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Systematic Review

The Role of Blockchain in Revolutionizing the Agricultural Sector

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Abstract: Since blockchain technology has proven to be effective in the development of a wide range of industries, its use in other fields is also being expanded. Agriculture is one such sector, where blockchain technology is being used to improve farm business operations. Today, several agribusiness firms are utilizing technology to improve food supply chain tracking. For example, Farmers Edge, the world's leading company that revolutionized the field of digital agriculture through its work in providing advanced artificial intelligence solutions, as well as new opportunities that give agriculture a globally advanced future for all stakeholders, has taken a significant step forward. The issue of blockchain network technology and its applications in agriculture will be discussed in this study, as well as the key advantages that this technology can provide, when employed to make the lives of both producers and consumers easier. In addition, a total of 79 research papers were evaluated, with a focus on the state of blockchain technology in agriculture, related issues, and its future importance, as well as relevant contributions to this new technology and the distributions of this study by different countries.

Keywords: blockchain; agricultural sector; artificial intelligence; food supply chain; digital agriculture

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1. Introduction

In domains such as e-commerce, agriculture, public services, and others, little is known about the function of blockchain in operations traceability. As a result, the goal of this study is to discover more about blockchain applications in operations and supply chain management, as well as how companies use blockchain to create and capture commercial value, particularly in agriculture. DLT (Distributed Ledger Technology)/blockchain is an intriguing new technology that has the potential to be a game-changer [1], and, in general, DLT are tamper-resistant and time-stamped databases [2]. They allow several parties to capture, validate, and distribute data over a network in a decentralized, synchronized, and transparent manner, with minimal human participation and intermediate processes [3]. Blockchain has the potential to alter the present economic and commercial paradigms, such as how the steam engine and the Internet sparked past industrial revolutions [4,5].

Many industries, including the financial sector, energy markets, supply chains, intellectual property management, 'virtual enterprises,' the public sector, and beyond, could benefit from blockchain technologies. [6]. Its capability to lower transaction costs, inject efficiencies into existing value chains, challenge revenue models, and open new markets is due to its ability to de-intermediate, improve transparency, and boost the ability to listen [7,8].

A blockchain is a distributed database that is shared across a network of computers. It is possible to contribute to the database but not to edit the existing data [9]. The database's legitimacy is checked on a regular basis by the network. While the most well-known application of blockchain is in the cryptocurrency Bitcoin, it is currently being employed in a variety of other ventures [10]. It is the platform's core technology that enables the creation of a safe means to record transactions and distribute them to signatories or any other target group with an Internet connection. It is, at its core, a highly democratic ledger that cannot be changed arbitrarily and is easily shared [11,12].

Blockchain offers the potential to improve financial management, origin, traceability, and transparency in food chains, as well as enable the creation of new markets and products, for agriculture in poor countries [13,14], since humanity deserves the best in terms of education, business, health care, and, even, grocery shopping. We always have fresh fruits and vegetables, dairy, and meat to live a healthy and delightful life, thanks to agricultural advancements.

However, have you ever been puzzled about the nutritional value of the food we buy? Was it sourced from reputable growers? What about the conditions of transit and storage? Is the quality, above all, commensurate with the price? Perhaps the answer has been found, thanks to technological advancements and the blockchain business.

The goal of this research was to broaden and deepen understanding of blockchain network technology and its applications in agriculture. That is in addition to the significant benefits that this technology may provide, when used to make the lives of both producers and customers easier. Whereby, a total of 144 research papers were retrieved from Web of Science database as targeted publications for a systematic review, with a focus on the state of blockchain technology in agriculture and related concerns, their contribution to this new technology, the distributions of this study by country, and blockchain's future importance, which are also discussed in this paper.

As a result, the research is separated into two primary sections:

First, exploring the use and benefits of blockchain in agriculture, as well as some real-world instances of blockchain applications.

Second, inside a few selected studies, a thorough systematic review was conducted to clarify the state of blockchain technology in agriculture. By following specific search criteria, in which two main keywords were chosen, "blockchain" and "agriculture". In addition, only English articles that had been published by specific publishers were included.

