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ORIGINAL ARTICLE

Digitalization of Agribusiness and its Impact on Productivity and Sustainability: A Systematic Literature Review

Lyailya Akhmetova [1] | Yerzhan Domalatov [1]* | Alma Baiguzhinova [1] | Igor Dubina [2] | Madina Bazhigaliyeva [1] |

[1]Sarsen Amanzholov East Kazakhstan University, Ust-Kamenogorsk, Kazakhstan.

[2]Altai State University, Barnaul, Russian Federation.

Correspondence
*Yerzhan Domalatov – PhD Candidate, Sarsen Amanzholov East Kazakhstan University, Ust-Kamenogorsk, Kazakhstan.
Email: domalatovkz@gmail.com

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Abstract
Digital transformation of the agro-industrial complex is seen as a key factor in increasing the productivity and resilience of agri-food systems in the face of climate instability and increasingly complex global supply chains. Despite the rapid growth of scientific publications, research results remain fragmented, and the mechanisms by which digital technologies influence economic and sustainability indicators are poorly systematized.

The purpose of this study is to summarize and critically analyze the scientific literature on the impact of digital technologies on efficiency of agricultural production, the sustainability of agri-food systems, and the role of data and platforms in shaping these effects. The paper addresses the following research questions: how do digital technologies influence agricultural productivity; to what extent do they contribute to environmental and economic sustainability; and what organizational and institutional conditions determine the effectiveness of digital transformation.

The study was conducted as a systematic review of scientific publications covering the period 2015-2025. Following a multi-stage selection process from an initial pool of over twenty-two thousand publications, fifty-six studies meeting criteria for topical relevance and methodological transparency were included in the final analysis.

The analysis shows that digitalization is creating a new production infrastructure based on data and analytics, which contributes to increased resource efficiency, reduced uncertainty, and improved coordination in supply chains. However, the sustainability of these effects significantly depends on the institutional environment, the level of infrastructure development, and the quality of data management. It is concluded that the long-term effectiveness of digital transformation is determined not only by the implementation of technologies but also by the alignment of organizational, infrastructural, and managerial factors.

KEYWORDS
Education, Higher Education, Education Policy, Human Capital, Knowledge Economy, Research Funding, Science Expenditure

1 | INTRODUCTION

In the 21st century, the agro-industrial complex is evolving under the influence of climate instability, volatility of global food markets, and increasing complexity of agri-food supply chains, which intensifies pressure on natural resources and raises demands for efficiency and sustainability. In this context, digital technologies such as remote sensing, artificial intelligence, digital platforms, and big data analytics are increasingly viewed as a key infrastructure for modern agricultural systems rather than merely auxiliary tools (FAO, 2019).

Digitalization has become one of the key drivers of transformation in modern agriculture and agribusiness. The rapid development of digital technologies, including artificial intelligence, the Internet of Things (hereinafter – IoT), blockchain, big data analytics, and digital platforms, is reshaping production processes, management systems, and supply chains in agri-food systems. These technologies enable more efficient resource use, improve decision-making, and contribute to increased agricultural productivity and sustainability. At the same time, existing policy analyses highlight several barriers that limit the large-scale adoption of digital technologies, including insufficient digital infrastructure, limited digital competencies among farmers, institutional constraints, and emerging risks associated with data ownership and market concentration (Jouanjean et al., 2020; OECD, 2022; World Bank, 2023).

The academic literature on the digitalization of agri-food systems has expanded rapidly over the past decade and now covers a wide range of technological and managerial topics. Existing studies examine the application of Internet of Things architectures, remote sensing technologies, artificial intelligence in precision agriculture, blockchain-based traceability systems, digital platforms for agricultural data exchange, and the role of digital technologies in strengthening supply chain resilience (Abbasi et al., 2022; Abiri et al., 2023; Shamshiri et al., 2024). In addition, several recent studies emphasize the growing role of digital platforms and data infrastructures in coordinating interactions between actors within agri-food systems, thereby reshaping value chains and market structures (Ahoa et al., 2026; Quan et al., 2024; Stanescu et al., 2025). Moreover, the integration of digital technologies with environmentally oriented farming practices is increasingly seen as an important factor influencing enterprise efficiency, food security, and the long-term sustainability of the agricultural sector (Akhmetkyzy et al., 2024; Baiguzhinova et al., 2025; Wang et al., 2025).

