Artificial Intelligence and Logistics Management in the Agricultural Sector: Bibliometric Analysis and Conceptual Model

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Abstract: The article presents a comprehensive bibliometric analysis of scientific publications indexed in the Scopus database, devoted to the application of artificial intelligence (AI) technologies in the logistics management of the agricultural sector. The study covers the full chronological period of observation and provides a quantitative and qualitative assessment of the dynamics of publications, the evolution of thematic domains and structural characteristics of the scientific field. The methodology includes the analysis of co-authorship, co-occurrence of keywords and visualization of terminological, geographical and temporal clusters using modern scientometric tools (VOSviewer, Bibliometrix). The results indicate a sharp increase in research interest after 2018, driven by the digital transformaion of agri-food supply chains, the progress of machine learning and the strengthening of requirements for transparency, efficiency and environmental sustainability of logistics processes. Leading scientific contributions in the analyzed Scopus sample were made by researchers from Italy, China and India, along with active participation from the UK, Ukraine, the UAE, Jordan, Egypt, Oman and Indonesia. Key research areas focus on demand and yield forecasting, optimization of transport routes and inventory management, cold chain automation, risk management and increased traceability using blockchain and AI-driven decision support systems. Based on the results, a conceptual model of AI-driven agri-logistics management was formed, which integrates three interrelated dimensions: technological (AI, ML, IoT, Big Data), organizational (processes, MLOps, digital governance) and sustainable (energy efficiency, waste reduction, CO_2 reduction). The model ensures the cyclicity of the Data–Decision–Sustainability loop and supports the development of practical solutions to increase the resilience, productivity and environmental responsibility of agricultural logistics systems. The research results can be used by agricultural enterprises, logistics operators and public policy bodies to implement intelligent supply management systems and develop sustainable food chains.

1 INTRODUCTION

Agri-food supply chains are undergoing a profound systemic transformation driven by the combined impact of climate risks, military and geopolitical shocks, structural changes in global demand and the rapid digitalization of business processes.

According to FAO and UNEP, food losses in supply chains from post-harvest processing to retail are estimated at 13.2%, while food waste at the retail, food service and household levels is estimated at 19%, equivalent to approximately 1.05 billion tonnes in 2022 [1], [2].

In addition, agri-food systems generate approximately one third of global anthropogenic greenhouse gas emissions, including logistics, processing and transportation of products [3], which reinforces the requirements for the implementation of innovative digital solutions aimed at increasing the efficiency of logistics processes and reducing the environmental footprint of production.

According to the International Energy Agency, data center electricity consumption could grow to 945 TWh by 2030, with artificial intelligence (AI) being a key driver of this growth [4], [5]. For agri-logistics, this poses the challenge of balancing the benefits of AI – supply chain optimization, demand forecasting, inventory management, and product quality monitoring – with the energy and carbon costs of digital technologies.

According to a global survey by McKinsey [6], 65% of organizations worldwide will use generative AI by 2024, almost double the previous year. However, only 45% of leaders are integrating digital risks into strategic supply chain planning [7], demonstrating a mismatch between the pace of AI adoption and the level of business management maturity. This is especially true for the agricultural sector, which is characterized by seasonality, spatial fragmentation and a multi-layered supplier structure.

The World Bank's Logistics Performance Index 2023 [8] confirms that a significant number of countries face low efficiency of logistics processes, especially in the areas of customs clearance, warehousing and "last mile" delivery – areas where AI technologies can provide the most tangible effect.

According to OECD research [9], the digitalization of agricultural production is a key factor in increasing productivity, but the level of integration of digital solutions still remains uneven. The use of machine learning algorithms can reduce transportation costs by 15-25%, and order fulfilment times by up to 30%. EIT Food surveys [10] show that over 70% of consumers in EU countries demand greater transparency of supply chains, which stimulates the use of blockchain and AI solutions for product traceability systems.

Analysis of scientific publications indicates a gradual transition to comprehensive management approaches to the integration of AI in logistics. M. Trabelsi et al. [11] identify six clusters of AI research in the agri-food sector; M. Remondino and A. Zanin [12] prove the impact of digitalization on the competitiveness and sustainability of agri-logistics; X. Hao and E. Demir [13] propose a TOE model (Technology – Organization – Environment) that explains the factors of successful implementation of intelligent technologies in supply chains.

Thus, a scientific gap has formed, associated with the insufficient integration of technological, managerial, institutional and environmental aspects of the application of artificial intelligence in agri-logistics systems, which necessitates the development of an appropriate conceptual model.

2 LITERATURE REVIEW

The issue of applying artificial intelligence in the logistics management of the agricultural sector is increasingly prominent in the modern scientific discourse, which is due to the combination of the digital transformation of the agri-food complex, the growth of climate risks, the complexity of global supply chains and the need to ensure the transparency of product movement.

Intelligent technologies are increasingly considered not only as a tool for automating operations, but also as a factor in the strategic management of food systems, capable of increasing their sustainability, adaptability and efficiency. In this context, artificial intelligence is integrated with blockchain, decision support systems, IoT sensor platforms and machine learning algorithms, forming a new paradigm of AI-driven agri-food supply chains.

