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ON AGRI-INNOVATION AND SUSTAINABILITY IN MODERN AGRICULTURE (AISMA-2026)

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Content

Special Issue For National Conference on Agri-Innovation and Sustainability in Modern Agriculture (AISMA-2026) at VGU, Jaipur

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(A No. 181) Continuous Decline in the Cultivation Area of Nutri-Cereals

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ABSTRACT
Nutri-cereals or millets, also known as nutritious cereal crops, play an important role in providing essential nutrients such as calcium, fiber, protein, iron, and many other micronutrients. Considering the high prevalence of micronutrient deficiency among India's large population, the decline in the cultivation area of these nutritious cereal crops poses a serious threat to nutritional security.

Recognizing the importance of these crops and with the aim of promoting their consumption among consumers, the Government of India took an active step in 2018 by officially renaming coarse cereals as Nutri-Cereals. To encourage farmers to cultivate millets, the government regularly announces attractive Minimum Support Prices (MSP) for these crops. However, despite these efforts, the declining trend in the cultivation area of nutri-cereals continues.

Why is the Cultivation Area of Nutri-Cereals Declining?

Impact of the Green Revolution

The Green Revolution increased food security but also caused some undesirable changes in cropping patterns. As a result, water-intensive crops such as rice, sugarcane, banana, and wheat expanded significantly, while the area under nutri-cereals decreased sharply from 44.34 million hectares in 1965–66 to 22.65 million hectares in 2021–22 (a decline of 49%).

Low Productivity and Weak Infrastructure

- Low productivity, poor availability of quality seeds, inadequate processing and value addition facilities, and weak market linkages for nutri-cereals.
- Nutri-cereals were historically considered as "food of the poor," and due to increasing preference for rice and wheat, their demand declined.
- Inadequate market demand and low price incentives discourage farmers from investing in millet cultivation, resulting in low productivity.

Changing Food Preferences

People's food habits and preferences change over time. If consumers shift toward other breakfast foods or convenience foods, it reduces the demand for nutri-cereals.

Increasing Competition

- The cereal market is highly competitive with many alternatives available to consumers.
- New breakfast products such as granola, oats, breakfast bars, and dairy-based breakfast options are becoming popular.
- This increased competition reduces the market share of nutri-cereals.
- Lack of Marketing and Innovation
- Lack of effective marketing strategies and product innovation creates challenges for nutri-cereals.
- Consumers are often attracted to new and innovative food products; if millets fail to innovate in processing, taste, and packaging, sales may decline.
- Taste and Consumer Perception
- Taste preferences strongly influence food success.
- If consumers perceive millets as less tasty, they shift to other more palatable options.

Benefits of Increasing Millet Cultivation

Nutritional Benefits

Millets are rich in dietary fiber, iron, folate, calcium, zinc, magnesium, phosphorus, copper, vitamins, and antioxidants. They can improve nutritional security and help combat malnutrition, especially among children and women.

Climate Resilience

Millets are drought-tolerant and pest-resistant crops that can be grown in marginal lands with low input cost. They are suitable for climate change conditions and reduce the risk of crop failure.

Environmental Sustainability

Millets require less water and energy and improve soil health and biodiversity. They also reduce greenhouse gas emissions and water pollution compared to rice and wheat.

Economic Empowerment

Millets provide income opportunities for small and marginal farmers, especially women and tribal communities. They also create opportunities for rural entrepreneurship through value addition and processing.

Examples of Important Millets and Their Benefits

Millet Benefits

Nutri-cereal/Millet	**Nutritional Value and Health Benefits**
Sorghum (Jowar)	Rich in protein, iron, antioxidants; helps reduce blood sugar and cholesterol
Pearl Millet (Bajra)	Rich in protein, fiber, calcium, magnesium, zinc; helps prevent anemia
Finger Millet (Ragi)	Highest calcium content among cereals; good for bones and diabetes
Foxtail Millet	Rich in protein, fiber, antioxidants; improves immunity
Kodo Millet	Low glycemic index; helps control diabetes and obesity
Barnyard Millet	High fiber and iron; improves digestion
Little Millet	Rich in minerals; helps reduce cholesterol
Proso Millet	Rich in protein and phosphorus; good for nervous system

Major Government Initiatives to Promote Millets

International Year of Millets (2023)

The United Nations declared 2023 as the International Year of Millets (proposed by India) to highlight their importance in nutrition and sustainable agriculture. India also celebrated 2018 as National Year of Millets.

Rebranding

The Government of India officially renamed millets as Nutri-Cereals to promote their nutritional value.

Farmer Welfare Schemes

Under the National Agriculture Development Scheme, the government allocated funds to promote millet production and post-harvest technologies.

Seed Kits and Equipment

- Government provides seed kits and necessary equipment to farmers and supports Farmer Producer Organizations (FPOs) for value chain development and marketing.
- Increase in MSP
- Minimum Support Price for millets has been increased to encourage farmers.
- Inclusion in Public Distribution System (PDS)
- Millets have been included in PDS to ensure a stable market and increase consumer access.

Way Forward

- Collaboration with the food industry to develop value-added millet products.
- Introducing millets in school mid-day meal programs.
- Awareness programs and nutrition workshops.
- Collaboration with doctors, dieticians, and nutritionists to promote millet-based diets.

Social media campaigns, competitions, and consumer engagement programs to promote millet consumption.

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(A No. 182) Crop Residue Management: An Alternative Uses and Mechanization Approaches to Prevent Burning in Cropping System

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ABSTRACT

In general, Crop residues are plant parts left in the field after crops have been harvested and threshed. Crop residue (CR) plays an important role in sustainable agriculture without scarifying productivity and improves the physical, chemical and biological properties of the soil. Crop residue can partially substitute the fertilizer nutrient but not replacing them completely. However, indiscriminate use of natural resources and overuse of agro-chemical including fertilizers etc., food grain production may stagnate in future. The recycling of crop residues has the advantage of converting the surplus farm waste into useful product for meeting nutrient requirement of crops.

In general, Crop residues are plant parts left in the field after crops have been harvested and threshed. Crop residue (CR) plays an important role in sustainable agriculture without scarifying productivity and improves the physical, chemical and biological properties of the soil. Crop residue can partially substitute the fertilizer nutrient but not replacing them completely. However, indiscriminate use of natural resources and overuse of agro-chemical including fertilizers etc., food grain production may stagnate in future. The recycling of crop residues has the advantage of converting the surplus farm waste into useful product for meeting nutrient requirement of crops. It also maintains the soil fertility and improves the overall ecological balance of the crop production system. Most farmers remove wheat straw for feeding the animals. However, management of the rice straw is a major challenge as it is considered to be a poor feed for the animals owing to high silica content. So, there is a need to adopt ways and means to manage this valuable resource. The paddy crop residue is burnt in-situ which is a common management practice in North India viz., Punjab, Haryana as well as Uttar Pradesh. Whereas, in rest of the country viz., Gujarat, Maharashtra, Tamil Nadu, Bihar, Assam, West Bengal and Jammu & Kashmir uses it as cattle feed, thatching for houses in rural areas, fuel for domestic cooking and industry, mulching material, compost making, power generation, bio

fuels and in boilers for parboiling paddy.

The main causes of crop residue burning are the time available between the rice harvesting and wheat sowing is very narrow and in the range of 20-30 days at the end of the *Kharif* season. Paddy is a water intensive crop and the high usage of water in its paddy cultivation can legally begin only around Mid-June, when the monsoons typically arrive over North India. During harvesting of paddy crop, the large units of harvesters leave 6- 10 cm of paddy stalk on the field and the removal of the paddy stalk that remains in the field is a labour-intensive process.

Management Practices & Alternative Uses Relating to Crop Residue:

1. **Paddy/ Wheat residue management:**

Rice straw is difficult to use as fodder and decomposes slowly in the field. Leaving the residue on the field isn't viable for farmers as it takes too long to degrade and can also transmit crop disease that may have occurred during the preceding paddy season. On the other hand, while sowing wheat in the midst of the stubble using a machine called happy seeder is possible, it has been adopted widely due to technical issues in operations, unavailability of machines and price issues. There are also off field end-use options for paddy residue including biomass of energy, mushroom production, cardboard/ paper making etc. Mechanization of crop residue management though most of these practices prevent soil damage that releases carbon and water into the atmosphere; promote soil and water conservation and increase productivity. Mechanical harvesting has become widespread because of displace or substitute for labour shortages.

2. **Surface retention and mulching:**

Mulching as a residue is known to cause problems in early wheat cultivation. It is also difficult by combine harvester, so straw management system is used to make mulching a more viable option is yet to be widely adopted by farmers as it entails fuel and other expenses. Direct drilling in surface mulched residues is a practice that leaves straw residues from a previous crop on the soil surface without any form of incorporation. The large volume of residues remaining on the surface often leads to mechanical failures, thus affecting sowing of seeds of the following crop. Surface retention of the residues may be the best option; it decomposes slowly on the surface, increasing the organic C and total N in the top 5-15 cm of soil, while protecting the surface soil from erosion. Retention of residue on the surface increased soil NO_3 concentration by 46% N, uptake by 29% and yield by 37% compared to burning.

The benefits of retention of crop remains on soil surface are as follows:

- Lesser weed growth
- Saves weedicides cost
- Improves physical, chemical and biological attributes of soils
- Recycling of plant nutrients
- Lowering fertilizer use in the next successive crops

3. **Farm mechanization and crop residue management:**

Resource conservation technologies (RCTs) based farm machinery provides a better promise in managing paddy residues for improving soil health, productivity, reducing pollution and achieving sustainable agriculture. For direct seeding of successive crop in loose and anchored straw load up to 10 t ha-1, advance technology of zero-till seed –cum- fertilizer drill/seed planters were available in the country. These technologies are valuable for managing crop residue for controlling of weeds, conserving soil moisture content and nutrients. The happy seeder technology represents a burst through for paddy-wheat crop rotation in NW India. Happy seeder is a most profitable and scaled residue management practices, on average 10% - 20% more profitable than burning. It can also lower the agriculture's contribution to India's to green house gases (GHG) emission.

4. **Bailing and removing the straw:**

For removal and collection of straw after combine harvesting and using the residue for off farm; straw baler machines is very promising technology & commercially available. These balers however, recover only 25 - 30% of potential straw yield after combining, depending upon height of plant cut by combines. Baler makes rectangular or round bales by collecting the loose straw from the ground. Machine can recover about 200-250 bales weighing between 15 and 30 kg with a size of 460x360 mm bale from combine harvested field. The speed of operation can be varied between 2-3 km h^{-1} in combine harvested fields depending upon field conditions. The fuel consumption varied between 8.5-11.0 l ha^{-1}. Thus baler provide a solution for eco-friendly residue management.

5. Crop residue as livestock feed:

Traditionally, the crop residues in India are utilized as animal feed such as or by supplementing with some additives. However, crop residues, being unpalatable and low in digestibility, cannot form a sole Multiple benefits of the rice residue management through concurrent use of SMS fitted combines and turbo happy seeder.

Suggestions for maintaining good crop residue management practices:

- Promote the use of crop residues for renewable energy production, which helps improve air and soil quality while mitigating climate change and global warming.
- Treat crop residues as valuable recyclable resources, similar to inputs like lime or gypsum, and encourage their application in agricultural fields as nutrient sources.
- Encourage the utilization of surplus crop residues through the establishment of biomass-based energy plants for efficient energy generation.
- Promote in-situ management practices, including:
- Rapid decomposition using chemical or biological methods
- Straw mulching through mechanical techniques
- Provide incentives and policy support to farmers to discourage open burning of paddy residues and adopt sustainable alternatives.

Conclusion:

Crop residues are of great economic value as livestock feed, fuel, valuable resources for agriculture and industrial raw material, but their management depends on regional and socio-economic conditions. With increasing mechanization, residue accumulation has become a major concern. Sustainable solutions include: In-situ methods: Happy Seeder, zero-tillage, mulching and Ex-situ methods: Bioenergy, briquettes, industrial use.

