Webology (ISSN: 1735-188X)
Volume 18, Number 6, 2021

Empowering Smart Agriculture Through Iot-Driven Blockchain Monitoring

S.Narasimmasubramanian[1], Dr S.ArumugaPerumal[2]

[1]Research Scholar (Register Number: 20123152291034) Department of Computer Science, S.T.Hindu College,Nagercoil-629002. Affiliated to Manonmaniam Sundaranar University Abishakapatti Tirunelveli, Tamilnadu India.
[2]Professsor & Head Department of Computer Science, S.T. Hindu College, Nagercoil-629002. Affiliated to Manonmaniam Sundaranar University, Abishakapatti, Tirunelveli, Tamilnadu, India.

Abstract
Agriculture is emerging as a crucial sector globally due to the significant increase in population. It is essential for a country's economic development. This paper aims to explore how the integration of IoT can address the core requirements of Blockchain, ultimately leading to the creation of IoT-based Blockchain applications. The proposed system explains how combining IoT (Internet of Things) with Blockchain technology can enhance intelligent agriculture. It highlights the main objectives of this integration, which include improving traceability and transparency in the supply chain, ensuring data security, managing resources more efficiently, promoting sustainability, and aiding in better decision-making. Examples provided show practical applications such as monitoring crop conditions, automating irrigation systems, and using smart contracts for crop insurance. Overall, the integration aims to make agriculture more efficient, transparent, and sustainable. To gather field and environmental data in real-time, including temperature, humidity, light intensity, and soil moisture content, the suggested design integrates several sensors. This data is stored on an IoT cloud platform, where it is analyzed to schedule irrigation using blockchain technology. The paper also examines the current algorithms and potential optimizations for an IoT-based Blockchain agriculture application. An intelligent agriculture application enables farmers to increase their agricultural yield while minimizing environmental impact and allows both farmers and customers to monitor plant growth. Internet of Things (IoT) and Blockchain are innovative technologies where each node participates in a distributed ledger, ensuring data transparency for agricultural inputs. This paper contributes to understanding how Blockchain integrated with IoT in agriculture offers a reliable, traceable, and transparent system for trade.

Keywords: Blockchain, IoT, DLT.

1. Introduction

Intelligent agriculture represents a new paradigm in the agricultural sector. This sector has to change to fulfill the growing need for food, as the world's population is expected to reach 8.5

billion by 2040. Integrating IoT with Blockchain offers an ideal solution for improving food production and ensuring food safety. Traditional agricultural methods may be improved by farmers using this new framework, and conventional agriculture will greatly promote food security with the application of Blockchain technology.

Traditional agriculture needs to be modernized through the adoption of ICT to bring it into the digital age. Intelligent agriculture should leverage digital technologies to maintain connections between farmers, consumers, and the land. To demonstrate how blockchain technology may be used to intelligent produce, this article will look at how it can be used to authenticate the reliability of agricultural inputs.

Digital technologies such as IoT, Blockchain, Machine Learning, and Cloud Computing are transforming the agricultural sector into a more intelligent and efficient industry. Blockchain, a form of Distributed Ledger Technology (DLT), consists of an expanding series of records, or blocks, that are connected through cryptography. It leverages a distributed ledger system using decentralized transactional databases. By using a peer-to-peer network, Blockchain allows new blocks to be added to the chain without disrupting existing ones. One of the key advantages of Blockchain technology is its ability to eliminate the need for intermediaries between two parties.

Blockchain has been described as the next evolution of the internet (Swan, 2015; Tapscott, 2016). In the context of agriculture, data from farm operations is transmitted to the Blockchain. IoT enables devices to connect to the internet using embedded software and sensors, facilitating the collection and exchange of data. Real-time data from farms is vital for enhancing productivity and sustainability in the agricultural sector. A Blockchain functions as a ledger where participants sequentially record information related to the production, transaction, and consumption of goods or services. To improve brand reputation, increase operational efficiency, create new market customers, and promote consumer confidence in farmers, this article looks at intelligent agriculture.

2. Related studies of Intelligent agriculture

Traditional agriculture uses manual power for its implementations. The existing methods are like sowing, weeding and irrigation system [1]. The manual methods of agricultural industry face many problems in and around world. So the farmers could not meet their productivity in time. The lack of wisdom in adopting new innovation in agriculture prevents farmers from monitoring the crops health, soil condition and water level. Agriculture in India is largely depending on monsoon. Production of food grains are very low level in the year by year.

