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Blockchain Technology in Agri Supply Chain Management: A Transformative Approach

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Abstract
The agri-supply chain plays a critical role in ensuring the efficient and reliable distribution of food and agricultural products to meet the global demand. However, this complex system is marred by numerous challenges, including transparency, traceability, and trust issues. In response to these challenges, blockchain technology has emerged as a promising solution. This abstract delves into the application of blockchain technology in agri-supply chain management, highlighting its potential to revolutionize the industry. Blockchain, with its decentralized and immutable ledger, provides an innovative framework for addressing several persistent issues within the agri-supply chain. It enables seamless and transparent tracking of products from farm to fork, ensuring that critical information related to production, transportation, and storage is securely recorded and readily accessible. Furthermore, the technology promotes trust and integrity by reducing the risk of fraud and the tampering of records, thus increasing overall supply chain reliability. This abstract discusses key use cases and benefits of blockchain technology in agri-supply chain management, including the reduction of food fraud, improved food safety, enhanced traceability, and the facilitation of smart contracts for seamless transactions. Additionally, it explores some notable challenges, such as scalability and interoperability, that need to be addressed for the widespread adoption of blockchain in the agri-supply chain. The analysis highlights the transformative impact of blockchain technology and concludes by highlighting the transformative potential of blockchain technology in agri-supply chain management, emphasizing how it can lead to greater efficiency, trust, and sustainability throughout the agricultural supply chain, ultimately benefiting consumers, producers, and the industry as a whole.

Keywords: Block chain, Traceability, Supply chain, Transformation, efficiency

1. INTRODUCTION

In recent years, the global agricultural landscape has witnessed a paradigm shift in the way supply chains operate, driven by the integration of cutting-edge technologies. Among these, blockchain technology has emerged as a revolutionary force, promising to reshape the foundations of traditional agricultural supply chain management. As the world grapples with the challenges of ensuring food security, sustainability, and efficiency in the face of a growing population and dynamic market demands, the application of blockchain in agriculture has gained significant attention.

Blockchain, originally developed as the underlying technology for cryptocurrencies like Bitcoin, is a decentralized and distributed ledger that ensures transparency, security, and immutability of data. Its potential applications extend far beyond the financial realm, finding a natural fit in industries that demand trust, security, and transparency—qualities critical to the success of agricultural supply chains. This research paper explores the multifaceted impact of blockchain technology on agri-supply chain management, delving into its potential to enhance traceability, reduce fraud, improve efficiency, and foster collaboration among stakeholders.

In the following sections, we will navigate through the fundamental concepts of blockchain technology and its relevance to the intricacies of agricultural supply chains. Additionally, this paper will examine real-world use cases and pilot projects that have implemented blockchain solutions to address challenges in areas such as product traceability, quality control, and stakeholder collaboration. Through a comprehensive analysis, we aim to provide insights into the transformative potential of blockchain technology in revolutionizing the agricultural supply chain, ultimately contributing to a more sustainable, secure, and responsive global food system.

2. POTENTIAL IMPACTS AND BENEFITS OF BLOCKCHAIN TECHNOLOGY IN THE AGRICULTURE SECTOR

A. **Enhanced Traceability:** Blockchain provides a transparent and immutable ledger that allows for the real-time tracking of agricultural products from farm to table. This enhanced traceability is crucial for identifying the origin of products, ensuring food safety, and meeting regulatory requirements.

B. **Reduced Fraud and Counterfeiting:** The decentralized nature of blockchain helps prevent tampering and fraud in the supply chain. By recording every transaction and movement of goods on a secure ledger, the technology reduces the risk of counterfeit products entering the market.

C. **Improved Efficiency:** Blockchain technology streamlines and automates various processes within the supply chain, such as inventory management, procurement, and payments. This can lead to increased operational efficiency, reduced paperwork, and faster transaction processing.

D. **Smart Contracts and Automated Processes:** Smart contracts, self-executing contracts with the terms of the agreement directly written into code, can automate various aspects of agricultural contracts and transactions. This can lead to quicker and more secure payments, as well as automated compliance with contractual obligations.

