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Wireless Sensors in IoT Based Agriculture by Using Block Chain Technology and Drones System

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ABSTRACT

The integration of cutting-edge technologies such as Wireless Sensors, the Internet of Things (IoT), Blockchain, and Drones in agriculture has the potential to revolutionize the industry. This paper explores the application of these technologies in agriculture, focusing on the benefits they bring to the sector. We delve into the significance of Wireless Sensors, the IoT, Blockchain, and Drones in enhancing agricultural practices, resource management, data security, and overall productivity. We also examine the challenges and potential solutions for the widespread adoption of this integrated approach in agriculture.

Keywords : Crop management, sustainable agriculture, smart farming, internet-of-things (IoT), block chain technology, drones in agriculture.

I. INTRODUCTION

Agriculture plays a crucial role in providing food security and sustainability for the growing global population. To meet the increasing demand, modern agriculture needs to be more efficient, cost-effective, and sustainable. The advent of wireless communication, the Internet of Things, blockchain, and drone technology offers innovative solutions to address the challenges faced by the agricultural sector.

A measure of environmentally friendly food production's persistence and sustainability is called sustainable agriculture [1]. In order to maintain farmers and resources, sustainable agriculture promotes agricultural methods and practises. It is Economically viable, it enhances land biodiversity, preserves water resources, lowers soil deterioration, and maintains a natural and healthy environment [2]. In order to protect natural resources, stop the loss of biodiversity, and cut greenhouse gas emissions, sustainable agriculture is crucial [3]. Sustainable agriculture is a way to increase farming productivity while maintaining the environment without fundamental necessities of the next generation.

Crop rotation, the management of nutritional deficiencies in crops, the management of pests and diseases, recycling, and water harvesting are the fundamental achievements of smart farming in terms of sustainable agriculture, all of which contribute to a safer environment overall. Living things rely on biodiversity, yet they are also polluted by waste emissions, pesticide and fertiliser usage, decaying dead plants, etc. A healthier habitat for living things is necessary since the release of greenhouse gases impacts plants, animals, humans, and the ecosystem [4]. In Figure 1.

India's greatest contributor, agriculture, accounts for 18% of the country's GDP and employs around 57% of the population in rural regions. Although India's overall agricultural production has grown through time, the proportion of growers has decreased, dropping from 71.9% in 1951 to 45.1% in 2011 [5]. According to the Economic Survey 2018, just 25.7% of the workforce in 2050 will be employed in agriculture. Increasing cultivation expenses, low per capita yield, poor soil upkeep, and migration to non-farming or more lucrative occupations cause agricultural families in rural regions to progressively lose the next generation of farmers. In order to introduce and accommodate digital connectivity with farmers at a time when the world is on the cusp of a digital revolution, it is appropriate to connect the agricultural landform with wireless technology.

II. RELATED WORK

This literature survey explores the current state of research and developments in the integration of wireless sensors, the Internet of Things (IoT), blockchain technology, and drones in agriculture. The aim is to understand how these technologies synergistically enhance agricultural practices, improve resource management, ensure data security, and boost overall productivity. By reviewing key research articles and publications, this survey aims to provide insights into the potential benefits, challenges, and future prospects of this integrated approach in smart agriculture.

Khan, S. et al. (2020). Wireless Sensor Network Applications in Precision Agriculture: A Review. Computers and Electronics in Agriculture, 169, 105195. This review paper highlights the role of wireless sensor networks in precision agriculture, covering applications such as soil moisture monitoring, climate control, and crop health assessment. The study discusses the impact of sensor data on decision-making for optimized agricultural practices.

Mishra, P. K. et al. (2019). Recent Advances in IoT-Based Precision Agriculture: A Comprehensive Survey. Computers and Electronics in Agriculture, 163, 104862. This comprehensive survey delves into recent advancements in IoT-based precision agriculture, including the use of wireless sensors to monitor crops, automate irrigation systems, and analyze environmental data for improved crop yields and resource efficiency.

