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FROM FARM SOIL TO CLIMATE SOLUTION: INDIA'S PATH TO CARBON-SMART AGRICULTURE RESTORING SOIL CARBON WHILE PROTECTING PRODUCTIVITY, PROFITABILITY AND RESILIENCE

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It gives me immense pleasure to present the inaugural issue of Agri UptoDate (January 2026)—a humble yet determined step toward bridging the gap between agricultural research, innovation, and real-world practice. This first volume reflects our core vision: to make credible, research-backed agricultural knowledge accessible to students, researchers, entrepreneurs, and farming communities alike.

Editor's Note



The current issue brings together a diverse range of themes that are highly relevant in today's rapidly transforming agri-ecosystem. Articles such as "Climate Change Impacts on Vegetable Crops" highlight the pressing challenges faced by production systems, while "Impact of Digitalization on Agriculture and Agripreneurship: A Research-Oriented Perspective" showcases how technology, innovation, and entrepreneurship are reshaping the future of agriculture. Practical and emerging areas such as Mushroom Farming, Lawn Establishment, and Maintenance provide practical value for readers seeking enterprise and livelihood opportunities. The inclusion of Service-Based Startups further expands the discussion beyond conventional farming, reflecting the growing importance of agri-services and knowledge-driven enterprises.

This issue is the result of sincere contributions from researchers, academicians, and young professionals, and I extend my heartfelt gratitude to all authors for sharing their insights and expertise. I also thank our readers for placing their trust in this new initiative.

We hope Agri UptoDate will evolve into a reliable platform for knowledge exchange, critical thinking, and innovation in agriculture. Your feedback, suggestions, and continued support will be crucial in shaping future issues. Happy reading and learning.

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Editor-in-Chief

Agri UptoDate

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FROM PADDY TO PULSES: IS INDIA'S MSP SIGNAL CHANGING?

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1. Introduction

For several decades, India's agricultural policy has emphasised cereals, especially paddy and wheat. This focus has contributed to improving domestic food security, following the Green Revolution. Later, regular procurement, the existing system of public distribution, the expansion of irrigation and support for inputs all served to boost cereal production in various areas. The same production system is now giving rise to increasing concerns regarding resource sustainability. In regions where paddy and wheat rotation is the main cropping pattern, intensive groundwater extraction through pumping, nutrient imbalances, and a decline in resource-use efficiency have become major issues for policymakers. At the same time, India must still meet a significant domestic demand for pulses and edible oils. Crop diversification, therefore, involves more than just asking farmers to change the crops they grow. Since farmers take into account expected returns, production risk, market access, the terms of procurement, and the availability of storage and processing facilities, MSP is only one element of this incentive structure and can therefore serve as a starting point for assessing whether the relative price environment has changed. When official MSP data are compared over a period of more than five decades, the policy situation has changed a great deal; in recent years, several pulses, oilseeds, and nutri-cereals have had considerably greater nominal increases in their MSP than traditional cereal crops.

2. From Ensuring Food Supply to Promoting Diversification

• The Green Revolution Era

In the mid-1970s, agricultural price policy was closely linked to an increase in foodgrain production; in the marketing season of 1975-76, paddy and coarse cereals were supported at about ₹74 per quintal, while wheat received a support price of ₹105 per quintal. According to historical government records, gram had a minimum support price of ₹95 in 1976-77, and tur and moong joined the minimum support price scheme at prices of ₹155 and ₹165 respectively in 1978-79. A policy structure was then developed to ensure foodgrain availability in central pool procurement through the Food Corporation of India (FCI) and state agencies. Wheat and paddy became two of the most important foodgrain crops central pool procurement.

• The 1990s and 2000s

In the decades that followed, the minimum support prices for most major crops increased by policymakers by taking into account changes in cost of production. Nevertheless, the effectiveness of a minimum support price depends not just on the announced price but also on whether farmers have reasonable access to procurement. It is important to make this distinction when considering crop diversification. Although a farmer might receive a higher announced MSP for a pulse or oilseed, if procurement is geographically restricted, the crop still carries more market risk than one with existing procurement arrangements.

3. The realignment of the structure, 2014-15 to 2026-27

The period from 2014 to 2015 offers a particularly useful point of comparison; official figures indicate considerable rises in MSP for cereals, pulses, oilseeds and nutri-cereals, although the extent of these increases varies greatly between crops.

Table 1: Commodity group wise comparative growth of MSPs, 2014-15 – 2026-27

Crop Group	Crop	MSP 2014-15 (₹/q)	MSP 2026-27 (₹/q)	Absolute Increase (₹/q)	Percentage Increase
Cereals	Paddy (Common)	1,360	2,441	1,081	79.50%
	Wheat	1,450	2,585	1,135	78.30%
	Maise	1,310	2,410	1,100	84.00%
	Ragi	1,550	5,205	3,655	235.80%
Pulses	Tur (Arhar)	4,350	8,450	4,100	94.30%
	Gram	3,175	5,875	2,700	85.00%
	Masur (Lentil)	3,075	7,000	3,925	127.60%
Oilseeds	Rapeseed/Mustard	3,100	6,200	3,100	100.00%
	Sesamum	4,600	10,346	5,746	124.90%
	Soyabean (Yellow)	2,560	5,708	3,148	123.00%

Source: Ministry of Agriculture and Farmers' Welfare, Government of India; the Commission for Agricultural Costs and Prices; and the historical MSP data.

Note: The figures for 2014-15 are taken from the official government records, whereas those for 2026-27 are based on the most recent approved MSPs.

In the first place, several types of pulses and oilseeds have shown a faster rate of nominal MSP growth than the main foodgrains; Masur rose by 127.6%, Sesamum by 124.9%, Soyabean by 123.0%, and Rapeseed/Mustard by 100.0%. This is a much higher increase than the 79.5% for Paddy (Common) and the 78.3% for wheat. Furthermore, nutri-cereals have seen significant price increases. The MSP for ragi has risen from ₹1,550 to ₹5,205 per quintal, which is an increase of 235.8%. This demonstrates the growing policy focus on millets due to their nutritional value and climate resilience. Third, a higher minimum support price does not necessarily result in higher returns at the farm level. The minimum support price is a nominal price signal, and the economic benefit to farmers will depend on cost of production, the probability of securing the minimum support price, transaction costs, and the availability of buyers.

4. Price Signals Against Market Reality

Prices for pulses and oilseeds have increased. The key question is whether farmers can consistently receive these prices.

4.1. Procurement Access

It is especially important to have a central pool procurement system. Although the system for procuring paddy and wheat is well established, procurement varies from state to state. For pulses and oilseeds, government procurement has been increased through mechanisms such as the Price Support Scheme under PM-AASHA. Recent government decisions show this expansion. In June 2026, the government agreed to carry out, on a large scale, the procurement of pulses and oilseeds under the Price Support Scheme for the states of Gujarat, Tamil Nadu, Uttar Pradesh, and Haryana. Although such interventions can enhance the credibility of the MSP as a price floor, their effectiveness will depend on the geographical coverage, the timing of the procurement and the farmers' ability to reach the designated procurement centres.