2. Fundamentals

2.1. The Use of Blockchain in Agriculture

The transmission of encrypted information is vital to every part of our modern life. Agricultural stakeholders want their personal data to be stored securely and not disclosed to third party companies and persons. That is exactly what blockchain provides—the effective protection and secure exchange of data [15,16]. Since the information in the network is written in blocks, it cannot be easily modified or read if access is not permitted. Moreover, all data are stored on decentralized networks that reduce the risks of hacking and fraudulent activity [17].

Currently, the blockchain network is predominately used in the financial field to monitor and confirm transactions as well as improve their speed and security [18]. The banks that have tested this technology appear to be quite satisfied with the results. Blockchain also helps with document verification and confirmation, as well as helping to speed up logistics processes [19].

However, how useful is a blockchain for agriculture? As mentioned, the network is great for accelerating and securing financial transactions—in the same way that it may help solve problems related to the financing of agricultural projects and lead to the further development of the entire industry [8,20]. The blockchain allows to control and accelerate the daily operations of the industry such as production, transportation, food processing, storage, and sale [21]. Blockchain technology is also great at solving problems related to the growing population, and, thus, the demand for food and the demand for quality products: first, logistics can be efficiently organized, and financing can be purchased using this network. Second, blockchain can be useful in determining food quality and preventing fraud [22,23].

In addition, the blockchain has a significant impact on the arrangement of the supply chain as a transparent and secure data exchange network that greatly simplifies cooperation between farmers, carriers, and customers [24]. This is vital for products with short expiration periods, as it helps reduce expenses and, therefore, the overall price of these products. When using the system, the farmer must enter all the details about the products they sell, as no one can remove or modify them, and, therefore [25], it will not be possible to sell the same dozen eggs twice—the system will detect fraud from other users. In addition, if the farmer is required to enter all product details, the system may be vulnerable to the submission of fraudulent or wrong data, which will become immutable [22].

2.2. The Benefits of Using Blockchain in Agriculture

The blockchain approach alone does not guarantee that farmers' income or beef quality will improve. The technology, instead, is rather a tool for automation, traceability, quality assurance, and more. With this technology, improvements in this area can be experienced [14]. The blockchain network may have some advantages when applied correctly in various industries, including the agricultural sector. For example, these benefits could be explained as the following:

- Transparent supplemented

Some customers want to know where the food they buy is grown, how it is delivered to the store, and whether the products meet quality standards. Due to blockchain technology, this information is accessible, and customers understand that it cannot be modified or hidden invisibly [22]. In this approach, if a QR code label is placed on, say, a beef package, the consumer may verify not only the animal's living conditions but also the shipping data, storage duration, and many more details [26,27].

- Secure system

The data on the blockchain network cannot be changed without the permission of both the seller and the buyer [28]. As a result of this technique, a dependable system that protects users from fraudsters and prevents fraud is created, which is a kind of system that is trustworthy to its users. The dependable system requires that the system be highly available (to legitimate users) while ensuring a high degree of service integrity [29]. For example, it is difficult to make a price decrease or increase without first discussing the pricing and finding a qualified team of software developers with reasonable rates reasonable portfolio that includes agricultural experience. For example, the company should be able to provide a well-designed and high-quality product with the required set of data records [30].

- Encourage investment

Owning a small business is often difficult. Finding loyal customers and establishing operations takes one to two years, and it can be challenging. Using blockchain technologies, small farm owners will be able to find investors and improve their business with the help of the Initial Coin Offering program (ICO), which is a type of funding similar to crowdfunding, with crypto currencies instead of regular payments [31]. All that needs to be done to turn ideas into reality is to convince people to invest in the project, although ICO is not regulated and guaranteed by the government, so startups do not need to cover additional legal expenses or hire a lawyer [32].

- Implementation of smart contracts

Smart contracts are written code developed by software developers that are connected into the network, and the technology itself considerably simplifies the process of delivering food and collecting the payment. Farmers do not have to wait weeks or months for their money to be returned; transactions are performed immediately, once the products are available. Furthermore, there are no intermediaries involved. As a result, farmers and their clients may be assured that all obligations are met [8].

- Stock market for farmers

Blockchain technology is represented on exchanges as well. Their operations remain the same, however, and stock markets can now benefit from the blockchain. Farmers can easily trade upcoming contracts at fixed prices for crops, livestock, fruits, vegetables, and other agricultural products. As a result, farmers will know their cost, and customers will not be surprised by price changes [13].

