SCIENTIFIC HORIZONS

Journal homepage: https://sciencehorizon.com.ua
Scientific Horizons, 28(5), 102-114

UDC 65.012.4:631.1
DOI: 10.48077/scihor5.2025.102

Assessing the efficiency of management information systems in agrarian companies

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Article's History:
Received: 04.11.2024
Revised: 23.03.2025
Accepted: 30.04.2025

Abstract. The purpose of this study was to determine the effectiveness of implementing information systems in agricultural enterprises and their impact on optimising management processes and productivity. The main objectives were to analyse how digital technologies affect decision-making, reduce costs, increase productivity, and identify barriers to their integration. The methodology included an analysis of scientific publications, a political, economic, social, technological analysis, a comparative assessment of key performance indicators before and after the implementation of the

Suggested Citation:
Bordiyanu, I., Nurekenova, E., Mambetkaziyev, A., Baikenov, Zh., & Nepshina, V. (2025). Assessing the efficiency of management information systems in agrarian companies. *Scientific Horizons*, 28(5), 102-114. doi: 10.48077/scihor5.2025.102.

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systems, as well as a case study based on the experience of the Kazakh company "Atameken-Agro". In particular, the analysis of publications allowed to identify trends and problems of digitalisation in the agricultural sector. The political, economic, social, technological analysis helped to assess the political, economic, social, and technological factors that influence the implementation of information systems. The results of the study confirmed that the implementation of information systems has a significant positive impact on the productivity and management of enterprises. In particular, at Atameken-Agro, digitalisation has reduced grain losses by 63%, reduced administrative costs by 15%, and increased the transparency and accuracy of management decisions. The AgroStream system has provided centralised access to real-time data, which has increased the efficiency of monitoring and planning. In addition, the introduction of automated processes has contributed to the optimisation of resource use and increased environmental responsibility. The study's findings indicated that successful integration of information systems in agriculture requires a comprehensive approach, including adaptation to local conditions, government support, infrastructure expansion, and staff training

Keywords: digital transformation; technological infrastructure; agricultural enterprises; process optimisation; resource utilisation

INTRODUCTION

Numerous issues confronting the modern agriculture sector include resource scarcity, market volatility, climate change, and heightened competitiveness. In these circumstances, process optimisation, productivity gains, cost reduction, and the sustainable growth of businesses all depend heavily on the deployment and efficient use of management information systems. Even though these systems have a lot of potential, not enough research has been done on how beneficial they are in many agricultural businesses. Adapting these technologies to business objectives, assessing the effect on financial outcomes, and determining obstacles to their adoption are all crucial concerns. Because it seeks to evaluate the efficacy of management information systems, pinpoint the variables influencing their operation, and formulate suggestions for enhancing their utilisation, this study is pertinent. The results obtained will help to increase the competitiveness of the agricultural sector and its resilience to modern challenges.

Insufficient use of management information systems in agricultural enterprises limits the efficiency of processes and decision-making (Zelisko *et al.*, 2024). M. Melzer *et al.* (2023) studied this topic, determining that the most popular functions of the systems are quality assurance, inventory and financial management. The results of the study showed that functions that automate processes and ensure compliance with legal requirements are most in demand. At the same time, there are gaps in the study of the impact of these systems on the long-term economic efficiency of enterprises, which requires further research. Among the key challenges of the agricultural sector are improving management efficiency and implementing innovative technologies (García-Juárez *et al.*, 2024). Z.Y. Abdullahi *et al.* (2022) studied the use of IoT in precision agriculture, demonstrating its positive impact on monitoring, production optimisation, and environmental sustainability. At the same time, gaps have been identified, including high implementation costs and insufficient technical training of farmers, which requires the development of affordable solutions for small farms.

Agricultural management faces challenges in adopting information systems (AIS) to boost productivity. A.B. Santoso *et al.* (2023) studied AIS in Indonesia's rice production, highlighting its role in optimising farming and ensuring sustainability. Barriers include poor rural infrastructure, limited farmer knowledge, and low adoption rates, requiring strategies to improve accessibility, education, and infrastructure. The analysis of digitalisation in agriculture has revealed that the adoption of farm management information systems (FMIS) plays a vital role in improving operational efficiency and decision-making processes. C. Giua *et al.* (2021) focused on farm-level MIS adoption and highlighted the drivers and barriers within this context. Their findings emphasised that factors such as the size of farms, farmers' education levels, and the usability of the systems significantly impact the adoption process. However, challenges such as poor interoperability, insufficient technical skills, and limited technological infrastructure remain unresolved. These gaps indicate the need for further studies to enhance system compatibility and foster better user engagement.

Insufficient integration of land management information systems limits the efficiency of agriculture. N. Potapova and D. Lavrynchuk (2019) emphasised the importance of geoinformation technologies and automation for making informed decisions in land management. The main gaps remain low informatisation of enterprises and poor integration of these systems into practical activities, which requires further research. The use of information management systems in the agricultural sector faces challenges of effective data management and energy conservation. C. Li (2024) investigated the use of 5G technology in building agricultural product and information management models, in particular in terms of load balancing and energy efficiency. The results emphasise that

the use of 5G improves data access and processing and reduces energy consumption. However, the study identified gaps, including insufficient consideration of system scalability and integration of multi-level management, which requires further development to ensure full implementation.