Adopting these practices under conservation agriculture will reduce residue burning, improve soil health, and ensure long-term agricultural sustainability.

"Stop Burning, Start Earning: Crop Residue to Resource"

(A No. 183) Technological Innovation's Effect on India's Agricultural Sustainability and Productivity

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ABSTRACT

Innovation in technology is causing a significant change in India's agricultural landscape. In order to increase productivity and guarantee food security, modern technology integration has become crucial as the nation struggles with issues like climate change, land degradation, and an expanding population. This study examines the influence of innovations like precision farming, remote sensing, mobile-based advisory services, and biotechnology on crop yield, resource efficiency, and farmer livelihoods. Through a review of recent trends and case studies across various agro-climatic zones, the paper highlights how technology adoption has led to improved decision-making, reduced input costs, and enhanced resilience against environmental stressors. Despite these gains, barriers such as limited access to infrastructure, digital illiteracy, and socio-economic disparities hinder widespread adoption. To promote sustainable agricultural growth in India, the results highlight the necessity of inclusive policy frameworks, focused training initiatives, and cooperative efforts between the public and private sectors as well as farming communities.

Agriculture remains the backbone of India's economy, employing nearly half of the workforce and contributing significantly to food security. However, the sector faces mounting challenges: climate variability, soil degradation, water scarcity, and the pressure of feeding a growing population. In this context, technological innovation has emerged as a transformative force. Precision farming, biotechnology, mobile-based advisory services, and remote sensing are reshaping agricultural practices, offering new pathways to sustainability and productivity. This article explores how these innovations influence crop yield, resource efficiency, and farmer livelihoods, while also addressing barriers to adoption and the need for inclusive policy frameworks.

Technological Innovations in Indian Agriculture

Precision Farming

Precision farming uses data-driven tools such as GPS, sensors, and drones to optimize input use. Farmers can monitor soil health, moisture levels, and crop growth in real time. In states like Punjab and Haryana, precision irrigation has reduced water consumption by up to 30 percent, while ensuring higher yields. By minimizing fertilizer and pesticide use, precision farming also contributes to environmental sustainability.

Remote Sensing and GIS

Satellite imagery and Geographic Information Systems (GIS) provide valuable insights into crop conditions, pest infestations, and weather patterns. For instance, the Indian Space Research Organisation (ISRO) has developed crop forecasting models that help policymakers and farmers anticipate production trends. Remote sensing has proven particularly useful in drought-prone regions, enabling timely interventions and resource allocation.

Mobile-Based Advisory Services

Digital platforms such as Kisan Call Centres and mobile apps deliver localized information on weather forecasts, market prices, and best practices. These services empower smallholder farmers, who often lack access to extension officers. In Maharashtra, mobile advisories have helped cotton farmers reduce pest damage by adopting timely spraying schedules, thereby lowering input costs and increasing profitability.

Biotechnology

Advances in biotechnology, including genetically modified crops and biofertilizers, have enhanced resilience against pests and diseases. Hybrid varieties of rice and maize have demonstrated higher yields under stress conditions. Biotechnology also supports sustainable practices by reducing reliance on chemical inputs and improving nutrient efficiency.

Impact on Productivity and Sustainability

Improved Decision-Making

Technology enables farmers to make evidence-based decisions. Precision farming tools provide accurate data on soil fertility, while mobile advisories guide farmers on crop selection and input use. This reduces guesswork and enhances efficiency.

Resource Efficiency

Water, fertilizer, and energy are critical yet scarce resources. Innovations such as drip irrigation, solar pumps, and sensor-based monitoring systems ensure optimal utilization. By reducing wastage, these technologies contribute to both economic savings and environmental conservation.

Enhanced Resilience

Climate change poses significant risks to Indian agriculture. Technologies like drought-tolerant crop varieties, weather forecasting models, and crop insurance platforms strengthen resilience. Farmers are better equipped to withstand floods, droughts, and pest outbreaks.

Livelihood Improvement

Beyond productivity, technology adoption improves farmer incomes and quality of life. Reduced input costs, higher yields, and better market access translate into greater profitability. Case studies from Andhra Pradesh show that farmers using digital platforms for market linkages earn 15–20 percent more than those relying on traditional channels.

Barriers to Adoption:

Despite the promise of technology, several obstacles hinder widespread adoption:

- Infrastructure Gaps: Rural areas often lack reliable electricity, internet connectivity, and storage facilities.
- Digital Illiteracy: Many farmers, especially older generations, struggle to use mobile apps and digital tools.
- Socio-Economic Disparities: Smallholder farmers with limited capital find it difficult to invest in advanced technologies.
- Policy and Institutional Challenges: Fragmented policies and inadequate extension services slow down technology diffusion.

Policy Recommendations:

To ensure inclusive and sustainable agricultural growth, the following measures are essential:

1. Inclusive Policy Frameworks: Government initiatives must prioritize smallholder farmers, ensuring subsidies and support for technology adoption.
2. Capacity Building: Training programs and farmer field schools can bridge digital literacy gaps.
3. Public-Private Partnerships: Collaboration between government agencies, agritech startups, and farmer cooperatives can accelerate innovation.
4. Infrastructure Development: Investments in rural connectivity, cold storage, and renewable energy are critical for scaling technology.
5. Community-Driven Models: Farmer Producer Organizations (FPOs) can pool resources, negotiate better prices, and collectively adopt technologies.

Conclusion:

Technological innovation is redefining India's agricultural landscape. Precision farming, biotechnology, remote sensing, and mobile advisories have demonstrated tangible benefits in productivity, sustainability, and farmer livelihoods. Yet, the journey toward widespread adoption requires overcoming barriers of infrastructure, literacy, and equity. By fostering inclusive policies, strengthening training initiatives, and encouraging cooperative efforts, India can harness technology to achieve food security, environmental sustainability, and rural prosperity. The future of Indian agriculture lies not only in innovation but in ensuring that innovation reaches every farmer, regardless of scale or socio-economic status.

(A No. 184) Determinants of Student's Choice of Agriculture as a Discipline: Evidence from Rajasthan, India

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ABSTRACT
Agriculture continues to play a vital role in the socio-economic development of India, particularly in rural regions where a significant proportion of the population depends on farming for their livelihoods. Agricultural education has therefore become an essential pathway for developing skilled professionals capable of improving productivity, sustainability, and innovation in the sector. The present study explores the factors influencing undergraduate students' decisions to pursue agriculture as their field of study in Rajasthan, India. Primary data were collected from 200 final-year agricultural students using a structured questionnaire. The findings reveal that better career opportunities, personal interest, and the desire to improve farmers' livelihoods are the most influential factors guiding students toward agricultural education. Parental advice and expectations of financial stability also contribute significantly to students' decisions, while external influences such as coaching institutes and peer advice have comparatively lower impact. The results emphasize the need for improved career counselling, enhanced employment opportunities, strengthening agricultural education that will not only benefit students but also contribute to the overall development and modernization of agriculture in India.

Agriculture remains a fundamental pillar of the Indian economy, playing a crucial role in providing employment opportunities and supporting rural livelihoods. Although economic development generally leads to a growing contribution from the industrial and service sectors, the relative share of agriculture in the economy tends to decline over time. Despite this shift, agriculture continues to be essential for food security, rural stability, and sustainable development. Educational institutions involved in agricultural training provide opportunities for students to develop expertise in various disciplines such as agronomy, soil science, plant protection, agricultural economics, horticulture, animal husbandry, and agribusiness management. Through these specialized areas, graduates can contribute to research, extension services, policy development, and entrepreneurship in agriculture. Over the past few decades, agricultural education has evolved significantly, reflecting the changing demands of modern agriculture. Globalization, technological advancements, climate change and shifting market dynamics have introduced new challenges and opportunities for the agricultural sector. As a result, educators and policymakers have increasingly emphasized the need to view agricultural education from a broader and more global perspective. This approach encourages students to understand international agricultural trends, adopt innovative technologies, and address global food security concerns. Students' decisions regarding their careers should be guided by adequate knowledge, reliable information, and proper counseling so that their choices align with their interests, abilities, and personal characteristics. Both internal factors, such as individual aspirations and talents, and external influences, including family support, educational environment, and job prospects, play an important role in shaping these decisions. Therefore, it is essential to provide students with awareness about emerging trends, potential career opportunities, and possible challenges associated with different professional fields. Such orientation can help them make informed and thoughtful choices about their future careers.

In the context of agricultural education, students' choices to pursue agriculture as a field of study are shaped by a variety of influences that include personal passion for farming and rural development. In recent years, agriculture has emerged as a dynamic sector offering diverse career opportunities in government services, private agribusiness companies, research institutions, non-governmental organizations, and entrepreneurial ventures. These opportunities also make agricultural education an attractive option for students seeking stable and meaningful careers.

In the context of Rajasthan, where agriculture remains a primary livelihood activity and most of the students are attached from their roots with agriculture, analyzing students' motivations becomes particularly important. The state's agricultural sector faces various challenges, including water scarcity, climate variability, and resource constraints. Developing a skilled and motivated agricultural workforce can play a key role in addressing these issues. Therefore, the present study aims to examine the major factors influencing undergraduate students' decisions to pursue agriculture as their field of study in Rajasthan. By identifying the motivations and perceptions of students, the study seeks to provide insights that can support educational institutions, policymakers, and agricultural organizations in strengthening agricultural education and promoting youth participation in the sector.

Methodology:

The present study was conducted by Rajveer *et al.* (2025) during the year 2025 to examine the factors and causes that influencing students' choice of agricultural education in Rajasthan. A structured questionnaire was used to collect primary data from undergraduate students pursuing agriculture as their field of study. The respondents consisted of 200 final-year students selected from different agricultural institutions and universities across various districts of Rajasthan.

A random sampling technique was generally employed to ensure that students from diverse socio-economic and geographical backgrounds were included in the study. This approach allowed the researchers to obtain a representative sample reflecting the broader population of agricultural students in the state. The questionnaire was carefully designed to gather all the possible information regarding students' demographic characteristics, motivations for choosing agriculture as a career option, and their perceptions about career opportunities and challenges within the field.

The data collection instrument included several statements related to factors that may influence students' decisions to pursue agricultural education. These factors included parental advice, personal interest, teacher guidance, peer influence, coaching institutes, career prospects, income expectations, and social status associated with the profession. Students were asked to indicate their level of agreement with each statement using a three-point Likert scale consisting of "**Agree**," "**Neutral**," and "**Disagree**."

Results and Discussion:

The findings of the study reveal that students' decisions to pursue agricultural education are influenced by a combination of factors that are illustrated in Table 1 below:

The undergraduate agricultural students in Rajasthan represent a varied socio-economic and regional background. Among the respondents, around 41% belong to the Jat community, known for its strong ties to farming and agricultural traditions. Approximately 6% of students are from the Meena community, another 6% from the Kumawat community, and 5% from the Brahmin community. Additionally, 3% of students identify as Jat Sikh, while the remaining participants come from other caste and social groups, reflecting the diversity of the sample. This distribution indicates that many students have roots in farming families, which likely influences their decision to pursue agricultural education and shapes their future professional aspirations within the sector.

One of the most significant findings is that **better career opportunities** emerge as the most influential factor motivating students to choose agriculture. Most respondents indicated that they perceive agriculture as a field offering diverse employment possibilities. These opportunities include positions in government departments, agricultural research organizations, private agribusiness companies, banks, and development agencies. In addition, agriculture provides prospects for entrepreneurship through activities such as agribusiness management, food processing, and modern farming enterprises. The perception of stable and rewarding career paths encourages students to consider agriculture as a viable professional option.

Another major factor influencing students' decisions is their **desire to improve farmers' livelihoods**. Many respondents that from their childhood should see their parents strongly working hard in their own fields and not to get enough returns due to lack of facilities, environmental constraints etc. expressed a strong commitment to contributing to the welfare of rural communities and addressing the challenges faced by farmers. This sense of social responsibility reflects the growing awareness among youth regarding the importance of agriculture for national development and food security.

