

# Blockchain and IoT in Smart Agriculture: Analysis, Opportunities, Challenges, and Future Research Directions

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**Abstract:** Agricultural trends indicate a shift towards smart farming and the effective use of modern technologies and machine learning to manage time and resources while reducing crop losses and saving time and resources. These emerging technologies, including the Internet of Things (IoT) and Blockchain (BC), play an effective role in precision agriculture applications. They have made it possible to provide reliable services to guarantee and improve agricultural productivity. The entire agricultural system is improved through real-time monitoring of fields, soil fertility, irrigation techniques, temperature and humidity control, weather monitoring, detection of crop diseases, monitoring of agricultural products, etc. This article aims to present a literature review to examine the issues and challenges related to the blockchain approach associated with IoT applications. It also highlights key ways in which the blockchain approach can support the improvement of IoT systems. Additionally, it examines existing blockchain applications and platforms to provide a comprehensive summary of how the blockchain approach cooperates with the IoT paradigm.

**Keywords:** smart farming; emerging technologies; blockchain; IoT

## 1 Introduction

Globally, the adoption of modern technologies in agriculture represents a crucial step toward improving the agricultural sector. Research and experiments conducted in precision agriculture have demonstrated that the application of innovative techniques and production methods can lead to both economic and technical advantages. The primary motivation behind embracing emerging technologies lies in their ability to facilitate rapid and highly accurate implementation of agricultural operations compared to traditional methods. However, not all techniques yield positive results when employed. To assess the impact of new technologies on the agricultural sector, it is essential to measure the development in production quantities achieved from crops. Therefore, it is crucial to ensure that it is designed for the specific environment and context. Rigorous testing in a targeted area is necessary to validate the technology's effectiveness and quality.

Numerous statistical reports have declared that precision agriculture accomplishes this, leading to further improvements in the global economy based on the use of cutting-edge technologies across all agricultural sub-sectors. According to market research and consulting firms, the global precision agriculture market will grow by an average of 13.7% to reach 10.55 billion USD by 2025 (Xinhuanet, 2020) [1]. Apart from global precision, the agriculture market is expected to grow from 7.0 billion USD in 2020 to 12.8 billion USD in 2025 at a compound annual growth rate (CAGR) of 12.7% (Markets and Markets, 2020) [2].

The agricultural sector today needs more innovations and new technologies to develop, avoiding the use of traditional technologies that were limited only to traditional monopolistic and centralized agricultural management systems. These systems would cause many difficulties, such as easily attacking the central system to manipulate the integrity of the data, and for this reason, lead to the application of blockchain technology in modern agriculture. It is considered one of the most important applications as

it works to improve agricultural system activities in particular supply chains, Internet of Things (IoT)-based systems, food safety, quality control, waste traceability, reliable analysis of operating data, and efficient exchange of contracts and transactions to reduce economic costs, which positively affects support for small farmers.

Internet of Things (IoT) represents a link between objects attached to a connection network (often wireless type Wi-Fi, Bluetooth, 4G) in view of transmitting, storing, or even processing data specific to these objects. The use of the digital transformation of this data makes it possible to convert it into services and actions.

Modern technology, using temperature sensors, humidity, aerial photography, and GPS technology, has brought dramatic changes to the field of agriculture, especially hydroponics. The application of IoT and blockchain in agriculture is expected to grow by at least 20% per year, and the global smart farming market is expected to reach \$15.3 billion by the end of 2025.

### 1.1 Outline of the Paper

The paper is divided into five sections:

- Section 1 provides a brief introduction to the article and research contributions.
- Section 2 includes a comprehensive and in-depth review of previous work relevant to investigating the importance of the Internet of Things (IoT), blockchain technologies, and developing intelligent systems and applications in precision agriculture. In addition, some tables describe important investigations previously carried out by researchers.
- Section 3 explains an episode on the role of the Internet of Things and blockchain technologies in smart farming.
- The main ideas of the technical aspects of the Internet of Things and Blockchain systems are clarified to form the future research directions proposed in section 4.
- Finally, section 5 concludes.

### 1.2 Our Contribution

This article reviews a literature survey on emerging IoT and blockchain technologies in digital agriculture that are important due to the rapid growth rate of scientific output. The remainder of this article is organized as follows: A well-detailed overview concerning the structures of two technologies, IoT and Blockchain. Synthesis summary of the adoption of these emerging technologies in the field of smart agriculture.

Finally, this research contains a comparative study of different IoT and blockchain platforms, as well as future directions on updating the applications of these technologies in the agricultural sector.

## 2 Related Work

Many publications and scientific research mentioned in this article show the importance of these techniques.

Pandithurai et al. (2017) [3] have proposed a wireless sensor network technology for agricultural engineering that could become an important turning point in the improvement and development of traditional agriculture. Internet of Things applications will be used to record, store, and update the activities of various sensors that farms can access to monitor fields, soils, and crop management.

Tran et al. (2018) [4] used the Internet of Things (IoT) to make agriculture smart so that farmers can estimate the ideal harvest time

There are many reasons to implement a smart farming solution in commercial and local agriculture as well as in various agriculture-related institutions and organizations. In a world where IoT is accelerating the adoption of automation and data collection, an important industry like agriculture can certainly benefit. Our project to make agriculture smarter will certainly contribute to the growth of this industry (Mishra, 2019) [5]. The authors enable the implementation of an IoT based device that can monitor soil moisture and temperature to grow and produce a good crop, and to turn on and off light and water pump remotely using clouds.