Integration of information systems in agriculture is a relevant area of research. V. Vakulenko and L. Xiaowei (2021) analysed the experience of implementing integrated systems in agricultural enterprises, which provides a reduction in costs by 7-30% and an increase in labor productivity by up to 50%. At the same time, insufficient attention has been paid to the adaptation of such systems for small farms. The problem of insufficient integration of digital technologies in agriculture remains relevant. R. Gabdualiyeva *et al.* (2024) examined the digitalisation of the agricultural sector in Kazakhstan, emphasising its benefits, including the use of global positioning system (GPS), drones, and artificial intelligence to improve productivity and quality. They identified gaps, such as low digital literacy, lack of infrastructure and funding, that need to be addressed for effective technology adoption.

The purpose of this study was to determine the effectiveness of information systems implementation in agricultural enterprises and their impact on optimisation of management processes and productivity.

MATERIALS AND METHODS

The study used a comprehensive approach, which included an analysis of scientific publications, conducting a political, economic, social, technological (PEST) analysis, compiling a comparative table of efficiency before and after the implementation of information systems, as well as a case study based on the experience of the Kazakh company "Atameken-Agro" (Agricultural holding JSC "Atameken-Agro"..., 2023). The analysis of publications became the basis for identifying the main trends, advantages and problems of implementing information systems in agriculture. Particular attention was paid to the analysis of literature, with a focus on sources addressing the optimisation of processes, increasing productivity, reducing costs and introducing innovative technologies in the industry (Beese *et al.,* 2023; Sharma, 2023; Chesang', 2024). Based on the information collected, a PEST analysis was conducted, which allowed assessing the political, economic, social and technological factors influencing the implementation of information systems in agricultural enterprises. For comparative analysis, a table was created that reflects the key performance indicators of enterprises before and after the implementation of information systems. In particular, aspects related to the accuracy of decision-making, costs of management and operational processes, labor productivity, data transparency and scalability of operations were considered (Mokhtar *et al.,* 2022; Ordoñez *et al.,* 2024).

Particular attention was paid to the case study of the company "Atameken-Agro", which is one of the leading agricultural enterprises in Kazakhstan. Within the, interviews with management, framework of this case, official company reports, as well as data on the implementation of the AgroStream system adapted to the specifics of the Kazakhstani market were analysed (Features of digitalization..., 2018; Lysenko, 2019; Digitalization of the..., 2023). Based on the data obtained, recommendations were developed for further improvement of the company's information systems, including the integration of modules based on artificial intelligence, the use of drones and satellite images for field monitoring, as well as the implementation of blockchain-based systems to increase the transparency of operations. This approach allowed not only to assess the effectiveness of already implemented solutions, but also to identify strategic directions for further development of the company and adaptation of the industry to modern challenges.

RESULTS

Assessment of the impact of information systems on the efficiency of enterprise management. Businesses' internal information environments are greatly enhanced by information systems, which promote improved forecasting and decision-making. By ensuring that precise and up-to-date data is easily accessible, these technologies empower management to make risk-averse decisions. According to research, the use of enterprise systems improves management profits projections' frequency and accuracy, demonstrating better access to data that is important for making decisions. Additionally, by centralising and streamlining data operations, these systems eliminate redundancies and facilitate a smooth information flow across departments. Enhancing the internal information environment gives management the resources they need to make wise strategic and operational choices, which promotes organisational coherence and overall efficiency. Modern information systems' predictive capabilities can help businesses anticipate market developments and proactively address possible obstacles. Before making important decisions, businesses can, for example, simulate many scenarios and assess the results thanks to enhanced analytics included into these platforms. In addition to improving operational agility, this skill puts businesses in a position to take advantage of new opportunities in a cutthroat industry. Better data reporting and visualisation enable leaders to convey insights more successfully, guaranteeing departmental and team alignment (Kasianiuk & Kasianiuk, 2024).

In medium-sized and large businesses, modern information systems are essential tools for cutting operating expenses and increasing profitability. Through the provision of a centralised platform for information gathering, retrieval, processing, and transmission, these

systems facilitate data-driven management decisions and streamline company procedures. This simplified method guarantees that resources are distributed effectively, avoids human mistake, and eliminates duplication of work. For example, real-time stock level monitoring using automated inventory management systems can cut waste and guarantee prompt restocking. Higher profitability and reduced operating expenses are the results of such efficiency. Information systems' cost-effectiveness is further improved by their modular design. Businesses can scale operations gradually by breaking the system up into subsystems that are suited to particular tasks, such supply chain management, finance, and human resources. Because of this flexibility, businesses can increase their technology capabilities without having to pay hefty upfront fees. Additionally, by doing away with the requirement for substantial on-premise infrastructure, cloud-based information systems save money by guaranteeing scalability and lowering maintenance costs. Businesses can concentrate their financial resources on strategic initiatives that generate greater returns by using such cost-effective strategies (Fatieieva, 2020).