- Agricultural cryptocurrency

Blockchain technology is often used in the context of Bitcoin and other cryptocurrencies. So, when it comes to the agricultural field, the PavoCoin—a digital currency similar to Bitcoin, developed and designed specifically for farmers. It provides a secure payment method throughout the entire system. The currency is used to increase transparency as well as speed up and simplify customer interactions [33].

2.3. Blockchain Use Cases

The advantages of using blockchain in agriculture have been explored, so it is time to talk about how the technology can be used in this field.

- Trace the food source

Stores must maintain all required certificates and other documents that may be requested when purchasing food or other products. However, these documents do not say for sure whether it was a sick chicken or cow, how it was fed, and so on. In the future, blockchain networks should enable users to find all relevant details regarding food production and transportation, thus saving them time when researching the history of the products purchased [34].

The blockchain system maintains all records without hidden modification, and a full description of the food's origins will be received—right on the smartphone, which is fast and easy. Thus, increasing the probability that the food purchased is safe and healthy [34].

For example, the technology is used by Walmart to supply livestock products from China and mangoes from Mexico to the United States. Walmart and IBM are currently working on a blockchain-based agricultural supply chain to apply transparency for retail customers [35]. The system encourages all parts of the "food chain" (farmers, suppliers, businesses, etc.) to enter their data into a single database based on the blockchain network.

The number of agricultural and food companies using the system is increasing daily [36]. For example, IBM worked with ten of the world's largest consumer goods and food firms to integrate blockchain into their supply chains. Walmart, Nestle, Unilever, McCormick, Tyson, Kroger, McLane, Driscoll's, Dole, and Golden State Foods [37] are among the companies that collectively generate more than half a trillion dollars in yearly global sales, so IBM's blockchain platform will assist food industries in increasing supply chain visibility and traceability as a result of the agreement. Maybe some of those companies will soon start accepting payments in Bitcoin and other cryptocurrencies [38].

- Prevent counterfeiting of raw materials

It is impossible to grow healthy livestock or plants if the purchased seeds and grains are of unsuitable quality. Moreover, low-quality materials may affect the farmers' business and lead to large expenditures [39]. Certainly, both small and big farmers are interested in buying quality products, and this is where the blockchain system comes into play [14]. This way, in the event that suppliers provide low-quality seeds, this information will be reflected in the network for other users to see. Not only customers, but also the farmers themselves, will be able to check all the black spots of the product they are going to buy, enabling farmers to make more informed purchased decisions.

The IBM blockchain technology used by the extension, for example, is predicated on transparency, revealing farmers' records and locating their produce in real time. Records reflecting the flow and conditions of product transportation may be examined, as well as sources checked and vital ingredients used, plus many other facts can be known with the help of this platform [14,22].

- Decentralized organizations

Small businesses and utilities are being displaced as large corporations gain a larger portion of the market. Companies dictate terms to small farmers, deciding what to cultivate, how to grow it, setting pricing, and so on. Farmers that rely on these clients and suppliers are not allowed to set their own terms because they risk losing too many orders. It is feasible that we will see a situation where the blockchain system allows for rule changes in the near future. Small firms can work directly with new clients, find permanent employment, receive finances, and, perhaps, create their own conditions of operation in this environment. In addition, consumers may receive high-quality products at reasonable prices while being confident that they are secure [40,41]. Not to mention, there are other obstacles in agribusiness, such as transportation and distribution, which are handled by traders.

- The quality controls

The combination of IoT technology and the blockchain network provides a secure storage system for information about livestock, crops, and other aspects. Using specific sensors, soil quality, a variety of pests, irrigation, and many other factors can be monitored on special phones or tablets [42]. These sensors send collected data to the cloud storage in the blockchain [43].

The Flux development team (an Israeli company) is currently working on a blockchain-based solution with the goal of creating a combination of IoT technology and artificial intelligence [44]. Eddy, the world's first Growbot developed by Flux, is specifically designed to ensure successful harvests and increased yields.

