Jurnal Ekonomi dan Pembangunan Vol. 33 No. 1 Tahun 2025
Journal Homepage: https://ejournal.brin.go.id/JEP
ISSN 0854-526x (print) | e-ISSN 2503-0272 (online)

DOI: 10.55981/jep.2025.11522

MAPPING TECHNOLOGY AND RISK OF TECHNOLOGY IN AGRICULTURAL SUPPLY CHAINS: A SYSTEMATIC LITERATURE REVIEW

Rr. Retno Rizki Dini Yuliana[1,2,*], **Alim Setiawan Slamet**[2], and **Suci Wulandari**[3]

[1] Research Center for Cooperatives, Corporations and People's Economy – BRIN, Jl. Gatot Subroto Kav.10, South Jakarta, Jakarta 12710, Indonesia; [2] IPB University, Kampus IPB Dramaga Jl. Dramaga, Bogor, West Java, 16680, Indonesia; [3]Center for Research on Social Welfare, Villages and Connectivity – BRIN, Jl. Gatot Subroto Kav. 10, South Jakarta, Jakarta, 12710, Indonesia

***Corresponding Author**: rizkidy@gmail.com

ABSTRACT

Digitalization in the agricultural supply chain is increasingly developing and contributing to increasing the agricultural sector's efficiency, transparency, and competitiveness. This study aims to map digital technologies that have been applied in the agricultural supply chain and identify risks that may arise from their implementation. Using the Systematic Literature Review (SLR) method based on the PRISMA approach, this study analyzed 114 articles from various relevant academic sources. The results of the studies show that blockchain technology, the Internet of Things (IoT), and digital platforms are the most widely used technologies in various agribusiness subsystems, including production, processing, distribution, and marketing. Various risks must be anticipated, such as technical risks (cyber attacks and system failures), regulatory risks (differences in policies between countries), and cultural risks (loss of traditional agricultural methods). The results of this study are expected to be a reference for policymakers and academics in developing sustainable agricultural supply chain digitalization strategies.

Keywords: Agricultural Supply Chain, Digitalization, Risk Technology.
JEL Classification: Q13, O33, D81, Q16

INTRODUCTION

The development of digital technology has penetrated various sectors, including agriculture. The digitalization of the agricultural supply chain changes traditional practices to digital businesses. Digitalization changes business models or provides new business models that have the potential to generate new (DSN) is a new supply chain terminology that is interconnected between each point so that it has the potential for greater interaction and connectivity (Mussomeli et al., 2016).

The integration of digital technology by stakeholders can optimize operations from farm to consumer (Ginige, et al., 2024). Currently, t he integration of technology into the agricultural system is expected to overcome various existing challenges such as climate change, increasing global food demand, and supply chain inefficiencies. Food traceability is also becoming increasingly important and a fundamental requirement for agriculture product in the future

Submitted : 05-06-2025
Revised : 24-06-2025
Accepted : 30-06-2025

(Conti, 2022; Latino et al., 2022). Therefore, digital technology has an important value in improving the efficiency of the agricultural product supply chain, which can contribute to overcoming the challenges of food security, transparency, competitiveness of the farming industry, and sustainability (Chakraborty & Das, 2024; Liu, 2023). Supply chain digitalization can be a solution by optimizing upstream-to-downstream management, increasing traceability, and reducing operational inefficiencies.

Literature reviews related to the application of digital technology in agricultural supply chains have been widely studied from a specific technological perspective. However, studies that comprehensively map various digital technologies in all agribusiness subsystems while expanding the risks of their application are still minimal. This is an important gap because in many developing countries such as Indonesia, the application of agricultural digitalization is still low due to the limited quality of human resources and supporting infrastructure. Inadequate digital infrastructure hinders farmers and agribusiness actors' adoption of new technologies, especially considering the still weak technological literacy and network infrastructure in remote areas. These problems emphasize that comprehensive research on the application of digital technology and its risks in the context of agribusiness is urgently needed.

This article will map digital technologies that have been applied to agricultural supply chains in various countries, then classify them based on their implementation in each link in the agricultural supply chain, as well as the risks of applying digital technology to the agricultural supply chain. The findings of this analysis are expected to be a reference for future research or policy formulation in designing a sustainable agricultural supply chain digitalization strategy so that it can support the equitable distribution of digital technology benefits for farmers while complementing previous literature by providing a comprehensive study that has not been available in previous studies. State the study gap or research problem, the importance/urgency of studying/researching this topic, and the academic contribution of the research.

LITERATURE REVIEW

The agricultural supply chain includes a series of processes starting from the production stage, processing, distribution, and marketing of agricultural products. The supply chain network requires strategic collaboration between various actors to improve the efficiency, quality, and product sustainability. In the supply chain, several actors work together and maintain their respective identities and autonomy. The supply chain development framework includes four main elements, namely network structure, business process chain, network management, and resource chain (Van Der Vorst, 2006).

In the agricultural supply chain, there is a value chain flow that plays an important role in generating economic benefits from the agricultural product value chain. The agricultural value chain flow includes products, information, and knowledge between smallholders and farmers. This flow also helps detect added value from each stage of the marketing, production, and consumption process (Wei, 2021). No less important is supply chain management. Supply chain management (SCM) is the management of processes that transform new raw materials into finished products. Agricultural commodities produced must go through a series of processes. Supply chain management is responsible for the efficient production and supply of products from the farm level to the consumer to reliably meet consumer needs in terms of quantity, quality, and price (Prazaath & Beula, 2020).

Digitalization is defined as the use of digital technology intended to change business models or provide new business models that have the potential to generate new revenue and value (O'Leary, 2022). The application of digital technology in the agricultural supply chain can integrate data from various stages and ultimately improve coordination and assist in the decision-making process. The digital supply chain can include three dimensions of production, namely vertical and horizontal integration within groups in the chain, product life cycle integration, and digital engineering activities throughout the value chain of a product and its related activities (Syromyatnikov et al., 2020).

RESEARCH METHOD

This study uses the Systematic Literature Review (SLR) method with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) approach. The PRISMA method was chosen because it has a systematic, transparent, and replicable framework, which distinguishes it from other SLR approaches. PRISMA uses a clear and systematic flowchart to report the process of searching, selecting, and excluding articles. This helps minimize subjective bias in selecting articles. The limitation of this method is that it takes a long time to systematically screen and evaluate hundreds or even thousands of articles. PRISMA only organizes articles collected and reported and performs content or data analysis.

There are five stages used to conduct a literature review using the PRISMA approach, namely defining eligibility criteria, defining information sources, selecting literature, collecting data, and selecting data items. Article search via Scopus with the keywords *agriculture AND digital AND supply AND chain* and found 462 documents. The search results were filtered with five criteria, namely the type of document selected was only an article published in 2019-2024, the type of journal article and conference proceedings, the publication stage was final and the language used was English. At this filtering stage, 243 documents were obtained. In the next stage, articles were selected based on their suitability to the topic based on the title, abstract, and existing keywords, and 174 documents were obtained. Based on this data, a search for available documents that can be downloaded was obtained, and 119 documents were obtained. The last stage was to check the suitability of the contents of the article with the topic and 114 appropriate documents were obtained. In summary, the stages of PRISMA are as follows.