4.2. The risks involved in production and yield

Farmers also weigh up the expected returns rather than looking just at the minimum support price. Crops such as pulses and oilseeds are subject to considerable comparative yield from different crops and production risks due to variations in rainfall and pest and disease outbreaks. As a result, a higher minimum support price does not necessarily offset the greater yield uncertainty associated with such a crop. Price incentives should therefore be supplemented by crop insurance, improved seed varieties, extension services and access to inputs at the right time.

4.3. The processing and local markets

Another limitation concerns the availability of post-harvest infrastructure. For paddy and wheat, there are well-developed systems covering procurement, storage and milling. Similarly, pulses and oilseeds need comparable local systems which include aggregation, grading, storage and processing. A farmer who lives a long way from a dal mill or an oilseed processor might have to pay higher transport and transaction costs, which in turn lowers the price he receives at the farm gate.

5. Translating Minimum Support Price Signals into Crop Diversification

Four policy measures can facilitate the translation of Minimum Support Price (MSP) signals into tangible crop diversification. First, Farmer Producer Organisations (FPOs) should be systematically integrated into procurement networks for pulses, oilseeds, and millets. FPOs can facilitate aggregation, quality testing, storage, processing, and coordination with government procurement agencies. Second, farmers transitioning from cereal-based systems to alternative crops often encounter transition costs and increased production risks. Targeted incentives, especially in regions experiencing groundwater stress, can mitigate these initial risks and promote the adoption of water-efficient crops. Third, the Agriculture Infrastructure Fund and related programmes should be leveraged to enhance village-level infrastructure for grading, storage, and primary processing of pulses and oilseeds. Local processing reduces transaction costs and enables farmers and producer organisations to capture a greater share of value beyond the farm gate. Finally, demand-side interventions are essential. Expanding the inclusion of appropriate pulses and millets in government nutrition initiatives, such as PM POSHAN and state-level food programmes, can generate more stable institutional demand. These measures would complement, rather than replace, procurement-based price support.

6. Conclusion

Over the longer term, the MSP record shows a significant shift in the nominal price incentives available to Indian farmers: from 2014-15 to 2026-27, many pulses and oilseeds saw much larger increases in their MSPs than paddy and wheat, and ragi saw a particularly large increase. The evidence does not show that MSP policy alone will result in crop diversification. Farmers are concerned with expected net returns, accounting for both production and market risks, rather than the MSP announced in isolation. The next phase of agricultural price policy should therefore focus on strengthening the mechanism that transmits the announced price into actual farm-gate returns, since decentralised procurement, aggregation through Farmer Producer Organisations, crop-risk management, local processing, and institutional demand can make higher minimum support prices more credible as incentives for diversification. India's problem is therefore not merely altering the price signal, but establishing the market institutions that enable farmers to respond to it.



TURNING WASTE INTO WEALTH: THE POTENTIAL OF FERMENTED ORGANIC MANURE IN SUSTAINABLE AGRICULTURE

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Introduction

The extensive use of chemical fertilizers in modern agriculture has led to a decline in soil fertility in India, making the soil increasingly acidic and posing a significant threat to the long-term sustainability of Indian agriculture. This situation endangers both the environment and the livelihoods of farmers. Excessive application of inorganic fertilizers has also resulted in severe environmental and health concerns, including soil erosion, pesticide toxicity, water pollution, depletion of groundwater levels, waterlogging, and loss of biodiversity. To mitigate the adverse effects of chemical fertilizers on soil health, the use of organic manure is strongly recommended. Organic amendments enhance the soil's physicochemical properties, maintain soil quality, and improve crop productivity. Soil quality encompasses both fertility and biological activity, which are closely interconnected, as the mineralization of essential organic nutrients depends on microbial biomass transformation. The increased fertilizer input and intensive land use result in multiple environmental problems, including the pollution in the watersheds caused by nitrogen (N) loss.

Carbohydrates, fiber, and proteins decompose most efficiently under specific pH levels and retention times. By optimizing environmental conditions based on the stage of decomposition, the breakdown of waste can be enhanced and accelerated. One effective approach to addressing this issue is anaerobic fermentation of manure and its effluents, followed by their application as fertilizers. The use of fresh manure is associated with certain agrotechnical difficulties, which leads not only to the contamination of cultivated areas with weed seeds but also carries the risk of environmental pollution.

To eliminate the negative phenomena discussed, a special technology of manure treatment is needed, which allows for increasing the concentration of nutrients, eliminating unpleasant odors, suppressing pathogenic microorganisms, and reducing the content of carcinogenic substances. There is need producing high-value organic fertilizers/manure through fermentation in a bioreactor, resulting in a natural biofertilizer rich in biologically active compounds and trace elements. Compared to traditional fertilizers such as manure and litter, biofertilizers offer several advantages in terms of nutrient availability, balanced composition, and a higher degree of humification of organic matter. These fertilizers/manures contain easily degradable organic nutrients that support microbial decomposition, enhance soil fertility and structure, and contribute to ecosystem stability. This holistic approach not only addresses climate change and soil degradation but also contributes to a more resilient and equitable agricultural system for the future. Additionally, they have high moisture content and a well-balanced mix of macro- and microelements that plants gradually release and absorb. Raw manure, a common farm waste, often becomes an environmental issue as it is typically left in piles, leading to water and air contamination and contributing to global warming. Despite the large volume of livestock feces, it holds significant potential for use as organic fertilizer/manure, supporting sustainable organic farming with higher export opportunities. A cow produces approximately 23.6 kg of solid feces per day, and with most farmers owning 6 to 7 cows, an individual farmer generates around 141.6 kg of feces daily or 4,248 kg per month. However, many farmers still rely on costly inorganic fertilizers such as urea. While raw manure can naturally decompose into organic fertilizer, this process is slow. When composted in a loosely folded black plastic bag at room temperature during summer, it takes about 16 weeks to fully break down.

The composting process can be accelerated to 2–3 weeks by adding activators or decomposers. Certain animal waste, including cow, goat, rabbit, chicken and quail feces, contains beneficial decomposing microorganisms known as Indigenous Micro-Organisms (IMO), which can enhance the breakdown of manure efficiently. Raw manure contains essential nutrients such as nitrogen, phosphorus, potassium, and water, with varying compositions depending on the animal source. Rabbit feces are rich in nitrogen and phosphorus, goat feces have higher potassium levels, while cow feces contain more water. Manure serves as a natural food source for microbes, fostering their growth and activity. It contains beneficial microorganisms such as *Nitrosococcus* sp., *Pseudomonas striata*, *Nitrosomonas* sp., *Mycorrhiza*, *Pseudomonas fluorescens*, *Streptomyces*, and *Trichoderma* sp.. Additionally, Indigenous Micro-Organisms (IMO) present in manure include *Rhizobium* sp., *Azospirillum* sp., *Azotobacter* sp., *Pseudomonas* sp., *Bacillus* sp., and phosphate-solubilizing bacteria. Preliminary studies on IMO have also detected lactic acid bacteria, along with other beneficial bacteria and fungi. Composting cow manure with IMO for 21 days produces organic fertilizer with a higher nitrogen content. Compared to inorganic fertilizers, organic fertilizers provide superior plant nutrition, improving soil fertility and boosting crop yields.

