



Unleashing the Game-changing Potential of Blockchain Technology in Agriculture Supply Chains: A Review

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ABSTRACT

The potential for utilizing this technology is high, especially for the agricultural sector, as it is believed to have the power to change the entire chain. It is a technology that is believed to help improve the tracking of products, starting from the farm and reaching the table, while ensuring the quality and safety of products and giving power to the farmers. Overall, implementing blockchain in agriculture could lead to more sustainable practices and a more resilient food system. A comprehensive search strategy was developed to identify relevant literature on blockchain technology applications. This was done according to the PRISMA guidelines. Searches were carried out on various databases, including PubMed, IEEE Xplore and Scopus. The keywords used were "blockchain technology," "applications," "benefits" and "challenges." Different inclusion and exclusion criteria were used to select relevant articles from the databases. Research shows that blockchain technology can improve the agricultural supply chain by enabling effective tracking and management, thereby addressing issues of fraud and counterfeit goods. It is predicted that most firms will embrace this technology by the year 2030, which will greatly affect the management of the food supply chain. Blockchain technology enables the sharing of data, helping farmers make informed decisions about resources while ensuring transparency in the distribution of foreign aid. Some of the problems associated with these technologies include high computing costs, the need for expertise and a lack of knowledge among agricultural stakeholders.

Key words: Agri-supply chain, Blockchain, Marketing, Technology.

The agricultural sector is an important sector in sustainable development and the food chain, but there are many issues associated with this sector. To meet the food needs of an estimated 9.6 billion people in 2050, there is a need for a 70% increase in food production. The sector has seen increased global integration. There is a need for effective management of the food supply chain, which requires coordinating food product flows from producers to consumers and involving various stakeholders (David *et al.*, 2022). Consumers feel dissatisfied with traditional food systems due to issues such as late deliveries without warning, low-quality items, damaged goods resulting from defective handling and expensive or inaccurate goods (Panghal *et al.*, 2024). This requires the use of models tailored to the sector's characteristics, including management, materials, infrastructure and government regulations and policies. There is a need for a steady flow of products and effective management practices for sustainable growth. As supply chains grow, they face rising costs, inefficiencies and complexities. There is a need for technology to address the challenge of effectively managing stakeholders and maximising returns. ICT applications are leading to unprecedented advancements in farming practices (Salokhe, 2025).

The next generation is quite enthusiastic about farming and looking forward to achieving high yield productivity using the latest technology (Vinod Chandra, 2023). This is a clear indication of the growing use of technology in the day-to-day activities of individuals, organizations and the government. Information and communication technology,

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including sensors and machines, has greatly impacted modern agriculture. Technologies like Internet of Things, Artificial Intelligence, Big Data and Blockchain Technology have become inevitable in supply chain industries (Al-Ammar and Ghanem, 2024; Sharma *et al.*, 2023). The agricultural sector has enormous potential for the use of blockchain technology, which serves as a decentralized ledger for the recording of transactions between various computers. This technology has the potential to bring about a paradigm shift in supply chain management by ensuring integrity, evidentiary support, authenticity, secure ownership and trust. By 2030, most firms are expected to use blockchain technology, underscoring the importance of exploring its use in food supply chain management.

Various preliminary studies have proved that blockchain technology can be highly beneficial for supply chains in the agricultural sector. Blockchain technology and Artificial Intelligence-based supply chain management can be considered a new approach for strengthening the integrity of organic food supply chains (Kim and AlZubi, 2024). This revolutionary technology is poised to shift the paradigm for how food is produced, distributed and consumed. The increased traceability, efficiency and accountability enabled by blockchain technology are poised to empower stakeholders across the entire supply chain, from farm to table. Thus, blockchain technology is not only changing the face of the agricultural sector but is also creating a future that is sustainable and trustworthy.

The existing literature on blockchain in agriculture is primarily focused on technical architecture, supply chain traceability and individual applications, but there is no integrated synthesis of applications, their respective benefits, evidence and limitations across the entire agri-business value chain. Hence, this SLR is required to provide a comprehensive, maturity-based analysis that explains the implications and research gaps in the agribusiness sector.

