

Sustainable Food Supply Chains Through Intelligent Technologies

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Abstract

Food supply chains operate within increasingly complex environments characterized by demand uncertainty, product perishability, resource constraints, environmental pressures, and the need for greater transparency across production and distribution networks. Intelligent technologies offer new mechanisms for addressing these conditions by improving visibility, coordination, forecasting, traceability, and operational decision-making throughout the food supply chain. This conceptual research article examines how artificial intelligence, the Internet of Things (IoT), blockchain-enabled traceability, predictive analytics, and intelligent automation can contribute to more sustainable food supply chains. The study synthesizes established literature on digital supply chains, food logistics, sustainable supply chain management, and intelligent technology applications to develop an integrated analytical perspective.

The analysis considers technological contributions across sourcing, production, storage, transportation, inventory management, distribution, and traceability while recognizing the economic, environmental, and social dimensions of sustainability. The conceptual synthesis indicates that intelligent technologies can strengthen demand forecasting, cold-chain monitoring, inventory coordination, provenance verification, and resource utilization, with potential implications for reducing avoidable food loss and operational inefficiency. These benefits are not automatic, however, because fragmented information systems, interoperability problems, implementation costs, data-governance concerns, cybersecurity risks, and uneven technological capabilities can constrain adoption.

The study argues that sustainable digital transformation of food supply chains requires technology selection to be connected with measurable sustainability objectives, organizational capabilities, interoperable data systems, and accountable governance. Intelligent technologies can consequently serve as important enablers of resilient and sustainable food systems when their deployment is aligned with operational realities and broader environmental and social responsibilities.

Keywords: Sustainable Food Supply Chain; Intelligent Technologies; Artificial Intelligence; Internet of Things; Food Traceability; Predictive Analytics; Digital Supply Chain

1. Introduction

Food supply chains connect agricultural production, processing, storage, transportation, wholesale activities, retail distribution, and final consumption through networks in which product quality, timing, information accuracy, and resource efficiency are closely interdependent. Unlike many non-food supply chains, these networks must frequently manage perishability, temperature sensitivity, biological

variability, seasonal production, and relatively short product life cycles. Disruptions or inaccurate decisions at one stage can therefore affect product availability, quality, economic value, and waste generation elsewhere in the network. At the same time, food systems are expected to meet growing demands for reliable supply while reducing environmental burdens and improving transparency. These interconnected pressures have made sustainability an increasingly important consideration in the design and management of food supply chains.

Sustainable food supply chain management requires coordination of economic performance with environmental stewardship and socially responsible practices. Conventional approaches based on fragmented records, periodic monitoring, and isolated organizational decisions may provide insufficient visibility for managing complex food networks. Information delays can contribute to inventory imbalances, inefficient transportation, inadequate temperature control, and difficulties in identifying the origin of quality problems. Intelligent technologies create opportunities to reduce these information gaps by generating, integrating, and analysing data across supply chain stages. Their value lies not simply in digitizing existing activities but in enabling more informed and coordinated decisions throughout the movement of food products.

Artificial intelligence, IoT-enabled sensing, predictive analytics, blockchain-based records, and intelligent automation represent particularly relevant technological capabilities within contemporary food supply chains. IoT devices can support continuous monitoring of temperature, humidity, location, and storage conditions, while analytical models can use operational and demand data to improve forecasting and inventory planning. Artificial intelligence can assist with pattern recognition, anomaly detection, logistics optimization, and decision support. Blockchain-based architectures may strengthen provenance and traceability where appropriately designed and integrated, although their usefulness depends on data quality and effective participation by supply chain actors. Together, these technologies can create more visible and responsive supply networks capable of supporting sustainability-oriented operational decisions.

Nevertheless, intelligent technology adoption does not inherently produce sustainable outcomes. Technology investments may generate limited value when organizations lack interoperable systems, reliable data, workforce capabilities, governance arrangements, or clearly defined sustainability objectives. Smaller producers and supply chain participants may also experience greater financial and technical barriers than larger organizations, potentially creating uneven digital participation. Cybersecurity, data ownership, privacy, and accountability introduce additional governance concerns as supply chains become increasingly interconnected. Accordingly, this study examines how intelligent technologies can contribute to sustainable food supply chains while critically considering the organizational, technological, and governance conditions required for effective implementation.

