Received: 19.03.2024. Revised: 30.05.2024. Accepted: 27.06.2024.

EKONOMIKA APK

https://doi.org/10.32317/2221-1055.2024030.10

Ekonomika APK, 31(3), 10-21

UDC 338.2

Improving business processes in the agricultural sector considering economic security, digitalization, risks, and artificial intelligence

Nataliia Zelisko*
PhD in Economic Sciences, Associate Professor
Lviv National Environmental University
80381, 1 V. Velykyi Str., Dubliany, Ukraine
https://orcid.org/0000-0002-2467-5585

Nataliia Raiter
PhD in Economic Sciences, Associate Professor
Lviv National Environmental University
80381, 1 V. Velykyi Str., Dubliany, Ukraine
https://orcid.org/0000-0002-7108-2539

Nataliia Markovych
PhD in Economic Sciences, Associate Professor
Lviv National Environmental University
80381, 1 V. Velykyi Str., Dubliany, Ukraine
https://orcid.org/0000-0001-6725-1355

Halyna Matskiv
PhD in Economic Sciences, Associate Professor
Lviv National Environmental University
80381, 1 V. Velykyi Str., Dubliany, Ukraine
https://orcid.org/0000-0002-1329-7355

Orysia Vasylyna
PhD in Economic Sciences, Associate Professor
Lviv National Environmental University
80381, 1 V. Velykyi Str., Dubliany, Ukraine
https://orcid.org/0000-0003-2124-3792

▸ **Abstract.** The study aimed to address ways to improve the efficiency of agribusiness through the introduction of modern technologies and innovative approaches. The methods of quantitative and qualitative analysis of financial indicators, analytical reviews, and specific examples of technology implementation were used to achieve this goal. The study emphasises the impact of digitalisation of the agricultural sector on improving economic security, efficiency and competitiveness. The introduction of digital technologies, such as the Internet of Things, process automation and precision farming, is helping to optimise production processes, reduce costs and improve product quality. The study results show that the concept of smart farming significantly increases the efficiency of agribusiness. The use of Big Data, blockchain technologies, drones and satellite technologies provides better management of agribusiness, while artificial intelligence helps to predict yields and optimise agricultural processes. Risk management in the agricultural sector, including insurance and financial instruments to hedge price fluctuations, is a key factor in enhancing economic stability. The experience of leading global companies such as John Deere, Agricultural Bank of China, Fruition Sciences, TE-FOOD and FieldView has shown the effectiveness of digital technologies and innovations in improving efficiency

▸ **Suggested Citation**: Zelisko, N., Raiter, N., Markovych, N., Matskiv, H., & Vasylyna, O. (2024). Improving business processes in the agricultural sector considering economic security, digitalization, risks, and artificial intelligence. *Ekonomika APK*, 31(3), 10-21. doi: 10.32317/2221-1055.2024030.10.

*Corresponding author

and sustainable development. Particular attention is devoted to the problems and prospects for the introduction of modern technologies in the agricultural sector of Ukraine on the example of Myronivsky Hliboproduct. An integrated model for improving the business processes of Myronivsky Hliboproduct is proposed, including the digitalisation of production processes, the introduction of blockchain technologies, the use of AI and risk management. Necessary steps to overcome existing challenges, such as insufficient funding for innovation, infrastructure constraints, staff training and cybersecurity, were determined. The implementation of the proposed measures will allow the company to become a leader in the implementation of innovations in the agricultural sector of Ukraine, increase competitiveness and ensure sustainable development in the future

▸ **Keywords:** agriculture; innovative technologies; precision farming; cybersecurity; competitiveness

▸ Introduction

The agricultural sector plays a key role in ensuring food security and economic development. Ensuring the economic security of agricultural enterprises is becoming increasingly important in the context of global challenges such as climate change and population growth. The introduction of modern digital technologies and artificial intelligence (AI) provides new opportunities to optimise business processes, reduce costs and increase productivity. Digital technologies, such as the Internet of Things (IoT), blockchain and Big Data, allow farmers to obtain accurate information to make informed decisions, which helps them to increase efficiency and competitiveness in the global market. The introduction of AI in the agricultural sector allows for analysing large amounts of data, forecasting crops and optimising the use of resources, which is critical to improving productivity and product quality. At the same time, the digitalisation of agribusiness helps to manage risks, improve transparency and ensure cybersecurity. As a result, agricultural enterprises that actively implement the latest technologies can reduce losses, increase efficiency and remain competitive in the global market. This study aims to identify ways to improve business processes in the agricultural sector of Ukraine through the integration of digital technologies, which will ensure sustainable development and economic security of enterprises.

To determine the trends and challenges in improving business processes in the agricultural sector, it is necessary to address the research and conclusions of leading scholars and practitioners in this area. M. Khanna (2021) pointed out the importance of digital transformation in the agricultural sector, emphasising that the introduction of digital technologies can significantly improve the efficiency of resource management. A study by A. Strizhkova *et al.* (2020), in turn, shows that the use of drones and sensor systems to monitor crops can reduce fertiliser and irrigation costs. R. Ben Ayed & M. Hanana (2021) addressed the role of AI in yield forecasting. According to them, machine learning algorithms can analyse large amounts of historical data and make accurate forecasts, which helps farmers plan their actions and minimise the risks associated with unpredictable weather conditions. A.S.A.F. Alam *et al.* (2020), in turn, proposed to introduce crop insurance systems that cover losses from natural disasters. M. Alkahtani *et al.* (2021) and A. Kolodiy *et al.* (2022) studied the impact of digital platforms on the interaction of agricultural enterprises and suppliers. Their research suggests that the use of blockchain technologies for supply chain management provides transparency and increases trust between market participants. S.A. Bhat & N.F. Huang (2021) studied the use of big data for management decision-making in the agricultural sector. A study by O. Hrynevych *et al.* (2022) demonstrated that analysing data on weather conditions, soils and markets allows farmers to plan production more accurately and reduce the risk of overproduction or shortages. K. Rijswijk *et al.* (2021) addressed the importance of cybersecurity in the context of the digital transformation of the agricultural sector. They stressed that the growing number of internet-connected devices in agriculture increases the risk of cyber threats. M. Carmela Annosi *et al.* (2020) studied the issues of sustainable development in the agricultural sector. They argued that the introduction of environmentally friendly technologies and practices not only reduces the negative impact on the environment but also contributes to the economic sustainability of enterprises.

In general, the analysis of the works of these authors emphasises the importance of a comprehensive approach to improving business processes in the agricultural sector, which includes digitalisation, risk management, economic security and the introduction of innovative technologies. These studies provide valuable information for agricultural enterprises seeking to improve their efficiency and sustainability in the face of rapid technological and economic change. However, the relationship between digitalisation, cybersecurity and the economic sustainability of agricultural enterprises in the face of global challenges and rapid market changes remains insufficiently researched.