One of the first works that systematically substantiated the use of intelligent methods to improve food supply chains is the study by M. Sharma et al. [14], which demonstrates the possibility of using big data, demand modelling and transport flow prediction algorithms. M. Remondino and A. Zanin [12] broaden the research focus, demonstrating the impact of digitalization on the competitiveness and sustainability of agri-logistics, emphasizing the integration of digital platforms, electronic document management and smart contracts. A significant contribution to the formation of the theoretical framework was made by P. De Bernardi et al. [15], who analyze innovative digital business models for the participation of agricultural producers, logistics operators and processing enterprises in the development of sustainable food networks. M. Trabelsi et al. [11] performed a systematic review, identifying six research clusters, among which the leading place belongs to logistical and operational aspects, including agri-routing, inventory management and product traceability. X.

Hao, and E. Demir [13] proposed a TOE model for assessing readiness for the implementation of AI in supply chains, but the model reveals some limitations in taking into account environmental and social parameters important for agricultural systems.

Some studies expand the subject dimension of digital logistics by integrating artificial intelligence into water security monitoring [16] or into blockchain-based agri-trade trust systems [17].

At the same time, the scientific literature shows a shift in priorities from the "operational benefit" of digital solutions to comprehensive models that can take into account energy impacts, carbon footprint and socio-economic accessibility of innovations.

Summarizing the results of the analysis, three key scientific trends can be identified:

1) convergence of technological platforms, within which AI is integrated with IoT, satellite monitoring, geo-analytics and autonomous vehicles;
2) transition to data as the basis of logistics management, which leads to the formation of demand forecasting models, optimization of warehousing and routing;
3) increasing role of environmental and social criteria, which involves reorienting logistics solutions to reduce food losses, minimize emissions and strengthen food security.

Critical analysis of sources allows us to outline a list of scientific gaps:

- terminological inconsistency of the concepts of AI in agri-logistics, smart agri-food supply chain, digital traceability, which complicates the codification of the conceptual apparatus;
- limited number of works adapted to agricultural specifics, including seasonality, biological risks, spatial dispersion of production and logistics;
- insufficient integration of environmental metrics, such as carbon footprint, data center energy consumption, cold chain emissions;
- low share of empirically verified solutions, while a significant part of the models remains simulative;
- data accountability and ethics are not yet a central research area, despite the increasing risks of cyber interference, algorithmic discrimination, and violation of farmers' privacy.

Thus, the current state of scientific research confirms the attention to artificial intelligence as an integrative basis for food network management, but indicates the absence of a complete AI-driven agri-logistics management framework that would combine technological, managerial, institutional, and environmental dimensions. This necessitates the formation of a conceptual model adapted to the requirements of digital food security in Ukraine and the global challenges of sustainable development.

3 METHODOLOGY

The purpose of the study is to summarize the current state of scientific developments at the intersection of artificial intelligence and logistics management in the agricultural sector, identify leading trends, intellectual dominants and scientific gaps, as well as form a conceptual model of AI-driven agri-logistics management, which integrates technological, managerial and environmentally sustainable dimensions of the digital transformation of agri-food supply chains.

Achieving the set goal involved solving the following research tasks: determining the dynamics of publication activity for 2008-2025; analyzing the structure of scientific cooperation (authors, countries, organizations, scientific journals); identifying key research clusters and areas of application of artificial intelligence in agri-logistics; systematizing the most intellectually influential works and their methodological approaches; summarizing scientific gaps and prospects for further research.

The methodological basis of the study is based on a combination of bibliometric analysis, systematic review of scientific publications and network mapping of knowledge. The search sample was formed in the Scopus database (Elsevier) using a combined query that combined key terms from three conceptual blocks: artificial intelligence (artificial intelligence, machine learning, big data analytics); logistics (logistics, supply chain management, routing, and inventory optimization); agricultural sphere or sector (agriculture, agri-food, food supply chain). The chronological boundaries of the analysis cover the years 2008–2025, which provides a tracing of the evolution of the research discourse from technical automation models to integrated strategic management solutions. In the primary sample, duplicates and irrelevant sources were eliminated according to the criteria of content relevance, the presence of agri-logistics and management components, as well as the availability of bibliographic metadata. As a result, the final array included 27 scientific publications, which create a sufficient information base for identifying the intellectual structure of the research area.

At the second stage, quantitative and network analysis was applied using VOSviewer and the Bibliometrix (R) bibliometric package. Maps of co-publication interaction were constructed at the level of authors, countries and organizations, as well as networks of co-citation and co-use of key terms. This allowed us to identify structural research cores, thematic clusters and trajectories of changes in scientific priorities. Special attention was paid to the analysis of thematic evolution, which demonstrated a gradual transition from engineering-algorithmic models to integrated management solutions aimed at ensuring sustainability, traceability and energy efficiency of logistics processes.

The final stage was a qualitative interpretation of the revealed patterns, which included content analysis of the most cited and methodologically significant publications [11]-[17].

