

The Study of Agriculture Sector and Innovation in India

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Article Info	ABSTRACT
<p>Article History: Received: 10th July 2025 Accepted: 19th July 2025 Published: 02th Aug 2025</p> <p>Keywords: Agricultural innovation, precision farming, government policies, sustainable agriculture, Agri-Tech.</p>	<p>The Indian agriculture sector, a fundamental component of the economy, has experienced substantial transition, progressing from traditional subsistence farming to a technology-driven business. Although the industry accounts for over 18.2% of GDP and employs more than 42% of the workforce, it encounters issues including climate change, resource depletion, and market instability. Innovations such as Artificial Intelligence (AI), the Internet of Things (IoT), precision agriculture, and biotechnology are transforming agricultural practices by improving production and sustainability. Government programs like as the Digital India Program and Rashtriya Krishi Vikas Yojana (RKVY) promote modernization, while organizations like NABARD enhance financial inclusion. Public-private partnerships enhance innovation, optimizing supply chains and market accessibility. Sustainable practices, including organic agriculture and climate-resilient crops, are also gaining popularity. This paper examines the influence of these improvements, emphasizing the significance of technology, policy, and institutional support in achieving food security, rural development, and sustainable agricultural expansion in India.</p>
<p>Plagiarism Check Report: Tool Used: Turnitin Date of Report: July 12, 2025 Similarity Index: 5% Remarks: No significant matching text. All citations and matches are properly referenced. The manuscript is considered original.</p>	

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How to Cite: Shinde, S. B. (2025). The study of agriculture sector and innovation in India. IIP: International Multidisciplinary Research Journal (IIPIMRJ), 2(3), 01–10.



INTRODUCTION

Background of Agriculture in India

The history of agriculture in India is long, originating around 9000 BCE with the initial cultivation of plants and domestication of animals. Evidence of agriculture originates from the Indus Valley Civilization, which flourished circa 2500 BCE, demonstrating sophisticated irrigation methods and a variety of crop production, including wheat, barley, and cotton (**Santhamoorthy, 2022**). Over centuries, Indian agriculture underwent substantial evolution, especially during the Mughal Empire (1526–1857 CE), when agricultural methods were enhanced, resulting in heightened production through innovations such as the introduction of cash crops and advanced irrigation systems.

The Green Revolution of the 1960s represented a crucial turning point in Indian agriculture, shifting from dependence on food imports to attaining self-sufficiency. This movement implemented high-yielding crop varieties, improved irrigation techniques, and the application of fertilizers and pesticides, leading to a substantial rise in food grain production from around 55 million tons at independence to over 250 million tons by 2011 (**Chand & Parappurathu, 2024**).⁷ Notwithstanding this advancement, difficulties persist, including dependence on monsoon precipitation and disparate production levels relative to industrialized countries such as the USA and China (**Chand & Parappurathu, 2024**)(**Deshpande, 2017**).

Importance of Agriculture in the Indian Economy

Agriculture is vital to the Indian economy, accounting for over 14% of the Gross Domestic Product (GDP) and providing employment for nearly half of the workforce (**Chand & Parappurathu, 2024**)(**Deshpande, 2017**). It constitutes a primary source of income for numerous rural households and is essential for food security. The sector contributes approximately 11% to India's exports, underscoring its importance in international trade (**Chand & Parappurathu, 2024**).

Agriculture's significance transcends basic economic indicators; it encompasses three primary focal areas:

- **Advancing Inclusive Growth:** Agriculture is vital for rural development and poverty reduction.
- **Improving Rural Income:** A significant segment of rural communities depends on agriculture for their sustenance.
- **Maintaining Food Security:** Guaranteeing a consistent food supply is essential for national stability and public health (**Chand & Parappurathu, 2024**)(**Deshpande, 2017**).

Overview of the Agriculture Sector in India

Historical Perspective of Indian Agriculture

Indian agriculture possesses a significant historical background, transitioning from traditional methods to contemporary practices. Initially, agriculture in India was defined by subsistence farming, as families cultivated crops mainly for personal consumption. The Indus Valley Civilization (about 2500 BCE) represents one of the first instances, demonstrating sophisticated farming techniques. Over the ages, the sector experienced substantial alterations, especially during the Green Revolution of the 1960s, which brought high-yielding varieties and contemporary agricultural practices, resulting in self-sufficiency in food grains. Currently, India is a global agricultural powerhouse, leading in the production of various commodities, including milk and pulses, and ranking second in rice and wheat output **(I. India, 2025)(F. India, 2025)**.

