Adoption of Blockchain Technology for ASCM Solution: A Systematic Literature Review

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Abstract – **With the global population projected to exceed 10.9 billion by 2100, agriculture faces significant strain. One approach to alleviate this pressure is through the use of blockchain technology, which could improve the traceability and transparency of agricultural products. This study investigates blockchain's characteristics, advantages, and challenges to determine its suitability for Agricultural Supply Chain Management (ASCM). The methodology involved selecting keywords and conducting searches for papers published between 2017-2021 across multiple scholarly databases including Google Scholar, Scopus, Cross Ref, Science Direct, and Emerald Insight. The PRISMA method was employed for the literature review, resulting in the analysis of 91 papers. The analysis identified the top ten most commonly discussed blockchain characteristics. Findings suggest that blockchain technology offers advantages such as increased operational efficiency, enhanced management data transparency, intelligent contract management, and mitigation of fraud, errors, and financial losses in ASCM. However, blockchain adoption faces challenges including regulatory hurdles, stakeholder relationships, data ownership, scalability issues, and knowledge gaps. This study contributes to the understanding of blockchain's potential in ASCM and underscores the importance of addressing these challenges for its effective implementation.**

Keywords – **Blockchain, ASCM, agriculture, prisma, SLR.**

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1. Introduction

The global agricultural system is facing significant challenges amidst projections of a steadily increasing world population, expected to reach 8.5 billion by 2030 and 9.7 billion by 2050, ultimately surpassing 10 billion by the end of the century [1]. Agriculture plays a crucial role in economic development, contributing substantially to a nation's prosperity [2]. It serves as a cornerstone for poverty alleviation, economic growth, and food security worldwide [3]. Notably, in countries like China, agricultural progress has been remarkable, with the capacity to feed 22% of the global population on just 9% of arable land [4].

In South Asian countries, agriculture contributes significantly to the GDP and employs approximately 55% of the rural workforce [5]. However, the agricultural sector grapples with multifaceted challenges, including the adverse impacts of climate change, land scarcity, drought, and the repercussions of rising food prices [6]. Moreover, supply chain inefficiencies exacerbate these challenges, stemming from the growing complexity at each phase of the supply chain [7]. With modern supply chains spanning multiple countries and involving numerous stakeholders, determining the origin and production processes of specific agricultural products has become increasingly difficult [8], [9]. His opacity presents obstacles in ensuring product authenticity and transparency to consumers. Implementing stricter regulations on information disclosure could be a solution [10].

With access to product history information, consumers gain better decision-making abilities by understanding the origin and quality of the products they purchase [11]. Transparency in supply chain management not only fosters trust but also enhances profitability for small and medium-sized farms [12]. Among emerging technologies, blockchain stands out as a promising solution to enhance traceability and transparency within agricultural supply chains [13].

The inception of blockchain technology dates back to 2008, with the publication of a whitepaper titled 'Bitcoin: A Peer-to-Peer Electronic Cash Section' by an individual or group using the pseudonym 'Nakamoto' [14]. Blockchain, essentially a shared database, records and shares transaction history across a decentralized network in a secure and immutable manner [15]. Leveraging cryptographic techniques, algorithms, and distributed consensus mechanisms, blockchain ensures data integrity and trust among network participants through the use of private and public keys [16]. In recent years, agriculture has embraced blockchain technology as a potential solution to address challenges related to food traceability, transparency, and reliability [17]. By enabling real-time tracking and tracing of agricultural products, blockchain enhances trust and integrity within supply chains [18].

Based on the background information provided, several gaps in existing research have been identified, which form the foundation for this study. Firstly, there is a lack of comprehensive discussion on the specific properties of blockchain technology that make it suitable for adoption in agricultural supply chain management (ASCM). Secondly, the potential benefits of adopting blockchain technology in ASCM have not been thoroughly explored. Lastly, there is limited understanding of the challenges associated with the adoption and implementation of blockchain technology in agricultural supply chains.

To address these gaps, the following research questions (RQs) have been formulated:

RQ 1: What specific characteristics of blockchain technology are most relevant for adoption in ASCM?

RQ 2: What are the potential advantages of integrating blockchain technology into ASCM practices?

RQ 3: What are the primary challenges and barriers to adopting blockchain technology in ASCM?

RQ 4: What models of blockchain systems are best suited for implementation in agricultural supply chain management?

This study aims to conduct a systematic literature review (SLR) to investigate and provide insights into these research questions. The article is organized into four main sections. The first section, the introduction, outlines the identified research gaps and presents the research questions. The second section describes the methodology employed, including the materials used and the application of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework in conducting the SLR. The third section presents the analysis of the literature review results and provides a discussion of the findings. Finally, the fourth section concludes the study, highlighting its limitations, offering suggestions for future research, and summarizing the key insights obtained.

