Chapter 20

Farm to Table Blockchain in Agricultural Supply Chains

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Abstract

Production, preparation, delivery, and shipping are all influenced by the growing inter-connectivity of agri-food supply chains. However, fraudulent conduct attracts attention to deficiencies in accountability, leading to monetary losses, concerns with customer confidence, and a decline in the worth of an organization's reputation. Blockchain technology has the potential for boosting transparency in international agricultural supply chains, thus mitigating concerns regarding fraudulent activities and advancing impartial, sustainable, and secure food production techniques. Data clarity in supply chains is challenging but they have been transformed into a sovereignty network that benefits users and raises food standards. Vulnerabilities with product traceability, transparency, and reliability in food supply chains and agricultural can be addressed using blockchain technology and Ethereum smart contracts. The study highlights the restricted application of blockchain technology in real-world scenarios and the importance of an authentic agricultural traceability system to address hazardous uses such as fertilizer and pesticide use. Blockchain-based agricultural supply chains optimize security and productivity by eliminating middlemen and centralized control. While agriculture, internet of Things (IoT) (Agri-Block-IoT) and blockchain connect data from IoT machine to sustain transparency, integrity, privacy in supply chain networks, smart agreements coordinate communication and exchange. The current study focuses on overcoming disruption in the management of complex agricultural supply chains by leveraging blockchain technologies to enhance traceability within the agri-food industry. This paper explores the integration of blockchain technology into agriculture and food supply chains by examining current initiatives and barriers. Despite the potential of transparency, there are still barriers to its widespread adoption by farmers and systems.

Keywords

Agri-Block-IoT, Farm-to-Fork Food Safety, Agricultural Traceability, Food Security

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1. Introduction

To ensure food safety as well as reduce the possibility of infection from carelessness or inadequate hygiene during the manufacture and storage stages, smart agriculture utilizes an effective, clean and reliable food supply chain system [1]. Given the rapidly changing food and agricultural supply chains triggered by the Internet of Things (IoT), the development of trustworthy, auditable, and transparent traceability systems using distributed ledger technology is essential [2]. Farmers struggle with data storage, retention, security, and transmission as they attempt to meet increasing production demands while maintaining sustainability. Climate change, rising input costs and energy scarcity are complex matters. Nowadays, the source of breakdown and data privacy are neglected in favor of centralized IoT-based agricultural platforms [3]. Using an agile methodology, the system was designed with the Hyperledger Sawtooth Blockchain, which facilitates self-directing management of sequential tasks and easy identification of participating parties to stakeholders [4]. Blockchain, cloud computing, IoT, machine learning, wireless sensor networks are all being integrated by ICT to transform digital agriculture. However, there is a lack of research on the variables influencing supply chain participants' ICT adoption [5]. Farm-to-table food quality and safety licensing has become necessary. The increasing threats to food safety and contamination day by day have given rise to the urgent need for a revolutionary traceability system, which is a vital mechanism for quality control that ensures adequate food supply chain product safety [6]. Blockchain technology addresses issues affecting agri-food supply networks by establishing data security and traceability. Farmers use the Inter-Planetary File System (IPFS) to store encrypted files in digital contracts, monitor agricultural growth and record environmental reports. IPFC reduces the storage problem and enhances data privacy [7]. Traditional food supply chains have shortcomings, such as ineffective distribution networks and fraudulent tracking of production and processing of food. Blockchain technology can help solve such issues, by facilitating immutable and trustless technology, facilitating open communication, and ensuring that farmers receive equitable payments [8]. Figure 1

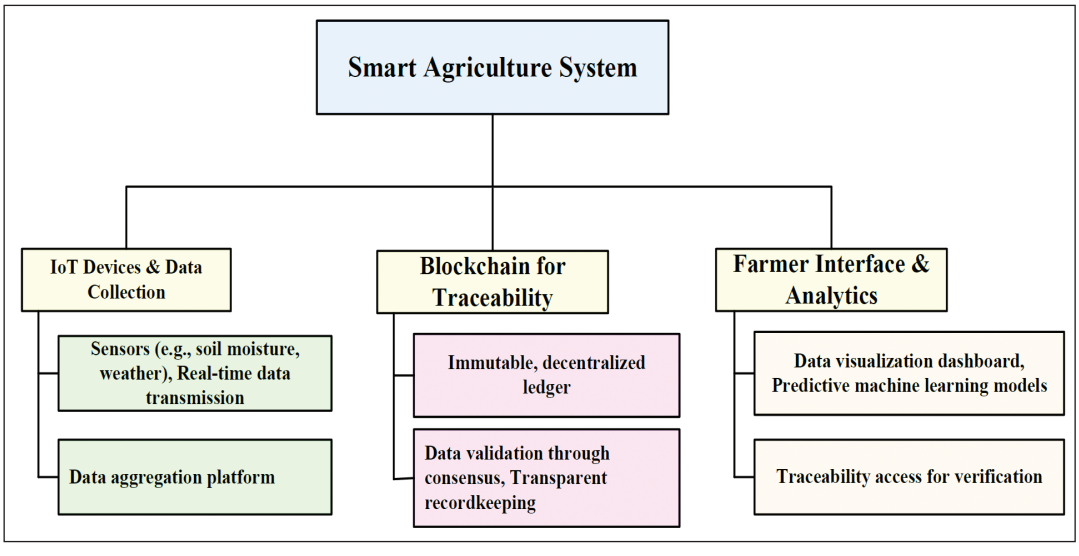

Figure 1. Smart Agriculture System

shows the integration of IoT, blockchain, and data analytics, all working together to enhance the supply chain of agriculture, ensures food safety, and optimizes traceability.