The generalization of their results and our own previous research [18]-[20] allowed us to form the basis of the conceptual model of AI-driven agri-logistics management, which involves the interaction of three levels:

1) technology (intelligent algorithms, machine learning, digital monitoring platforms);
2) organization (logistics processes, human resources competencies, innovative culture, risk management);
3) sustainability (energy efficiency, carbon footprint reduction, food security, transparency and traceability of supply).

The methodological reliability of the study is ensured by the interdisciplinary approach, the use of proven bibliometric tools, documentation of the stages of sample formation and adherence to ethical principles of scientific data processing. The main limitations are the dependence of the results on the specifics of the Scopus database, the different duration of the "citation life cycle" of new publications and the uneven representation of regional studies.

Given that the dataset is limited to Scopus-indexed publications, certain regional scientific schools may be underrepresented. Nonetheless, for identifying dominant structural patterns and intellectual clusters, Scopus provides a sufficiently reliable and consistent bibliographic basis.

The applied methodology allows not only to quantitatively outline the dynamics of scientific development of the topic, but also to identify intellectual centers, structural connections and research gaps that form the basis for further modelling of the transformation of agri-logistics based on artificial intelligence. The next section is devoted to the results of bibliometric analysis and interpretation of the identified scientific trends.

4 RESULTS

This section presents the results of bibliometric analysis and extensive interpretation, which serve as the basis for the formation of a conceptual model of AI-driven agri-logistics management. First, the network of co-occurrence of keywords was analyzed, which made it possible to identify a number of terminological clusters that reflect the main thematic areas of research.

On the network map of co-occurrence (Fig. 1), each node corresponds to a key term, and the links between them demonstrate the frequency of their joint use within one document; the thickness of the links indicates the intensity of such associations, and the grouping into clusters is displayed using different colours. As a result, ten interconnected clusters were identified, each of which represents a separate, but at the same time integrated aspect of the digital transformation of agri-logistics.

One of the most saturated clusters is associated with digital technologies in the agricultural sector. It includes keywords such as "Artificial Intelligence", "Machine Learning", "Big Data", "Internet of Things", "Blockchain", "Precision Agriculture", as well as terms reflecting general digitalization trends such as "Industry 4.0", "Automation", "Digitization". The joint appearance of "artificial intelligence" with "supply chain management" indicates the formation of a stable scientific core, in which AI is considered as a key tool for managing agri-food supply chains, focused on data analysis, automation and optimization of operations. It is in this cluster that forecasting models, machine learning algorithms for planning, as well as solutions related to the Internet of Things and sensor infrastructure are concentrated. The second significant cluster characterizes the research on supply chain management and ensuring their sustainability. The concepts "Logistics 4.0", "Supply Chain", "Resilience", "Performance", "Information Sharing", "Dual-Carbon" dominate here. They reflect the desire of researchers to combine digital technologies with approaches to increasing the efficiency and resilience of logistics systems in the face of climate, market and geopolitical risks. The emphasis on information exchange and carbon aspects indicates the importance of transparency, reducing emissions and supporting the sustainability of agri-food chains.

A separate cluster is related to strategic management and information systems. The most common terms in this segment are “Strategic Management”, “Business Strategy”, “Decision Support Systems”, “Strategic Information Systems Planning”. It reflects research focused on developing strategies for the implementation of artificial intelligence, planning and development of information infrastructure, building decision support systems for agricultural logistics. In such works, AI is considered not only as a set of algorithms, but as an element of strategic changes that affects management models, organizational culture and institutional mechanisms.

Another important cluster concerns agri-food chains and innovations in agribusiness. The terms “Agri-Food”, “Agribusiness”, “Innovative Technologies”, “Digital Marketing”, as well as “Bibliometric” and “Systematic Literature Review” dominate here. This indicates a growing attention to comprehensive research on agri-food systems, innovative business models, digital marketing tools and bibliometric approaches to knowledge systematization. Within this direction, researchers focus on the transformation of agri-food chains, rethinking the interaction between producers, processors, logistics operators and end consumers.

The cluster dedicated to sustainable development and business models is also important. The keywords here are “Sustainability”, “Grand Challenges”, “Business Model”, “Business Model Innovation”, “Food Industry”. It reflects the efforts of the scientific community to integrate the principles of sustainable development into the concept of food industry management, the implementation of environmentally friendly and socially responsible business models based on digital solutions and intelligent analytics. Thus, a connection is formed in the scientific field between technological innovations and the transformation of the business logic of the functioning of agri-food systems.