In earlier method, the farmers stored their data in manual manner. They applied the fertilizers and water their seeds in manual manner. Our proposed work leverages digital technology to maintain connectivity among farmers, consumers, and the land. Blockchain can document key details, such as the time and location of grain crop planting, the types of fertilizers and crop protection methods used, the harvest dates, and the specific field locations of each harvested load. This information is securely stored in individual blocks on the Blockchain.

An IoT-based Blockchain solution offers an innovative approach to conducting agricultural activities by minimizing human labor and optimizing the use of available resources. This approach addresses the issue of labor shortages in agriculture and enhances production capabilities through the use of sensors, gateways, and cloud servers.

Recently, Blockchain technology has gained significant popularity for enhancing the security of data transmission in IoT-enabled smart systems [2]. A growing number of issues are related to agricultural product traceability. Research that secures the monitoring of agricultural supplies using Blockchain technology was offered as a solution to this problem [3]. Furthermore, this research covers a range of management practices, including crop fertilization and irrigation. A decentralized method ensures the integrity of operational data by using blockchain technology to capture data from dispersed producers, farmers, sellers, and consumers. Blockchain-based infrastructure was suggested as part of a smart agricultural concept [4]. This design offers essential protection for preserving data integrity within the agricultural sector. By implementing Blockchain, smart agriculture supports users and farmers, guaranteeing the immutability of valuable and high-quality information [5].

Paper [6] authors explained the importance of IoT based Blockchain technology improved the high yield of production in the agricultural industry. In Paper [7], the authors propose using immutable and distributed ledger systems for managing records. This technology ensures that environmental data integrity is protected for participants engaged in transparent data management. Paper [8] authors explained the application of block chain will make it possible for farmers and retailers to know about the authenticity and the origin of the inputs they by simply using their smart phones to scan the block chain bar code on each product.

3. Proposed works

This paper proposes using Blockchain and IoT technology in intelligent agriculture to enhance trust between farmers and consumers, improve brand reputation, boost operational efficiency, and open up new market opportunities. By leveraging these technologies, the agricultural sector can achieve greater transparency, security, and efficiency. This proposed work aims to use Blockchain and IoT technology in intelligent agriculture. The goal is to enhance traceability, security, and efficiency in farming. By integrating these technologies, the system will provide reliable data on crop conditions, automate processes, and ensure transparency in the supply chain, ultimately improving trust, operational efficiency, and opening up new market opportunities.

3.1 Blockchain bases

Blockchain is made up of an expanding series of records called blocks, which are connected through cryptographic techniques. Every block holds the transaction data, a timestamp, and the cryptographic hash of the block before it. This method is represented using a Merkle tree structure.

Blockchain represents the next evolution in digital technology, forming the foundation of a new kind of internet. It is essentially a data structure in which each block is connected to the previous one. As a cutting-edge technology, Blockchain is renowned for its security and enhanced privacy across a variety of applications, including e-governance, social networking, e-commerce, transportation, logistics, professional communication, and more.

Blockchain refers to a high-performance technology that emphasizes security, where a digital ledger is kept. This ledger is highly transparent, leaving no room for manipulation of records by intermediaries or administrators.

All transaction records are recorded in the Blockchain ledger, and the operations are finalized using various protocols and algorithms that are resistant to third-party hacking. A Blockchain functions as a linked list of blocks, where each block contains a set of sequential transactions. It can be considered a specialized type of database with additional features.

Blockchain is a decentralized and distributed ledger that records various types of transactions within a peer-to-peer network. This network comprises numerous computers, ensuring that data cannot be changed without the agreement of the entire network. Blockchain technology is represented as a collection of blocks with transactions organized in a predetermined order. These blocks may be kept in a simple database or as a flat file.

Database	**Block chain**
Centralized	Decentralized
Permissioned	Permissionless
Require administrator	No administrator

3.2 Types of Blockchain

Blockchains vary based on the type of data they manage, the accessibility of that data, and the actions users can perform. Consequently, they can be categorized into public and private blockchains, as well as permissioned and permissionless blockchains.

It's crucial to remember that certain authors interchange the phrases "permission" and "public.", particularly in the context of cryptocurrencies, but this does not apply to IoT applications. Anyone may participate as a basic node or as a miner/validator on a public blockchain without requiring permission from third parties. Currencies such as Litecoin, Ethereum, and Bitcoin are examples of public blockchains [9].