2. Blockchain Integrated Agri-Food Supply chain

Agricultural fraud demands traceability in food supply chains, but traditional solutions face cost and security concerns when adopted. Blockchain technology has the potential to solve these problems and improve quality control and management [9]. Blockchain technology has potential solutions to issues such as adverse financial impacts, brand value degradation, compromised consumer trust, fraud, supply chain transparency in agri-food supply chains [10]. Supply chains are transforming into automated infrastructure, which has advantages but also presents complications for traceability and data origin tracking. Although Ethereum blockchain and smart contracts are employed in a blockchain-based agriculture and food solution, conventional supply chains still lack accountability, transparency, and predictability [11]. The increased attention on food safety and corruption as a result of globalized industry and agricultural production has made robust traceability systems imperative. To authenticate requirements such as the country of origin, crop development stages, and quality regulations, blockchain presents an innovative approach for traceability in these intricate ecosystems [12]. By resolving credibility challenges, blockchain technology is transforming the effectiveness of supply chains. It is anticipated to enhance schedules, interruptions, and intermediaries in sustainable agriculture supply chains (ASC) [13]. By leveraging blockchain technology, the suggested approach eliminates the necessity for agents and centralization by establishing an open platform for cooperative farming. Traceability is accessible via Agri-Block-IoT, while smart contracts manage transactions and connectivity [14]. Table 1 shows the use of blockchains in agriculture.

Blockchains are critical for agriculture since they deliver supply chain management and food origin supervision. They offer enhanced safety, rendering data impenetrable. Agri-business operations can operate more efficiently due to the real-time updates on the quality of goods and transit time that IoT devices, including smartphone apps, provides [15]. Examining blockchain's potential use in agriculture,

Table 1. Uses of Blockchain in Agriculture

	Topics	Details
1	Blockchain in Agri-Food Supply Chains	Addresses issues like financial impacts, brand degradation, consumer trust, fraud, and transparency in agri-food supply chains [10].
2	Automated Supply Chain Infrastructure	Transformation into automated systems enhances efficiency but complicates traceability and data origin tracking [11].
3	Traceability with Blockchain	Blockchain ensures robust traceability systems for food safety and quality, addressing concerns in globalized agriculture [12].
4	Enhanced Supply Chain Effectiveness	Blockchain resolves credibility challenges, improving schedules, reducing intermediaries, and supporting sustainable agriculture supply chains [13].
5	Agri-Block-IoT and Smart Contracts	Provides an open platform for cooperative farming, enhances traceability, and automates transactions and connectivity through smart contracts [14].

specifically focusing on issues related to food traceability and potential difficulties arising from the heavy application of pesticides and fertilizers [16]. Despite the need for additional scale and adoption, NFC and RFID technologies are promoting sustainability and transparency in agri-food supply chains, strengthening customer trust, and ensuring accountability [17]. Automation and IoT technologies, such as barcodes, QR codes, RFID, and wireless sensor networks, create effective transparency and traceability solutions imperative due to the complexity of agricultural supply chain management [18]. With its capacity to link untrusted nodes in intricate food supply chains and guarantee protocol adherence, blockchain technology offers integrity and dependability [19].

3. Recommendations

Based on the literature review conducted for this study, we propose following recommendations for improved agri-food supply chain.

- An integrated assessment of blockchain's performance in delivering cost-effectiveness, scalability, and efficiency when paired with cutting-edge technologies like IoT, AI, big data, and cloud computing has been missing from currently available studies.
- Blockchain technology eliminates challenges with agricultural data tracking through streamlining supply chain management in agriculture by facilitating peer-to-peer transactions directly without the need for intermediaries or financial institutions.
- Subsequent studies should investigate the regulations and standards pertaining to the agriculture industry, prioritizing stakeholder participation while carefully analyzing government roles in enforcing consistent standards throughout the supply chain.
- In order to facilitate the seamless integration of dispersed technologies, a new agricultural supply chain architecture must guarantee interoperability, scalability, security, privacy of personal data, and ease storage problems.
- In the agricultural supply chain, a shortage of information security and confidentiality has a detrimental effect on data transmission accuracy and discourages stakeholder transparency.
- Future studies should concentrate on empirical assessments of blockchain's effectiveness in real-time agri-food supply chains, with a particular emphasis on properties such as the source, accountability traceability, and immutability.

Conclusion

According to the literature review, there are still many unexplored blockchain, artificial intelligence, and IoT applications in agriculture, with very few real systems being created and put into place. To assess their possible advantages, real-time applications are required. This literature review explores blockchain technology's potential in the agricultural sector, focusing on food traceability issues, identifying current trends, challenges, and unresolved research questions. With the use of blockchain technology, a self-governing, transparent smart farming network involving all parties involved can be established. Agri-Block-IoT eliminates middlemen by fusing blockchain technology with IoT to monitor and create traceability for transactions throughout the agricultural supply chain. Blockchains and Industry 4.0 advancements are enhancing agricultural and food supply chain agility. However, challenges like disparities in digital infrastructure, awareness, and human resource capabilities need to be addressed to ensure widespread adoption.

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