Despite the rapid expansion of research in this field, the existing literature remains fragmented in several important respects. First, many studies examine technological innovations without systematically linking them to measurable economic or sustainability outcomes. Second, environmental and economic effects of digitalization are often analyzed separately, which limits the development of integrated analytical models of sustainability in agri-food systems. Third, issues related to agricultural data governance and the institutional regulation of digital platforms remain insufficiently explored empirically.

The study addresses three research questions:

RQ1. How do digital technologies influence agricultural productivity and production efficiency?

RQ2. To what extent do digital solutions contribute to the environmental and economic sustainability of agri-food systems?

RQ3. What organizational and institutional conditions determine the effectiveness of digital transformation in agriculture?

The novelty of this study lies in developing an integrated analytical perspective on the digital transformation of agri-food systems by linking three previously fragmented research dimensions: digital production infrastructures (including IoT, artificial intelligence, and data platforms), measurable productivity and sustainability outcomes, and governance mechanisms related to data ownership, platform coordination, and value distribution within digital ecosystems. Thus, the study aims to conduct a systematic review of academic literature on digital technologies in agribusiness and evaluate their impact on productivity, sustainability, and governance in agri-food systems.

2 | METHODOLOGY

This study employs a systematic literature review (hereinafter – SLR) conducted in accordance with the PRISMA framework, which ensures transparency and reproducibility in the identification, screening, selection, and synthesis of scientific publications (Page et al., 2021). The use of PRISMA reduces the risk of selection bias and provides a structured procedure for documenting the formation of the final body of literature. This methodological approach is widely used in studies examining digital transformation and agri-food systems, as it facilitates systematic comparison of empirical findings and identification of research gaps (Rocha de Avila & Barbosa, 2025; Klerkx et al., 2019).

The literature search was conducted in January 2026 using the ScienceDirect database, which provides broad coverage of peer-reviewed journals in agricultural sciences, engineering, information technology, economics, and management. ScienceDirect was selected for its strong representation of interdisciplinary research on digital agriculture and agri-food systems. To reduce potential database bias, additional relevant studies were identified through manual searches of reference lists and Google Scholar. The review covers the period from 2015 to 2025, corresponding to the active development of the Agriculture 4.0 concept and the rapid growth of research on digital technologies in agriculture. Only publications written in English were included. The search was performed in the Title, Abstract, and Keywords fields to improve thematic precision. The analysis considered only peer-reviewed research articles and review papers.

To ensure relevance, subject filters related to agri-food systems and digital technologies were applied, including Agricultural and Biological Sciences, Environmental Science, Computer Science, Engineering, Energy, Business, Management and Accounting, Economics, Econometrics and Finance, and Social Sciences. Publications unrelated to agricultural production or agri-food systems were excluded during the screening stage. The search strategy was based on predefined keyword combinations reflecting the main analytical dimensions of the study, including digital transformation in agriculture, artificial intelligence applications, Internet of Things technologies in precision agriculture, digital platforms in agricultural value chains, and sustainability in digital agriculture. These keyword combinations were used to identify relevant studies addressing productivity, efficiency, resilience, and sustainability in agri-food systems.

The initial search results by year are presented in Table 1 and demonstrate a steady increase in publication activity, particularly in studies focusing on digital transformation and artificial intelligence in agriculture.

Research articles predominate in all queries, indicating the predominantly empirical nature of literature. At the same time, differences in the share of Review articles are noticeable across combinations, reflecting the varying degrees of theoretical systematization of the thematic areas. This structure confirms the feasibility of a high-quality thematic synthesis and explains the rejection of a meta-analysis due to the high heterogeneity of designs and metrics. Figure 1 shows the structure of the selected dataset by publication type (Research vs. Review) for five search combinations.

The final sample included studies that simultaneously met the following criteria:

Table 1 Number of publications by keyword combinations for 2015–2025

Year	Combination No.1	Combination No.2	Combination No.3	Combination No.4	Combination No.5
2015	2	52	4	0	0
2016	4	78	7	3	0
2017	20	132	20	3	1
2018	34	186	33	14	4
2019	88	339	73	42	1
2020	165	582	103	46	10
2021	340	850	134	113	28
2022	535	1318	250	126	32
2023	675	1687	255	151	62
2024	1269	3087	507	207	117
2025	1928	4938	1109	378	128

Note: compiled by the authors based on the ScienceDirect database

(1) Thematic relevance: the study examines the application of digital technologies in the agro-industrial complex or agri-food systems, including IoT, artificial intelligence and machine learning, remote sensing, FMIS/DSS systems, digital platforms, traceability technologies, and data analytics.

