ISSN: 3048-6580

AgroPedia
e - Publication for Agriculture Popular Articles
Volume: 03, Issue: 07 (July, 2026)
Available online at: https://www.agropedia.co.in

Blockchain Technology in Agricultural Supply Chains: Enhancing Transparency, Traceability, and Trust

Shivani Jha[1] and **Ayushi Pal**[2]

[1]Young Professional-II, ICAR-National Research Centre for Makhana, Darbhanga, Bihar
[2]Assistant Professor, Department of Agricultural Economics and Extension, Lovely Professional University, Jalandhar, Punjab
**Corresponding author - jha.shivani123@gmail.com*

Introduction

Agriculture plays a crucial role in ensuring food security, generating employment, and supporting rural livelihoods across the world. As agricultural markets become increasingly interconnected, agricultural products travel through complex supply chains involving farmers, aggregators, processors, transporters, wholesalers, retailers, and consumers. Managing these supply chains efficiently has become a major challenge due to issues such as lack of transparency, food fraud, quality deterioration, information asymmetry, and inefficient record-keeping.

Consumers today are more conscious about food quality, safety, sustainability, and ethical production practices than ever before. They seek information regarding where their food comes from, how it was produced, and whether it meets quality and safety standards. However, conventional agricultural supply chains often lack reliable mechanisms for tracking products throughout their journey from farm to consumer. Records are frequently maintained manually or in fragmented databases, making them vulnerable to errors, manipulation, and loss of information.

The rapid advancement of digital technologies has opened new opportunities for transforming agricultural systems. Technologies such as Artificial Intelligence (AI), Internet of Things (IoT), Big Data Analytics, Remote Sensing, Cloud Computing, and Blockchain are increasingly being adopted to improve agricultural productivity and supply chain management. Among these innovations, blockchain technology has emerged as a revolutionary tool capable of enhancing transparency, traceability, accountability, and trust within agricultural supply chains.

Blockchain is a decentralized digital ledger that records transactions securely and permanently across a distributed network of computers. Once information is entered into the blockchain, it cannot be altered without network consensus, ensuring data integrity and security. This unique feature makes blockchain particularly suitable for agricultural supply chains where multiple stakeholders need access to reliable and verifiable information.

By providing a transparent and tamper-proof record of transactions, blockchain can help farmers receive fair prices, improve product traceability, reduce food fraud, enhance consumer confidence, and streamline supply chain operations. Furthermore, blockchain can be integrated with IoT sensors, artificial intelligence, and smart contracts to create intelligent and efficient agricultural ecosystems capable of supporting sustainable development and food security.

Understanding Blockchain Technology

Blockchain is essentially a digital record-keeping system where information is stored in interconnected blocks. Each block contains a set of transactions, a timestamp, and a unique cryptographic code linking it to the previous block. This creates a chain of blocks that is highly secure and resistant to tampering.

Unlike traditional databases controlled by a single authority, blockchain operates on a decentralized network where all participants maintain copies of the ledger. Any modification requires consensus from network participants, making fraudulent activities extremely difficult.

Key Features of Blockchain

- Decentralization
- Transparency
- Immutability
- Security
- Traceability
- Real-time data sharing
- Smart contract functionality

Why Blockchain is Important in Agriculture

Agricultural supply chains often suffer from poor coordination and lack of transparency. Farmers may not know the final market price of their products, while consumers often lack information about the origin and quality of food products. Blockchain bridges this information gap by creating a shared, trustworthy platform accessible to all stakeholders.

Major challenges addressed by blockchain include:

- Food fraud and adulteration
- Lack of product traceability
- Delayed payments
- Counterfeit agricultural products
- Poor supply chain coordination
- Market inefficiencies
- Quality assurance issues

Applications of Blockchain in Agricultural Supply Chains

1. Product Traceability

One of the most significant applications of blockchain is end-to-end traceability. Every stage of production, processing, storage, transportation, and retailing can be recorded digitally.

Consumers can scan QR codes on food packages to obtain information about:

- Farm location
- Crop variety
- Cultivation practices

- Harvest date
- Processing details
- Transportation records

This increases consumer confidence and supports informed purchasing decisions.

2. Food Safety Management

Food contamination incidents can lead to severe health and economic consequences. Blockchain enables rapid identification of contamination sources by maintaining complete records of product movement.

In case of contamination, affected products can be traced and recalled quickly, minimizing risks to consumers and reducing financial losses.

3. Smart Contracts

Smart contracts are automated agreements that execute predefined actions when specific conditions are met.

For example:

- Produce is delivered.
- Quality standards are verified.
- Payment is automatically transferred to the farmer.

This reduces paperwork, transaction costs, and payment delays while enhancing trust among stakeholders.

4. Organic Certification and Quality Assurance

Consumers increasingly demand organic and sustainably produced food products. Blockchain can securely store certification records and inspection reports, enabling easy verification of:

- Organic products
- Fair-trade commodities
- Sustainable farming practices
- Geographical indication (GI) products

This reduces fraudulent claims and strengthens certification systems.

5. Agricultural Finance and Credit Access

Smallholder farmers often struggle to access formal credit due to insufficient documentation. Blockchain-generated transaction records can serve as credible evidence of production activities and marketing performance.

Financial institutions can use these records to assess creditworthiness and provide loans more efficiently.

6. Crop Insurance Management

Blockchain facilitates transparent insurance claim processing by maintaining accurate records of farm operations, weather conditions, and crop losses. This can reduce disputes and speed up claim settlements.