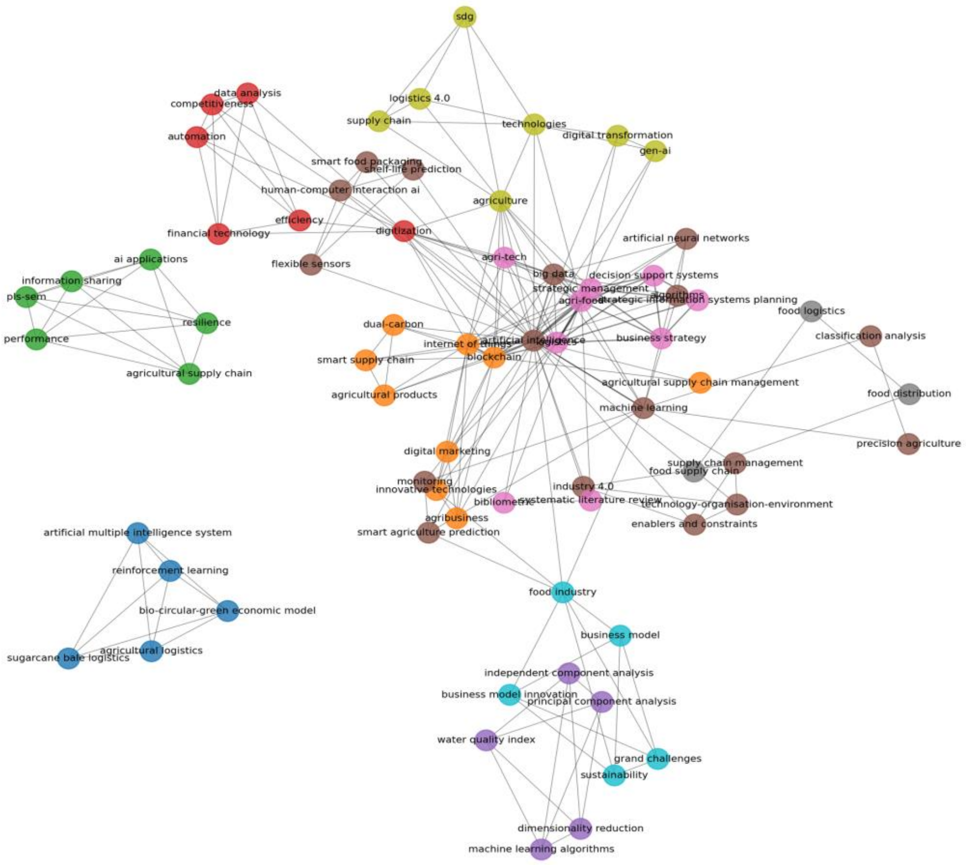

Figure 1: Keyword co-occurrence network (clusters highlighted in different colors).

A separate group is made up of specialized clusters that reflect narrowly focused research. For example, the cluster with the terms “Sugarcane Bale Logistics”, “Bio-Circular-Green Economic Model”, “Reinforcement Learning” illustrates the application of reinforcement learning in the logistics of the sugar industry and its connection with circular and “green” economic models. Another small cluster, which combines “Water Quality Index”, “Machine Learning Algorithms”, “Principal Component Analysis”, indicates the use of machine learning methods for monitoring and managing water quality in the agricultural sector. Such highly specialized areas complement the overall picture, demonstrating the breadth of application of AI in areas related to logistics.

Summarizing the analysis of the co-occurrence of keywords, it can be stated that the research field covers several interrelated areas: the implementation of AI and related digital technologies in the logistics processes of agricultural production; increasing the efficiency, sustainability and transparency of supply chains; strategic management of information systems and innovations in agribusiness; development of sustainable business models and solutions focused on minimizing losses and carbon footprint. The set of identified clusters forms a conceptual map of the research field, the center of which is the integration of artificial intelligence and logistics management of agri-food chains.

A temporal analysis of the development of the topic confirms the dynamic nature of the formation of this direction. As shown in Figure 2, the first single publications appear in 2008 and 2017, after which the activity remains low and uneven until 2019. Starting from 2019–2020, there is a steady increase in the number of publications, which turns into a rapid surge in 2025, when more than half of the entire array of analyzed works is published.

Such a jump correlates with the global explosive interest in artificial intelligence, generative models and their application in the field of logistics and agri-food systems. The growth of publication activity indicates the formation of a research community, the consolidation of digital agriculture development programs and the awareness of the strategic role of AI for food security.

The geographical structure of research confirms the international and distributed nature of the development of this topic. The analyzed publications involve authors affiliated with more than fifty scientific institutions in the world, with only two organizations having more than one publication.

Beijing Academy of Agriculture and Forestry Sciences is represented in two works, as is the University of Macedonia, known for its research in the field of bibliometrics and digital logistics. The remaining institutions are represented by single publications, among them are leading universities and scientific centers in China, Europe and other regions, such as Beijing Life Science Academy, National Tsing Hua University, Adam Smith Business School (University of Glasgow), etc. This picture indicates the absence of monopolization of the research field by one center and, at the same time, the formation of an extensive network of scientific groups.