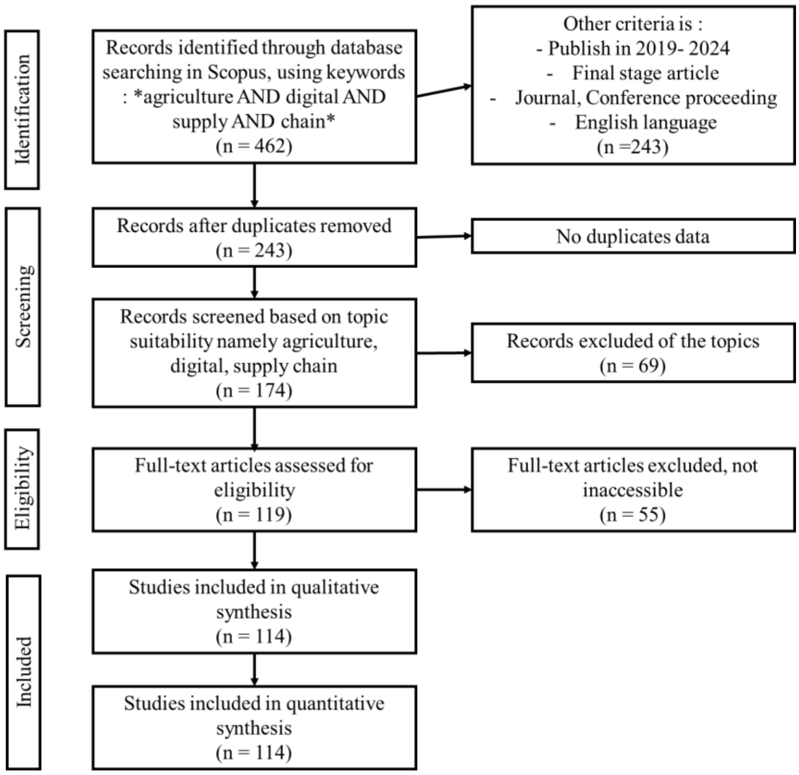
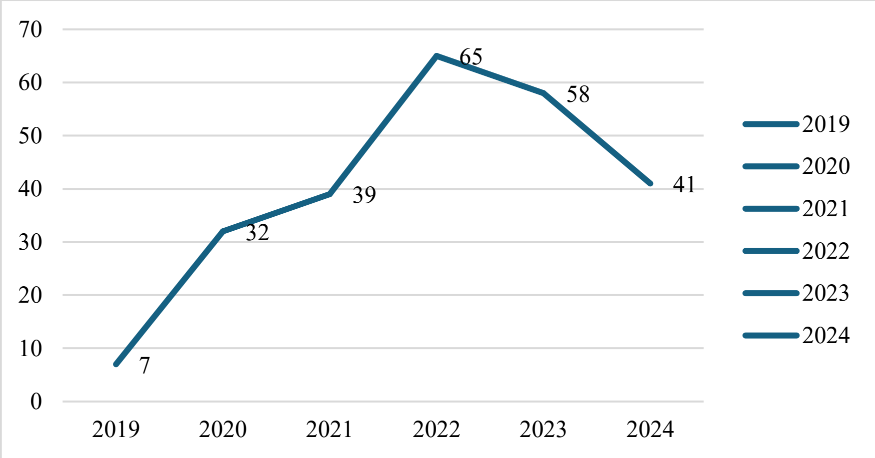


Figure 1. Systematic Literatur Review Stages

The articles are then mapped to see what technologies have been applied in the agricultural sector based on subsystems, what technologies are most widely used, which countries are studied in the articles, and what risks arise from the application of technology in this agricultural sector.

RESULTS AND DISCUSSION

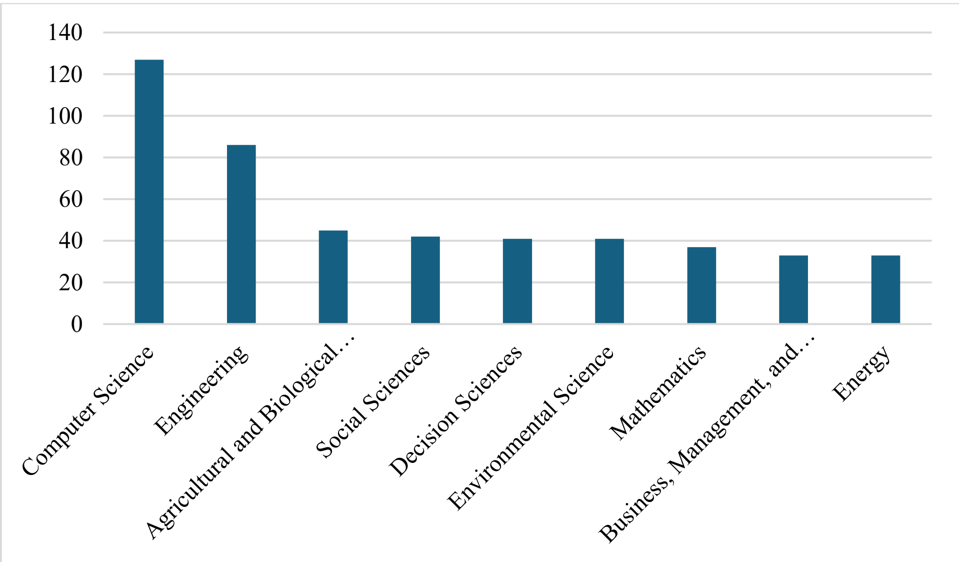
Article data obtained from the results of the Scopus search amounted to 462 documents. Articles related to Agriculture, Digital, and Supply Chain were collected in the last 6 years, namely from 2019 to 2024. Judging from the trend, articles on this topic were most widely published in 2022. This shows that this topic is interesting to study by researchers and academics, although in 2023 and 2024 the number decreased. The downward trend in 2023 may occur because the focus of researchers and academics has shifted to new topics or derivatives of newer digital technologies. The downward trend in 2024 is because data collection was carried out in August 2024. Not only is it increasingly interesting to study but also the application of technology to the supply chain in agriculture is increasingly being applied by people in various countries. This shows that the increasing use of technology in agriculture can increase the competitiveness of the agricultural sector.



Source: Scopus, 2024

Figure 2. Year of Article Publication

Based on the scientific subject area, these articles mostly come from the fields of computer science and engineering. These two scientific fields are closely related to digital technology. In third and subsequent positions are the fields of agriculture and biology, social sciences, decision sciences, environmental sciences, mathematics, business and management, and energy. This also shows that the agricultural is a strategic sector that receives attention from various scientific fields. Especially related to the development of technology applied in the agricultural sector.



Source: Scopus, 2024

Figure 3. Subject Area Article

Technology Mapping

Agriculture is divided into several subsystems that are integrated and support agricultural activities, starting from the upstream subsystem, production subsystem, downstream subsystem, and supporting subsystem. The performance of each subsystem will influence each other so that the sustainability and efficiency of agribusiness require good synergy between all subsystems. Technological transformation in the agricultural subsystem can support increased efficiency, reduce risk, and create added value at every stage of the agricultural system. Based on the results of the SLR, digital technology that has been applied in the agricultural sector can be seen in Table 1.

Table 1. Type of Technology based on Agricultural Subsystem

Sub System	Type of Technology
Upstream system	Digital-twin (Mengi et al., 2024; Tasic & Cano, 2024; Xinhua et al., n.d.); genomic optimization (Mengi et al., 2024); smart farming with IoT, block chain, and sensors (Khandelwal et al., 2021; Rahman et al., 2023; Shao et al., 2023); artificial intelligence (Monteiro & Barata, 2021; Siropyan et al., n.d.); deep learning (Xia et al., n.d.); robots (Javaid et al., 2022; Peteinatos et al., 2020; Popescu et al., 2022); agricultural automation (Xia et al., n.d.); greenhouse monitoring, drone-based crop imaging (Misra et al., 2022); Artificial Neural Networks (ANNs) (Peteinatos et al., 2020); and image processing (Frikha et al., 2023).
On Farm	Sensors, automatic machines, digital applications (Popescu et al., 2022); IoT (Adhitya et al., 2020; Frikha et al., 2023; Javaid et al., 2022; Karras et al., 2022; Prakash et al., n.d.), block chain, big data, computer utilization on grain production, deep learning, artificial intelligence (X. Du et al., 2023; Javaid et al., 2022; Monteiro & Barata, 2021; Peteinatos et al., 2020; Siropyan et al., n.d.; Xinhua et al., n.d.); virtual and augmented reality (Javaid et al., 2022); digital phenotyping in poultry (Issa et al., 2024); digital cameras (Peteinatos et al., 2020); intelligent farm machines (Misra et al., 2022).
Down stream system	Digital technology (Abdullayev et al., 2023); digital twin (Henrichs et al., 2022); 3D food printing, thermal and nonthermal food processing (Manaf & Yusof, 2021); Warehouse Receipt System (WRS) with blockchain (Shao et al., 2023); IoT-based load cell sensors (Saputra et al., 2022); agricultural machinery (He & Xiong, 2023).
Marketing system	Internet-of-Agro-Things (IoAT) for delivered supply chain statistics temperature and humidity data (Vangipuram et al., 2023); application (Acharya et al., 2024; Conti, 2022; Shrivastava & Pal, 2019); NFC (Conti, 2020, 2022; Latino et al., 2022a); logistics circulation systems (Lei et al., 2023), decision support system (Arduin & Saïdi-Kabeche, 2022; D'Oronzio & Sica, 2021; Yusianto et al., 2020); geographic information system (Arduin & Saïdi-Kabeche, 2022; Yusianto et al., 2020); smartphone application (Arduin & Saïdi-Kabeche, 2022); block chain (Valencia-Payan et al., 2023); sensors (Xu et al., 2023); data analytics (Scuderi et al., 2022; Xu et al., 2023); e-commerce (Chaudhary & Suri, 2021; Csordás et al., 2022; X. Du et al., 2023; Guo et al., n.d.; Nurhayati et al., 2024; Yan, 2024); cold storage (Zielińska-Chmielewska et al., 2021); machine learning (Addou et al., 2024; Ancín et al., 2022; Quadras et al., 2023; Shrivastava & Pal, 2019); smart contract (Addou et al., 2024; Goyal et al., 2023; Peng et al., 2022; Valencia-Payan et al., 2023; C. Yang & Sun, 2020); IoT (Addou et al., 2024; Ancín et al., 2022; Brassesco et al., 2022; Cook et al., 2022; Goyal et