The study was carried out in Indira University, Pune, Maharashtra, in 2025. This study follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist, as recommended by Moher *et al.* (2009). This guideline helps authors in presenting a clear and accurate picture of a systematic review and meta-analysis, as depicted in Fig 1. The PRISMA framework provides a comprehensive, evidence-based checklist that identifies essential items beneficial for the critical evaluation of published literature. To systematically evaluate the vast body of research on this topic, the PRISMA guidelines use

a structured flow diagram to visually represent the selection of relevant studies. This approach not only aids in organising the literature but also ensures a rigorous methodological framework that underpins the integrity of the review process. By following these established guidelines, the study aims to minimize bias and improve the reliability of its conclusions, ultimately contributing to the advancement of knowledge in the field.

Search strategy

A detailed search strategy was developed to procure the relevant data. The researcher has decided to use Scopus and Google Scholar databases for the study. The search terms that are being used to procure the relevant data are "Blockchain technology," "Agri supply chain," "Agriculture AND Blockchain technology," "Blockchain technology applications" and "Blockchain technology challenges."

Inclusion and exclusion criteria

Exclusion criteria for Blockchain technology:

- (1) Year.
- (2) Document type.
- (3) Publication stage.
- (4) Language.

Inclusion criteria for Blockchain technology:

- (1) Keywords.
- (2) Year.
- (3) Article, review and conference papers.
- (4) English language.
- (5) Publication stage.
- (6) Only relevant papers.

After deleting duplicates from 1951 data, 1948 papers were obtained. Out of 1948 papers, 1873 papers were excluded and 75 papers were obtained. Out of 75, 12 papers

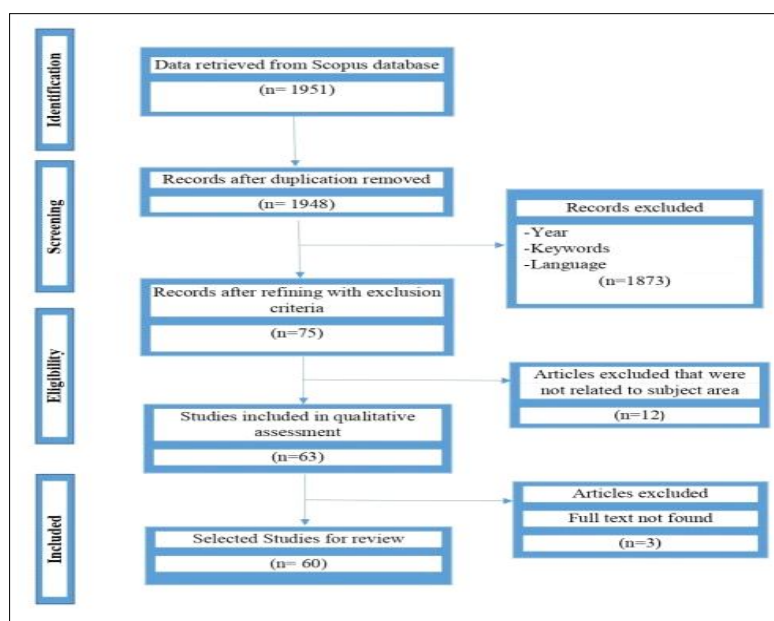


Fig 1: SLR flowchart created with PRISMA (2002-2024), Source: (Moher *et al.*, 2009).

were excluded and 63 papers were obtained. Out of 63, 3 papers were excluded and 60 papers were obtained.

Research questions

RQ1: How can blockchain technology enhance the efficiency and transparency of the Agricultural supply chain?

RQ2: What impacts can be expected to emerge due to the extensive adoption of blockchain technology in the agricultural supply chain?

RQ3: What particular issues can blockchain technology help address in the supply chain of the agri-food sector?

The aim of this research is to provide a thorough analysis of how blockchain technology works to combat food fraud, improve food safety and showcase its revolutionary power in transforming the food sector like never before.

RQ1: How can blockchain technology enhance the efficiency and transparency of the Agricultural supply chain?

Data dissemination

Information collection, sharing and analysis using BT would help farmers take decisions regarding crop management. It would help in better irrigation and fertilisation, thus increasing productivity and sustainability in farming. The basic concept is that BT would be beneficial for farmers and would help them take decisions regarding crops, pesticides, fertilisers, equipment, weather conditions and financial transactions. It would help them take decisions through synchronised information and analysis, thus increasing the quality and quantity of products and productivity and sustainability in farming. For example, based on Fuzzy Logic, the blockchain-based Smart Watering System would apply objective information regarding plants and environmental conditions to help the farmer take decisions regarding optimal watering of plants (Liu *et al.*, 2021).