E. **Data Sharing and Collaboration:** Blockchain facilitates secure and transparent sharing of data among stakeholders in the upply chain, including farmers, suppliers, distributors, and retailers. This improved data sharing can lead to better collaboration, coordination, and decision-making amongthe various entities involved in the agricultural supply chain.

F. **Access to Finance for Farmers:** Blockchain-based systems can provide a transparent and verifiable record of a farmer's production history and transactions. This data can be leveraged to establish creditworthiness, making it easier for farmers to access financial services such as loans.

G. **Market Access and Certification:** Blockchain can be used to certify and verify the authenticity of organic or fair-trade products, providing consumers with a transparent view of a product's journey from the farm to the market. This can be a valuable asset for producers seeking to differentiate their products and access premium markets.

H. **Sustainability and Compliance:** Blockchain technology can assist in tracking and verifying sustainable and ethicalpractices in agriculture. This is increasingly important as consumers and

regulatory bodies demand greater transparency and adherence to environmental and social standards.

3. EXAMPLES OF HOW BLOCKCHAIN TECHNOLOGY HAS BEEN APPLIED IN VARIOUS ASPECTS OF THE AGRICULTURAL SUPPLY CHAIN

Food Traceability:

A. **IBM Food Trust:** IBM Food Trust is a blockchain-based platform that enables end-to-end traceability of food products. It allows participants in the food supply chain, including farmers, processors, distributors, and retailers, to trace the origin and journey of food products. Major retailers and food companies have been involved in piloting this platform to enhance transparency and traceability.

Supply Chain Management:

B. **Walmart and IBM's Blockchain Pilot:** Walmart collaborated with IBM on a blockchain pilot project to improve the traceability of pork products in China. The project aimed to enhance the efficiency of tracking and documenting the production and delivery of pork from farm to store, reducing the time taken to trace the source of products.

Coffee Production:

C. **Transparent Supply Chains for Coffee (e.g., Farmer Connect):** Some coffee producers have implemented blockchain to provide consumers with visibility into the coffee supply chain. This includes details about the origin of coffee beans, the farming practices used, and the journey from the farm to the consumer. Such initiatives promote transparency and fair-trade practices.

Fruit and Vegetable Supply Chains:

D. **TE-FOOD: TE-FOOD**: is a blockchain-based food traceability solution that has been used in various countries to track and trace the supply chain of fruits, vegetables, and other food products. It helps in verifying the authenticity of food products and ensuring compliance with quality standards.

Fisheries and Seafood Industry:

E. Bumble Bee Foods and SAP: Bumble Bee Foods, in collaboration with SAP, implemented a blockchain solution to trace the supply chain of yellowfin tuna. This initiative aimed to improve transparency and combat illegal, unreported, and unregulated (IUU) fishing practices.

Dairy Industry:

F. **Fonterra's Blockchain Pilot:** Fonterra, a New Zealand-based dairy cooperative, has explored blockchain technology to enhance traceability in its supply chain. By using blockchain, Fonterra aimed to provide consumers with detailed information about the journey of dairy products from farm to shelf.

Cocoa Production:

G. **Kuapa Kokoo Farmers' Cooperative and Tony's Choco lonely:** This collaboration in the cocoa industry focuses on using blockchain to trace the cocoa supply chain. By providing transparency, the initiative seeks to address issues such as child labor and promote fair trade practices.

Wine Industry:

H. **EY's Blockchain Solution for Wine Traceability:** EY (Ernst & Young) has developed a blockchain solution for tracking the provenance of wine. The technology ensures the authenticity of premium wines and helps in preventing fraud in the wine supply chain.

These examples highlight the diverse applications of blockchain technology in agriculture, ranging from traceability and supply chain management to sustainability and fair-trade practices.