This review paper provides an overview of IoT-based smart agriculture applications, discussing how IoT technologies, including wireless sensors, enable real-time monitoring, data analysis, and automated decision-making for precision farming.

Kourtis, A. T. et al. (2021). A Comprehensive Survey of IoT Applications in Agriculture. Sensors, 21(9), 2957. This survey examines a wide range of IoT applications in agriculture, focusing on how wireless sensors and IoT platforms are integrated to optimize resource usage, reduce environmental impact, and ensure sustainable farming practices.

Qu, Y. et al. (2019). Applications of Blockchain Technology in Agriculture: A Comprehensive Review. Computers and Electronics in Agriculture, 163, 104871. This comprehensive review paper explores the potential applications of blockchain technology in agriculture, discussing its role in supply chain management, food traceability, and data security. The study emphasizes the importance of data integrity and transparency in modern agriculture.

Tang, W. et al. (2020). A Review of Blockchain Technology Applications in Agriculture Sector. Agricultural Water Management, 231, 106041.

This review focuses on various use cases of blockchain technology in agriculture, including smart contracts for transparent transactions, tracking of agricultural products, and ensuring fair compensation to farmers in supply chains.

This paper discusses the applications of drones in agriculture, highlighting their role in crop monitoring, disease detection, and precision spraying. The study also addresses the potential benefits of integrating drone data with IoT platforms.

Torres-Sánchez, J. et al. (2018). Multi-Sensor UAV-based Mapping and Classification of Crops. Remote Sensing, 10(7), 1092.

This research paper presents a multi-sensor drone-based mapping and classification approach for crops. It demonstrates the utility of drones in collecting high-resolution data for precision agriculture and crop analysis.

The literature survey indicates a growing interest in the integration of wireless sensors, IoT, blockchain technology, and drones in agriculture. Researchers and practitioners recognize the potential of this integrated approach to revolutionize farming practices, increase productivity, and address challenges faced by the agricultural sector. However, some challenges remain, such as data privacy, standardization, and adoption barriers. Continued research and development are needed to fully unlock the potential of this technology integration in smart agriculture.

III. PROPOSED IOT WITH BLOCKCHAIN SMART FARMING MODEL

The study work that has been presented has demonstrated that the Internet of Things (IoT) and block chain technology can play a significant role in smart agriculture and the food supply chain, and that all stakeholders can benefit from these developments without the assistance of a reliable third party. As illustrated in Fig. 15.6 in this chapter, we tend to suggest a smart model that is built on IoT and blockchain architecture to carry out smart agricultural operations in creative ways.

IoT, blockchain, and the retail industry make up our three-part smart model. The Internet of Things (IoT) component relates to data produced by sensors placed on the farm. IoT devices will generate data that will be stored in the system. For example, production information, including vital details and production log information like the product name, origin, etc., will be recorded during the production stage. Later, product growing information will also be recorded at various times, and all stakeholders will have access to this information. The second section deals with the functions that blockchain will carry out for data storage, consensus, encryption, decryption, and verification. It will use smart contracts to execute the relevant logic at precise times, which will make the system more scalable, streamline the procedure, and decrease costs. The process items will be sent to successful bidders (distributors, retailers) when the production phase is complete. This is the third stage, which relates to the retail market.

