Journal of Research in Science and Engineering (JRSE)
ISSN: 1656-1996 Volume-6, Issue-7, July 2024
DOI: 10.53469/jrse.2024.06(07).17

Analysis of Blockchain Technology Challenges and Potential Research Directions Faced by the Agricultural Industry

Naresh Kumar Miryala

Dean, Faculty of Science and Technology, International University of East Africa, Kampala, Uganda

Abstract: ***Agriculture is a critical industry for delivering to consumer's food that is sufficient, affordable, safe, and sustainable fodder, and diverse agricultural products. It is critical to make the producer - consumer interaction work efficiently and productively by utilizing different technologies. Industry 5.0 - supported blockchain technology was developed to provide accurate transaction records to all agri - food value chain participants. This study is a systematic literature review that identifies the most recent developments in blockchain technology, the main applications and challenges in the agri - food value chain, as well as the experiences of countries that have good experience using blockchain technology in the agricultural industry, to enable other countries that want to use blockchain technology to do so from a more informed perspective. It employs analysis. According to the findings, blockchain technology, in conjunction with current ICT and IoT technologies, has enhanced the management of the agri - food value chain in five major areas: information reliability, information security, production, cost, and use of water. By realizing the potential of blockchain technology and performance improvements in areas such as food safety, food quality, cost - effectiveness, and food traceability, this study can contribute to the existing literature and future research in the field of agricultural value chain management.***

Keywords: Food sustainability; traceability; blockchain technology; security and transparency; digitization

1. Introduction

The main driver of innovation in human development is agriculture. The industrial revolution that gave rise to our cities and towns in the 1700s was triggered by the British agricultural revolution. Because of the evolution and support provided by plants and animals, it has largely increased steadily. For instance, imported plant and animal species were essential to commercial Australian agriculture. On the other hand, agriculture still makes use of technology. By developing farming inputs like seeds, assets, and agricultural supplies as well as agricultural outputs like wheat, wool, and cotton, Potts and Kastelle (2017) boosted agricultural production.

Technological advancements are new inputs or innovative methods to transform them into results through the advancement of technology for expertise and security. Agricultural technical innovation is primarily concerned with the farm and its potential production. Farms, on the other hand, give crops, cattle, and potential information. These data are information records that add value to the products that leave the farm. Such information is useful to all those that contract, process, transport, and serve as intermediaries or principal buyers for farm products. For data to be useful, it must not only be created and connected, but also be reliable. The development of blockchain closes the gap between the farm and the rest of the world. It helps by making off - farm storage of data gathered on the farm more affordable to transport.

1.1. BlockchainTechnology

Using a middleman - free electronic system called blockchain, it is possible to retain electronic records and validate and verify them. All users have access to the data, it is all publicly available, and the records are unchangeable and cannot be altered or deleted. Concepts related to governance, accountability, transparency, adaptation, availability, usefulness, manageability, and sustainability. Blockchain decentralized computing network that allows data to be recorded and exchanged while simultaneously offering security and anonymity. If the data is distributed, only the person with the private key can conduct transactions.

Improving agriculture is not a one - size - fits - all effort. The food chain needs to be more justifiable in order to boost consumer confidence and purchase intent. Identification and treatment of contamination sources depend on the tracking and validation of data across the food supply chain. Sustainability management investigates the factors that influence young Irish farmers will utilize machine learning and big data research, as well as cloud computing technology, for smart farming. Agricultural ICT necessitates ongoing coordination among diverse technologies.

Blockchain may be an evolutionary next step in the chain of production of food, as well as a way of increasing supply chain accountability by transferring correct data across supply chain stakeholders. The overall visibility of food goods across the supply chain will become a reality following the integration of Internet of Things and blockchain. The primary benefits of blockchain and the Internet of Things in the food supply chain include real - time monitoring and sensing of original food items from the source, which helps to identify key bottlenecks. Farmers employ chemical fertilizers, insecticides, and other materials to promote crop productivity, and vegetable growers frequently use toxic pesticides to spray vegetables to improve profitability, and people buy the same vegetables to eat, which is a problem. Traditional Internet of Things (IoT) traceability systems, which employ technologies like Near Field Communication (NFC), Wireless Sensor Networks

(WSN), and RFID, may track and record precise information during all phases of production, processing, distribution, and consumption. For the monitoring and tracking of food quality, it can offer useful information.

As a result, it is challenging for the majority of consumers to obtain complete transaction details and trace the provenance of goods. To ensure that products are secure, high quality and sustainable, consumers and those in the food chain must be thoroughly informed on the product life cycle (PLC). Since agri - food traceability has become a pressing concern for farmers, producers, cold chain managers, governments, and consumers, concerns relating to data privacy and tamper - proofing are crucial. As no single party in the supply chain may change existing information, blockchain technology is considered as a potential technology that can help in the establishment of trust mechanisms for tackling transparency and security concerns. Blockchain is a distributed and decentralized system made up of blocks with a time stamp and a cryptographic hash connecting them.

1.2. Agriculture's Branches and the Associate Procedures

Agriculture, which includes horticulture, includes the science of livestock, animal husbandry, agricultural production, soil management, and agronomy breeding in addition to the cultivation of plants, fruits, and vegetables. Numerous agricultural branches and sub - branch are shown in Figure 1.