In a private Blockchain, the network access is restricted by the owner. Many private Blockchains are also permissioned, meaning they control which users are allowed to perform transactions, execute smart contracts, or act as miners within the network. An example of a permissioned Blockchain is Hyperledger Fabric [10].

3.3 Internet of Things basis

The Internet of Things is a network of real-world items, or "things," that are equipped with sensors, electronics, software, and network connections to gather and share data. Improved efficiency, accuracy, and financial gain occur from more direct integration between computer-based systems and the real world through the IoT. This is made possible by items' remote sensing and control via current network infrastructure.

3.4 IoT in Intelligent agriculture

Data acquisition in intelligent agriculture involves using microcontrollers to collect data from sensors, which can be connected either through wires or wirelessly, such as room temperature sensors. This data, initially in the form of electrical signals, is converted into digital signals during data processing. The raw or irrelevant data is then transformed into meaningful information, like temperature in Celsius or Fahrenheit. For data communication, the data is converted into packets and sent through wired or wireless connections to multiple nodes.

Monitoring in intelligent agriculture involves keeping the latest information on soil moisture and fertility. Irrigation can be selectively applied to dry zones to reduce the water resources required, while water management includes studying weather conditions in fields to forecast ice formation, rain, snow, or wind changes. This ensures accurate control of plant growth conditions to achieve the highest efficiency.

4. Implementation of Blockchain Nodes

Intelligent agriculture provides the farmers to digitized the farm activities

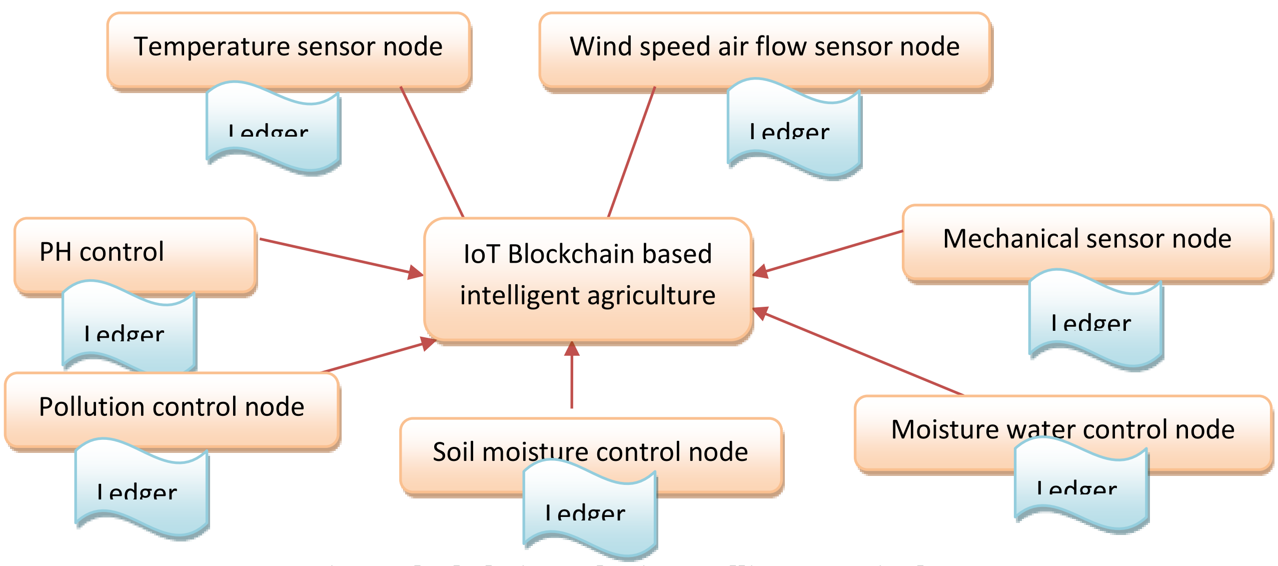


Fig4.1Blockchain nodes in Intelligent Agriculture

This paper provides a design for the architecture of an IoT-based Blockchain application for intelligent agriculture. It outlines how the nodes in the Blockchain receive data from sensors connected to the agricultural monitoring system. The nodes involved in the IoT Blockchain-based intelligent agriculture are detailed below and illustrated in Figure 4.1.