	al., 2023; Ibrahim et al., 2020; Kamble et al., 2022; Karunanayaka et al., n.d.; Keates, n.d.; Khandelwal et al., 2021; Latino et al., 2022b; Lumbantobing et al., 2023; Madumidha et al., 2019; Misra et al., 2020; Ranganathan et al., 2022; Senturk et al., 2023; Tasic & Cano, 2024; Valencia-Payan et al., 2023; Yusianto et al., 2020).
Supporting system	Cloud/edge computing (Ancín et al., 2022; Bergier et al., 2021; Z. Du et al., 2020; Latino et al., 2022a; Nesterenko et al., 2020; Ranganathan et al., 2022); platform agricultural supply chain finance (Zheng et al., 2020), digital finance (Huang & Nik Azman, 2023; Parlasca et al., 2022); digital payment (Quayson et al., 2020a); platform (Bai & Wang, n.d.; Bergier et al., 2021; EYu, 2020; Fortunato et al., 2021; Ibrahim et al., 2020; Piantari et al., 2020; Ramachandran et al., 2021a; Rivza et al., 2019; Saini et al., 2023; Zheng et al., 2020); website (Alkahtani et al., 2021; Rai et al., 2024); block chain (Addou et al., 2024; Alkahtani et al., 2021; Ancín et al., 2022; Bonetti et al., 2024; Chen et al., 2021; Z. Du et al., 2020; Khan et al., 2022; Khandelwal et al., 2021; Latino et al., 2022a; Madumidha et al., 2019; Malik et al., n.d.; Nagariya et al., 2022; Patel et al., 2024; Premchandran & Batchu, 2023; Quayson et al., 2020a; Ramachandran et al., 2021a; Saji et al., 2020; Saranya & Maheswari, 2022; Shahid et al., 2020; Shrivastava & Pal, 2019; Thakare et al., n.d.; Thume et al., 2022; Udalov et al., 2023; Xu et al., 2023; C. Yang & Sun, 2020); smart contract (Goyal et al., 2023; Peng et al., 2022; C. Yang & Sun, 2020); IoT (Panigrahi et al., 2024); digital twins (Gallego-García et al., 2022); ethereum (Lou et al., 2023); digital training (Quayson et al., 2020a); e-drones (Quayson et al., 2020b; Shankar et al., n.d.); application (Sankpal et al., 2023); satellite monitoring (Lou et al., 2023); artificial intelligent (Ahmadi & Jackson, n.d.; Ancín et al., 2022; Holzinger et al., 2024; Misra et al., 2020; Rivza et al., 2019; Shankar et al., n.d.; Yusianto et al., 2020); website (Alkahtani et al., 2021; Rai et al., 2024); Intelligent Spatial Decision Support Systems (ISDSS) (Yusianto et al., 2020); automation (D'Oronzio & Sica, 2021; Rivza et al., 2019); data mining technologies (Lumbantobing et al., 2023); precision livestock farming technologies (Ahmadi & Jackson, n.d.); Smart Farming and Short Food Supply Chains (SFSCs) (Lioutas & Charatsari, 2020); Smart Farming Technology (SFT) (Giua et al., 2022), distributed ledger technology (Griffin et al., 2022); RFID, NFC, QR codes (Latino et al., 2022a).

In the upstream subsystem, the use of technology is utilized to assist pre-production activities such as land preparation, procurement of raw materials, preparation of agricultural equipment and machinery, preparation of seeds, and so on. One of the technologies utilized is a digital twin that helps model and optimize the cultivation process, such as selecting the best varieties or setting optimal plant conditions, such as planting systems and planting patterns (Tasic & Cano, 2024).

The use of technology in upstream subsystems will help farmers increase efficiency and productivity through the allocation of appropriate input use, both in terms of quantity and quality; cost savings and support sustainability due to optimization of input use; and assist farmers in decision-making system because the data they have is obtained in real-time (Tasic & Cano, 2024; Udalov et al., 2023). The farm subsystem is the core of the agribusiness system. Activities in the on-farm subsystem include production or cultivation activities, and resource management to produce primary agricultural products. Technology in the on-farm subsystem will assist in the management of the use of available resources so that it can produce optimal production results. Technology in the on-farm subsystem will also help make cultivation activities easier from planting until harvesting. The use of computers with several software can be used to increase the efficiency and effectiveness of plant seed use (Chandio et al., 2024). Sensors will help farmers record various production activities and IoT will provide information according to the real time of the plant. Furthermore, Big Data can be used by farmers to predict future trends and assist in making the right decisions (Javaid et al., 2022).

In the harvesting process, automatic machine technology such as automatic picking can help farmers speed up the harvesting process which was previously done manually so that it can save time and human energy. Automatic machines that are elaborated with deep learning and AI are used to detect fruit conditions quickly and very accurately (Xia et al., n.d.). Such as using a combine harvester to harvest rice that is ready to be harvested. The next subsystem is the downstream subsystem, this subsystem is also known as the processing subsystem. This subsystem includes processing activities from primary products to semi-finished or finished products so that they have added value. Three-Dimensional (3D) food printing technology is one of the technologies in the sophisticated downstream subsystem for designing food with pre-loaded recipes and operated using computers, cellphones, or IoT (Manaf & Yusof, 2021). 3D objects appeared to have volume and depth, making them appear more real or realistic. A warehouse receipt system (WRS) with blockchain technology is one of the breakthroughs in digitalizing the warehousing system that contributes to the efficiency of resource allocation because it can reduce transfer, shipping, and monitoring costs (Shao et al., 2023). IoT and sensors can also be used in the warehousing system for measuring the weight and recording of goods in the warehouse, thereby assisting in the inventory system in the warehouse (Saputra et al., 2022).

The marketing subsystem includes the distribution process, logistics, promotion, and sales of products from producers to consumers. Technology has generally been widely applied to this subsystem, especially in the promotion and sales lines. The Internet-of-Agro-Things (IoAT) in the marketing subsystem helps monitor and maintain the visibility of agricultural products that are stored and shipped (Vangipuram et al., 2023). Another technology that can be utilized is a smartphone with NFC technology that can be used to support traceability in the supply chain and tends to be inexpensive (Conti, 2020, 2022; Latino et al., 2022). Furthermore, the digital technology utilized in the marketing subsystem is e-commerce. Digital marketing can increase marketing efficiency, market reach and marketing volume.

Another important subsystem in the agribusiness system is the supporting subsystem. This subsystem supports the smooth running of activities in other subsystems. This supporting subsystem includes financial institutions, education or training, policies, and research. The use of technology in this supporting subsystem has grown rapidly in every field. Technology in the financial sector has developed rapidly in supporting transfer transactions, payments, financing, and investment. This technology can support the agricultural business system to access financial, buying, and selling transactions such as mobile financial services, digital payments, and digital finance. Financial digitalization can increase financial inclusiveness and increase agricultural business income (Huang & Nik Azman, 2023; Parlasca et al., 2022). Digitalization has also entered the field of education and training which makes it easier for people from all walks of life to gain insight and knowledge related to cultivation techniques, post harvest, marketing, and current issues in agriculture (Quayson et al., 2020). Agricultural Supply Chain Finance based on e-commerce can improve transaction transparency, improve the efficiency of supply chain financing operations, and ensure the security of information for all parties in logistics transactions, information flow, business flow, and capital flow based on e-commerce platforms (Zheng et al., 2020). Overall, the most widely used types of technology are blockchain, IoT, and platform technology (see Figure 4). These three technologies are most frequently mentioned in articles related to the digitalization of technology in the agricultural sector. These technologies are also applied in almost every agricultural subsystem and are interconnected with each other. This shows that digital technology currently plays an important role in supporting the progress and sustainability of the farming sector.