2. Review of Literature

2.1 Sustainable Food Supply Chains and the Transition Toward Digital Coordination

Research on sustainable supply chain management has progressively expanded beyond conventional cost, quality, and delivery considerations to include environmental performance, resource efficiency, social responsibility, and long-term resilience. Within food systems, sustainability is particularly complex because supply chains involve biological products, geographically dispersed actors, variable production conditions, and substantial dependence on timely logistics. Literature on food supply chain

management has therefore emphasized coordination, information sharing, traceability, quality assurance, and waste reduction as important dimensions of improved supply chain performance.

Digitalization has extended this research by demonstrating how information technologies can improve coordination among producers, processors, logistics providers, distributors, and retailers. Digital supply chain systems can reduce information asymmetry and provide more timely knowledge regarding inventories, demand conditions, transportation, and product status. However, the literature also indicates that digital transformation requires organizational redesign and interorganizational cooperation. Technology adoption produces stronger operational benefits when information can move effectively across organizational boundaries and when participating actors possess the capability to translate digital information into appropriate decisions.

2.2 Artificial Intelligence, IoT, and Predictive Intelligence in Food Logistics

Artificial intelligence and IoT technologies provide complementary capabilities for managing food logistics. IoT infrastructure generates continuous operational information through connected sensors and tracking devices, whereas AI and analytical techniques can convert these data into forecasts, classifications, alerts, and optimization recommendations. Within cold chains, sensor-based monitoring can identify temperature deviations that may compromise food quality. In inventory and distribution activities, predictive analytics can improve estimates of demand and support decisions concerning replenishment, allocation, and transportation.

The literature further suggests that intelligent analytics can improve responsiveness in supply chains characterized by uncertainty. Machine learning techniques can analyse historical and real-time information to identify demand patterns or operational anomalies that conventional analytical approaches may overlook. Nevertheless, prediction quality remains dependent on the relevance, representativeness, and reliability of underlying data. Intelligent food logistics therefore requires robust data management alongside advanced analytical capability. Poor data quality can convert technological sophistication into unreliable decision support rather than sustainable operational improvement.

2.3 Traceability, Transparency, and Technology-Enabled Sustainability

Traceability is a particularly important function in food supply chains because organizations may need to determine where products originated, how they were handled, and where specific batches moved throughout distribution networks. Digital traceability systems can improve the accessibility and integrity of supply chain records. Blockchain has attracted particular attention because distributed ledgers can provide tamper-resistant records and shared transaction histories among authorized participants. In suitable contexts, these characteristics can strengthen provenance verification and facilitate faster identification of affected products during quality or safety incidents.

However, technological traceability should not be equated automatically with trustworthy or sustainable supply chains. A digital record can preserve inaccurate information if erroneous data are entered at the source, and technological complexity may increase implementation costs without producing proportional sustainability benefits. The literature therefore supports a broader interpretation in which intelligent traceability is combined with data verification, interoperable standards, organizational accountability, and sustainability performance assessment. Under these conditions,

intelligent technologies can contribute not only to operational visibility but also to more accountable management of resources, product quality, and supply chain relationships.

3. Objectives of the Study

3.1 Examining the Role of Intelligent Technologies in Sustainable Food Supply Chain Management

The primary objective of this study is to examine the role of intelligent technologies in improving the sustainability and efficiency of food supply chain management. The research focuses on understanding how advanced digital technologies such as artificial intelligence, Internet of Things (IoT), predictive analytics, blockchain systems, and intelligent automation contribute to better coordination, transparency, and operational performance across food supply networks.

Intelligent technologies provide opportunities to transform conventional food supply chains into connected and data-driven systems. By enabling real-time monitoring, improved forecasting, automated decision support, and enhanced traceability, these technologies can help organizations reduce operational inefficiencies, minimize food losses, and improve resource utilization. This objective analyses how technological integration supports the economic, environmental, and social dimensions of sustainable supply chain development.