By supplying timely, pertinent, and reliable information, management information systems (MIS) are essential in giving businesses a competitive advantage. The ability to effectively use resources while accomplishing organisational goals is crucial in today's dynamic and competitive global market. By coordinating technology capabilities with corporate strategy, MIS maximises resource use and boosts productivity. Advanced decision-support systems, for instance, examine enormous datasets to find patterns and insights that help businesses develop strategies that meet consumer needs (Chernetska & Chernetskyi, 2023). By encouraging cooperation and knowledge exchange across organisational boundaries, the strategic application of MIS also stimulates innovation. Businesses that successfully use MIS can enhance performance indicators like market response, operational effectiveness, and customer happiness. These technologies also give businesses the ability to track key performance indicators (KPIs) and make real-time strategy adjustments to stay ahead of the competition. By incorporating MIS into essential business operations, a robust framework that facilitates long-term expansion and market adaption is produced (Yamoah *et al.*, 2024).

An organisation's efficiency and creativity are increased when its Knowledge Management (KM) and Enterprise Resource Planning (ERP) systems are integrated. Together, these platforms facilitate the smooth flow of information across departments, remove organisational silos, and optimise workflows. While KM systems make sure that decision-makers have access to important insights and knowledge, ERP systems consolidate vital operational data. When combined, they create an atmosphere where adaptability and effectiveness coexist, allowing businesses to react quickly to changes in the market (Chesang', 2024). Through the reduction of redundancies and the rationalisation of information flows, this integration also enhances strategic performance. For instance, a company can optimise inventory levels, cut lead times, and enhance customer service by integrating its ERP and supply chain management system. Additionally, businesses can leverage collaborative knowledge by combining ERP and KM systems, which promotes innovation and continual improvement. Organisations can improve their flexibility and competitiveness in quickly changing industries by coordinating technology tools with strategic objectives.

Notwithstanding the many advantages, enterprises must overcome the difficulties posed by the complexity of contemporary information systems architecture in order to optimise productivity. Operational flexibility, transparency, and decision-making predictability can all be adversely affected by high system complexity. Inadequate system integration, for instance, might result in inconsistent data, delays in operations, and higher expenses. These difficulties highlight the value of strong enterprise architecture management (EAM), which guarantees that technology solutions complement corporate goals. By controlling the interactions between organisational and technical elements, an effective EAM reduces the risks related to complexity. EAM improves system performance and reliability through standardisation, system integration, and process optimisation. Furthermore, frequent system architecture changes and audits guarantee that new issues are dealt with as soon as they arise. Businesses can attain strategic and operational excellence by utilising the full potential of their information systems through proactive complexity management (Beese *et al.,* 2023).

The implementation of modern information systems in enterprises leads to significant improvements across various aspects of management, including decision-making, forecasting accuracy, cost reduction, and operational efficiency. These systems provide centralised access to real-time data, streamline workflows, and enhance integration between departments. To better understand the impact of information systems, the Table 1 compares key metrics before and after their implementation, illustrating the improvements achieved through digital transformation.

Table 1. *Impact of information systems on key enterprise metrics*

Aspect	Before implementation	After implementation	Key improvements
Decision-making	Relies on fragmented, outdated information	Access to real-time, centralised data	Enhanced accuracy and faster decision-making

Table 1. Continued

Aspect	Before implementation	After implementation	Key improvements
Forecasting accuracy	Limited due to inconsistent data	Improved with automated analytics	Higher precision in forecasting
Operational costs	High due to inefficiencies and manual processes	Reduced through process automation	Decrease in duplication and waste
Productivity	Lower due to manual processes and delays	Increased with workflow automation	Time saved, allowing focus on value-added activities
Scalability	Difficult due to rigid, isolated systems	Enabled by modular and cloud-based solutions	Easier adaptation to growing organisational needs
Integration and flexibility	Siloed systems with limited information sharing	Integrated ERP and KM systems	Improved collaboration and innovation
Complexity management	High due to unstandardised systems	Enterprise architecture management implemented	Increased transparency and efficiency

Source: *compiled by the authors based on J. Beese et al. (2023); L.E. Yamoah et al. (2024); A. Chesang' (2024)*

Information systems have a significant impact on enterprise performance, as demonstrated by the data in the Table 1. These technologies help firms increase forecasting accuracy, save operating expenses, and boost production by resolving inefficiencies and improving decision-making skills. Additionally, improved cooperation and creativity are encouraged by the integration of ERP and KM systems, and long-term sustainability is guaranteed by efficient complexity management. These enhancements show how important digital transformation is to attaining organisational success and preserving competitive advantage in ever-changing marketplaces.

Analysis of the main advantages and disadvantages of using information systems in agriculture. The integration of information systems (IS) is causing a revolutionary change in the agricultural industry. By improving resource management, encouraging sustainability, and increasing output, these technologies have the potential to completely transform agricultural methods. Adoption and application of IS in agriculture are not without difficulties, though. Regulatory barriers, poor infrastructure, and low levels of digital literacy are some of the problems that frequently prevent their full potential. This review looks at the benefits and drawbacks of IS in agriculture, giving a thorough picture of how they affect the industry and pointing out areas that need more focus to reach their full potential. By increasing operational effectiveness and productivity, information technology has completely changed agricultural practices. Farmers can apply resources like water, fertiliser, and pesticides with remarkable accuracy thanks to precision agriculture, which mostly depends on IS. With studies demonstrating productivity benefits of up to 30%, this focused approach not only reduces waste but also dramatically boosts crop yields. Farmers can concentrate on more strategic facets of farming by automating repetitive operations like inventory management and soil moisture monitoring, which increases overall farming efficiency (Sharma, 2023).