2. Methodology

Two steps were involved in the material and method process: firstly, an article search method, and secondly, a systematic literature review using PRISMA. The article search process was conducted on November 3, 2021, to ensure the references used were up to date. Specifically, papers from the last five years (2017, 2018, 2019, 2020, and 2021) were considered. Five databases were utilized for reference retrieval: Google Scholar, Scopus, Crossref, Science Direct, and Emerald Insight. A total of 25,823 papers were identified using the keywords ('influencing' OR 'adoption' OR 'implementation') AND ('blockchain' OR 'block chain') AND ('supply chain') AND ('agriculture'). Among these, there were 12,600 papers from Google Scholar, 21 from Scopus, 388 from Crossref, 11,922 from Science Direct, and 892 from Emerald Insight. The use of these keywords yielded 25,823 suitable papers, as illustrated in Figure 1.

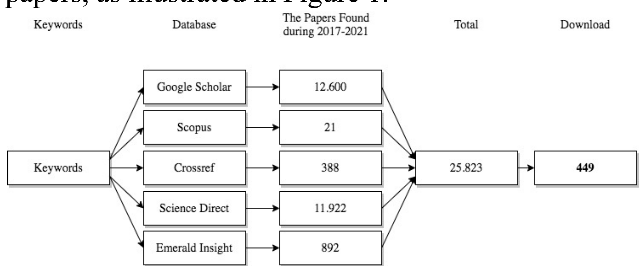

Figure 1. Searching through five databases

Twenty-five thousand eight hundred twenty-three papers were identified across five databases, from which relevant papers addressing the research question were sought using the PRISMA method, as illustrated in Figure 2. As depicted in Figure 2, 449 papers were downloaded from the aforementioned databases. The steps of identification, screening, eligibility, and inclusion were performed following the PRISMA guidelines based on the number of papers.

Zero papers were identified from sources other than the five specified databases. Following the download of 449 papers, 32 duplicates were discarded, resulting in a total of 417 papers for review.

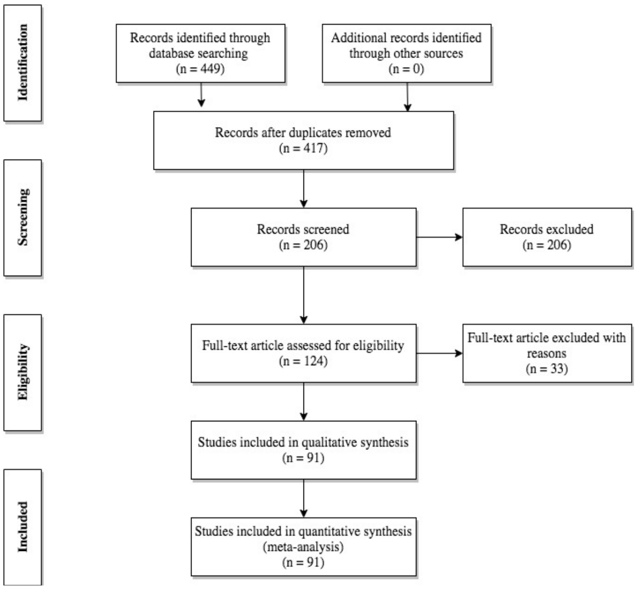

Figure 2. Selection of articles using PRISMA

Subsequently, the PRISMA process continued with screening, during which titles were read and abstracts of 206 papers relevant to the research were selected. After eligibility assessment, the number of papers was further reduced to 124. The subsequent step involved qualitative and quantitative synthesis to analyze the content, ultimately leading to the selection of the most pertinent paper from among the 91 remaining.

The second stage comprised analyzing the 91 selected papers. Initial review involved examining the demographics and trends of the publishing outlets, including publication types, titles, Quartile classifications, and characteristics. Additionally, characteristics of the most prolific institutions were explored, encompassing institution names, number of papers, and percentage contributions. Academic backgrounds of authors, such as department affiliations, were also considered. Publication trends were further analyzed, covering publication years and paper subjects, along with keyword classifications. It's noteworthy that not all papers provided keywords; therefore, only those with included keywords are summarized.

3. Results

This phase elucidated the outcomes of the analysis conducted through the PRISMA method. The ensuing discussions and study results are intended to address research inquiries, including the properties of blockchain that necessitate adoption, the anticipated benefits, and the challenges constituting barriers to the adoption of blockchain technology.