3. Materials and Methods

The literature search was conducted on 10 November 2021. The Web of Science database was selected as a fundamental database for this systematic review. However, extra sources were used in this article but were not included in the systematic review, as these sources were used only in clarifying the background of the research topic. This study uses the following search criteria:

1. The document must be related in the research topic "blockchain in agriculture".
2. The terms "blockchain" and "agriculture" must be mentioned in the topic.
3. The terms "blockchain" and "agriculture" must be mentioned in the abstract.
4. The year of publication must be between 1 January 2015 and 31 December 2021.

Following this search criteria, the search query produced 144 results. As a primary step in evaluating the quality of the included scientific publication, specific criteria were used as follows: (a) the language of the document must be English; (b) the types of the document include review article, research article, and early access; and (c) only documents published by Elsevier, IEEE, Mdpi, Springer Nature, Wiley, Frontiers Media Sa, Emerald Group Publishing, and Taylor & Francis were included.

This primary screening step suggested to keep 79 scientific publications to be targeted in the secondary screening step, in which 17 were a review article type and 62 were a research article type. From this publication, 7 were tagged as early access. The full text of each publication was fully reviewed for qualification. The characteristics of the selected document in terms of its publishers is revealed in Table 1.

Table 1. The characteristics of the selected documents in terms of their publishers.

Publishers	Record Count	% of 79
Elsevier	30	37.975
Mdpi	15	18.987
IEEE	12	15.19
Frontiers Media Sa	6	7.595
Springer Nature	6	7.595
Wiley	4	5.063
Emerald Group Publishing	3	3.797
Taylor & Francis	3	3.797

In addition, Figure 1 shows the country-related trend of the primary-screened publications, in which the majority of them are from China, India, England, and the USA.

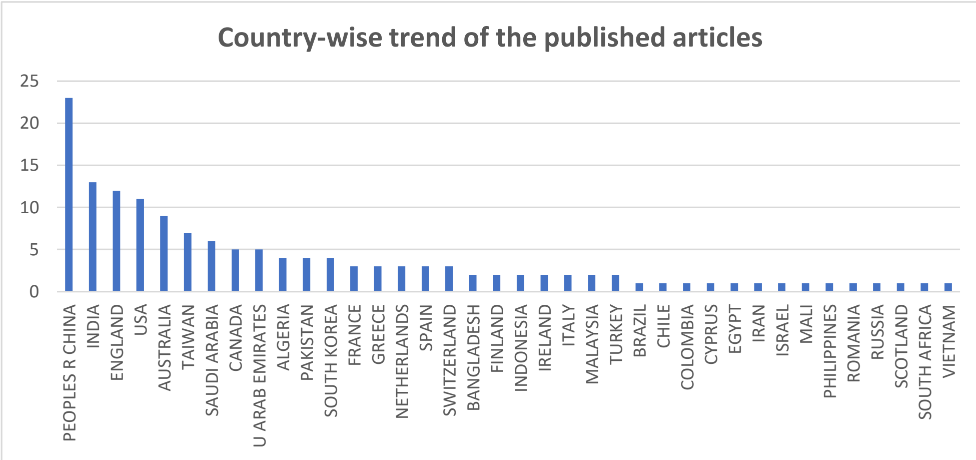

Figure 1. Primary screened publications country-related trend; source: own construction.

Since this review is more focused on the situation of blockchain technology in agriculture sector and its related issues, 27 publications were removed after the full text review because their main objectives were not related to the agriculture sector. Eventually, 52 scientific publications were included in the analysis. Figure 2 explains the PRISMA 2020 flow diagram.