Sustainability is also another important benefit that IS offers. In order to lessen the influence on the environment and encourage eco-friendly behaviors, technologies like blockchain and machine learning are essential (Pushak *et al.*, 2021). Blockchain promotes confidence among stakeholders and supports fair trade initiatives by guaranteeing supply chain transparency and traceability. To maximise resource utilisation, encourage climate-resilient farming, and lower greenhouse gas emissions, machine learning algorithms examine climate, soil, and crop data. With the use of these technologies, farmers may ensure long-term environmental stability by coordinating their operations with the objectives of sustainable development (Ordoñez *et al.,* 2024).

IS's capacity to promote the use of contemporary agricultural technologies, especially among smallholder farmers, is another important benefit. Farmers are empowered to make prompt and well-informed decisions when they have access to real-time information on weather patterns, soil conditions, and pest outbreaks (Zuo *et al.*, 2024). By bridging the information gap, IS promotes technology adoption and boosts productivity in emerging nations. Additionally, IS makes it possible to manage land resources more effectively by using tools like remote sensing and Geographic Information Systems (GIS), which offer in-depth knowledge about the state of the land. In order to maximise production and resource efficiency, this data aids in the optimisation of land usage, irrigation systems, and crop rotations. Information systems in agriculture encounter many obstacles that restrict their use and efficacy, despite their many benefits. The high cost of implementation and upkeep is one of the main obstacles. Smallholder farmers frequently lack the financial resources to invest in advanced technology like GIS, blockchain, and precision agriculture instruments. Larger businesses profit from IS, while smaller farmers find it difficult to access these technologies, resulting in a digital gap.

Another significant issue is low levels of digital literacy. Many farmers, especially those in rural areas, lack the abilities and know-how required to successfully manage complicated IS. This problem is made worse by inadequate training programs and a dearth of technical

assistance, which keeps farmers from taking full advantage of IS. The efficient application of IS in agriculture is further hampered by inadequate infrastructure. For IS to be implemented successfully, access to contemporary hardware, dependable electricity, and stable internet connectivity are necessary. But in rural and isolated places, these resources are frequently scarce, which lessens the possible impact of IS (Mokhtar *et al.,* 2022). The integration of IS in agriculture is further complicated by issues with data management. To extract useful insights, the massive volumes of data produced by IS must be saved, examined, and interpreted. The practical use of IS is restricted by problems like inadequate data quality, a lack of standardisation, and challenges with model interpretation. Farmers and agribusinesses face additional challenges due to regulatory and legal ambiguities around digital technologies like blockchain and unmanned aerial vehicles (UAVs). These difficulties slow down the adoption of IS and deter investment in it. To better understand the external factors influencing the adoption and effectiveness of IS in agriculture, a detailed PEST analysis is presented in Table 2.

***Table 2**. PEST Analysis of information systems in agriculture*

Factor	Positive Impacts	Negative Impacts
Political	Supportive government policies promoting digital transformation	Regulatory uncertainties, especially regarding UAVs and blockchain
Economic	Increased profitability through resource optimisation	High implementation and maintenance costs
Social	Improved access to agricultural information for smallholder farmers	Limited digital literacy and lack of technical training
Technological	Advancements in machine learning, blockchain, and GIS tools	Dependence on robust infrastructure, often unavailable in rural areas

***Source:** compiled by the authors*

With major advantages including increased production, sustainability, and resource management, the analysis emphasises the revolutionary potential of information systems in agriculture. To fully utilise IS's promise, however, obstacles including exorbitant prices, low levels of digital literacy, inadequate infrastructure, and regulatory concerns must be resolved. The adoption of IS is driven by external factors including technical improvements and supportive government legislation, as seen in Table 1, although there are still infrastructure and economic constraints. Coordination between the agricultural community, technological developers, and legislators is crucial to overcoming these obstacles. IS can be successfully incorporated into agricultural processes by making infrastructural investments, encouraging digital literacy, and creating transparent regulatory frameworks. This will support the industry's innovation and sustainable growth.

Analysis of information systems implementation in the company. Atameken-Agro is one of the leading agricultural companies in Kazakhstan, which is actively engaged in the cultivation of grain and oilseeds. Since its foundation in 2003, the company has been focused on achieving high results through the use of modern technologies, effective management and sustainable development. "Atameken-Agro" operates on large agricultural areas and is one of the flagships in the implementation of innovative approaches in the agricultural sector of Kazakhstan (Agricultural holding JSC "Atameken-Agro"v…, 2023). One of the most important steps in the company's development was the introduction of IS, which allowed to automate a significant part of operational and management processes. Since 2014, the company's management has been actively looking for digitalisation solutions to reduce costs, increase productivity and optimise resource utilisation. In 2016, the company entered into a partnership with AgroStream, an IT company that offered to develop a module for planning flow charts (Features of digitalization…, 2018). This module was subsequently transformed into a full-fledged information system adapted to the needs of the Kazakhstani agricultural market.