Figure 1: Disciplines andsub - discipliness in agriculture

1.3. Agriculture's Biggest Problems and Potential Blockchain Solutions

Figure 2 summarizes fundamental problems of agriculture and maps them to solutions that can be given by blockchain technology.

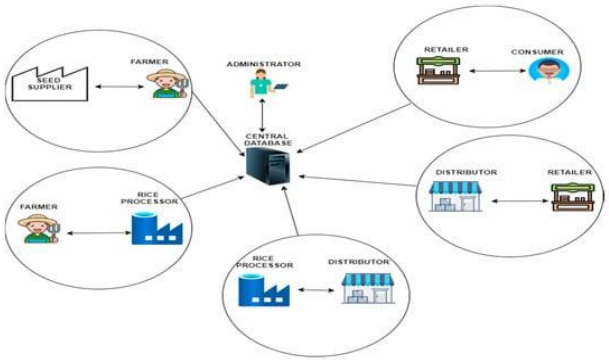

Figure 2: Agriculture challenges mapped to blockchain - based solutions

Blockchain serves as a distributed, unchangeable, and unhackable ledger where ecosystem participants can keep transactions. Information regarding the condition of the ecosystem can be found in this data resource with confidence. In an agricultural ecosystem, the essential information about farm status, inventory, contracts, and administration are collected and recorded on the blockchain. Farmers can achieve higher decentralization, provenance, nonrepudiation, payment, and automation of the commodities transaction with the use of this reliable data storage technique.

1.4. Motivation and Contribution

The motivation behind this paper is the emergence of blockchain technology and its application in the supply chain ecosystem. Due to its immutability property, blockchain can offer better security, increase trust, and prevent unwanted alteration. Blockchain technology and the Internet of Things in agriculture and food systems supply overcome information dependability challenges. The majority of the solutions are ad hoc or work in isolation. Due to limitations in the existing literature, we decided to create a futuristic smart modelbased on smart technologies to satisfy the requirements of each and every agricultural stakeholder and the food supply chain by combining IoT and blockchain technology, which allows for traceability management to be applied throughout the food supply chain and addresses the main centralized format challenges of trust, transparency, and accountability These constraints compelled us to create a distributed, efficient, and secure system to improve crop productivity, assure end - to - end traceability of agricultural items, and prevent food fraud in the supply chain. The goal would be to create a distributed and automatic farm food supply chain traceability model that allows for the implementation of multiple quality levels based on consumer needs. The paradigm employs not only transaction data but also smart contracts, allowing for end - to - end traceability and data security.

2. Literature Review

The broadly defined verticals spanning agriculture, as shown in Survey and review are shown in Figure 4, together with IoT and sensor - based smart agriculture, including supply chains, funding, commercialization, governance, and obstacles. The influence of the research in each vertical direction is briefly covered in this section.

One of the emerging technologies that will have an impact on most areas that function in a collaborative setting is blockchain technology. A distributed ledger system is used. that enables various entities to interact with one another directly in a peer - to - peer network without the need for a middleman. It has several properties, as illustrated in that support more openness and trust in a cooperative setting (Figure 2).

Because of its decentralized character, it cannot be controlled by a single entity. The agreement of all parties on the execution of a transaction is referred to as consensus. It has a provenance capability that allows the history of every transaction to be tracked back. All transactions are updated in the distributed ledger so that they are visible to all network nodes that are linked to it. Immutability is one of

the most significant characteristics that make it tamper - proof. Once a transaction is recorded on the distributed ledger, it cannot be changed or deleted. Smart contracts are also supported. A smart contract is a computer program that encapsulates the logic of a contract entered into between two or more entities.

2.1. Blockchain Research and Review on Agriculture

Potential uses, a look ahead, astute trends, environmentally friendly and sustainable projects, enabling technology, reducing problems and obstacles, offering solutions, optimizing supply chains, fortifying security measures, and contemporary finance are some of the primary categories into which this article falls. A review is conducted regarding Agriculture 5.0 and the future of agricultural industrialization. and blockchain applications in agriculture are examined. Studies of cases of IoT solutions constructed using blockchain platforms explored, demonstrating how blockchain may handle privacy and security concerns in tandem with green IoT. This paper gives an overview of blockchain - based traceability solutions based on a study of smart agriculture traceability systems for agriculture and highlights the need for novel privacy - preserving strategies.
A look at blockchain - based applications in the food industry and traceability systems. Future and intelligent agricultural technologies are provided for the application of blockchain in industries other than Bitcoin. A look at agricultural insurance applications on the blockchain as an example of financial governance in the agriculture industry. IoT uses in smart agriculture. In the section of Anada’s plan for policy and research on blockchain relevance, a case study is offered. It discusses data management in e - agricultural and illustrates security concerns in smart cities and agricultureIoT and blockchain integration for agriculture is discussed in terms of a business viewpoint on - farm applications in the blockchain. An overview of blockchain - based pest control solutions is offered, as well as blockchain technology for the agriculture food sector and a look at future technologies in the transformative agriculture system.

2.2. Blockchain applications in agriculture combined with IoT, smart technologies, and sensors

The food supply chain can be made more secure, transparent, and traceable with the help of a new technology using blockchain. IoT may be used to gather sensor data, It can then be applied to raise the agricultural output's efficiency. By fusing blockchain and IoT, an intelligent and safe agriculture system can be produced. Food safety and quality can be ensured, food origins can be tracked, and agricultural production may be optimized by utilizing blockchain, IoT, smart technology, and sensors in agriculture.