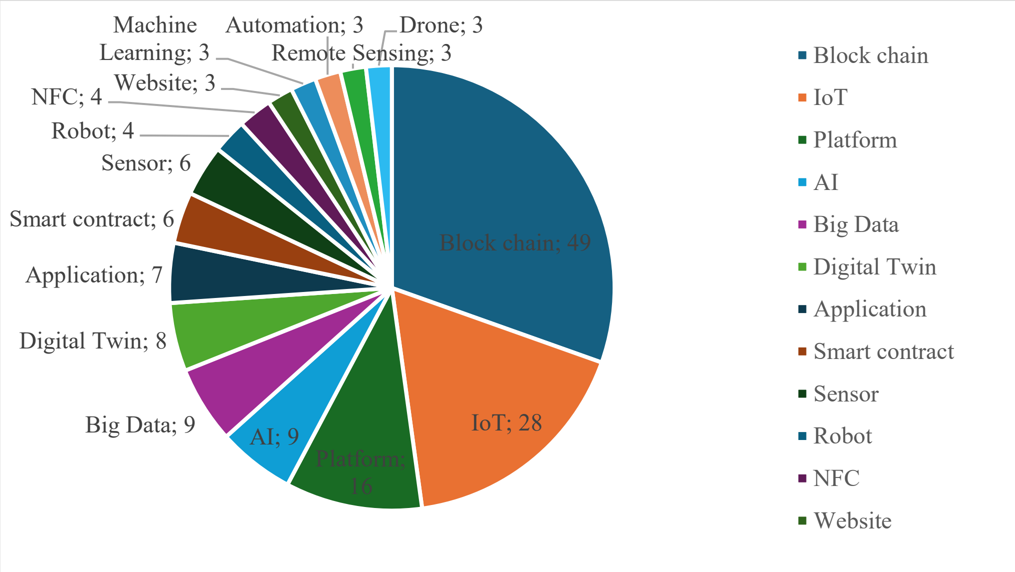


Figure 4. Most Analyzed Technologies in Journals

IoT in the upstream subsystem is used to monitor soil conditions, weather, humidity, and plant nutrient needs. This information can be used by Farmers in decision-making related to the farming business. IoT and blockchain can be integrated into a digital twin for monitoring, tracking, and optimizing productivity (Tasic & Cano, 2024). The application of blockchain in the supply chain can increase transparency and traceability because all parties in the supply chain can record, store, and view every activity in the supply chain (Goyal et al., 2023). Blockchain technology is an important element in the modern agricultural system because this technology can be relied on to store data, facilitate transactions, be timely, and increase trust through transparency and traceability of data (Udalov et al., 2023). The food traceability system must ensure food safety and quality control, enable authentication, fraud prevention, and control by authorities, and increase consumer security and trust (Conti, 2022). Meanwhile, digital platforms can integrate the use of technology into various agricultural product supply chain activities so that they are easier for users to use.

The application of digital technology in the agricultural sector has been implemented in many countries. Of the 114 articles obtained, only 33 articles mentioned the name of the country being studied (see Figure 5). The most studied countries are India, China, and Africa. The three countries are more widely studied in the application of digital technology in the agricultural sector because they are influenced by government policy factors, infrastructure conditions, demographic conditions public awareness, and support for capacity building. The governments in each country also have policies that support the application of digital technology such as support for infrastructure and smart technology in China, the integrated national program eNAM (Electronic National Agriculture Market) in India, and support for collaboration between African governments and organizations to attract investment. The technological infrastructure and internet penetration in India and China have been quite high, evenly distributed, and affordable. The Chinese government is actively providing assistance and capacity building to increase technology adoption at the farmer level. Likewise, young farmers in Africa tend to have adopted technology and have better digital literacy.

The use of technology in Indonesia is only discussed in one article. This shows that the use of digital technology in the agricultural supply chain in Indonesia has not been widely implemented or may not have been widely studied by researchers or academics. The low utilization of digital technology in Indonesia is thought to be due to the uneven distribution of digital infrastructure, low digital literacy among farmers, suboptimal government policies and support, and social and cultural factors that often hinder technology adoption.The topic of study related to the digitalization of the agricultural supply chain specifically in several countries that have not been studied much, especially in developing countries such as Indonesia, is an interesting research opportunity to be studied in the future. Developing countries may face obstacles in implementing this system due to limited resources (Ramachandran et al., 2021).

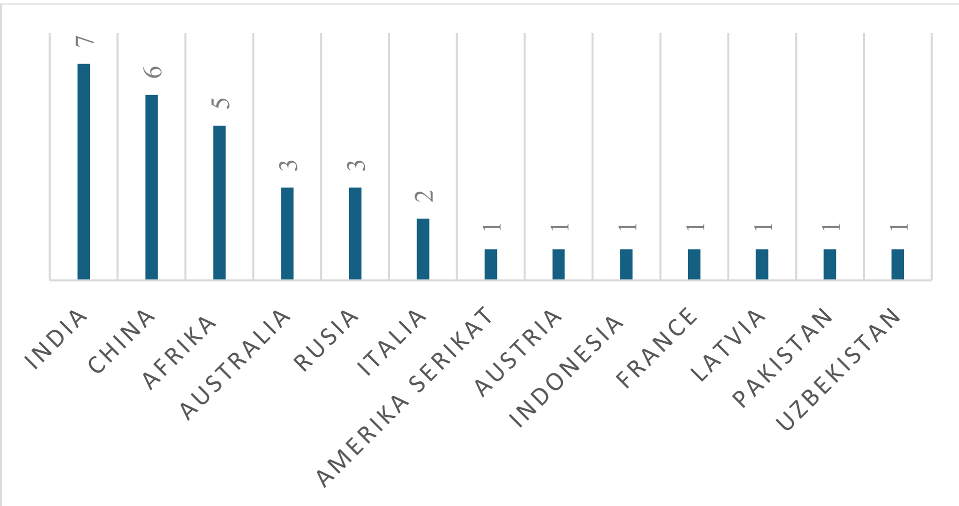


Figure 5. Countries studied in the article

Risk Mapping

The main challenge the agricultural sector faces is making the right decisions under uncertain conditions. Every activity in the agricultural supply chain contains risks and uncertainties.

Climate conditions, land, and other production factors often contain risks faced in the upstream and on-farm subsystems. Meanwhile, market conditions and political-economic stability are generally risks in the downstream and marketing subsystems (Zhai et al., 2023). Therefore, risks need to be identified early on to determine the severity of the risk event and the chances of it occurring in the supply chain (Indrasari et al., 2024). The use of technology in the supply chain certainly also has the potential for risks that can disrupt activities in the agricultural supply chain. So it is necessary to know what risks are likely to arise from the use of this digital technology.

This article tries to identify the risks of technology in the supply chain based on the SLR article data search. There are not many articles that discuss the risks of supply chain technology. The search results from the articles used as SLR data found only four articles that reviewed the risks in them.

Table 2. Risk Mapping Results Reviewed in the Journal

Risk Classification	Types of Risk	Forms of Risk
Risiko Teknologi	System Operation Risks (Gallego-García et al., 2022)	Error in system operation
	Technical risks (Gallego-García et al., 2022; Zheng et al., 2020)	Cyber attack, system failure
Regulatory and Reputational Risks	Regulatory risk (Ramachandran et al., 2021a; Zheng et al., 2020; Zscheischler et al., 2022)	weak supervision of digital systems from a legal perspective, differences in regulations between countries/regions
	Reputational risk (Ramachandran et al., 2021)	influence of reputation of producing country/institution
System Risk	Data security and privacy risks (Ramachandran et al., 2021; Zscheischler et al., 2022)	data leak, data misuse
	Credit risk (Zheng et al., 2020)	Misuse of funds, data, or default
Cultural Risk	Technology adoption risks (Zscheischler et al., 2022)	The erosion of conventional agricultural techniques
	Cultural risk (Gallego-García et al., 2022; Zscheischler et al., 2022)	The erosion of local community culture

Technology offers transparency of data and information, but every data and information recorded in the system depends on the data quality entered into the system. So inaccuracies and errors in data in the system can have an impact on decisions made by the system to be wrong or inappropriate (Ramachandran et al., 2021). Therefore, in quantitative research, good and correct data becomes an important factor in implementing digitalization technology. Good data must be in accordance with formal legal regulations, in accordance with social and life ethics, and in accordance with professional ethics. Meanwhile, correct quantitative data is valid, representative and generalizable data.

Technical risks in supply chain technology can occur due to vulnerable network systems and low quality of human resources (HR) professionals. Hacked or disrupted network systems can cause system operations to be hampered and have an impact on economic losses. Likewise, if there is an error in the operator's human resources (HR), it can cause system failure and even data misuse and credit failure (Zheng et al., 2020). The rapid development of technology is often not accompanied by changes in the regulations that govern it. So chaos may occur in industries that use technology because technology producers set their policies for unilateral benefit and can also violate the rights of other parties (Zheng et al., 2020). Each country has different standards and regulations related to food safety and biosecurity. So regulatory harmonization is needed by the WTO to overcome this. In an automated system, a company's identity and reputation are used as the basis for decision-making for the level of inspection. If this reputation system is not managed properly or can be manipulated, then unfairness can occur in the compliance process (Ramachandran et al., 2021a). Regulatory risk occurs because rapid technological developments are often not accompanied by existing regulations to regulate them. So that technology companies can enter and monopolize the market (Zscheischler et al., 2022).