Personal interest in agriculture also plays a crucial role in shaping students' educational choices. As we discussed earlier, a significant proportion of students comes from several communities like Jat, Jat sikh, Meena, Kumhar etc. that strongly ties with agriculture from their roots and have passion for agricultural activities from their childhood and curiosity about scientific farming methods motivated them to pursue this discipline. Their familiarity with farming environments and their interest in agricultural sciences encourage them to explore the field further through formal education.

Parental influence represents another important factor affecting students' career decisions. In many cases, parents encourage their children to pursue agricultural education because of family involvement in farming activities. Parents often believe that formal education in agriculture will enable their children to manage farms more efficiently, adopt improved technologies, and secure stable employment opportunities. The parents believed that with the proper knowledge of improved practices, they can definitely improve the financial and livelihood conditions of the farmers of the nation.

The expectation of **higher earnings and financial stability** also influences students' choices, although it is not the most dominant factor. Students recognize that agriculture-related careers can offer long-term economic benefits through employment in government services, research institutions, agribusiness firms, and consultancy services. Students also believed that if either due to any reasons they failed to get any government jobs, nevertheless with the use of improved knowledge they start their own business and do progressive farming on their own farms and earn a good income.

Another factor considered by students is the **social status associated with agricultural professions**. With increasing recognition of the importance of agriculture for national development, careers in this sector are gradually gaining respect and prestige. Agricultural professionals such as scientists, extension officers, and agribusiness managers are viewed as contributors to rural development and food security.

In contrast, the study indicates that **teacher guidance and peer influence** have relatively limited impact on students' decisions to pursue agricultural education. While teachers provide valuable information and support during the educational process, students appear to rely more heavily on their personal interests and family advice when selecting their field of study.

The least influential factor identified in the study is the **role of coaching institutes**. Unlike other more important fields such as engineering or medicine, where coaching institutions play a major role in entrance exam preparation and career selection, agricultural education appears to depend less on such external support systems. Students pursuing agriculture often rely more on university programs, practical training, and field experiences to develop their skills and knowledge.

Overall, the results suggest that students' decisions to pursue agricultural education are primarily driven by career prospects, personal motivation, and a desire to contribute to the agricultural sector. This is because of that many of the communities of Rajasthan involved directly or indirectly with agriculture from their roots. Students seen from their early age that their parents do too much hard work in the field but cannot get much of the return as they expect. These conditions encourage the students to opt agriculture as a future discipline so that they can improve the livelihood of the farmers.

Table 1. Factors behind students' choice of agricultural education in Rajasthan

Reason	Agree	Percentage (%)	Neutral	Percentage (%)	Disagree	Percentage (%)
Parental advice	127	63.50	50	25.00	23	11.50
To improve farmers livelihood	158	79.00	37	18.50	5	2.50
Teacher's guidance	108	54.00	53	26.50	39	19.50
Friends/Relative's advice	84	42.00	62	31.00	54	27.00
Self-interest	158	79.00	30	15.00	12	6.00
Coaching's influence	58	29.00	59	29.50	83	41.50
Better career scope	167	83.50	26	13.00	7	3.50
High earnings expectations	119	59.50	61	30.50	20	10.00
Social status offered by career	104	52.00	73	36.50	23	11.50

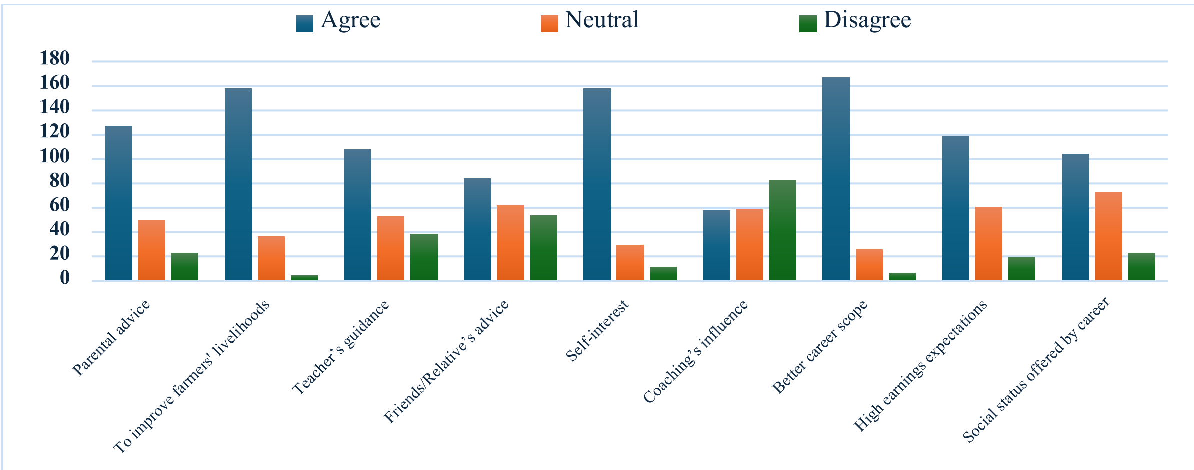

Fig. 1. Factors behind student's choice Agriculture as a career option

Conclusion:

The present study provides valuable insights into the factors influencing students' decisions to pursue agriculture as their field of study in Rajasthan. The findings indicate that career opportunities, personal interest, and the aspiration to improve farmers' livelihoods are the most significant motivations guiding students toward agricultural education. Parental encouragement and expectations of financial stability also play important roles. The results of this study highlight the need for educational institutions and policymakers to focus on strengthening agricultural education and promoting career opportunities in the sector. Furthermore, improving employment opportunities, supporting agricultural startups, and encouraging innovation can enhance the attractiveness of agricultural careers for young graduates. Government agencies, research institutions, and private organizations should collaborate to create a supportive environment that encourages youth participation in agriculture.

SCAN QR FOR MORE

(A No. 185) Scientific Harvesting and Post-Harvest Operations for Quality Maize Production

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ABSTRACT

Harvesting is an important stage in maize (Zea mays L.) production which directly affects grain quality and yield so that profitability and better industrial utilization can be maximized. Understanding the proper harvesting time and handling techniques can reduce losses, maintain nutritional value and ensure market requirements.

Harvesting is an important stage in maize (Zea mays L.) production which directly affects grain quality and yield so that profitability and better industrial utilization can be maximized. Understanding the proper harvesting time and handling techniques can reduce losses, maintain nutritional value and ensure market requirements.

Physiological Maturity in Maize: When to Harvest

Maize reaches physiological maturity when the grains attain their maximum dry weight, but the moisture content does not reach safe storage level.

Key Indicators of Maturity:

- **Black Layer Formation:**

  A black layer forms at the base of each kernel, which indicates the stoppage of nutrient flow from cob to kernels. When the husk dries at this stage, the cob can be harvested.

- **Kernel Hardness:**

  Kernels become hard, firm and dented (for dent corn) or smooth (for flint corn types). Generally, it takes 10–20 days after black layer formation depending on season.

- **Moisture Content:**

  Harvesting is optimum when grain moisture content is between 20–25%. Shelling as seed should be done below 17% moisture. However, for safe storage, moisture should be reduced to 12–14%, which is measured by moisture meter.

Key Considerations for Mechanical Harvesting

- **Combine Adjustment:** Ensure proper speed and header height to avoid grain damage

- **Harvest Timing:** Avoid harvesting during rain or high humidity; grain moisture should be 15–18% and plant should have strength to avoid shattering losses

Post-Harvest Handling and Drying

After shelling, grain moisture is still high and not safe for storage, therefore proper handling is necessary:

- Avoid making heaps before drying
- Reduce moisture to 12–14% to prevent fungal growth and aflatoxin
- **Natural Drying:** Dry cobs for 1–2 weeks with husk under sunlight
- **Artificial Drying:** Use dryers for uniform drying
- Drying temperature should not exceed 43°C
- Shelling can be done manually or mechanically

Storage Management

- Maintain temperature below 15°C and humidity below 65%

- Use silos or hermetic storage bags
- Regular inspection for insects and rodents
- Use neem leaves or fumigation (methyl bromide 680–900 g/acre)
- **Maize Harvesting Methods**

Method	Description	Advantages	Disadvantages
Manual Harvesting	Hand picking of cobs; whole plant can also be cut	Low cost, selective harvesting	Labour intensive, time consuming
Mechanical Harvesting	Use of combine harvester	Faster, reduces labour cost	High initial investment, grain damage risk
Cob Picker	Picking with or without husk	Same	Requires training & investment
Reaper	Whole plant cutting	Same	Requires space for drying

Best Practices to Reduce Post-Harvest Losses

- Harvest at correct time
- Dry grains properly after harvesting
- Regular monitoring of storage
- Apply integrated pest management

Important Measures for Quality Maize Production

- Avoid stress through proper irrigation and drainage
- Dry grains below 14% moisture
- Top cutting after maturity
- Maintain aeration in storage
- Pre-harvest application of Atoxigenic isolate A. flavus
- Manage pests and weeds
- Proper nutrient management
- Avoid late sowing
- Follow crop rotation
- Avoid mechanical damage
- Avoid heaping of cobs/grains

Aflatoxin Management in Maize

Background

Aflatoxin is a major quality issue in maize used for food, starch, DDGS and feed. It is more severe in kharif season due to low temperature during harvesting in Northern and Central India. Uneven crop growth, immature cobs and damage increase contamination, which further increases due to high moisture and poor post-harvest management.

Factors for Aflatoxin Contamination

- High humidity and erratic rainfall
- Water stress, pest damage, nutrient deficiency
- Improper agronomic practices
- Moisture above 13%
- Poor storage conditions

Integrated Aflatoxin Management

Crop Management

- Use resistant varieties
- Select tight husk varieties
- Avoid late sowing
- Maintain proper irrigation and drainage
- Weed and pest management
- Balanced fertilization
- Crop rotation
- De-topping and de-husking
- Use of atoxigenic strains (10 kg/ha at knee high stage)

(A No. 186) Soil Health Card in India: Transforming Agriculture from the Ground Up

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ABSTRACT

Soil is the foundation of agriculture and the lifeblood of every farmer's livelihood. In India, where agriculture supports almost half of the population and contributes significantly to India's economy, ensuring soil fertility is critical to sustainable food production, rural prosperity, and environmental welfare. Yet decades of continuous cropping, excessive use of chemical fertilizers, monoculture practices, and mismanagement have degraded soil health across vast swathes of farmland. To counter this, the Government of India launched the **Soil Health Card (SHC) Scheme** in **February 2015** as a flagship initiative aimed at scientifically monitoring and improving soil quality.

The Soil Health Card is more than a simple record - it is a **data-driven tool** that provides farmers with detailed information on the nutrient status of their soil and tailored recommendations on fertiliser use, bio-fertilisers, organic amendments, and soil corrective measures. Over nearly a decade since its launch, the SHC scheme has become one of India's most ambitious agricultural reforms, issuing **tens of crores of cards, strengthening soil testing infrastructure, and promoting balanced nutrient management** across the country.

What is the Soil Health Card?

A **Soil Health Card** is a personalized document provided to farmers that shows:

- The **nutrient levels** of their soil - including macro-nutrients such as **Nitrogen (N), Phosphorus (P), Potassium (K)** and sulphur, as well as essential **micro-nutrients** like zinc, iron, copper, manganese and boron;
- **Soil pH, electrical conductivity and organic carbon content**;
- Recommendations on the **type and amount of fertiliser** to be applied;
- Advice on organic inputs, bio-fertilisers, and soil amendment requirements to improve productivity and long-term soil health.

Soil testing is conducted through a vast network of **static, mobile and mini soil testing laboratories** spread across states, which collect and analyse soil samples, and generate the SHC - valid typically for **three years**.