There was a universal agreement that the majority of surveys and reviews are incomplete and vertical - specific. That part of the study that remains provides, thus, vertically specific coverage throughout numerous research in all areas.

Figure 3: Agriculture blockchain integration with IoT, smart technology, and sensors

As with other blockchain - based applications including Smart contracts can be used to manage digital animal identification, food safety and provenance, and supply chain management, land registry procedures, and farmer's credit programs. It describes collection, storage, and sharing, as well as how IoT sensors and blockchain might be used to build an autonomous greenhouse environment. Food safety, supply chain management, and traceability can all benefit from IoT sensors by interpreting sensor data and demonstrating big - data analysis. We are concentrating on enhanced data management, a decentralized market for agricultural goods and services, food supply chain management, supply chain transparency, security, and quality, decentralized big data and knowledge, climate, weather, and agricultural production data. In addition, by presenting a new provenance

2.3. Blockchain use in agriculture for financial gain

The usage of blockchain technology is used in a variety of areas, including supply chain and finance. By enabling autonomous financial settlement, audit, and reconciliation systems that are more open and detectable fraud, the agricultural industry could undergo a revolution because to the technology. Consequently, a secure payment and transaction system for the agricultural sector might be created using blockchain technology.

KRanTi, a program for farmer credit powered by blockchain created in India, was aimed at assisting the nation's small and marginal farmersto receive financing more swiftly. The authors go on to explain how the initiative works and how they expect it to increase India's agricultural and food supply chain's effectiveness. This strategy teaches farmers how to use smart contracts to increase their income in the agricultural supply chain. Agrion Block is an Agriculturalist that can safely gather and store data on their crops and livestock using a blockchain - based data harvesting technology. Farmers also have access to crucial data and services from partners in the public and private sectors. Individual farmers can also create digital identities that can be used on the site.

They contend by using smart contracts, the various supply chain partners will be able to coordinate their efforts exchange information more effectively. This would result in greater food traceability, lower prices, and more efficiency. ICT (information and communication technology) has the potential to shorten the process's duration and increase its

effectiveness. Lenders' ability to make better decisions is enhanced by using ICT to improve the quality of the information at their disposal. For the purpose of protecting data from agricultural sensors and other equipment, the platform uses blockchain technology. Farmers will be in a better position to monitor data and manage their crops. The strategy aims to increase the effectiveness and transparency of the food supply chain while outlining potential advantages for both consumers and food producers. The proposal aims to lower costs and improve supply chain transparency and traceability while helping small and medium - sized enterprises (SMEs) secure funding.

2.4. Blockchain Technology for Supply Chain Management in Agriculture

People nowadays want to know where their food originates from. A desire to eat healthy, along with increased acceptance of the technology in all areas, has led agribusinesses to seek supply chain management software Enhancing food safety food quality, and the capacity to track back thecomplete farming supply chain. **Demand for information about food**

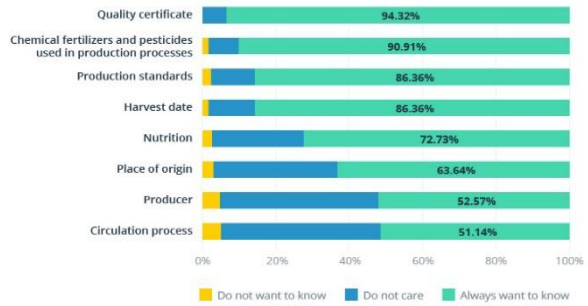

Figure 4: Distribution of the food supply chain.

The Internet of Things has proven to be a critical technology and a key factor in the digital revolution as demonstrated by Industry 4.0 and 5.0. IoT is predicted to rely more on sensing devices, a wide range of data, and more connected devices in varied network topologies. As a result, it is necessary to refer to it as the Internet of Things 2.0. The Internet of Things 2.0 is shifting away from sensors and data technology and toward actionable insight. When IoT is integrated with cloud computing, artificial intelligence, and machine learning, it becomes more efficient. Another key contribution to the digital transformation of numerous fields is the integration of blockchain technology with IoT. Blockchain is expected to bring $176 billion to the global economy by 2025 and $3 trillion by 2030 by combining it with IoT. The most relevant blockchain and IoT predictions for 2030 are depicted in Figure 8.

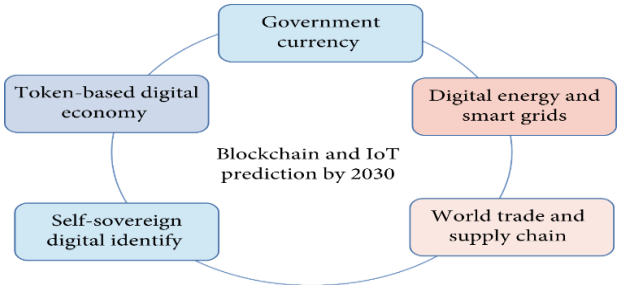

Figure 5: Blockchain and IoT prediction by 2030.