Designing an IoT based system for farmers to remotely receive updates on soil moisture, temperature, and other parameters of a farm will also allow farmers to control pumps and supply plant water via internet or mobile phone application (Vadapalli, 2020) [6]. Olakunle Elijah et al. (2018) [7] present how the combination of IoT and data analytics can make agriculture smart. Authors indicate

that IoT integrates many technologies, such as the wireless sensor network (WSN), cloud computing, middleware systems, etc.

Farooq et al. (2019) [8] explain the main components of the Internet of Things, showing the use of innovative applications based on smartphones by presenting sensors developed in the agricultural sector.

Rahman et al. (2020) [9] indicate existing challenges in confronting IoT based smart agriculture. Additionally, a data sharing system should be scalable and distributed using a high-performance smart contract platform.

Integrating blockchain technology with the Internet of Things is an approach used by researchers (Biswas et al., 2021) [10]. Developing smart agriculture is crucial, as it offers farmers a secure and open transaction method to increase their profits. Others believe (Umamaheswari et al., 2019) [11] that the agricultural sector will reap the benefits of IT by introducing innovation and deployment of blockchain technology in IoT applications to improve quality of life, which today should be a trending topic in the research community (Abdelmaboud et al., 2022) [12]. IoT systems enable the integration of a range of existing advanced solutions and technologies, such as (WSN), cloud computing, big data, and end-user applications (Quy et al., 2022) [13].

Chigurh et al. 2021 [14] used blockchain and cloud computing to create a transparent, tamper-proof digital marketplace platform for agricultural products where farmers and consumers can create a cooperative method of farming.

Many applications of blockchain (BC) and IoT in smart agriculture are improving various aspects of agricultural systems, particularly supply chain quality, product management (Chen et al., 2017; Liu et al., 2014) [15; 16] and Internet of Things (IoT) based systems (Biswas et al., 2021) [10]. Baranwal et al. (2016) [17] aims to accentuate innovative technologies, especially the Internet of Things (IoT), in agriculture to solve many problems, such as rodent identification, crop threats, and notifications in real-time based on the processing of information without human intervention, also referred to as the Secure Trust Model (Zhu and Badr, 2018) [18]. Some applications can be developed using existing blockchain platforms (Abdelmaboud, et al., 2022; Choto and Wafula, 2019) [12; 19] to facilitate quick and easy developments.

Emerging IoT and blockchain technologies in the agricultural sector are also complex. These technologies will require more open futuristic research and challenges. The following part will present research works on the adoption of IoT/BC in smart agriculture.

(Table 1) provides a brief summary of research into the use of emerging technologies and machine learning in intelligent agriculture.

**Table 1.** Related existing research work based on the adoption of IoT and blockchain in precision agriculture

| Survey Paper | Year of Publication | Use Case / Contributions                                      | Technology                                                 |
|--------------|---------------------|---------------------------------------------------------------|------------------------------------------------------------|
| [17]         | 2016                | Smart security and monitoring devices for agricultural sector | IoT                                                        |
| [3]          | 2017                | AGRO-TECH : A digital model for monitoring soil and crops     | IoT/ Blockchain Cloud Computing.                           |
| [20]         | 2021                | Smart contract/Smart agriculture                              | Blockchain /IoT                                            |
| [21]         | 2021                | The Digital Agricultural Revolution                           | AI; Big Data;Cloud Computing; Robotics; IoT and Blockchain |
| [4]          | 2018                | Green Agriculture System                                      | IoT and Processing Techniques                              |
| [18]         | 2018                | Fog Computing Security Architecture                           | IoT/Blockchain                                             |
| [22]         | 2019                | DeepChain                                                     | Deep Learning with Blockchain                              |
| [19]         | 2019                | A platform for agriculture smart contracts                    | NEO blockchain                                             |
| [6]          | 2020                | Smart-Agriculture                                             | IoT                                                        |

|      |      |                                                        |                                   |
|------|------|--------------------------------------------------------|-----------------------------------|
| [23] | 2020 | Smart Indoor Farming Management System                 | Assistant Robot and Mobile App    |
| [24] | 2021 | Novel Hydration System for Smart Agriculture           | IoT                               |
| [10] | 2021 | BIoT : IoT-based system to monitor agricultural fields | Blockchain based IoT              |
| [25] | 2021 | Secure Trust Model Enable Smart agriculture            | Blockchain for Internet of Things |
| [26] | 2022 | Cyber-Security                                         | IoT based on ANN                  |

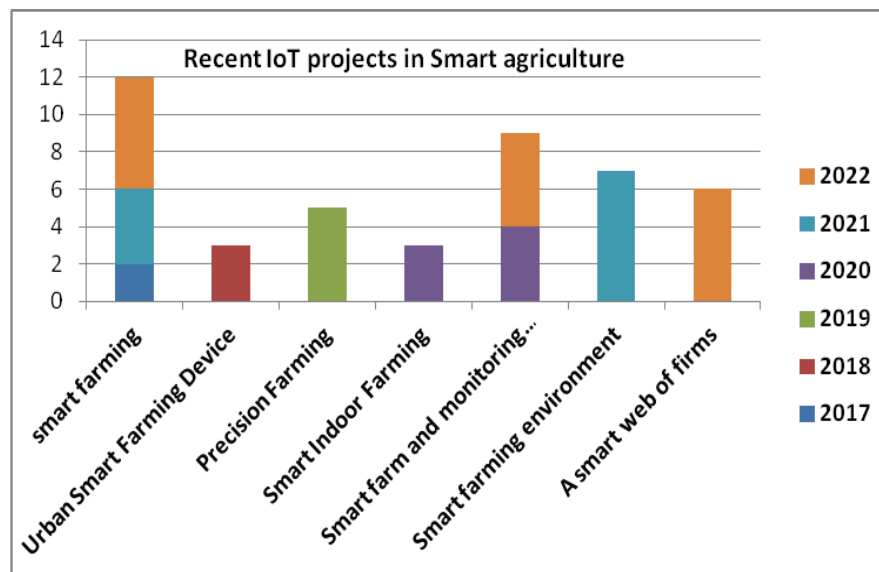
The combination of IoT and blockchain will make the farm more independent, intelligent, far more efficient, and better at the management of precision farming.