The study aimed to develop a comprehensive model for improving business processes in the agricultural sector by integrating digital technologies, AI, and risk management strategies. The objectives of the study were to determine the impact of digital technologies on the efficiency of business processes in the agricultural sector, to study methods of ensuring the economic security of agricultural enterprises in the context of digital transformation, to study strategies for managing risks associated with cybersecurity in the agricultural sector.

▸Materials and methods

The research on this topic included quantitative and qualitative analysis of financial indicators, analytical reviews, as well as specific examples of the use of technology in the agricultural sector. International organisations such as the International Finance Corporation (IFC) (Agribusiness & Forestry, n.d.) and the Europe: Turning the recovery into enduring growth (2024) were analysed. The annual financial reports of agricultural enterprises were used to analyse the financial condition of companies, including Myronivsky Hliboproduct (MHP) (Investor Relations &

Corporate Governance. Annual reports, n.d.), 2023 Annual Report (2023), and the Annual Reports (n.d.). The reports of Fruition Sciences (n.d.), TE-FOOD (n.d.) and FieldView – the driving force behind your farm's future (n.d.) were also analysed. These companies are engaged in the introduction of advanced technologies in the agricultural sector, and their reporting provides information on the financial efficiency of the implemented technologies. Data on financial indicators such as revenue, profit, production costs, loan servicing, labour costs and other expenses were collected and analysed. This analysis included identifying trends and fluctuations in financial performance from 2019 to 2023. In addition, the comparison of financial indicators between different companies was used to determine the impact of the introduction of digital technologies on their financial condition.

The study analysed the state of digital technologies in the agricultural sector of Ukraine and assessed the level of their use and spread among agricultural enterprises. The availability and effectiveness of the implementation of modern technologies, such as monitoring and control systems, process automation, IoT, blockchain technologies, AI, and others, are investigated. The availability of infrastructure for the implementation of digital solutions, the level of technological equipment of agricultural enterprises, and the readiness of staff to use the latest technologies were analysed.

The financial indicators were analysed using quantitative analysis, identifying the main trends in changes in revenues, expenses and profits of companies from 2019 to 2023. The financial performance of different companies was compared to identify patterns in the use of digital technologies and their impact on financial results. This included analysing information on specific examples of the implementation of these technologies in various agricultural companies, as well as assessing their impact on production processes and economic efficiency.

Specific examples of IoT, process automation and precision farming in agricultural enterprises were investigated to assess the effectiveness of these technologies in increasing productivity, reducing costs and improving product quality. Particular attention was devoted to the role of blockchain technologies in ensuring transparency and traceability of supply chains, including an analysis of blockchain projects for farmers' lending, product tracking and risk management. In addition, the use of AI to optimise agricultural processes, resource management, weather and risk forecasting was explored. Methods and tools for risk management in the agricultural sector, including insurance, financial instruments to hedge price fluctuations and the development of business plans to identify and manage risks, were also explored. Approaches to ensuring cybersecurity in the face of growing volumes of digital systems and data were analysed. These methods and materials were used to conduct a comprehensive analysis of the economic security of agricultural enterprises and develop an integrated model for improving the business processes of Myronivsky Hliboproduct through the introduction of modern technologies. The company is one of the largest agricultural enterprises in Ukraine engaged in the production and sale of agricultural products and has a major impact on the country's economy.

▸ Results

Economic security is critical for the sustainability and success of agricultural enterprises in the face of market instability and changing economic conditions. It is critical for the sustainability of agricultural enterprises and their success in the face of market volatility and changing economic conditions. Economic security covers a wide range of measures and approaches aimed at protecting the financial interests of an enterprise, preventing financial losses and ensuring sustainable development (Nhemachena *et al.*, 2020). Financial planning and control are key components of ensuring the economic security of agricultural enterprises. These processes include a detailed analysis of cash flows, crop costs, loan servicing, labour costs and other expenses. It is necessary to control the receipt and expenditure of funds to ensure the stability of the financial position of the enterprise (Abbasi *et al.*, 2022). For instance, regular monitoring and analysis of financial flows allow us to identify deviations from the plan, such as overspending on fertiliser purchases or a decrease in revenue from product sales and take prompt corrective action.

Analysis of financial flows was used to identify threats and respond to them on time. If a company detects a decline in prices for its products on the market, it may decide to change its sales strategy or look for new markets to avoid financial losses. Planning and controlling the cost of seeds, fertilisers, crop protection products and other inputs is necessary for the reduction of costs and profitability increase. The introduction of precision farming was used to optimise the use of fertilisers and pesticides, which reduces their consumption and improves yields. Agribusinesses often depend on credit to finance their operations; therefore, it is necessary to develop effective debt management strategies to avoid excessive financial burdens and maintain creditworthiness. For instance, the use of financial instruments such as hedging can help agricultural enterprises protect themselves from the risk of rising interest rates on loans (Misra *et al.*, 2020). In addition, regular analysis of the company's financial position can be used to promptly identify liquidity problems and take measures to resolve them, for example, by restructuring debt or raising additional funding.

Labour costs are a significant item of expenditure for agricultural enterprises. Optimisation of these costs through process automation and the use of modern technologies can significantly improve production efficiency. For instance, the use of automated harvesting systems or drones to monitor crops can reduce the need for manual labour, which reduces labour costs and increases productivity (Garg *et al.*, 2022). The implementation of Farm Management Systems provides more efficient planning and control of production processes, which also helps to optimise costs. Particular attention should be devoted to the management of financial risks that may affect the stability and development of an agricultural enterprise. The main financial risks include fluctuations in commodity prices, changes in foreign exchange rates, legislative changes and climatic conditions. Changes in agricultural commodity prices can have a significant impact on the income of agricultural enterprises. A drop in grain prices or an increase in the cost of meat can change the

economic environment of a business (Eli-Chukwu, 2019). According to the International Monetary Fund, the impact of changes in agricultural prices can account for up to 20% of changes in the income of agricultural enterprises in different regions of the world. The use of financial instruments such as futures contracts and options help to hedge price risks and ensure revenue stability. According to the International Finance Corporation, up to 70% of large agricultural enterprises in the United States use futures contracts to mitigate price risks (Europe: Turning the recovery into…, 2024).

Agricultural enterprises that export products or depend on imported inputs are exposed to currency risks. Currency hedging reduces the impact of currency fluctuations on the company's financial results. According to a study by the International Monetary Fund, up to 60% of businesses in the European Union use currency hedging to protect themselves from currency risks. Changes in legislation, such as new tax rates, regulation of agricultural activities, or changes in the rules of export-import operations, can affect the financial stability of a business (Europe: Turning the recovery into…, 2024). It is necessary to keep abreast of legislative changes and adapt business strategies to the new environment. Weather disasters, such as droughts, floods or other natural events, can seriously affect the yields and financial performance of agricultural enterprises (Javaid *et al.*, 2023). Crop insurance and the use of agrometeorological data for risk forecasting help minimise the negative impact of climate change. A key aspect of improving the efficiency of agricultural enterprises is the introduction of modern digital technologies, such as AI, Big Data, drones and satellite technologies. These technologies help to optimise production processes, reduce costs and increase productivity. For example, AI can analyse large amounts of data to predict yields and optimise resource use, which can reduce costs and increase efficiency (Fathi *et al.*, 2022). The use of digital technologies also helps agricultural enterprises adapt to market changes, increasing their competitiveness in the global market.