Because a proper food traceability system is not available in the modern world, the problem of health and food safety is developing day by day. The most common cause of foodborne illness is contamination, which is difficult to trace in the traditional food supply chain because the process is not visible. However, IoT with a blockchain system will solve the problem by establishing a distributed system and removing the third party from the system at the same time. Concerns regarding the ingredients in the food products that consumers purchase exist and the origins of the products they buy in the traditional supply chain. The essential issue here is to pique the curiosity of customers, which is tough to do because the system is closed. By constructing the essential issue here is to pique the curiosity of customers, which is tough to do because the system is closed. IoT and blockchain technology have the potential to eliminate these difficulties by increasing customer trust. In this system, each product has a digital identity that stores information from the place of origin to the retailer's end. IoT combined with blockchain can result in a more transparent and linked system.

Traceability is the ability to track an item's or product's life cycle, movement, or position across its supply chain. Traceability is enabled in a blockchain - based supply chain management system by using tamper - resistant timestamps and digital signatures. The provenance of a good or service is tracked and verified using a blockchain - based provenance system. Anything's origins can be tracked with this approach. Food, wine, artwork, and antiquities, this method can track their history. Businesses may verify that they are offering the highest - quality products and services to their clients by monitoring the country of origin of their goods or services. This strategy can also help businesses prevent fraud and counterfeiting.

To promote sustainable development by implementing blockchain technology in agricultural supply chains. The possible advantages of creating an agricultural supply chain that enables improved transparency and traceability of organic food products for both producers and consumers. The testing findings demonstrated that this approach would significantly lower transaction costs and increase buyer - farmer confidence. Four levels of blockchain maturity exist: basic, intermediate, advanced, and expert. A corporation must fulfill the prerequisites at each level in order to move up the ladder. Consequently, the methodology may be applied to evaluate an organization's blockchain performance and pinpoint areas in need of development.

2.5 Using Blockchain to Manage Livestock

Accuracy and efficiency in stock management can be improved by utilizing blockchain technology in livestock management. Blockchain technology can digitize and make visible the entire process, increasing the accuracy of stock data and making it error - proof. Furthermore, by automating transaction tracking and documentation, blockchain can enhance the stock - management procedure. These data showthat there is a demand in the United States for blockchain - traced beef. They suggested fish producers keep their data in a secure manner using an infrastructure built on blockchain. Massive amounts of agricultural data

are intended to be safely and impenetrably stored for farmers by means of this platform.

Data reconciliation across Farmers, processors, merchants, and consumers are among the supply chain stakeholders made feasible by a blockchain - based reconciliation system intended to boost consumer confidence in the traceability of the beef supply chain. By doing this, the route of beef from farm to table would be documented in a transparent and unchangeable manner, guaranteeing that all parties involved have access to the same data. The authors claim that this would improve supply chain transparency and traceability while also boosting consumer confidence in the safety and quality of cattle products. The device measures temperature, pH, dissolved oxygen, and ammonia levels, among other characteristics relating to water quality. Transparent and impenetrable data collection and analysis are made possible by the capture and storage of sensor data on a blockchain.

2.6 Blockchain's use in Agriculture for Governance, Management, and Production

Still, there are a few noteworthy instances of how technology is being applied to enhance food governance, administration, and production. This can help create a more open and effective food production system and reduce the need for central authorities to control food production. Lastly, the governance of the food system may be enhanced by blockchain technology. To track food subsidies and other government activities related to food, for instance, it can establish a more accountable and transparent system.

The results of the simulation demonstrate that Blockchain technology has the potential to improve the marketing and production efficiency of organic vegetables. Transparency, traceability, and cost savings are just a few advantages that the technology can offer. However, it also brings to light a number of problems that need to be resolved before blockchain is widely applied in agriculture, including the requirement for regulatory clarity and standards. The algorithm aims to enable the safe, efficient, and decentralized management of these resources and can be applied to control the distribution of new and renewable energy sources.

With the help of blockchain technology, the suggested app creates a decentralized market place where producers and buyers may communicate and do business without the need for an intermediary, allowing small farmers in poor nations to sell their produce directly to consumers. Farmers can get better pricing for their products, while shoppers can get fresh local produce. AgroChain is a blockchain - based network that effectively and transparently links farmers with agribusinesses and consumers. Technology can help reduce the possibility of fraudulent activity while also improving farmers' ability to track the quality and quantity of their produce. They contend that the process may be made more time - consuming and efficient by using information and communications technology (ICT), and the public can receive higher - quality information as a result.

3. Research Methodology and Proposed Model

We've recommended a solution that enhances the ecosystem of the supply chain by utilizing blockchain technology and associated ideas. In the traditional method, the manufacturer of the product creates the product and the customer consumes it. A producer makes a product and sells it to a processor for data processing at the next step of the supply chain ecosystem. At the highest level of the supply chain system, the distributor purchases it from the processor. The next tier of merchants are bought it from the distributor. The retailer then sells the item to the end customer. In this conventional method, Blockchain technology, which is decentralized, is used in our proposed paradigm. Decentralized means that no single party may control the entire supply chain ecosystem. Because it enables a peer - to - peer network model, there will be no client - server method. Every piece of data will be distributed fashion. Should a few of the systems malfunction, the network's performance will be unaffected. Every transaction is transparent to all stakeholders. Historical data is also stored in the blockchain so that the consumer may readily authenticate the product's origin. The primary components of the proposed model'sblockchain - supported supply chain ecosystem are it supports a peer - to - peer network of Interplanetary File System, digital documents, Ethereum Blockchain, and System Users, there will be no client - server approach. All of the components are linked together so that they can communicate with one another. These blockchain - enabled components are addressed further below.