Steps for Preparation of FOM at farm

1. Collection and Mixing:- Collect the organic material (cow dung, crop residue, etc.) and place it on a clean surface.

- Dissolve jaggery in water and mix it with the cow urine. Add the EM solution.

2. Layering: Spread a layer of organic material (10-15 cm thick).

- Sprinkle the prepared microbial mixture on the layer to inoculate it with beneficial microbes.

3. Moisture Control: Ensure the mixture is moist but not waterlogged (about 60% moisture).

- Cover the pile with a jute sack or plastic sheet to retain moisture and protect it from direct sunlight or rain.

4. Fermentation Process: Leave the mixture for 15–30 days. Turn it every 5–7 days to uniform fermentation and aeration.

- The temperature will rise initially, indicating microbial activity. It will gradually stabilize as the process nears completion.

5. Completion: The manure is ready when it turns dark brown, has a crumbly texture, and emits a pleasant earthy smell.

Preparation of FOM at large scale (CBG):

- The leftover rice straw is collected for further processing instead of being burned.
- Rice straw undergoes pre-treatment to break down its structure and improve its usability for digestion.
- The pre-treated rice straw is fed into a biogas plant, where it undergoes anaerobic digestion to produce biogas (methane-rich gas).
- The byproduct of anaerobic digestion is digestate, which is a nutrient-rich material.
- Digestate can be further processed into fermented organic manure for improved agricultural productivity.
- The organic manure is applied to fields, completing the cycle by enhancing soil fertility for the next round of rice cultivation.



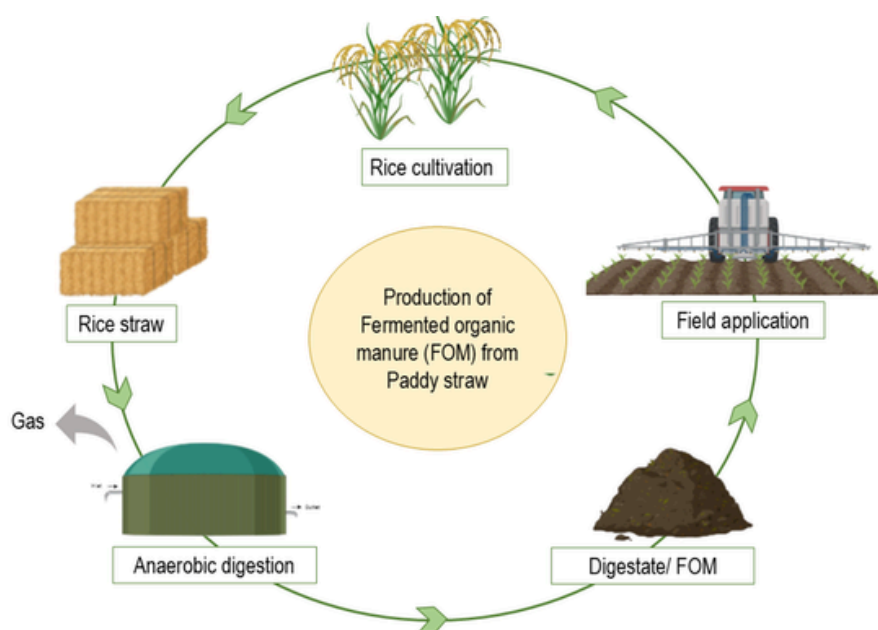
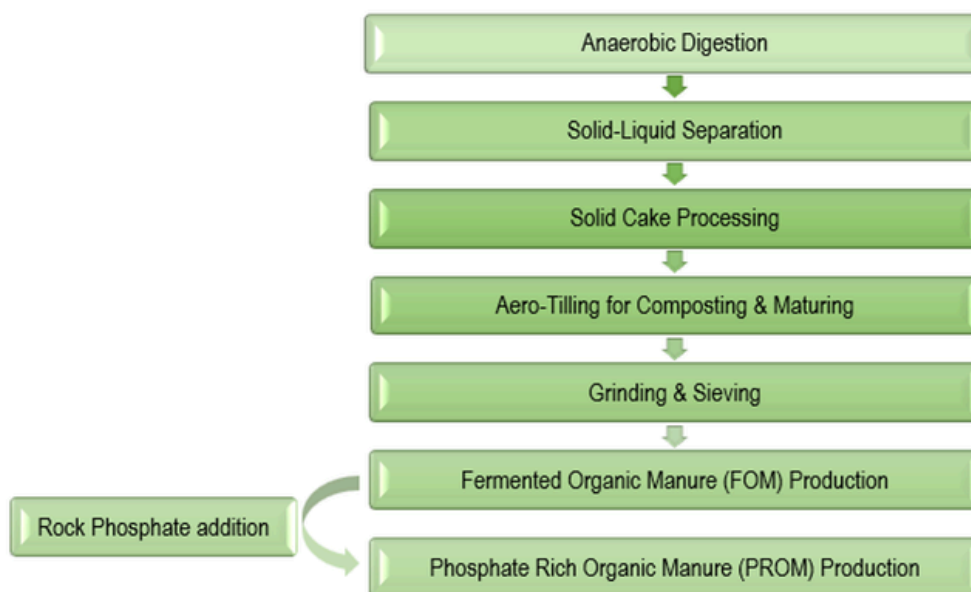


Figure 1. Diagrammatic representation of production process for preparation of FOM at large scale (CBG):



Flow chart 1. Production process outline of FOM/ LFOM/ PROM

- **Anaerobic Digestion:** Organic material undergoes anaerobic digestion in a biogas plant, producing slurry as a byproduct.
- **Solid-Liquid Separation (SLS):** The slurry is separated into liquid (used for LFOM) and solid cake (used for FOM & PROM production).
- **Solid Cake Processing:** The solid cake undergoes windrow formation and microbial culture addition to initiate composting.
- **Aero-Tilling for Composting & Maturing:** The composting process is accelerated using aero tilling, which ensures proper aeration for microbial activity.
- **Grinding & Sieving:** The matured compost is subjected to hammer milling/grinding to reduce the particle size. The material is then sieved to <4mm for uniform texture.
- **Fermented Organic Manure (FOM) Production:** The sieved material is bagged and packed as FOM (Fermented Organic Manure).
- **Phosphate Rich Organic Manure (PROM) Production:** Rock phosphate is added to the sieved material, followed by pelletization to create PROM

Table 1: FOM specifications

Particulars Particle	Content	Heavy metals	Maximum Quantity (mg/kg)
Moisture percent by weight	30-70%	Arsenic	10
NPK nutrients should not be less than	1.20%	Cadmium	5
Total Organic carbon (minimum)	14%	Chromium	50
C:N ratio	30:1	Copper	300
Particle size	Minimum 90% material should	Mercury	0.15
pH	6.5-8.4	Nickel	50
Pathogens	NIL	Lead	100
Conductivity (as dS/m) not more than	4	Zinc	1000