3.2 Evaluating the Contribution of Digital Intelligence to Food Supply Chain Efficiency and Resilience

The second objective of this study is to evaluate the contribution of digital intelligence toward improving efficiency, responsiveness, and resilience within food supply chains. The research examines how intelligent systems support activities such as demand forecasting, inventory management, transportation optimization, cold-chain monitoring, and quality control.

The objective further explores how intelligent technologies enable food supply chains to respond effectively to uncertainty caused by market fluctuations, climate-related disruptions, supply shortages, and changing consumer expectations. Digital intelligence provides organizations with analytical capabilities that support proactive decision-making and improved coordination among supply chain participants. This evaluation considers the relationship between technological adoption and sustainable operational outcomes.

3.3 Identifying Future Development Strategies for Intelligent and Sustainable Food Systems

The third objective of this study is to identify future development strategies for creating intelligent, resilient, and sustainable food supply chains. The research examines emerging opportunities associated with advanced artificial intelligence models, autonomous logistics systems, integrated digital platforms, and next-generation traceability solutions.

The study also investigates important factors influencing successful adoption, including technological accessibility, interoperability, data governance, cybersecurity, organizational readiness, and stakeholder collaboration. Future sustainable food supply chains require balanced integration of technological innovation with responsible governance, environmental objectives, and inclusive participation among producers, distributors, retailers, and consumers.

4. Research Methodology

4.1 Research Design and Conceptual Framework

This study adopts a conceptual research design to examine the role of intelligent technologies in developing sustainable food supply chains. The conceptual approach is appropriate because the research focuses on analysing existing digital supply chain frameworks, intelligent technology applications, sustainability models, and technology-enabled operational strategies rather than conducting direct empirical experimentation. The study integrates perspectives from sustainable supply chain management, digital transformation, food logistics, artificial intelligence, and information systems research.

The conceptual framework of the study is based on the relationship between intelligent technologies, supply chain visibility, operational efficiency, sustainability performance, and resilience enhancement. It considers intelligent technologies as strategic capabilities that enable organizations to collect, process, and utilize supply chain information for improved decision-making. The framework evaluates how artificial intelligence, IoT, blockchain, predictive analytics, and automation contribute to sustainable food supply chain development.

4.2 Data Sources and Literature Analysis Approach

The study utilizes secondary data sources collected from peer-reviewed research articles, academic publications, sustainable supply chain studies, food logistics research, digital transformation literature, and intelligent technology frameworks. The literature-based methodology enables systematic examination of existing knowledge related to technology-driven supply chain improvement, food sustainability, traceability, and operational optimization.

The literature analysis process involved identifying major research themes associated with intelligent technologies, supply chain sustainability dimensions, technological benefits, implementation barriers, and future innovation pathways. The collected information was organized according to technology applications, supply chain functions, sustainability outcomes, and governance requirements. This thematic synthesis approach supported the development of a comprehensive understanding of intelligent technology integration in food supply systems.

4.3 Analytical Framework and Evaluation Parameters

The analytical framework evaluates intelligent technology applications in sustainable food supply chains through multiple dimensions, including supply chain visibility, operational efficiency, resource optimization, traceability improvement, sustainability performance, and resilience capability. These parameters were selected because they represent important indicators for assessing the contribution of digital intelligence toward sustainable food system development.

The evaluation process considers both technological and organizational factors influencing successful implementation. Technological factors include artificial intelligence systems, IoT networks, blockchain platforms, predictive analytics tools, and automated logistics solutions. Organizational factors include digital capability, data governance practices, stakeholder coordination, infrastructure readiness, and sustainability objectives. This multidimensional approach enables a comprehensive assessment of intelligent supply chain transformation.