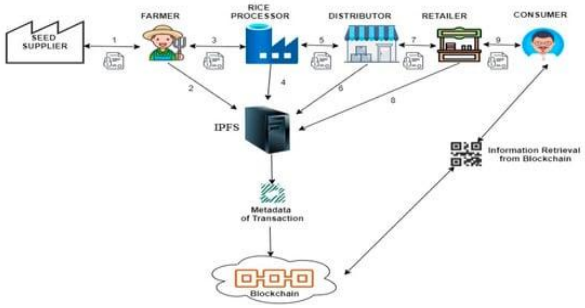

Figure 8 Blockchain Supported Supply Chain Ecosystem

1) Digital Documents: These are the paperwork that various parties, including the producer, distributor, retailer, and so forth, post while producing and shipping their products to clients. such as purchase orders, dispatch advice, payment advice, and so forth. One of the most important features of the suggested paradigm is this. Because these documents will be seen by multiple entities during the process, their security and integrity are critical because tampered with or altered documents might lead to fraud. Such fraud might result in significant losses for stakeholders, undermining their faith. Sohe Ethereum blockchain, the following element of the suggested strategy, is used to offer decentralized access control.

2) Ethereum Blockchain: Ethereum is an open - source blockchain platform for developing decentralized apps. It uses a ledger to keep track of transactions. Transactions pertaining to document access can be saved using this

method. Document access transactions cannot be updated due to the blockchain's immutability. Because of the blockchain's block size limitations, documents cannot be stored on the Ethereum blockchain. To save digital documents, off - chain storage is essential. IPFS, which will be addressed later, is used to meet our demand for off - chain storage.

3) IPFS: A distributed system for storing and retrieving data, including papers, webpages, and apps, is the Interplanetary File System. Any file can be addressed by its content thanks to the content - addressing approach it uses. Whenever a file is stored on IPFS, a distinct cryptographic hash is generated and returned. To locate or identify that file, use this hash. As long as two files with identical contents have the same hash, it also avoids data duplication. In the suggested paradigm, digital documents will be secured and saved on IPFS.

4) System User: Any process stakeholder, such as a customer, retailer, distributor, or manufacturer, might be the system user. Each system user is given a pair of keys that they can use to access the digital documents associated with them.

3.1 Smart Agriculture

The agri - food systems provide critical data and information on natural resources that support all types of farming. Figure 13 depicts data and information flow, as well as product flow from input to output via various value - adding stages, and money flow from output to input. Data and information are generated and managed by many actors and stakeholders based on their requirements and capacities. Traditional data management methods are centralized and vulnerable to faulty data, data distortion and misuse, and cyber - attack. Environmental monitoring data, for example, is typically maintained by centralized government entities with vested interests. They have the ability to influence data - driven decision - making.

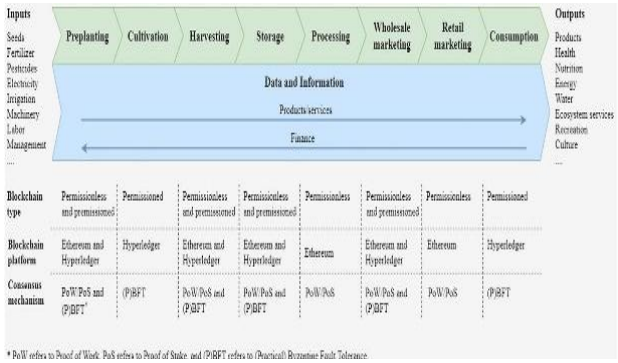

Figure 9: Along the food value chain, information and data are exchanged.

The influence of blockchain, particularly in agriculture, opens up a wide range of possibilities, the most motivating and beneficial approach would be to relate well - known blockchain technology to a specific subdomain of agriculture in order to better understand pilot research initiatives that would aid academics and practitioners.

3.2 IoT - Based Agriculture Protocol for the Smart Model

IoT nodes are ideal for cluster farms because they consume less energy than WSN and can be further reduced through an efficient clustering protocol. Therefore, this research proposed a new clustering protocol IoT - based agriculture, as shown in Figure 8, based on the LEACH protocol, to reduce energy consumption and extend network life.

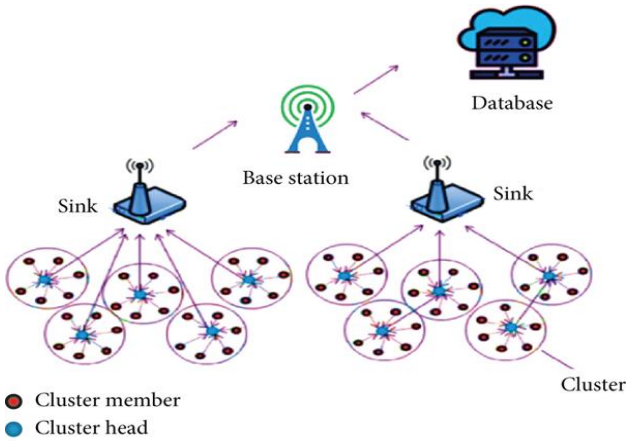

Figure 10: IoT based agriculture clustering protocol

3.2.1 Assumption for Simulation

The simulation assumptions are listed below. (i) IoT nodes a re randomly installed on a cluster farm. (ii) IoT nodes send h ello messages to the base station with local information. (iii) The initial number of clusters is calculated by taking the opti mal values to vary with node density before the node starts t o expire, and the smaller clusters become larger clusters. (iv) The base station and sink are installed outside the cluster far m.