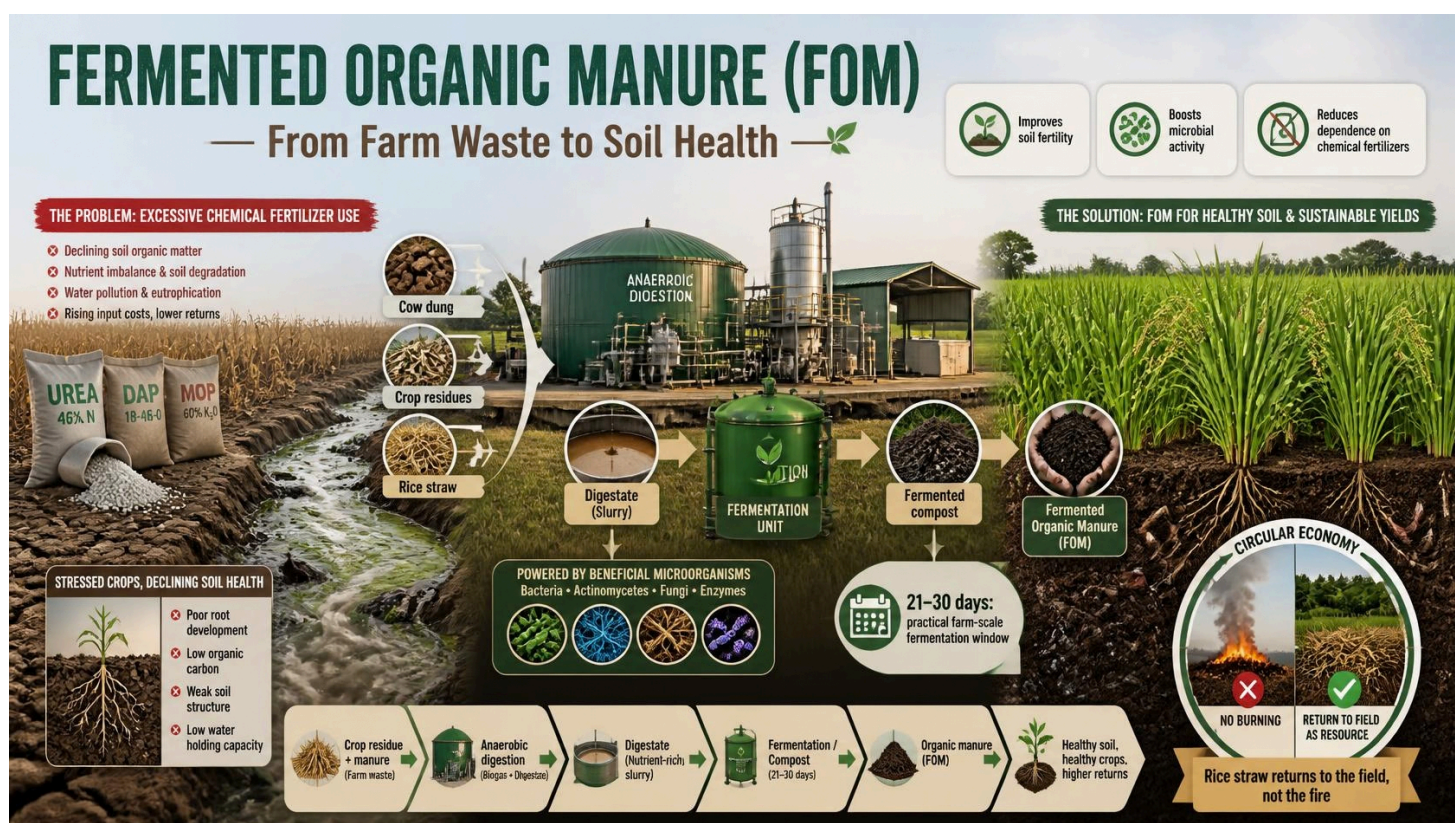
Initiatives of Government of India: Government is implementing dedicated schemes for promotion of organic farming in the country viz. Paramparagat Krishi Vikas Yojana (PKVY) and Mission Organic Value Chain Development in North East Region (MOVCDNER) since 2015-16. Under these schemes, farmers are encouraged to take up organic cultivation using organic inputs and the schemes provide end to end support to farmers' i.e. from production to marketing of organic produce. Hands-on training to farmers about on-farm production of organic fertilizers and its use are integral part of these schemes. In order to promote the use of bio-fertilizers, ICAR has developed improved and efficient strains of bio-fertilizers specific to different crops and soil types. Liquid Bio-fertilizer technology with higher shelf-life has also been developed.

Benefits of Fermented Organic Manure

- Improves soil structure and fertility
- Enhances microbial activity in the soil
- Boosts plant immunity and growth
- Reduces dependency on chemical fertilizers

Conclusion

The excessive use of chemical fertilizers in agriculture has led to soil degradation, environmental pollution, and health risks, threatening the sustainability of farming. Organic amendments, particularly biofertilizers, manures produced through fermentation, offer a viable alternative by enhancing soil fertility, improving microbial activity, and ensuring balanced nutrient availability. Anaerobic fermentation and the use of Indigenous Micro-Organisms (IMO) accelerate the decomposition process, making organic manures more efficient and eco-friendly. Utilizing manure effectively through composting and fermentation can help mitigate pollution, reduce dependency on inorganic fertilizers, and promote sustainable agriculture. Transitioning to organic biofertilizers is crucial for preserving soil health, improving crop productivity, and ensuring long-term environmental stability.



FINANCIAL LITERACY AMONG INDIAN FARMERS: A SECONDARY-DATA ANALYSIS OF LEVELS, DETERMINANTS AND CONSEQUENCES

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1. Introduction

Agriculture remains the backbone of the Indian economy, engaging over half of the country's workforce and contributing a substantial share of national output. Nevertheless, the sector is persistently marked by income volatility, fragmented landholdings, dependence on monsoons and heavy reliance on informal credit, which together expose farm households to recurrent financial shocks. In this context, financial literacy has come to be recognised as a key determinant of household economic resilience. Lusardi and Mitchell (2014) define financial literacy as people's knowledge of and ability to use basic financial concepts in everyday financial decision-making, operationalised through the widely adopted "Big Three" questions covering interest rates, inflation, and risk diversification.

The importance of this construct is amplified in developing economies. Drawing on the S&P Global Financial Literacy Survey, which covers more than 140 economies, Klapper, Lusardi and van Oudheusden (2015) found that worldwide, only about one in three adults is financially literate, with women, people with low incomes, and the less educated disproportionately affected. For Indian farmers, low literacy is compounded by limited formal access to financial services, making them vulnerable to exploitative lending, poor investment choices, and inadequate risk management. Successive policy interventions (financial inclusion drives, the Kisan Credit Card (KCC), the Pradhan Mantri Jan Dhan Yojana and NABARD-led financial literacy programmes) have widened access to formal accounts.



However, scholars argue that access alone is insufficient. Without the knowledge, attitudes and behaviours conducive to sound financial planning, inclusion does not translate into well-being.

This paper synthesises secondary evidence to answer three questions: (i) What is the prevailing level of financial literacy among Indian farmers? (ii) Which socio-economic factors determine it? Moreover, (iii) What are its consequences for farm-household financial outcomes? By consolidating findings from national surveys and empirical studies, the paper situates farmer financial literacy within the broader agenda of building an inclusive and financially resilient Viksit Bharat by 2047.

