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Blockchain in Indian Agriculture: Opportunities, Challenges, and the Road Ahead

*Dr. S. Lokesh Babu, Dr. K. Kiran Kumar Reddy, Dr. D. Vijay KumarNaik,
Sri Hari Sadu and Dr. G. Lalita Siva Jyothi

Krishi Vigyan Kendra, Nellore, SPSR, Acharya N.G. Ranga Agricultural University,
Lam, Guntur, Andhra Pradesh, India

*Corresponding Author's email: drlokeshbabu24@gmail.com

Agriculture continues to be a cornerstone of India's economy, providing livelihoods to nearly half of the population and contributing significantly to national food security. For the financial year 2025-26, the sector is projected to achieve a growth rate of 3-3.5%, building on record crop production in 2024-25. Agriculture and allied activities accounted for 17.8% of India's GDP in 2023-24, highlighting the sector's enduring economic importance despite a declining share relative to industry and services. The government has set an ambitious foodgrain production target of 354.64 million tonnes for 2025-26, surpassing the previous year's record of 353.96 million tonnes, reflecting a continued emphasis on increasing productivity and ensuring food self-sufficiency.

Over the past five years, Indian agriculture has witnessed notable shifts in cropping patterns, productivity, and diversification. Expansion in maize, pulses, and horticulture, coupled with steady growth in allied sectors such as dairy (projected growth 11-13%) and fisheries, reflects farmers' adaptation to changing market demand, government incentives, and climate considerations. Government initiatives have also evolved, with schemes such as Pradhan Mantri Fasal Bima Yojana (PMFBY), Modified Interest Subvention Scheme (MISS), and the Agricultural Infrastructure Fund (AIF) addressing risk management, financial inclusion, and post-harvest efficiency. New programs for 2025-26, including the Prime Minister Dhan-Dhaanya Krishi Yojana (PMDDKY), National Mission on High Yielding Seeds, and Mission for Aatmanirbharta in Pulses, aim to improve productivity, promote diversification, and achieve self-sufficiency in critical crops.

Despite these positive trends, the sector faces enduring challenges. Climate change, characterized by erratic monsoons, heatwaves, and extreme weather events, poses risks to crop yields and livestock productivity. Structural issues such as fragmented land holdings, low average yields, and water management constraints limit mechanization and efficiency, while urban migration has contributed to labor shortages in rural areas. Additionally, market inefficiencies, price volatility, and inadequate rural infrastructure continue to undermine farmer incomes and post-harvest management. Against this backdrop, technological interventions have emerged as a critical tool to enhance productivity, transparency, and sustainability. Integrating digital solutions, precision farming, and blockchain-based supply chain management can improve traceability, automate transactions, and optimize resource use. This article explores how emerging technologies, combined with targeted government initiatives and policy support, can help India navigate structural and environmental challenges while sustaining agricultural growth and rural livelihoods in 2025-26 and beyond.

What Exactly Is Blockchain?

At its core, **blockchain** is a decentralized digital ledger that records transactions securely across a network of computers. Each record, or *block*, is linked to the one before it, creating

an immutable “chain.” No single authority can alter or delete entries, making the system transparent and tamper-proof. In agriculture, blockchain can track every step from seed to shelf ensuring **authenticity, traceability, and trust**. For Indian farmers, who often face issues like fake seeds, delayed payments, and price exploitation, this transparency can be transformative. There are different types of blockchains. **Public blockchains** are open to anyone, **private blockchains** are controlled by a single organization, and **consortium blockchains** are managed by a selected group of stakeholders. Each transaction is verified and added to the chain by participants called miners, ensuring accuracy and security. By combining blockchain with technologies like IoT and AI, real-time data from farms such as soil health, weather, and crop status can be captured, analyzed, and used for smarter farming decisions.

The adoption of blockchain in Indian agriculture is gaining momentum, with the India Blockchain in Agricultural Supply Chains market valued at around **USD 420 million**, driven by the increasing need for traceability and digital adoption. Recognizing its potential, the Indian government has launched initiatives to integrate blockchain into agriculture. These initiatives not only increase farmers’ confidence but also enhance the credibility of Indian produce in domestic and international markets.