(2) Outcomes: the article provides empirical results or conceptual conclusions linking digitalization to productivity or efficiency indicators (e.g., yield, production costs, technical efficiency, total factor productivity, losses, product quality) and/or resilience indicators (resource efficiency, environmental performance, resilience to shocks, supply chain resilience, traceability).

(3) Mechanisms and context: the study analyzes implementation mechanisms and institutional conditions, including issues related to data governance, platform models, regulatory frameworks, competencies, and value distribution.

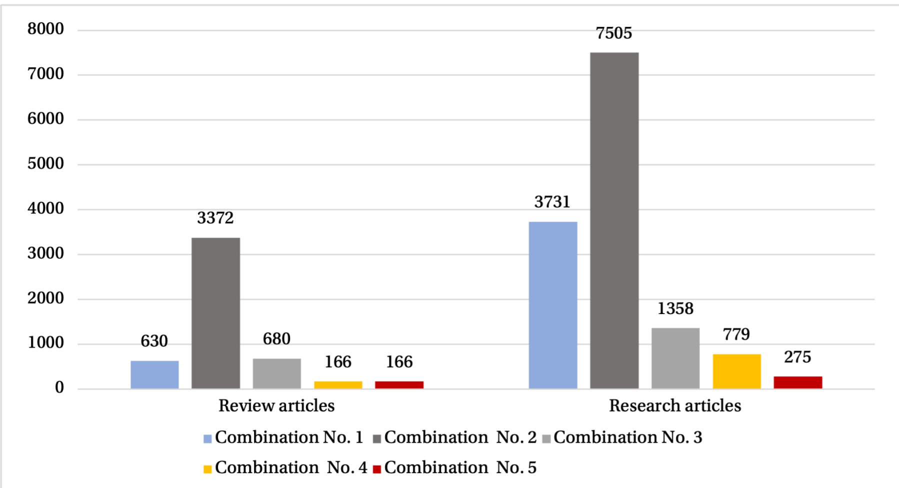

Figure 1 Number of scientific papers by type review articles and research articles for 2015-2025 according to the ScienceDirect database

The following types of publications were excluded from the analysis:

(1) Non-peer-reviewed and non-scientific materials: editorial notes, short communications, news and review reports without a description of methods, materials without a research design and without extractable results.

(2) Irrelevant research object: publications not related to the agro-industrial complex/agri-food chains or examining digital technologies outside of an agricultural context.

(3) Duplicates/versions: duplicate records and earlier versions of already included papers.

(4) Technology-only without outcome logic: articles that do not link digital technologies to productivity/sustainability outcomes or for which this link cannot be extracted from the text (e.g., descriptions of architectures without impact assessments and without analytical interpretation of the consequences).

(5) Disciplinary irrelevance: papers primarily related to clinical/biomedical topics without connection to agri-food systems were excluded as irrelevant.

The selection of publications was conducted according to the PRISMA framework, which comprises three main stages: identification, screening, and inclusion. The quantitative results of the selection process are presented in Figure 2.