The evolution of IoT in recent years has provided many opportunities to promote precision agriculture. (Table 2) lists various research works concerning the adoption of the Internet of Things in agriculture.

**Table 2.** Synthesis of the various previous works for adoption of Internet of Things in smart agriculture

| Survey Paper | Year of Publication | Use Case / Contributions                          | Technology      |
|--------------|---------------------|---------------------------------------------------|-----------------|
| [27]         | 2017                | smart farming                                     | IoT             |
| [28]         | 2018                | Urban Smart Farming Device                        |                 |
| [29]         | 2019                | Precision Farming                                 | IoT             |
| [23]         | 2020                | Smart Indoor Farming (using robot and mobile app) | IoT             |
| [30]         | 2020                | Smart farm and monitoring system                  | IoT             |
| [31]         | 2021                | Smart farming                                     | IoT             |
| [32]         | 2021                | Smart farming environment                         | Robotic and IoT |
| [33]         | 2022                | Smart farming                                     | IoT             |
| [34]         | 2022                | Smart web of farms                                | IoT             |

These projects (Figure 1) aim to enhance agricultural productivity, sustainability, and resilience. As technology continues to evolve, we can expect even more exciting developments in the intersection of IoT and smart agriculture.



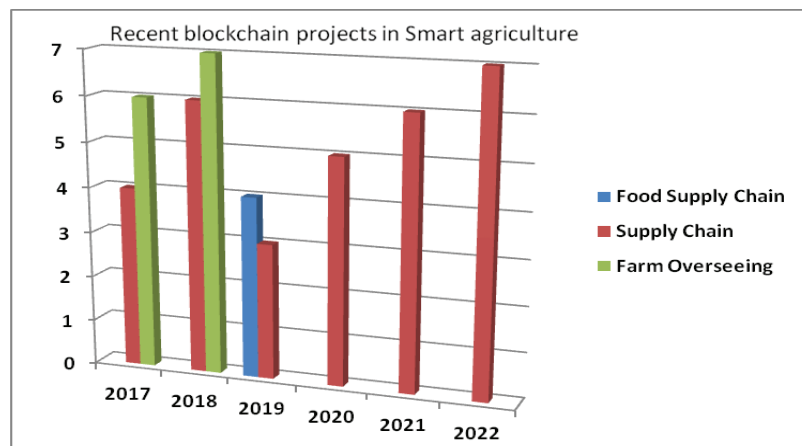
**Figure 1.** Recent Internet of Things (IoT) projects in smart agriculture

As a more detailed explanation of the previous work related to blockchain (BC) and its current innovations in the context of smart agriculture, (Table 3) presents an exhaustive survey of the previous work based on blockchain (BC) and their current innovations in smart agriculture.

**Table 3.** Synthesis of research work on the adoption of blockchain in smart agriculture

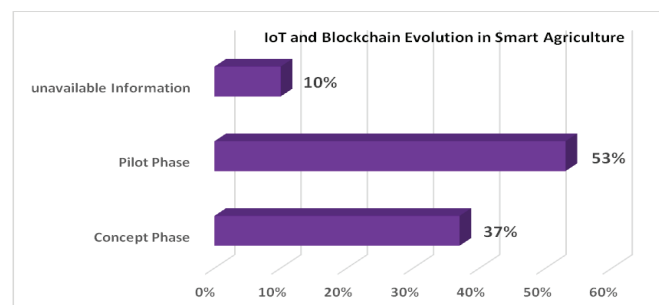
| Survey Paper | Year of Publication | Use Case / Contributions                                  | Technology                       |
|--------------|---------------------|-----------------------------------------------------------|----------------------------------|
| [15]         | 2017                | Supply Chain Quality Management                           | Blockchain                       |
| [35]         | 2017                | Farm Overseeing/Monitoring system for water distributions | Blockchain                       |
| [36]         | 2018                | Supply Chain                                              | Double Blockchain chain system   |
| [37]         | 2018                | Farm Overseeing                                           | Blockchain                       |
| [38]         | 2019                | Food Supply Chain Management                              | Blockchain                       |
| [39]         | 2020                | Supply Chain Management                                   | Blockchain                       |
| [40]         | 2021                | Supply Chain Management                                   | Blockchain based system with IoT |
| [41]         | 2022                | Supply Chain Management                                   | Blockchain                       |
| [42]         | 2022                | Supply Chain System                                       | Blockchain                       |

The evolution of blockchain and IoT research in smart agriculture holds promise for sustainable food production, efficient supply chains, and resilient farming practices (Figure 2).



**Figure 2.** Evolution of blockchain and internet of things research in smart agriculture

Precision agriculture aims to optimize farming practices by leveraging real-time data, automation, and smart devices to improve crop yields, resource efficiency, and sustainability. The combination of IoT and blockchain (Figure 3) offers great potential for improving traceability, supply chain transparency, and data-driven decision-making in the agricultural sector.



**Figure 3.** IoT and Blockchain progress in precision agriculture

Many researchers are exploring and deploying these IoT/Blockchain technologies due to improved agricultural productivity. These emerging technologies are important and effective in precision agriculture applications, as they provide reliable services.