3.1 Demographics and Trend Characteristics Publishing

The study commenced with 25,823 titles listed from 5 publishing outlets. A thorough title review ensued, leading to the download of 449 papers, while 32 duplicate papers were removed, resulting in an initial selection of 417 papers. Subsequently, a PRISMA-based review was carried out on these papers, yielding 91 papers deemed relevant to address the research question of this study.

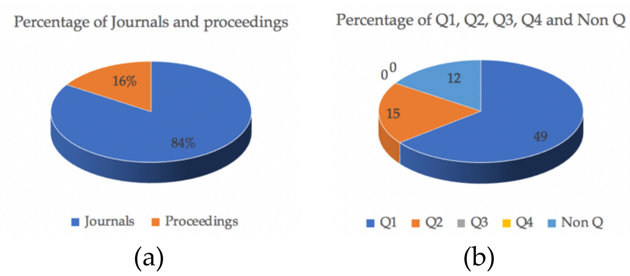

Figure 3. Represents the percentage of data used in the study. (a) The percentage of journals instead of productions; (b) The percentage of papers in the Q1, Q2, Q3, Q4, and non-Q categories

According to Figure 3, 84% (76 titles) of the 91 papers were taken from journals, while 21% (15 titles) were taken from proceedings (a). Figure 3 depicts the percentage of the number of journals and proceedings. 84% of the papers, or 76 titles, are classified into several quartiles (Q). Figure 3 (b) above explains the percentages in the Q1 classification of up to 64% (49 papers), Q2 of up to 20% (15%), Q3 and Q4 of up to 0% (0 titles), and 26% that are not in the Q category (12 papers).

3.2 Demographics and Trend Characteristics Most Productive Institutions

Among the 91 thoroughly reviewed papers, there were 308 authors hailing from 45 countries worldwide. Noteworthy countries represented include Australia, Austria, Belgium, Brazil, the United Arab Emirates, the United Kingdom, the United States of America, and Jordan.

As illustrated in Figure 4 below, 22 countries had more than four authors each. India topped the list with 62 authors, followed by China with 38, the United Kingdom with 31, Italy with 24, and Australia, Canada, France, Norway, Saudi Arabia, the United Arab Emirates, Jordan, and Greece. Additionally, there were 23 other countries with one, two, or three authors each.

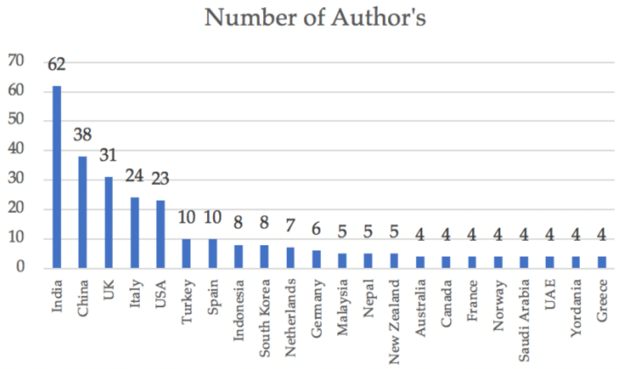

Figure 4. Number of Authors in 35 Countries

3.3 Demographics and Trend Characteristics Author's Academics Backgrounds

This section will delineate the educational backgrounds of the 308 authors from the 91 papers included in the literature review. The authors were categorized into two main groups: academics and practitioners from the industry. Among the 308 authors, 19 were practitioners or industry professionals, while 289 were academics. Notably, authors with an academic background constituted the majority, representing a significant percentage difference. Specifically, 93.83% of the authors were from academic backgrounds, whereas 6.17% were practitioners. The academics were further classified into various departments based on the affiliations mentioned in their papers, which were identified through Google Scholar searches. Similarly, individuals from the industry documented their work affiliations accordingly.

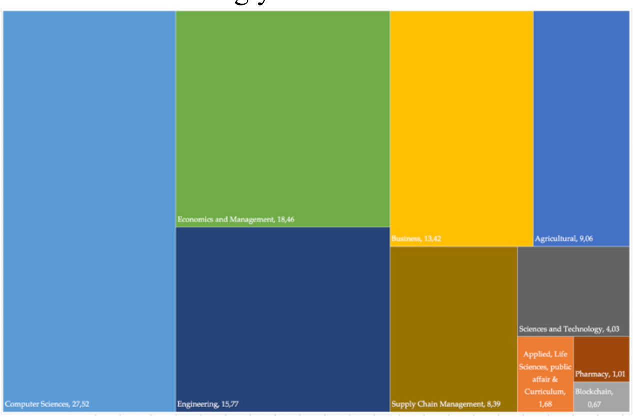

Figure 5. Backgrounds of academic authors

Among the 308 authors, the backgrounds of ten individuals could not be traced, while the remaining ten were academics and practitioners. The 298 authors were then categorized into ten disciplines: Agricultural Sciences, Applied Life Sciences, Public Affairs & Curriculum, Blockchain, Business, Computer Sciences, Economics and Management, Engineering, Pharmacy, and Sciences and Technology, and Supply Chain Management (Refer to Figure 5).