- Temperature sensor node
- Wind speed air flow sensor node

- Mechanical sensor node
- PH control node
- Pollution control node&Moisture
- Soil moisture control node& water control node

4.2 System architecture

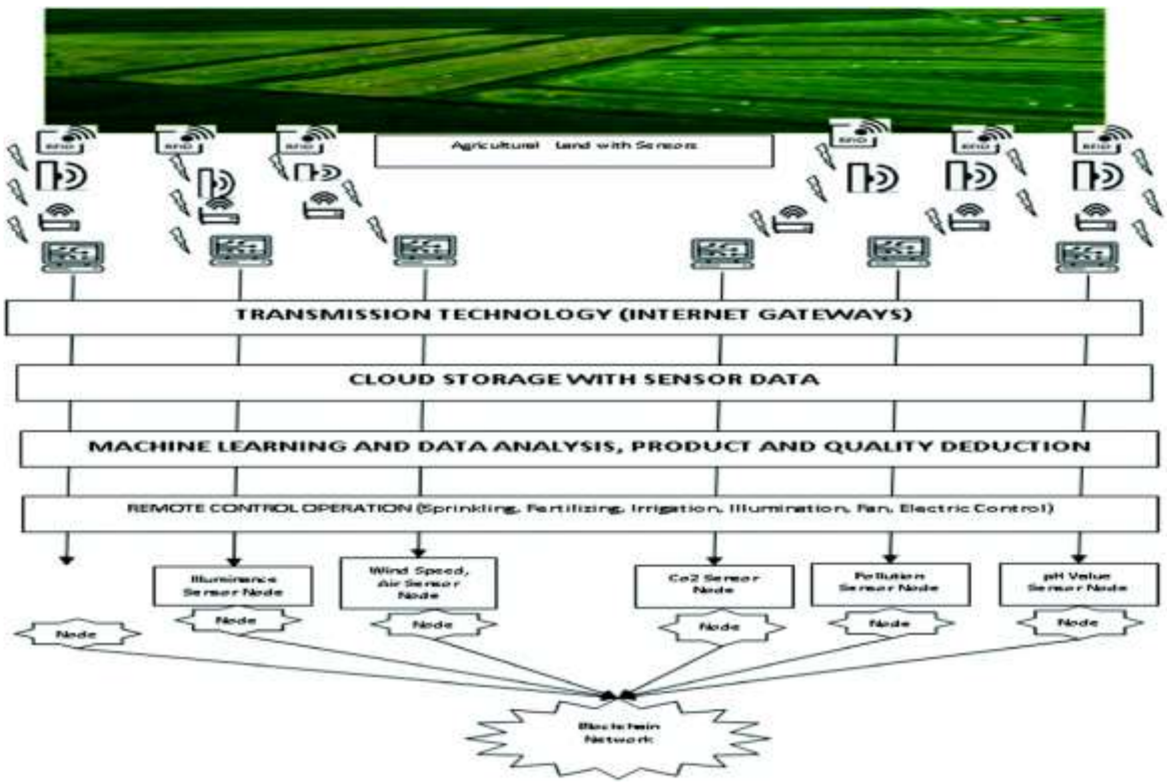


Fig 4.2.1Emerging technologies in smart agriculture

4.3 Soil moisture sensor node

Every node in the network functions as a miner and keeps a local copy of the Blockchain that includes all validated transactions. These transactions involve accessing, storing, and monitoring sensor data at each node. For instance, in the case of a single node, such as a soil moisture sensor node, the process of handling its content is as follows:

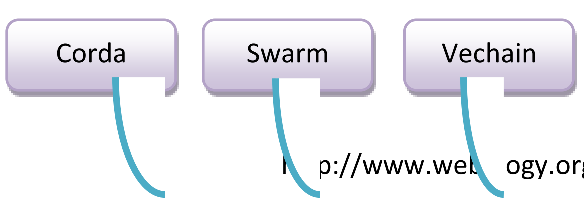
1. Soil moisture sensor data transaction
2. Storing the soil moisture information transaction
3. Accessing the soil moisture information transaction
4. Monitoring the soil moisture status transaction

All sensor nodes in the intelligent agricultural system may be used using the four processes described. The sensors carry out their processes and store information in the blocks of the network chain. Combining Blockchain with other technologies like the Internet of Things can significantly enhance crop production. For instance, IoT sensors can collect data on water levels, soil temperature, and fertilizer usage, and transmit this information to the Blockchain.