4. PROCESS OF BLOCKCHAIN MANAGEMENT IN SUPPLY CHAIN MANAGEMENT:

Blockchain management in the supply chain involves leveraging blockchain technology to enhance transparency, traceability, and efficiency in the movement of goods and information across the supply network. Below is a step-by-step process highlighting how blockchain can be managed within a supply chain:

A) **Identifying Use Case and Participants:** Define the specific use case for implementing blockchain in the supply chain. Identify the key participants in the supply chain, including suppliers, manufacturers, distributors, logistics providers, retailers, and possibly even end consumers.

B) **Selection of Blockchain Platform:** Choose a suitable blockchain platform based on the requirements of the supply chain. There are various blockchain platforms available, each with its own features and capabilities. Consider factors such as scalability, consensus mechanism, and smart contract support.

C) **Establishing a Consortium or Network:** Form a consortium or network of participants who will be part of the blockchain. Participants may need to agree on governance structures, data standards, and the rules governing the use of the blockchain. Consortiums can be formed by industry players or by a third-party entity overseeing the blockchain.

D) **Designing the Blockchain Architecture:** Work on designing the architecture of the blockchain. Define how data will be structured, stored, and accessed. Determine whether the blockchain will be public, private, or a hybrid. Address scalability issues and plan for interoperability with existing systems.

E) **Integration with Existing Systems**: Integrate the blockchain solution with existing supply chain management systems and databases. Ensure seamless communication between the blockchain and other IT systems to facilitate data flow across the supply chain.

F) **Data Input and Validation:** Participants in the supply chain input relevant data into the blockchain. This can include information about the production of goods, quality checks, shipping details, and more. Data entries are validated by consensus mechanisms to ensure accuracy and prevent tampering.

G) **Smart Contracts Implementation (Optional):** If applicable, design and deploy smart contracts to automate certain processes within the supply chain. Smart contracts can automatically execute predefined actions when specific conditions are met, streamlining activities like payments, compliance checks, and order fulfilment.

H) **Real-time Tracking and Visibility:** Leverage the blockchain for real-time tracking and visibility across the supply chain. Every participant with access to the blockchain can trace the journey of goods from the source to the destination. This transparency enhances trust and helps identify and address issues promptly.

I) **Verification and Compliance:** Use the blockchain to verify the authenticity and compliance of products. This is particularly important in industries with strict regulatory requirements. The immutable nature of the blockchain ensures that compliance records are secure and unalterable.

J) **Secure and Efficient Payments:**If applicable, facilitate secure and efficient payments using blockchain technology. Smart contracts or blockchain-based payment systems can automate payment processes, reduce transaction costs, and minimize the risk of fraud.

K) **Continuous Monitoring and Improvement:** Regularly monitor the performance of the blockchain in the supply chain. Gather feedback from participants and continuously improve the system based on evolving business needs and technological advancements.

5. SAHYADRI FARMERS PRODUCER COMPANY LIMITED – A CASE STUDY

Sahyadri Farms was registered as a Farmer Producer Company (FPC) in 2010 under the provision introduced in Companies Act, 1956, Government of India. It's a collective that is owned and managed by farmers. It is India's largest Farmer Producer Company and has highest share of grape exports from India compared to any other. Majority of the farmers within the collective are small landholding farmers. Sahyadri Farms partnered with Emertech Innovations Pvt Ltd to onboard the valuechain allied activities on a Blockchain platform named AgroTrust, The project for Fruits & Vegetables traceability began in April 2019, and lasted until June, 2022. A total of 5.2 million Blockchain-backed QR codes were printed during the project duration. The project for cotton-to-cloth initiative, under SFPCL's allied initiative of Sahyadri Farms Sustainable Grassroots Initiative Limited (SFSGIL) with the commercial brand name of 'RU', began its live operations in February,2022 with over 35,000 Blockchain-backed QR codes bring printed on T-shirts.The project seeks to incrementally add more information to the QR codes with subsequent integrations and development of new modules. AgroTrust blockchain transparency solution is a consortium blockchain network based on the principle of 'One Crop, One Blockchain'.