4.4 Research Procedure and Interpretation Method

The research procedure followed a structured process involving identification of intelligent technology concepts, analysis of sustainable food supply chain models, evaluation of digital transformation approaches, and interpretation of future development opportunities. Qualitative thematic analysis was applied to examine patterns within the selected literature and identify significant relationships between intelligent technologies and sustainable supply chain outcomes.

The interpretation process involved comparative analysis of different intelligent technology applications and their contribution to food supply chain sustainability. The findings were synthesized to identify effective technological approaches, operational advantages, and potential improvement areas. Ethical considerations related to data security, transparency, technological responsibility, environmental sustainability, and equitable participation were incorporated throughout the research process.

Table 1: Research Methodology Framework

Research Component	Description
Research Design	Conceptual research design based on sustainable supply chain and intelligent technology frameworks
Data Sources	Peer-reviewed studies, food logistics research, digital transformation literature, and technology models
Research Approach	Qualitative thematic analysis and conceptual synthesis
Evaluation Parameters	Visibility, efficiency, traceability, sustainability, resilience, and resource optimization
Interpretation Method	Comparative analysis of intelligent technology applications in food supply chains

Table Interpretation: The methodology framework demonstrates that the study follows a structured conceptual approach by combining sustainable supply chain perspectives with intelligent technology analysis. The selected research components support systematic evaluation of how digital intelligence improves food supply chain transparency, efficiency, sustainability, and future resilience.

5. Analysis

5.1 Evaluation of Intelligent Technologies in Sustainable Food Supply Chain Management

The analysis indicates that intelligent technologies have become important enablers for improving sustainability, transparency, and efficiency within food supply chains. Technologies such as artificial intelligence, Internet of Things (IoT), blockchain, predictive analytics, and intelligent automation provide advanced capabilities for monitoring supply chain activities, analysing operational data, and supporting timely decision-making. These technologies help organizations manage complex food

networks by improving information flow between producers, logistics providers, distributors, and retailers.

The findings demonstrate that intelligent technologies contribute to sustainable food supply chains by reducing operational inefficiencies, improving product traceability, minimizing food losses, and supporting better resource management. Real-time monitoring systems enable organizations to maintain product quality, particularly in temperature-sensitive supply chains, while predictive analytics improves demand forecasting and inventory planning. However, the effectiveness of these technologies depends on data reliability, technological integration, infrastructure availability, and organizational readiness.

5.2 Strategic Impact of Digital Intelligence on Food Supply Chain Performance

Digital intelligence significantly influences food supply chain performance by improving visibility, coordination, and resilience. The analysis reveals that AI-based forecasting systems help organizations anticipate demand variations, optimize inventory levels, and reduce unnecessary waste. IoT-enabled monitoring improves logistics management by providing continuous information about product conditions, location, and transportation processes.

Furthermore, intelligent technologies support sustainable decision-making by enabling organizations to identify inefficiencies and implement targeted improvements. Blockchain-based traceability systems can strengthen transparency and consumer confidence, while automated logistics solutions improve operational efficiency. The strategic value of digital intelligence lies in integrating multiple technologies into a coordinated supply chain ecosystem rather than implementing isolated technological solutions.

5.3 Comparative Assessment of Intelligent Technology Applications in Food Supply Chains

The comparative assessment examines major intelligent technologies used in sustainable food supply chains, including artificial intelligence analytics, IoT-based monitoring, blockchain traceability systems, predictive analytics platforms, and intelligent automation solutions. These technologies represent different approaches for improving supply chain sustainability and operational performance.

The analysis indicates that artificial intelligence and IoT systems provide significant contributions because they directly improve decision-making and real-time visibility. Blockchain technology strengthens transparency and traceability, while predictive analytics supports planning and risk management. Intelligent automation improves operational efficiency by reducing repetitive activities and enhancing logistics performance.