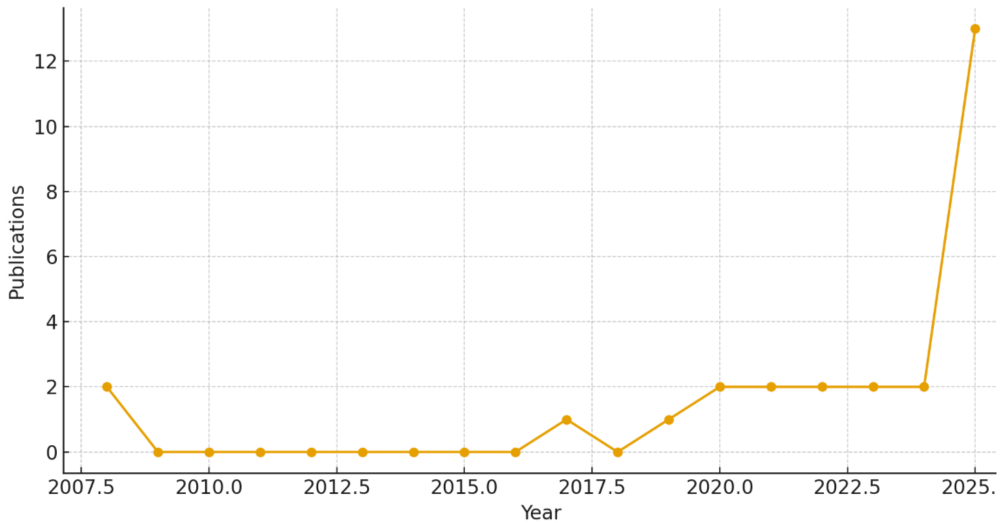

Figure 2: Dynamics of the number of publications on the selected topic by year.

The distribution of authorship by country is also quite diverse. In total, the participation of researchers from twenty-one countries was recorded. The leading positions in terms of the number of publications are occupied by Italy, China and India, for each of which the field of agri-food systems is of strategic importance. Several countries, including the United Kingdom, Ukraine, the United Arab Emirates, Jordan, Egypt, Oman, and Indonesia, have two publications each. As summarized, the range of key participants includes European and Asian states, as well as individual countries in the Middle East and Africa. This indicates, on the one hand, the global nature of the issue, and on the other, the different motives for its actualization: from the need for food security in countries with high dependence on imports to the aspirations of large agricultural economies to increase the efficiency and resilience of their own supply chains. To summarize the terminological field, a "word cloud" of the author's key terms was constructed (Fig. 3).

Although the USA is widely recognized as a global leader in AI research, it is underrepresented in our Scopus sample because many U.S. publications focus on general supply chain management rather than agricultural logistics specifically, and therefore did not meet the inclusion criteria.

The visualization shows the dominance of such concepts as "Artificial Intelligence", "Agri-Food", "Logistics", "Machine Learning", "Blockchain", "Strategic Management", which form the core of the research topic. Smaller terms, in particular "Resilience", "Sustainability", "Digital Marketing", "Precision Agriculture", reflect the specific emphases of individual studies related to sustainable development, precision agriculture and new communication tools in agribusiness. In general, the structure of the cloud confirms the multidisciplinary nature of the direction and the mutual interweaving of technological, managerial and industry aspects.

Based on the generalization of the dominant terms, their additional classification was carried out according to several semantic blocks (Table), which reproduce the logic of the research field. In particular, the technological cluster associated with the application of artificial intelligence algorithms for logistics needs (demand and yield forecasting, route optimization, inventory planning, anomaly detection); the transparency and trust cluster, which concentrates solutions based on blockchain, tracing systems, cold chain monitoring and product quality; the management cluster, focused on the framework for the implementation of digital technologies, risk management, and the maturity of organizational processes; the sustainability and energy efficiency cluster, which covers research on minimizing food losses, reducing emissions, and increasing resilience; and the data and integration cluster, which considers issues of data quality, system interoperability, cloud-edge processing, and IT solution integration architectures.

Each of these blocks is associated with certain types of tasks and methods – from regression models and deep learning to optimization algorithms, multi-criteria evaluation schemes and carbon accounting tools – as well as with expected effects in the form of cost reduction, logistics cycle times, loss reduction and increased system resilience.

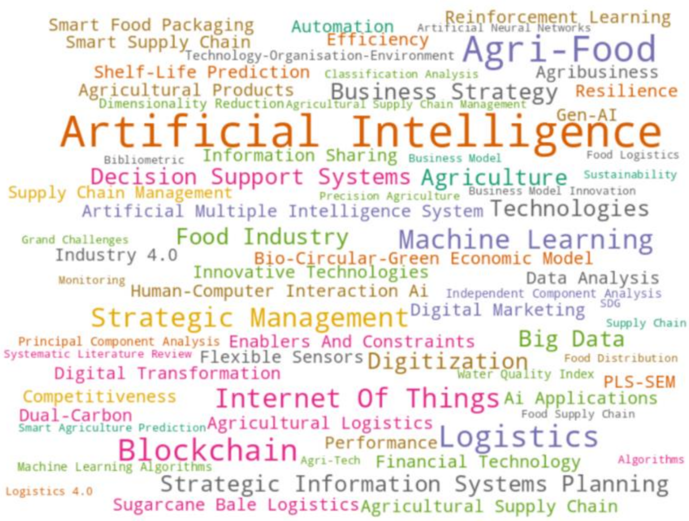

Figure 3: Author keyword cloud (the larger the word, the more often it occurs).