Mastery of technology is generally controlled by large companies so that data security and privacy are at risk of being misused or even traded. In addition, this also reduces its sovereignty over the data it owns (Zscheischler et al., 2022). Some companies also have concerns about sharing their production data with the government and competitors (Ramachandran et al., 2021a). Digital Twin relies on high connectivity through the Internet of Things (IoT), cloud computing, and big data analytics. This increases the risk of cyberattacks and data leaks that can compromise agricultural operations (Gallego-García et al., 2022). The use of technology can have an impact on changes in agricultural techniques and local culture, resulting in changes in land structure and use, changes in resources, disruption of ecological balance, and reduced biodiversity (Zscheischler et al., 2022). The use of technology on the agricultural side is often hampered by the lack of adequate technological infrastructure by farmers. In addition, the adoption of technology by farmers is also often hampered by culture in the agricultural sector. Therefore, the agricultural sector tends to be slow in adopting new technologies (Gallego-García et al., 2022). This study presents potential technologies that can be utilized in the agricultural sector and can then be studied further for application in agricultural systems in other countries. Further research on the future challenges of implementing technology in this agricultural system and upstream-downstream supply chain systems.

CONCLUSION AND RECOMMENDATION

The application of digital technology in the agricultural supply chain is growing, with the highest publication trend in 2022. The digitalization of the agricultural supply chain involves various technologies, including Smart Farming, blockchain, the Internet of Things (IoT), digital platforms and e-commerce, which are applied in many subsystems such as upstream, on-farm, downstream, marketing, and support.

Digital technology provides benefits in increasing the efficiency, productivity, transparency, and sustainability of the agricultural sector. However, its application in developing countries, including Indonesia, is still limited and has not been widely studied in research. Some of the main challenges in implementing this digital technology include operational risks, regulations, data security, and adoption of culture and infrastructure.

This study identified several risks faced such as cyber-attacks, system failures, weak regulations, and impacts on local agricultural culture. Risk mitigation strategies and regulatory harmonization are needed to ensure the sustainability of digital technology systems in the agricultural supply chain. The digitalization of the agricultural supply chain has great potential to increase the efficiency, productivity and competitiveness of the agricultural sector but requires a strategic approach to its implementation that considers risk factors and infrastructure readiness and still maintain local culture.

ACKNOWLEDGMENTS

Thanks are due to the National Research and Innovation Agency for providing research funding for this study through the 2024 BARISTA Programme (Research Assistance for Research Talents).

DISCLOSURE STATEMENT

There is no potential conflict of interest in this article.

REFERENCES

Abdullayev, M., Yusupov, M., Mardonov, A., Mirzaaxmedov, N., Allayorov, R., & Khakimov, B. (2023). Strengthening of Food Security Through Development of Digital Technologies in the Food Production and Processing Chain. *ACM International Conference Proceeding Series*, 304–313. https://doi.org/10.1145/3644713.3644753

Acharya, N., Khatiwada, P., Pandey, R., Niroula, S., & Chapagain, P. (2024). Crop Recommendation System Using Machine Learning: A Comparative Study. *International Journal on Engineering Technology*, *1*(2), 302–311. https://doi.org/10.3126/injet.v1i2.66708

Addou, K., El Ghoumari, M. Y., Archdir, S., & Azouazi, M. (2024). A Web3 Model Boosted by IoT and Machine Learning to Bring Transparency and Sustainability to the Food Supply Chain. *Lecture Notes in Networks and Systems*, *930 LNNS*, 14–25. https://doi.org/10.1007/978-3-031-54318-0_3

Adhitya, Y., Prakosa, S. W., Köppen, M., & Leu, J. S. (2020). Feature extraction for cocoa bean digital image classification prediction for smart farming application. *Agronomy*, *10*(11). https://doi.org/10.3390/agronomy10111642

Ahmadi, B. V., & Jackson, E. L. (n.d.). *Perspectives of digital agriculture in diverse types of livestock supply chain systems. Making sense of uses and benefits*.

Alkahtani, M., Khalid, Q. S., Jalees, M., Omair, M., Hussain, G., & Pruncu, C. I. (2021). E-agricultural supply chain management coupled with blockchain effect and cooperative strategies. *Sustainability (Switzerland)*, *13*(2), 1–30. https://doi.org/10.3390/su13020816

Ancín, M., Pindado, E., & Sánchez, M. (2022). New trends in the global digital transformation process of the agri-food sector: An exploratory study based on Twitter. *Agricultural Systems*, *203*. https://doi.org/10.1016/j.agsy.2022.103520

Arduin, P. E., & Saïdi-Kabeche, D. (2022). Dignity in Food Aid Logistics Is Also a Knowledge Management and Digital Matter: Three Inspiring Initiatives in France. *Sustainability (Switzerland)*, *14*(3). https://doi.org/10.3390/su14031130

Bai, Y., & Wang, Q. (n.d.). *Flexible Operation Model in Chinese Rural Agricultural Supply Chains with Cold Storages*.

Bergier, I., Papa, M., Silva, R., & Santos, P. M. (2021). Cloud/edge computing for compliance in the Brazilian livestock supply chain. *Science of the Total Environment*, *761*. https://doi.org/10.1016/j.scitotenv.2020.143276

Bonetti, E., Bartoli, C., & Mattiacci, A. (2024). Applying blockchain to quality food products: a marketing perspective. *British Food Journal*, *126*(5), 2004–2026. https://doi.org/10.1108/BFJ-12-2022-1085

Brassesco, M. E., Pintado, M., & Coscueta, E. R. (2022). Food system resilience thinking: from digital to integral. *Journal of the Science of Food and Agriculture*, *102*(3), 887–891. https://doi.org/10.1002/jsfa.11533

Chakraborty, S., & Das, S. (2024). Financial Literacy in MSMEs: Challenges and Growth. *Library Progress International*. https://bpasjournals.com/library-science/index.php/journal/article/view/3728

Chandio, A. A., Ozdemir, D., Gokmenoglu, K. K., Usman, M., & Jiang, Y. (2024). Digital agriculture for sustainable development in China: The promise of computerization. *Technology in Society*, *76*. https://doi.org/10.1016/j.techsoc.2024.102479

Chaudhary, S., & Suri, P. K. (2021). Framework for agricultural e-trading platform adoption using neural networks. *International Journal of Information Technology (Singapore)*, *13*(2), 501–510. https://doi.org/10.1007/s41870-020-00603-9

Chen, H., Chen, Z., Lin, F., & Zhuang, P. (2021). Effective management for blockchain-based agri-food supply chains using deep reinforcement learning. *IEEE Access*, *9*, 36008–36018. https://doi.org/10.1109/ACCESS.2021.3062410

Conti, M. (2020). Food traceability in fruit and vegetables supply chain. *52nd IEEE International Symposium on Circuits and Systems, ISCAS 2020*.

Conti, M. (2022). EVO-NFC: Extra Virgin Olive Oil Traceability Using NFC Suitable for Small-Medium Farms. *IEEE Access*, *10*, 20345–20356. https://doi.org/10.1109/ACCESS.2022.3151795

Cook, S., Jackson, E. L., Fisher, M. J., Baker, D., & Diepeveen, D. (2022). Embedding digital agriculture into sustainable Australian food systems: pathways and pitfalls to value creation. *International Journal of Agricultural Sustainability*, *20*(3), 346–367. https://doi.org/10.1080/14735903.2021.1937881

Csordás, A., Pancsira, J., Lengyel, P., Füzesi, I., & Felföldi, J. (2022). The Potential of Digital Marketing Tools to Develop the Innovative SFSC Players' Business Models. *Journal of Open Innovation: Technology, Market, and Complexity*, *8*(3). https://doi.org/10.3390/joitmc8030122

D'Oronzio, M. A., & Sica, C. (2021). Innovation in Basilicata agriculture: From tradition to digital. *Economia Agro-Alimentare*, *23*(2), 1–18. https://doi.org/10.3280/ecag2-2021oa12210

Du, X., Wang, X., & Hatzenbuehler, P. (2023). Digital technology in agriculture: a review of issues, applications and methodologies. *China Agricultural Economic Review*, *15*(1), 95–108. https://doi.org/10.1108/CAER-01-2022-0009