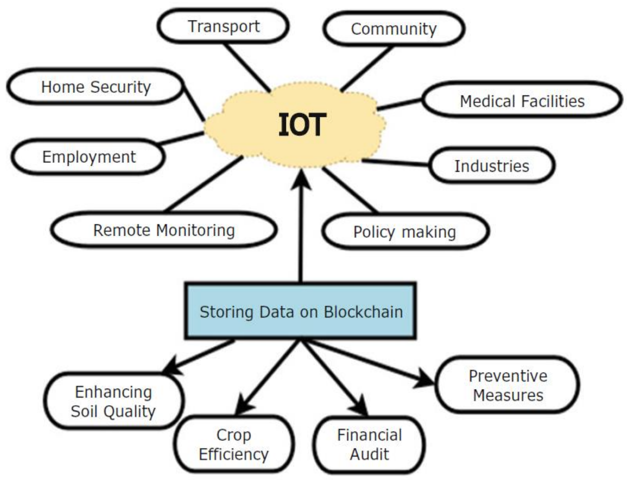

Fig. 1. Block diagram of IoT with blockchain smart farming model

IV. PROCEDURE FOR IOT OPERATION

Step 1: Crop health will be monitored by IoT devices, and information will be generated to help farmers make timely decisions about crop development. Collected data will be recorded on the blockchain.

Step 2: Machine learning is employed to obtain deeper insight information and will offer more detailed information such as crop production prediction, crop growth factor, demand forecasts, and suggestions to enhance crop quality. Machine learning algorithms can also assist farmers in improving their irrigation system. In order to enable stakeholders like farmers, investors, innovators, and merchants to obtain access equally, machine learning data will be maintained on the blockchain.

Step 3: To prevent authority control and lower the danger of data hacking, the data gathered by adopting machine learning will be organised using "Interplanetary File System (IPFS)" on the blockchain over a decentralised server. In contrast to the created block chain, which contrasts to establish different rules, the available system is saved for accessing the information through a centralised server by which we can prevent the aspects of hacking. The purpose of smart contracts is to make it easier for certain stakeholders to trade data that has been saved on the blockchain. At the same time, information will be displayed to each participant in the agriculture market, creating a uniform platform that will increase efficiency.

V. TECHNOLOGY BEHIND BLOCKCHAIN

Bitcoin's global influence increased considerably, and China created two-thirds of those coins using blockchain technology. Blockchain specialists claim that it has revolutionised daily life. Block chain is the decentralised ledger that contains cryptocurrency stored in the form of transactions that take place in the form of a system as the digital currency. Block chain and cryptography are combined to enable the existence of the fundamental elements of digital currency, which are decentralised and designated as "Bitcoin."

The block chain is generally believed to have been created only for monetary purposes.

However, by implementing a decentralised operating structure, it might be helpful to other zones. In light of this context, we made the decision to use its potentials in the "agricultural food supply chain."

Many businesses, including those in banking, healthcare, education, the food industry, and management, are currently paying attention to blockchain, an emerging technology. Blockchain is gaining interest mostly because to its special properties, which may be used to do the same task with the same degree of dependability without the aid of an authentication system, and which can be managed solely by a trustworthy intermediary using a decentralised approach. Blockchain created new paths and introduced trustless networks since it allows transactions to be made without relying on third parties.

Transactions between various parties are now speedier since the role of middlemen has been abolished. The usage of cryptography may also help to secure the security of the data.

Companies participating in the food supply chain are now dealing with a number of difficulties, including the need for a large staff to satisfy the demand of all outlets and delays and defaults in the delivery of commodities. Companies have digitalized their processes to help stakeholders and expand their business in the imparting supply chain in order to address these issues. However, doing so tends to increase the risk of various attacks on the databases, where malicious users are somehow able to update, steal, or delete the data. Attacks by hackers on data, particularly in the agriculture, may result in significant problems, but the blockchain platform can offer a safe solution to these challenges with decentralised, autonomous, and reliable data and transportation management.

VI. IOT IN AGRICULTURE: A Must

An IoT-connected device may detect its environment, collect the appropriate readings, and communicate the information via the internet to a server where it can be stored for later use or to another device, such as a smartphone, where a user can access the information. This enables an under review system to be continuously monitored. The user can make judgements about the activities to be taken in such a monitored environment [5].