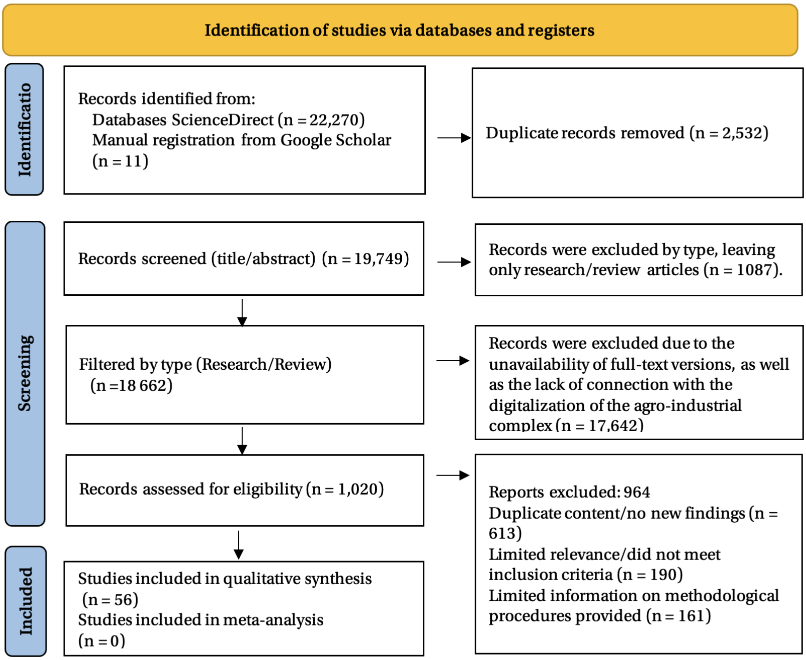

Figure 2 PRISMA flow diagram of the study selection process

To ensure methodological rigor and transparency, all studies included at the full-text eligibility stage were subjected to a standardized methodological quality assessment based on the logic of the Mixed Methods Appraisal Tool (MMAT). The framework was adapted to the interdisciplinary nature of research on digitalization in agri-food systems, with particular attention to the transparency of digitalization indicators, validity of analytical methods, and reproducibility of productivity and sustainability outcomes. The methodological assessment included five criteria, each evaluated using a three-level scoring scale: 0 – missing or unclear; 1 – partially addressed; 2 – fully addressed and transparent.

The evaluation criteria were defined as follows:

(1) Data transparency: data sources, sample or object of analysis, study period, and contextual conditions are clearly described.

(2) Validity of methods: analytical methods are appropriate for the research objectives (e.g., econometric modelling, structural equation modelling, stochastic frontier analysis, simulation modelling, or qualitative methods) and applied correctly.

(3) Operationalization of digitalization: the digitalization construct or indicator is clearly defined and measurable in a reproducible manner.

(4) Operationalization of outcomes: productivity or sustainability indicators are clearly defined and supported by explicit causal logic.

(5) Bias management – robustness checks, sensitivity analysis, alternative model specifications, or discussion of methodological limitations are provided.

The overall methodological quality score for each study was calculated by formula (1):

$$Q_i = \sum_{k=1}^{5} C_{ik} \tag{1}$$

where:

Q_i – the total methodological quality score for study i;

C_{ik} – the score assigned to criterion k (ranging from 0 to 2);

k – index of the evaluation criterion.

The maximum possible score for each study is therefore given by formula (2):

$$Q_{max} = 10 \tag{2}$$

Publications were excluded if they contained critical methodological limitations that made their findings non-verifiable. Such limitations included the absence of a clear description of data sources and analytical methods, the lack of measurable outcome indicators, inconsistency between the research design and the stated conclusions, as well as non-transparent operationalization of digitalization variables or performance indicators. Based on the resulting scores, the methodological quality of the studies was interpreted according to the following classification. Studies scoring 8–10 points were classified as high quality, indicating a high level of methodological transparency and reproducibility. Studies scoring 5–7 points were considered moderate quality, reflecting acceptable methodological rigor with some limitations. Studies scoring 0–4 points were classified as low quality, indicating insufficient methodological transparency.

Following the PRISMA selection procedure, 56 studies were included in the final review. Among them, 31 studies were classified as high quality and 25 studies as moderate quality. The average methodological quality score across the included studies was 7.4, indicating generally acceptable methodological rigor in the reviewed literature. To assess the robustness of the findings, a sensitivity analysis was conducted by excluding studies classified as moderate quality and repeating the thematic synthesis using only high-quality studies. The exclusion of moderate-quality studies did not substantially alter the overall analytical patterns identified in the review, suggesting that the main findings are robust.

To enable systematic comparison across the reviewed literature, a standardized data extraction matrix was developed. The extraction process followed a predefined coding protocol designed to capture the key analytical dimensions of digital transformation in agri-food systems, including technological, economic, and institutional characteristics of the analyzed studies. The coding framework allowed the consistent identification of digital technologies applied in agriculture, the segments of the agri-food value chain addressed, the productivity and sustainability outcomes analyzed, and the contextual factors influencing the adoption and performance of digital solutions.

The structure of the data extraction matrix used in the review is presented in Table 2.

Table 2 Data extraction matrix used in the systematic literature review

Analytical dimension	Extracted variable	Examples of indicators
Digital technologies	Type and class of digital technologies	IoT sensors, artificial intelligence and machine learning models, UAV and remote sensing systems, decision support systems, digital platforms, blockchain
Agri-food system segment	Segment of the agri-food value chain	Crop production, livestock farming, agricultural processing, agri-logistics, agricultural markets
Productivity outcomes	Indicators of production performance	Yield, total factor productivity, technical efficiency, cost reduction, product quality
Sustainability and resilience	Environmental and system resilience indicators	Water efficiency, energy efficiency, environmental performance metrics, supply chain resilience, traceability
Contextual moderators	Institutional and infrastructural factors	Digital infrastructure availability, investment intensity, digital competencies, institutional environment, data governance regimes

Note: compiled by the authors

The coding process enabled the systematic comparison of heterogeneous empirical studies and facilitated the thematic synthesis of the effects of digitalization on productivity, sustainability, and resilience within agri-food systems.