2. Review of Literature

The measurement of financial literacy owes much to Lusardi and Mitchell (2011), whose "Big Three" instrument has been incorporated into surveys in more than 40 countries and has repeatedly been shown to predict financial behaviour. Klapper and Lusardi (2020) demonstrate that, unlike in advanced economies, financial literacy in developing countries often declines rather than rises with age, and is strongly linked to financial resilience.

In the Indian farm context, Maji and Laha (2023) provide the most comprehensive assessment, analysing secondary data on 11,030 farmers from the Financial Inclusion Insights survey; they report an average literacy score of only about 33 per cent, conclude that the majority of Indian farmers are financially illiterate, and identify significant regional variation. Extending this line of work, subsequent research links literacy to specific outcomes. Studies on savings behaviour find that financial literacy and financial confidence are instrumental in shaping whether farmers save regularly, with only around 43 per cent of sampled farmers saving consistently (Maji & Laha, 2023). At the state level, Das and Maji (2025) surveyed 505 farmers in West Bengal. They found that a mere 32.87 per cent were financially disciplined, with an average literacy score of just 1.80, evidence of very poor literacy, yet demonstrated that literacy and confidence significantly improve financial discipline. Complementary work on paddy farmers in the same region shows that dimensions of financial literacy reduce technical inefficiency in production, connecting financial knowledge to real agricultural performance.

Regional micro-studies echo these findings. Research on farmers in Kalaburagi, Karnataka, using the OECD toolkit, classified 39 per cent of farmers as having low literacy, 32 per cent moderate and only 29 per cent high, and found literacy to be significantly influenced by age, education, farm income and bank-account ownership, while itself shaping the uptake of crop insurance, KCC, mobile banking and agricultural loans. Collectively, the literature converges on a consistent narrative: farmer financial literacy in India is low and uneven, is driven by education and economic status, and materially affects savings, borrowing, discipline and efficiency.

3. Methodology

This study adopts a descriptive, secondary-data research design. It relies entirely on published sources, comprising (a) national survey reports, principally NABARD's Second All India Rural Financial Inclusion Survey (NAFIS) 2021-22 and the Financial Inclusion Insights survey; (b) peer-reviewed empirical studies published in journals such as the *Agricultural Finance Review* and *Management Matters*; and (c) cross-country benchmarks from the S&P Global Financial Literacy Survey and the Global Financial Literacy Excellence Center.

The analytical approach is interpretive and comparative. Reported statistics on literacy levels, savings, indebtedness and their determinants were extracted, tabulated and compared across sources and over time to identify convergent patterns. Financial literacy in the underlying studies is predominantly measured using the S&P Global/Big Three framework (interest, inflation, and risk diversification) and, in some micro-studies, the OECD toolkit, encompassing knowledge, attitude, and behaviour. As the study uses only aggregate published data, no primary data collection or ethical clearance was required; its principal limitation is dependence on the definitions, samples and reference periods of the original sources, which are not always directly comparable.

4. Results and Discussion

4.1 Level of Financial Literacy

The evidence points to low but improving literacy. Analysing the Financial Inclusion Insights data, Maji and Laha (2023) find an average literacy score of roughly 33 per cent among Indian farmers, with most respondents financially illiterate. The more recent NAFIS 2021-22 offers a nationally representative and encouraging trend: the proportion of rural respondents demonstrating good financial literacy rose from 33.9 per cent in 2016-17 to 51.3 per cent in 2021-22, and sound financial behaviour rose from 56.4 per cent to 72.8 per cent over the same period (NABARD, 2024). Table 1 summarises the key indicators.

Indicator (rural / farm households)	2016-17	2021-22
Respondents with good financial literacy	33.90%	51.30%
Respondents with sound financial behaviour	56.40%	72.80%
Households reporting any savings	50.60%	66.00%
Households with outstanding debt	47.40%	52.00%
Agri-households borrowing from institutional sources	60.50%	75.50%
Average monthly household income (₹)	8,059	12,698

Source: Compiled from NABARD (2024), NAFIS 2021-22.

4.2 Determinants of Financial Literacy

Across studies, a stable set of determinants emerges. Maji and Laha (2023) identify education, landholding size, income level, and age as significant predictors, using censored tobit and structural equation models. Micro-level evidence from Karnataka similarly finds age, education, farm income and bank-account ownership to be significant, with the model explaining roughly 67 per cent of the variation in literacy and a significant F-ratio (18.52). Studies of savings behaviour also identify household size, financial shocks, gender, farm ownership, the household financial decision-making process, religion, and educational attainment as significant. The recurring salience of education and economic status suggests that literacy gaps are embedded in broader structures of rural disadvantage rather than purely informational.

4.3 Consequences for Financial Outcomes

Higher financial literacy is consistently associated with better outcomes. It improves savings behaviour, as only about 43 per cent of sampled farmers saved regularly, with literacy and confidence acting as key drivers (Maji & Laha, 2023). It strengthens financial discipline: Das and Maji (2025) show that literacy and confidence significantly increase the likelihood that a farmer is financially disciplined, an important channel, given that only a third of their West Bengal sample qualified as disciplined. Literacy also has productive spillovers, reducing technical inefficiency among paddy farmers and thereby linking financial knowledge to farm performance. Importantly, the coexistence in NAFIS 2021-22 of rising literacy with rising indebtedness, with outstanding-debt incidence climbing to 52.0 per cent even as institutional borrowing expanded to 75.5 per cent of agri-households, suggests that literacy shapes not merely whether farmers borrow but how prudently they use formal credit.

5. Conclusion and Recommendations

This paper finds that financial literacy among Indian farmers, though improving, remains a structural constraint on rural well-being. Average literacy is modest, unevenly distributed across regions, and shaped predominantly by education, income, landholding and access to formal finance; where literacy is higher, farmers save more, exhibit greater financial discipline and farm more efficiently. Given agriculture's centrality to the Viksit Bharat 2047 vision, closing the literacy gap is both a welfare and a growth imperative.

The study offers the following recommendations: Financial education should be given to farmers in their own local language through NABARD, banks and Financial Literacy Centres, and it should be planned around how money comes in and goes out for farm families in different seasons and the risks they face, instead of using the same general lessons for everyone. This guidance should reach farmers through places they already deal with, such as Kisan Credit Card renewals, Farmer-Producer Organisations, village cooperative credit societies and self-help groups, so that they get the right advice at the exact time they are making real money decisions. Special focus should be given to women farmers, small farmers and people with little schooling, as studies show they know the least about managing money, and their lessons should keep women's needs in mind and be taught by people from their own community. Mobile phones and digital tools should also be used to spread this knowledge, along with proper safety measures, because farmers who understand money matters are far more likely to use mobile banking, crop insurance and bank loans in the right way.

At the same time, financial education should be made part of school lessons and government farm advice services, as suggested in the National Education Policy (NEP) 2020, so that people learn about money from a young age and keep building on it throughout their lives. Farmers' knowledge of money matters should also be checked at regular intervals by expanding the existing NAFIS survey, to track progress and send help where the gaps are the widest. In the end, simply giving farmers access to banks is not enough. What really matters is helping them use these services wisely, as this will decide whether India's farmers can handle risks, build up their savings and property, and fully share in the growth and prosperity expected for a developed India by 2047.