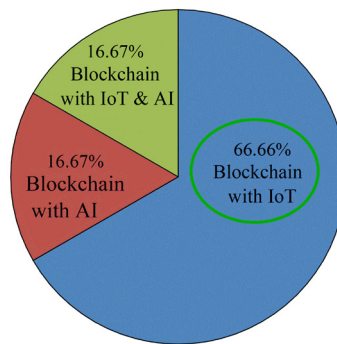
Smart agriculture relies on modern technologies to ensure and improve agricultural productivity, soil fertility, irrigation technologies, temperature, and humidity control.

Blockchain should present existing solutions to provide permanent security and the ideal performance of the IoT network in precision agriculture.

### 3 Overview of Emerging Technologies

#### 3.1 Blockchain Technology with IoT and AI in Agriculture

In the coming decades, Blockchain technology will make applications more secure and transparent, while artificial intelligence will provide application analytics to make IoT applications connected and efficient. The integration of blockchain with IoT and AI is playing an important role in the future of agriculture and healthcare in managing food supply chains, pharmaceutical supply chains, product traceability, smart contracts, product monitoring, and smart connected forecasting. (Figure 4) shows that most (66.67%) of the available projects that only combine Blockchain with Agricultural IoT play an important role in our daily life.



**Figure 4.** Paper distribution of IoT and AI with Blockchain in agriculture

**Blockchain technology, Internet of Things (IoT), and Artificial Intelligence (AI)** converge in the field of agriculture to shape the next wave of digital transformation. Together, they offer innovative solutions to address challenges related to food supply chains, drug traceability, smart contracts, product monitoring, and intelligent predictions. Integrating these technologies can make agriculture more efficient, sustainable, and resilient, contributing to global challenges such as food security and climate change.

#### 3.2 Internet of Things (IoT)

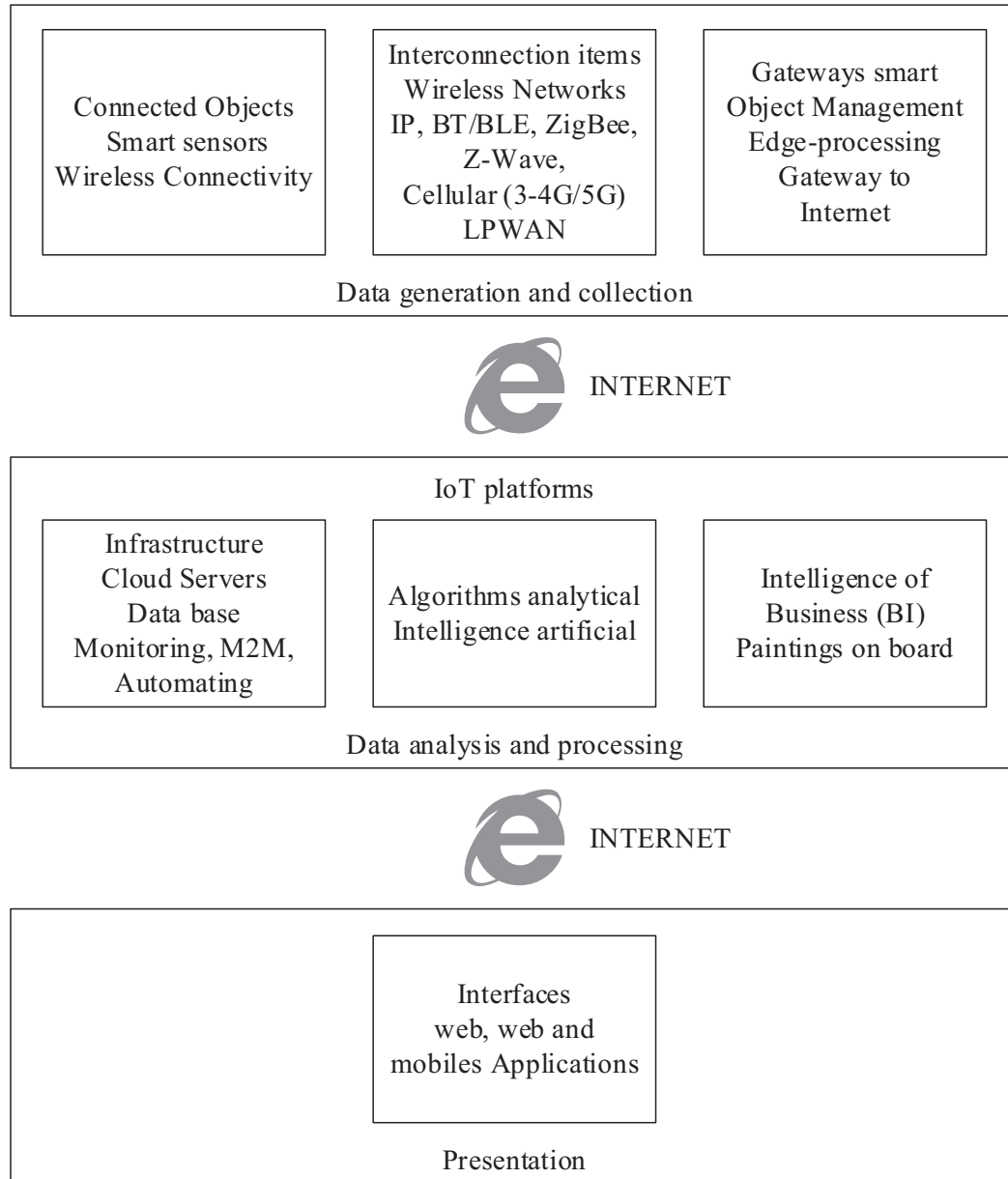
Kevin Ashton was the first to use the term “Internet of Things” in 1991 [43] to describe radio frequency identification (RFID) microchips. According to Cisco Internet Business Solutions Group (IBSG), Internet of Things (IoT) was created between 2008 and 2009 [44] when more “things or objects” were connected to the Internet than people.