Given the heterogeneity of the included studies in terms of technologies, research designs, and evaluation metrics, a qualitative thematic synthesis was applied. This approach allowed the systematization of empirical and conceptual findings and the identification of consistent patterns in research on the digital transformation of agri-food systems.

The analysis was conducted in three stages. First, the selected studies were reviewed and coded according to key parameters, including the type of digital technology, productivity and sustainability outcomes, mechanisms of digitalization, and contextual implementation conditions. Second, the results were grouped into four thematic blocks: digital technologies as production infrastructure; productivity and efficiency effects; environmental, economic, and supply chain sustainability; and the role of platforms, data, and governance mechanisms.

Despite following PRISMA guidelines, the study has several limitations. First, the main dataset was derived from the ScienceDirect database, which may limit the coverage of studies published in other databases. Second, many analyzed studies focus on short-term effects of digital technology adoption, as digital transformation in agri-food systems remains a relatively recent research field. Third, the results depend on contextual factors such as institutional environments, levels of economic development, and digital infrastructure. These factors should be considered when generalizing the findings and highlight the need for further research.

3 | RESULTS

The analysis shows that digitalization in agriculture is increasingly interpreted not as the introduction of isolated technologies but as the development of an integrated production infrastructure combining data collection, analytics, and management decision-making within a unified cyber-physical system. In this framework, agricultural production is organized around a continuous cycle of data acquisition, processing, and operational intervention, enabling digital technologies to influence both productivity and sustainability. At the architectural level, such infrastructure typically integrates several technological layers, including farm management information systems (FMIS), sensor networks, data platforms, and decision-support tools. For example, Acharya Balkrishna et al. (2023) show that modern digital agricultural ecosystems are often built around FMIS-based structures integrating data from sensors, remote sensing platforms, and agricultural service applications. Similarly, Muhammed et al. (2024) demonstrate that the technological core of such infrastructures increasingly relies on AIoT architectures combining IoT sensor networks, artificial intelligence, and distributed computing for continuous monitoring of soil moisture, temperature, crop conditions, and livestock health. Navarro et al. (2020) further emphasize the importance of connectivity architectures, including wireless sensor networks, low-power wide-area networks, satellite communication, and cloud computing platforms, which enable interoperability between distributed agricultural data systems.

Mamabolo et al. (2025) show that integrating soil sensors, remote sensing technologies, and machine-learning algorithms enables early diagnosis of crop diseases and soil degradation, thereby improving the efficiency of agricultural resource use. Chin et al. (2024) propose the ROAM framework, which integrates sensor data streams, predictive analytics, and optimization algorithms to support adaptive farm management under uncertainty. In a broader sense, Wolfert et al. (2017) argue that the use of big data technologies in smart farming allows predictive analytics and real-time operational decision-making, thereby transforming traditional farm management models and reshaping agri-food supply chains.

Finally, the broader implications of digital agricultural infrastructure for sustainable development remain uneven across regional and institutional contexts. While technologies such as drone monitoring, sensor networks, and machine-learning analytics can improve resource efficiency and environmental performance (Gamage et al., 2024), their large-scale adoption is often constrained by infrastructural limitations, institutional barriers, and insufficient digital competencies among farmers (Fakhraddine et al., 2025).

Empirical evidence indicates that digital technologies significantly improve farm-level efficiency and production performance. For example, Yu et al. (2025) show that a 1% increase in digital investment raises technical efficiency by about 0.029%, while related technologies increase milk yields and profit margins, and Sargani et al. (2025) demonstrate that digital adoption and agricultural infrastructure explain up to 68% of the variance in agricultural productivity. Digital technologies also enhance productivity by reducing information asymmetry and improving farmers' access to services, finance, and market information. For instance, Kitole et al. (2024) show that digital tools significantly improve access to extension services, pest management, market information, and financial services among smallholder farmers in Tanzania, while Narayanamurthy et al. (2025) demonstrate that satellite-based data analytics reduces information asymmetry in agricultural lending and supports more accurate credit assessment.