TREES HAVE GENES TOO 'WHAT THE WORLD'S NEW REPORT ON FOREST GENETIC RESOURCES MEANS FOR INDIA'

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Walk into any roadside nursery and watch how people buy saplings. They check the height of the plant, the colour of the leaves and, of course, the price. Almost nobody asks the one question that matters most: where did the seed come from? Yet that invisible detail, the genetic make-up of the plant quietly decides whether the tree will survive a scorching May, shrug off a termite attack, or grow straight enough to fetch a good price at the timber market twenty years later.

Foresters call this hidden wealth 'forest genetic resources'. FAO defines them as the heritable materials within and among tree and other woody plant species that have actual or potential economic, environmental, scientific or societal value. Put simply, it is the variation inside a species that lets one neem tree tolerate drought better than its neighbour, or one teak population produce finer wood than another. That variation is what allows forests, and the farmers who depend on trees, to adapt when conditions change.

In 2025 the Food and Agriculture Organization (FAO) of the United Nations published the Second Report on the State of the World's Forest Genetic Resources, the first global stocktaking in more than a decade. Its findings deserve far more attention in India than they have received so far.

A global health check for trees

The report draws on information from 77 countries that together hold about 77 percent of the world's forest area. Some of its numbers are worth pausing on. There are roughly 58,000 tree species on Earth, along with about 1,600 woody bamboos and nearly 500 rattans.



Figure 1. Key global figures from FAO's Second Report on the State of the World's Forest Genetic Resources (2025).

Around 30 percent of tree species are threatened, and most of these are found in tropical and subtropical regions.

Countries together reported more than 2,800 species of trees and other woody plants, of which nearly 1,800 have been genetically characterised. Around 1,400 species are covered by in situ conservation programmes and about 1,100 by ex situ programmes. That sounds impressive until you set it against the 58,000 tree species that exist. The report is candid that, although information has improved, it remains inadequate and most woody species are still poorly studied.

One finding is especially relevant to anyone who grows trees. Common, widely distributed species still hold much of their genetic diversity, but rare and threatened species have lost a significant amount of it. The main culprits are familiar: deforestation, degradation, climate change, fire, pests, diseases and invasive species. The report also notes that more than two-thirds of countries run national tree-seed programmes, yet many of them face shortages of seed and planting material.

On the technology side, only about 19 percent of reporting countries said they use genomic tools in tree breeding. Genetically modified lines exist for more than 30 tree species but are rarely used in practical forestry, and gene editing remains at an early research stage. The conversation has not ended with the report either; FAO's Intergovernmental Technical Working Group on Forest Genetic Resources met again in Rome in May 2026 to take the follow-up forward.

Why should India read this report closely?

India is one of the world's mega diverse countries and shares parts of four global biodiversity hotspots: the Himalaya, the Western Ghats, the Indo-Burma region and Sundaland through the Nicobar Islands. Most of our forests are tropical or subtropical, which is exactly where the report says threatened tree species are concentrated. In other words, the global warning applies to us with extra force.

There is a second, more practical reason. A large share of India's timber, fuelwood and fodder now comes from trees grown outside forests, on farm bunds, in agroforestry blocks and along roads and canals. India adopted its National Agroforestry Policy in 2014, becoming the first country to adopt a national policy dedicated to agroforestry. Farmers in Punjab, Haryana and western Uttar Pradesh plant poplar and eucalyptus by the lakh, while *Melia dubia*, teak and bamboo are spreading in the south. Many of these plantations rest on a surprisingly narrow genetic base: a handful of popular clones multiplied again and again. When large areas are planted with genetically similar material, a new pest or disease can pose a greater risk of widespread damage. Diversity is not an academic luxury; it is crop insurance.



Figure 2. A clonal poplar-based agroforestry plantation illustrating the use of genetically uniform planting material in farm-based tree production

What India already has in place?

India is not starting from zero. The Indian Council of Forestry Research and Education (ICFRE) and its institutes, such as the Institute of Forest Genetics and Tree Breeding (IFGTB) in Coimbatore, and Himalayan Forest Research Institute etc., have long worked on seed production areas, seed orchards, clonal banks and provenance trials for species like teak, eucalyptus, casuarina and sandalwood. State forest departments maintain seed stands, and the country's network of protected areas, biosphere reserves and community-protected sacred groves conserves many tree populations where they grow naturally.

Indian scientists are also active internationally. In January 2026, IFGTB hosted the International Conference on Population and Conservation Genetics in Coimbatore, together with IUFRO and the Asia-Pacific Forest Genetic Resources Programme (APFORGEN). The themes discussed there, from landscape genomics and local adaptation to tree seed systems for restoration and forensic timber identification, show how quickly the science is moving.



Figure 3. In situ and ex situ conservation of forest genetic resources work best as complementary strategies.
Source: Author's illustration based on FAO (2025)

The gaps we still need to close

Despite this foundation, three gaps stand out. The first is information. Like many countries in the FAO report, India lacks a complete, easily accessible inventory of the genetic diversity of its important tree species, especially lesser-known ones such as wild fruit trees, medicinal trees and fodder species. We cannot protect what we have not measured.

The second is planting material. A farmer can buy certified wheat seed with a label telling its variety and source, but quality control for tree seedlings is far weaker. Many saplings come from unregistered nurseries that collect seed from whichever trees are nearest, sometimes only two or three of them. Such seed lots may have a narrow genetic base, resulting in reduced genetic diversity and potentially poorer adaptation or performance.

The third is climate. Trees live for decades, so a seedling planted today must cope with the climate of 2050. Choosing the right provenance, meaning the right geographic source of seed, is becoming as important as choosing the right species.

What farmers and extension workers can do?

Not every solution needs a laboratory. Farmers can ask nurseries for the source of seed or the clone number and prefer registered nurseries and those linked to forest departments, ICFRE institutes, agricultural universities or Krishi Vigyan Kendra's. Planting a mix of several clones or seedlots rather than a single clone spreads the risk. Old local trees such as mahua, jamun, khejri, neem and native acacias on field boundaries and village commons are living gene banks and deserve protection rather than the axe. Where communities collect their own seed, the golden rule is to gather it ideally from many healthy, unrelated trees standing well apart, rather than from one convenient tree beside the road.