The Internet of Things Global Standards Initiative (IoT-GSI) working group, led by the International Telecommunication Union (ITU), considers the IoT as: global infrastructure for an information-based society, making it possible to create advanced services by interconnecting objects (physical or virtual) using existing or evolving interoperable information and communication technologies.

These authors endorse the adoption of digital and emerging technologies such as ML, M2M, IoT, Cloud and Blockchain as secure storage for data in the agricultural sector. These IoT-related technologies, such as sensors and machine learning, offer greater insight into the conditions in agriculture for high yields and risk mitigation.

### 3.2.1. Layers of IoT architecture

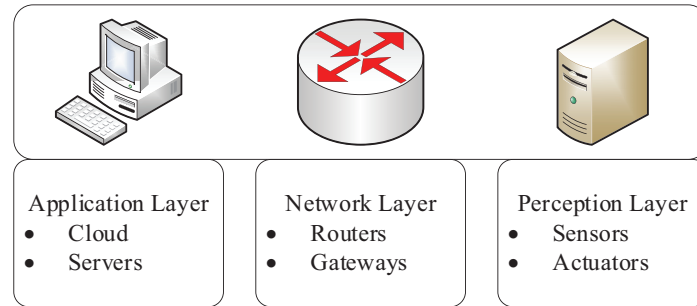
IoT architecture is the structured framework that enables Internet-connected devices to communicate with each other. It is made up of several layers (Figure 5), each playing a specific role. Although not covering all possibilities, the following group of architectures should give a better understanding of fundamental design considerations and key functional layers typical in an IoT environment.



**Figure 5.** Global IoT architecture

#### a) 3-layer IoT architecture

- **Perception layer:** This layer consists of sensors, actuators, and peripheral devices that interact with the environment. The information collected by these sensors may relate to location, changes in the air, environment, movement, vibration, etc.
- **Network or transmission layer:** This carries and transmits information collected from physical objects through sensors.
- **Application layer:** This layer carries the responsibility of providing services to the applications. The services may vary for each application as they depend on the information collected by the sensors (Figure 6).

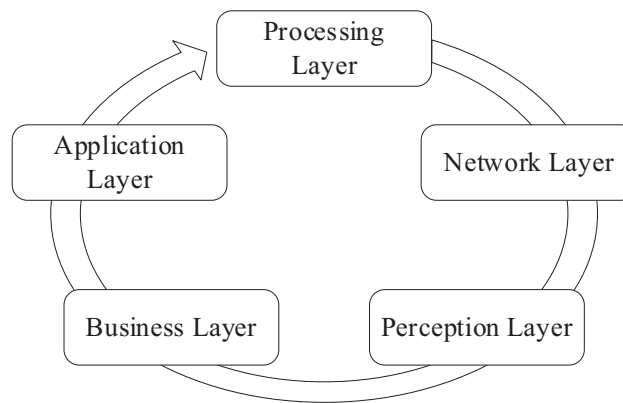


**Figure 6.** Conventional 3-layer IoT architecture

**b) 5- layer IoT architecture**

The model has two other layers. This architecture can meet the requirements of the IoT (Figure 7).

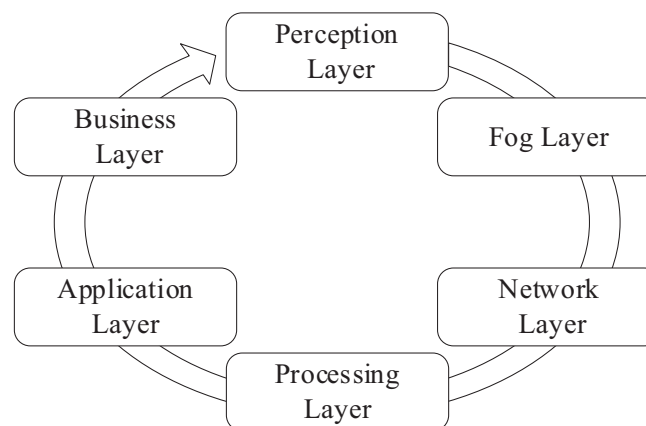
- **Perception Layer or Middleware Layer:** This layer consists of sensors, actuators and peripheral devices that interact with the environment. This layer is responsible for identifying and collecting information. There are many types of sensors attached to objects to collect information such, as RFID. These sensors are chosen according to the needs of the applications.
- **Business Layer:** This layer helps manage user privacy. It is responsible for managing and controlling the application, business, and profit models of the IoT.