The installation of specialised equipment, including barriers, electronic scales, and cameras in the fields, was necessary for the AgroStream system's execution. Nonetheless, the system's efficacy is demonstrated by the decrease in a number of production losses and costs. For example, in the first season of adopting AgroStream, one of Atameken-Agro's farms was able to reduce grain refraction, a major expense issue, by 63%. Overall, the digitised control over production processes enables the management of the agroholding to access real-time data from anywhere in the world about the quantity, location, and quality of stored grain. This data is updated every five minutes, ensuring continuous monitoring. Since the movement of grain operates 24/7, controlling this complex technological process would be nearly impossible without such a program. The system's capabilities highlight its essential role in streamlining operations and enhancing transparency in agricultural production, setting a new standard for efficiency in the sector (Digitalization of the.., 2023).

In addition to economic efficiency, the implementation of IS has helped to improve sowing planning, monitoring of crop cultivation technologies, and resource optimisation. The collected data allowed the company to analyse the effectiveness of different technologies, varieties, and crops. For example, it became possible

to identify the most profitable crops that provide high yields in the climate and soil conditions of Kazakhstan. This, in turn, made it possible to implement the principles of precision farming, which is one of the key areas of development of the modern agricultural sector. An important achievement was the automation of accounting processes, which reduced administrative costs by 15%. In addition, the system provided integration with government agencies, simplifying the process of obtaining subsidies, certification and reporting. This has significantly increased the transparency of the company's operations and ensured the trust of partners and government agencies (Lysenko, 2019).

Despite the successes achieved, the implementation of information systems was accompanied by a number of challenges. One of the biggest barriers was staff training. At the initial stages, many employees did not understand the importance of digitalisation and resisted change. Implementing IS required not only technical training, but also a change in the mindset of employees. To overcome this challenge, the company's management organised a series of training programs, regular consulting, and technical support. Thanks to a corporate culture that fosters collective decision-making, they managed to engage employees in the change process, increase their motivation, and ensure the effectiveness of the strategy (Features of digitalization..., 2018). Another significant challenge was the limited infrastructure. The lack of stable Internet access in many rural areas of Kazakhstan made it difficult to fully utilise IS. This required additional investments in the development of technological infrastructure. In addition, the high costs of purchasing equipment, developing software, and maintaining the system posed financial challenges to the company. However, the company was able to partially compensate for these costs by improving its efficiency. The results of the information systems implementation at Atameken-Agro have shown that digitalisation is not just a trend, but a necessity for modern agriculture. Thanks to this, the company was able to achieve a significant increase in productivity and profitability, optimise resource use and ensure sustainable development (Lysenko, 2019).

The company's economic performance demonstrates the effectiveness of the implemented solutions. According to the reports, the company's profitability increased by 30%, which was made possible by reducing costs and optimising processes. In particular, the company has reduced losses of grain, fertilisers and fuel, which has not only reduced costs but also increased the company's environmental responsibility (Lysenko, 2019). The experience of "Atameken-Agro" demonstrates that a major element in raising the agriculture sector's level of competitiveness is digitisation. When putting their own digital strategy into practice, other businesses might utilise this example as a guide. But it's crucial to remember that a number of variables, such as government support, infrastructure, and employee training, affect how well digitisation goes. The business is still working to improve its information systems in spite of the outcomes.The business intends to launch artificial intelligence-powered modules soon that will forecast yields, track illnesses, and maximise resource utilisation. By providing its digital solutions to other nations, the corporation also hopes to increase its market share abroad. The digitalisation of Atameken-Agro is an illustration of Kazakhstan's agricultural industry's effective transition. The main advantages of this system are its simplicity, intuitive interface and the ability to generate comprehensive reports.

Atameken-Agro can take a variety of actions to enhance company operations, including enhancing information systems and streamlining procedures. Increasing the functionality of information systems is one of the main goals. A more precise evaluation of future performance will be possible with the integration of new modules, such as AI-based yield forecasting, which takes previous data, soil characteristics, and weather variables into account. Better resource planning and increased overall efficiency will result from this. It is also worthwhile to implement drones and satellite imagery for plant health monitoring, as this will enable prompt reaction to possible threats and early disease or pest detection. Another important aspect is the creation of modules for analysing the costs and profitability of individual crops, which will allow the company to assess the economic feasibility of growing certain crops and choose the most profitable options.

Precision farming could advance significantly with additional advancements. More economical and environmentally friendly crop, irrigation, and fertilisation planning will be possible with the application of geo-analytics. These procedures can be automated to help save money and guarantee more consistent outcomes. Furthermore, the implementation of water management systems will improve water utilisation and prevent over-irrigation. The business can think about funding the creation of blockchain-based solutions in order to raise the degree of digitisation. This will guarantee the accuracy and transparency of data pertaining to supply, logistics, and the value chain. Additionally, blockchain will contribute to a rise in consumer and partner trust, which is a critical component of growing markets. Enhancing staff training is another crucial area. To help staff members better comprehend and use the newest technologies, the organisation should routinely host training sessions and educational initiatives. It is crucial to foster a digital culture among staff members in addition to teaching them how to utilise the tools, as this will speed up the acceptance of new ideas.