Opportunities:

Transparency in the Agri-Food Supply Chain

In the agri-food sector, ensuring traceability-the capacity to track a product’s journey from farm to consumer-is fundamental to maintaining food safety, authenticity, and quality. Blockchain technology strengthens this process by providing a transparent, real-time record of every stage in the supply chain, from seed procurement to retail distribution. This is particularly significant in India, where issues like food adulteration, contamination, and mislabeling continue to challenge consumer confidence and export reliability. By enabling all stakeholders-including farmers, processors, regulators, and consumers-to access verified data on product origin and movement, blockchain promotes accountability and trust across the value chain.

A compelling example comes from **Andhra Pradesh**, where blockchain technology was used to trace the complete lifecycle of **red chillies** from cultivation in local farms to final export. Each transaction and handling step was digitally recorded, creating an immutable and verifiable history of the product. This not only enhanced transparency but also empowered farmers by giving them access to verified records, improving their market credibility, and helping them secure **better price premiums** in international markets (Ramesh et al., 2022).

Enhancing Trust and Combating Fraud through Blockchain

Fraud and misrepresentation remain persistent challenges in the agri-food sector, often taking the form of **false labeling**, adulteration, or mixing of inferior-quality goods with premium products. Such practices not only undermine consumer confidence but also damage the reputation and export value of Indian agricultural commodities (Singh, 2023). Blockchain technology offers a powerful safeguard against these issues through its **immutable and transparent ledger system**, which ensures that every recorded transaction or data entry remains tamper-proof and verifiable. This integrity of information makes it far more difficult for fraudulent activities to go unnoticed.

A notable example comes from **Gujarat**, where a leading **dairy cooperative** adopted blockchain to authenticate and monitor the quality of its milk supply. By continuously verifying data across production, testing, and distribution stages, the system created an unalterable chain of trust that drastically reduced instances of adulteration and mislabeling. The initiative not only improved operational accountability but also strengthened **consumer confidence** in the purity and reliability of the cooperative’s dairy products (Sharma & Kapoor, 2022).

Blockchain for Smarter Supply Chains, Payments, and Food Safety in Indian Agriculture

Blockchain technology is increasingly being recognized as a transformative force in **agricultural supply chain management**, particularly in India, where smallholder farmers often face inefficiencies, delayed payments, and information asymmetry. By **digitizing and decentralizing** supply chain processes, blockchain minimizes dependence on intermediaries and enables **direct linkages between farmers, processors, and retailers**, leading to higher profit margins and reduced transaction costs. According to a 2024 NITI Aayog assessment, digital traceability and blockchain-based logistics can potentially increase farmers' net returns by **10-20%** by improving transparency and eliminating middlemen. Integrated with **IoT (Internet of Things)** technologies, blockchain systems can provide farmers with **real-time data** on soil conditions, crop health, weather forecasts, and market trends, empowering them to make more informed decisions about sowing, harvesting, and selling (Joshi, 2023).

Blockchain for Land Ownership, Surveying, and Sustainable Farm Management

In India, land ownership has long been plagued by paperwork, missing records, and disputes. Farmers often struggle with delays in land registration, conflicting documents, and opaque record-keeping systems. Even with government efforts like the Digital India Land Records Modernization Programme, only about 68% of cadastral maps were digitised by 2023, and around 78% of villages in Telangana had computerized land records (Telangana Today, 2024).

Enter blockchain, the technology behind cryptocurrencies, now making waves in agriculture. By creating a tamper-proof, decentralized ledger, blockchain ensures that land transactions—from registration to lease agreements—are secure, transparent, and verifiable. In Telangana, the “Blockchain District” pilot project digitised thousands of property records with Tech Mahindra's support, enabling real-time verification and faster access for landowners. Nearly 68% of participants reported increased trust in the system (IMPRI, 2025).

Andhra Pradesh is following suit. In Amaravati, over 100,000 land records were moved to a blockchain-linked GIS system, cutting verification times by more than 50% (TID Working Paper, 2024). Beyond reducing disputes, these records help farmers access customized crop advice, irrigation planning, and credit, turning accurate land data into a powerful tool for sustainable agriculture. Smart contracts embedded in blockchain also automate payments, ensuring farmers are paid instantly for leases or sales without intermediaries. With this combination of transparency, speed, and resilience—even in natural disasters—blockchain is reshaping land management in India, offering farmers security, efficiency, and a fair stake in the agricultural economy.