Du, Z., Wu, Z., Wen, B., Xiao, K., & Su, R. (2020). Traceability of animal products based on a blockchain consensus mechanism. *IOP Conference Series: Earth and Environmental Science*, *559*(1). https://doi.org/10.1088/1755-1315/559/1/012032

EYu, K. (2020). Directions of Digital Technologies Development in the Supply Chain Management of the Russian Economy. In *Int. J Sup. Chain. Mgt* (Vol. 9, Issue 4). http://excelingtech.co.uk/

Fortunato, R. B., Monteiro Zina, A. R. A., Breyer, S., Malias Paulino, D. F., & Santos, C. (2021). EatLOCAL: A platform that connects local farmers, consumers, municipalities and non-governmental organisations. *Procedia Computer Science*, *196*, 566–571. https://doi.org/10.1016/j.procs.2021.12.050

Frikha, T., Ktari, J., Zalila, B., Ghorbel, O., & Amor, N. Ben. (2023). Integrating blockchain and deep learning for intelligent greenhouse control and traceability. *Alexandria Engineering Journal*, *79*, 259–273. https://doi.org/10.1016/j.aej.2023.08.027

Gallego-García, S., Gallego-García, D., & García-García, M. (2022). Sustainability in the agri-food supply chain: a combined digital twin and simulation approach for farmers. *Procedia Computer Science*, *217*, 1280–1295. https://doi.org/10.1016/j.procs.2022.12.326

Giua, C., Materia, V. C., & Camanzi, L. (2022). Smart farming technologies adoption: Which factors play a role in the digital transition? *Technology in Society*, *68*. https://doi.org/10.1016/j.techsoc.2022.101869

Goyal, A., Kanyal, H. S., & Sharma, B. (2023). Analysis of IoT and Blockchain Technology for Agricultural Food Supply Chain Transactions. *International Journal on Recent and Innovation Trends in Computing and Communication*, *11*(3), 234–241. https://doi.org/10.17762/ijritcc.v11i3.6342

Griffin, T. W., Harris, K. D., Ward, J. K., Goeringer, P., & Richard, J. A. (2022). Three Digital Agriculture Problems in Cotton Solved by Distributed Ledger Technology. *Applied Economic Perspectives and Policy*, *44*(1), 237–252. https://doi.org/10.1002/aepp.13142

Guo, H., Narkhede, B., & Glaros, A. (n.d.). *Digital technologies in local agri-food systems: Opportunities for a more interoperable digital farmgate sector*.

He, Z., & Xiong, Z. (2023). Research on Pattern Matching of Dynamic Sustainable Procurement Decision-Making for Agricultural Machinery Equipment Parts. *IEEE Access*, *11*, 1–17. https://doi.org/10.1109/ACCESS.2022.3232124

Henrichs, E., Noack, T., Piedrahita, A. M. P., Salem, M. A., Stolz, J., & Krupitzer, C. (2022). Can a byte improve our bite? An analysis of digital twins in the food industry. *Sensors*, *22*(1). https://doi.org/10.3390/s22010115

Holzinger, A., Fister, I., Fister, I., Kaul, H. P., & Asseng, S. (2024). Human-Centered AI in Smart Farming: Toward Agriculture 5.0. *IEEE Access*, *12*, 62199–62214. https://doi.org/10.1109/ACCESS.2024.3395532

Huang, S., & Nik Azman, N. H. (2023). Enhancing Food Security through Digital Inclusive Finance: Evidence from Agricultural Enterprises in China. *International Journal of Environmental Research and Public Health*, *20*(4). https://doi.org/10.3390/ijerph20042956

Ibrahim, R. E., Elramly, A., & Hassan, H. M. (2020). Open systems science: digital transformation and developing business model toward smart farms' platform. *International Journal of Circuits, Systems and Signal Processing*, *14*, 1054–1073. https://doi.org/10.46300/9106.2020.14.134

Indrasari, L. D., Komari, A., Tripariyanto, A. Y., Santosa, H. B., Siswanto, E., Vitasmoro, P., Pradana, J. A., & Salsabilah, V. K. (2024). Design of sustainable green supply chain management using house of risk. *AIP Conference Proceedings*, *2952*(1). https://doi.org/10.1063/5.0212379

Issa, A. A., Majed, S., Ameer, A., & Al-Jawahry, H. M. (2024). IoT and AI in Livestock Management: A Game Changer for Farmers. *E3S Web of Conferences*, *491*. https://doi.org/10.1051/e3sconf/202449102015

Javaid, M., Haleem, A., Singh, R. P., & Suman, R. (2022). Enhancing smart farming through the applications of Agriculture 4.0 technologies. *International Journal of Intelligent Networks*, *3*, 150–164. https://doi.org/10.1016/j.ijin.2022.09.004

Kamble, N. N., Mali, S. M., & Patil, C. H. (2022). Use of Blockchain Technology in Agriculture Domain. *Lecture Notes in Networks and Systems*, *314*, 877–884. https://doi.org/10.1007/978-981-16-5655-2_84

Karras, A., Karras, C., Drakopoulos, G., Tsolis, D., Mylonas, P., & Sioutas, S. (2022). SAF: A Peer to Peer IoT LoRa System for Smart Supply Chain in Agriculture. *IFIP Advances in*

Information and Communication Technology, *647 IFIP*, 41–50. https://doi.org/10.1007/978-3-031-08337-2_4

Karunanayaka, C., Vidanagamachchi, K., & Wickramarachchi, R. (n.d.). *Transforming Agriculture Supply Chain with Technology Adoption-: A Critical Review of Literature*.

Keates, O. (n.d.). *The design and validation of a process data analytics methodology for improving meat and livestock value chains*.

Khan, H. H., Malik, M. N., Konečná, Z., Chofreh, A. G., Goni, F. A., & Klemeš, J. J. (2022). Blockchain technology for agricultural supply chains during the COVID-19 pandemic: Benefits and cleaner solutions. *Journal of Cleaner Production*, *347*. https://doi.org/10.1016/j.jclepro.2022.131268

Khandelwal, C., Singhal, M., Gaurav, G., Dangayach, G. S., & Meena, M. L. (2021). Agriculture Supply Chain Management: A Review (2010-2020). *Materials Today: Proceedings*, *47*, 3144–3153. https://doi.org/10.1016/j.matpr.2021.06.193

Latino, M. E., Menegoli, M., Lazoi, M., & Corallo, A. (2022a). Voluntary traceability in food supply chain: a framework leading its implementation in Agriculture 4.0. *Technological Forecasting and Social Change*, *178*. https://doi.org/10.1016/j.techfore.2022.121564

Latino, M. E., Menegoli, M., Lazoi, M., & Corallo, A. (2022b). Voluntary traceability in food supply chain: a framework leading its implementation in Agriculture 4.0. *Technological Forecasting and Social Change*, *178*. https://doi.org/10.1016/j.techfore.2022.121564

Lei, D., Lin, H., & Tai, Y. (2023). Research on Innovation of Agricultural Product Logistics Circulation System under the Background of Big Data †. *Engineering Proceedings*, *38*(1). https://doi.org/10.3390/engproc2023038054

Lioutas, E. D., & Charatsari, C. (2020). Smart farming and short food supply chains: Are they compatible? *Land Use Policy*, *94*. https://doi.org/10.1016/j.landusepol.2020.104541

Liu, G. (2023). Research on Empowering Agricultural Products Supply Chain with Digital Technology. *Proceedings - 2023 International Conference on Industrial IoT, Big Data and Supply Chain, IIoTBDSC 2023*, 294–299. https://doi.org/10.1109/IIoTBDSC60298.2023.00059

Lou, J. T., Bhat, S. A., & Huang, N. F. (2023). Blockchain-based privacy-preserving data-sharing framework using proxy re-encryption scheme and interplanetary file system. *Peer-to-Peer Networking and Applications*, *16*(5), 2415–2437. https://doi.org/10.1007/s12083-023-01529-2

Lumbantobing, R. D. H., Ratnayake, R. M. C., Simatupang, T. M., Okdinawati, L., & Mulyono, N. B. (2023). On the Necessity for Digital Transformation in Agriculture Supply Chains: A Review from Task, Organization, Behavior, and Application Perspectives. *Lecture Notes in Mechanical Engineering*, 484–492. https://doi.org/10.1007/978-3-031-17629-6_50

Madumidha, S., Siva Ranjani, P., Vandhana, U., & Venmuhilan, B. (2019). A theoretical implementation: Agriculture-food supply chain management using blockchain technology. *Proceedings of the 2019 TEQIP - III Sponsored International Conference on Microwave Integrated Circuits, Photonics and Wireless Networks, IMICPW 2019*, 174–178. https://doi.org/10.1109/IMICPW.2019.8933270