John Deere, one of the world's leading agricultural machinery manufacturers, is known for its innovations in digital technology and AI. The company is actively implementing technologies that automate agricultural processes, increasing efficiency and reducing costs. Their tractors and harvesters are equipped with sensors, GPS systems and intelligent algorithms that allow them to optimise the operation of their machinery in real-time. One of the company's key products is the John Deere Operations Centre platform, which enables farmers to monitor and analyse data from their fields. This platform is used by farmers to receive accurate data on yields, soil conditions and weather conditions. The introduction of such technologies has reduced fertiliser and fuel costs by up to 15% and increased yields by 20% through precise application of fertilisers and plant protection products. 2023 Annual Report (2023) is also working with leading technology companies such as NVIDIA to develop AI in agriculture. For instance, their autonomous tractors can independently determine the best routes and ploughing depth using sensor data and machine learning algorithms. This not only reduces fuel costs but also reduces the negative impact on the soil, which is important for sustainable farming. This technology helped the company to increase its revenues and net profit significantly from 2019 to 2023 (Fig. 1).

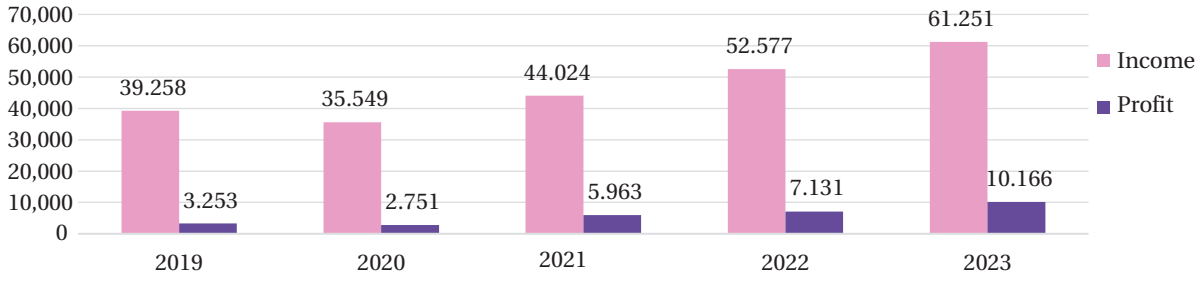

Figure 1. Financial performance of John Deere from 2019 to 2023, USD million
Source: compiled based on data from 2023 Annual Report (2023)

The table shows that John Deere has shown a steady upward trend in revenues and profits over the past five years. From 2019 to 2023, the company's revenue increased by almost 56%, reaching $61.3 billion in 2023. This demonstrates the success of the company's business processes and its ability to adapt to changes in the market.

Agricultural Bank of China, one of the largest banks in China, is actively implementing blockchain technologies to improve transparency and efficiency in the agricultural sector. The use of blockchain provides full traceability of supply chains and increased trust between all market participants. One of the bank's most successful projects is the introduction of a blockchain platform for lending to farmers. Through this platform, farmers can receive loans secured by future harvests. The blockchain ensures transparency of all transactions and ensures that collateral and crop data cannot be altered or falsified. This significantly reduces the risks for banks and allows farmers to receive financing on more favourable terms. In 2022, the Annual Reports (n.d.) successfully tested a blockchain system for lending to farmers in Guangdong province. During the first six months of using the system, more than 3,000 loans were issued, totalling more than 300 million RMB (approximately 45 million USD). Blockchain technology reduced the processing time for loan applications from several weeks to a few days, allowing farmers to receive the necessary funds for agricultural work more quickly. Figure 2 shows the company's key financial indicators.

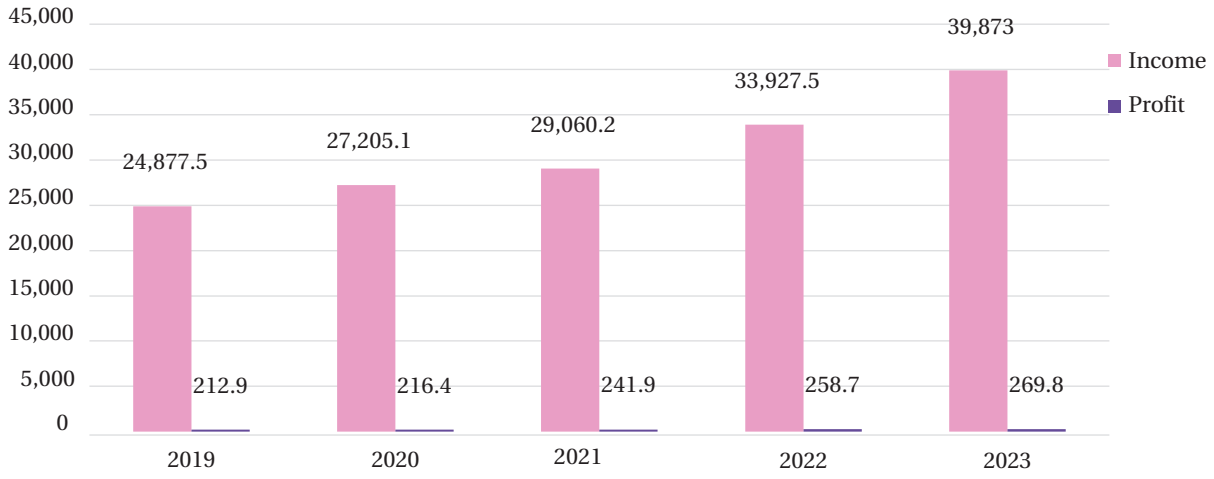

Figure 2. Financial performance of Agricultural Bank of China from 2019 to 2023, billion yuan
Source: compiled based on annual reports of the Annual Reports (n.d.)

The Agricultural Bank of China also shows a steady upward trend in revenues and profits. Between 2019 and 2023, the company's revenue increased by 60%, reaching 39.9 trillion yuan in 2023, which is a testament to the successful use of technology.

Fruition Sciences, with offices in France and the US, is a pioneer in the use of digital technology and AI for vineyard management. The company specialises in integrating IoT and analytical algorithms to monitor and optimise irrigation processes. Their system uses numerous sensors that measure soil moisture, temperature, solar radiation and other critical parameters. The received data is transferred to the cloud platform, where it is analysed using AI algorithms. This allows growers to receive precise recommendations on the optimal time and volume of irrigation, reducing water consumption and improving the quality of the grapes. For instance, one study showed that using the Fruition Sciences system reduced water consumption by 20% while improving grape yields and quality (Fruition Sciences, n.d.).