Table. Thematic clusters of key concepts in the research field "Artificial Intelligence and Logistics Management in the Agricultural Sector" (Scopus, 2008–2025).

Cluster	Core Keywords	Topic Extensions	Typical Tasks/Methods	Expected Effects
AI technologies for logistics	artificial intelligence; machine learning; deep learning; prediction; optimization	demand forecasting; routing; scheduling; inventory; anomaly detection	regression/gradient models; LSTM/GRU; ensemble methods; VRP heuristics; reinforcement learning	reduction of logistics costs and cycle time; higher forecasting accuracy; reduced food losses
Transparency and trust	blockchain; traceability; provenance; cold chain; quality monitoring	smart contracts; IoT sensors; HACCP integration	DLT; chain signature/hashing; event registries; integration with WMS/TMS	reduction of cold chain losses; improved compliance and auditability
Management frameworks and organizational change	supply chain management; S&OP; decision support; risk management; TOE	governance; data policies; ModelOps/MLOps; maturity models	multi-criteria decision models; process mapping; maturity assessment	shorter time-to-value; improved risk governance; scalability of AI solutions
Sustainability and energy efficiency	sustainability; food loss/waste; energy efficiency; CO_2; resilience	eco-design logistics; circularity; green KPIs	LCA/carbon accounting; IT energy-KPIs; network optimization	reduced emissions and food waste; enhanced supply chain resilience
Data and system integration	big data; data quality; interoperability; API; cloud-edge	ERP/WMS/TMS; telemetry; satellite; weather	data pipelines; feature store; data contracts	continuous data flows; model stability; increased system reliability

These clusters form a framework for a model where technological solutions are captured by organizational processes, and the result is measured by sustainable indicators.

As a result, bibliometric analysis allowed us to identify a structured system of knowledge about the research area: the latest trends, key thematic axes, active scientific centers and countries, as well as intellectual connections between the main concepts. Based on these results, a conceptual model of agri-logistics management based on artificial intelligence is proposed, which is designed to integrate technological, process and industry components into a single analytical field.

The proposed model (Fig. 4) considers the application of artificial intelligence in the logistics processes of the agricultural sector as a multi-level integrated system. Its core is formed by three interconnected areas: technological, covering digital algorithms, machine and deep learning systems, big data analytics, the Internet of Things, blockchain platforms and other AI tools; process, at the center of which is logistics management with its functions of planning, inventory management, optimization of transport routes, organization of warehousing and coordination between chain participants; and industry, which reflects the specifics of the agricultural sector – from primary production and processing to agri-food networks and relevant organizational structures. These three dimensions interact with each other through a system of "bridges" that represent specific points of application of AI in the logistics of agricultural production.

The conceptual model is based on several key principles. First, the principle of functional integration is implemented, according to which artificial intelligence does not act as an autonomous application, but is built into all main stages of the logistics cycle – from demand forecasting and resource planning to inventory management, route formation, supply control and end-user service.

Secondly, the principle of digital transformation of the agricultural sector is applied: logistics is considered as an information-rich process, where the movement of material flows is inseparable from the movement of data, and therefore, is subject to digitization, automation and intellectualization. Thirdly, the principle of sustainable development is taken into account, which involves the systematic processing of environmental, economic and social aspects of logistics solutions: artificial intelligence should not only increase efficiency, but also reduce food losses, optimize resource use, contribute to reducing emissions and strengthening food security.

Fourthly, the model is based on the principle of adaptability and flexibility, when learning algorithms enable rapid response to changes in the external environment – weather fluctuations, price shocks, supply disruptions – and provide dynamic adjustment of logistics strategies in real time.

Structurally, the model assumes that the technological block of artificial intelligence covers a wide range of tools: from big data analytics and forecasting methods to deep neural networks, reinforcement algorithms, computer vision systems for product quality control, blockchain solutions for traceability and distributed event registries, as well as IoT sensor networks for monitoring fields, warehouses, transport and storage conditions. The logistics block includes the functions of supply and procurement planning, inventory and warehouse infrastructure management, optimization of transport routes and distribution, coordination of interaction between producers, processors, logistics operators and retail networks. The industry block focuses on the specifics of agricultural production, agri-food chains and the structure of agribusiness, which necessitates the consideration of seasonality, biological variability, climate risks and regulatory restrictions.

Within this architecture, the main functional areas of AI application are highlighted. These include forecasting yield, demand and price trends, which allows for more informed planning of production volumes and logistics flows; optimizing routes, schedules and the use of transport resources to reduce time, fuel and product quality losses; automating operations through the use of drones, robotic systems and sensor platforms for data collection and primary processing; real-time monitoring of the movement of goods and their storage conditions, which allows for timely identification of risks and intervention before significant deviations occur; ensuring traceability of agri-food products from producer to end consumer using blockchain platforms; and supporting solutions aimed at reducing food losses, managing the carbon footprint and increasing the overall sustainability of the supply chain.