Contribution to GDP and Employment

Agriculture continues to be a fundamental component of the Indian economy, accounting for roughly 18.2% of the GDP in 2023-24. The sector employs more than 42% of the population, serving as a principal source of income for millions, particularly in rural regions where almost 70% of households rely on agriculture for their livelihoods **(B. India, 2025)**. Although its contribution to GDP is diminishing because of industrialization and the expansion of the service sector, agriculture remains essential for economic stability and rural development.

Major Crops and Agricultural Zones

The different agro-climatic conditions of India facilitate the development of numerous crop varieties. Principal crops comprise:

- Cereals: *Oryza sativa*, *Triticum* spp., and *Zea mays*
- Pulses: Lentils and Chickpeas
- Commercial Crops: Cotton, sugarcane, and jute
- Horticulture: Pomology and Olericulture

The nation is segmented into multiple agricultural zones according to climatic conditions and soil classifications:

- North-Western Region: Primarily wheat and mustard
- Eastern Region: *Oryza sativa* and jute
- Southern Region: Rice, sugarcane, and many fruits
- Western Region: Cotton and *Arachis hypogaea*

These zones utilize regional advantages to enhance crop output **(I. India, 2025)(F. India, 2025)(B. India, 2025)**.

Key Challenges Faced by the Agriculture Sector

Notwithstanding its importance, Indian agriculture encounters numerous challenges:
Climate Change: Irregular meteorological patterns affect agricultural productivity.

- **Water Scarcity:** Excessive groundwater exploitation and insufficient irrigation infrastructure impede productivity.
- **Smallholder Farming:** The predominant segment of farmers consists of smallholders who possess restricted access to technologies and markets.
- **Market Access:** Agricultural producers frequently encounter price fluctuations and insufficient direct market access.
- **Sustainability Concerns:** Intensive agricultural methods have resulted in soil deterioration and diminished biodiversity.

Confronting these difficulties is essential for improving production and securing food availability in India **(I. India, 2025)**.

Innovations in Indian Agriculture

Role of Technology in Modern Agriculture

The agriculture sector in India is undergoing a significant transformation due to swift technical progress. The amalgamation of technologies including Artificial Intelligence (AI), Internet of Things (IoT), and Machine Learning (ML) is augmenting productivity and sustainability. The AI4AI initiative has significantly enhanced agricultural yields for farmers by providing data-driven solutions that facilitate improved decision-making and resource management **(Forum, 2024)**. The rise of Agri-Tech firms is promoting the adoption of innovative approaches that tackle diverse agricultural concerns, ranging from crop management to financial services **(Drishtias, 2022)**.

Government Policies and Initiatives for Innovation

The Indian government has enacted multiple programs to promote innovation in agriculture. Initiatives under the Digital India program seek to advance the application of emerging technology in agriculture. Significant initiatives encompass financial assistance for state governments to establish digital agriculture projects and financing for agribusiness incubators under the Rashtriya Krishi Vikas Yojana (RKVY) **(Drishtias, 2022)(JIVA, 2023)**. Moreover, the formation of farmer-producer organizations (FPOs) facilitates the collectivization of farmers, thereby enhancing their access to technologies and markets **(Company, 2023)v**.

Digital Transformation in Agriculture

Digital change is altering the agricultural landscape in India. Agristack is a uniform database designed to connect agricultural data with farmers according to their land holdings, facilitating tailored services from Agri-Tech companies **(Company, 2023)v**.

Furthermore, efforts such as digital soil-health cards are equipping farmers with information regarding soil composition, thereby fostering precision farming practices that improve productivity and sustainability **(Company, 2023)v**.