The Government has also developed **digital infrastructure** such as the **Soil Health Card Portal and mobile app**, with QR codes that allow farmers to access their SHC online in **multiple languages**, making it easier to interpret the results and act on recommendations.

Objectives of the Soil Health Card Scheme

The SHC scheme aims to:

1. **Provide farmers with soil nutrient status** and specific fertiliser

recommendations based on scientific testing;

2. Promote **balanced and efficient fertiliser use**, reducing dependency on excessive chemical fertilisers;
3. Strengthen soil testing infrastructure and lab capacity at district and village levels;
4. **Improve crop yields** and overall farm productivity;
5. **Enhance soil fertility** and sustainability of agriculture over the long term;
6. Support **eco-friendly farming** by encouraging organic and integrated nutrient management practices.

These goals reflect a shift from blanket, one-size-fits-all fertiliser application to **site-specific nutrient management**, which can address soil nutrient imbalances and boost agricultural efficiency.

Implementation and Progress

Since its inception in 2015, the Soil Health Card scheme has seen **remarkable expansion**:

- By **2025**, the Government reported having distributed **over 25 crore Soil Health Cards** to farmers across India.
- More than **8,200 soil testing labs** - including static, mobile, mini and village-level facilities - have been established nationwide to ensure timely soil testing and card generation.
- Integration with the **Rashtriya Krishi Vikas Yojana (RKVY)** has strengthened funding, digitization, and monitoring of soil health activities as part of holistic agricultural development.
- Advanced technologies like **GIS-based soil mapping** and **mobile testing units** have enhanced coverage and data quality.

The Government continues to emphasize outreach through digital platforms, extension services, and collaboration with state agriculture departments to ensure timely soil analysis and broad adoption of recommendations.

Impact on Farmers and Agricultural Practices

1. Balanced Fertiliser Use and Cost Savings

One of the most direct impacts of Soil Health Cards is the **shift from excessive fertiliser use to balanced application** based on scientific recommendations. Multiple studies and government data show that:

- Farmers following SHC guidance reduce the use of expensive chemical fertilisers like urea, and instead apply only what the soil needs. This has led to **reduced input costs**.
- The National Productivity Council reported an **8-10% reduction in chemical fertiliser use** as a result of SHC adoption in some regions.

By lowering unnecessary fertiliser expenditure, farmers can improve **profit margins**, particularly for small and marginal farmers who are most sensitive to input cost fluctuations.

2. Increased Crop Productivity and Efficiency

Balanced nutrient management enhances soil fertility and crop yields. Field data and research have highlighted:

- Studies showing that adoption of SHC recommendations can increase yields significantly - for instance, increases of **5-25% in tested areas**.
- A research study in Uttar Pradesh found that farmers who implemented SHC recommendations saw notable increases in yields of wheat, paddy and sugarcane, while also reducing production costs.

Improved yields mean higher production volumes and potential increases in income, contributing to rural livelihoods and food security.

3. Environmental Sustainability

Soil Health Cards contribute to **environmentally sustainable agriculture** by:

- Reducing **nutrient runoff** and groundwater contamination linked to overuse of fertilisers;
- Promoting the use of **organic inputs** and bio-fertilisers to improve soil organic matter and microbial activity;
- Encouraging farmers to adopt practices that **restore soil health over the long term**.

Balanced use of fertilisers also helps mitigate **greenhouse gas emissions** from agricultural soils and reduces the negative impacts of nutrient pollution in water bodies.

4. Improved Awareness and Scientific Farming

The SHC scheme has played a key role in **educating farmers** about soil health, nutrient dynamics, and the importance of site-specific nutrient management. The adoption of digital tools and language-friendly cards has improved farmers' understanding and engagement.

Moreover, extension efforts through agronomy workshops, village campaigns and agriculture helplines help farmers interpret card recommendations and integrate them into crop planning decisions.

Challenges Facing the Scheme

Despite its successes, the Soil Health Card initiative faces several persistent challenges:

1. Awareness and Comprehension Gap

Not all farmers fully understand how to interpret SHC results or apply the guidelines effectively. Research shows that **farmer comprehension of older card formats was low**, and only improved significantly after redesigns and outreach efforts.

Limited awareness limits the scheme's potential to influence farming behaviour across all regions.

2. Infrastructure Limitations

Although thousands of labs exist, **coverage gaps remain**, especially in remote rural areas:

- Soil sample collection and timely testing can be inconsistent due to **staff shortages, logistical constraints or lack of transport**.
- Some labs struggle with outdated equipment or insufficient technical capacity to process large volumes of samples with high precision.

These gaps result in delays in issuing cards - often arriving after key sowing seasons, reducing their practical utility.

3. Scope of Testing

Currently, the SHC scheme focuses on **12 chemical parameters**, which provides valuable nutrient data but may not fully reflect other critical soil health aspects, such as **physical structure or biological properties** (like soil microbial activity). Experts suggest broadening the range of indicators to gain a more holistic understanding of soil health.

4. Implementation Variability Across Regions

In some areas, soil sampling methods and data quality may vary, leading to **generic or one-size-fits-all advice** rather than precise, location-specific guidance. Strengthening standard operating procedures and quality control measures remains essential.

The Way Forward

To increase the Soil Health Card scheme's effectiveness and benefit more farmers, several steps can be taken:

1. Expand Monitoring Parameters

Incorporate **physical and biological indicators** like soil texture, bulk density, water retention, microbial biomass, and enzyme activity to complement chemical analysis and provide a comprehensive soil assessment.

2. Enhance Infrastructure and Capacity

Invest further in soil testing laboratories, mobile units, digital systems, and skilled personnel - especially in hard-to-reach rural pockets - to ensure timely and accurate testing.

3. Strengthen Farmer Engagement and Training

Continuous farmer education through **workshops, field demonstrations, mobile advisories, and community extension programs** can improve comprehension and adoption of SHC recommendations, enabling farmers to make better nutrient management decisions.

4. Tailored Recommendations and Crop Planning Support

Develop more **crop-specific and field-specific guidance** that considers crop rotation patterns, rainfall variability, and soil type diversity to make SHC prescriptions more actionable for farmers.

5. Encourage Organic and Integrated Practices

Promote **bio-fertilizers, green manures, composting and cover cropping** as part of soil care strategies to enhance organic carbon and structural health, besides chemical nutrient balance.

Conclusion

The Soil Health Card scheme represents a **milestone in India's agricultural reforms** - a scientific, data-driven approach that empowers farmers with knowledge about their soil, fosters balanced fertiliser use, enhances productivity, cuts input costs, and promotes sustainability. With over **25 crore cards issued nationwide and ongoing innovations in digital delivery**, it continues to reshape the way Indian agriculture views and manages soil fertility.

However, its long-term success depends on addressing implementation bottlenecks, expanding soil health parameters, strengthening lab infrastructure, bridging the awareness gap, and integrating SHC insights into broader cropping and farm management decisions. As soil health improves, the potential for **higher farm incomes, sustainable land use and resilient agricultural systems** also grows - making the Soil Health Card scheme a cornerstone of India's journey toward sustainable, scientific, and prosperous farming.

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SCAN QR FOR MORE

(A No. 187) Silicon: A Powerful Tool for Enhancing Productivity and Resilience in Organic Farming Systems

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ABSTRACT

Organic farming has gained global importance as a sustainable agricultural system that aims to maintain soil fertility, environmental health and food safety without excessive reliance on synthetic inputs. However, crop productivity in organic farming systems is often challenged by nutrient limitations and increased susceptibility to environmental stresses. In this context, silicon (Si), commonly referred to as silica in agricultural practices, has emerged as a beneficial element that significantly improves plant growth, productivity and stress tolerance. Although silicon is not classified as an essential nutrient for plants, numerous studies have demonstrated its vital role in strengthening plant tissues, improving physiological efficiency and enhancing plant resistance against biotic and abiotic stresses.

Silicon is absorbed by plants mainly in the form of monosilicic acid from the soil solution and is subsequently deposited in plant tissues as amorphous silica. This deposition enhances mechanical strength, improves water use efficiency and activates several plant defense mechanisms. In organic farming systems, the use of silica through natural sources such as crop residues, compost and mineral amendments can improve soil health, nutrient availability and crop productivity. Therefore, integrating silica management strategies into organic farming practices offers a promising approach to achieving sustainable and resilient agricultural production systems.

Sustainable agriculture has become a global priority due to increasing concerns over soil degradation, climate change and environmental pollution caused by excessive use of chemical fertilizers and pesticides. Organic farming has emerged as an environmentally friendly agricultural system that emphasizes ecological balance, biodiversity conservation and sustainable crop production. Despite its numerous advantages, organic farming often faces limitations in maintaining high crop productivity and plant health because synthetic agrochemicals are either restricted or completely prohibited. Therefore, identifying natural alternatives that can enhance plant growth and improve stress tolerance is essential for the success of organic farming systems.

Silicon has recently attracted significant attention in agricultural research because of its remarkable beneficial effects on plant growth and development. Silicon is the second most abundant element in the Earth's crust, accounting for nearly 27% of the total crustal composition. However, only a small fraction of this silicon is present in a soluble form that can be absorbed by plants. Plants primarily take up silicon from the soil in the form of monosilicic acid (H_4SiO_4). Once absorbed, silicon is transported through the plant vascular system and eventually deposited in various plant tissues. These silica deposits strengthen plant cell walls, improve plant rigidity, and provide protection against environmental stresses.

In organic farming systems, where maintaining plant health through natural means is essential, silica plays a critical role in improving crop performance, enhancing nutrient use efficiency and increasing resistance to both biotic and abiotic stresses.

Natural Sources of Silica in Organic Farming

Silicon occurs naturally in soils but is mostly present in insoluble forms that are not readily available to plants. Therefore, supplying additional sources of plant available silica becomes important in organic farming systems.

Several natural materials used in organic agriculture contain significant amounts of silica. Among these, rice husk ash is considered one of the richest sources of silica. Rice husk contains approximately 15-20 percent silica, which becomes more available to plants when the husk is burned and converted into ash.

Similarly, crop residues such as wheat straw, bamboo leaves and sugarcane bagasse also contain considerable quantities of silica. When these residues decompose in soil, they gradually release soluble silicon that can be absorbed by plants. Another promising approach for enhancing silicon availability in organic farming systems is the use of silicon solubilizing microorganisms. Certain bacteria and fungi are capable of dissolving insoluble silicate minerals through the production of organic acids. These microorganisms convert unavailable forms of silicon into soluble forms, thereby increasing silicon availability in the rhizosphere.

Mechanism of Silicon Uptake and Deposition in Plants

Plants absorb silicon primarily through their root systems in the form of monosilicic acid present in the soil solution. The uptake process is facilitated by specialized silicon transport proteins located in the root cell membranes. After absorption, silicon is transported through the xylem along with water to different plant parts such as leaves, stems and reproductive organs. During transpiration, the soluble silicon gradually polymerizes and forms silica gel, which is deposited in plant tissues. These silica deposits accumulate mainly in epidermal cells, cell walls and intercellular spaces. The presence of silica in plant tissues enhances mechanical strength, improves leaf erectness, and reduces lodging in many crops.

The improved structural strength of plants allows them to maintain optimal leaf orientation, which enhances light interception and photosynthetic efficiency. As a result, plants treated with silica often show better growth and higher biomass production.

Role of Silica in Enhancing Plant Growth and Development

Silicon plays an important role in promoting plant growth and development through multiple physiological and biochemical processes. One of the major benefits of silica application is the improvement in plant height and vegetative growth. Silicon deposition strengthens plant tissues and enhances structural stability, allowing plants to grow more vigorously. Silicon also contributes to improved photosynthesis by increasing chlorophyll content and maintaining better leaf structure. Leaves treated with silica remain more erect, which improves light interception and enhances photosynthetic activity. In addition, silicon stimulates root development and improves root architecture. A well-developed root system enables plants to absorb water and nutrients more efficiently, which ultimately contributes to improved plant growth and biomass accumulation.