Table 2: Comparative Analysis of Intelligent Technologies in Food Supply Chains

Intelligent Technology	Primary Function	Sustainability Benefit	Supply Chain Contribution
Artificial Intelligence Analytics	Data analysis and decision support	Improved resource planning	Very High

Intelligent Technology	Primary Function	Sustainability Benefit	Supply Chain Contribution
IoT Monitoring Systems	Real-time product and logistics tracking	Reduced waste and improved quality control	Very High
Blockchain Traceability	Secure supply chain records	Enhanced transparency and trust	High
Predictive Analytics	Demand and risk forecasting	Better inventory management	High
Intelligent Automation	Automated operational activities	Improved efficiency and reduced losses	High

Table Interpretation: The table demonstrates that artificial intelligence analytics and IoT monitoring systems provide very high contributions because they directly enhance decision-making, visibility, and operational control across food supply chains. Blockchain, predictive analytics, and intelligent automation further strengthen sustainability by improving transparency, forecasting accuracy, and process efficiency.

6. Challenges

6.1 Technology Integration, Infrastructure Limitations, and Adoption Challenges

One of the major challenges associated with implementing intelligent technologies in sustainable food supply chains is the complexity of technology integration across diverse supply chain networks. Food supply chains involve multiple stakeholders, including farmers, processors, logistics providers, distributors, retailers, and consumers, each operating with different technological capabilities and information systems. Integrating intelligent platforms across these interconnected stages requires compatible systems, reliable communication networks, and effective coordination mechanisms.

Furthermore, many organizations face challenges related to infrastructure readiness, investment requirements, and technology accessibility. Small-scale producers and suppliers may experience difficulties adopting advanced technologies due to high implementation costs, limited digital resources, and insufficient technical support. The successful adoption of intelligent supply chain solutions requires scalable technologies, supportive investment models, and approaches that consider the operational realities of different supply chain participants.

6.2 Data Governance, Cybersecurity, and Information Management Challenges

Another significant challenge in intelligent food supply chains is managing the large volumes of data generated through digital platforms, sensors, analytics systems, and traceability mechanisms. Effective use of intelligent technologies depends on accurate, timely, and reliable information. However, differences in data standards, incomplete information sharing, and inconsistent data practices can reduce the effectiveness of digital supply chain systems.

In addition, increasing digital connectivity introduces cybersecurity and data governance concerns. Food supply chains increasingly rely on interconnected systems for monitoring, forecasting, and operational decisions, making them vulnerable to unauthorized access, data manipulation, and privacy risks. Organizations require strong cybersecurity measures, transparent data policies, and responsible information management practices to ensure secure and trustworthy digital transformation.

6.3 Sustainability Alignment, Economic Feasibility, and Stakeholder Collaboration Challenges

The implementation of intelligent technologies must be aligned with broader sustainability objectives rather than focusing only on operational efficiency. Although digital technologies can reduce waste, improve logistics, and optimize resource utilization, their environmental and economic impacts must also be considered. Technology investments may require significant financial resources, continuous maintenance, and regular system improvements, which can create challenges for organizations with limited capabilities.

Moreover, sustainable food supply chains require collaboration among multiple stakeholders with different priorities and levels of technological readiness. Producers, businesses, policymakers, and technology providers must work together to establish common standards, improve information sharing, and create inclusive innovation models. Without effective collaboration, intelligent technologies may deliver limited sustainability benefits and fail to address wider food system challenges.

Key challenges requiring attention include:

- Interoperable systems are necessary for effective technology integration.
- Strong data governance improves trust in digital supply chain systems.
- Affordable solutions support wider technology adoption.
- Stakeholder collaboration strengthens sustainable transformation.
- Responsible implementation improves long-term technology value.

7. Discussion

7.1 Intelligent Technologies as Enablers of Sustainable Food Supply Chain Transformation

The findings of this study demonstrate that intelligent technologies provide significant opportunities for transforming conventional food supply chains into more sustainable, transparent, and resilient systems. Technologies such as artificial intelligence, Internet of Things (IoT), blockchain, predictive analytics, and intelligent automation enable organizations to improve visibility across supply chain operations and make more informed decisions. These capabilities are particularly valuable in food systems where product quality, timing, resource efficiency, and traceability directly influence sustainability outcomes.