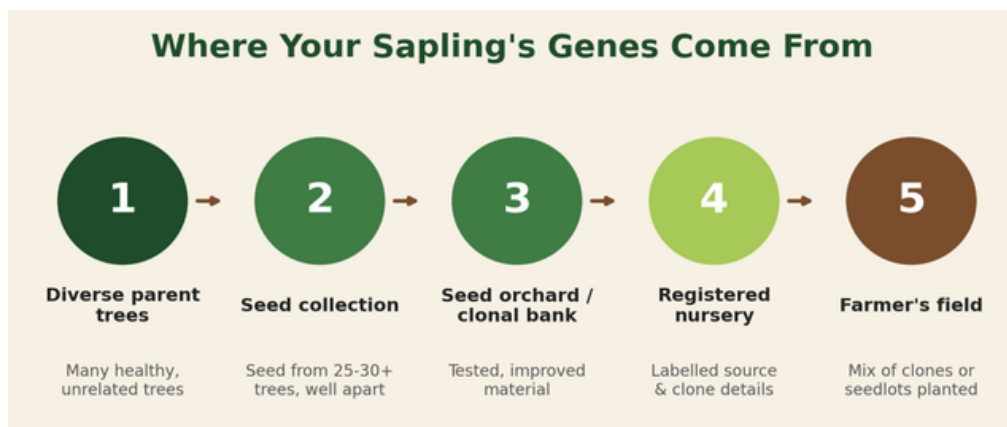


Figure 4. From diverse parent trees to the farmer's field: the pathway of quality forest reproductive material.



Figure 5. Ban oak (*Quercus leucotrichophora*): acorns, foliage and nursery-raised seedlings. HFRI has established a Seed Production Area (SPA) for this important Himalayan fodder species to support quality seed production, regeneration and conservation.

At the policy level, the priorities follow naturally from the FAO report: a national strategy and inventory for forest genetic resources, a practical certification system for forest reproductive material, more support for community seed banks and village nurseries, and wider use of modern genomic tools to identify climate-resilient populations before they disappear.

Conclusion

The FAO report carries a simple message: the diversity hidden inside tree species is shrinking faster than we are studying it. For India, where large numbers of farmers depend on trees for income, that is not a distant environmental concern but a question of livelihoods. The next time you buy a sapling, ask where its seed came from. That small question may be the first step towards forests, and farms, that can stand up to whatever the coming decades bring.

FROM FARM SOIL TO CLIMATE SOLUTION:

India's Path to Carbon-Smart Agriculture Restoring soil carbon while protecting productivity, profitability and resilience

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1. Introduction

India's soils are carrying a hidden deficit. Estimates suggest that intensively cultivated regions have shed 30–40% of their original organic carbon stocks since the 1970s, driven mainly by deep tillage, residue removal, and continuous cereal cultivation. The consequences show up in ways farmers feel before they see them: waterlogging in some fields, moisture stress in others, and fertiliser doses that keep rising without proportionate yield gains. Average SOC across the Indo-Gangetic Plains - India's food bowl has fallen to around 0.3–0.5%, roughly one-third of the 1% threshold considered adequate for productive, climate-adaptive farming. A 20% reduction in water-holding capacity is one measurable consequence; higher irrigation requirements and declining fertiliser-use efficiency are two others.

The global picture adds a different kind of urgency. Improved cropland management could sequester 1.8–2.6 Gt CO₂ yr⁻¹ worldwide, and India's updated NDC has committed to creating an additional 2.5–3.0 Gt CO₂-eq carbon sink by 2030 through land-use improvements [3]. Soil carbon sits at the intersection of these two concerns - agronomic productivity and climate responsibility which is precisely why it deserves attention beyond the research station.

2. Key SOC-Restoration Practices

2.1 Zero Tillage and Residue Management

Every pass of a mouldboard or disc plough breaks apart the macro-aggregates that protect organic matter from microbial breakdown. The carbon released this way has been estimated at 0.1–0.3 t ha⁻¹ annually, a slow haemorrhage that compounds over decades. Zero-tillage interrupts this cycle simply by leaving the soil undisturbed. When combined with rice-straw retention (rather than burning), field trials across Punjab and Haryana showed annual SOC gains of 0.04–0.06%, modest in absolute terms but meaningful against a background of steady loss [4]. The Kapurthala pilot ran from 2019 to 2022; over those three seasons, SOC climbed from 0.38% to 0.61%, a 61% relative improvement that farmers on the project could see reflected in reduced waterlogging and softer seedbed conditions.

2.2 Biochar Amendment

Biochar is not a fertiliser in the conventional sense, it supplies almost no immediately available nutrients. Its value lies in persistence. The highly condensed aromatic carbon rings that form during pyrolysis (400–700 °C) resist microbial breakdown for centuries, effectively locking carbon into the soil profile [5]. In Betul district, Madhya Pradesh, ICAR-NIASM researchers applied biochar at 5 t ha⁻¹ to rainfed fields between 2020 and 2023. SOC rose from 0.52% to 0.79% over that period, water retention improved by 18%, and urea requirement fell by 12%.

For smallholders, perhaps the most relevant finding was the cost of production: simple pyrolysis kilns fabricated locally for under ₹15,000 per unit can convert paddy husk or cotton stalks, materials that farmers currently burn into a soil amendment with measurable long-term returns.

2.3 Cover Crops and Agroforestry

The window between Kharif harvest and Rabi sowing typically six to eight weeks, is often left as bare fallow. Sowing dhaincha or cowpea during this period costs little and returns a great deal: 60–120 kg N ha⁻¹ fixed biologically, plus 2–4 t of dry biomass that, when incorporated, feeds soil microbial communities over the following season [2]. Long-term IGFR plots at Jhansi, where dhaincha had been incorporated for eight consecutive years, recorded a 0.28% absolute rise in SOC and a ₹4,200 ha⁻¹ yr⁻¹ reduction in fertiliser spending both of which hold up to scrutiny even after accounting for the cost of the seed. Agroforestry tells a similar story at a longer timescale. Tree-crop systems like poplar or moringa intercropped with wheat in Maharashtra, contribute 1.5–3.2 t C ha⁻¹ yr⁻¹ through root turnover and leaf litter, pathways that open-field monocultures cannot replicate. In Nashik district, poplar-wheat plots saw SOC rise from 0.41% to 0.68% across three years.

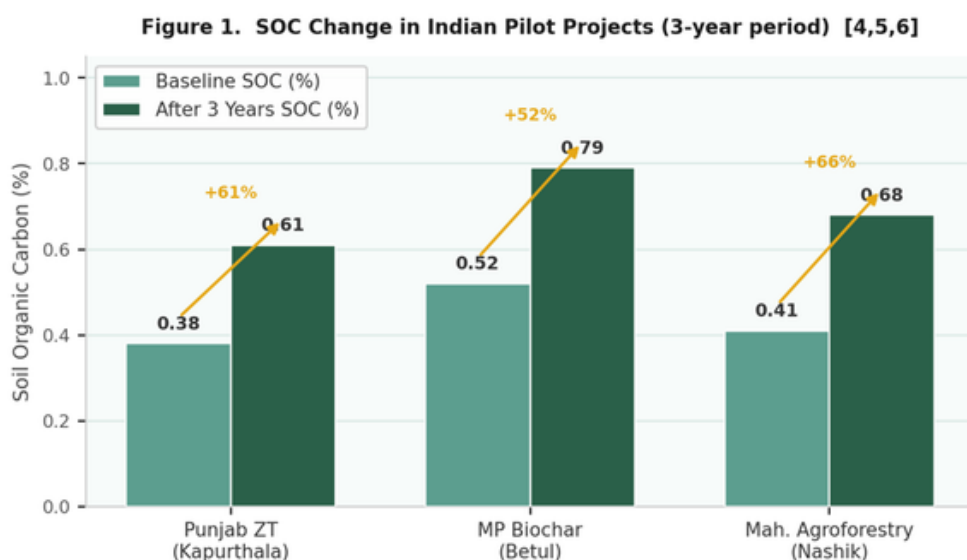


Figure 1. SOC change (%) at three Indian pilot project sites over a 3-year period. Hatched bars = baseline; solid bars = post-intervention

3. Comparative Practice Benefits

Table 1. Summary of SOC-building practices and their farm-level impacts in India.