Malik, S., Dedeoglu, V., Kanhere, S. S., Jurdak, R., & Paik, H. -Y. (n.d.). *Traceable, trustworthy and privacy preserving agri-food supply chains*. https://www.foodstandards.gov.au/industry/foodrecalls/recallstats/pages/default.aspx

Manaf, Y. N., & Yusof, Y. A. (2021). Emerging trends in sustainable food processing industry. *IOP Conference Series: Earth and Environmental Science*, *757*(1). https://doi.org/10.1088/1755-1315/757/1/012076

Mengi, E., Becker, C. J., Sedky, M., Yu, S. Y., & Zohdi, T. I. (2024). A digital-twin and rapid optimization framework for optical design of indoor farming systems. *Computational Mechanics*, *74*(1), 31–43. https://doi.org/10.1007/s00466-023-02421-9

Misra, N. N., Dixit, Y., Al-Mallahi, A., & ... (2020). IoT, big data and artificial intelligence in agriculture and food industry. *... of Things Journal*. https://ieeexplore.ieee.org/abstract/document/9103523/

Misra, N. N., Dixit, Y., Al-Mallahi, A., Bhullar, M. S., Upadhyay, R., & Martynenko, A. (2022). IoT, Big Data, and Artificial Intelligence in Agriculture and Food Industry. *IEEE Internet of Things Journal*, *9*(9), 6305–6324. https://doi.org/10.1109/JIOT.2020.2998584

Monteiro, J., & Barata, J. (2021). Artificial intelligence in extended agri-food supply chain: A short review based on bibliometric analysis. *Procedia Computer Science*, *192*, 3020–3029. https://doi.org/10.1016/j.procs.2021.09.074

Mussomeli, A., Gish, D., & Laaper, S. (2016). *The rise of the digital supply network*.

Nagariya, R., Mukherjee, S., Baral, M. M., Patel, B. S., & Venkataiah, C. (2022). The Challenges of Blockchain Technology Adoption in the Agro-based Industries. *International Journal of Mathematical, Engineering and Management Sciences*, *7*(6), 949–963. https://doi.org/10.33889/IJMEMS.2022.7.6.059

Nesterenko, N. Y., Pakhomova, N. V., & Richter, K. K. (2020). Sustainable development of organic agriculture: Strategies of Russia and its regions in context of the application of digital economy technologies. *Vestnik Sankt-Peterburgskogo Universiteta. Ekonomika*, *36*(2), 217–242. https://doi.org/10.21638/spbu05.2020.203

Nurhayati, W., Rahman, W. A., Nurfarah, W., Zulkifli, W., Zainuri, N., Amira, H., & Anwar, K. (2024). Model for Responsive Agriculture Hub via e-Commerce to Sustain Food Security. In *IJACSA) International Journal of Advanced Computer Science and Applications* (Vol. 15, Issue 5). www.ijacsa.thesai.org

O'Leary, D. E. (2022). Digitization, Digitalization and Digital Transformation in Accounting, Electronic Commerce and Supply Chains. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4307305

Panigrahi, A., Pati, A., Dash, B., Sahoo, G., Singh, D., & Dash, M. (2024). ASBlock:An Agricultural based Supply Chain Management using Blockchain Technology. *Procedia Computer Science*, *235*, 1943–1952. https://doi.org/10.1016/j.procs.2024.04.184

Parlasca, M. C., Johnen, C., & Qaim, M. (2022). Use of mobile financial services among farmers in Africa: Insights from Kenya. *Global Food Security*, *32*. https://doi.org/10.1016/j.gfs.2021.100590

Patel, N., Shukla, A., Tanwar, S., & Singh, D. (2024). KRanTi: Blockchain-based farmer's credit scheme for agriculture-food supply chain. *Transactions on Emerging Telecommunications Technologies*, *35*(4). https://doi.org/10.1002/ett.4286

Peng, X., Zhang, X., Wang, X., Li, H., Xu, J., & Zhao, Z. (2022). Construction of rice supply chain supervision model driven by blockchain smart contract. *Scientific Reports*, *12*(1). https://doi.org/10.1038/s41598-022-25559-7

Peteinatos, G. G., Reichel, P., Karouta, J., Andújar, D., & Gerhards, R. (2020). Weed identification in Maize, sunflower, and potatoes with the aid of convolutional neural networks. *Remote Sensing*, *12*(24), 1–22. https://doi.org/10.3390/rs12244185

Piantari, E., Ashaury, H., Junaeti, E., & Nagalla, V. H. (2020). An Architecture of E-Marketplace Platform for Agribusiness in Indonesia. *Proceedings of the 7th Mathematics, Science, and Computer Science Education International Seminar, MSCEIS 2019*. https://doi.org/10.4108/eai.12-10-2019.2296542

Popescu, G. C., Popescu, M., Khondker, M., Clay, D. E., Pampana, S., & Umehara, M. (2022). Agricultural sciences and the environment: Reviewing recent technologies and innovations to combat the challenges of climate change, environmental protection, and food security. *Agronomy Journal*, *114*(4), 1895–1901. https://doi.org/10.1002/agj2.21164

Prakash, C., Pal Singh, L., Gupta, A., & Singh, A. (n.d.). *Smart Farming: Application of Internet of Things (IoT) Systems*.

Prazaath, B., & Beula, D. H. (2020). Supply chain management in agriculture. *Heber International Conference on Applied Actuarial Science, Mathematics, Management and Computer Science 2020*, 297–304. https://archives.ourheritagejournal.com/index.php/oh/article/view/696

Premchandran, D., & Batchu, C. (2023). *Solana a new blockchain revolution for Indian Agri products using Cloud based wallet*. https://doi.org/10.21203/rs.3.rs-2759437/v1

Quadras, D., Rigon, B., da Silva, E. R., & Frazzon, E. (2023). Challenges and perspectives for agribusiness logistics chain in the Industry 4.0 era. *Procedia CIRP*, *120*, 1422–1427. https://doi.org/10.1016/j.procir.2023.09.187

Quayson, M., Bai, C., & Osei, V. (2020a). Digital Inclusion for Resilient Post-COVID-19 Supply Chains: Smallholder Farmer Perspectives. *IEEE Engineering Management Review*, *48*(3), 104–110. https://doi.org/10.1109/EMR.2020.3006259

Quayson, M., Bai, C., & Osei, V. (2020b). Digital Inclusion for Resilient Post-COVID-19 Supply Chains: Smallholder Farmer Perspectives. *IEEE Engineering Management Review*, *48*(3), 104–110. https://doi.org/10.1109/EMR.2020.3006259

Rahman, M., Kohinoor, M. S. R., & Sami, A. A. (2023). Enhancing Poultry Farm Productivity Using IoT-Based Smart Farming Automation System. *2023 26th International Conference on Computer and Information Technology, ICCIT 2023*. https://doi.org/10.1109/ICCIT60459.2023.10441525

Rai, S. K., Singh, J. P., Kumar, K., & Alhamzi, K. H. M. (2024). An Empirical Exploration of E-Agriculture System Acceptance, Satisfaction, and Usage. *International Journal of Electronic Government Research*, *20*(1). https://doi.org/10.4018/IJEGR.344814

Ramachandran, G. S., Deane, F., Malik, S., Dorri, A., & Jurdak, R. (2021a). Towards Assisted Autonomy for Supply Chain Compliance Management. *Proceedings - 2021 3rd IEEE International Conference on Trust, Privacy and Security in Intelligent Systems and Applications, TPS-ISA 2021*, 321–330. https://doi.org/10.1109/TPSISA52974.2021.00035

Ramachandran, G. S., Deane, F., Malik, S., Dorri, A., & Jurdak, R. (2021b). Towards Assisted Autonomy for Supply Chain Compliance Management. *Proceedings - 2021 3rd IEEE International Conference on Trust, Privacy and Security in Intelligent Systems and Applications, TPS-ISA 2021*, 321–330. https://doi.org/10.1109/TPSISA52974.2021.00035

Ranganathan, V., Kumar, P., Kaur, U., Li, S. H. Q., Chakraborty, T., & Chandra, R. (2022). Re-Inventing the Food Supply Chain with IoT: A Data-Driven Solution to Reduce Food Loss. *IEEE Internet of Things Magazine*, *5*(1), 41–47. https://doi.org/10.1109/IOTM.003.2200025

Rivza, B., Vasilevska, D., & Rivza, P. (2019). Impact of digital innovation on development of agriculture in Latvia. *Engineering for Rural Development*, *18*, 682–687. https://doi.org/10.22616/ERDev2019.18.N485

Saini, S., Jirli, B., & Ranjan Padhan, S. (2023). Analysis of factors promoting the usage of electronic National Agriculture Market in Rajasthan, India. In *CURRENT SCIENCE* (Vol. 125, Issue 6).