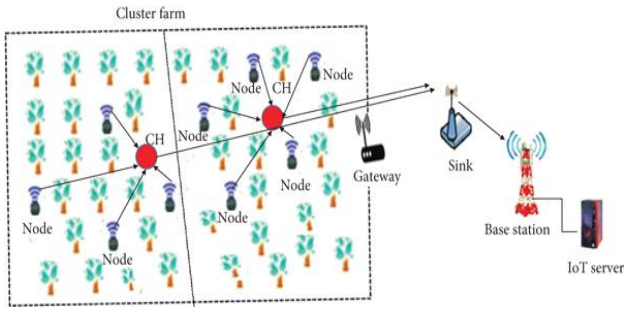

Figure 11 IOT - based Agriculture cluster farm and data tran smission

4. Proposed Method of Initialization Phase

A cluster farm with a total size of m2 was chosen and divided into clusters, with 100 IoT nodes deployed at random in each cluster. The capabilities of the IoT nodes, such as soil moisture monitoring, temperature monitoring, and crop disease tracking, were chosen. Cluster nodes are distributed in such a way that one cluster node communicates only with the cluster heads of their respective clusters, not with other cluster nodes. The CH of each cluster is responsible of communicating sensed data to the BS via the sink node. A widely used LEACH "First Order Radio Model" is used to broadcast a small message across a distance of d to attain a reasonable SNR.

Blockchain has the ability to alter food and agricultural supply networks and to promote transparency and traceability from farm to table by offering a safe, decentralized record for tracking the provenance of food products. This could help address a number of problems facing the agriculture and food industries, including fraud, waste, and food safety. Furthermore, blockchain - based applications have the potential to enhance stakeholder communication and logistics throughout the supply chain.

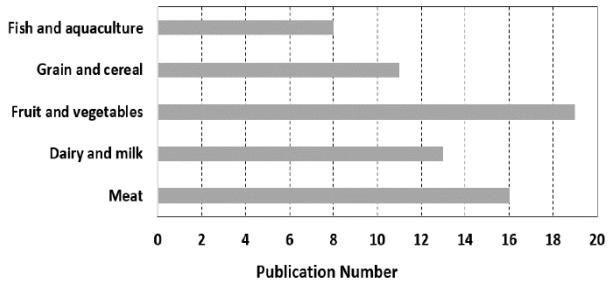

Figure 12 (a): Blockchain Technology's Function in Promoting Traceability Systems

The Internet of Things (IoT) and blockchain technologies can be combined to produce a more effective and efficient food supply chain. They draw attention to the fact that whereas IoT devices can provide real - time data on food product conditions. Blockchain enables the secure and transparent tracking of data. It is conceivable to create a system that can track food from farm to table and identify supply chain problems practically instantly by integrating these two technologies. This kind of system may help reduce food waste, enhance food safety, and boost the effectiveness of the food supply chain. It is stated how an inventive method uses Using blockchain technology, data collected from greenhouse sensors can be managed and stored securely, after which the data areput to use of blockchain - based service

A decentralized sustainable agriculture architecture was built and detailedwith the intention of establishing a decentralized market for agricultural goods and services as well as giving farmers access to information and tools that will enable them to enhance their business operationsBlockchain and IoT can assist in swiftly identifying issues and sources of contamination by tracing the food products from farm to table, allowing for the timely recall of faulty goods. By revealing details about the location and timing of food production, this traceability system can also aid in the prevention of food waste.

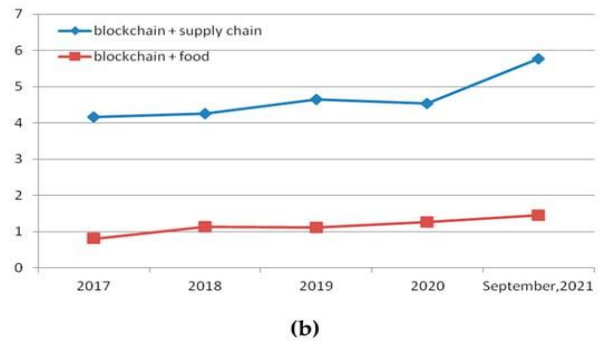

Figure 12 (b): Blockchain Technology in Encouraging Agri - Food Production Traceability Systems

The system tracks the passage of items from farm to table using RFID tags and sensors, with the blockchain acting as data storage, creating an immutable record that can be used to verify product authenticity. Additionally, the device comes with a smartphone application that lets users scan RFID tags. Blockchain has a lot of potential applications in cold food chain logistics. Cold chain logistics and traceable solutions for fresh agricultural items were investigated using blockchain technology. According to the authors, A system like this might offer a technical assurance for the whole food safety tracking process, from farm to table. Work on leveraging a dual - chain blockchain to establish traceability for agricultural e - commerce using the Vennia algorithm. The authors describe a blockchain - powered data monitoring, sharing, and privacy - protection strategy for a secure and reliable agricultural product tracing system. Traditional traceability systems have a single point of failure, which the proposed solution avoids. Additionally, it provides fine - grained data access control, guaranteeing that the data is only accessible to those who are permitted.