TE-FOOD is a Vietnamese company that is actively implementing blockchain to ensure transparency and traceability of food supply chains. The company is working with local farmers, manufacturers and retailers to implement a system that allows them to track food from farm to table. Using the TE-FOOD blockchain platform, all product information, including the place of cultivation, production methods, transportation and storage conditions, is stored unchanged and available to all participants in the supply chain. This provides consumers with detailed information about the origin of products and increases their trust in food quality. One of the company's successful projects is cooperation with pork producers in Vietnam. As a result of the implementation of the blockchain system, the supply chain tracking time was reduced by 50%, which significantly reduced the risks of fraud and counterfeiting (TE-FOOD, n.d.). In addition, consumers were able to check all product information using QR codes, which increased the level of trust in local producers.

FieldView, a product of Bayer Germany, uses advanced digital technology and AI to manage farmland. The platform combines data from various sources, including sensors, drones and satellite imagery, to create comprehensive field maps and analytical reports. FieldView enables farmers to monitor crop health in real-time, analyse soil and weather data, and receive recommendations for optimising crops, fertilisation and irrigation. AI algorithms are used in the platform to accurately determine the water and nutrient needs of plants, which reduces costs and increases yields. For instance, using FieldView increased corn yields by 10% and reduced fertiliser costs by 15% on a farm in Germany (FieldView – the driving force…, n.d.). With accurate data analysis and crop management recommendations, farmers can make more informed decisions and achieve better results.

The previous examples demonstrate how various agricultural enterprises around the world are using modern technology to increase efficiency, reduce costs and ensure the sustainability of their operations. The introduction of digital technologies, blockchain and AI opens new opportunities for agribusiness and contributes to its development in the face of rapidly changing economic and climate conditions. As one of the largest agricultural countries in Europe, Ukraine is gradually introducing modern technologies to improve the efficiency of agricultural production. The use of digital technologies, blockchain and AI is becoming more widespread, although there are certain challenges and limitations. Ukrainian agricultural enterprises are actively implementing digital technologies to optimise production processes. The use of sensors, drones and satellite imagery allows farmers to obtain accurate data on field conditions, yields, soil moisture and other important parameters. For instance, precision farming platforms such as eFarmer and AgroOnline allow farmers to manage their fields through mobile apps and web interfaces (Ihnatko, 2021). These platforms collect and analyse data in real-time, enabling informed decisions on fertilisation, irrigation and crop protection. The use of drones to monitor fields is becoming more and more common. Drones provide detailed images of fields, allowing farmers to identify problem areas, assess the condition of crops and plan agronomic measures. This increased yields and reduced resource costs.

Blockchain technologies are still at the stage of experimental implementation in the Ukrainian agricultural sector but already have the potential to significantly improve the transparency and efficiency of supply chains. One of the first projects in this area is Agrocontrol, a blockchain platform for tracking supply chains. The introduction of AI in Ukraine's agricultural sector is slower, but there are already examples of successful use of this technology. AI is used to analyse large amounts of data to optimise various aspects of agricultural production. For example, IMK uses machine learning algorithms to predict yields and plan crops. This improves the accuracy of forecasts and optimises the use of resources. AI is also used to analyse sensor data and satellite imagery, which identifies problems in the fields and takes timely action. Another example is the Agrieye platform, which uses AI to analyse satellite imagery and weather data, allowing farmers to plan agronomic activities and optimise the use of fertilisers and pesticides.

Although the introduction of digital technologies, blockchain and AI in the Ukrainian agricultural sector is still at an early stage, there are already positive examples of successful use of these technologies. The gradual digitalisation of the agricultural sector is helping to improve production efficiency, reduce costs and ensure transparency in supply chains. However, further development requires addressing challenges such as insufficient funding, lack of proper infrastructure and the need for training.

Investor Relations & Corporate. Annual reports (n.d.) is one of the largest agricultural holdings in Ukraine, known for its vertically integrated structure, which includes all stages of production from growing grains and oilseeds to producing meat and food products. MHP has a significant market share and plays a key role in the country's agricultural sector, making it a good example for analysing the introduction of modern technologies. Figure 3 shows the key financial indicators of MHP from 2019 to 2023.

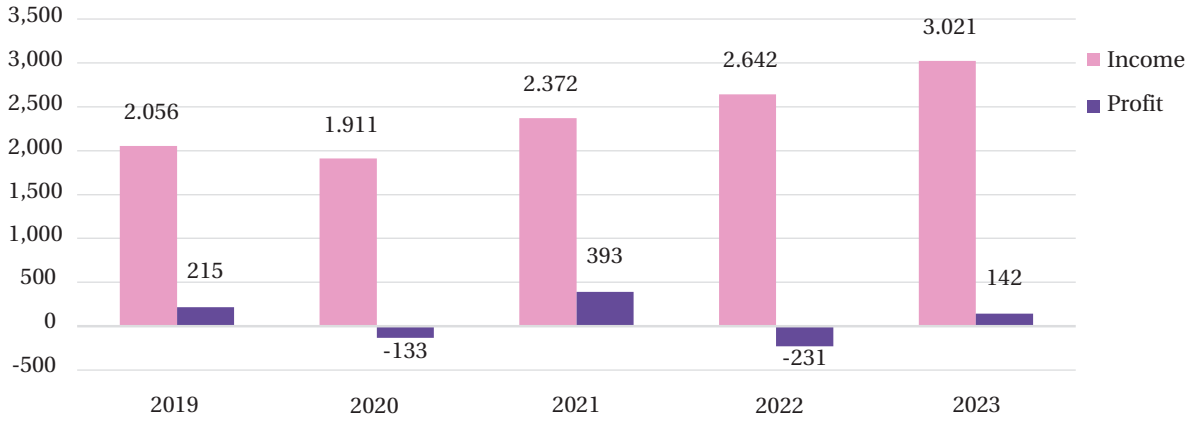

Figure 3. MHP's financial performance from 2019 to 2023, USD million
Source: compiled based on Investor Relations & Corporate Governance. Annual reports (n.d.)

The company showed a significant increase in revenues, which indicates its stability and potential for development. However, fluctuations in profit levels indicate difficulties faced by an enterprise in different economic conditions. The sustainability and effectiveness of management strategies that allow a company to adapt to changes in the market and achieve positive financial results in the medium term are important. MHP faces several problems and challenges. One of the main problems is insufficient funding for innovation. The high costs of implementing modern technologies can be an obstacle to full-scale innovative solutions. For instance, the installation of soil monitoring sensors, drones for field surveys and satellite systems requires significant financial investment.