Practice	SOC Gain (3 yr)	Yield Effect	Cost Change
Zero Tillage + Residue	0.23%	+5–10% wheat	–₹2,500/ha/yr
Biochar (5 t/ha)	0.27%	+8–15% maize	–12% urea
Cover Crop (dhaincha)	0.18%	N-saving equiv.	–₹4,200/ha/yr
Agroforestry (poplar)	0.27%	+timber income	+₹8,000/ha/yr

4. Government Schemes Supporting SOC Restoration

Several central government programmes already provide financial support for the practices described above, though farmers often do not realise they qualify [3,7]:

Table 2. Central government schemes with direct links to SOC-building in Indian agriculture

Scheme	SOC Linkage	Farmer Benefit
PM-PRANAM	Rewards states for chemical fertiliser reduction	State savings shared as incentive payments
NMSA (Soil Health)	Soil Health Cards; subsidises bio-inputs & organic amendments	Free soil testing; subsidy on bio-inputs
PMKSY (Watershed)	Watershed SOC builds water retention & reduces irrigation need	Lower irrigation cost; crop insurance rebates
RKVY-RAFTAAR	Funds zero-tillage machinery & biochar production units	Subsidy up to 80% for SC/ST farmers

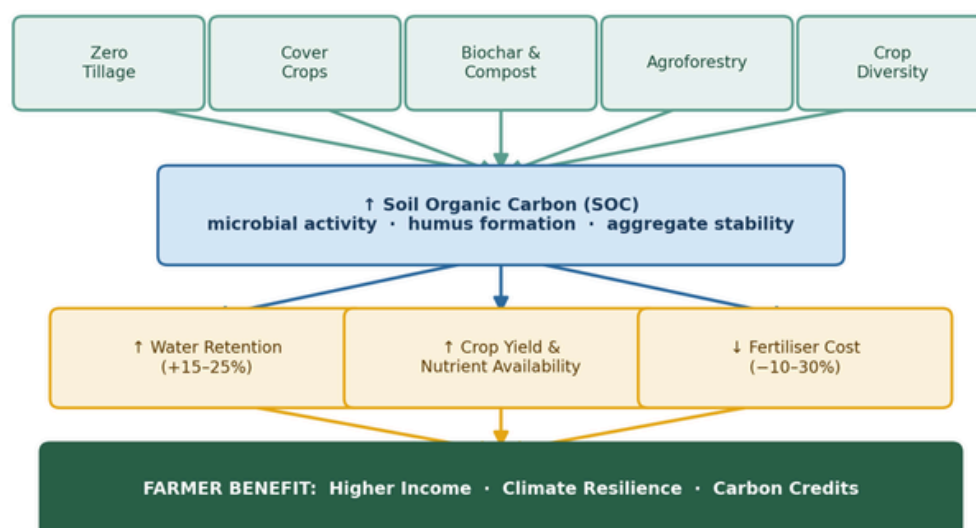


Figure 2. Conceptual flow of SOC restoration: from farm practices to farmer benefits

5. Adoption Pathway and Carbon Market Potential

Extension workers consistently report that farmers adopt new soil practices most readily when returns appear within a single season and inputs are locally available without complicated procurement [7]. Group biochar production, piloted by FPOs in Madhya Pradesh and Maharashtra, brought per-unit fabrication costs down by roughly 35% — enough of a reduction to shift the economics for small landholders. These same FPOs have begun aggregating carbon credits through Verra VCS and Gold Standard, an option that individual farmers on 1–2 ha plots cannot realistically pursue on their own.

The scale numbers are worth stating plainly. A 0.2% SOC improvement across 50 million ha of Indian cropland translates to roughly 200 Mt CO₂-eq sequestered. At voluntary market prices of \$5–15 per tonne, that opens a supplementary income stream in the range of ₹40,000–1,20,000 crore annually — on top of the yield and input-cost gains the same practices already deliver. Whether these projections survive contact with actual carbon accounting protocols is an open question, but the directional case for serious policy attention is hard to dismiss.

6. Conclusion

Soil does not feature prominently in India's climate policy conversations, yet the field data reviewed here makes a strong case for putting it there. Farmers in Kapurthala, Betul, and Nashik achieved 38–65% SOC gains over three growing seasons — without subsidised technology and, in one case, while cutting their fertiliser bill by over ₹4,000 per hectare annually [2,4,5,6]. The barriers to wider adoption are real: patchy extension coverage, fragmented landholdings, and carbon markets still learning how to reliably verify soil sequestration. None of these is unfamiliar territory, and none is beyond the reach of institutions that already exist — PM-PRANAM, NMSA, and FPOs that have already shown they can aggregate what individual smallholders cannot access alone [7]. A deliberate policy decision to treat soil carbon with the same seriousness currently given to solar or EV deployment would, in effect, give India's 140 million ha of farmland two jobs at once: producing food, and drawing down carbon.

References



Important DAYS IN OCTOBER

Celebrating Agriculture, Livestock,
Nutrition and Rural Communities

World Animal Welfare Day

Focuses on livestock and farm animal care.



Promotes human and responsible animal care



Ensures better health, welfare and productivity



SECOND
THURSDAY
OF
OCTOBER

World Chicken Day

Celebrates poultry farming and production.



Recognizes the role of poultry in food security



Highlights its contribution to rural livelihoods



Supports sustainable and responsible poultry farming



SECOND
FRIDAY
OF
OCTOBER

World Egg Day

Highlights the nutritional and agricultural value of eggs.



Rich source of high-quality protein and essential nutrients



Contributes to food security and sustainable agriculture



International Day of Rural Women

Honors the crucial role of women in agriculture and rural development.



Recognizes their contribution to food production and nutrition



Promotes gender equality in agriculture



Supports rural women's empowerment and livelihoods



World Food Day

Marked by the FAO to promote global food security and sustainable agriculture.



Raises awareness on the importance of safe and nutritious food



Supports sustainable and resilient food systems



Encourages collective action to end hunger and build a better food future



Apple Day

Celebrates orchards, apple varieties, and local food heritage.



Recognizes the cultural and economic value of apples



Promotes orchard conservation and local varieties



Supports sustainable horticulture and rural livelihoods



TECHNOLOGY OF THE MONTH



HD 3463

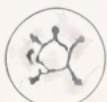
High yield, highly disease resistant,
highly nutritious and of strong industrial value



60

q/ha

AVERAGE
YIELD



12.10%

PROTEIN



40.1

ppm

IRON



33.80%

WET GLUTEN



**RUST
RESISTANCE**

High resistance
to leaf & stripe
rusts



**BREAD
QUALITY**

Excellent loaf
volume, soft
texture &
appealing crumb



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