Intelligent farming

To mitigate the problem of labor shortage and improve the efficiency of the sector, the use of autonomous technologies is becoming increasingly common. The range of smart farming technologies, including those used from 2000 to 2023, comprises seven major technologies: Internet of Things (IoT), cloud computing, precision agriculture, AI, robotics and automation, big data analytics and smart irrigation (Raj and Prahadeeswaran, 2025). Starting from seeds to the sale of agricultural products, all the players can contribute to the provision of important information. The information would be available through the blockchain and all statistics would be unalterable. The pressing issues that these technologies seek to address, such as better use of resources, food security, product traceability and increasing profitability for farmers, are just a few among the important issues that these technologies address for the agricultural sector (Morchid *et al.*, 2025). The most important feature of the blockchain technology that is used for the development of smart agriculture is decentralization.

The potential and value of the blockchain technology for the agricultural sector have led to the emergence of a new technology known as smart agriculture, which uses IoT sensor technology. One such technology is for a greenhouse, where a private blockchain is used and the farmer can manage this technology centrally. Moreover, a general-purpose technology that uses IoT technology and blockchain technology has also been introduced. The basic principle that is followed is to ensure trust among the players who use the blockchain technology. The different stakeholders can use the information that is generated through the use of smartphones for each step, starting from seeds to sales.

Food supply chain management

In the current digital era, the food industry uses online communication to save time and reduce costs. Globalization has increased the complexity of supply chains, raising concerns about food safety, quality and traceability. Blockchain technology can address these issues by enhancing trust and transparency between producers and consumers (Balkundri *et al.*, 2023). The main benefits of blockchain in supply chain management include better product traceability and improved coordination among stakeholders. Implementing blockchain can also enhance data integrity, efficiency, sustainability, safety, social responsibility and waste management (Ellahi *et al.*, 2024). This not only helps businesses and farmers increase value and bargaining power in the market but also provides them with accurate information about food production. Currently, retailers such as Walmart, JD.com and Alibaba are utilising blockchain technology to ensure supply chain traceability.

Transactions of agricultural products

Blockchain technology changes how agricultural product transactions occur by ensuring a secure, transparent digital record of supply chains from farm to market. It also uses private-key encryption to ensure the authenticity of data from planting to harvest. A study by Yao and Zhang (2022) highlights the effectiveness of blockchain technology in improving product traceability and reducing signaling costs in supply chain management. Digital payment systems also improve safety and lower transaction costs, particularly with the integration of cryptocurrency. Such developments promote customer and seller trust, allowing farmers to access a broader market and raise their revenue. The successful implementation of this technology requires proper training on blockchain basics and its applications in agriculture.

Use of blockchain in agri finance

The blockchain technology is expected to revolutionize the agriculture industry through the provision of autonomous financial settlement, auditing and reconciliation tools. This is expected to promote transparency and discourage fraudulent activities. The blockchain technology is also expected to develop a payment and transaction system in

the agricultural sector. Kranti is a blockchain-based farmer's credit scheme developed and implemented in the industry. The main goal of the technology is to assist the farmer in accessing credit facilities. Agri On Block is a blockchain-based data harvesting solution developed and implemented in the industry. The main goal of the technology is to assist the farmer in harvesting and storing data on crops and cattle. The technology also enables the farmer to access relevant information and services from the government and private sector. The solution also enables the farmer to obtain an identity to access financial services and other benefits (Krithika, 2022). The blockchain technology has been applied in the agricultural sector at the following stages to promote evolution in the sector: chain in Agriculture for Finance (Krithika, 2022).

Agri insurance

Climate change has made agriculture unpredictable. Farmers are now resorting to agricultural insurance. Various insurance schemes are available, but index-based insurance, enabled by blockchain technology, is a better alternative to indemnity-based insurance. Wang *et al.* (2022), used agricultural weather index insurance as an example to design the insurance process and targeted solutions for agricultural index insurance through blockchain applications, complemented by technologies such as DSSAT and satellite remote sensing. The technology of blockchain has the potential to simplify complex transactions, increase measurement accuracy, reduce administrative costs and build trust and transparency among the parties involved, thereby lowering the cost of transactions related to pay-for-outcome incentives (Chung and Adriaens, 2024).