Computer Sciences emerged as the predominant scientific background, encompassing 82 authors (27.52% of the total 298 authors), followed by Economics and Management with 55 authors (18.46%). Engineering secured the third position with 47 authors, accounting for 15.77% of the total. Subsequently, Business constituted 13.42%, Agriculture 9.06%, Supply Chain Management 8.39%, Sciences and Technology 4.03%, and Applied Life Sciences, Public Affairs & Curriculum at 1.68%. Pharmacy recorded minimal representation at 0.01%, and Blockchain had only two authors, representing 0.67% of the total.

3.4 Demographics and Trend Characteristics Publication

The sub-themes that follow would explain which themes are used in each title. There were similarities among the 91 titles examined and themes that differed from other titles. Based on the keywords used, the four themes would be grouped into the following subchapters: implementation, blockchain, supply chain, and agriculture. The four points are grouped from 2017 to 2021, with the results shown in Figure 6.

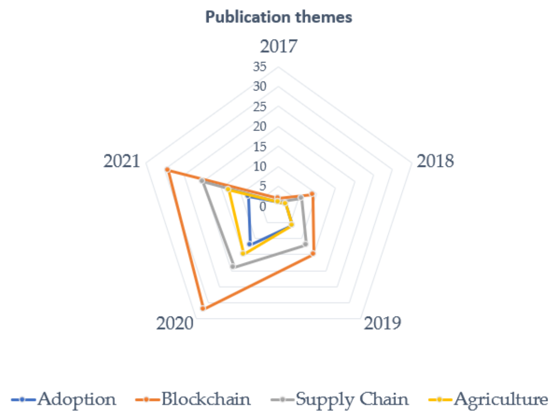

Figure 6. Characteristics of 2017-2020 publication themes

From 2017 to 2021, the blockchain theme emerged as the most prominent, with 87 papers published within this timeframe. The distribution across the years was as follows: two papers in 2017, nine papers in 2018, fifteen papers in 2019, 32 papers in 2020, and 29 papers in 2021. Following blockchain, the supply chain theme ranked second with 58 papers, agriculture followed with 37 papers, and adoption was the least represented with 29 papers. The term "adoption" appeared in 1 paper in 2017, two papers in 2018, six papers in 2019, 12 papers in 2020, and 29 papers in 2021. Generally, there was a decrease in the number of papers published across these four themes in 2021.

3.5 Demographics and Trend Characteristics Keyword Analysis

The subsequent step involved conducting a mapping exercise to assess the extent of progress made by others in the research field. Mapping tools were utilized to gather descriptive results and various information pertaining to the advancement of the scientific field and the execution of research endeavors. VOS Viewer, a mapping tool, facilitated bibliometric data analysis [19]. It functioned as a computer program designed for creating and viewing bibliometric maps [20] enabling users to analyze bibliometric data [21]. Moreover, VOS Viewer integrated a text-mining feature for generating and visualizing correlations within article or publication citations [22]. The outcomes of the network visualization are depicted in Figure 7.