The discussion highlights that intelligent technologies should be viewed as strategic enablers rather than independent solutions. Their effectiveness depends on how successfully organizations integrate digital capabilities with supply chain strategies, sustainability objectives, and stakeholder coordination mechanisms. When appropriately implemented, intelligent systems can reduce food losses, improve resource utilization, strengthen operational planning, and support more responsible food production and distribution networks.

7.2 Contribution of Digital Intelligence to Food System Resilience and Sustainability

The analysis indicates that digital intelligence contributes significantly to improving food system resilience by enabling predictive decision-making, real-time monitoring, and adaptive supply chain management. Artificial intelligence-based analytics can support demand forecasting, risk identification, and operational optimization, while IoT technologies provide continuous information regarding transportation conditions, storage environments, and product quality. These capabilities help organizations respond more effectively to disruptions and changing market conditions.

The discussion further emphasizes that sustainability improvements require integration of technological innovation with environmental and social considerations. Intelligent technologies can support waste reduction, efficient logistics, and improved resource management, but their long-term value depends on responsible implementation practices. Organizations must ensure that digital transformation contributes to broader sustainability goals rather than focusing only on short-term operational improvements.

Important implementation aspects include:

- Intelligent systems improve supply chain visibility and coordination.
- Predictive analytics supports proactive operational decisions.
- Digital monitoring improves food quality management.
- Technology integration strengthens supply chain resilience.
- Sustainable practices enhance long-term food system performance.

7.3 Future Development of Intelligent and Sustainable Food Supply Chain Ecosystems

Future food supply chains are expected to become increasingly intelligent through integrated digital platforms, advanced analytics, autonomous systems, and connected supply chain networks. These developments can create more adaptive food systems capable of responding to production uncertainties, consumer expectations, environmental challenges, and global supply disruptions. Future intelligent supply chains will require greater integration between technological innovation and sustainability-oriented management practices.

The discussion suggests that future development depends on improving technological accessibility, strengthening digital infrastructure, developing common data standards, and encouraging collaboration among supply chain stakeholders. Producers, technology providers, policymakers, and businesses must collectively develop governance frameworks that support secure, transparent, and inclusive digital transformation. Intelligent technologies will create the greatest sustainability impact when they are implemented through responsible strategies that consider economic feasibility, environmental protection, and social value creation.

Future development priorities include:

- Advanced analytics can improve future supply chain forecasting.
- Integrated platforms can enhance supply network coordination.
- Secure digital systems can strengthen traceability.
- Collaborative innovation can accelerate sustainable transformation.
- Responsible technology governance can improve long-term outcomes.

8. Conclusion

Sustainable food supply chains through intelligent technologies represent an important pathway for improving transparency, efficiency, resilience, and environmental responsibility within global food systems. This study highlights that technologies such as artificial intelligence, Internet of Things (IoT), blockchain, predictive analytics, and intelligent automation provide significant opportunities to transform traditional supply chain structures into connected and data-driven ecosystems. These technologies enable organizations to improve operational visibility, optimize resource utilization, enhance traceability, and support more informed decision-making across food production and distribution networks.

The analysis demonstrates that intelligent technologies contribute to sustainable food supply chain development by reducing inefficiencies, minimizing food losses, improving inventory management, strengthening quality control, and supporting predictive decision-making. Digital intelligence enables organizations to respond more effectively to supply uncertainties, consumer expectations, and environmental challenges. However, technological adoption alone cannot guarantee sustainability outcomes; successful transformation requires integration with organizational capabilities, effective governance mechanisms, reliable data systems, and stakeholder collaboration.

The study further concludes that several challenges influence the successful implementation of intelligent technologies in food supply chains, including infrastructure limitations, technology costs, data governance concerns, cybersecurity risks, interoperability issues, and unequal digital capabilities among supply chain participants. Addressing these challenges requires inclusive strategies that support technological accessibility, strengthen digital skills, establish secure information systems, and encourage collaboration between producers, businesses, policymakers, and technology providers.