Role of Silica in Abiotic Stress Tolerance

Abiotic stresses such as drought, salinity, extreme temperatures and heavy metal toxicity significantly reduce crop productivity in many agricultural regions. Silicon has been shown to enhance plant tolerance to these environmental stresses through various physiological mechanisms. Under drought conditions, silicon improves water use efficiency by reducing excessive transpiration and maintaining better leaf water status. Silicon also enhances the activity of antioxidant enzymes that protect plant cells from oxidative damage caused by water deficit. In saline soils, excessive accumulation of sodium ions can disrupt plant metabolic processes and inhibit growth. Silicon helps mitigate salinity stress by regulating ion balance within plant cells and reducing sodium uptake. Silicon also plays an important role in protecting plants against heavy metal toxicity. It forms stable complexes with toxic metals such as cadmium and aluminum, thereby reducing their uptake and accumulation in plant tissues.

Role of Silica in Plant Defense Against Pests and Diseases

One of the most remarkable benefits of silica in agriculture is its ability to enhance plant resistance against pests and diseases. Silica deposited in plant tissues acts as a physical barrier that makes it more difficult for pathogens and insect pests to penetrate plant surfaces. This protective layer reduces the susceptibility of plants to fungal infections and insect attacks. In addition to this mechanical protection, silicon also activates several plant defense mechanisms. It stimulates the production of phenolic compounds, lignin and phytoalexins, which are important components of the plant immune system. Silicon-treated plants often exhibit increased activity of defense-related enzymes such as peroxidase, polyphenol oxidase and chitinase. These enzymes play a crucial role in suppressing pathogen growth and preventing disease development.

Impact of Silica on Soil Health and Nutrient Availability

Soil health is a fundamental component of successful organic farming systems. Silicon plays a significant role in improving soil physical, chemical and biological properties. Silicon contributes to improved soil structure by promoting soil aggregation and porosity. Improved soil structure enhances water infiltration, aeration and root penetration. Silicon also influences the availability and uptake of essential nutrients such as phosphorus, nitrogen and potassium. In some soils, silicon can reduce phosphorus fixation, thereby increasing its availability for plant uptake. Furthermore, silica amendments stimulate beneficial soil microorganisms that are involved in nutrient cycling and organic matter decomposition. These microbial processes are essential for maintaining soil fertility in organic farming systems.

Effect of Silica on Crop Yield and Quality

Numerous scientific studies have demonstrated that silica application significantly improves crop yield and quality. In cereal crops such as rice, wheat and maize, silicon strengthens plant stems and reduces lodging, which allows plants to maintain upright growth and utilize sunlight more efficiently. Silicon also improves nutrient use efficiency and enhances biomass production, leading to higher grain yield and better crop performance. In horticultural crops, silica application has been reported to improve fruit firmness, shelf life and resistance to post-harvest diseases. These improvements contribute to better market quality and reduced post-harvest losses.

Silicon has emerged as a powerful and sustainable tool for improving crop productivity and resilience in organic farming systems. Although it is not classified as an essential plant nutrient, its beneficial effects on plant growth, stress tolerance and soil health make it an important component of sustainable agriculture. Silicon strengthens plant tissues, enhances photosynthetic efficiency, improves nutrient uptake and increases resistance against pests and diseases. In organic farming systems, the use of natural silica sources such as crop residues, compost and silicate minerals can significantly improve soil fertility and crop performance. Therefore, integrating silica management into organic farming practices offers a promising strategy for achieving sustainable agricultural production while maintaining environmental balance.

(A No. 188) An Analysis of Technology's Potential to Increase Agricultural Productivity

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ABSTRACT

Traditional farming methods have been transformed by the incorporation of technology, which has created new opportunities to improve sustainability, productivity, and efficiency. This study explores how technological innovations, including digital tools, mechanization, precision farming, and data-driven decision-making, can increase agricultural productivity in a variety of farming systems. By examining case studies and empirical data, the research highlights how innovations like GPS-enabled equipment, sensor-based irrigation, mobile advisory platforms, and biotechnology have contributed to optimized resource use, reduced labor dependency, and increased crop yields. The findings reveal that while technology adoption has led to significant gains in productivity, challenges such as affordability, digital literacy, and infrastructure gaps continue to hinder widespread implementation, especially among smallholder farmers. In order to close the digital divide and fully utilize agricultural technology, the paper's conclusion emphasizes the significance of inclusive policy frameworks, capacity-building programs, and cooperative efforts.

Agriculture is the backbone of India's economy, employing millions and ensuring food security for a vast population. Yet, the sector faces persistent challenges: fragmented landholdings, climate variability, post-harvest losses, and limited access to modern infrastructure. In this context, technological innovation has emerged as a critical driver of transformation. From mechanized equipment to mobile-based advisory services, technology is reshaping farming practices, enhancing productivity, and improving profitability. This article examines how innovations such as precision farming, data-driven tools, and digital platforms are influencing agricultural outcomes, while also highlighting barriers to adoption and the need for inclusive policy support.

Technological Innovations in Agriculture

Data-Driven Decision-Making Tools

Modern agriculture increasingly relies on analytics and digital platforms to guide decisions. Soil sensors, weather forecasting models, and crop monitoring apps provide farmers with real-time insights. These tools reduce uncertainty, allowing farmers to choose optimal sowing dates, irrigation schedules, and fertilizer application. In regions like Karnataka, data-driven advisories have helped farmers increase yields by aligning crop cycles with rainfall patterns.

Mobile-Based Advisory Services

Mobile technology has bridged the gap between farmers and extension services. Apps such as *Kisan Suvidha* and *IFFCO Kisan* deliver localized information on weather, pest management, and market prices. Farmers in Maharashtra have reported significant reductions in crop losses after adopting mobile advisories that alerted them to pest outbreaks. These services empower smallholders who traditionally lacked access to timely guidance.

Mechanized Equipment

Mechanization reduces labor dependency and enhances efficiency. Tractors, harvesters, and seed drills enable faster operations, minimizing delays during critical stages of cultivation. In Uttar Pradesh, mechanized harvesting has reduced post-harvest losses in wheat, ensuring better quality grain and higher incomes. Mechanization also addresses labor shortages, which have become more pronounced due to rural-urban migration.

Precision Farming

Precision farming integrates GPS, drones, and sensor technologies to optimize resource use. Farmers can monitor soil moisture, nutrient levels, and crop health with accuracy. In Punjab, precision irrigation has reduced water consumption by nearly 25 percent while maintaining high yields. By minimizing fertilizer and pesticide use, precision farming contributes to environmental sustainability and cost savings.

Impact on Productivity and Profitability

Crop Yield Improvements

Technological interventions have consistently demonstrated yield gains. Hybrid seeds, precision inputs, and timely advisories ensure healthier crops. Studies show that farmers using precision farming techniques achieve 15–20 percent higher yields compared to traditional practices.

Resource Efficiency

Water, fertilizer, and energy are scarce resources in Indian agriculture. Technologies such as drip irrigation, solar pumps, and sensor-based monitoring systems ensure optimal utilization. This not only reduces costs but also conserves natural resources, aligning with sustainability goals.

Income Generation

Digital platforms have expanded market access. Farmers can now sell produce directly to buyers through e-commerce channels, bypassing intermediaries. In Andhra Pradesh, farmers using digital marketplaces reported income increases of up to 30 percent. Mechanization and reduced post-harvest losses further contribute to profitability.

Reduced Labor Dependency

Mechanized equipment and automation reduce reliance on manual labor. This is particularly important in regions facing labor shortages. Farmers benefit from timely operations, reduced drudgery, and improved efficiency.

Barriers to Adoption

Despite the benefits, several challenges hinder widespread adoption of technology:

- **Financial Constraints:** Smallholder farmers often lack the capital to invest in advanced equipment or digital tools.
- **Digital Literacy:** Limited familiarity with smartphones and apps restricts the use of mobile advisories.
- **Infrastructure Gaps:** Poor connectivity, inadequate storage facilities, and unreliable electricity limit technology penetration.
- **Socio-Economic Disparities:** Marginalized farmers, especially women and landless laborers, face greater barriers to accessing innovations.

Policy Recommendations

To maximize the benefits of technology in agriculture, the following strategies are essential:

1. **Focused Policy Support:** Subsidies and credit schemes should prioritize smallholders, enabling them to access modern tools.
2. **Farmer Education:** Training programs and digital literacy initiatives can empower farmers to adopt and utilize technology effectively.
3. **Inclusive Innovation Strategies:** Technologies must be tailored to diverse agro-climatic zones and socio-economic contexts.
4. **Infrastructure Development:** Investments in rural connectivity, cold storage, and renewable energy are critical for scaling innovations.
5. **Public-Private Partnerships:** Collaboration between government agencies, agritech startups, and farmer cooperatives can accelerate adoption.

Conclusion

Technology holds immense potential to transform Indian agriculture by increasing productivity, profitability, and sustainability. Data-driven tools, mobile advisories, mechanization, and precision farming have already demonstrated significant benefits in crop yields, resource efficiency, and income generation. However, barriers such as financial limitations, digital illiteracy, and infrastructural gaps must be addressed to ensure inclusive growth. With focused policy support, farmer education, and collaborative innovation strategies, India can harness technology to secure long-term economic sustainability for its farming communities. The future of agriculture lies not only in adopting technology but in ensuring that every farmer, regardless of scale or background, can benefit from its promise.

(A No. 189) Precision Agriculture: A Route to Long-Term Agricultural Growth

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ABSTRACT

Utilizing cutting-edge technologies to maximize resource utilization and improve sustainability, precision farming is a revolutionary approach to agriculture. This study explores how tools such as Geographic Information Systems (GIS), Global Positioning Systems (GPS), remote sensing, variable rate technology (VRT), and sensor-based monitoring contribute to site-specific crop management. By enabling farmers to make data-driven decisions, precision farming minimizes input waste, improves soil health, and boosts crop yields while reducing environmental impact. The study presents effective case studies that show improved ecological resilience and profitability in a variety of agroclimatic zones. Despite its potential, widespread adoption faces challenges including high initial investment, technical skill gaps, and limited infrastructure in rural areas. The article's conclusion highlights the necessity of cooperative innovation, farmer training initiatives, and supportive policies in order to fully utilize precision agriculture in accomplishing sustainable development objectives.

Agriculture in India is at a crossroads. With rising population pressures, climate variability, and resource constraints, traditional farming practices often struggle to deliver sustainable productivity. Precision agriculture offers a revolutionary approach by integrating cutting-edge technologies such as Geographic Information Systems (GIS), Global Positioning Systems (GPS), remote sensing, variable rate technology (VRT), and sensor-based monitoring. These tools enable site-specific crop management, allowing farmers to optimize inputs, improve soil health, and enhance yields while reducing environmental impact. This article explores the role of precision agriculture in promoting sustainability, its impact across agro-climatic zones, barriers to adoption, and strategies for inclusive growth.

Core Technologies in Precision Agriculture

Geographic Information Systems (GIS)

GIS provides spatial data on soil types, land use, and crop distribution. Farmers can map their fields, identify variability, and plan input application accordingly. In states like Madhya Pradesh, GIS-based soil mapping has guided fertilizer use, reducing costs and improving nutrient efficiency.

Global Positioning Systems (GPS)

GPS technology enables accurate field navigation and machinery guidance. Farmers can apply seeds, fertilizers, and pesticides with precision, minimizing overlap and wastage. GPS-enabled tractors have been successfully deployed in Punjab, ensuring uniform sowing and reducing fuel consumption.

Remote Sensing

Satellite imagery and drones provide real-time data on crop health, pest infestations, and water stress. Remote sensing has proven particularly useful in drought-prone regions, where early detection of stress allows timely interventions. ISRO's satellite-based crop monitoring programs have supported both farmers and policymakers in anticipating production trends.