A cloud - based information supervisory system for agricultural product traceability is presented; this technology may provide a useful means of boosting the monetary worth of agricultural products. They suggest enhancing the effectiveness of supply chain management and cutting expenses by implementing a cloud - based agricultural product tracking system. Technology indicates that agricultural products can have a comprehensive and trustworthy traceability system. This can raise customer knowledge and enhance product management, which will raise the general caliber of agricultural products. A unique approach for agricultural product origin tracing based on blockchain technology is presented. Three nodes comprise the system: an auditor, a buyer, and a farmer. The farmer nodes are in charge of registering agricultural product information, the buyer nodes of tracking the sources of the items, and the auditor nodes of verifying the veracity of the information recorded by the farmer nodes.

The authors investigate how blockchain technology might be applied to agricultural product traceability systems, with the goal of reducing information asymmetry and increasing transparency in the perishable agricultural product supply chain. The authors develop a model that considers different degrees of information asymmetry and demand uncertainty while valuing blockchain technology. The results show that blockchain technology can enhance market outcomes and supply chain efficiency.

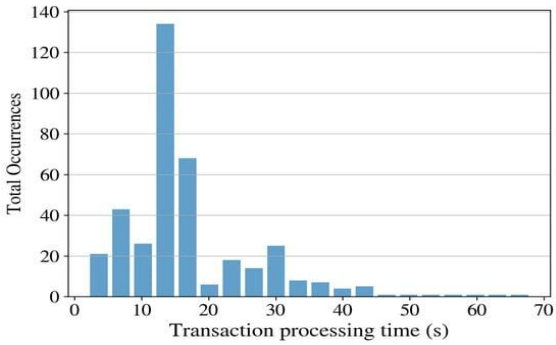

Figure 13: Features and Expense of Blockchain Technology Integration with Promoting Traceability Systems in Agri - Food Production

A method for placing blockchain nodes on virtual machines spread across several data centers to be used in an agricultural product tracking system. The node and network parameters, as well as the deployment process, are described in depth. To improve system performance and scalability. Cloud, blockchain, and IoT technologies have the potential to boost agricultural output and efficiency by increasing transparency and traceability. The data, application, and smart contract layers comprise a platform for collecting, evaluating, and sharing crop - breeding data that was decentralized, transparent, and impervious to tampering.

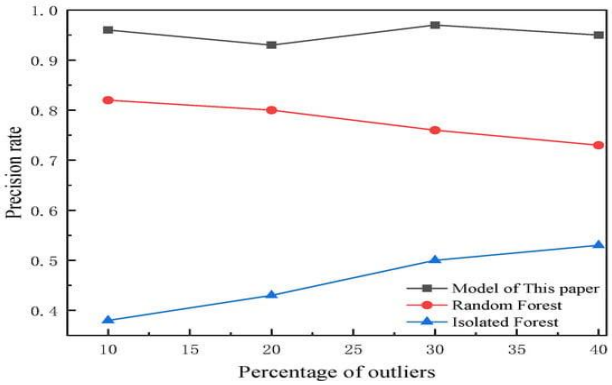

Figure 14: Design and execution of a blockchain - based data sharing traceability system using smart contracts

The data, application, and smart contract layers comprise a platform designed to offer a transparent, tamper - proof, and decentralized data storage system for collecting, evaluating, and sharing crop - The raw data gathered from field experiments is stored by the data layer. The user interface for accessing and querying data is provided by the application layer. The access control and data sharing policies are set by the smart - contract layer. An extensive analysis of blockchain technology's application to sustainable e - agriculture.

5. Conclusion and Future Research

A variety of benefits have come from using blockchain in the food supply chain, including the capacity to expand and evolve toward a distributed network and the capacity to establish a trustless environment for all processes. Despite the fact that blockchain is entirely trustworthy, it is difficult to develop complete confidence between agricultural goods supplier and customer. Current IoT - based agriculture systems are frequently isolated, with roles limited to agriculture environment monitoring and farmers unable to directly communicate with market buyers, whereas current blockchain - based food supply chain systems focus solely on the supply chain with no option to track food products back to their source to ensure product quality. By include IoT in this piece, we have created a thorough approach to the agriculture and food supply chain.

In this paper, a revolutionary approach was used to construct aninnovative smart farming and food supply chain model. This offers farmers a fresh approach to get agricultural information. Information on agricultural yields, soil temperature, insect infestation, and soil quality, all of which are crucial for optimal crop output, may be sent to farmers using IoT, as well as precise data that can be utilized to improve farming operations. Crop tracking can be used to maintaining accurate records of crop growth. Blockchain, which gives real - time updates on the food safety status to all supply chain partners, significantly decreases the vulnerability of centralized information networks, and makes them more accessible and secure, is another feature that sets the smart model apart. The smart model will considerably increase the reliability and efficiency of the food supply chain, hence raising food safety and regaining the trust of consumers in the food industry. Future studies should examine the potential applications of blockchain technology for enhancing the sustainability of various agri - food systems.