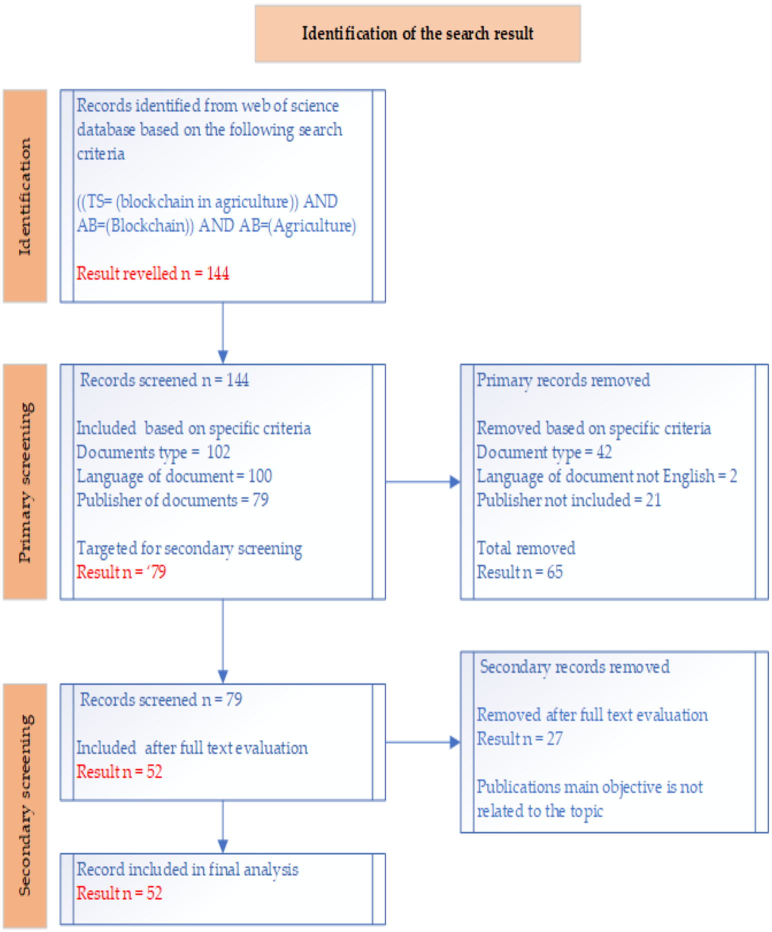

Figure 2. PRISMA 2020 flow diagram of search results; (source: own illustration based on [45]).

An Excel sheet table was created for the 52 publications that are included in the quantitative analysis. For each publication, the main keywords, main contribution, and key results were documented. Based on this table, the findings were summarized and compared by both authors.

4. Results

The summary of the qualitative review for the screened scientific publication is presented in Table 2. As for each selected publication, firstly, the main keywords used in the topic have been recorded, in which the keywords might facilitate new researchers in finding the most common keywords in the blockchain on an agriculture topic faster. Secondly, each publication's main objective and contribution were recorded, to make it easier to get to know the core value of each publication. The contributions of the screened publications covered the topic from several aspects, such as blockchain application in agriculture, agriculture blockchain based modeling, and the benefits and challenges of blockchain implementation in the agriculture sector.

Table 2. Summary of review result.

No	Year	Author	Keywords	Main Contraption
1	2017	[46]	Blockchain, IoT, precision agriculture, agricultural data, distributed ledger	Proposed an integrated model of an ICT e agriculture with blockchain technology and suggested evaluation tools of technical and social suitability of ICT agriculture blockchain based system.
2	2019	[13]	Blockchain, digital agriculture, food supply chain	Blockchain impacts in agriculture and food supply chain by reviewing a present and ongoing initiatives and project, as well as, discussing the challenges barriers and benefits of blockchain technology application.
3	2019	[47]	Supply chain, IoT, distributed database, artificial intelligence, ICT, traceability	Presented a panorama map of the scientific studies of the blockchain application in the agri-food sector, using terms mapping analysis via a Visualization of Similarities analysis.
4	2019	[48]	Blockchain, Ethereum, smart contracts, traceability, Soybean, agricultural supply chain, food safety.	Proposed a generic solution to improve traceability of soybean agriculture supply chain by utilizing the Ethereum blockchain and smart contract at among to enhance food safety and quality.
5	2019	[49]	Organic vegetables, blockchain, TAP (Traceability Agricultural Product); Ethereum	By using Ethereum the study suggested a model to solve the authenticity of the production and marketing process of an organic vegetable market.
6	2020	[50]	Precision agriculture, blockchain technology, IoT, challenges and solutions	The application of blockchain and IoT technology in enhancing the efficiency of precision agriculture, mainly by examining the benefits and solutions that can be gained by applying blockchain in developing new applications in precision agriculture.
7	2020	[51]	Electronic services, sustainable development, rural economy, online sales	Evaluated how convenience is the application of blockchain technology in e-agriculture compared to traditional agriculture, in terms of the usefulness of its application and products' online sales, as well as examining the impact of farmer age on that convenience level.
8	2020	[8]	Food supply chain, agricultural insurance, smart agriculture. smart contract	Reviewed the application of block chain in food supply chains, agricultural insurance, smart farming, and transactions of agricultural products, discussing the challenges of smallholder farmers data security