Crop and food production

Food systems are becoming increasingly fragmented, with intricate regulatory compliance requirements (Pakseresht, 2024). Blockchain and IoT are transforming the food processing industry by bringing the spotlight to the manufacturers and distributors. This technology enables flexible usage of agricultural services and promotes competitive agriculture. The key advantages of blockchain technology in FCSs include enhanced traceability of food, collaboration, efficiency and optimised food trading processes (Rajab *et al.*, 2020).

Whether risk management

Unpredictable weather during crop planting is a challenge for farmers and a factor in their survival. Too much rain in spring can cause plants to struggle, making it hard for them to absorb water, impeding root growth and impacting respiration. The opacity of food chain platforms makes consumers hesitant to accept drastic price increases, shying away from their own responsibility. Blockchains can enhance traceability, enabling farmers and other stakeholders to understand changes in food prices across the food distribution sector. Blockchain platforms employ smart

contracts to monitor climatic factors for crop insurance. Farm sensors record data on soil conditions, atmospheric temperatures and leaf moisture, which are then recorded in the blockchain. The clear platform enables farmers to make informed decisions and process claims for weather-related damage. Approved claims trigger automatic payments to the farmer's wallet. Although there are promising developments in applying blockchain technology to emergency management, challenges remain in fostering global cooperation and innovation (Shevchuk, 2025).

Managing agricultural finance

The use of blockchain technology in the agricultural sector is aimed at resolving the problems mentioned above. The use of blockchain technology in the agricultural sector is part of the emerging technology in the sector, known as e-agriculture and is transforming the sector to resolve the food crisis in the new century (Lin *et al.*, 2020). The blockchain technology is aimed at promoting transparency and decentralized regulation in the financial sector. The technology offers a contract platform with access to all the parties. This promotes equity in food processing, acts as a means of transaction authentication and offers storage. Auditing is done independently using the blockchain technology, thus promoting cost-effective automated auditing and ease of payment examination. The blockchain technology has the potential to reduce the complexity of transactions, improve measurement accuracy, reduce administrative costs and promote trust and transparency among the parties to the agreement, thus reducing the cost of transactions related to pay-for-outcome incentives (Chung and Adrians, 2024).

Livestock management

Moreover, blockchain technology can further improve the efficiency and accuracy of every step of the process of livestock stock management by digitalizing every process and automating the entire process of tracking and recording transactions. Blockchain technology is not only helpful in the security and authenticity of the data but can open up new possibilities for the efficient and transparent management of agriculture and animal husbandry (Yang *et al.*, 2025). This has been implemented in the beef industry of the U.S., making the entire process more transparent and traceable. However, the consumers are willing to pay a premium for the beef product traceable on a blockchain system. Blockchain technology has shown exceptional benefits in the development of a platform for the safe storage of data for fish farmers, which has further enhanced the level of trust among the consumers of the meat product. Traceability of the supply chain is also included so that the reconciliation of the data can be performed among the concerned actors of the supply chain, *i.e.*, the farmer, processor, retailer and consumer. This would further induce a sense of trust among the consumers regarding the quality and safety of the beef product and would further improve the transparency and traceability of the value chain.

According to a study, the quality of the live fish being transported in a waterless mode can be tracked with the help of a blockchain-based wireless sensor node. This technology would not only improve the quality and safety of the product but would further reduce the production costs of the product and would even make the food supply chain more transparent (Krithika, 2022). Moreover, animal and food safety are correlated with each other and the risk or variation in the health of the animal would directly affect the food safety of the product. There is a need to introduce an authentication system so that the diets of the animals can be authenticated and a new approach can be developed to define the foodstuffs so that the animal feeding practices can be authenticated (Tsoukas *et al.*, 2022).