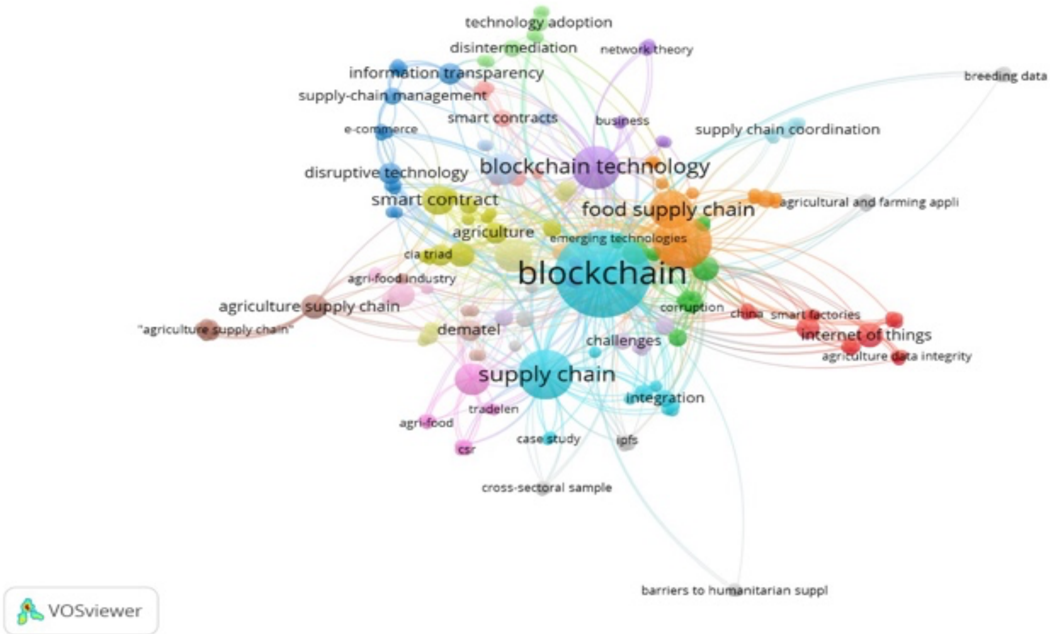

Figure 7. Network of keywords, the output of the co-occurrence analysis

The mapping of the 91 papers resulted in a co-occurrence analysis of 208 keywords and 208 thresholds, utilizing a minimum number of keyword occurrences set at 1.5. Notably, blockchain emerged with the highest total link strength, registering 117 occurrences and 50 link strengths. Following blockchain, traceability was associated with the blockchain, recording a total link strength of 52 and 19 occurrences. Subsequently, the supply chain followed with a total link strength of 35 and 17 occurrences. In fourth place was food safety, with a total link strength of 28 and 8 occurrences, while the food supply chain ranked fifth with 27 link strengths and ten occurrences.

Blockchain technology holds significant potential across a spectrum of agricultural issues, spanning from global consortia to local farming communities [23]. Its integration into agriculture is crucial [24] particularly in fostering transparency within the food supply chain [25]. Blockchain finds utility in supply chain management for tasks such as tracing, crime prevention, enhancing manufacturing and distribution integration, and implementing smart contracts [26].

Traceability, historically, has had multiple definitions, with the initial proposed by the International Organization for Standardization in 1994 [27]. Food traceability encompasses the collection, storage, and transmission of comprehensive information about food, feed, food producers, animals, or pertinent substances at every stage of the food supply chain. This enables product inspection for safety and quality control, facilitating traceability to the source and tracking down products as necessary from the customer's perspective. Crucially, providing product information regarding its origin, manufacturing, modification, and storage meets the pressing demands of customers [28].

Supply chain management is pivotal in agriculture, being a primary source of employment in numerous countries [29]. The agricultural supply chain system is intricate due to its involvement of numerous entities/agencies across multiple stages. Blockchain technology has recently showcased its efficacy in addressing various challenges within agricultural supply chain systems [30], fostering trust among businesses and offering advantages such as reducing intermediaries, minimizing delayed payments, and streamlining transaction times [31]. Moreover, the Beidahuang group in China, with ownership of over 10 million hectares of land, has engaged in the rice traceability process. The objective of traceability is to ensure production process and product quality, streamline logistics distribution, and enhance farmers' income. Blockchain facilitates obtaining information from breeding to growth, storage to seed processing, transportation, and sales processes [32].

Food safety concerns, including biological contamination, toxic chemical pollution, and opacity in the supply chain, have garnered increased attention [33]. Leveraging the characteristics of decentralization, traceability, and immutability, blockchain emerges as a pertinent and applicable technology for food traceability [34]. A blockchain-based trading system has been proposed recently, with security analyses indicating enhancements in transaction security and privacy protection [35, 36].

In the context of the food supply chain, blockchain technology has been utilized to gather data on farm egg deliveries. This technology's ability to establish a traceable and transparent food supply chain empowers consumers with necessary information for informed food purchasing decisions. Improved traceability and transparency strengthen customer relationships, enhance efficiency, and mitigate risks and costs associated with food recalls, fraud, and product losses for stakeholders in the food supply chain [12]. In decentralized and distributed agricultural supply chain management, blockchain offers an efficient and robust mechanism to enhance food traceability and transparently validate the quality, safety, and sustainability of agricultural products [37, 38]. The immediate benefits of this technology include heightened transparency, traceability, trustworthiness, and authenticity [39, 40].

4. Discussion

The findings in this study provide strong empirical evidence on the adoption of blockchain technology and its benefits in the ASCM field.