5. Benefits of IoT based Blockchain Technologies in Agriculture

1. With the use of blockchain technology, peer-to-peer transactions may take place openly and without the involvement of middlemen, such as banks in the case of cryptocurrency or middlemen in agriculture. By removing the need for a central authority, this technology shifts the basis of trust from relying on an authority figure to depending on cryptographic techniques and a decentralized network. This approach helps to rebuild trust between farmers (producers) and consumers, potentially lowering transaction costs in the agri-food market.
2. This technology provides a dependable method for tracking transactions between anonymous parties, allowing for the rapid detection of fraud and errors. Additionally, incorporating smart contracts can further address issues (Haveson et al., 2017; Sylvester, 2019). Considering how intricate the agri-food system is, it assists in addressing the difficulty of product monitoring along the extended supply chain. Consequently, this technology offers solutions to concerns related to food quality and safety, which are of significant importance to consumers, governments, and other stakeholders.
3. When applied to agriculture, this technology can document the details of crop planting, including the timing, location, types of fertilizers used, harvest dates, and the growing regions. The decentralized ledger technology assists in monitoring these valuable commodities and helps minimize instances of illegal harvesting and shipping fraud.
4. Farmers face unpredictable weather conditions, and employing blockchain to monitor and forecast these changes can be vital for enhancing crop resilience, stabilizing prices, and potentially preserving jobs.
5. Emerging technologies are revolutionizing crop and soil monitoring. Sensors, e-noses, drones, and other IoT devices are used to monitor soil conditions, nutrient requirements, and disease profiles, providing recommendations for corrective measures. Agritech companies like CropIn, Intello Labs, Gramophone, Fasal, and others are leveraging machine learning and AI for predictive agricultural analytics, such as predicting weather, sowing times, and irrigation schedules.

Moreover, emerging technologies are becoming integral to supply chain management. Agritech firms are utilizing data analytics and blockchain to enable smart supply chain management and market linkages, establishing credentials and authenticity. This technology allows tracking a product's journey from seed to store shelf, giving customers a clear view of the product's path through the supply chain.



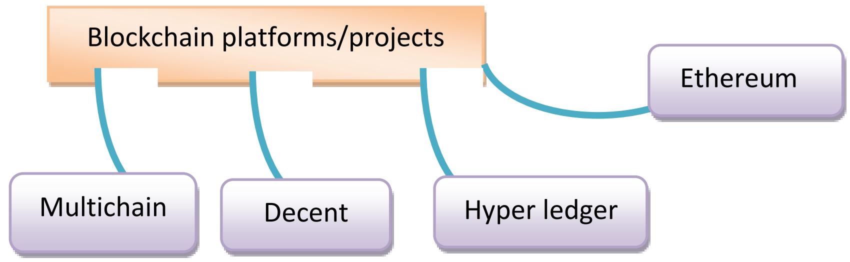
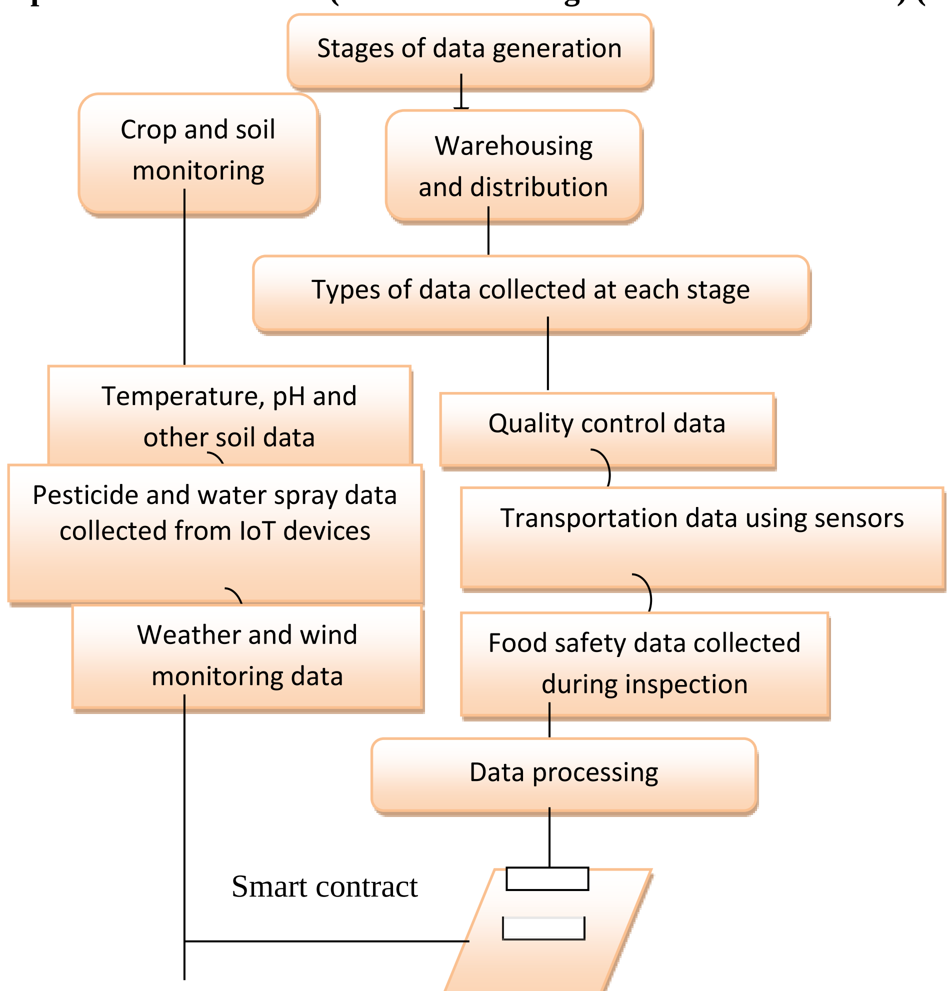