**Figure 7.** Conventional 5-layer IoT architecture

**c) IoT architecture based on Fog computing layer**

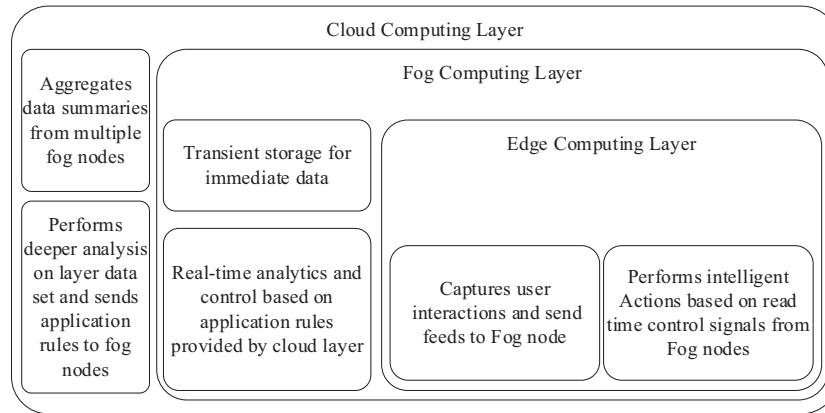
In this layer, the data processing and functional processing capabilities are redirected to the peripheral elements of the network environment within the IoT ecosystem. This allows a reduction in localized latency greater than all the previous layers (See Figure 8).



**Figure 8.** IoT architecture based on Fog computing layer

#### d) Hybrid IoT architecture: Fog / Edge / Cloud computing

Fog and Edge architectures (Figure 9) can be hybridized with cloud-centric IoT architectures if deemed well-suited to a project's requirements and business goals. The diagram below shows a combination using a nested configuration.



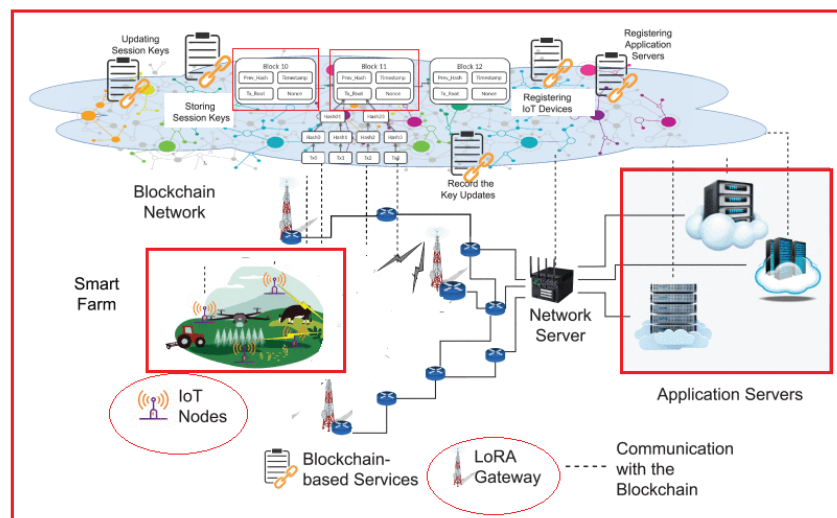
**Figure 9.** Hybrid IoT architecture: Fog / Edge / Cloud computing

#### 3.2.2. IoT Architecture System

The system architecture setup is shown in (Figure 10). It consists of four distinct entity types: IoT devices, a network server, application servers, and a blockchain platform. They interact as follows:

- **IoT devices:** These devices communicate with the network server using LoRA (Long Range) technology. Specifically, battery-powered IoT devices send the measured data to the network server via gateways pre-registered with the latter.
- **Network server:** This plays a central role in receiving data from IoT devices. Depending on the different applications deployed, the network server transmits the data received to one or more application servers.
- **Application servers:** These servers process the data received and perform various specific applications related to precision agriculture, such as soil monitoring, irrigation control, crop disease detection, etc.
- **Blockchain platform:** This ensures the security and traceability of transactions between the different players in the system. Agricultural data is recorded securely in the blockchain, without requiring the intervention of a trusted third party.

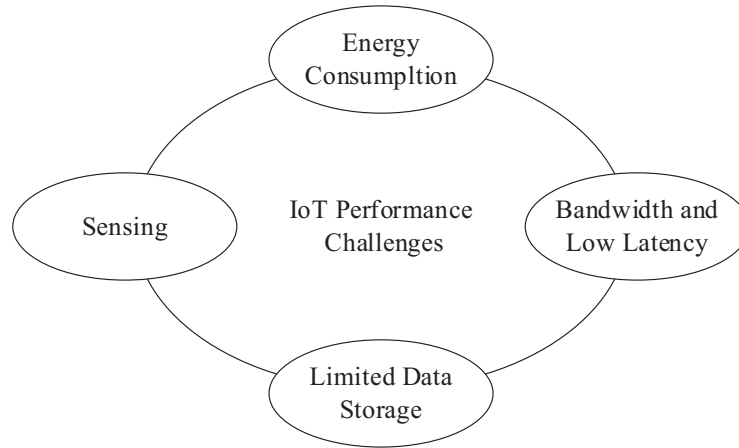
By combining these entities, the system aims to improve the efficiency and reliability of precision agriculture through the convergence of IoT and blockchain.



**Figure 10.** System Architecture

### • IoT Performance Challenges in Precision Agriculture Networks

Currently, due to the growing demand for precision agriculture, the IoT has become a must-have technology for the agricultural industry. IoT challenges in smart agriculture have also been highlighted. (Figure 11) delves into performance challenges faced by Internet of Things (IoT) networks in the context of precision agriculture. These challenges are critical for ensuring efficient and reliable data communication in agricultural settings:



**Figure 11.** Hybrid IoT architecture: Fog/ Edge/ Cloud computing

### • Smartphone agricultural applications description using IoT

Currently, smartphones are necessary devices in the digital agricultural sector thanks to their mobility, which accords with the nature of agriculture. Today, these tools are installed with many types of sensors in order to bring about various agricultural tasks. Each IoT device accommodates one or more sensors that gather existing data and provide accurate information via real-time mobile applications (Table 4) provides a systematic review of mobile applications mentioned in research literature, categorized accordingly.