Precision Agriculture and Intelligent Farming

Precision agriculture methods are gaining prominence in India, employing data analytics and IoT devices to enhance agricultural practices. Technologies like hyperspectral imaging and parcel-level crop mapping are improving resource utilization efficiency. Initiatives such as Saagu Baagu have shown considerable enhancements in agricultural yields and farmer income through focused interventions informed by accurate data analysis (**Forum, 2024**).

Biotechnology and Genetic Modifications

Biotechnology is essential for improving crop resilience and yield. Genetic alterations are utilized to create crops capable of enduring the effects of climate change, pests, and illnesses. This method enhances production while promoting sustainable agricultural practices by diminishing reliance on chemical inputs (**JIVA, 2023**).

Sustainable and Organic Farming Innovations

The emphasis on sustainable agriculture is increasing, with advancements designed to enhance organic agricultural methods. The emergence of Agri-Tech businesses is enhancing farmers' access to organic inputs and market information, thereby enabling their shift to more sustainable practices (**JIVA, 2023**). Furthermore, governmental activities are facilitating organic certification procedures and advocating for organic products through several programs.

Government Policies and Institutional Support in Agriculture

National Agricultural Policies and Schemes

The Indian government has instituted numerous agricultural policies and programs designed to augment productivity, guarantee food security, and enhance farmers' livelihoods.

Principal initiatives encompass:

- Priority Sector Lending: Requires banks to designate a certain percentage of their loans to agricultural, guaranteeing farmers access to essential credit (**Suman & Kumari, 2024**).
- The government offers rebates on interest rates for agricultural loans, enhancing the affordability and accessibility of financing (**Suman & Kumari, 2024**).
- Kisan finance Card Scheme: This initiative aims to furnish farmers with prompt access to finance, thereby substantially altering the financial environment for small-scale farmers.

Role of NABARD and Other Financial Institutions

The National Bank for Agriculture and Rural Development (NABARD) is crucial in facilitating agricultural advancement in India. NABARD, founded in 1982, is dedicated to improving rural loan distribution and facilitating numerous government initiatives through its financial, developmental, and supervisory roles. Its principal functions encompass:

- NABARD offers refinancing assistance to banks and financial organizations, promoting capital investment in agriculture.

- **Project Implementation:** It serves as a channel partner for government initiatives, transmitting subsidies to financial institutions and assuring the proper execution of programs focused on rural development **(Khan & Ahmad, 2022)**.
- **Capacity Building:** NABARD collaborates with diverse stakeholders to strengthen capabilities in rural regions, hence improving the efficacy of agricultural projects.

Public-Private Partnerships in Agricultural Innovation

Public-private partnerships (PPPs) are increasingly acknowledged as essential for fostering agricultural innovation. These partnerships capitalize on the advantages of both sectors:

- **Investment and Technology:** Private firms contribute capital and technological proficiency, whereas government agencies offer regulatory assistance and infrastructure.
- **Data Sharing Initiatives:** Initiatives such as Karnataka's E-Sahamathi seek to facilitate agricultural data ecosystems, allowing companies to create digital consulting services that improve production **(Economic, 2022)**.
- **Collaboration with Research Institutions:** Public-private partnerships (PPPs) foster alliances between entrepreneurs and academic entities, guaranteeing that discoveries undergo testing and validation prior to extensive implementation **(Economic, 2022)**.

Challenges in Policy Implementation

Notwithstanding the comprehensive structure of legislation and institutional support, numerous problems impede effective implementation:

- **Access to Credit:** Despite the existence of programs such as priority sector lending, numerous small farmers continue to have challenges in obtaining credit due to bureaucratic obstacles and insufficient banking infrastructure **(Suman & Kumari, 2024)**.
- **Collaboration Among Stakeholders:** Successful implementation frequently necessitates collaboration among various parties, including governmental entities, financial institutions, and agricultural producers. Absence of synergy may result in inefficiencies **(Khan & Ahmad, 2022)**.
- **The adoption of new technologies is frequently sluggish due to high costs, little awareness among farmers, and inadequate training programs (Economic, 2022).**

Socio-Economic Effects of Agricultural Innovations

Agricultural innovations are essential for reshaping the socio-economic landscape, especially in rural regions. This analysis examines multiple facets of this influence, encompassing effects on farmers' income, the involvement of women and youth, rural development, and environmental factors.