At the organizational level, studies show that the productivity effects of digitalization depend not only on technological adoption but also on institutional and managerial capacity. For example, Santos et al. (2024) find that the digital maturity of agri-food cooperatives is shaped by factors such as digital infrastructure, organizational readiness, and technological capabilities, with significant variation explained by firm size and financial resources. At the operational and research levels, digital technologies such as IoT-based smart irrigation systems (Mamun et al., 2025) improve resource efficiency, while AI tools accelerate knowledge generation and data analysis in agricultural research (Lamanna et al., 2025).

From an environmental perspective, digital agricultural technologies primarily contribute to sustainability by improving resource efficiency, particularly in water, energy, and agrochemical use. A growing body of research highlights the role of smart irrigation systems that integrate IoT sensors, artificial intelligence algorithms, and renewable energy infrastructure. A systematic review by Nurmalitasari et al. (2025) shows that AI-driven solar-powered irrigation systems allow continuous monitoring of soil moisture, weather conditions, and crop water demand, enabling real-time adjustments to irrigation schedules. Empirical evidence summarized in the review indicates that such systems can increase water use efficiency by up to 70%, while crop yields may increase by 15-40% depending on crop type and climatic conditions. These technologies also reduce energy consumption by integrating photovoltaic systems, contributing to lower greenhouse gas emissions and improved environmental performance in agricultural production systems.

Digital technologies contribute to environmental sustainability by enabling precision crop protection and reducing excessive use of agrochemicals. For example, AI-based pest monitoring systems achieve identification accuracy of about 98%, allowing early detection of infestations and reducing the need for large-scale pesticide spraying (Javed et al., 2025). Similarly, deep learning models for plant disease detection often achieve classification accuracies exceeding 99% and significantly outperform traditional machine-learning approaches, highlighting the potential of artificial intelligence to improve environmental performance while maintaining agricultural productivity (Majdalawieh et al., 2025). In this regard, Aijaz et al. (2025) highlight that the diffusion of artificial intelligence technologies in agriculture remains constrained by several structural barriers, including insufficient digital infrastructure, limited digital literacy among farmers, and regulatory uncertainty related to agricultural data governance.

Digital agricultural platforms generate economic value by aggregating and processing large volumes of agricultural data, integrating sources such as satellite imagery, production data, weather monitoring, and market information into unified decision-support systems. Empirical evidence shows that such platforms reduce information asymmetries and improve production and marketing decisions for farmers (Borrero & Mariscal, 2022), while their governance reflects tensions between open data sharing and proprietary control within platform ecosystems (Bustamante, 2023). At the same time, the diffusion of digital platforms depends on infrastructural and socio-economic conditions, including digital infrastructure, technical knowledge, farm size, and data privacy concerns, while the absence of standardized indicators complicates cross-country comparisons of digital agriculture adoption (Dibbern et al., 2024).

Recent research increasingly links platform digitalization with sustainability and ESG governance, highlighting the rapid growth of this field and the expanding role of AI-driven platforms in monitoring and managing ESG performance across supply chains (Kumar & Shah, 2025; Nevi et al., 2025). At the same time, studies emphasize that the expansion of digital platform ecosystems creates new governance challenges related to market concentration, institutional capacity, and regulatory frameworks (Ochieng, 2024), while digital data systems are becoming essential for ensuring transparency and sustainability reporting in agri-food supply chains (Truant et al., 2024). Finally, stakeholder perceptions also play an important role, as digital agriculture technologies are associated with improved economic stability but still raise concerns about environmental and social impacts, highlighting the importance of trust and inclusive governance in digital transformation (MacPherson et al.,

Table 3 Comparative analysis of the effects of digitalization of the agro-industrial complex according to international literature