Table 2. *Cont.*

No	Year	Author	Keywords	Main Contraption
9	2020	[52]	Precision agriculture, safe farming, Blockchain, IoT	Discussed the precision agriculture efficiency by applying the IoT system and blockchain technology in safe farming applications, such as animal attack tracking, mainly via a Repelling and Notifying System.
10	2020	[53]	Agriculture data, integrity, permissioned network. Security	The study focused on the quality of agriculture data and how it is possible by applying blockchain technology the agriculture data integrity can be ensured.
11	2020	[54]	Security, privacy authentication, smart agriculture, greenhouse	Examined the challenges on privacy and security issues related to green IoT-based agriculture and presented several threats effected green IoT based agriculture such as attacks against privacy, authentication, confidentiality, availability, and integrity properties.
12	2020	[55]	Energy management, blockchain technology	Investigated farm energy management strategy and how blockchain can improve the energy utilization of the produced energy from the photovoltaic cell.
13	2020	[56]	Agriculture supply chain, blockchain barriers	Determined the adaptation barriers of the blockchain in the Indian agricultural supply chain and introduced an integrated model of the adaptation barriers and the interrelation and intensity of the relationship among them.
14	2020	[57]	Artificial intelligence, blockchain, edge computing, smart agriculture	Discussed the huge agriculture input data processing difficulties, in terms of speed and accuracy, due to the large area coverage of agriculture and the variety of production objects, and evaluated the opportunity and challenge of using Edge computing along with other blockchain-based technology to ensure agriculture data quality.
15	2020	[58]	Accountability, blockchain, supply chain, credibility, reputation, trust, traceability	Suggested a blockchain model that solved the issue of agri-food supply chain traceability credibility and auditability.
16	2020	[59]	Blockchain, yield estimation, production, smart contracts	The study suggested a blockchain-based solution to improve yield estimation of agricultural products.
17	2020	[50]	Precision agriculture, blockchain technology, Internet of things, challenges and solutions	The study looked at the advantages and solutions that may be acquired by using blockchain to construct new precision agriculture applications.
18	2020	[60]	Agricultural supply chain, machine learning, sustainability, smart farming	The study emphasized how techniques might help agricultural supply chains ASCs and lead to ASC sustainability.
19	2020	[61]	Digital agricultural, democratization, electronic agriculture, ICT technology, Blockchain	The research studied the implications and logical links between institutional and technological notions such agricultural democratization, agricultural autocratization, centralization, and decentralization.
20	2020	[62]	Agriculture supply chain, blockchain, distributed ledger, traceability	The research gave an overview of how blockchain technology can be used to improve traceability in the agri-food industry.
21	2020	[63]	Blockchain technology, sustainability, agriculture supply chain, traceability, transparency	The study determined the enablers of blockchain technology adoption in agriculture supply networks and their relationships.
22	2021	[64]	Food supply chains, blockchain, traceability	Outlined the use of blockchain technology in the Canadian food and agriculture industry.