It is implemented using the Multichain protocol which is a built by taking of Bitcoin client and enhanced for permissioned blockchains. Consensus mechanism used in this protocol is a randomized validation based on distributed agreement between permissioned block validators similar to PBFT. Multichain allows fine grained permissions control at address or node level and implements streams which are on-chain key-value data stores with timestamps and publisher identity. Streams are used to record and retrieve immutable data onto a blockchain. **(Gaurav Somwanshi et al 2022)**

Upon scanning the QR code of the item, customer can see - Know Your Farmer, Know Your Money, Know Your Journey and Know Your Food, along with Sahyadri Farms brand logo and 'Why Blockchain?' content for making consumers aware about the technology. one can witness by scanning QR of SKU, in which one can see the amount received by the farmer with respect to how much the end consumer is paying for the final product. Owing to the nature of the data availability and data capture, the QR codes could show varying degrees of information. Transparency regarding how much money goes to the farmer defined per SKU is a first of its kind initiative in India. Consumer awareness and consciousness is now being channelized by offering them visibility of what happens in the journey of the food that they consume. The rising awareness, along with maintenance of food quality and safety standards, leads to more consumers for the farmer collective which in turn enables the collective to off er better prices to the farmers. As of 28th June, 2022, more than 5.2 million QR codes have been printed with a range of 5000 to 24,000 QR codes depending upon supply and consumer demand of fruits and vegetables. For SFSGIL-RU brand, over 35,000 T-shirts are equipped with a Blockchain-backed QR code. The successful implementation has been covered by the mainstream media for Blockchain-based traceability and transparency **(Wadke 2020).**

It's important to note that the adoption of blockchain technology in agri-supply chain management is an evolving process. While the potential benefits of implementing blockchain technology in agriculture are significant, there are several challenges that need to be addressed for successful adoption.

6. SOME OF THE KEY CHALLENGES ADOPTION OF BLOCKCHAIN TECHNOLOGY

A. **Lack of Awareness and Education:** Many farmers and stakeholders in the agriculture sector may not be familiar with blockchain technology. There is a need for awareness campaigns and educational programs to help them understand the benefits and functionalities of blockchain in the context of agriculture.

B. **Limited Infrastructure:** In certain regions, especially in developing countries, there may be limited access to the necessary technological infrastructure, such as reliable internet connectivity and computing devices. Blockchain implementation requires a robust technical infrastructure, and the lack of it can hinder adoption.
C. **Data Standardization:** The agricultural sector involves diverse stakeholders, each maintaining their own data standards and systems. Achieving interoperability and seamless data exchange between these systems can be challenging. Establishing common data standards is crucial for the effective implementation of blockchain.
D. **Integration with Existing Systems:** Many agricultural businesses already use various software and management systems. Integrating blockchain technology with existing systems can be complex and may require modifications to ensure compatibility and smooth data flow.
E. **Costs of Implementation:** The initial costs associated with implementing blockchain technology, including infrastructure setup, software development, and staff training, can be substantial. For small-scale farmers or organizations with limited resources, these costs may pose a barrier to adoption.
F. **Scalability:** As the number of transactions and participants in the blockchain network increases, scalability becomes a concern. Some blockchain platforms may face challenges in handling a large volume of transactions efficiently. Scaling solutions are necessary to accommodate the needs of a growing agricultural ecosystem.
G. **Regulatory Uncertainty:** The regulatory environment for blockchain in agriculture may not be clearly defined in some regions. Uncertainty regarding legal frameworks and compliance requirements can slow down adoption, as stakeholders may be hesitant to invest in a technology with uncertain regulatory implications.
H. **User Trust and Acceptance:** Building trust among farmers, suppliers, and other participants is essential for the success of a blockchain initiative. Resistance to change, scepticism, or a lack of trust in the new technology can be significant hurdles in the adoption process.
I. **Privacy and Security Concerns:** Protecting sensitive agricultural data and ensuring the privacy of participants are critical considerations. Blockchain itself provides a high level of security, but it is essential to address concerns related to data access, permission controls, and identity management.
J. **Environmental Impact (Proof of Work):** Some blockchain networks, especially those that use proof-of-work consensus mechanisms, are criticized for their environmental impact due to energy-intensive mining processes. This concern may lead to hesitation in adopting blockchain technology in regions with a strong focus on sustainability.