4.1. Characteristics of Blockchain Technology

RQ 1 seeks to understand the characteristics of blockchain technology that render it essential for agricultural supply chain management. Table 1 outlines ten key characteristics of blockchain technology that render it suitable for application in agricultural supply chain management.

Table 1. 10 Characteristics of blockchain

No	Characteristics	Resource
1	Distributed Ledger	[18] [41] [42][43] [44] [45] [46][47][48] [49] [50] [51][52] [53][54][55] [56][57] [58][59] [60][61] [62]
2	Tranparency	[18][12][37][63][13][38][39][40][64][31][11][65][66][42][67][68][69][70][45][46][71][47][72][48][73][74][75][76][77][78][79][80][81][49][82][83][50][84][53][85][86][87][88][56][89][90][91][57][92][93][94][95][58][96][97][98][99][100][101][102][61]
3	Decentralized	[41] [13] [39] [64] [31] [44][46] [72][73] [75] [78] [103] [50][84][86] [56][89][104] [58] [105] [106] [59] [97] [98]
4	Secure	[18] [41] [38] [64] [31] [65] [42] [68] [70] [46][71] [26] [47] [72][74] [75] [80] [49] [82] [50] [107] [84] [53] [55] [86] [89][90] [57] [92] [108][94][95][106][96][109][110][97][98][111][99][112][113] [60][101][61][62]
5	Tracking	[18] [114] [38][40][66] [69] [70] [115] [75] [116] [103] [51] [52] [53] [87][56] [110] [59] [99] [112] [101]
6	Efficiency	[18][41][12][42][117][50][55][90][104][109][97][98][111][99] [102][61]
7	Smart Contracts	[64] [31] [42] [70] [45] [26] [72] [73] [116] [79] [49][103] [82] [83] [107] [52] [84] [118] [56] [90] [108] [95] [105][110] [110] [97] [98] [112] [101] [102]
8	Traceability	[114][12] [37] [38] [39] [40] [64] [31][11][66]

No	Characteristics	Resource
		[119] [43] [68][69] [70] [44] [45] [46] [71] [26][72] [48][115] [73][76][116] [79] [81] [49] [103][83][50][120][51] [52] [84] [85] [55][87][88] [89][121][91] [57] [92] [94] [95][58] [96] [97] [111] [99] [61] [62]
9	Speed	[68] [46] [72] [73] [117] [78] [80] [49] [53] [90] [92] [100]
10	Immutable	[13] [39] [40] [64] [31] [43] [67] [68] [72] [74] [75] [77] [79] [81] [49] [83][120][51][84][53][85][92][104] [93] [95] [58] [110] [59][100] [102]

The ten most discussed blockchain properties selected from the analysis of 91 papers are as follows: transparency, mentioned in approximately 62 papers; traceability, in 54 papers; security, in 46 papers; smart contracts, in 30 papers; immutability, in 30 papers; decentralization, in 24 papers; distributed ledger, in 23 papers; tracking, in 21 papers; efficiency, in 16 papers; and speed, in 14 papers.

4.2 The Benefit of Adoption of Blockchain Technology

The challenges encountered in agricultural supply chain management include information asymmetry, farmers' need for equitable compensation, and the inherent short shelf life of agricultural products [18]. In underdeveloped and remote regions, there's a pressing need to enhance sufficiency levels as agricultural enterprises struggle to meet demand independently [9]. Damage to agricultural records during warehousing and transactions can erode trust and necessitate reliance on third-party intermediaries [114]. Issues such as information sharing difficulties, transparency gaps, information imbalances, food fraud, and trust deficits require immediate attention [13]. Therefore, securing agricultural data during pre- and post-harvest and production stages is imperative to prevent product counterfeiting, expiry breaches, and other related problems [38].

The array of challenges within supply chain management underscores the diverse nature of these issues. Blockchain technology offers a promising solution for managing supply chains, enabling product tracing and ensuring data transparency [11]. Widely recognized for its transformative potential, blockchain is poised to enhance both global and local supply chains by improving operational efficiency, data management, responsiveness, transparency, and smart contract execution [42]. Moreover, blockchain holds the promise of reducing fraud and errors in agricultural supply chains, thereby bolstering security [67].

Furthermore, it is anticipated that blockchain technology will mitigate financial losses, crop contamination, and spoilage, ultimately leading to increased profits in shorter durations [68]. Utilizing blockchain ensures information certainty through validated quality and security enhancements [69]. This section addresses RQ 2 concerning the benefits of employing blockchain technology in agricultural supply chain management (ASCM).