Table 2. *Cont.*

No	Year	Author	Keywords	Main Contraption
23	2021	[65]	Agriculture sensors monitoring, smart agriculture	A generalized blockchain-based security architecture has been suggested after defining the main requirements in smart agriculture.
24	2021	[66]	Blockchain, agriculture supply chains	In the agriculture project, analyzed blockchain projects based on factors such as their inception dates, types of blockchain, status, sectors applied to, and type of organization that was created.
25	2021	[67]	Food tracking, blockchain technique, IoT, smart model	Proposed a hybrid smart model with an innovative method for converting traditional agricultural to smart agriculture, taking into account both blockchain and Internet of Things (IoT) properties.
26	2021	[68]	Blockchain agriculture, supply chain, blockchain model	Provided an internet-based solution for agriculture supply chain management and control.
27	2021	[69]	Blockchain governance, blockchain framework, blockchain ecosystem	Employed a reference framework to better understand different blockchain applications and select essential criteria for new agri-food use cases.
28	2021	[70]	Food and agriculture, blockchain, R package bibliometrix, VOSviewer	By using the R package bibliometrix and the Visualization of Similarities (VOS) viewer application, expand a graphical mapping of the bibliographic information of food and agriculture research.
29	2021	[71]	Technology adoption, blockchain, agroindustry innovations	Investigated corporate financing patterns and blockchain usage in the agricultural industry.
30	2021	[72]	Smart agriculture, network performance, quality of service	FarMarketplace is a new blockchain-based farming marketplace platform that has been proposed.
31	2021	[73]	Precision livestock farming, blockchain, big data analytics, livestock agriculture	Examined the current state of Precision Livestock Farming (PLF) technologies, particularly biometric sensors, big data, and blockchain technology, in terms of digitalizing animal agriculture.
32	2021	[74]	Agricultural artificial intelligence, agricultural automation, smart agriculture	Three common smart agricultural development modes (precision agriculture, facility agriculture, and order agriculture) have been discussed.
33	2021	[75]	Grape wine supply chain, technology adoption, traceability, blockchain	The study considered the grape wine supply chain and used a rating-based conjoint analysis to identify a few potential drivers of blockchain technology adoption.
34	2021	[76]	Blockchain, hierarchical model, rural green credit investigation	Investigated rural green credit using a blockchain hierarchical paradigm.
35	2021	[77]	Agricultural, blockchain, cross-chain, data security	Presented a double blockchain solution based on the Inter Planetary File System (IPFS) for agricultural sampled data protection on an IoT network.
36	2021	[78]	Blockchain, 4th industrial-revolution, farmers, innovation support	The study looks at the literature on information and communication technologies (ICTs) and blockchain technology (BTs) in agriculture from 2011 to 2020.
37	2021	[79]	Agriculture supply chains, agriculture 4.0, productivity, industrial agriculture	Examined the current state of industrial agriculture, as well as the lessons learnt from industrialized agricultural production patterns, procedures, and the industrialized agri-food supply chain.
38	2021	[80]	Blockchain technology, artificial intelligence, deep learning, smart agriculture.	Proposed a Secured Privacy-Preserving Framework (SP2F) for smart agriculture in UAVs (Unmanned Aerial Vehicles).

Table 2. *Cont.*

No	Year	Author	Keywords	Main Contraption
39	2021	[81]	Agricultural internet of things (IoT), smart agriculture, smart farming, sustainable agriculture	Outlined emerging technologies for the agricultural IoT, such as unmanned aerial vehicles, wireless technologies, open-source IoT platforms, and software-defined networking, as well as summarized existing surveys.
40	2021	[82]	Trust, cross-border trade, food, agriculture	Investigated new features for a human–machine reconciliation mechanism that allows agriculture and supply chain operators to share responsibility in supplying accredited traceability data to customers.
41	2021	[83]	Blockchain, trust management, supply chain, non-cooperative game	Provided a non-cooperative game-based green supply chain framework, by developing a more scientific game theory model based on the Bayesian formula, which blends past experience with current conditions.
42	2021	[84]	Sustainable agricultural, supply chain management, blockchain, environment	Web design features were used to incorporate the blockchain effect into agricultural supply chain management.
43	2021	[85]	Blockchain, edge computing, organic agricultural supply chain, traceability	Discussed the organic agricultural supply chain, by using blockchain's immutability and the Edge computing concept to build a substantial trust framework.
44	2021	[86]	Functional agriculture, privacy protection, monitoring data, blockchain	Presented a storage technique for agricultural monitoring data based on sustainable blockchain technology, by focusing on the storage and privacy protection scheme for monitoring data.
45	2021	[87]	Information and communication technology, digital agriculture, blockchain	Examined the influence of an agricultural cross-channel information strategy based on information and communications technology as well as blockchain technology on retailer pricing strategy and customer behavior.
46	2021	[88]	Block chain technology, agricultural data sharing, cloud computing platform	Conducted a thorough examination of the benefits of blockchain-based large data sharing and developed a blockchain-based big data sharing model.
47	2021	[89]	Intellectual property, precision agriculture, IoT	Examined the privacy and security concerns of precision agriculture based on the IoT.
48	2021	[90]	Food loss and food waste, food production, food security, circular economy	Presented an outline of the circular economy and alternative food production technologies such as cellular agriculture.
49	2021	[91]	Blockchain, data analytics, Internet of Things, smart agriculture	For managing and coordinating the use of excellent quality seeds and water resources among communities, an effective seed quality monitoring and smart water management system was built using IoT and blockchain technology.
50	2021	[92]	Blockchain, innovation management, digital transformation, agricultural sector	Through a survey review of the literature, this paper examines the effects of blockchain applications in agriculture and the food supply chain.
51	2021	[93]	Blockchain, agriculture supply chain, sustainable, food security	To ensure long-term food security in India, the study identified blockchain drivers and modeled them using an integrated MCDM (Multiple Criteria Decision Making) approach.
52	2021	[94]	Blockchain, agriculture supply chain, sustainable	Identified emergent issues for future blockchain study, with an emphasis on agricultural and supply chain management.