Infrastructure constraints also pose challenges, especially in remote agricultural regions and in areas affected by the war in Ukraine. They may not have the right infrastructure to support digital technologies. For instance, the effective use of IoT sensors and other digital tools requires a stable and fast internet connection, which may be unstable or non-existent. This complicates the implementation of digitalisation projects and reduces the effectiveness of the implemented technologies. Staff training is critical to the successful implementation of new technologies. In many cases, employees of agricultural enterprises do not have sufficient knowledge and skills to work with modern technologies. To use precision farming systems effectively, workers need to be trained to recognise and respond to the data provided by these systems. This requires a significant investment in training and development, which can be a significant financial and organisational hurdle for a company. As the number of digital systems and data volumes increase, the risks of cyberattacks increase, which can have serious consequences for MHP. The use of digital technologies involves the storage and transmission of a large amount of confidential data, including information on yields, crop plans, financial data, and more. Vulnerability to cyber threats can lead to data leakage, information loss, or even production processes stopping.

Despite the existing problems, MHP has significant prospects for further development through the introduction of modern technologies. The integration of digital technologies, blockchain technologies, AI, and effective risk management can significantly improve MHP business processes (Fig. 4). To implement this integrated model, it is necessary to address the existing problems and challenges faced by the company, as well as to take into account the overall state of digitalisation in Ukraine.

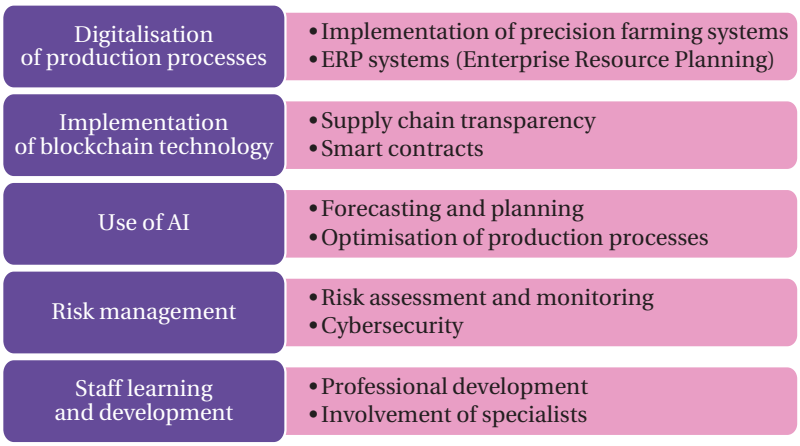

Figure 4. An integrated model for improving business processes at "Myronivsky Hliboproduct"
Source: compiled by the authors

The main components of the integrated model include the digitalisation of production processes, the introduction of blockchain technologies, the use of AI and risk management. The first step is the digitalisation of production processes. The introduction of precision farming systems will allow the installation of sensors to monitor soil, moisture, temperature and other parameters. The use of drones and satellites to regularly inspect fields and collect data, as well as software to analyse the collected data, will allow us to provide recommendations on optimising fertilisation, irrigation and other agronomic measures. Integration of ERP systems to manage all aspects of production, from the purchase of raw materials to the sale of finished products, will automate management processes, reducing costs and increasing efficiency (Duong *et al.*, 2019).

The introduction of blockchain technologies will ensure the transparency of supply chains. The development and implementation of a blockchain platform for tracking products from the field to the end consumer will ensure transparency at all stages of production, increasing the trust of consumers and partners. The use of smart contracts to automate contractual relationships with suppliers and partners minimises the risk of counterfeiting and fraud due to the immutability of blockchain data. The use of AI will improve forecasting and planning. Analysis of large amounts of data using AI can be used to predict yields, plan crops and optimise resource use. The development and implementation of machine learning algorithms to identify patterns and improve decision-making will help optimise production processes. The use of AI for real-time monitoring and adjustment of production processes, as well as automatic detection and resolution of production problems, will increase operational efficiency.

Risk management is an important aspect of the integrated model. Implementation of specialised systems to assess and monitor risks related to production, supply and financial aspects of the company's operations will allow for effective risk management. The employment of AI to predict potential risks based on historical data analysis minimises potential threats. Cyber security is also an important element. Implementation of modern means of protecting data and information systems from cyberattacks, as well as regular training of personnel on cybersecurity and development of strategies for responding to cyberattacks, will ensure that the company is protected from cyber threats. Staff training and development is critical to the successful implementation of new technologies. Developing and implementing advanced training programmes for employees focused on mastering new technologies and working methods, as well as organising practical training and seminars to teach staff how to work with new digital tools and systems, will help ensure the required level of competence. Engaging experts in digital technologies, blockchain and AI, as well as establishing cooperation with universities and research institutes to train highly qualified specialists, will contribute to the successful implementation of the integrated model (Komarek *et al.*, 2020).

The integration of digital technologies, blockchain, AI and effective risk management can significantly improve the efficiency of MHP business processes. Addressing existing problems and challenges, such as insufficient funding for innovation, infrastructure constraints, staff training and cybersecurity, is critical to the successful implementation of this integrated model. Implementation of the proposed measures will allow the company to become a leader in innovation in the Ukrainian agricultural sector, increase competitiveness and ensure sustainable development in the future.

▸ Discussion

The results of the study underline the critical importance of economic security for the stability and success of agricultural enterprises in the face of market instability and changing economic conditions. The key aspects of ensuring economic security include financial planning and control, diversification of products and markets, and the introduction of modern digital technologies. These measures reduce financial risks, optimise the use of resources and ensure the stability of the company's financial position.

O. Solosich *et al.* (2021) addressed the role of state support in ensuring the economic security of agricultural enterprises. In their paper, they argue that government subsidies and soft loans play a crucial role in maintaining the financial stability of agricultural companies. D. Pan *et al.* (2020), in turn, showed that enterprises that receive

state support are less dependent on market fluctuations and have more stable financial performance. This confirms the findings of the current study on the importance of financial planning, although its focus was more on internal strategies of enterprises rather than external support. Financial planning and control are key components of economic security. Agricultural enterprises must carefully analyse their financial flows, considering the costs of growing crops, servicing loans, labour and other expenses. It is also necessary to identify and manage financial risks that may arise from fluctuations in commodity prices, changes in exchange rates, changes in legislation or climatic conditions. Effective financial planning allows businesses to minimise risks and ensure a stable financial position even in the face of uncertainty.

Diversification of products and markets is another important aspect of economic security (Nunes & Sytnychenko, 2024). Expanding the range of products helps to reduce the risk of losses in the event of changes in market demand or price changes. The development of new sales markets, including export markets, helps to reduce dependence on the domestic market and expand the audience of consumers (Abdullayev *et al.*, 2024). This reduces the risks associated with fluctuations in individual markets and increases the company's resilience to external shocks. A.A. Adenle *et al.* (2019) addressed the importance of international markets for the economic security of agricultural enterprises. They investigated how export strategies affect revenue stability and risk mitigation. S. Fan & C. Rue (2020) showed that enterprises that actively develop exports are less vulnerable to domestic market fluctuations. These findings are in line with current findings on market diversification as an important aspect of economic security. However, the focus was more on product diversification, while the authors examined international trade in detail.