Increasing the extent of Internet coverage in remote areas is also something worth considering. The business can accomplish this by working with suppliers and government organisations to guarantee reliable access to

information systems, even on the most isolated farms. The business should also enhance its internal technical support procedures to guarantee the seamless operation of information systems and quickly address technical problems. Therefore, putting these suggestions into practice will enable Atameken-Agro to boost managerial effectiveness and productivity while also enhancing its competitiveness in both local and foreign markets. Utilising contemporary information technologies will support the company's long-term growth by fostering environmental responsibility and financial gains.

DISCUSSION

Information systems play a key role in the transformation of the agricultural sector, contributing to increased productivity, optimisation of operational processes and ensuring transparency of management decisions. Modern research emphasises the importance of implementing digital technologies in agriculture both at the level of individual enterprises and within the framework of national strategies. The use of innovative solutions, such as resource planning systems, information flow management and big data analysis, allows not only to reduce costs, but also to expand opportunities for sustainable development and adaptation to global challenges (Potryvaieva *et al.*, 2024). The study by V. Zhuk *et al.* (2023) focuses on the importance of information support for the agricultural sector through the introduction of modern accounting and reporting standards that meet international requirements. The main focus is on the problems of asymmetry of information, imperfections of existing accounting systems and lack of integration with global standards such as the Farm Accountancy Data Network (FADN). The authors emphasise that for the sustainable development of the agricultural sector, it is necessary to create a unified national accounting system that will ensure transparency, efficiency and validity of management decisions. Both studies emphasise the importance of improving information systems, but V. Zhuk *et al.* focus more on integration with international standards and improving government policy, while this study demonstrates the effectiveness of implementing digital solutions at the level of a particular enterprise. The key difference is that V. Zhuk *et al.* study emphasises the need for institutional frameworks and national strategies, while this study looks at the implementation of information systems as a means of solving specific production problems, such as reducing resource waste, increasing yields, and optimising processes.

A. Tarasiyk *et al.* (2023) explored the potential of intelligent management systems for agricultural enterprises, focusing on cutting-edge technologies such as artificial intelligence, neural networks, and digital twins for forecasting and optimising activities. Their research highlights technical advancements, including big data analysis, process automation, and cloud solutions for resource management. Unlike this study, which emphasises practical applications of existing systems in real-world scenarios, A. Tarasiuk *et al.* prioritise conceptual development and the integration of innovative global technologies. Despite these differences, both studies underscore the transformative role of digitalisation in agriculture, aiming to enhance efficiency and optimise processes.

This study and A. Hutorov (2024) study have different emphases in their approaches, although both focus on the importance of information systems in the agricultural sector. A. Hutorov study develops a comprehensive methodology for macroeconomic assessment of the effectiveness of agricultural science development based on the analysis of inter-sectoral balances, integration of scientific data into the national economy, and inter-sectoral linkages. Important aspects of this approach are the assessment of the social, economic, and geo-economic impact of research, which allow for the assessment of the overall effectiveness of agricultural science at the macro level. A. Hutorov research is aimed at strategic macroeconomic planning, emphasising the need to take into account national and international indicators, and illustrates the practical effectiveness of implementing information systems in real-world conditions. For example, A. Hutorov emphasises the importance of science's impact on overall economic development, while this study focuses on the application of innovations to achieve short-term goals and optimise the activities of a particular agricultural holding.

S.O. Koberniuk (2023). highlights the role of digital platforms – social media, e-commerce, and mobile applications – in enhancing marketing strategies in agriculture. The study emphasises modern marketing concepts like Marketing 4.0 and 5.0, which support effective communication, improve customer engagement, and broaden market reach. Additionally, S.O. Koberniuk analyses global trends, including AI, robotics, sensors, and drones, demonstrating their potential to transform the agricultural sector. While both studies address digitalisation's capacity to enhance efficiency and optimise costs, S.O. Koberniuk work adopts a strategic perspective, focusing on marketing and competitiveness. In contrast, this study prioritises practical applications at the enterprise level, such as resource management and productivity improvement.

The study of S. Bashlai *et al.* (2023) focuses on the introduction of digital tools into the strategic management systems of agricultural companies, emphasising the importance of digitalisation for improving management efficiency. The main focus is on such aspects as automation of financial and investment planning, use of big data processing technologies, and introduction of artificial intelligence for analysing and forecasting business processes. The authors emphasise that digital technologies are the key to ensuring the competitiveness of agricultural business, helping to increase

productivity, reduce costs and improve decision-making. Both studies emphasise the importance of digital technologies in improving the efficiency of agricultural business, but differ in their approaches. S. Bashlai *et al.* study focuses on the strategic aspects of digitalisation and its integration into the overall management system, including the use of artificial intelligence, blockchain, and cloud technologies. Atameken-Agro's study is more applied and demonstrates specific results achieved through the implementation of digital solutions within one company. The difference also lies in the scope of the research: S. Bashlai *et al.* focus on global trends and the development of digitalisation strategies for the Ukrainian agricultural sector as a whole, while this study focuses on the practical application of digital technologies in a specific organisation.