The implementation of the model involves the participation of a wide range of stakeholders. For farmers and agribusinesses, it means access to forecasting tools and recommendation systems that help make more informed production and logistics decisions. Logistics operators gain the opportunity to apply intelligent routing systems, fleet management and transportation monitoring.

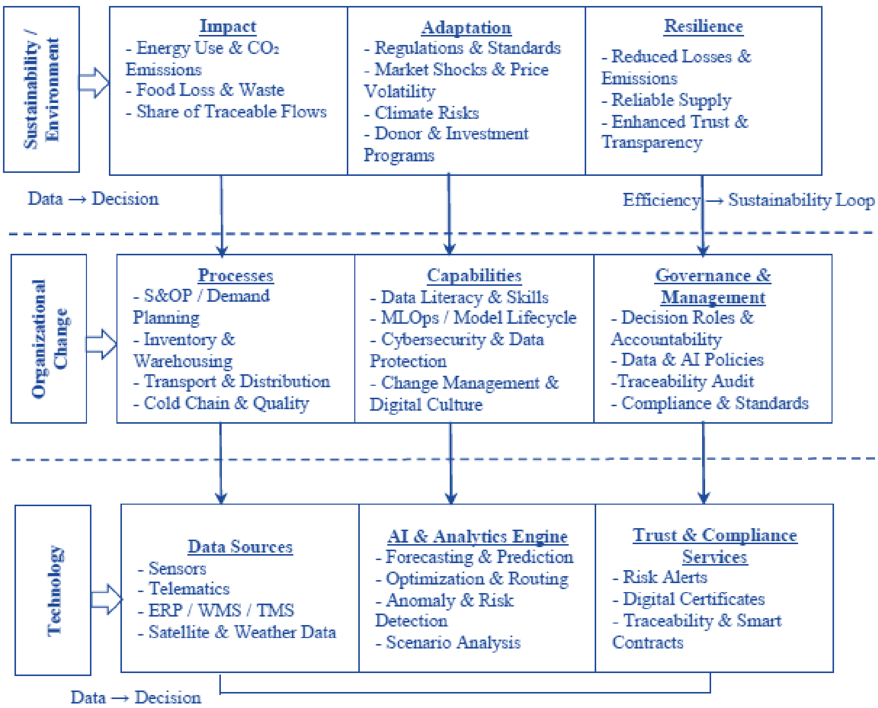

Figure 4: Conceptual model of ai-driven agri-logistics management [18-20].

Government authorities and regulators can use the model to develop smart agriculture policies and digital transformation of agri-food systems focused on food security and climate resilience. Research institutions and IT companies, in turn, act as developers of algorithms, digital platforms and analytical services, providing the scientific and technological basis for the functioning of the model.

The expected results of implementing the conceptual model are related to reducing transportation and storage costs, increasing the accuracy and reliability of supply, significantly reducing food losses and product damage in the supply chain, strengthening transparency and trust between participants in the agri-food network, as well as increasing the overall resilience of systems to external shocks. An important consequence is also the deepening of the digital transformation of agricultural logistics, which creates new opportunities for integration into global food chains and support for sustainable development goals. Thus, the result of the bibliometric analysis and further conceptual generalization is a model that not only describes existing research trends, but also offers a holistic theoretical and methodological framework for further empirical research and practical implementation of AI-driven agri-logistics management.

5 DISCUSSION AND RESEARCH LIMITATIONS

The results obtained demonstrate the growing relevance of research on the application of artificial intelligence in the logistics management of the agricultural sector, which is confirmed by the formation of an interdisciplinary scientific space at the intersection of digital technologies, supply chain management and sustainable development concepts.

The identified thematic clusters demonstrate the strengthening of the integration of machine learning and data analytics in the forecasting and optimization of logistics processes, the actualization of blockchain solutions to ensure transparency and traceability of agri-food chains, as well as the spread of research on risk management, decision-making and increasing the environmental sustainability of supplies. Such a structure of the scientific field indicates a gradual transition from isolated technical cases to a systemic conceptual understanding of digital agri-logistics as a key element of global strategies for sustainable, transparent and resilient food systems.

Comparison of the obtained results with the work of various leading scientists [11]-[15] gives grounds to assert that the majority of existing theoretical approaches focus on technological and organizational determinants of the implementation of artificial intelligence, but to a lesser extent reflect the environmental, energy and socio-economic consequences of the digital transformation of agri-food chains.

Even within the framework of popular theoretical frameworks, in particular the TOE-framework, the environmental, resource and carbon components of logistics remain auxiliary, which creates a noticeable imbalance between technological innovations and the principles of sustainable development. The conceptual model of AI-driven agri-logistics management proposed in the study is aimed at overcoming this discrepancy, combining three dimensions – Technology, Organization and Sustainability – into a holistic architecture focused on managing digital data flows, operational processes and performance indicators of the logistics activities of the agricultural sector.