Variable Rate Technology (VRT)

VRT allows farmers to apply inputs such as fertilizers and pesticides at variable rates depending on field conditions. This reduces overuse, improves soil health, and enhances productivity. In Tamil Nadu, VRT adoption has led to significant reductions in fertilizer costs while maintaining high yields.

Sensor-Based Monitoring

Soil and crop sensors provide continuous data on moisture, nutrient levels, and plant growth. Farmers can adjust irrigation and fertilization schedules based on sensor feedback. In Gujarat, sensor-based irrigation systems have reduced water usage by nearly 25 percent, contributing to sustainability.

Impact of Precision Agriculture

Optimized Resource Utilization

Precision farming ensures efficient use of water, fertilizers, and energy. By applying inputs only where needed, farmers reduce wastage and conserve resources. This aligns with India's sustainability goals and helps mitigate environmental degradation.

Improved Soil Health

Balanced input application prevents nutrient depletion and chemical buildup. Precision agriculture promotes long-term soil fertility, ensuring sustainable productivity. Case studies from Andhra Pradesh show that precision nutrient management has improved soil organic matter levels.

Enhanced Crop Yields

Data-driven decisions and targeted interventions result in healthier crops and higher yields. Farmers using precision technologies have reported yield increases of 15–20 percent compared to conventional practices.

Reduced Environmental Impact

Precision farming minimizes chemical runoff, reduces greenhouse gas emissions, and conserves biodiversity. By lowering pesticide use, it also protects pollinators and beneficial organisms.

Economic Profitability

Beyond sustainability, precision agriculture enhances profitability. Reduced input costs, higher yields, and better resource efficiency translate into improved farmer incomes. In Karnataka, precision irrigation systems have boosted profits by lowering water and energy expenses.

Barriers to Adoption

Despite its potential, precision agriculture faces several challenges in India:

- High Initial Investment: Advanced equipment and technologies require significant capital, which smallholder farmers often lack.
- Technical Skill Gaps: Farmers need training to operate GPS systems, sensors, and data analytics tools.
- Infrastructure Limitations: Poor connectivity, unreliable electricity, and inadequate storage facilities hinder adoption.
- Socio-Economic Disparities: Marginalized farmers, especially women and landless laborers, face greater barriers to accessing precision technologies.

Policy Recommendations

To fully harness the potential of precision agriculture, the following strategies are essential:

1. Cooperative Innovation: Farmer Producer Organizations (FPOs) can pool resources and collectively adopt precision technologies.
2. Farmer Training Initiatives: Capacity-building programs and digital literacy campaigns can bridge skill gaps.
3. Supportive Policies: Subsidies, credit schemes, and targeted government programs should prioritize smallholder farmers.
4. Infrastructure Development: Investments in rural connectivity, renewable energy, and cold storage are critical for scaling precision agriculture.
5. Public-Private Partnerships: Collaboration between government agencies, agritech startups, and research institutions can accelerate innovation.

Conclusion

Precision agriculture represents a transformative pathway toward long-term agricultural growth in India. By integrating GIS, GPS, remote sensing, VRT, and sensor-based monitoring, farmers can optimize resource use, improve soil health, and enhance productivity while reducing environmental impact. Case studies across diverse agro-climatic zones demonstrate its potential to strengthen ecological resilience and profitability. However, widespread adoption requires overcoming barriers of cost, skill, and infrastructure. With cooperative innovation, farmer training, and supportive policies, precision agriculture can play a pivotal role in achieving sustainable development objectives and ensuring food security for future generations.

(A No. 190) Integrated Farming System: A Sustainable Approach to Agricultural Development

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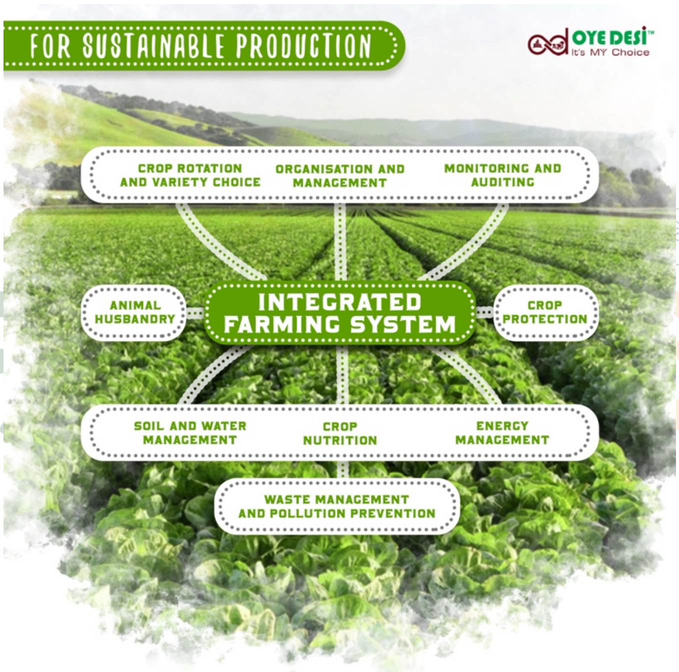
ABSTRACT

Indian agriculture faces multiple challenges such as small and fragmented landholdings, declining soil fertility, rising input costs, climate variability, and unstable farm incomes. Traditional farming practices that rely on a single crop or enterprise often fail to provide economic stability and resilience to farmers. In this context, the **Integrated Farming System (IFS)** has emerged as a promising approach for achieving **sustainable, profitable, and resource-efficient agriculture**.

An Integrated Farming System involves the **judicious integration of various agricultural enterprises** such as crops, livestock, fisheries, poultry, agroforestry, and allied activities on a single farm. The waste or by-products of one component are used as inputs for another, thereby maximizing resource use efficiency and minimizing external inputs. IFS is particularly suitable for small and marginal farmers, who constitute the majority of Indian farming households.



Concept of Integrated Farming System

The Integrated Farming System is a **holistic and multidisciplinary approach** to farming, where different farm enterprises are interlinked to support one another. Unlike monocropping systems, IFS focuses on **diversification, recycling, and synergy** among farm components.

For example, crop residues can be used as fodder for livestock, animal dung can be converted into compost or biogas, and nutrient-rich pond water can be used for irrigating crops. This integration reduces waste, lowers production costs, and enhances overall farm productivity.

Objectives of Integrated Farming System

The main objectives of IFS include:

1. Increasing **farm income** through diversification
2. Ensuring **year-round employment** for farm families
3. Improving **soil fertility and environmental sustainability**
4. Reducing dependence on external inputs
5. Enhancing **nutritional security**
6. Building **climate resilience** in agriculture

These objectives align closely with national goals of sustainable development and doubling farmers' income.

Components of Integrated Farming System

1. Crop Production

Crop cultivation remains the central component of IFS. Cereals, pulses, oilseeds, vegetables, fruits, and fodder crops are grown in a planned manner.

Crop diversification and crop rotation improve soil health, reduce pest incidence, and stabilize income.

2. Livestock Component

Livestock such as cattle, buffaloes, goats, sheep, and pigs play a vital role in IFS. They provide milk, meat, manure, and draught power. Animal dung is a valuable resource for preparing **farmyard manure, vermicompost, and biogas**, which reduce the need for chemical fertilizers.

3. Poultry and Duck Farming

Poultry and duck farming require low investment and provide quick returns. Poultry droppings are rich in nutrients and can be used directly in fish ponds or compost pits, enhancing nutrient recycling within the system.

4. Fisheries

Fish farming can be integrated with crop and livestock systems, especially in areas with water availability. Fish ponds utilize farm waste efficiently, and pond silt serves as a nutrient-rich fertilizer for crops.

5. Agroforestry and Horticulture

Trees, fruit crops, and vegetables provide additional income, improve microclimate, reduce soil erosion, and increase carbon sequestration. Agroforestry also supplies fuelwood, fodder, and timber.

Resource Recycling in IFS

A defining feature of IFS is **efficient recycling of resources**. Examples include:

- Crop residues → livestock feed
- Livestock waste → compost/biogas → crop nutrients
- Poultry droppings → fish feed
- Pond water → crop irrigation

This closed-loop system enhances productivity while reducing environmental pollution and input costs.

Benefits of Integrated Farming System

1. Enhanced Farm Income

IFS provides income from multiple sources, reducing the risk of crop failure. Studies show that integrated farms earn **30–50% higher income** compared to monocropping systems.

2. Employment Generation

By engaging family labor in different enterprises throughout the year, IFS ensures **continuous employment**, reducing rural migration.

3. Improved Soil Health

Organic manure and crop residues enhance soil organic matter, microbial activity, and nutrient availability, leading to sustainable soil productivity.

4. Environmental Sustainability

IFS minimizes waste, reduces chemical input use, and promotes biodiversity. It helps in conserving water, soil, and energy resources.

5. Nutritional Security

Integrated systems provide diverse food products such as cereals, pulses, vegetables, fruits, milk, eggs, and fish, improving household nutrition.

IFS and Climate Resilience

IFS enhances resilience against climate change by diversifying income sources and reducing dependency on a single crop. In case of drought, livestock or horticulture may sustain income, while crop residues support animals during fodder scarcity.

Government Support and Promotion

The Government of India promotes IFS through various schemes:

- National Mission on Sustainable Agriculture (NMSA)
- Rashtriya Krishi Vikas Yojana (RKVY)
- Krishi Vigyan Kendras (KVKs)
- Natural and Organic Farming Missions

Demonstration farms and training programs help farmers adopt IFS models suitable to their region.

Challenges in Adoption

Despite its advantages, IFS faces challenges such as:

- Initial capital investment
- Lack of technical knowledge
- Limited access to credit and markets
- Small land size constraints

Addressing these issues through policy support and extension services is essential.

Way Forward

To promote IFS adoption:

- Strengthen farmer training and capacity building
- Provide financial incentives and credit support
- Develop region-specific IFS models
- Promote market linkages and value addition

Conclusion

The Integrated Farming System represents a **sustainable and inclusive pathway for agricultural development** in India. By integrating crops, livestock, fisheries, and allied enterprises, IFS enhances income, employment, soil health, and environmental sustainability. For small and marginal farmers facing economic and climatic uncertainties, IFS offers a practical solution for achieving resilience and prosperity. Widespread adoption of Integrated Farming Systems can play a crucial role in transforming Indian agriculture into a **productive, sustainable, and farmer-friendly sector**.

(A No. 191) A Study of Farmer Awareness and Utilization of ICT Tools in Agriculture

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ABSTRACT

By facilitating timely information access, enhancing decision-making, and simplifying farm operations, information and communication technology (ICT) tools are increasingly influencing agriculture's future. With an emphasis on mobile phones, internet platforms, radio, television, and agricultural kiosks, this study examines farmers' awareness of and use of ICT tools. Drawing on field data and participatory interviews, the research reveals that while mobile phones are widely used for basic communication and SMS-based advisories, awareness of advanced tools such as precision agriculture apps, GPS-enabled devices, and online market portals remains limited. The findings highlight a significant gap between awareness and actual usage, often driven by factors such as digital literacy, affordability, and infrastructure availability. In order to close this gap and advance inclusive digital transformation in agriculture, the study highlights the necessity of focused training initiatives, localized content delivery, and policy support**.**

Information and Communication Technology (ICT) has emerged as a transformative force in agriculture, offering farmers timely access to information, improved decision-making, and simplified farm operations. In India, where smallholder farmers dominate the agricultural landscape, ICT tools such as mobile phones, internet platforms, radio, television, and agricultural kiosks are increasingly shaping farming practices. However, awareness and utilization of advanced ICT applications remain uneven, reflecting challenges of digital literacy, affordability, and infrastructure. This article examines farmer awareness and usage patterns of ICT tools, highlights gaps between knowledge and practice, and proposes strategies for inclusive digital transformation in agriculture.