Fish industry

In 2018, a report was published by the FAO and the title was "The State of World Fisheries and Aquaculture," and the report claimed that a total output of 179 million metric tons was achieved. The products included those for human consumption and a few for fishmeal and oil production. Half of the traded fish catches are processed into fillets and portions and identifying these is a problem. This is a serious problem and a study was done to show that up to 50% of fish products need to be corrected and this is because they are wrongly labeled. Contamination and other issues, such as storage, may also happen. The traceability in the supply chain for fish products and aquaculture is important since it helps to identify defective products, hence ensuring a recall (Tsoukas *et al.*, 2022).

Blockchain technology has the potential to improve the traceability of seafood products and this will enable stakeholders to verify the authenticity and legitimacy of the products, as stated by Pratiwi *et al.* (2024).

RQ2: What are the impacts likely to arise from the large-scale use of blockchain technology in the agricultural supply chain?

Better quality control and food safety

Crop failure is a major problem that is widespread and touches every farmer across the globe. It is often attributed to unfavorable climatic changes or lack of rain. This is a common problem for every farmer and natural calamities are inevitable. However, to mitigate these problems, IBM and other organizations are spending millions of dollars on smart agriculture and developing IoT devices that help farmers monitor soil, pests and irrigation issues and these devices are connected to a blockchain ledger. This would help the farmers get a better understanding of the situation and this would help reduce financial losses and improve the quality of food, saving lives (Patel *et al.*, 2022).

Supply chain: Improved traceability

The blockchain technology is reliable in providing information regarding food origin, producer, freshness and environmental conditions. However, there is a potential for third-party agribusiness to manipulate this process. For instance, in

India, large distributors stored onions in storage facilities, leading to a shortage in the market and an increase in price, considered an abusive criminal offence. The application of blockchain technology helps prevent criminal offences and promotes equity in food production. It helps protect food supply chains through companies like Provenance, which applies blockchain technology to protect food supply chains and provide information to consumers regarding products, supply chains and materials for enhanced consumer confidence in products.

Increase in farmers' efficiency

Currently, farmers depend on different third-party service providers to monitor their goods and services. However, moving this information to different service providers can be laborious. Centralizing this information for them in one place and making it readily available to them can help them speed up operations. Centralizing this information for them can help them monitor various aspects, like the number of animals, health conditions, food consumed, varieties of food, varieties of crops, cultivation, payment of employees, personnel calendar, income and expenses, more effectively. By monitoring all aspects through a single application, it is less likely for them to lose valuable information, unlike various methods, which often do this (Patel *et al.*, 2022). Lakhan *et al.* (2025) stated that blockchain technology is considered the strongest technology for decentralization, thus promoting transparency and efficiency in blockchain-based harvesting.

Equitable pay-out for farmers

The money collected from the farmers might not happen immediately due to some problems. A significant part of the money collected from the farmers is done using wire transfers. Therefore, it is very difficult for the farmers to get an optimal price for the goods they produce. The intelligent contracts will enable the merchants and the farmers to transact directly without any intermediaries. Therefore, the farmers will be able to get an optimal price for the goods they produce. One of the major problems with the countries like India is the time it takes to provide the payment to the farmers. The farmers have been growing at a rate of 7 to 8 per cent, while the agricultural sector is growing at a rate of merely 2 to 3 per cent. The blockchain technology will help improve the lives of the farmers and save lives. Second, studies have shown that the farmers who have used the blockchain technology have been able to improve the agricultural income. The PSM method has shown that the farmers who have used the blockchain technology have been able to earn more than the farmers who have not used the technology. The amount earned by the farmers using the blockchain technology is ₹ 25829.16. Therefore, it is true that the blockchain technology used in the agricultural sector will help improve the quality of the food being produced. Therefore, the revenue will also increase. Lakhan *et al.* (2025) have shown that the blockchain technology used in harvesting has empowered the farmers and the consumers.

Food security

According to the United Nations Committee on World Food Security, food security has been defined as: "Every person has physical, economic and sufficient access to clean, nutritious food to meet their dietary preferences for an active and healthy life, regardless of their circumstances." The existing supply chain is adding to the problem. Blockchain is the answer to food security. Blockchain technology is capable of fulfilling the pressing need while facilitating the flow of foreign aid in an open manner. Blockchain helps in maintaining the highest standards in all areas, ranging from the fields to the retail stores. The study done by (Arora, 2020) indicated some important observations related to the application of blockchain technology in the case of food security, creating an unalterable record and the ability to ensure the accuracy of data.