The digitalisation of the agricultural sector is a key factor in improving its economic security, efficiency and competitiveness in the face of current challenges (Buka *et al.*, 2023). The introduction of digital technologies helps to optimise production processes, reduce costs and improve product quality. One of the main elements of this transformation is the concept of smart farming, which includes the use of IoT, process automation and precision farming. These technologies can be used to collect and analyse data on the condition of crops, soils and climatic conditions, which contributes to more efficient resource management. M.A. Dayıoğlu & U. Turker (2021) analysed the impact of digital technologies on the efficiency of agricultural production. Their findings indicate that the introduction of automated farm management systems contributes to a significant reduction in costs and an increase in productivity. J. Clapp & S.L. Ruder (2020), in turn, focused on the use of unmanned aerial vehicles for field monitoring, which coincides with current findings on the use of drones and satellite technology. However, the authors' research is more focused on the technical aspects of implementing these technologies, while there is a need to consider economic and managerial aspects.

The use of Big Data and blockchain technologies has significant potential for agribusiness. Big data collects, stores and analyses huge amounts of information to make informed management decisions. Blockchain provides transparency of all transactions and operations, which contributes to full transparency and traceability of supply chains (Stender *et al.*, 2024). Drones and satellite technologies provide unique opportunities for monitoring crops and forecasting yields, which allows for accurate planning of agrotechnical measures. J.A. Delgado *et al.* (2019) also studied the role of Big Data in the agricultural sector. They concluded that analysing large amounts of data provides more accurate crop forecasting, optimised resource use, and more efficient management decisions. The current findings on the importance of digitalisation and the use of Big Data are confirmed by the authors' results, but the importance of blockchain technologies for supply chain transparency should also be considered. The introduction of AI in the agricultural sector opens many opportunities to increase the productivity and efficiency of crop cultivation. AI helps to predict crops, optimise resource use, and automate processes, which reduces costs and increases profitability. For instance, AI-powered analytics systems can adapt the use of water, fertilisers, and pesticides to the needs of each specific area of the field.

Effective risk management is an essential component of ensuring the stability and success of agricultural enterprises. The use of insurance, financial instruments such as options and futures, as well as the development and implementation of business plans and risk management strategies, help to minimise the impact of risks on the business (Tanchyk *et al.*, 2024). An important area of risk management is the development of risk mitigation technologies and careful planning and analysis of markets. N.T. Huong *et al.* (2019) studied the impact of climate change on the economic security of agricultural enterprises. They noted that unpredictable weather changes and extreme climatic conditions have a significant impact on the yields and financial stability of agribusiness. N. Möhring *et al.* (2020) proposed the introduction of crop insurance as an effective risk management tool. The current study also mentioned risk management, including insurance, but focused more on digital technologies for monitoring and forecasting crops. This highlights additional approaches to mitigating climate-related risks.

The use of modern technologies by the world's leading agricultural companies, such as John Deere, Agricultural Bank of China, Fruition Sciences, TE-FOOD and others, demonstrates the success of their implementation to increase efficiency and reduce costs. Ukrainian agricultural enterprises are also gradually introducing modern technologies, which allow them to increase production efficiency, reduce costs and ensure transparency of supply chains (Wrzecińska *et al.*, 2023). However, challenges such as insufficient funding, lack of proper infrastructure, and the need for training need to be addressed to further develop. J. Janker *et al.* (2019) focused on the social aspects of the economic security of agricultural enterprises. They studied the impact of HR policies and the level of digital education of employees on production efficiency and economic stability of companies. They found that enterprises that invest in the training and development of their employees have higher productivity and better financial performance. Although the current study focuses more on technological and economic aspects, the authors' findings add to the vision of the importance of human capital for economic security.

The models of successful implementation of modern technologies presented by the world's leading agricultural companies can serve as an example for Ukrainian enterprises. They demonstrate that investments in technology bring tangible results in the form of increased production efficiency, reduced costs and higher yields. Ukraine needs to intensify the process of introducing modern technologies, develop infrastructure and train specialists to ensure the sustainable development of the agricultural sector. An analysis of other authors' studies confirms the complexity and multifaceted nature of approaches to ensuring the economic security of agricultural enterprises. Key aspects such as state support, climate risk management, digitalisation, development of export strategies, use of big data and investment in human capital are proving to be important components of the successful functioning of agricultural enterprises.

Conclusions

This study provides a comprehensive analysis of the importance of economic security for the stability and success of agricultural enterprises in the face of market volatility and changing economic conditions. The main aspects considered include financial planning and control, product and market diversification, digitalisation of the agricultural sector, use of big data and blockchain technologies, and the introduction of AI.

An analysis of successful examples of digital technologies, such as John Deere, Agricultural Bank of China, Fruition Sciences, TE-FOOD and FieldView, shows the prospects for implementing these innovations in the agricultural sector. John Deere's revenues increased by 56% from 2019 to 2023, reaching $61.3 billion. And Agricultural Bank of China increased its revenue by 60% from 2019 to 2023, reaching 39.9 trillion yuan. The study also covered the state of the Ukrainian agricultural sector and identified the potential for the introduction of modern technologies in this area. An example of this potential is the analysis of MHP's operations and the identification of problems and challenges that this company faces in the context of innovation. Based on the study, an integrated model was developed to improve MHP's business processes. This model includes five key components: digitalisation of production processes, implementation of blockchain technologies, application of AI, effective management risk, and training and development of personnel. These components are aimed at ensuring transparency, optimising production processes, and reducing risks for the company.

A limitation of this study is the insufficient scope of the topics and examples considered to cover all uses of modern technologies in the agricultural sector. Further research could expand the scope of the technologies considered by examining their impact on various aspects of agricultural production, including environmental and socio-economic aspects. In addition, research could focus on the effectiveness of the implementation of individual technologies in different regions and conditions.

Acknowledgements

None.

Conflict of interest

None.

References

[1] 2023 Annual Report. (2023). Retrieved from https://s22.q4cdn.com/253594569/files/doc_financials/2023/ar/2023-deere-company-annual-report.pdf.

[2] Abbasi, R., Martinez, P., & Ahmad, R. (2022). The digitization of agricultural industry – a systematic literature review on Agriculture 4.0. *Smart Agricultural Technology*, 2, article number 100042. doi: 10.1016/j.atech.2022.100042.

[3] Abdullayev, K., Abdullayev, R., Yusifov, E., Babazade, I., & Fataliyeva, G. (2024). Main areas of development of the digital economy in the Republic of Azerbaijan. *Economics of Development*, 23(1), 78-88. doi: 10.57111/econ/1.2024.78.

[4] Adenle, A.A., Wedig, K., & Azadi, H. (2019). Sustainable agriculture and food security in Africa: The role of innovative technologies and international organizations. *Technology in Society*, 58, article number 101143. doi: 10.1016/j.techsoc.2019.05.007.