7. Supply Chain Transparency

Blockchain provides real-time visibility into supply chain operations, enabling stakeholders to monitor inventory, transportation conditions, and product quality throughout the value chain.

This transparency improves accountability and strengthens business relationships.

Integration with Emerging Technologies

The true potential of blockchain can be realized when integrated with other digital technologies.

Blockchain and IoT

IoT sensors can collect real-time data on:

- Soil moisture
- Temperature
- Humidity
- Storage conditions
- Transportation environments

Blockchain securely stores these data, ensuring authenticity and reliability.

Blockchain and Artificial Intelligence

AI algorithms can analyze blockchain data to:

- Predict market demand
- Optimize logistics
- Detect supply chain risks
- Improve decision-making

Blockchain and Remote Sensing

Satellite imagery and drone-based monitoring systems can provide field-level information that can be recorded and verified through blockchain platforms.

Benefits of Blockchain in Agriculture

Benefits for Farmers

- Better market access
- Improved bargaining power
- Faster payments
- Reduced dependence on intermediaries
- Enhanced trust among buyers

Benefits for Consumers

- Food safety assurance
- Product authenticity verification
- Increased transparency
- Better purchasing decisions

Benefits for Agribusinesses

- Reduced fraud
- Improved inventory management
- Enhanced operational efficiency
- Better regulatory compliance

Benefits for Governments

- Improved food safety monitoring
- Better agricultural data management
- Efficient policy implementation
- Enhanced export competitiveness

Challenges in Adoption

Despite its advantages, blockchain implementation faces several challenges:

- Limited digital literacy among farmers
- High implementation costs
- Inadequate rural internet connectivity
- Lack of technical expertise
- Data privacy concerns
- Regulatory uncertainties
- Limited awareness among stakeholders

Addressing these challenges requires investment in digital infrastructure, capacity building, and supportive policy frameworks.

Future Prospects

The future of blockchain in agriculture appears highly promising. Governments, research institutions, agribusiness firms, and development organizations are increasingly exploring blockchain-enabled agricultural ecosystems.

As digital agriculture expands, blockchain is expected to support:

- Climate-smart agriculture
- Sustainable food systems
- Carbon credit verification
- Precision agriculture
- Digital marketplaces
- Farmer Producer Organizations (FPOs)
- International agricultural trade

The integration of blockchain with AI, IoT, drones, and cloud computing will further enhance agricultural productivity, transparency, and sustainability.

Conclusion

Blockchain technology has emerged as a transformative innovation capable of addressing many long-standing challenges in agricultural supply chains. By enhancing transparency, traceability, accountability, and efficiency, blockchain helps create trust among farmers, consumers, agribusinesses, and policymakers. The technology offers significant opportunities for improving food safety, reducing fraud, facilitating market access, and supporting sustainable agricultural development. Although challenges related to infrastructure, awareness, and implementation remain, continued technological advancements and supportive policies are likely to accelerate blockchain adoption in agriculture. As agriculture moves toward digital transformation, blockchain will play a vital role in building resilient, transparent, and farmer-centric food systems.

References

Awan, S.H., Ahmed, S., Ali, M., and Khan, R. 2024. Blockchain technology and sustainable agricultural supply chains: Opportunities and challenges. Journal of Agriculture and Food Research, 15: 100987.

Caro, M.P., Ali, M.S., Vecchio, M., and Giaffreda, R. 2018. Blockchain-based traceability in agri-food supply chains. Proceedings of the IEEE International Conference on Service-Oriented System Engineering, 1–8.

Casino, F., Dasaklis, T.K., and Patsakis, C. 2019. A systematic literature review of blockchain-based applications. Telematics and Informatics, 36: 55–81.

Kamble, S.S., Gunasekaran, A., and Arha, H. 2020. Understanding blockchain technology adoption in supply chains. International Journal of Production Research, 58(7): 2009–2033.

Kamilaris, A., Fonts, A., and Prenafeta-Boldú, F.X. 2019. The rise of blockchain technology in agriculture and food supply chains. Trends in Food Science & Technology, 91: 640–652.

Lin, Q., Wang, H., Pei, X., and Wang, J. 2023. Food safety traceability system based on blockchain and Internet of Things technologies. Food Control, 145: 109460.

Rejeb, A., Rejeb, K., Simske, S., and Treiblmaier, H. 2022. Blockchain technology in agriculture and food supply chains: A review of

applications, challenges and future research directions. Computers and Electronics in Agriculture, 196: 106822.

Sharma, R., Singh, G., and Kumar, P. 2024. Digital transformation of agricultural value chains through blockchain technology. Agricultural Systems, 223: 104102.

Tian, F. 2017. A supply chain traceability system for food safety based on blockchain technology. International Conference on Service Systems and Service Management, 1–6.

Tripoli, M., and Schmidhuber, J. 2018. Emerging Opportunities for the Application of Blockchain in the Agri-food Industry. FAO and ICTSD, Rome, Italy.

Yadav, V.S., Singh, A.R., Raut, R.D., and Govindarajan, U.H. 2020. Blockchain technology adoption barriers in the Indian agricultural supply chain. Resources, Conservation and Recycling, 161: 104877.

Zhao, G., Liu, S., Lopez, C., Lu, H., Elgueta, S., Chen, H., and Boshkoska, B.M. 2019. Blockchain technology in agri-food value chain management: Applications, challenges, and future directions. Computers in Industry, 109: 83–99.