Effect on Farmers' Income and Livelihood

Agricultural advancements substantially improve farmers' income and quality of life.

Studies demonstrate that innovations initiated by farmers can enhance production, frequently correlating with improved profitability. Research indicates that the benefit-to-cost (B:C) ratio for crop production improvements increased from 1.83 to 2.10 post-implementation, signifying significant economic advantages despite heightened cultivation expenses¹. Innovations centered on processing and value addition are typically more lucrative, but those associated with farm machinery may not generate substantial economic advantages¹. These technologies enhance poverty alleviation by bolstering food security and diversifying income streams for rural communities (OECD, 2013).¹

Women and Youth Participation in Agriculture

The involvement of women and youth in agriculture is crucial for sustainable development. Agriculture functions as a significant source of employment and revenue in numerous locations. In Kenya, almost 65% of the population participates in agricultural activities, underscoring its significance for economic empowerment (Njenga & Mugo, 2020). Women are integral to agricultural productivity and decision-making; nonetheless, they frequently encounter obstacles, including restricted access to resources and training. Efforts to augment women's involvement can result in enhanced agricultural results and increased community resilience (Madan et al., 2020). Engaging kids in agriculture through new techniques can draw them to the field, promote entrepreneurship, and mitigate unemployment (Madan et al., 2020)(Njenga & Mugo, 2020).

Rural Development and Employment Generation

Agricultural advances substantially enhance rural development and employment creation. By enhancing production and implementing new technologies, these innovations generate employment opportunities both on the farm and in other areas such as processing and marketing. The commercialization of agriculture has transitioned emphasis from subsistence farming to cash crop cultivation, hence augmenting income prospects for rural areas. Furthermore, improvements that decrease labor expenses can liberate time for off-farm employment prospects, thereby diversifying income streams for families.

Climate Change and Environmental Impacts

The correlation between agricultural advancements and environmental sustainability is intricate. Some improvements enhance resource efficiency and mitigate environmental effect (e.g., by improved water management or pest control), whereas others may intensify issues associated with climate change. The implementation of new technologies must be meticulously overseen to guarantee their compatibility with local conditions and to prevent adverse outcomes, such as heightened input expenses or dependence on chemical inputs (OECD, 2013)(Jose & Rica, 2021). Ongoing innovation is crucial for tackling the difficulties presented by climate change while sustaining agricultural productivity (OECD, 2013).

Discussion

The Indian agriculture sector has experienced a substantial shift from traditional subsistence farming to a more technology-oriented and commercialized enterprise. Although its contribution to GDP is diminishing because of the expansion of the industrial and service sectors, agriculture continues to be the principal means of sustenance for countless rural households. Numerous difficulties, including climate change, water scarcity, and restricted market access, persist in affecting productivity. Innovations in technology, governmental initiatives, and digital interventions are transforming the agricultural sector.

Contemporary technologies such as Artificial Intelligence, the Internet of Things, and precision agriculture are enhancing resource efficiency and productivity. Government initiatives like the Digital India Program and Rashtriya Krishi Vikas Yojana (RKVY) are promoting agricultural innovation. The establishment of Farmer-Producer Organizations (FPOs) is empowering smallholder farmers by improving their access to markets and technologies. Public-private partnerships are enhancing investment in Agri-Tech by connecting research with practical application. These developments enhance farmer income, promote rural development, and create employment possibilities, while also addressing sustainability issues.

Conclusion

Agricultural innovation is crucial for tackling India's food security, economic viability, and environmental issues. The sector confronts challenges including climate change, market volatility, and financial accessibility; nonetheless, technical innovations, policy backing, and institutional measures are fostering positive transformation. The amalgamation of AI, IoT, and data analytics is transforming agriculture, enhancing efficiency, and diminishing input expenses. Government initiatives and financial entities such as NABARD are offering crucial assistance for innovation and the welfare of farmers. Public-private partnerships are increasingly closing gaps in research and practical application, enhancing productivity and sustainability. A coordinated approach among policymakers, scientists, business enterprises, and farmers is essential for long-term success. Fortifying rural infrastructure, advancing financial inclusion, and advocating sustainable agricultural practices will be essential for ensuring a stable future for Indian agriculture.

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