[5] Agribusiness & Forestry. (n.d.). Retrieved from https://www.ifc.org/en/what-we-do/sector-expertise/agribusiness-forestry.

[6] Alam, A.S.A.F., Begum, H., Masud, M.M., Al-Amin, A.Q., & Filho, W. L. (2020). Agriculture insurance for disaster risk reduction: A case study of Malaysia. *International Journal of Disaster Risk Reduction*, 47, article number 101626. doi: 10.1016/j.ijdrr.2020.101626.

[7] Alkahtani, M., Khalid, Q.S., Jalees, M., Omair, M., Hussain, G., & Pruncu, C.I. (2021). E-agricultural supply chain management coupled with blockchain effect and cooperative strategies. *Sustainability*, 13(2), article number 816. doi: 10.3390/su13020816.

[8] Annual Reports. (n.d.). Retrieved from https://www.abchina.com/en/investor-relations/performance-reports/annual-reports/.

[9] Ben Ayed, R., & Hanana, M. (2021). Artificial intelligence to improve the food and agriculture sector. *Journal of Food Quality*, 1, article number 5584754. doi: 10.1155/2021/5584754.

[10] Bhat, S.A., & Huang, N.F. (2021). Big data and ai revolution in precision agriculture: Survey and challenges. *IEEE Access*, 9, 110209-110222. doi: 10.1109/ACCESS.2021.3102227.

[11] Buka, S., Tkachuk, V., Kondratiuk, V., Tonkha, O., & Slobodyanyuk, N. (2023). Prospects for agribusiness in Ukraine over the next 5 years. *International Journal of Environmental Studies*, 80(2), 291-298. doi: 10.1080/00207233.2022.2157630.

[12] Carmela Annosi, M., Brunetta, F., Capo, F., & Heideveld, L. (2020). Digitalization in the agri-food industry: The relationship between technology and sustainable development. *Management Decision*, 58(8), 1737-1757. doi: 10.1108/MD-09-2019-1328.

[13] Clapp, J., & Ruder, S.-L. (2020). Precision technologies for agriculture: Digital farming, gene-edited crops, and the politics of sustainability. *Global Environmental Politics*, 20(3), 49-69. doi: 10.1162/glep_a_00566.
[14] Dayıoğlu, M.A., & Turker, U. (2021). Digital transformation for sustainable future – Agriculture 4.0: A review. *Journal of Agricultural Sciences*, 27(4), 373-399. doi: 10.15832/ankutbd.986431.
[15] Delgado, J.A., Short Jr, N.M., Roberts, D.P., & Vandenberg, B. (2019). Big data analysis for sustainable agriculture on a geospatial cloud framework. *Frontiers in Sustainable Food Systems*, 3, article number 00054. doi: 10.3389/fsufs.2019.00054.
[16] Duong, T.T., Brewer, T., Luck, J., & Zander, K. (2019). A global review of farmers' perceptions of agricultural risks and risk management strategies. *Agriculture*, 9(1), article number 10. doi: 10.3390/agriculture9010010.
[17] Eli-Chukwu, N.C. (2019). Applications of artificial intelligence in agriculture: A review. *Engineering, Technology & Applied Science Research*, 9(4), 4377-4383.
[18] Europe: Turning the recovery into enduring growth. (2024). Retrieved from https://www.imf.org/en/News/Articles/2024/05/14/sp051424-alfred-kammer-at-the-ecb-house-of-the-euro-brussels.
[19] Fan, S., & Rue, C. (2020). The role of smallholder farms in a changing world. In S. Gomez Paloma, L. Riesgo & K. Louhichi (Eds.), *The role of smallholder farms in food and nutrition security* (pp. 13-28). Cham: Springer. doi: 10.1007/978-3-030-42148-9.
[20] Fathi, M., Haghi Kashani, M., Jameii, S.M., & Mahdipour, E. (2022). Big data analytics in weather forecasting: A systematic review. *Archives of Computational Methods in Engineering*, 29, 1247-1275. doi: 10.1007/s11831-021-09616-4.
[21] FieldView – the driving force behind your farm's future. (n.d.). Retrieved from https://cropscience.bayer.co.uk/fieldview.
[22] Fruition Sciences. (n.d.). Retrieved from https://fruitionsciences.com/.
[23] Garg, S., Sinha, P., & Singh, A. (2022). Overview of augmented reality and its trends in agriculture industry. In T. Senjyu, P. Mahalle, T. Perumal & A. Joshi (Eds.), *IOT with smart systems. Smart innovation, systems and technologies* (pp. 627-636). Singapore: Springer. doi: 10.1007/978-981-16-3945-6_62.
[24] Hrynevych, O., Blanco Canto, M., & Jiménez García, M. (2022). Tendencies of precision agriculture in Ukraine: Disruptive smart farming tools as cooperation drivers. *Agriculture*, 12(5), article number 698. doi: 10.3390/agriculture12050698.
[25] Huong, N.T., Bo, Y.S., & Fahad, S. (2019). Economic impact of climate change on agriculture using Ricardian approach: A case of northwest Vietnam. *Journal of the Saudi Society of Agricultural Sciences*, 18(4), 449-457. doi: 10.1016/j.jssas.2018.02.006.
[26] Ihnatko, M. (2021). Synergy of agricultural business and it industry of Ukraine as the key to economic growth. *European Scientific Journal of Economic and Financial Innovations*, 2(8), 31-38. doi: 10.32750/2021-0203.
[27] Investor Relations & Corporate Governance. Annual reports. (n.d.). Retrieved from https://mhp.com.ua/en/mhp-se.
[28] Janker, J., Mann, S., & Rist, S. (2019). Social sustainability in agriculture – A system-based framework. *Journal of Rural Studies*, 65, 32-42. doi: 10.1016/j.jrurstud.2018.12.010.
[29] Javaid, M., Haleem, A., Khan, I.H., & Suman, R. (2023). Understanding the potential applications of artificial intelligence in agriculture sector. *Advanced Agrochem*, 2(1), 15-30. doi: 10.1016/j.aac.2022.10.001.
[30] Khanna, M. (2021). Digital transformation of the agricultural sector: Pathways, drivers and policy implications. *Applied Economic Perspectives and Policy*, 43(4), 1221-1242. doi: 10.1002/aepp.13103.
[31] Kolodiy, A., Kolodii, I., Zelisko, N., & Prokopyshyn, O. (2022). Use of blockchain technology as a prospect element of management in product traceability systems. *Review of Economics and Finance*, 20, 612-616. doi: 10.55365/1923.x2022.20.70.
[32] Komarek, A.M., De Pinto, A., & Smith, V.H. (2020). A review of types of risks in agriculture: What we know and what we need to know. *Agricultural Systems*, 178, article number 102738. doi: 10.1016/j.agsy.2019.102738.
[33] Misra, N.N., Dixit, Y., Al-Mallahi, A., Bhullar, M.S., Upadhyay, R., & Martynenko, A. (2020). IoT, big data, and artificial intelligence in agriculture and food industry. *IEEE Internet of things Journal*, 9(9), 6305-6324. doi: 10.1109/JIOT.2020.2998584.
[34] Möhring, N., Dalhaus, T., Enjolras, G., & Finger, R. (2020). Crop insurance and pesticide use in European agriculture. *Agricultural Systems*, 184, article number 102902. doi: 10.1016/j.agsy.2020.102902.
[35] Nhemachena, C., Nhamo, L., Matchaya, G., Nhemachena, C.R., Muchara, B., Karuaihe, S.T., & Mpandeli, S. (2020). Climate change impacts on water and agriculture sectors in Southern Africa: Threats and opportunities for sustainable development. *Water*, 12(10), article number 2673. doi: 10.3390/w12102673.
[36] Nunes, P., & Sytnychenko, K. (2024). Strategic forecasts for circular economy transition: Evaluation of the role of technology in economic development. *Economics, Entrepreneurship, Management*, 11(1), 25-36. doi: 10.56318/eem2024.01.025.
[37] Pan, D., Yang, J., Zhou, G., & Kong, F. (2020). The influence of COVID-19 on agricultural economy and emergency mitigation measures in China: A text mining analysis. *PLoS One*, 15(10), article number e0241167. doi: 10.1371/journal.pone.0241167.
[38] Rijswijk, K., Klerkx, L., Bacco, M., Bartolini, F., Bulten, E., Debruyne, L., Dessein, J., Scotti, I., & Brunori, G. (2021). Digital transformation of agriculture and rural areas: A socio-cyber-physical system framework to support responsibilisation. *Journal of Rural Studies*, 85, 79-90. doi: 10.1016/j.jrurstud.2021.05.003.