An interconnected network of devices that can continuously send and receive data from one another makes up a smart sensing environment. Additionally, it is equipped with the potential to make judgements on behalf of users and take actions to better the environment. This alteration of the environment necessitates continued observation of the surroundings and leads to an environment that is always changing. A smart sensing system may send the user the monitored data, actions done, and environmental effects of those activities. Additionally, the user may decide to impose a different course of action from that chosen by the devices' decision support system while they are working together. In order to assimilate the condition of the field, understand how it affects growth, and determine the activities necessary on the field for a better outcome of a decent product, an agricultural field needs a smart sensing system.

Precision Agriculture (PA), also referred to as "Site Specific Crop Management (SSCM)," is a method for automating the management of agricultural crops, fields, and animals using a "smart sensing system" that can accommodate an environment that is tailored to the system's current requirements by using the technology that has been widely disseminated. Included are the following:

Using both distant and local sensors, the following steps are taken: a) gathering objective spatial and time-sensitive data; b) applying filtering techniques to extract pertinent data; c) incorporating AI-specific decision-making algorithms; and d) using actuation systems to carry out the necessary actions. These managerial techniques can aid in reducing the problems related to food production, distribution, and sustainability. [6], [7].

VII. BLOCKCHAIN TECHNOLOGY AND ITS EVOLUTION IN SMART AGRICULTURE

Maintaining the accuracy and authenticity of the information is often the responsibility of a central authority in a network of systems that exchange crucial information and utilise it for additional processing. A centralised system that is prone to failure might result in a significant loss of crucial data that is required for crucial applications. It is useful to transfer the authoritative responsibilities to a decentralised system in order to solve such catastrophic issues.

By using a commitment protocol to add a new block to the blockchain through a process known as mining and a consensus protocol to ensure consistency among various local copies, multiple systems can maintain a local copy of a public ledger known as a blockchain using blockchain technology [6]. By permitting numerous authority points with multiple nodes, such a system prevents single point failure since, in the event of a node failure, all nodes linked to it will be routed to another node as long as the network is not disconnected. A distributed system without a central node can be further improved upon in which all nodes collaboratively preserve the crucial data [7]. A blockchain is a type of data structure that is secured using cryptographic methods and composed of a number of data blocks connected linearly and chronologically to form a chain. Each block contains a header giving the preceding block's hash, the root of the merkle hash tree, and the time in seconds that it was added [8]. It is important to keep in mind that a block's contents might differ from one application to the next [9].

VIII. DRONES IN AGRICULUTRE

Drones, also known as Unmanned Aerial Vehicles (UAVs), have become increasingly prevalent in agriculture due to their ability to provide valuable data and perform various tasks that benefit farmers and agricultural practices. The integration of drones in agriculture has opened up new possibilities for precision farming, increased productivity, reduced costs, and more sustainable practices. Here are some of the key applications and benefits of drones in agriculture:

Crop Monitoring and Health Assessment: Drones equipped with high-resolution cameras and multispectral sensors can capture detailed images of crops and provide valuable insights into their health and development. These images can be analyzed using specialized software to identify areas of stress, nutrient deficiencies, pest infestations, and diseases. By detecting problems early, farmers can take timely and targeted action, reducing crop losses and optimizing yield.

Precision Agriculture: Drones enable precise and efficient application of inputs such as fertilizers, pesticides, and water. With the aid of GPS technology, drones can follow pre-defined flight paths and accurately distribute resources based on specific crop requirements. This practice, known as variable rate application, optimizes resource utilization and minimizes wastage, resulting in cost savings and reduced environmental impact.

Soil Analysis: Drones equipped with sensors can assess soil properties such as moisture levels, pH, and nutrient content. This data helps farmers make informed decisions about soil management practices, including fertilization and irrigation strategies, tailored to specific field conditions.

Mapping and Surveying: Drones can quickly and accurately survey large areas of farmland, creating detailed 3D maps and digital elevation models. These maps assist in land surveying, boundary mapping, and crop area estimation, aiding in farm planning and management.

Livestock Monitoring: Drones equipped with thermal cameras can be used to monitor and track livestock, identifying potential issues such as sick or missing animals. This technology improves animal welfare and enhances overall herd management.