ICT Tools in Indian Agriculture

Mobile Phones

Mobile phones are the most widely adopted ICT tool among farmers. They serve as basic communication devices and platforms for SMS-based advisories on weather, pest management, and crop practices. In states like Maharashtra and Uttar Pradesh, mobile advisories have helped farmers reduce crop losses by providing timely alerts. Despite their widespread use, most farmers rely on basic functions rather than advanced agricultural apps.

Internet Platforms

Internet access enables farmers to explore online market portals, e-commerce platforms, and government websites offering agricultural information. However, usage remains limited due to connectivity issues and low digital literacy. Farmers with internet access often use it for general communication rather than specialized agricultural purposes.

Radio and Television

Traditional media such as radio and television continue to play a vital role in disseminating agricultural information. Programs broadcast by *All India Radio* and *Doordarshan* provide weather updates, market prices, and best practices. These tools are particularly valuable for farmers in remote areas with limited digital infrastructure.

Agricultural Kiosks

ICT kiosks established in rural areas provide farmers with access to information on crop management, government schemes, and market linkages. Initiatives like *e-Choupal* have demonstrated success in connecting farmers to markets and reducing dependency on intermediaries. However, kiosk usage is often restricted to regions with strong institutional support.

Advanced Tools

Precision agriculture apps, GPS-enabled devices, and online market portals represent the next stage of ICT adoption. These tools offer site-specific recommendations and direct market access. Yet, awareness and utilization remain low, particularly among smallholder farmers, due to affordability and technical skill requirements.

Findings from Field Data and Farmer Experiences

Participatory interviews and field surveys reveal a significant gap between awareness and actual usage of ICT tools:

- High Awareness, Low Utilization: While most farmers are aware of mobile advisories and television programs, fewer actively use advanced apps or GPS devices.
- Digital Literacy Challenges: Farmers often struggle to navigate smartphone applications, limiting their ability to benefit from advanced ICT tools.
- Affordability Constraints: High costs of smartphones, internet data, and GPS devices deter smallholder farmers from adopting advanced technologies.
- Infrastructure Limitations: Poor connectivity and unreliable electricity in rural areas restrict ICT penetration.

Impact of ICT Tools

Improved Decision-Making

ICT tools provide farmers with timely information on weather, soil health, and pest outbreaks. This enables evidence-based decisions, reducing risks and improving efficiency.

Enhanced Productivity

Access to advisories and market information helps farmers optimize input use and crop selection, leading to higher yields.

Market Access

Digital platforms and kiosks connect farmers directly to buyers, improving price transparency and profitability.

Reduced Post-Harvest Losses

Timely information on storage and market conditions helps farmers minimize losses and improve income stability.

Barriers to Adoption

Despite their potential, ICT tools face several barriers in Indian agriculture:

- Digital Literacy Gaps: Many farmers lack the skills to use smartphones and apps effectively.
- Affordability Issues: High costs of devices and services limit adoption among smallholders.
- Infrastructure Deficits: Poor internet connectivity and electricity supply hinder ICT usage.
- Socio-Economic Disparities: Marginalized groups, including women and landless laborers, face greater challenges in accessing ICT tools.

Policy Recommendations

To close the gap between awareness and utilization, the following strategies are essential:

1. Focused Training Initiatives: Capacity-building programs should teach farmers how to use mobile apps, online portals, and GPS devices.
2. Localized Content Delivery: ICT tools must provide information in local languages and culturally relevant formats.
3. Policy Support: Government subsidies and schemes should prioritize smallholder farmers, enabling affordable access to ICT tools.

4. Infrastructure Development: Investments in rural connectivity, electricity, and digital kiosks are critical for scaling ICT adoption.
5. Public-Private Partnerships: Collaboration between government agencies, agritech startups, and farmer cooperatives can accelerate digital transformation.

Conclusion

ICT tools are reshaping Indian agriculture by facilitating timely information access, enhancing decision-making, and simplifying farm operations. Mobile phones, radio, and television remain the most widely used tools, while advanced applications such as precision agriculture apps and GPS devices are still in their early stages of adoption. The gap between awareness and utilization reflects challenges of literacy, affordability, and infrastructure. To achieve inclusive digital transformation, India must invest in farmer training, localized content, supportive policies, and strong public-private partnerships. By bridging these gaps, ICT tools can empower farmers, improve productivity, and contribute to long-term agricultural sustainability.

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(A No. 192) Integrated Pest Management in Soybean: Enhancing Productivity with Ecological Sustainability

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ABSTRACT

Soybean (*Glycine max* L. Merrill) is a major oilseed and protein-rich crop, contributing significantly to global vegetable protein and edible oil production. However, its productivity, particularly in India, is limited by various abiotic and biotic stresses, among which insect pests play a crucial role. Major pests such as *Spilarctia obliqua*, *Helicoverpa armigera*, *Spodoptera litura*, *Oberea brevis*, and *Bemisia tabaci* cause severe yield losses through defoliation, stem damage, and sap sucking. Integrated Pest Management (IPM) offers a sustainable and eco-friendly approach to managing these pests. It involves accurate pest identification, regular monitoring, and decision-making based on economic threshold levels. IPM integrates cultural practices like crop rotation and intercropping, mechanical methods such as removal of infested plant parts and trap installation, and biological control through conservation and augmentation of natural enemies and microbial agents. Chemical control is used judiciously with selective pesticides to minimize environmental risks. Overall, IPM reduces pest pressure, lowers pesticide dependence, and enhances crop productivity and profitability, making it a vital strategy for sustainable soybean cultivation.

Soybean (*Glycine max* L. Merrill) is one of the most important oilseed and protein-rich crops cultivated worldwide, contributing nearly 60% of the global vegetable protein supply and about 30% of edible oil production. India contribute 3.81% of total production of the world (FAO, 2024)with an area of 123 lakh ha, production of 127.2 lakh tonnes and productivity of 1028 kg/ha. Rajasthan stands at 3rd position in total area (9.89 lakh ha) and production (6.87 lakh ha), but in terms of productivity, it has fall behind with 695 kg/ha (DA & FW, 2026). The low productivity is may due to abiotic and biotic stresses. Among the biotic stresses, insect pests belong to lepidoptera, hemiptera, coleoptera can affect the yield.

Major insect pests of soybean

1. Bihar Hairy Caterpillar, *Spilarctia obliqua* (Arctiidae: Lepidoptera)

Medium sized brown adult moths with a red abdomen lay eggs in cluster on the underside of leaves and emerged larva covered with long yellowish to greyish hairs. Young larvae feed gregariously on chlorophyll mostly on the under surface of the leaves, due to which the leaves look like brownish-yellow in colour. In later stages the larvae eat the leaves from the margin. The leaves of the plant give an appearance of net or web

2. Gram Pod Borer: *Helicoverpa armigera* (Noctuidae: Lepidoptera)

Adults are light pale brownish yellow stout moth. Forewings are olive green to pale brown with a dark brown circular spot in the centre. Hind wings are pale smoky white with a broad blackish outer margin. Female adults lay eggs singly on the flowers or pod and emerged larvae varies in color from greenish to brown. It has dark brown grey lines on the body with lateral white lines and also has dark and pale bands.

pupation occurs in soil, leaf, pod and crop debris.

3. Tobacco Caterpillar: *Spodoptera litura* (Noctuidae: Lepidoptera)

Adults lay egg in mass on undersurface of the leaves, larvae emerged are Velvety black with yellowish green dorsal strips and lateral white bands. Adults are with greyish brown colored forewings and wavy white marking. Hind wings are white in colour with a brown patch along the margin. Larvae feed on the chlorophyll of the leaves. The eaten leaves give the appearance of whitish yellow web.

4. Girdle Beetle: *Oberea (Obereopsis) brevis* (Cerambycidae: Coleoptera)

The freshly emerged adult is yellow, red and brown on the head, thorax and bases of elytra. Grubs are white, soft-bodied worm with a dark head. Girdling of stems and petioles is the major symptoms where inside of the stem is eaten by the larvae and a tunnel is formed inside the stem. The leaves of plant of infected portion are unable to get the nutrient and are dried up. In later stages the plant is cut at about 15 to 25 cm above the ground.

5. Whitefly: *Bemisia tabaci* (Aleyrodidae: Hemiptera)

Nymphs of whiteflies are greenish yellow, oval in outline and adults are minute insects with yellow body covered with a white waxy bloom. Both adults and nymphs feed on leaves by sucking cell sap. Whitefly infestation results in chlorotic spots on the leaves which latter coalesce forming irregular yellowing of leaf tissue, causes premature defoliation. At severe infestation, development of sooty mold can be seen on the infested part.

Integrated pest management of insect pests of soybean

Integrated Pest Management (IPM) has emerged as a scientifically sound and environmentally sustainable strategy for managing soybean pests. IPM integrates multiple compatible approaches, including cultural, biological, mechanical, and chemical methods, to maintain pest populations below economic threshold levels while minimizing risks to human health and the environment. The approach emphasizes regular pest monitoring, use of resistant varieties, conservation of natural enemies, and judicious application of safer pesticides only when necessary. By adopting such a holistic framework, IPM enhances ecological balance, improves crop productivity, and increases farmers' profitability.

Pest identification:

Identification of the insect pest or diagnosis of the infestation is the preliminary and most crucial step in the IPM. Unambiguous diagnosis assists in making decisions and prevent the environmental risks, also their consequences.

Pest sampling:

Assessing the population or incidence would determine the status of the pests or damage. Sampling may be number of insects per leaf or plant (sucking pests) or pod (pod borers) or number of plants infested or damaged (girdle beetle, defoliators). Sampling directs to the concept of threshold which helps to decide either to proceed for the control measures or relying on the natural control through extrinsic/intrinsic resistant factors. Economical threshold for every pest varies with crop and regions depending on the economic importance of the crop. Sampling also helps in decision making process through assessing the activity of natural enemies, biotic or abiotic stresses against pests. In spite of presence of all these factors, still the pests need a control measures, then moving towards the pillars of the IPM (Cultural, Biological, Physical, Mechanical and Chemical methods) found to be feasible.

Pest monitoring

The pests in the field should be monitored to prevent the crossing of economical threshold. Monitoring can be done through damage assessment (per cent of plants/pods infested), by using traps (sticky traps, pheromone traps, water pan traps etc.). Monitoring helps in decision making about the pest management.

1. **Cultural management:**

Crop rotations with cereal crops which will break the continuity of soil borne pests as well as attract beneficial insects and predatory birds. Reducing the tillage intensity saves the hibernating natural enemies. Other than these many cultural practices like application of balanced dose of biofertilizers and nutrients, cleaning of infected stubbles followed by deep summer ploughing, optimal fertilizer application, timely sowing, proper seedbed conditions and depth of sowing, optimum seeding rate and plant population, regular scouting, rogueing and destruction of infected crop/plant parts, elimination of collateral/alternate and reservoir hosts, crop rotation and intercropping, cultivation of soybean in rainy season only and avoidance of mono varietal culture would play major role in preventing and also in managing the pest population.

Inter-cropping soybean either with asafetida (early maturing variety) or maize or sorghum in the sequence of 4 rows of soybean with 2 rows of intercrop should be practiced. Such bio-diversity will help in build-up and conservation of natural bio control fauna viz., coccinellid beetles, *Chrysoperla* etc. In girdle beetle and semilooper endemic areas, intercropping with maize or sorghum should be avoided. Castor can be used as trap crop for tobacco caterpillar and Dhaincha for girdle beetle. Use of resistant varieties is the important practice which is more eco-friendly and also economical too. In spite development of resistance in the pests as counterpart, in all direction this practice holds good. Use of refugia can also a strategy to prevent the resistance in the insect pest due to use of resistant varieties (Sharma *et al*., 2014)

Ecological Engineering for Pest Management: It is the additional part of the cultural management which is the manipulation of the ecosystem in favour of the natural enemies which ultimately reduce the pest infestation, meanwhile it also enhances the aesthetic value of the field. Further, this system is eco-friendly and also provides additional income along with reducing the cost of protection.