Bibliometric analysis has shown an important shift in the focus of scientific research: from technical and algorithmic experiments and engineering solutions to assessing the impact of artificial intelligence on productivity, resilience, food security and energy efficiency of logistics networks. This trend indicates a transition to a more mature phase of the development of the scientific tradition, within which AI is considered not only as a tool for automation, but also as a strategic resource for the formation of adaptive, digital and low-carbon food systems.

It is important to note that the conceptual model proposed in this study remains analytical. Its practical applicability should be validated in future empirical research involving enterprise-level data, case studies, simulation modelling, or pilot implementations in agri-food supply chains.

Despite the results obtained, the study has a number of limitations that affect interpretation and can be taken into account in future works. First, the use of a single Scopus database leads to linguistic and regional selectivity, which may limit the representation of studies from countries that do not have established channels of scientific indexing, in particular, countries in Africa, Central Asia, the Middle East and regions affected by military or climate crises.

Secondly, the time lag of citations of new works (2024-2025) does not provide a complete assessment of their scientific impact, and therefore the results of the distribution by citations may be partially underestimated.

Thirdly, the difference in the indexing approaches of journals complicates the unification of author metadata and keywords, which may affect the accuracy of building network structures. Fourthly, the proposed conceptual model is of a theoretical and analytical nature and requires further validation based on applied cases, panel data of enterprises or simulation experiments.

Taking into account the above aspects determines the following trajectory of scientific research: the transition from descriptive and bibliometric description to empirical testing of the model at the level of enterprises, logistics clusters or national food systems.

This opens up prospects for expanding research in the areas of assessing the economic feasibility of implementing AI, developing methods for monitoring carbon footprints, integrating cybersecurity mechanisms, and analyzing informal institutions of trust in digital agro-logistics networks.

Given these challenges, the proposed results form the basis for the formation of more in-depth conceptual and managerial approaches that can be used in the future to develop intelligent decision support systems and new food and logistics security policies.

6 CONCLUSIONS

The conducted research allowed us to comprehensively characterize the current state and dynamics of the development of scientific publications dedicated to the application of artificial intelligence in the logistics management of the agricultural sector, as well as to identify the leading trends in the transformation of food chains in the direction of digital, transparent and environmentally sustainable agri-logistics.

The analysis of publication activity showed an exponential growth in the number of scientific developments after 2020, which indicates the emergence of a new interdisciplinary direction integrated into the global scientific discourse on sustainable and resilient food systems. The geography of author collaborations demonstrates the formation of a European-Asian center of scientific influence, which unites research groups from Italy, China, India, Great Britain and a number of other countries, while the participation of Ukraine, although still limited, indicates the prospects for the development of its own research school in the field of digital agri-logistics.

The identified cluster areas of the scientific field allow us to distinguish four conceptual dimensions of research:

1) technological, covering machine learning algorithms, big data analytics and intelligent decision support systems;
2) managerial, related to digital governance, supply coordination and risk management;
3) environmentally sustainable, which focuses on energy efficiency, reducing food losses and CO_2 emissions;
4) the dimension of transparency and trust, which is associated with the use of blockchain and traceability systems in agri-food chains.

The generalization of these areas formed the basis of the proposed conceptual model of AI-driven agri-logistics management, which combines three macro-levels – Technology, Organization and Sustainability – and provides a cyclical connection between data flows, management decisions and indicators of the effectiveness of logistics operations.

The practical results of the model provide grounds to argue that the implementation of AI in agri-logistics can provide significant operational, economic and environmental effects, in particular, reducing the time and costs of logistics operations, increasing the accuracy of routing and warehouse planning, reducing food losses and the carbon footprint of supplies, as well as increasing institutional transparency and trust between chain participants.

In view of this, it is advisable to formulate practical recommendations for different levels of logistics policy implementation. At the enterprise level, the priorities are the implementation of a centralized data management policy, the use of MLOps infrastructure, the launch of pilot projects on demand forecasting, route optimization and cold chain control, as well as the creation of KPI panels for assessing energy efficiency and CO_2 emissions.

At the industry level, standardization of traceability requirements, the development of public registers of “green” logistics initiatives and the stimulation of cluster cooperation between agricultural producers, research institutions and technology companies are important.

At the level of state policy, it is advisable to include digital agro-logistics in food security and energy resilience strategies, to involve EU funding programs and international organizations (FAO, World Bank, IFC), and to create a national AI & Agri-Logistics Competence Center as a platform for knowledge transfer and best practices.

At the same time, the results of the study open up a number of prospects for further scientific work. Important areas of future research are the empirical validation of the conceptual model based on data from agricultural enterprises in Ukraine and EU countries, the development of regional indices of digital resilience of agro-logistics systems, the improvement of methods for quantitative assessment of the energy and carbon balance of the use of AI in food chains, the analysis of social trust in traceability systems and data cybersecurity, as well as the expansion of bibliometric analysis on Web of Science, Dimensions, and Google Scholar for deeper coverage of local scientific schools.

Solving these problems will contribute to the formation of a mature theoretical and applied platform for AI-oriented agri-logistics and strengthen the contribution of research to the implementation of strategies for the sustainable and safe development of food systems.

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