Fig 5.1 Platforms of Blockchain technology

A Blockchain is a digital, decentralized, peer-to-peer, and immutable public ledger or registry. Each transaction is associated with a string of characters known as a hash. This hash contains a timestamp, a unique identifier, a code connecting it to the preceding hash, and a private key for ownership verification. Every transaction serves as a link in a chain that can be traced back to the previous link, extending all the way to the start of the chain, referred to as the genesis block.

6. Implementation Process (Data transferring from sensors to Blocks) (I/O Flow)



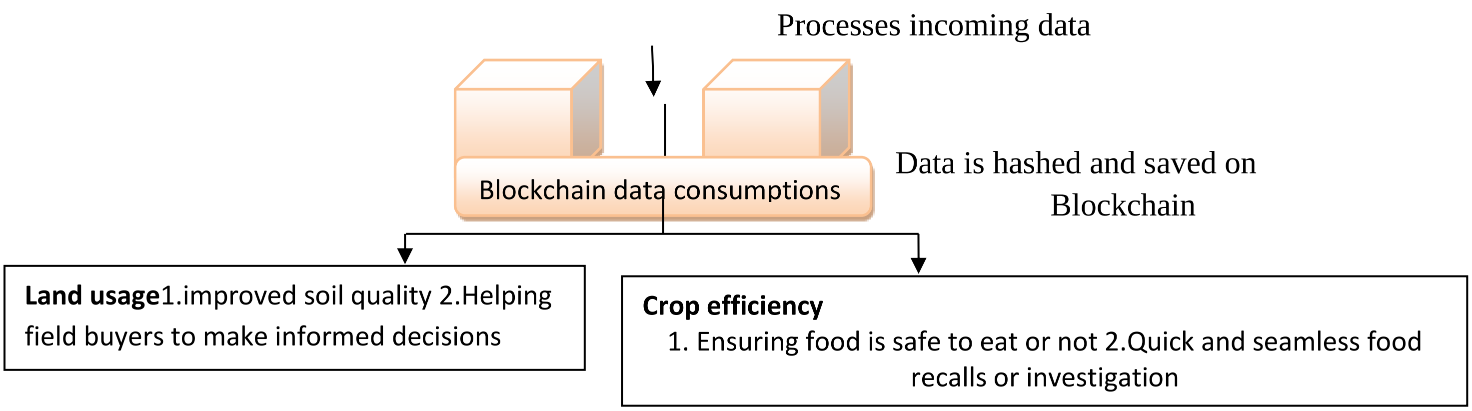


Fig 6.1 Process of Blockchain with IoT in agriculture sector

Step 1: Data generation using IoT devices

IoT sensors and devices play a crucial role in modern agriculture by generating valuable data that can help farmers make well-informed decisions about crop growth. These devices collect a wide range of information, such as soil moisture levels, temperature, humidity, and light intensity. However, the raw data gathered from IoT devices needs to be structured and analyzed to extract meaningful insights. By organizing this data effectively, farmers can optimize irrigation schedules, predict pest infestations, and enhance overall crop management, leading to increased productivity and sustainability in agriculture.