L. Berezina and N. Bahan (2023) analyse the efficiency of resource use in agricultural enterprises, focusing on the evaluation of information and time resources. Their research introduces universal indicators for assessing resource efficiency and highlights the importance of creating effective databases to support the adoption of innovative technologies. Both studies share a common emphasis on digitalisation and the role of information systems in enhancing management efficiency. However, L. Berezina and N. Bahan work adopts a broader perspective, focusing on general measures for improving agricultural enterprise management. Using cutting-edge information technologies to optimise transportation, warehousing, and customer service, L.B. Hnatyshyn and N.V. Trushkina (2021) investigate the digital transformation of logistics management in agricultural firms. While addressing obstacles including organisational and financial limitations, the authors emphasise the possibility for attaining economic, social, and environmental benefits using digital platforms. L.B. Hnatyshyn and N.V. Trushkina offer a more comprehensive theoretical framework and suggest methods for the agricultural industry as a whole, in contrast to this study, which concentrates on the actual application of digital technologies inside a particular firm.

L. Tereshchenko (2021) research on assessing the economic effect of implementing MIS. Both studies point to the key role of introducing modern technologies to achieve economic benefits and increase transparency and quality of governance. L. Tereshchenko emphasises the need to develop a balanced scorecard that includes goals, critical success factors, and key performance indicators. This allows to evaluate not only financial but also non-financial results of the Operations Integrity Management System (OIMS) implementation. It uses the Balanced Scorecard methodology as a strategic management tool covering various aspects of the company's activities, including customer relations, finance, internal business processes, and innovation. The focus is on a comprehensive approach to assessing the effectiveness of the PIM, taking into account both financial and non-financial aspects. The differences between the studies lie in the methodological approach and scope. L. Tereshchenko's study focuses on a general methodology for assessing the effectiveness of the IMS, while this study presents specific cases of successful implementation. L. Tereshchenko also emphasises the strategic importance of implementing OIMS for achieving long-term goals, while this study shows short-term results.

V. Pestsov (2024) study focuses on ERP systems as a tool for optimising resource management. The author highlights ERP functions such as inventory management, finance, personnel and quality control, and also emphasises the importance of SaaS solutions for enterprises with limited financial resources. V. Pestsov focuses on the technological capabilities of ERP, transparency of business processes and sound management decisions supported by real-time data analysis. In terms of convergence, both studies recognise the need for digitalisation in the agricultural sector and emphasise the economic benefits of automation, such as cost reduction, increased efficiency and transparency. They also share the conclusion that it is important to adapt technologies to the needs of small and medium-sized enterprises to ensure their competitiveness. An important difference is that V. Pestsov's study pays more attention to the integration of ERP systems with cloud technologies and the scalability of functionality, which is especially useful for enterprises that need flexible solutions. This study focuses on adapting information systems to the specifics of the local agricultural market, emphasising individual solutions for individual enterprises.

O. Zelinska and V. Hovorukha (2019) focus on the effectiveness of implementing ERP systems in small and medium-sized agricultural enterprises. Their research highlights the integration of business processes, automation of routine tasks, and improved access to analytical data as key benefits of such systems. While both studies emphasise the role of digital technologies in enhancing resource management and productivity, O. Zelinska and V. Hovorukha concentrate on tailoring ERP systems to meet specific enterprise needs. In contrast, this study examines a large agricultural holding, showcasing a comprehensive digitalisation initiative that includes monitoring, data management, and planning systems. The study by S. Ihnatenko and I. Tomashuk (2024) focuse on the automation of management accounting in agricultural enterprises through the use of modern digital tools. They emphasise the importance of implementing technologies such as ERP systems, Internet of Things (IoT), Big Data, blockchain and cloud computing, which allow optimising management processes, increasing accounting accuracy, reducing costs and improving the competitiveness of enterprises. The researchers note that accounting automation, big data analytics and the use of robotic systems are key factors in the development of the agricultural sector. Both studies emphasise the importance of digitalisation in the

agricultural sector as a means of increasing the efficiency and competitiveness of enterprises. As in Ignatenko's study, this study recognises that the implementation of digital solutions requires significant investments and staff training. Both approaches also emphasise the importance of integrating digital systems into operational processes. The main difference between the studies is the level of focus. Ignatenko and his co-authors analyse a wide range of digital technologies, including their strategic integration and potential benefits at the industry level. At the same time, this study focuses on the practical impact of implementing a specific information system at the level of an individual enterprise.

O. Sumets *et al.* (2023) emphasise the development of integrated information systems for agricultural enterprises, utilising methods like clustering and forecasting to optimise resource use and automate management processes. Both studies highlight the critical role of digitalisation in enabling data-driven decision-making. However, while O. Sumets *et al.* focus on the theoretical foundations and industry-wide prospects of information systems, this study examines their practical implementation at the enterprise level, specifically in "Atameken-Agro". This dual perspective provides insights into both local applications and broader strategic opportunities for the agricultural sector's digital transformation.