Challenges in adoption of Block chain technology in Agriculture

Despite the transformative potential of blockchain technology in India's agricultural sector, its adoption faces several significant challenges. One major barrier is **regulatory ambiguity**. The absence of standardized policies across states and regions creates uncertainty, making it difficult for stakeholders to implement blockchain solutions confidently (Zhao et al., 2019). Additionally, the **digital divide** poses a challenge, as many developing regions lack the infrastructure and technical expertise required for blockchain systems, leaving technologically advanced areas to progress faster while others lag behind (Kamilaris et al., 2019).

Privacy and security concerns also remain critical. Although blockchain provides enhanced security, the loss of private keys can result in irreversible loss of access to digital assets, raising significant risks regarding data protection (Kamilaris et al., 2019). Moreover, **transaction delays** are inherent in blockchain networks that use Proof-of-Work mechanisms. For example, Bitcoin transactions may take up to 10 minutes to confirm, which is considerably slower than traditional payment systems like VISA or PayPal (Kohad et al., 2020).

As blockchain databases expand, **storage limitations** become increasingly evident. The growing size of the blockchain can slow performance and extend synchronization times

for new users (Dhaliwal & Malik, 2021). **High energy consumption** is another challenge, particularly in mining-based systems. Studies estimate that mining a single Bitcoin transaction consumes around 7 megajoules of energy, comparable to the energy required to mine platinum (Hern, 2018). Finally, the **high cost of implementation** including investment in specialized hardware, software, and skilled personnel poses a significant obstacle for small and medium-sized agricultural enterprises seeking to leverage blockchain technology (Akella et al., 2023). Collectively, these challenges highlight the need for supportive policies, infrastructure development, and scalable solutions to enable wider adoption of blockchain in Indian agriculture.

Government Initiatives Addressing Blockchain Challenges

Recognizing these challenges, the Government of India has launched several initiatives to promote blockchain adoption in agriculture:

National Blockchain Framework (NBF): Launched in September 2024 with a budget of ₹64.76 crore, the NBF aims to accelerate the development and deployment of permissioned blockchain-based applications. Key components include the Vishvasya Blockchain Stack and the National Blockchain Portal, deployed across NIC data centers in Bhubaneswar, Pune, and Hyderabad. As of October 2025, over 34 crore documents have been verified on the blockchain platform (pib.gov.in).

Digital Agriculture Mission: Approved in September 2024, this mission envisions the creation of a Digital Public Infrastructure (DPI) for agriculture, including AgriStack and the Krishi Decision Support System. These initiatives aim to drive innovative, farmer-centric digital solutions and make reliable crop-related data accessible (sansad.in).

Maharashtra's MahaAgri-AI Policy 2025-2029: This policy integrates artificial intelligence and blockchain to improve crop monitoring, weather forecasting, market analytics, pest control, and overall farm productivity. A blockchain-based system is being introduced to trace farm produce, especially for export-quality crops (timesofindia.indiatimes.com).

The Digital Harvest: Blockchain's Next Frontier in Indian Agriculture

Blockchain technology is rapidly emerging as a transformative force in India's agricultural sector, addressing persistent challenges in traceability, transparency, and supply chain efficiency. Its immutable digital ledger ensures the authenticity of farm produce, reduces fraud, and fosters trust among farmers, consumers, and stakeholders. When combined with IoT and AI, blockchain enables real-time data analysis, supporting better crop management, yield forecasting, and market access. Government initiatives including pilot projects, policy reforms, and subsidies alongside private sector innovations, are making this technology increasingly accessible, even in digitally underserved regions. Farmers benefit from informed decision-making, timely payments via smart contracts, and enhanced profitability, while consumers gain verified information on product origin, quality, and ethical sourcing. Though challenges such as high costs, energy requirements, regulatory gaps, and infrastructural limitations remain, targeted policy support and technological advancements are bridging these barriers. Blockchain is poised to become a cornerstone for a **transparent, resilient, and sustainable agricultural ecosystem in India**, improving farmer incomes and strengthening supply chains.

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