Step 2: Data Preprocessing

Data enrichment is essential to improve the quality of captured information. Before saving the collected data on the Blockchain, it needs to be properly structured. Adding details such as timestamp, location, and data type helps organize the information, making it more valuable and useful.

Step 3: Making data more insightful with machine learning algorithms

Machine learning is used to analyze sensor data and provide insightful information. Farmers and other interested parties may use this information to quickly modify their irrigation systems. By storing this data on the Blockchain, all participants in the agricultural market such as growers, innovators, producers, service providers, and retailers can access it transparently.

Step 4: Data gets saved on the Blockchain

The distributed storage platform IPFS (Interplanetary File System) is used for saving the critical data that comes from machine learning. The addresses of these files are hashed and recorded on the Blockchain. Smart contracts then manage the transfer of this data between designated stakeholders in the system.

Table 6.2: IoT-based agriculture success stories.

Countries	Application sub domain	Success stories
Thailand	Water management	A water control system has been created using Wireless Sensor Networks (WSN) to monitor water usage across an entire field. This system was tested and deployed in three different fields in Thailand. The findings indicated that temperatures between 29°C and 32°C should be maintained for maximum production in lemons and vegetables, and humidity levels between 70% and 80% should be maintained for best lemon development [10].
Taiwan	Soil cultivation	To monitor soil conditions for precision agriculture, Taiwan is introducing the cost-effective AgriTalk IoT-based platform [11]. This platform was tested in three different fields dedicated to turmeric cultivation. The implementation of the AgriTalk system led to an increase in chlorophyll levels by 40% to 60% compared to traditional methods, and also resulted in a 70% reduction in water usage. Additionally, the platform generated a revenue of \$140,000 from an investment of \$14,000, representing a significant improvement over previous cultivation practices. Electronics 2020, 9, 319 25 of 41
Brazil	Soil humidity and temperature monitoring.	An IoT-based Agri Prediction model described in [12] offers affordable methods for predicting soil humidity and temperature. Following the deployment of this model, the weight of arugula leaves increased by up to 14.29%, and their size grew by up to 17.94%.
India	Monitor moisture content, temperature, humidity, pesticides, animals CO_2, and light.	In [13], an IoT-based robotic system was introduced to monitor agricultural parameters such as pesticides, moisture, and animal movement. Practical implementation of the system yielded highly satisfactory results, demonstrating that it is user-friendly, durable, and reduces labor costs. Additionally, [14] developed a remote sensing control system to track greenhouse gases, temperature, soil moisture, and light. This system was used for monitoring bell pepper plants, and the results showed an increase in yield while allowing farmers to oversee their farms remotely.
China	Environment monitoring	A low-power and cost-effective system has been developed to monitor greenhouse environmental conditions [15]. Implementation of this system has proven it to be reliable

		and effective in lowering labor costs. Additionally, IoT technologies used in the Zhongyi demonstration park in Shandong Province have resulted in reductions of up to 60% in fertilization costs and 80% in pesticide costs. Managing a 300-mu park originally required 60 laborers, but the adoption of IoT technology cut labor costs by about 60% [16].
Africa	Monitoring animal's location, behavior and pasture grazing.	The authors suggested an approach to follow the movements of animals in the field and examine their grazing patterns to monitor their behavior [17]. Africa has been using this technology to assess and monitor the health of the animals.
Malaysia	Fruit traceability	To guarantee quality monitoring, Malaysia's Minister of Science, Technology, and Innovation (MOSTI) unveiled Mi-Trace and My Traceability Sdn Bhd (MTSB), two IoT-based agricultural solutions.

7. Conclusion

In conclusion, Blockchain and IoT technologies have the potential to create a new paradigm in the agriculture sector. This paper highlights how IoT-based Blockchain concepts enable farmers to respond swiftly, optimize resources, and enhance crop performance, leading to increased yields and food productivity. Several countries have successfully adopted Blockchain-based IoT methods in the smart agriculture sector. These technologies are significantly transforming the agriculture industry and are considered crucial for improving agricultural productivity. Blockchain technology holds great potential for success within the agriculture sector. By recording every transaction and movement of agricultural products on an immutable ledger, Blockchain ensures that all stakeholders, from farmers to consumers, can verify the authenticity and quality of the produce. This technology also simplifies processes, minimizes fraud, and fosters trust among participants, resulting in more efficient and dependable agricultural practices. Blockchain possesses distinct features that make it highly beneficial for the agriculture and supply chain sectors. Collaborative ecosystem facilitated by Blockchain foster knowledge exchange, innovation and research collaboration in the agricultural community.