Mitigation of food fraud

With the help of traceability and accountability offered by blockchain technology, food frauds can be prevented. The problem of deceptive advertisements has been rising, especially with GMO, herbal and antibiotic food products. Nevertheless, with the help of blockchain technology and Internet of Things, the entire chain can be effectively monitored and controlled. The IoT devices, along with RFID tags, help in sharing information about the entire chain, including an accurate record of transactions carried out at every stage, *i.e.*, factories, farms and warehouses. With blockchain technology, frauds can be prevented in many more transactions carried out in the chain, thus ensuring transparency and efficiency, saving millions for large distribution companies (Kumar *et al.*, 2021).

Sustainable development

It is already present in many initiatives related to waste management. For example, Plastic Bank is a recycling initiative that engages individuals from different parts of the world in its territory and rewards them for dropping off collected plastic wastes to recycling centers through digital tokens. The tokens can be used to purchase different items from stores, such as food or a phone charger. The initiative has been successful, with over 1 million individuals participating in the program after its implementation and over 2,000 collector units installed in Haiti since 2014. Agora Tech Lab, similar to Plastic Bank, promotes different initiatives related to a circular economy through rewards for good behavior. The use of blockchain technology in railway stations helps measure and report different wastes through accurate statistics on how they are disposed of and what actions are implemented next. Although not fully refined, different commercial options are also available, such as Recereum and Swachhcoin. Blockchain can also be used to educate individuals about the environmental effects of food production, such as those related to soils, water and lands. The sustainable use and management of agricultural fields, water resources and soils, along with proper management and rational use, are essential for

achieving different United Nations Sustainable Development Goals (Kamilaris *et al.*, 2019).

Controlling operational cost

By eliminating intermediaries and brokers, blockchain technology helps stores save on costs. It also allows suppliers and farmers to be aware of the incentives for other products. In addition, the use of blockchain technology in the agrarian products market helps reduce transaction costs. The sector is highly dependent on first-hand information regarding a firm's participation in the supply chain before engaging in any business activity. The transparency offered by the ledger, where all parties can access it, minimizes the need for all parties to investigate the credit worthiness and ability of another party to perform during the completion of a contract. In essence, blockchain technology allows for direct trade between parties in terms of agrarian products without the need for trust from a third party (Kumar *et al.*, 2021).

Best price and payment options

Agribusiness producers can also provide quicker and less costly payment options through the use of blockchain technology. For instance, traditional payment options such as wire transfers are more costly and there are also huge payment delays associated with agricultural products from different national agricultural boards around the world. This problem could potentially be solved through blockchain technology, as a blockchain application has been developed to facilitate transactions between two individuals, allowing them to do so safely, cheaply and in a quick manner and smart contracts can also be used to facilitate payments under certain conditions, providing assurance to the buyer (Kumar *et al.*, 2021).

RQ3: What specific challenges can blockchain technology address in the agri-food supply chain?

Digital gap between developed and developing countries

However, the adoption of blockchain technologies is challenging in developing countries because of the high cost of equipment and expertise. This could lead to the emergence of a digital divide between developed and developing countries (Deshmukh and Patil, 2022).

Policy framework

In many countries, along with the adoption of blockchain, regulatory problems are also likely to occur and without a proper framework for the use of blockchain in agriculture, its overall adoption may not take place. Blockchain technology is still under development and research. Government guidelines on the adoption of technology are important for the smooth implementation of blockchain technology in agro-based industries. Without such support from the government, many industries may not be able to use blockchain technology (Hasan *et al.*, 2024; Nagariya *et al.*, 2022; Yadav *et al.*, 2020).

Information protection and data security

The challenges facing the adoption of the blockchain technology in the agricultural sector include the issue of

privacy and security. The use of agricultural supply chain networks with the inclusion of devices makes them vulnerable to hacking, leading to the illegal harvest of data or control of the operations of the device. All the parties involved in the blockchain network have access to the data on the network. However, the parties involved in the value chain may be competitors and may not appreciate the implications of the use of blockchain technology (Liu *et al.*, 2021; Yadav *et al.*, 2020). The industries are worried about the chances of the data being compromised or lost.

There is also the concern that the competitors might take advantage of the data sharing in the agricultural sector (Nagariya *et al.*, 2022).