Overcoming these challenges requires a collaborative effort from industry stakeholders, policymakers, and technology developers. As the technology matures and best practices are established, the adoption of blockchain in agriculture is likely to become more widespread**.**

7. CONCLUSION

In conclusion, the research paper has delved into the transformative potential of blockchain technology within the intricate landscape of agricultural supply chain management. The multifaceted impact of blockchain in enhancing transparency, traceability, and trust has emerged as a promising solution to address the evolving challenges faced by the global agricultural sector. Blockchain's ability to establish a decentralized and secure ledger has significantly altered the traditional paradigms of supply chain management. The immutability of the blockchain ensures that every transaction and movement of

agricultural products is recorded transparently, providing stakeholders with an unprecedented level of visibility and traceability. This transparency not only fosters accountability but also acts as a powerful tool in addressing issues related to food safety, fraud prevention, and adherence to quality standards. Real-world examples and pilot projects have been scrutinized, highlighting the practical applications of blockchain technology in addressing specific challenges within agricultural supply chains. Whether it be the verification of organic or fair-trade certifications, the reduction of fraud, or the facilitation of efficient payment systems, blockchain has proven to be a versatile and impactful solution.

As the agricultural sector continues to grapple with issues of sustainability, efficiency, and global demand, the adoption of blockchain technology stands out as a beacon of innovation. However, it is essential to acknowledge the challenges that accompany this transformation, including issues of infrastructure, data standardization, and the need for widespread education among stakeholders.

REFERENCES

1. Nakamoto, S. (2008). Bitcoin: A Peer-to-Peer Electronic Cash System. Retrieved from https://bitcoin.org/bitcoin.pdf
2. Tapscott, D., & Tapscott, A. (2016). Blockchain revolution: how the technology behind bitcoin is changing money, business, and the world. Penguin.
3. Mougayar, W. (2016). The Business Blockchain: Promise, Practice, and Application of the Next Internet Technology. John Wiley & Sons.
4. Iansiti, M., & Lakhani, K. R. (2017). The Truth About Blockchain. Harvard Business Review, 95(1), 118-127.
5. Swan, M. (2015). Blockchain: blueprint for a new economy. O'Reilly Media.
6. Huckle, S., Bhattacharya, R., & White, M. (2016). Internet of Things, blockchain and shared economy applications. Procedia Computer Science, 98, 461-466.
7. Yin, R. K. (2014). Case study research: Design and methods. Sage Publications.
8. World Food Programme. (2017). Building Blocks: Blockchain in UNICEF's Humanitarian Cash Transfers. Retrieved from https://innovation.wfp.org/project/blockchain-unicefs-humanitarian-cash-transfers
9. Khatri, V., & Dahiya, R. (2019). An Overview of Smart Contracts and Their Potential in Agriculture. Journal of Advanced Research in Dynamical and Control Systems, 11(05), 1083-1090.
10. Food and Agriculture Organization (FAO). (2018). Digitization of Agricultural Value Chains in India: A Guidebook. Retrieved from http://www.fao.org/3/ca2310en/ca2310en.pdf PricewaterhouseCoopers (2016, October) Fighting $40bn food fraud to protect food supply. PricewaterhouseCoopers Malaysia.
11. Ministry of Agriculture, Government of India (2013) Policy and Process Guidelines for Farmer Producer Organisations.
12. Tiwari S (2020, December 9) MSP and Public Procurement.
13. Gaurav Somwanshi*, Pratap Deshmukh, Ganesh Anantwar, Manish Verma, Areeb Mohammad Khan, Aarti Tiwari, Danish Siraj, Gunvant Sarpate, Mandar Darade, Vikas Taklikar, Netan Mangal, Syed Burair, Renuka Paturkar, Gajendra Sahu and Rohit Dhivare Empowering Farmers with Blockchain-based Transparency Throughout the Value Chain Indian J. Plant Genet. Resour. 35(3): 41–45 (2022)