In conclusion, intelligent technologies provide a strong foundation for developing sustainable and resilient food supply chains capable of addressing future food system challenges. The future of food supply chain management will increasingly depend on the effective combination of digital intelligence, sustainability principles, and responsible innovation practices. Organizations that successfully integrate intelligent technologies with strategic sustainability objectives will be better positioned to create efficient, transparent, and environmentally responsible food systems.

References

1. Ahumada, O., & Villalobos, J. R. (2009). Application of planning models in the agri-food supply chain: A review. *European Journal of Operational Research*, 196(1), 1–20.
2. Akkerman, R., Farahani, P., & Grunow, M. (2010). Quality, safety and sustainability in food distribution: A review of quantitative operations management approaches. *OR Spectrum*, 32, 863–904.
3. Baryannis, G., Validi, S., Dani, S., & Antoniou, G. (2019). Supply chain risk management and artificial intelligence: State of the art and future research directions. *International Journal of Production Research*, 57(7), 2179–2202.
4. Ben-Daya, M., Hassini, E., & Bahroun, Z. (2019). Internet of Things and supply chain management: A literature review. *International Journal of Production Research*, 57(15–16), 4719–4742.
5. Bosona, T., & Gebresenbet, G. (2013). Food traceability as an integral part of logistics management in food and agricultural supply chain. *Food Control*, 33(1), 32–48.

6. Choi, T. M. (2018). Blockchain-technology-supported platforms for diamond authentication and certification in luxury supply chains. *Transportation Research Part E: Logistics and Transportation Review*, 117, 127–138.
7. Cui, T., & Idota, H. (2018). Improving supply chain performance with blockchain technology. *Journal of Industrial Engineering and Management*, 11(4), 817–836.
8. Dolgui, A., Ivanov, D., & Sokolov, B. (2019). The impact of digital technologies on supply chain resilience. *International Journal of Production Research*, 57(3), 829–846.
9. FAO. (2019). *The State of Food and Agriculture: Moving Forward on Food Loss and Waste Reduction*. Food and Agriculture Organization.
10. Kamilaris, A., Fonts, A., & Prenafeta-Boldú, F. X. (2019). The rise of blockchain technology in agriculture and food supply chains. *Trends in Food Science & Technology*, 91, 640–652.
11. Kshetri, N. (2018). Blockchain's roles in meeting key supply chain management objectives. *International Journal of Information Management*, 39, 80–89.
12. Manavalan, E., & Jayakrishna, K. (2019). A review of Internet of Things in supply chain management. *Journal of Industrial Information Integration*, 14, 1–11.
13. Min, H. (2010). Artificial intelligence in supply chain management: Theory and applications. *International Journal of Logistics Research and Applications*, 13(1), 13–39.
14. Pournader, M., Shi, Y., Seuring, S., & Koh, S. C. L. (2020). Blockchain applications in supply chains: A systematic review. *International Journal of Production Research*, 58(7), 2063–2081.
15. Queiroz, M. M., Telles, R., & Bonilla, S. H. (2020). Blockchain and supply chain management integration: A systematic review. *Supply Chain Management: An International Journal*, 25(2), 241–254.
16. Sharma, R., Kamble, S., Gunasekaran, A., Kumar, V., & Kumar, A. (2020). A systematic literature review on machine learning applications for sustainable supply chain management. *International Journal of Production Research*, 58(9), 2730–2756.
17. Tsolakis, N., Niedenzu, D., Simonetto, M., Dora, M., & Kumar, M. (2022). Supply network design and planning for sustainable food systems. *Production Planning & Control*, 33(12), 1119–1135.
18. Verdouw, C., Wolfert, S., Beulens, A., & Rialland, A. (2016). Virtualization of food supply chains with the internet of things. *Journal of Food Engineering*, 176, 128–136.
19. Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M. J. (2017). Big data in smart farming: A review. *Agricultural Systems*, 153, 69–80.
20. Zhao, G., Liu, S., Lopez, C., Lu, H., Elgueta, S., Chen, H., & Boshkoska, B. M. (2019). Blockchain technology in agri-food value chain management: A synthesis of applications. *International Journal of Production Research*, 58(7), 2081–2097.