5. Discussions

Distributed ledger and smart contract technologies to open the door to a unique opportunity towards greater efficiency, transparency, and traceability of value—and information-sharing activities within the agricultural sector. These technologies can improve agricultural supply chains and develop rural development interventions in several ways, through the use of digital records, encryption, and completing transactions and storing data without intermediaries [95]. These technologies also have the potential to simplify and integrate agricultural supply chains, improve food safety, facilitate access to business financing and other forms of agricultural financing, improve market transparency (while increasing legal certainty about land tenure systems), and enhance accountability relating to compliance with international agreements related to agriculture [14].

Moreover, customers and stockholders are increasingly interested in not just the origin of food, but also suppliers and their destinations, and the blockchain may ensure all of this. Agriculture is currently the market sector that can profit the most from adopting the blockchain. The blockchain is a distributed, unchangeable ledger that makes it easier to record transactions and track assets in a corporate network. It also delivers real-time, transparent data in a non-modifiable format [25]. In other words, it ensures that orders, payments, accounts, and, most importantly, production are all tracked, giving shareholders and customers more trust.

The blockchain also enables the collection of a significant amount of data, ranging from seed quality to crop growth and, even, to the distribution path, resulting in process transparency and protection for producers that use environmentally good practices but are sometimes financially disadvantaged [70].

Furthermore, blockchain is one of the many technologies that the agriculture sector is incorporating into its smart agriculture strategy. In order to ensure precision farming and food safety, a system that facilitates and maintains data must be developed [8].

Farmers and producers should consider taking advantage of this opportunity, since those that participate in the blockchain may be able to boost their competitiveness in the consumer product market.

6. Conclusions

The application of blockchain agriculture is still in the early stage, although there are ongoing research, projects, and initiatives to gain the most benefits of introducing blockchain-based technology in agriculture. These ongoing processes are centered around topics such as traceability, transparency, creditability, and auditability of agricultural data via blockchain based technology. Moreover, they are developing useful models or applications that can be used to improve the performance of the agriculture sector.

This research provided a summary of the qualitative review for the screened scientific article, with the goal of facilitating research and future in-depth research for academics interested in blockchain, particularly in the agriculture sector. First, the primary keywords used in the topic were recorded for each selected publication, which may aid new researchers in locating the most popular keywords in the blockchain in the agricultural topics more quickly. Second, the major purpose and contribution for each publication were also noted, making it easy to understand the fundamental value of each publication.

It can be seen that by drawing the line, blockchain networks are gaining increased traction each year. Blockchain technology has already been adopted in a number of areas of our lives, making things easier and more comfortable for us. Many services that rely on "behind the scenes" blockchain technology will become widely used, just as computer abilities have become widespread without an awareness of the technology behind computing operations.

Additionally, farmers and customers can easily discover each other, interact, make a profit, and, of course, develop and deliver safe and healthy food to our homes, thanks to the usage of blockchain in agriculture. However, several challenges and gaps in the literature remain about the usefulness of and reliability on blockchain technology in agriculture business. Two of these challenges include the complexity and operating cost at the microlevel, as well as the regulation that should be developed to govern the safe use of this growing technology in a vital sector such as the agriculture sector.

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