**Table 4.** Smartphone agricultural applications description

| Applications Name                 | Category          |                             |               |                                         |                        |                                  |
|-----------------------------------|-------------------|-----------------------------|---------------|-----------------------------------------|------------------------|----------------------------------|
|                                   | Precision Ag Apps | Agriculture Calculator Apps | Soil Sampling | Agriculture Management Information Apps | Commodity Pricing Apps | News and Weather Information App |
| Farm Progress Growing Degree Days | ✓                 |                             |               |                                         |                        |                                  |
| Farm calculators                  |                   | ✓                           |               |                                         |                        |                                  |
| Ag PhD Soybean Diseases           | ✓                 |                             |               |                                         |                        |                                  |
| Blend Calculators                 |                   |                             |               |                                         |                        |                                  |
| Soil App                          |                   |                             | ✓             |                                         |                        |                                  |
| Farm Future                       |                   |                             |               |                                         | ✓                      |                                  |
| SOIL Sampler                      |                   |                             | ✓             |                                         |                        |                                  |
| Agri Zone                         |                   |                             |               |                                         |                        | ✓                                |
| Farm Manager                      |                   |                             |               | ✓                                       |                        |                                  |
| Farma Partner                     |                   |                             |               |                                         | ✓                      |                                  |
| Agriapp                           |                   |                             |               | ✓                                       |                        |                                  |
| Farm Progress Growing             |                   |                             |               |                                         |                        | ✓                                |
| Ag mobile                         |                   |                             |               |                                         |                        | ✓                                |

### 3.2.3. IoT Platforms

The Internet of Things IoT requires powerful software platforms to meet the needs demanded by IoT use cases. These platforms play a crucial role in connecting devices, managing data flow, and enabling seamless communication within the IoT ecosystem.

(Table 5) shows an in-depth survey of IoT platforms with a summary comparison according to which features were mentioned in varying degrees.

**Table 5.** Comparison of IoT platforms [45][46]

| Platform Name              | Microsoft                 | IBM              | Amazon              |
|----------------------------|---------------------------|------------------|---------------------|
|                            | IoT Hub                   | IBM Watson IoT   | AWS IoT             |
| Object Storage             | Yes                       | Yes              | Yes                 |
| Device-Gateways            | Yes                       | Yes              | Yes                 |
| Device_Protocols           | AMQP;HTTP                 | MQTT             | Web Sockets         |
| Device-Device SDK          | Open source SDK           | Yes              | Open SDK            |
| Device_security            | TLS                       | TLS              | X.509               |
| Notifications and Alerts   | Yes                       | Yes              | Yes                 |
| Big Data                   | Yes with HD Insight       | ----             | Yes with Amazon EMR |
| Machine Learning           | Yes/API (managed Service) | ----             | Yes                 |
| Analytics-Cold Path        | Yes                       | Yes              | Yes                 |
| Analytics-Cold Path        | Yes                       | Yes              | Yes                 |
| Visualization              | Yes                       | Yes              | Yes                 |
| Field Service Integrations | Manual /Partners          | Manual /Partners | Manual /Partners    |

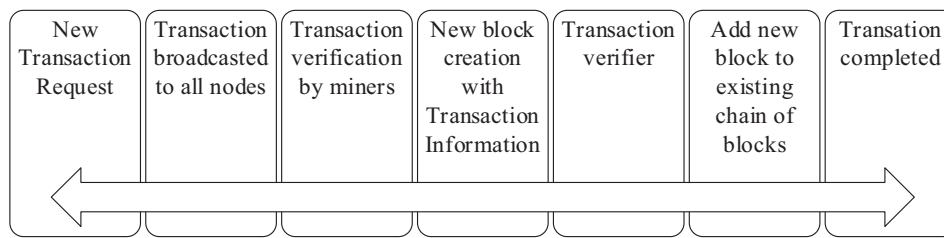
IoT platforms play a pivotal role in enabling seamless communication, data management, and application development within the ever-expanding world of connected devices. This comparison shows that most IoT software platforms are not designed with the system performance aspects of IoT deployments in mind, which are critical in practice.

### 3.3 Blockchain Technology

Blockchain technology was originally invented for crypto-currencies and evolved from Bitcoin in 2008 by Satoshi Nakamoto [47].

The objective is to provide producers with a “data passport” solution to protect the sharing of information collected on their operations. Blockchain designates a database that takes a global history of various exchanges carried out between its users during its creation. This database should be better secured and distributed as it is shared by its users, without an intermediary, allowing everyone to check the validity of the chain (Zheng et al., 2017) [48]. Blockchain can create transactions stored and recorded in a ledger that is maintained by a group of connected computers without the need for a trusted authority from a central entity (Biswas et al., 2019) [49]. Each record is called a block; each block contains a section of data and a “hash” generated from the data in each block using cryptography. Blocks are linked together by referring to the hash of the previous block. When creating a new block, all network nodes can share in the block validation process. A back reference pointing to the parent block should automatically attach to the end of the blockchain. It can easily detect any illegal manipulation of previously created blocks because the hash of modified blocks is notably different from the hash of unchanged blocks. However, since the blockchain is distributed throughout the network, malicious activities from other nodes in the network can be easily identified (Dai et al. 2019) [50].

A blockchain is a chain of data records that are distributed across a decentralized network of computers (Figure 12), meaning that there is neither central authority nor a single point of failure. Each computer keeps its own copy of the ledger (blocks), and any update requires the approval of a majority of machines in the network, making it impossible to manipulate.