References

[1] Yadav, S.; Kaushik, A.; Sharma, M.; Sharma, S. Disruptive Technologies in Smart Farming: An Expanded View with Sentiment Analysis. *AgriEngineering* **2022**, *4*, 424–460. [**Google Scholar**]

[2] V. S. Manjula, Face Recognition System using Bio Metrics & Security, International Journal of Computer Science Engineering and Information Technology Research (IJCSEITR), ISSN (P): 2249 - 6831; ISSN (E): 2249 - 7943, Vol.6, Issue 2, Apr 2016, 51 - 62 [**Google Scholar**]

[3] Bhattacharya, S.; Dey, N. Smart Agriculture Implementation—Blockchain IoT - Based Approach. In Proceedings of International Conference on Industrial Instrumentation and Control; Lecture notes in electrical engineering; Springer Nature: Singapore, 2022; pp.87–97, ISBN 9789811670107. [**Google Scholar**]

[4] Song, L.; Wang, X.; Merveille, N. Research on Blockchain for Sustainable E - Agriculture. In Proceedings of the 2020 IEEE Technology & Engineering Management Conference (TEMSCON), Novi, MI, USA, 3–6 June 2020. [**Google Scholar**]

[5] Dr. V. S. Manjula, Image Edge Detection and Segmentation by using Histogram Thresholding method Journal of Engineering Research and Application, ISSN: 2248 - 9622, Vol.7, Issue 7, (Part - 6) July 2017, pp.76 - 83 [**Google Scholar**]

[6] Sheaffer, C. C.; Moncada, K. M. *Introduction to Agronomy: Food, Crops, and Environment*; Cengage Learning: Boston, MA, USA, 2012. [**Google Scholar**]

[7] Naik, G.; Suresh, D. N. Challenges of Creating Sustainable Agri - Retail Supply Chains. *IIMB Manag. Rev.2***018**, *30*, 270–282. [**Google Scholar**] [**CrossRef**]

[8] Menon, S.; Jain, K. Blockchain Technology for Transparency in Agri - Food Supply Chain: Use Cases, Limitations, and Future Directions. *IEEE Trans. Eng. Manag.2***022**, 1–15. [**Google Scholar**] [**CrossRef**]

[9] Dr. V. S. Manjula, Face Detection Identification and Tracking by PRDIT Algorithm using Image Database for Crime Investigation International Journal of Computer Applications (0975 – 8887) Volume 38– No.1*0, January 2012.* [**Google Scholar**]

[10] Xiong, H.; Dalhaus, T.; Wang, P.; Huang, J. Blockchain Technology for Agriculture: Applications and Rationale. *Front. Blockchain* **2020**, *3*, 7. [**Google Scholar**] [**CrossRef**]

[11] Ehsan, I.; Irfan Khalid, M.; Ricci, L.; Iqbal, J.; Alabrah, A.; Sajid Ullah, S.; Alfakih, T. M. A conceptual model for blockchain - based agriculture food supply chain system. *Sci. Program.2***022**, *2022*, 7358354. [**Google Scholar**] [**CrossRef**]

[12] Awan, S.; Ahmed, S.; Ullah, F.; Nawaz, A.; Khan, A.; Uddin, M. I.; Alharbi, A.; Alosaimi, W.; Alyami, H. IoT with BlockChain: A Futuristic Approach in Agriculture and Food Supply Chain. *Wirel. Commun. Mob. Comput. Conf.2***021**, *2021*, 5580179. [**Google Scholar**] [**CrossRef**]

[13] Klerkx, L.; Jakku, E.; Labarthe, P. A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda. *NJAS Wagening. J. Life Sci.2***019**, *90–91*, 100315. [**Google Scholar**] [**CrossRef**]

[14] Kamble, S. S.; Gunasekaran, A.; Gawankar, S. A. Achieving sustainable performance in a data - driven agriculture supply chain: A review for research and applications. *Int. J. Prod. Econ.2***020**, *219*, 179–194. [**Google Scholar**] [**CrossRef**]

[15] Ferrag, M. A.; Shu, L.; Yang, X.; Derhab, A.; Maglaras, L. Security and Privacy for Green IoT - based Agriculture: Review, Blockchain Solutions, and Challenges. *IEEE Access* **2020**, *8*, 32031–32053. [**Google Scholar**] [**CrossRef**]

[16] Friha, O.; Ferrag, M. A.; Shu, L.; Maglaras, L.; Wang, X. Internet of things for the future of smart agriculture: A comprehensive survey of emerging technologies. *IEEE/CAA J. Autom. Sin.2***021**, *8*, 718–752. [**Google Scholar**] [**CrossRef**]

[17] Yang, X.; Shu, L.; Chen, J.; Ferrag, M. A.; Wu, J.; Nurellari, E.; Huang, K. A Survey on Smart Agriculture: Development Modes, Technologies, and Security and Privacy Challenges. *IEEE/CAA J. Autom. Sin.2***021**, *8*, 273–302. [**Google Scholar**] [**CrossRef**]

[18] Chowdhury, M. J. M.; Ferdous, M. S.; Biswas, K.; Chowdhury, N.; Muthukkumarasamy, V. A Survey on Blockchain - Based Platforms for IoT Use - Cases. *Knowl. Eng. Rev.2***020**, *35*, E19. [**Google Scholar**] [**CrossRef**]

[19] Biswas, M.; Akhund, T. M. N. U.; Ferdous, M. J.; Kar, S.; Anis, A.; Shanto, S. A. BIoT: Blockchain Based Smart Agriculture with Internet of Thing. In Proceedings of the 2021 Fifth World Conference on Smart Trends in Systems Security and Sustainability (WorldS4), London, UK, 29–30 July 2021. [**Google Scholar**]

[20] Kamble, N. N.; Mali, S. M.; Patil, C. H. Use of blockchain technology in agriculture domain. In *ICT Analysis and Applications*; Lecture Notes in Networks and Systems; Springer: Singapore, 2022; pp.877–884.