Digital transformation unit	Main results in the literature	Empirical effect	Institutional and technological constraints	Identified research GAP
Production infrastructure (IoT, AIoT, UAV, DSS)	Digitalization creates a continuous data-analytics-action loop (Acharya et al., 2023; Muhammed et al., 2024; Chin et al., 2024)	Increased resource management accuracy, reduced losses, and improved adaptability (Mamun et al., 2025)	High demands on energy, connectivity and equipment compatibility (Navarro et al., 2020)	Lack of universal architectures scalable for developing countries
Productivity and efficiency	Digital investments improve technical efficiency and reduce costs (Yu et al., 2025; Sargani et al., 2025)	Increased TFP, reduced feed and labor costs, improved market access (Kitole et al., 2024; Santos et al., 2024)	Heterogeneity of effects by farm size and region	There is no single indicator of "digital productivity premium"
Environmental sustainability	AI and IoT enable precise management of water, soils, and chemistry (Nurmalitasari et al., 2025)	Reduced water consumption, lower emissions, increased crop yields	Dependence on infrastructure and digital literacy of farmers (Fakhraddine et al., 2025)	Environmental effects are rarely integrated into economic models.
Supply chain resilience	Digitalization enhances knowledge integration and resilience supply chains (Sargani et al., 2025)	Reducing market risks, increasing transparency	Lack of data on small producers (Narayanamurthy et al., 2025)	Lack of quantitative models of the resilience effect
Platforms and data	Platforms are creating new markets but changing the balance of social and commercial values. (Bustamante, 2023; Borrero 2022, Agyekumhene et al., 2018)	Expanding access to credit and markets	Issues of trust, privacy, and governance	Lack of data governance research in the agro-industrial complex
AI and ESG models	AI in platforms can enhance ESG value and legitimacy (Nevi et al., 2025)	Improving chain monitoring and SDG compliance	Fragmentation of ESG data standards (Kumar & Shah, 2025)	Weak empirical validation in agriculture
AI in biological processes	AI is radically improving disease selection and diagnosis. (Dublino & Ercolano, 2025; Javed et al., 2025)	Increased accuracy, reduced chemical load	"Black-box" models, lack of high-quality datasets (Majdalawieh et al., 2025)	There is no connection between AI accuracy and environmental KPIs
Social and institutional sustainability	Digitalization depends on regulators, education, and trust (Anam et al., 2025; Fleming et al., 2021; Eastwood et al., 2021)	Growing farmer inclusion and community resilience	Risk of increasing inequality and digital divide	The Lack of Equitable Digitalization Models

Note: compiled by the authors based on a systematic review of the literature according to the PRISMA

2025).

Governance of digital agriculture also depends on stakeholder perceptions and the social acceptance of digital technologies. MacPherson et al. (2025) show that stakeholders associate digital agriculture with improved economic stability and resource efficiency, although concerns remain regarding environmental and social impacts. Foresight studies further indicate that the future development of Agriculture 4.0 will depend on the interaction between technological progress, institutional governance, and societal expectations, highlighting the importance of responsible innovation and anticipatory governance frameworks (Fleming et al., 2021; Eastwood et al., 2021).

Overall, the comparative synthesis of the reviewed literature indicates that digital platforms, data infrastructures, and governance regimes form the institutional backbone of the digital transformation of agri-food systems. While digital technologies provide the technical capacity for data-driven decision-making, their sustainability and scalability depend heavily on governance structures regulating data ownership, interoperability standards, trust mechanisms, and the distribution of economic value within platform ecosystems. Despite the rapid expansion of platform-based digital agriculture solutions, important research gaps remain, particularly regarding the quantitative evaluation of governance regimes and their influence on the economic performance, resilience, and sustainability of agri-food systems.

A comparative analysis of a corpus of 56 publications demonstrates that digital transformation in the agro-industrial complex is not a linear process of implementing individual technologies, but rather the formation of a complex production system in which technological, economic, and institutional factors are interconnected. Table 3 summarizes the key findings of the literature, including the main effects of digitalization, limitations to implementation, and identified research gaps.

A summary of the results shows that digital technologies have significant potential to improve the productivity and sustainability of agricultural and food systems, but this potential is realized unevenly and depends on the institutional environment, infrastructure, and human capital. The most significant gap in the literature remains the lack of integrated models that link digital technologies, data, economic outcomes, environmental impacts, and governance mechanisms into a unified analytical framework.