Scalability issues

Another scalability problem is related to latency. Considering the theoretical security level, a large number of nodes is required to validate each transaction. This was always a performance problem and the size of the blockchain was increasing the synchronization time. Moreover, the number

Table 1: Overview of blockchain applications in agri supply chains: Benefits, evidence and limitations.

Application	Benefit	Evidence	Limitation
Information provision	Environmental sustainability, enhance productivity, better decision making	High cost, low awareness, data privacy	Smart watering using blockchain optimizes irrigation based on environmental factors (Liu <i>et al.</i> , 2021).
Intelligent farming	Food security, automation, efficiency	Scalability, energy use, skill gaps	IoT, AI and blockchain allow for non-repudiable farm data from seed to sale (Raj and Prahadeeswaran, 2025).
Food supply chain management	Food safety, traceability, transparency	Regulations, data sharing resistance	Retailers (Walmart, JD.com, Alibaba) apply blockchain for traceability (Balkundri <i>et al.</i> , 2023).
Transactions of agricultural products	Best price and payment options, faster payments	High cost, digital literacy	Blockchain minimizes signalling and transaction costs (Yao and Zhang, 2022).
Application of blockchain in agriculture for finance	Financial inclusion, fraud detection	Regulatory gap, digital divide	Kranti and AgriOnBlock offer farmer credit and identity (L.B., 2022).
Agricultural insurance	Automation layouts, lower admin cost	Data dependency, scalability	Blockchain-based weather index insurance facilitates automated claims (Wang <i>et al.</i> , 2022).
Crop and food production	Traceability, efficiency, compliances	Data storage, IoT data volume	Blockchain-IoT platforms support smart contracts and yield estimation (Rajeb <i>et al.</i> , 2020).
Controlling weather crisis	Faster compensation, price transparency	Technical complexity	Smart contracts initiate payments for climate-related damage (Shuvchek, 2025).
Managing agricultural finance	Transparency, automated auditing	High cost, skill shortage	Blockchain supports decentralized finance and auditing (Lin <i>et al.</i> , 2020).
Livestock management	Food safety, trust	Privacy, cost	Blockchain-based beef traceability enhances market value (Yang <i>et al.</i> , 2025).
Fish industry	Seafood traceability, fraud reduction	Regulatory complexity	Blockchain improves seafood authentication (Tsoukas <i>et al.</i> , 2022). Blockchain improves seafood authentication (Tsoukas <i>et al.</i> , 2022).

of transactions and time for a block are also affecting the computation time for transaction validation (Hasan *et al.*, 2024; Liu *et al.*, 2021; Yadav *et al.*, 2020).

High cost and technical expertise

The speed of transactions carried out through blockchain technology is only 7 transactions per second, causing latency and increasing the time required to process transactions. The cost, complexity and energy consumption associated with blockchain technology have given rise to serious concerns. The willingness of consumers to pay a high price for incorporating blockchain technology into existing systems in the agrifood sector has been noted (Liu *et al.*, 2021; Yadav *et al.*, 2020). Nevertheless, there exist high financial costs associated with implementing blockchain technology, including training and development costs. Concerns exist about the profitability of a firm after implementing blockchain technology. Large firms can risk taking up innovative technologies, while small firms find it hard to do so (Nagariya *et al.*, 2022).

Low awareness among stakeholders

There is a need to ensure that the different parties involved in the agricultural supply chain operation are made aware of the latest developments. There are challenges to the adoption of blockchain technology in the agro-industry sector and these challenges are related to the lack of awareness regarding the latest technologies. The employees need to have appropriate knowledge and skills regarding the application of blockchain technology. There is a need to focus on the training and development of the workforce regarding the application of blockchain technology (Nagariya *et al.*, 2022; Yadav *et al.*, 2020).

Data storage constraints in blockchain

The public blockchain network may also require additional storage space. The level of data generated through the monitoring process, as discussed, is quite high and hence the storage capacity may not be sufficient, making the system unsustainable. The possible solution to this problem is that a system of off-chain storage, such as IPFS, may be implemented, which would be an efficient approach to dealing with the problem and making the system sustainable (Hasan *et al.*, 2024).