**Figure 12.** Structure of blockchain

### 3.3.1. Blockchain Technical Components

- **Decentralized database:** At the heart of the blockchain is a decentralized database. Unlike traditional databases controlled by a central authority, blockchain data is distributed across a network of computers (nodes). Each node maintains a copy of the entire ledger, ensuring redundancy and resiliency.
- **Transactions and blocks:** The Blockchain records transactions in blocks. Each block contains a set of transactions. When a new transaction occurs, it is grouped with others into a block. These blocks are then linked together in chronological order, forming a chain (hence the name “blockchain”).
- **Cryptographic hash:** To ensure data integrity, each block includes a cryptographic hash of the previous block. This hash acts as a unique identifier for the block and ensures that any tampering with previous data will be immediately detectable.
- **Consensus mechanisms:** Blockchain networks rely on consensus mechanisms to validate and agree on the state of the ledger. Common mechanisms include proof of work (PoW) and proof of stake (PoS). PoW involves miners solving complex mathematical puzzles to add new blocks, while PoS relies on validators who hold a stake in the network.
- **Smart contracts:** Smart contracts are self-executing programs stored on the blockchain. They automatically perform predefined actions when specific conditions are met. Ethereum, for example, popularized smart contracts and enabled decentralized applications (DApps).
- **Public blockchains:** Open to everyone, public blockchains (e.g. Bitcoin, Ethereum) allow anyone to participate, validate transactions, and read the ledger.
- **Private blockchains:** Reserved for a specific group of participants, private blockchains are often used for enterprise applications. They prioritize privacy and control.
- **Private and public keys:** Users interact with the blockchain using cryptographic keys. A private key allows users to sign transactions, while a corresponding public key serves as their address on the network.
- **Mining and validation:** In PoW-based blockchains, miners compete to solve puzzles and validate transactions. Successful miners add new blocks to the chain. In PoS, validators are chosen based on their stake in the network.
- **Immutability:** Once data is added to the blockchain, it becomes immutable. It cannot be modified or deleted without the agreement of the network.
- **Security and trust:** The decentralized nature and cryptographic security of blockchain make it resistant to fraud and tampering. Trust is established through network consensus rules.

### 3.3.2. Blockchain platforms

Blockchain platforms play an important role in the world of decentralized technologies. These platforms enable the creation and management of various Web3 functions, including smart contracts, NFTs, and decentralized finance (DeFi). Each platform has its unique features, benefits, and community support. Choosing the right platform depends on specific use cases and requirements.

Many blockchain platforms (Table 6) are mentioned and currently available, such as Ethereum, Hyperledger, and Coco.

**Table 6.** Comparison of blockchain platforms [51] [52]

| Platform Name                 | Ethereum                                   | Hyperledger Fabric                                                                  | Coco                                           |
|-------------------------------|--------------------------------------------|-------------------------------------------------------------------------------------|------------------------------------------------|
| Description of platform       | Generic blockchain platform                | Modular blockchain platform                                                         | Blockchain ledger framework                    |
| Programming Language          | Solidity                                   | Go,Java                                                                             | Different languages for smart contracts        |
| Governance                    | Ethereum developers                        | Linux Foundation                                                                    | Microsoft                                      |
| Open source                   | Yes                                        | Yes                                                                                 | Yes                                            |
| Consensus                     | Mining based on Proof-of-Work ledger level | Broad understanding of consensus that allows multiple approaches; Transaction Level | Caesar consensus or other consensus algorithms |
| Smart Contracts               | Smart contract code                        | Smart Contract code                                                                 | Enterprise smart Contract                      |
| Currency                      | Ether Tokens via smart contract            | None Tokens Via chaincode                                                           | None                                           |
| Per missioning                | No                                         | Fine-grained permissions                                                            | Coarse-grained permissions                     |
| Transaction Confirmation Time | ~12 sec                                    | “Instantaneous”                                                                     | “Instantaneous”                                |
| Transaction Cost              | A fee must be paid                         | No fee                                                                              | There’s a cost in credits currency             |
| Privacy                       | No                                         | Yes                                                                                 | Yes                                            |

This comparison table describes some blockchain platforms for developing a private blockchain. A blockchain platform should be general, not limited to financial applications, and contain broad community support to achieve future maintenance.

## 4 Future Work

Our future plan is to apply these techniques to create applications that meet our goals in the advancement of smart agriculture. This work suggests future research directions in the field of intelligent applications for precision agriculture that combine modern technologies and machine learning [53]. Furthermore, creating new blockchain models can serve as a meaningful solution to the grand challenge of IoT-based precision farming systems. Blockchain plays a key role in replacing traditional methods of storing, sorting, and sharing agricultural data in the form of files, making it more reliable, stable, transparent, and decentralized in precision agriculture. The integration of the two technologies of the Internet of Things and blockchain in agriculture will make the management of precision agriculture more independent, smarter, and more efficient. The connection between blockchain and IoT should also be closely explored to further explore use cases for precision farming technology.

## 5 Conclusion

The article proposes a detailed literature review to examine the latest developments in IoT systems and blockchain technology in the field of smart agriculture.

Our main objective is to demonstrate the importance of these proposed emerging technologies and their architectures. This study summarizes precision agriculture as an approach used in large or small farm management and crop control through information technology and the use of agricultural applications. It draws on existing modern IoT/blockchain technologies to guarantee and improve agricultural productivity, soil fertility, irrigation technologies, and temperature and humidity control.

For these technologies to become mainstream, it is essential to solve scalability and cost issues. Further research is needed to make IoT and blockchain solutions more affordable and accessible to small farms. The future of smart agriculture lies in the convergence of these technologies, their acceptance by industry players, and their adaptation to the specific needs of farms.

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