4 | CONCLUSION

This study aimed to systematize and critically analyze the international scientific literature on digitalization in the agro-industrial complex, focusing on its impact on the productivity and sustainability of agri-food systems. The use of a systematic review methodology in accordance with the PRISMA standard helps to structure this extensive and fragmented body of research and examine digital transformation not only as a technological phenomenon but also as a complex economic, institutional, and managerial process. The analysis revealed that the impact of digital technologies on productivity and sustainability is nonlinear and determined by a combination of interrelated factors. Digitalization is most effective when technologies are integrated into sustainable production, organizational, and management systems, supported by data infrastructure, competencies, and institutional support. In the opposite situation, implementing digital solutions can lead to limited or unstable outcomes, exacerbating structural imbalances, transaction costs, and digital inequality. This confirms the conclusion that the digital transformation of the agro-industrial complex is a multi-level process in which technological, organizational, and institutional factors act as mutually reinforcing elements. The analysis also revealed that the sustainability of agri-food systems is shaped by the intersection of environmental, economic, and logistical aspects. However, existing literature often considers these dimensions separately. This limits the ability to construct integrated models that simultaneously assess the impact of digitalization on resource efficiency, supply chain stability, and long-term economic performance. Thus, one of the key findings of the article is the confirmation of the need for a comprehensive approach to assessing the effects of digitalization, taking into account the interrelationships between different types of sustainability. Data management and platform ecosystems are particularly important in the current digital transformation of agri-food systems. A literature review has shown that data governance regimes, interoperability standards, trust mechanisms, and the distribution of benefits among supply chain participants largely determine the sustainability and scalability of digital solutions. In this context, digital platforms act not only as technological tools but also as institutional coordination mechanisms that influence market structure, access to resources, and the balance of economic power. The scientific contribution of this study lies in the systematic integration of technological, economic, and institutional aspects of digitalization in the agro-industrial complex into a single analytical framework. This allows us to consider Agriculture 4.0 as a complex sociotechnical system in which performance is determined by the alignment of technologies, institutions, and management practices. This approach overcomes the fragmentation of existing research and clarifies directions for further development of the theory of digital transformation of agri-food systems. The practical significance of these results lies in their recognition of the need to shift from selectively implementing individual technologies to developing holistic digital ecosystems, including data infrastructure, platform services, regulatory mechanisms, and human capital development. For countries with emerging markets and a high share of small producers, such a systemic approach is essential for transforming digitalization from a source of structural imbalances into a tool for sustainable and inclusive development. At the same time, the study identifies several research gaps. In particular, the number of studies developing integrated models for assessing the effects of digitalization that simultaneously consider economic, environmental, and value chain indicators, as well as institutional data management regimes, remains limited. Long-term empirical studies that allow for assessing the sustainability of digitalization effects over time are also insufficient. In this regard, a promising direction for further research is the development of comprehensive analytical models that integrate indicators of productivity, sustainability, and the institutional characteristics of the digital environment, as well as comparative cross-country and longitudinal studies to identify sustainable patterns in the digital transformation of agri-food systems.

AUTHOR CONTRIBUTION

Writing – original draft: Lyailya Akhmetova, Yerzhan Domalatov.
Conceptualization: Lyailya Akhmetova, Yerzhan Domalatov, Madina Bazhigalieva.
Formal analysis and investigation: Lyailya Akhmetova, Alma Bayguzhinova, Igor Dubina.
Funding acquisition and research administration: Lyailya Akhmetova, Yerzhan Domalatov, Alma Bayguzhinova, Madina Bazhigalieva.
Development of research methodology: Igor Dubina, Yerzhan Domalatov, Madina Bazhigalieva.
Software and supervisions: Yerzhan Domalatov, Igor Dubina, Madina Bazhigalieva.
Data collection, analysis and interpretation: Alma Bayguzhinova, Madina Bazhigalieva.
Visualization: Alma Bayguzhinova, Lyailya Akhmetova, Yerzhan Domalatov, Igor Dubina.
Writing review and editing research: Yerzhan Domalatov, Igor Dubina, Alma Bayguzhinova.

CONFLICT OF INTEREST

No conflict of interest/competing interest is reported by the authors.

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AUTHOR BIOGRAPHIES

Lyailya Akhmetova – Master of Humanities Sciences, Sarsen Amanzholov East Kazakhstan University, Ust-Kamenogorsk, Kazakhstan. Email: lyailya-a@mail.ru, ORCID ID: https://orcid.org/0000-0002-3460-8634

***Yerzhan Domalatov** – PhD Candidate, Sarsen Amanzholov East Kazakhstan University, Ust-Kamenogorsk, Kazakhstan. Email: domalatovkz@gmail.com, ORCID ID: https://orcid.org/0000-0001-9955-9282

Alma Baiguzhinova – PhD Candidate, Sarsen Amanzholov East Kazakhstan University, Ust-Kamenogorsk, Kazakhstan. Email: alma.b.78@mail.ru, ORCID ID: https://orcid.org/0000-0002-3414-2213

Igor Dubina – Doc. Sc. (Econ.), Professor of the Department of Economics and Econometrics of the Altai State University, Barnaul, Russian Federation. Email: dubina@mail.asu.ru, ORCIDID:https://orcid.org/0000-0002-6241-0932

Madina Bazhigaliyeva – Master of Economics Sciences, Sarsen Amanzholov East Kazakhstan University, Ust-Kamenogorsk, Kazakhstan. Email: madina.ddn.2023@gmail.com, ORCID ID: https://orcid.org/0009-0008-6987-4327

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