References

[1] S.Arumugaperumal, S.Sethuramalingam, "Technology adoption for the growth of Agriculture" International conference paper (IIAC 2019) March 2019.

[2] Van Wassenaer L, van HiltenM, van Ingen E, van AsseldonkM. Applying blockchain for climate action in agriculture: state of play and outlook. Food & Agriculture Org; 2021.

[3] Rahman MU, Baiardi F, Ricci L. Blockchain smart contract for scalable data sharing in IoT: a case study of smart agriculture. 2020 IEEE Global Conference on Artificial Intelligence and Internet of Things (GCAIoT), IEEE; 2020. p. 1–7.

[4] Shakhbulatov D, Arora A, Dong Z, Rojas-Cessa R. Blockchain implementation for analysis of carbon footprint across food supply chain. 2019 IEEE International Conference on Blockchain (Blockchain), IEEE; 2019. p. 546–51.

[5] Anand SJ. Iot-based secure and energy efficient scheme for precision agriculture using blockchain and improved leach algorithm. Turkish J Computer Math Educ (TURCOMAT). 2021;12(10):2466–75.

[6] Shyamala devi, Aparna joshi "Design of IoT Blockchain based smart agriculture for Enlightening safety and security" www.researchgate.net /publication /333170167. May 2019.

[7] By agricultural data coalition april 26,2019 source:digital farming farm to fork

[8] By Santosh sarangi "How to leverge emerging technologies"? May26,2020 src: Financial express

[9] Litecoins. Accessed: apr 10,2018[online]. Available : http://litecoin.com

[10] Muangprathub, J.; Boonnam, N.; Kajornkasirat, S.; Lekbangpong, N.; Wanichsombat, A.; Nillaor, P. IoT and agriculture data analysis for smart farm. Comput. Electron. Agric. 2019, 156, 467–474. [CrossRef]

[11] Chen, W.L.; Lin, Y.B.; Lin, Y.W.; Chen, R.; Liao, J.K.; Ng, F.L.; Chan, Y.-Y.; Liu, Y.-C.; Wang, C.-C.; Chiu, C.-H.; etal.AgriTalk:IoTforprecisionsoilfarmingofturmericcultivation. IEEEInternetThingsJ.2019,6,5209–5223. [CrossRef]

[12] dos Santos,U.J.L.; Pessin, G.; daCosta, C.A.; daRosa Righi, R.AgriPrediction: A proactiveinternet ofthings model to anticipate problems and improve production in agricultural crops. Comput. Electron. Agric. 2019, 161, 202–213. [CrossRef]

[13] Krishna, K.L.; Silver, O.; Malende, W.F.; Anuradha, K. Internet of Things application for implementation of smart agriculture system. In Proceedings of the 2017 International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), Palladam, India, 10–11 February 2017; pp. 54–59.

[14] Pallavi, S.; Mallapur, J.D.; Bendigeri, K.Y. Remote sensing and controlling of greenhouse agriculture parameters based on IoT. In Proceedings of the 2017 International Conference on Big Data, IoT and Data Science (BID), Pune, India, 20–22 December 2017; pp. 44–48.

[15] Dan, L.I.U.; Xin, C.; Chongwei, H.; Liangliang, J. Intelligent agriculture greenhouse environment monitoring system based on IOT technology. In Proceedings of the 2015 International Conference on Intelligent Transportation, Big Data and Smart City, Halong Bay, Vietnam, 19–20 December 2015; pp. 487–490.

[16] ANewEngineforRuralEconomicGrowthinthePeople'sRepublicofChina. Availableonline: https://www. adb.org/sites/default/files/publication/455091/internet-plus-agriculture-prc.pdf(accessedon24September2019).

[17] Nóbrega, L.; Tavares, A.; Cardoso, A.; Gonçalves, P. Animal monitoring based on IoT technologies. In Proceedings of the 2018 IoT Vertical and Topical Summit on Agriculture-Tuscany (IOT Tuscany), Tuscany, Italy, 8–9 May 2018; pp. 1–5.