Saji, A. C., Vijayan, A., Sundar, A. J., & Baby Syla, L. (2020). Permissioned Blockchain-Based Agriculture Network in Rootnet Protocol. *Advances in Intelligent Systems and Computing*, *1059*, 265–273. https://doi.org/10.1007/978-981-15-0324-5_23

Sankpal, P. K., Khedekar, A. S., Bhardwaj, S. D., & Kadu, R. (2023). Crops Recommendation: An Extensive Review and Comparative Study of Machine Learning Methods. *2023 6th*

IEEE International Conference on Advances in Science and Technology, ICAST 2023, 423–426. https://doi.org/10.1109/ICAST59062.2023.10454983

Saputra, M. I., Sulistivanti, S. R., Setyawan, F. X. A., Murdika, U., & Handiko, Y. T. (2022). Modeling of Digital Scale Based on IoT. *2022 FORTEI-International Conference on Electrical Engineering, FORTEI-ICEE 2022 - Proceeding*, 32–35. https://doi.org/10.1109/FORTEI-ICEE57243.2022.9972950

Saranya, P., & Maheswari, R. (2022). BLOCKCHAIN-BASED TRACEABILITY MODEL WITH A CASE STUDY OF RICE SUPPLY CHAIN (RSC). In *Journal of Engineering Science and Technology Special Issue on DLSCMA*.

Scuderi, A., Timpanaro, G., La Via, G., Pecorino, B., & Sturiale, L. (2022). The Innovation Strategy for Citrus Crop Prediction Using Rough Set Theory. In X. Yang, S. Sherratt, N. Dey, & A. Joshi (Eds.), *Lecture Notes in Networks and Systems* (Vol. 236, pp. 403–412). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1007/978-981-16-2380-6_35

Senturk, S., Senturk, F., & Karaca, H. (2023). Industry 4.0 technologies in agri-food sector and their integration in the global value chain: A review. *Journal of Cleaner Production*, *408*. https://doi.org/10.1016/j.jclepro.2023.137096

Shahid, A., Almogren, A., Javaid, N., Al-Zahrani, F. A., Zuair, M., & Alam, M. (2020). Blockchain-Based Agri-Food Supply Chain: A Complete Solution. *IEEE Access*, *8*, 69230–69243. https://doi.org/10.1109/ACCESS.2020.2986257

Shankar, G., Purna Kumari, V., Neelambaram, B., Repalli, V., Nagpal, P., Dhote, S., & Professor, A. (n.d.). *REVOLUTION AGRI-FOOD SYSTEMS: LEVERAGING DIGITAL INNOVATIONS FOR EQUITABLE SUSTAINABILITY AND RESILIENCE*. https://doi.org/10.48047/AFJBS.6.8.2024.520-530

Shao, D., Kombe, C., & Saxena, S. (2023). An ensemble design of a cash crops-warehouse receipt system (WRS) based on blockchain smart contracts. *Journal of Agribusiness in Developing and Emerging Economies*, *13*(5), 762–774. https://doi.org/10.1108/JADEE-02-2022-0032

Shrivastava, S., & Pal, S. N. (2019, November 1). A framework for next generation agricultural marketing system in Indian context. *2019 5th IEEE International WIE Conference on Electrical and Computer Engineering, WIECON-ECE 2019 - Proceedings*. https://doi.org/10.1109/WIECON-ECE48653.2019.9019983

Siropyan, M., Celikel, O., & Pinarer, O. (n.d.). *Artificial Intelligence Driven Vertical Farming Management System*.

Syromyatnikov, D., Geiko, A., Kuashbay, S., & Sadikbekova, A. (2020). Agile Supply Chain Management in Agricultural Business. In *Int. J Sup. Chain. Mgt* (Vol. 9, Issue 3). http://excelingtech.co.uk/

Tasic, I., & Cano, M. D. (2024). An orchestrated IoT-based blockchain system to foster innovation in agritech. *IET Collaborative Intelligent Manufacturing*, *6*(2). https://doi.org/10.1049/cim2.12109

Thakare, P., Dighore, N., Chopkar, A., Chauhan, A., Bhagat, D., & Tote, M. (n.d.). *Implementation of Block Chain Technology in Public Distribution System*.

Thume, M., Lange, J., Unkel, M., Prange, A., & Schürmeyer, M. (2022). Blockchain-based traceability in food supply chains: requirements and challenges. In *Int. J. Sustainable Agricultural Management and Informatics* (Vol. 8, Issue 3).

Udalov, A., Udalova, Z., & Postnikova, L. (2023). Application of Blockchain Technologies in Digital Agriculture. In *Lecture Notes in Networks and Systems* (Vol. 509). https://doi.org/10.1007/978-3-031-11058-0_169

Valencia-Payan, C., Grass-Ramírez, J. F., Ramirez-Gonzalez, G., & Corrales, J. C. (2023). Smart Contract to Traceability of Food Social Selling. *Computers, Materials and Continua*, *74*(3), 4703–4728. https://doi.org/10.32604/cmc.2023.031554

VAN DER VORST, J. G. A. J. (2006). Performance measurement in agri-food supply-chain networks. In *Quantifying the Agri-Food supply Chain* (pp. 15–26). Springer Netherlands. https://doi.org/10.1007/1-4020-4693-6_2

Vangipuram, S. L. T., Mohanty, S. P., & Kougianos, E. (2023). AgroString 2.0: A Distributed-Ledger based Smart Agriculture Framework to Ensure Transparency in Food Delivery. *OCIT 2023 - 21st International Conference on Information Technology, Proceedings*, 444–449. https://doi.org/10.1109/OCIT59427.2023.10431089

Wei, W. (2021). The path of improving the value chain flow of agricultural products industry under the effect of technology agglomeration. *Acta Agriculturae Scandinavica Section B: Soil and Plant Science*, *71*(7), 613–619. https://doi.org/10.1080/09064710.2021.1890203

Xia, Y., Nguyen, M., & Yan, W. Q. (n.d.). *A Real-time Kiwifruit Detection Based on Improved YOLOv7*.

Xinhua, Z., Yiwei, S., Kaiqiang, S., Liang, Z., & hui, D. (n.d.). *Research on Key Technologies of CCUS Supply Chain Digital Twin System for Smart Agriculture*.

Xu, Z., Jain, D. K., Neelakandan, S., & Abawajy, J. (2023). Hunger games search optimization with deep learning model for sustainable supply chain management. *Discover Internet of Things*, *3*(1). https://doi.org/10.1007/s43926-023-00040-7

Yan, L. (2024). Optimization of Digital Marketing Strategies for Agricultural Product Circulation in the E-commerce Supply Chain. *Computer-Aided Design and Applications*, *21*(S4), 91–102. https://doi.org/10.14733/cadaps.2024.S4.91-102

Yang, C., & Sun, Z. (2020). Data Management System based on Blockchain Technology for Agricultural Supply Chain. *IEEE International Conference on Data Mining Workshops, ICDMW*, *2020-November*, 907–911. https://doi.org/10.1109/ICDMW51313.2020.00130

Yusianto, R., Marimin, Suprihatin, & Hardjomidjojo, H. (2020, September 16). Intelligent spatial decision support system concept in the potato agro industry supply chain. *2020 International Conference on Computer Science and Its Application in Agriculture, ICOSICA 2020*. https://doi.org/10.1109/ICOSICA49951.2020.9243233

Zhai, T., Wang, D., Zhang, Q., Saeidi, P., & Raj Mishra, A. (2023). Assessment of the agriculture supply chain risks for investments of agricultural small and medium-sized enterprises (SMEs) using the decision support model. *Economic Research-Ekonomska Istrazivanja* , *36*(2). https://doi.org/10.1080/1331677X.2022.2126991

Zheng, Q. M., Zheng, M. X., & Dou, Y. Q. (2020). *Research on mode and risk prevention of agricultural supply chain finance based on e-commerce*.

Zielińska-Chmielewska, A., Mruk-Tomczak, D., & Wielicka-Regulska, A. (2021). Qualitative research on solving difficulties in maintaining continuity of food supply chain on the meat market during the COVID-19 pandemic. *Energies*, *14*(18). https://doi.org/10.3390/en14185634

Zscheischler, J., Brunsch, R., Rogga, S., & Scholz, R. W. (2022). Perceived risks and vulnerabilities of employing digitalization and digital data in agriculture – Socially robust orientations from a transdisciplinary process. *Journal of Cleaner Production*, *358*. https://doi.org/10.1016/j.jclepro.2022.132034