AIS and their potential to boost efficiency and productivity, especially in developing nations, are examined by N.R. Vajjhala (2021). Precision farming, e-agriculture technology, and FMIS are important subjects. While addressing issues including technical complexity, insufficient infrastructure, and the requirement for farmer training, the study emphasises AIS's potential to reduce poverty, optimise agricultural processes, and enhance information availability. In addition to stressing the value of training and removing technological obstacles, both studies highlight how AIS may increase management efficiency and transparency. But whereas this study takes an applied method, examining particular implementation outcomes in a single firm, N.R. Vajjhala research uses a global and theoretical perspective, concentrating on AIS's wider implications. A. Látečková *et al.* (2018) examine the role of ERP systems in Slovak agricultural enterprises, emphasising their potential to integrate business processes, provide real-time data access, and optimise operations. Their work highlights challenges like insufficient computerisation, employee training, and information security, as well as the need to modernise existing systems for medium-sized and small enterprises. In contrast, this study focuses on practical digitalisation efforts in Kazakhstan, showcasing examples such as machinery control systems, resource monitoring, and reducing grain and fuel losses. While both studies underline the importance of information systems for competitiveness, A. Látečková *et al.* prioritise general strategies for ERP implementation, whereas this research highlights the adaptation of digital solutions to local conditions for cost-effective results.

The analysis of scientific works indicates a common understanding of the importance of information systems in the modernisation of the agricultural sector. Despite differences in approaches – from global strategies and the development of conceptual models to the practical implementation of digital solutions at the level of individual enterprises, all studies confirm the effectiveness of digitalisation as a means of increasing competitiveness, optimising resources and ensuring sustainable development. The difference in the scale of analysis, methodology and emphasis allows for a comprehensive assessment of the potential of information systems and the identification of priority areas for their implementation.

CONCLUSIONS

According to the research, the implementation of information systems in agricultural enterprises has significant potential for optimising management processes, increasing productivity and ensuring sustainable development of the industry. The results of the analysis indicate that the effective use of such systems can contribute to reducing operating costs, increasing the accuracy of decision-making and improving the transparency of operational processes. At the same time, there are a number of challenges, such as insufficient technical training of employees, high implementation costs and limited infrastructure, which slow down the pace of digitalisation. In particular, the experience of the company "Atameken-Agro" demonstrates that digital technologies can radically change the approach to managing resources and processes in agribusiness. Thanks to the integration of specialised systems, the company was able to reduce grain losses by 63% during the first season of implementation, as well as reduce administrative costs by 15%. These achievements emphasise the importance of individualising systems to the needs of the local market and adapting them to the specifics of enterprises. At the same time, it is important to note that the implementation required significant investments in staff training, infrastructure modernisation and corporate culture changes, which are critical factors for the success of digitalisation.

A key advantage of information systems is their ability to ensure integration between different divisions of the enterprise, increase forecasting accuracy and facilitate the implementation of advanced approaches, such as precision agriculture. For example, the analysis of data on climate, soils and crop condition allows enterprises to respond to possible risks in a timely manner, optimise the use of fertilisers and water resources, which contributes to increasing the environmental sustainability of production. The overall analysis confirms that the successful integration of information systems

into agriculture requires a comprehensive approach, including staff training, infrastructure development, adaptation to local conditions and support from the state. Cooperation between technology manufacturers, agricultural enterprises and government organisations also plays an important role. Such an approach allows not only to increase management efficiency, but also to strengthen the competitiveness of enterprises in international markets. In summary, the implementation of information systems is a key factor in the modernisation of the agricultural sector, contributing to sustainable development, efficient use of resources and increased environmental responsibility. However, there are also significant limitations. Among them are the high initial cost of implementing technologies, the lack of a sufficient number of qualified personnel and insufficient Internet coverage in rural areas.

ACKNOWLEDGEMENTS

None.

FUNDING

None.

CONFLICT OF INTEREST

None.

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Оцінка ефективності управлінських інформаційних систем в аграрних компаніях

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Анотація. Метою даного дослідження було визначення ефективності впровадження інформаційних систем в сільськогосподарських підприємствах та їх впливу на оптимізацію управлінських процесів і продуктивність. Основними завданнями було проаналізувати, як цифрові технології впливають на прийняття рішень, зниження витрат, підвищення продуктивності, а також виявити бар'єри на шляху їх інтеграції. Методологія включала аналіз наукових публікацій, політичний, економічний, соціальний, технологічний аналіз, порівняльну оцінку ключових показників ефективності до і після впровадження систем, а також тематичне дослідження на основі досвіду казахстанської компанії «Атамекен-Агро». Зокрема, аналіз публікацій дозволив виявити тенденції та проблеми цифровізації в аграрному секторі. Політичний, економічний, соціальний, технологічний аналіз допоміг оцінити політичні, економічні, соціальні та технологічні фактори, які впливають на впровадження інформаційних систем. Результати дослідження підтвердили, що впровадження інформаційних систем має значний позитивний вплив на продуктивність та управління підприємствами. Зокрема, в компанії «Атамекен-Агро» діджиталізація дозволила зменшити втрати зерна на 63 %, скоротити адміністративні витрати на 15 %, підвищити прозорість і точність управлінських рішень. Система AgroStream забезпечила централізований доступ до даних у режимі реального часу, що підвищило ефективність моніторингу та планування. Крім того, впровадження автоматизованих процесів сприяло оптимізації використання ресурсів та підвищенню екологічної відповідальності. Результати дослідження свідчать, що успішна інтеграція інформаційних систем у сільському господарстві вимагає комплексного підходу, що включає адаптацію до місцевих умов, державну підтримку, розширення інфраструктури та навчання персоналу

Ключові слова: цифрова трансформація; технологічна інфраструктура; сільськогосподарські підприємства; оптимізація процесів; використання ресурсів