[39] Solosich, O., Popelo, O., Nusinova, O., Derhaliuk, M., & Tulchynska, S. (2021). Ensuring economic security of regions as a potential-forming space in the conditions of intellectualization. *Academy of Entrepreneurship Journal*, 27(6), 1-8. doi: 10.18559/ref.2021.1.6.
[40] Stender, S., Tsvihun, I., Balla, I., Borkovska, V., & Haibura, Yu. (2024). Innovative approaches to improving the agricultural sector in the era of digitalization of the economy. *Scientific Horizons*, 27(3), 154-163. doi: 10.48077/scihor3.2024.154.
[41] Strizhkova, A., Tokarieva, K., Liubchych, A., & Pavlyshyn, S. (2020). Digital farming as direct of digital transformation state policy. *European Journal of Sustainable Development*, 9(3), 597-606. doi: 10.14207/ejsd.2020.v9n3p597.
[42] Tanchyk, S., Pavlov, O., & Babenko, A. (2024). Theoretical substantiation and development of ecologically friendly farming system in Ukraine. *Plant and Soil Science*, 15(2), 55-66. doi: 10.31548/plant2.2024.55.
[43] TE-FOOD. (n.d.). Retrieved from https://te-food.com/.
[44] Wrzecińska, M., Czerniawska-Piątkowska, E., Kowalewska, I., Kowalczyk, A., Mylostyvyi, R., & Stefaniak, W. (2023). Agriculture in the face of new digitization technologies. *Ukrainian Black Sea Region Agrarian Science*, 27(3), 9-17. doi: 10.56407/bs.agrarian/3.2023.09.

Покращення бізнес-процесів в аграрному секторі з урахуванням економічної безпеки, цифровізації, ризиків та штучного інтелекту

Наталія Зеліско
Кандидат економічних наук, доцент
Львівський національний університет природокористування
80381, вул. В. Великого, 1, м. Дубляни, Україна
https://orcid.org/0000-0002-2467-5585

Наталія Райтер
Кандидат економічних наук, доцент
Львівський національний університет природокористування
80381, вул. В. Великого, 1, м. Дубляни, Україна
https://orcid.org/0000-0002-7108-2539

Наталія Маркович
Кандидат економічних наук, доцент
Львівський національний університет природокористування
80381, вул. В. Великого, 1, м. Дубляни, Україна
https://orcid.org/0000-0001-6725-1355

Галина Мацьків
Кандидат економічних наук, доцент
Львівський національний університет природокористування
80381, вул. В. Великого, 1, м. Дубляни, Україна
https://orcid.org/0000-0002-1329-7355

Орися Василина
Кандидат економічних наук, доцент
Львівський національний університет природокористування
80381, вул. В. Великого, 1, м. Дубляни, Україна
https://orcid.org/0000-0003-2124-3792

▸ **Анотація.** Дане дослідження було направлене на вивчення шляхів підвищення ефективності агробізнесу через впровадження сучасних технологій та інноваційних підходів. Для досягнення цієї мети було використано методи кількісного і якісного аналізу фінансових показників, аналітичні огляди та розглянуто конкретні приклади впровадження технологій. Основний акцент зроблено на вплив цифровізації аграрного сектора на підвищення його економічної безпеки, ефективності та конкурентоспроможності. Запровадження цифрових технологій, таких як Інтернет речей, автоматизація процесів та точне землеробство, дозволяє оптимізувати виробничі процеси, знижувати витрати та покращувати якість продукції. Результати дослідження показують, що концепція «розумного фермерства» значно підвищує ефективність агробізнесу. Використання Big Data, блокчейн-технологій, дронів та супутникових технологій дозволяє краще управляти агробізнесом, тоді як штучний інтелект допомагає прогнозувати врожайність та оптимізувати агротехнічні процеси. Управління ризиками в аграрному секторі, включаючи страхування та фінансові інструменти для хеджування цінових коливань, є ключовим фактором для підвищення економічної стабільності. Досвід провідних світових компаній, таких як John Deere, Agricultural Bank of China, Fruition Sciences, TE-FOOD та FieldView, показав ефективність впровадження цифрових технологій та інновацій для підвищення ефективності та сталого розвитку. Особливу увагу приділено проблемам і перспективам впровадження сучасних технологій в аграрному секторі України на прикладі компанії «Миронівський Хлібопродукт». Запропонована інтегрована модель покращення бізнес-процесів «Миронівського Хлібопродукту». включає цифровізацію виробничих процесів, впровадження блокчейн-технологій, використання ШІ та управління ризиками. Для подолання існуючих проблем, таких як недостатнє фінансування інновацій, інфраструктурні обмеження, навчання персоналу та забезпечення кібербезпеки, визначено необхідні кроки. Реалізація запропонованих заходів дозволить компанії стати лідером у впровадженні інновацій в аграрному секторі України, підвищити конкурентоспроможність та забезпечити сталий розвиток у майбутньому

▸ **Ключові слова:** сільське господарство; інноваційні технології; точне землеробство; кібербезпека; конкурентоспроможність