Environmental Monitoring: Drones can be used to assess the impact of environmental factors on agriculture, including water stress, flooding, erosion, and land degradation. This information helps in implementing sustainable land management practices and mitigating potential risks.

Cost-Effectiveness: The use of drones in agriculture can reduce the need for manual labor and expensive equipment, leading to cost savings for farmers. Drones are relatively affordable and versatile, making them accessible to small-scale farmers as well.

Data Integration with IoT and AI: Drones can be integrated into Internet of Things (IoT) platforms and connected to Artificial Intelligence (AI) systems. This integration allows for real-time data analysis, enabling farmers to make data-driven decisions for better farm management.

Despite the numerous advantages, the adoption of drones in agriculture also faces challenges. These include regulatory restrictions, safety concerns, data management and analysis, and the need for specialized training for drone operation and data interpretation. As drone technology continues to evolve, these challenges are expected to be addressed, and the full potential of drones in agriculture will be realized, contributing to more sustainable and efficient farming practices.

IX. INTEGRATION OF TECHNOLOGIES IN AGRICULTURE

A potent combination results from the integration of wireless sensors, the IoT, blockchain, and drones in agriculture. Wireless sensors may provide real-time data to an IoT platform, which interprets it and uses blockchain-enabled smart contracts to provide farmers with insightful information. Drones can carry out certain activities, like targeted spraying, with extreme accuracy and efficiency when they are directed by the data gathered.

In order to improve agricultural practises, optimise resource management, increase decision-making, and encourage sustainability, different digital instruments, hardware, and software are strategically combined. Farmers can build a farming environment that is more effective and data-driven by incorporating these technologies. The following are some crucial areas where technology integration is changing agriculture:

Wireless sensors with the Internet of Things (IoT): Real-time data gathering and communication are made possible by the IoT, which connects numerous devices and sensors. Including wireless sensors in agricultural areas allows for the monitoring of vital parameters including crop health, soil moisture, temperature, and humidity. Farmers may use this data to make educated decisions about irrigation, fertilisation, and pest management thanks to the IoT systems that receive it.

Precision farming is made possible by the combination of GPS, GIS (Geographic Information Systems), and drone technology. Farmers may utilise GPS-guided equipment and comprehensive field maps to precisely administer resources like water, fertiliser, and pesticides, reducing waste and increasing production.

Cryptocurrency technology: A safe and open method of recording and sharing data throughout the agricultural supply chain is made possible by blockchain technology. Farmers can follow their goods' complete route from production to consumption by incorporating blockchain, assuring traceability, authenticity, and fair trade practises.

Artificial intelligence and machine learning: These techniques analyse enormous datasets gathered from several sources, including sensors, drones, and satellites. Predictive analytics, crop disease detection, and individualised advice are all features of these technologies that help farmers increase production and allocate resources more effectively.

Remote sensing: By using remote sensing tools like satellite imaging and drones, farmers can monitor vast swaths of land and evaluate the health of their crops, their prospective yields, and insect infestations. The operation of the farm may be fully understood by fusing remote sensing data with data from other sources.

Robotics and automation: By incorporating these technologies, labor-intensive processes like planting, weeding, and harvesting become more efficient. Robots and autonomous machines are capable of working around-the-clock, assuring the timely and accurate execution of farm tasks, increasing output and lowering labour expenses.

Weather Forecasting and Climate Data: Farmers may better organise their operations depending on weather patterns by integrating weather forecasting and climate data with farming practises. This connection helps to reduce risks brought on by extreme weather occurrences and optimise irrigation programmes and planting dates.

Farm Management Software: Farm management software provides a centralised platform for farmers to analyse, plan, and manage their operations effectively. It incorporates data from multiple sources, including IoT sensors and drones. These software programmes provide functions for enhanced decision-making, including financial tracking, inventory management, and data visualisation.