Given the novelty of blockchain technology, there is a skill shortage in this area

There is a significant skills gap in applying blockchain technology in agriculture. Very few people have the necessary knowledge and skills to apply blockchain technology to the management of the agri-food value chain (Zhao *et al.*, 2019). This is a major challenge for the sector, as many people, including farmers, producers and supply chain managers, may lack the knowledge and skills to apply blockchain technology.

As blockchain technology continues to develop and its adoption in the agricultural supply chain increases to improve transparency, traceability and efficiency, it is important to note a skills gap that needs to be addressed. It is important to have educational programs and training sessions that focus on the agricultural sector in order to help individuals and organizations understand and adopt these new technologies. Investing in skills development makes it easier to adopt blockchain technology and increases productivity, trust and sustainability in the agricultural sector.

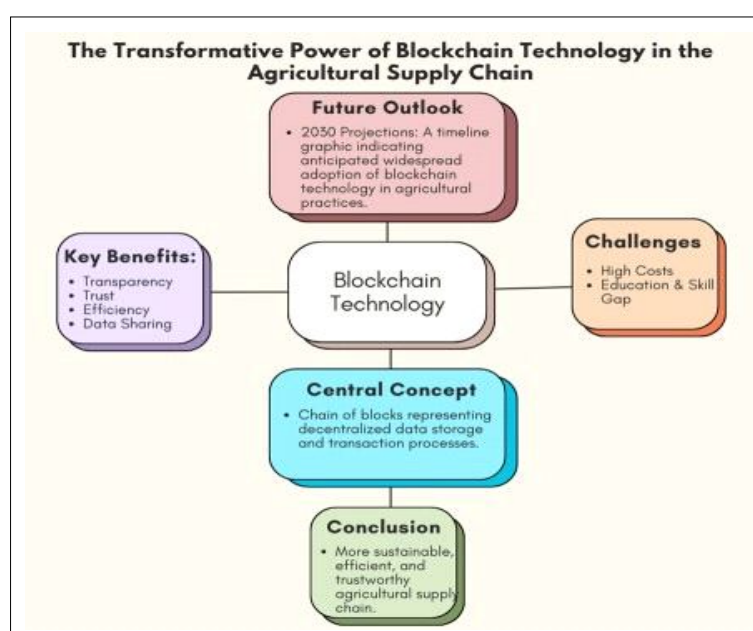


Fig 2: Conceptual diagram of power of blockchain technology in agri supply chain.

The use of blockchain technology in agriculture is at different levels of maturity. Food supply chain management and transactions are the most mature, mainly due to the adoption of retailers and the need for traceability. Agricultural finance and insurance are growing and provide substantial value to farmers through financial inclusion and faster payments, although hindered by regulatory and digital challenges. Smart agriculture and climate resilience solutions are still emerging, mainly due to technological and infrastructure complexities. As discussed above Table 1 shows overview of blockchain applications in Agri supply chains its benefits, evidence and limitations. In general, retailers derive the most value from mature traceability solutions, while farmers derive the most value from finance, insurance and transaction-related solutions.

Theoretical and practical implications

At present, there are no regulations for blockchain technology and a standard has not been established yet. The application of blockchain technology in the food industry introduces new issues, particularly concerning security and innovation. There is a need to establish a regulatory framework that addresses the existing data governance gap by providing guidelines. The guidelines should ensure that particular data is protected while encouraging the traceability of food products in the supply chain. Additionally, blockchain technology has a positive impact on sustainable food systems by improving the traceability of sustainable sourcing practices. This will help reduce food waste and ensure an efficient food supply chain, as the food industry promotes sustainability. As blockchain technology has a potential impact on the supply chain, there is a need to overcome the challenges faced in it. As depicted in Fig 2.

CONCLUSION

In conclusion, the potential of blockchain technology is enormous and its application will have a significant impact on the agricultural supply chain. As derived from the literature review, the application of blockchain technology presents an opportunity for data collection and analysis, thus enabling farmers to make informed decisions concerning their crops. However, the application of this revolutionary technology is likely to face major challenges, among them being the availability of advanced computing facilities, expertise and high levels of education among the players in the agricultural sector. All these challenges need to be overcome to ensure the application of blockchain technology is fully utilized to attain its maximum potential.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are

responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

No animals are used for this study.

Conflict of interest

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