Features of this system are,

1) providing food in the form of pollen and nectar for adult natural enemies,

2) proving shelters such as overwintering sites, moderate microclimate and alternate host,

3) planting the flowering plants such as sunflower, sesame, okra, chrysanthemum, marigold, onion, coriander, carrot, mustard, radish, etc. compatible cash crops along the field border by arranging shorter plants towards main crop and taller plants towards the border to attract natural enemies as well as to avoid immigrating pest population

4) avoiding the application of chemical pesticides, when the Pest: Defender is favourable.

2. Mechanical management:

Collection and destruction of girdle beetle infested plant parts, egg masses and gregariously feeding larvae of hairy caterpillar and tobacco caterpillar should be done. Erection of bird perches @ 10-12/ha and installation of pheromone traps @ 10/ha for monitoring incidence of *S. litura* and *H. armigera* (*Lit lure* and *Heli lure,* respectively). Use of Yellow sticky traps to manage sucking pests (mainly for whiteflies)

3. Biological management ((Sharma *et al*, 2014)

a. Conservation:

Conserve spiders, coccinellid beetles, tachinid fly, praying mantids, dragon fly, damsel fly, *Chrysoperla* and meadow grass hoppers by minimizing the use of broad spectrum pesticides. Release *Telenomus remus* @ 50000/ha against *S. litura*.

b. Microbial control

1. Spraying of *Bacillus thuringiensis var. kurstaki*, Serotype H-39, 3b, Strain Z-52 @ 0.75 to 1.0 kg/ha will manage the semilooper complex and defoliators

2. Spraying of Sl NPV @ 250 LE/ha for *Spodoptera litura*, and Ha NPV@ 100 LE/acre along with one tea spoon of indigo and sticker for *Helicoverpa armigera* is the most effective method. For early stages of larva and sucking pests, NSKE @ 5% yields good result.

c. Augmentation

Egg parasitoids-*Trichogramma chilonis*, *Tetrastichus* spp. and *Telenomus* spp. against *Spodoptera litura* and *Helicoverpa armigera*

Larval parasitoids : *Ichneumon promissorius*, *Carcelia* spp, *Diglyphus isaea* against *Spodoptera litura* and *Helicoverpa armigera*

Larval and pupal parasitoids: *Xanthopimpla flavolineata* against *Spodoptera litura* and *Helicoverpa armigera*

Pupal parasitoids: *Encarsia formosa* and Eretmocerus spp against white fly, Lissopimpla excels Pupal Parasitoids of *Helicoverpa armigera*

4. Chemical management (Sharma *et al*, 2014)

Pest	Chemical
Sucking pests (Whiteflies)	Imidacloprid 17.8 SL 100 -125 ml in 700 L of water per ha, Thiamethoxam 25% WG - 100 to 200 grams in 700 L of water per ha,
Bihar Hairy Caterpillar, *Spilarctia obliqua*	Apply chlorpyriphos 20 EC @ 1.5 lit/ha or triazophos 40 EC @ 1.0 lit/ha or quinalphos 25 EC @ 1.5 lit/ha.
Girdle beetle *Oberea (Obereopsis) brevis*	Chlorantraniliprole 18.5% SC @ 150 ml/ha
Tobacco caterpillar (*Spodoptera litura*) and semi loopers	Chlorantraniliprole 18.5% SC @ 150 ml/ha
Pod borer, *Helicoverpa armigera*	Indoxacarb 15.8% EC @ 333 ml/ha followed by Chlorantraniliprole 18.5% SC @ 150 ml/ha (15-20 days interval should be maintained

Conclusion

In conclusion, Integrated Pest Management represents a holistic and sustainable approach for managing soybean pests and diseases. By combining cultural, biological, ecological, and chemical strategies, IPM effectively reduces pest pressure, minimizes environmental risks, and enhances crop productivity. The evidence from field studies clearly demonstrates that IPM practices not only lower disease incidence and pest populations but also improve overall crop performance and profitability. Therefore, widespread adoption of IPM is essential for achieving sustainable soybean production in the face of increasing ecological and agricultural challenges.

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(A No. 193) Role of IoT-Based Smart Farming in Enhancing Agricultural Productivity

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ABSTRACT

The rapid advancement of digital technologies has significantly transformed modern agriculture, with the Internet of Things (IoT) emerging as a key enabler of smart farming. IoT-based agricultural systems integrate sensors, communication networks, cloud computing, and automation to facilitate real-time monitoring and data-driven decision-making. This paper examines the role of IoT in enhancing agricultural productivity by improving resource use efficiency, reducing operational costs, and increasing crop yield and quality. The study also discusses the components, applications, advantages, challenges, and future prospects of IoT in agriculture. The findings suggest that IoT-based smart farming is essential for achieving sustainable agriculture and ensuring global food security under changing climatic conditions.

Agriculture remains a critical sector for economic development and food security, particularly in developing countries like India. However, conventional farming practices are increasingly challenged by climate change, declining soil fertility, water scarcity, and rising input costs. These challenges necessitate the adoption of innovative technologies to enhance productivity and sustainability.

The Internet of Things (IoT) has emerged as a transformative technology in agriculture, enabling the development of smart farming systems. IoT refers to a network of interconnected devices capable of collecting and exchanging data in real time. In agriculture, IoT applications include soil monitoring, climate sensing, automated irrigation, and livestock tracking.

IoT-based smart farming enables farmers to make informed decisions by providing real-time insights into field conditions. According to Kumar *et al.* (2024), IoT technologies significantly improve farm efficiency and productivity by optimizing resource utilization. Similarly, Dhanaraju *et al.* (2022) reported that smart farming systems reduce input costs while increasing yield and profitability.

Figure 1. IoT sensor technology

2. Concept of IoT-Based Smart Farming

IoT-based smart farming is an advanced agricultural approach that utilizes interconnected devices and data analytics to improve farm management. It involves the deployment of sensors, communication technologies, and cloud-based platforms to monitor agricultural processes. The core concept of IoT in agriculture is based on continuous data collection and analysis. Sensors installed in the field gather information on soil moisture, temperature, humidity, and nutrient levels. This data is transmitted to cloud servers, where it is processed and analyzed to generate actionable insights. As highlighted by Nawaz (2025), IoT enables precision agriculture by allowing farmers to apply inputs such as water and fertilizers in a targeted manner. This not only improves productivity but also reduces environmental impact.

3. Components of IoT in Agriculture

IoT-based smart farming systems consist of several interconnected components:

3.1 Sensors

Sensors play a crucial role in data collection. They measure parameters such as soil moisture, temperature, humidity, and nutrient levels.

3.2 Connectivity

IoT devices rely on communication technologies such as Wi-Fi, Bluetooth, LoRaWAN, and cellular networks for data transmission.

3.3 Cloud Computing

Cloud platforms store and process large volumes of data, enabling real-time analysis and decision-making.

3.4 Data Analytics

Data analytics tools convert raw data into meaningful insights, helping farmers optimize their operations.

3.5 Automation Systems

Automation tools such as smart irrigation systems, drones, and robotic equipment perform farming tasks efficiently.

According to Pawar (2024), the integration of these components enhances farm efficiency and reduces manual intervention.

4. Applications of IoT in Agriculture

IoT has diverse applications in agriculture, contributing significantly to productivity enhancement:

4.1 Precision Farming

Precision agriculture involves site-specific management of crops, ensuring optimal use of inputs.

4.2 Smart Irrigation

IoT-based irrigation systems automatically regulate water supply based on soil moisture levels, reducing water wastage.

4.3 Crop Monitoring

Real-time monitoring helps detect diseases, pests, and nutrient deficiencies at an early stage.

4.4 Livestock Monitoring

IoT devices track animal health, feeding patterns, and movement, improving livestock productivity.

4.5 Climate Monitoring

Weather sensors provide real-time data, enabling farmers to make informed decisions regarding planting and harvesting.

5. Role of IoT in Enhancing Agricultural Productivity

IoT plays a pivotal role in improving agricultural productivity through various mechanisms:

5.1 Efficient Resource Utilization

IoT enables precise application of water, fertilizers, and pesticides, reducing wastage and improving efficiency (FAO, 2023).

5.2 Real-Time Decision Making

Farmers can respond quickly to changing field conditions, minimizing crop stress and losses.

5.3 Automation of Farming Operations

Automation reduces labor dependency and enhances operational efficiency.

5.4 Improved Crop Yield and Quality

Optimal growing conditions provided by IoT systems result in higher yields and better-quality produce.

5.5 Risk Management

IoT-based early warning systems help mitigate risks associated with pests, diseases, and adverse weather conditions.

6. Advantages of IoT-Based Smart Farming

IoT-based smart farming offers numerous advantages:

- Increased productivity
- Reduced input costs
- Improved crop quality
- Enhanced sustainability
- Better farm management

According to the World Bank (2024), digital agriculture technologies can significantly improve productivity and resilience in farming systems.

7. Challenges in IoT Adoption

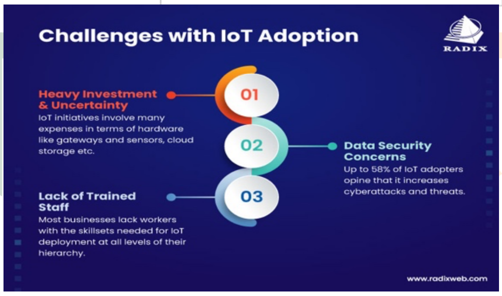

Fig 2. Challenges in IoT Adoption

8. IoT and Sustainable Agriculture

IoT contributes to sustainable agriculture by promoting efficient resource use and reducing environmental impact. It helps conserve water, minimize chemical usage, and improve soil health.

IoT-based smart farming aligns with the Sustainable Development Goals (SDGs), particularly those related to food security and environmental sustainability (FAO, 2023).

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9. Case Studies

S. no.	Location / Country	IoT Application Used	Crop	Key Findings	Reference
1	India (Maharashtra)	Smart Irrigation System (Soil Moisture Sensors + Automated Pumps)	Sugarcane	Water use reduced by 30–40%; crop yield increased by 20%	Patil *et al.* (2023)
2	India (Punjab)	Precision Farming using IoT Sensors	Wheat	Improved fertilizer efficiency; yield increased by 15%	Kumar *et al.* (2024)
3	USA (California)	IoT-based Climate & Soil Monitoring	Grapes (Vineyard)	Improved crop quality and reduced disease incidence	Zhang *et al.* (2022)
4	China	Smart Greenhouse (IoT Sensors + Automation)	Vegetables	25–30% increase in productivity and better resource use efficiency	Li *et al.* (2023)
5	Israel	Advanced Smart Irrigation & Fertigation	Citrus Crops	Water savings up to 50%; higher fruit quality	FAO (2023)
6	Africa (Kenya)	IoT + Mobile-based Advisory System	Maize	Yield increased by 18%; better pest management	World Bank (2024)
7	Netherlands	IoT + AI Smart Greenhouse	Tomato	High yield with minimal resource input; energy-efficient production	Nawaz (2025)
8	Australia	Livestock Monitoring using IoT Sensors	Dairy Farming	Improved animal health and milk production by 10–15%	Smith *et al.* (2023)

10. Future Prospects

The future of IoT in agriculture is promising, with advancements in AI, robotics, and blockchain technology.

6. Integration with AI for predictive analytics
7. Use of drones for crop monitoring
8. Blockchain for supply chain transparency
9. Expansion of smart farming in developing countries

Nawaz (2025) emphasized that the integration of IoT with AI will further enhance agricultural productivity and sustainability.

11. Conclusion

IoT-based smart farming represents a paradigm shift in agriculture, enabling efficient, data-driven farming practices. It enhances productivity, reduces costs, and promotes sustainability. Despite challenges such as high costs and technical barriers, the potential benefits of IoT are substantial.

With appropriate policy support, infrastructure development, and farmer training, IoT can revolutionize agriculture and contribute to global food security.

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