, which is sustainable but slow and sporadic, needs scaling up to enable a substantial solution. This book brings together several critical and interconnected aspects which can lead to sustainability in our food systems — from soil health to crop insurance, from voluntary carbon markets to weather forecasting and agro-weather advisories, and from GHG emissions from livestock to encouraging resilient breeds in poultry farming. The book offers an understanding of where we stand and what are the key gaps, challenges and possibilities across each aspect, and sets an agenda for future action that can help our farmers, people, environment and the climate.



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