4.3 Blockchain Technology Adoption Challenges

Several challenges arise in implementing blockchain technology in agricultural supply chain management, as outlined in RQ 3. One notable challenge is the absence of a verification mechanism to authenticate the accuracy of input raw data. Additionally, the costs associated with implementation are often unpredictable, particularly in longstanding supply chain systems [40]. Challenges also encompass data standardization, governance, and privacy mechanisms [43]. The development of both public and private blockchain networks presents a complex technical hurdle, compounded by system requirements that hinder blockchain scalability. Ensuring data ownership, accessibility, and control is crucial, as transparency and inclusivity for stakeholders must be guaranteed [46].

Despite the promising potential of blockchain technology in ensuring food traceability, several limitations persist, including regulatory constraints, stakeholder relationships, data ownership issues, and scalability concerns [48]. From the farmer's perspective, adopting blockchain technology entails increased knowledge requirements, costs, and technological complexities, leading to hesitancy in adoption [74]. Establishing stakeholder trust in supply chain management emerges as a primary challenge. Additionally, organizational regulations, maintaining information clarity within the supply chain network, preventing data corruption to mitigate fraud, enhancing communication and coordination among partners, identifying products suitable for adoption, verifying product authenticity through process tracing, and addressing stakeholders' intentions during implementation are all critical considerations [77]. Moreover, the implementation of hyper-ledgers and smart contracts holds promise in addressing numerous challenges [26].

4.4 Blockchain model for ASCM

This section addresses RQ 4, demonstrating that the application of blockchain technology in agricultural supply chain management systems yields positive impacts on transparency, security, accountability, efficiency, and various other aspects. Presented below is a simplified model for a blockchain-based agricultural supply chain management system, depicted in Figure 8.

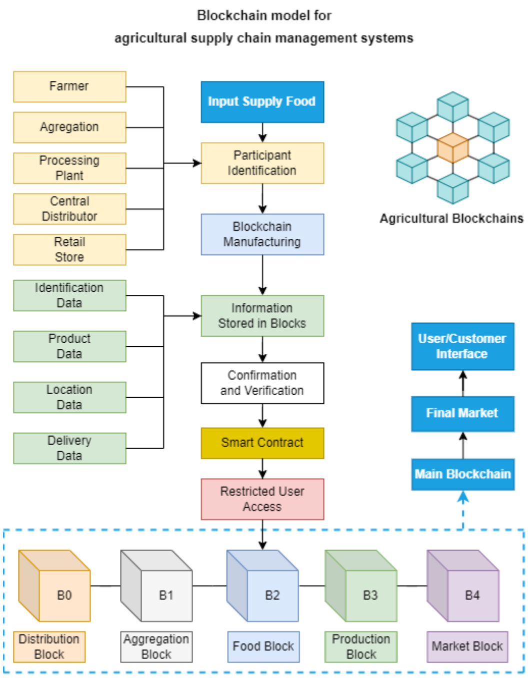

Figure 8. Agriculture Blockchain Model

Based on figure 8 provides information that this model consists of seven main stages before agricultural data is connected to the blockchain system, namely:

1. Input Supply Food
   This section initiates the process of identifying and gathering information on various types of agricultural products.
2. Identification of Participants in the Supply Chain
   This section provides information about key participants who play significant roles in the supply chain of agricultural products. Firstly, farmers are responsible for planting and harvesting agricultural products. Aggregators serve as collectors of products from farmers and transport them to processing plants. At processing plants, agricultural products are processed into finished goods. Central distributors are tasked with distributing these finished products to retail stores, while retail stores sell agricultural products directly to consumers.
3. Blockchain Manufacturing
   This section outlines that each participant in the supply chain will possess a node within the blockchain network. Each node will store information regarding every transaction, delivery, or receipt of products. Subsequently, the node will document this information in a new block and link it to the preceding block, thereby establishing a blockchain.
4. Information stored in Blocks
   Each block contains first identification data about producers, distributors, and other parties involved in each transaction. Both product data Detail agricultural products such as type, quantity, and quality. The third location data: Information about the location and time of delivery of products in the supply chain. Fourth shipping data: Information about transportation and logistics used during shipping.
5. Confirmation and Verification
   This section checks that every time a transaction occurs, the nodes in the blockchain network must confirm and verify the transaction before it is included in a new block. This section prevents errors and ensures proper data consistency across the network.
6. Smart Contracts
   Smart contracts are crucial because they function as automated protocols or code executed based on specific events or conditions. These protocols can prove beneficial in supply chain management systems, facilitating tasks such as managing payments, scheduling shipments, and more. By enabling blockchain processes to become more automated and efficient, smart contracts enhance the overall effectiveness of the system.
7. Restricted User Access
   This section serves as a security measure within the blockchain system, restricting access to information in the supply chain based on the role of each participant. For instance, farmers are only granted access to information pertinent to their own farms, whereas central distributors can solely access information regarding product delivery to retail stores.