Integrating sustainable agriculture technology, such as conservation tillage, cover crops, and water management systems, helps to lessen environmental impact and preserve soil health. Sustainable Agriculture and Environmental Monitoring. Tools for environmental monitoring measure things like biodiversity, carbon sequestration, and water quality, allowing farmers to use more environmentally friendly methods.

Market Access and Online Shopping: Integrating e-commerce platforms enables farmers to communicate with customers directly, doing away with middlemen and assuring fair pricing. Farmers now have more access to markets and the means to forge closer ties with customers thanks to this integration.

In conclusion, the use of technology in agriculture has enormous potential for converting conventional agricultural methods into systems that are data-driven, effective, and sustainable. These technologies have the potential to revolutionise the world's agricultural industry as they develop and become more widely available, assuring future food security and environmental sustainability.

X. CHALLENGES

Combining IoT (Internet of Things) with blockchain technology in agriculture can bring several benefits, such as improved traceability, enhanced data security, and streamlined supply chains. However, there are specific challenges that arise when implementing these technologies in agriculture:

Connectivity and Infrastructure: Both IoT and blockchain rely on internet connectivity to function effectively. In rural and remote agricultural areas, internet access may be limited, leading to issues with data transmission and real-time updates.

Cost of Implementation: Integrating IoT devices and blockchain systems into existing agricultural operations can be expensive. Smallholder farmers or those with limited financial resources may find it challenging to adopt these technologies without significant financial support.

Data Privacy and Security: While blockchain is known for its robust security, the data collected from IoT devices must be secure before it enters the blockchain. Any vulnerability in the IoT system can lead to tampered or compromised data, potentially undermining the integrity of the entire blockchain.

Interoperability: Standardization and interoperability between different IoT devices and blockchain platforms are essential to ensure seamless data exchange. Lack of standardization can create data silos and hinder the sharing of critical information.

Scalability: As agricultural systems grow in size and complexity, the scalability of both IoT and blockchain becomes crucial. The technology must be able to handle a growing number of devices, transactions, and participants without compromising performance.

Education and Training: Farmers and agricultural stakeholders need to be educated about the benefits and proper use of IoT and blockchain technology. A lack of understanding or training can lead to underutilization of the technologies or incorrect implementation.

Regulatory and Legal Frameworks: Integrating blockchain in agriculture raises legal questions regarding data ownership, smart contracts, and liability. Additionally, agricultural regulations may need to adapt to accommodate the use of these emerging technologies.

Energy Consumption: IoT devices require power, and in some cases, continuous monitoring and transmission of data can increase energy consumption. This can be a concern in areas with unreliable or limited energy access.

Complexity: Implementing IoT and blockchain requires technical expertise and a deep understanding of both technologies. The complexity involved in setting up and maintaining such systems may be a deterrent for some farmers.

Adoption and Resistance to Change: Agriculture is often a traditional industry, and introducing new technologies can be met with resistance. Convincing farmers to adopt IoT and blockchain solutions might require extensive awareness campaigns and demonstration of tangible benefits.

To address these challenges effectively, stakeholders must work together to develop user-friendly, cost-effective, and scalable solutions tailored to the specific needs of the agricultural sector. Additionally, providing support and training to farmers during the adoption process can help maximize the potential benefits of IoT and blockchain technologies in agriculture.

XI. FUTURE PROSPECTS AND CONCLUSION

The future of agriculture lies in the integration of advanced technologies to address the challenges of food security, resource scarcity, and climate change. The combination of wireless sensors, the IoT, blockchain, and drones presents a promising solution for sustainable, efficient, and transparent agriculture. As the technology continues to evolve and becomes more accessible, its adoption is expected to witness significant growth, bringing about a paradigm shift in the global agricultural landscape. In conclusion, the fusion of wireless sensors, the IoT, blockchain, and drones represents a pivotal step towards smart agriculture. This integrated approach empowers farmers with data-driven decision-making capabilities, streamlines supply chains, and ensures sustainable practices, ultimately contributing to a more resilient and productive agricultural sector.

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