The blocks that make up the main blockchain in Figure 8 are the initiation of the food supply chain in general. Code B0-B4 means Block 0-Block 4; each block has a general structure, as shown in Figure 9.

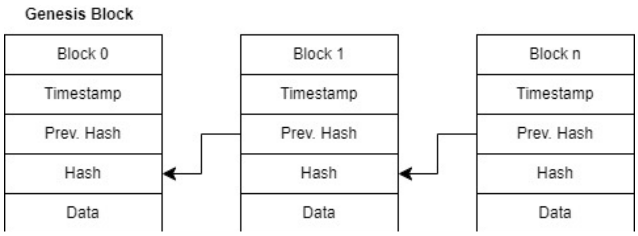

Figure 9. General Data Blockchain Structure

Figure 9 presents details on the constituent components of each block. Every block includes timestamp data, a previous hash, a hash, and additional data. As the data volume expands, so does the size of the block. The mathematical model of the farming blockchain in this study is represented by Equation (1).

$$f(x) = \sum_{i=1}^{10} x_1 \quad (1)$$

Equation (1) models the indicators that make up an agricultural blockchain according to the needs of this study. The following details the model description $f(x)$ represents the function that builds the agricultural blockchain; x_1-x_{10} represents 10 blockchain characteristics based on Table 1. The following is a mathematical model for recording each input as in Equation (2).

$$\sum_{i=1}^{n} r_1 = 1 \quad (2)$$

Equation (2) models the addition of data in one block. The r_1 symbol represents new data and tracks data. Each participant in the blockchain has a private key. Here is a mathematical model to calculate the frequency of adding data to the blockchain, as in Equation (3).

$$f(r, B) = \sum_{i=1}^{n} r_1 * \sum_{i=0}^{m} B_0 \quad (3)$$

Equation (3) is a function to determine the frequency of adding data based on the amount of data and available blocks. B_0 is a symbol that represents a block on the blockchain. The following is a mathematical model for measuring system efficiency values, such as Equation (4).

$$E = 100 - \left(\frac{U_B * N_s}{\sum_{i=1}^{n} r_n} \right) \quad (4)$$

Equation (4) describes the efficiency calculation in the agricultural blockchain system. The E symbol stands for efficiency, U_B as the number of participants in the system; N_s the number of services available on the system; and the total amount of data. Implementing this approach into practice can increase the safety and quality of agricultural products while fostering trust among all supply chain partners. It is crucial to remember that this model is merely an overview and applies blockchain technology effectively; careful consideration must be given to the needs and peculiarities of the current agricultural supply chain management system.

5 Conclusion

According to a systematic literature review, the agricultural system faces severe strain due to projected population increases, expected to reach 8.5 billion by 2030 and 9.7 billion by 2050, up from 7.7 billion in 2019. Climate change, land scarcity, drought, rising food prices, and inefficient supply chains are anticipated to present significant challenges to the agricultural sector by 2050. To address existing supply chain issues, establishing a traceable and transparent supply chain is imperative, allowing all stakeholders to monitor the agricultural process from planting to consumer hands. Reliable technology is necessary to achieve traceability and transparency in agricultural supply chains, with blockchain technology emerging as a viable solution. Blockchain offers an efficient mechanism for enhancing food traceability and transparency, enabling the tracing of agricultural product origins.

A total of 449 papers on publishing outlets' demographics and trend characteristics were downloaded, with 91 papers subjected to in-depth analysis. Of these, 84% were sourced from journals and 21% from proceedings. These papers were classified into Quartiles (Q), with Q1 receiving the most attention (64%). Various educational backgrounds were represented among the authors, with computer sciences accounting for 27.52%, economics and management 18.46%, engineering 15.77%, business 13.42%, supply chain management 8.39%, agriculture 9.06%, sciences and technology 4.03%, applied life science 1.68%, pharmacy 1.01%, and blockchain 0.67% of the total.

VOS Viewer's analysis of demographics and trend characteristics revealed the five keywords with the highest total link strength to be blockchain, traceability, supply chain, food safety, and food supply chain. RQ1 (regarding the properties of blockchain technology that must be adopted) has been addressed in this paper. The ten most frequently cited properties identified were transparency, traceability, security, smart contracts, immutability, decentralization, distributed ledger, tracking, efficiency, and speed. Transparency was identified as the most compelling reason for adopting blockchain technology in agricultural supply chain management, as it fosters trust among stakeholders.

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