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Artificial Intelligence in Agricultural Engineering as A Factor in Ensuring the Economic Security of Enterprises

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ABSTRACT
This article examines the current application of artificial intelligence (AI) in agriculture, which contributes to the economic security of enterprises. It analyzes the growth rate of the global AI market in the agricultural sector, as well as the scale and dynamics of AI technology implementation in domestic and international agricultural companies. The study is based on a comprehensive analysis of tabular statistical data and a comparison of regional and industry indicators, using market reports from leading research companies and data from government and industry sources. It examines technological solutions from domestic and international companies, as well as government support mechanisms and infrastructural aspects of AI implementation. Key AI technologies include machine learning (47% of the market), computer vision (25%), and robotics (4%), used in precision farming, crop monitoring, yield forecasting, and risk management. Domestic developments, such as Cognitive Pilot and Sber Business Soft, demonstrate effective solutions adapted to Russian conditions. International leaders (John Deere, Bayer, IBM, Microsoft) demonstrate impressive results in increasing yields (up to 25%), reducing water consumption (up to 30%), and reducing pesticide use (up to 90%). The main barriers to implementation remain high initial costs, a shortage of qualified personnel, and infrastructure limitations, particularly in Russia. This article highlights the short-, medium-, and long-term development prospects for the industry, focusing on the expanded use of autonomous equipment, generative AI, and biotechnology. The use of artificial intelligence in agricultural engineering is rapidly growing and has significant potential for transforming agriculture. The economic efficiency of these technologies is demonstrated by increased yields, reduced costs, and a rapid return on investment, which contributes to the economic security of enterprises.
Key words: *Artificial intelligence, economic security, agricultural engineering, machine learning, computer vision, robotics, agriculture, digital transformation*

INTRODUCTION

Modern agriculture is undergoing revolutionary changes thanks to the implementation of artificial intelligence (AI) technologies. Market data analysis shows that the global AI market in agriculture is experiencing rapid growth, with a projected compound annual growth rate (CAGR) of 19% to 26% through 2030-2034. In Russia, 12-15% of agricultural companies are already using AI technologies, and another 37% are planning to implement them, demonstrating significant potential for industry development. Expert estimates predict a 25% increase in gross value added by 2025 in crop production and a 13% increase in livestock production with the widespread adoption of AI [1, 2, 3]. Let's look at research on the global AI market in agriculture.

Market growth dynamics. The global artificial intelligence market in agriculture is experiencing impressive growth rates. According to various research firms, the market size in 2024 is estimated to range from $0.8 billion to $4.7 billion, with projected growth to $7 billion to $13 billion by 2030–2034. The CAGR ranges from 19.48% to 26.3%, making this segment one of the fastest growing in agricultural technology [1, 2, 3, 4, 5].

The generative AI market in agriculture is particularly impressive, with a market value of $215-226 million in 2024 and projected to grow to $2.0-2.2 billion by 2033-2034, with a CAGR of 25-29%. This indicates growing interest in more sophisticated AI solutions in the agricultural sector [4].

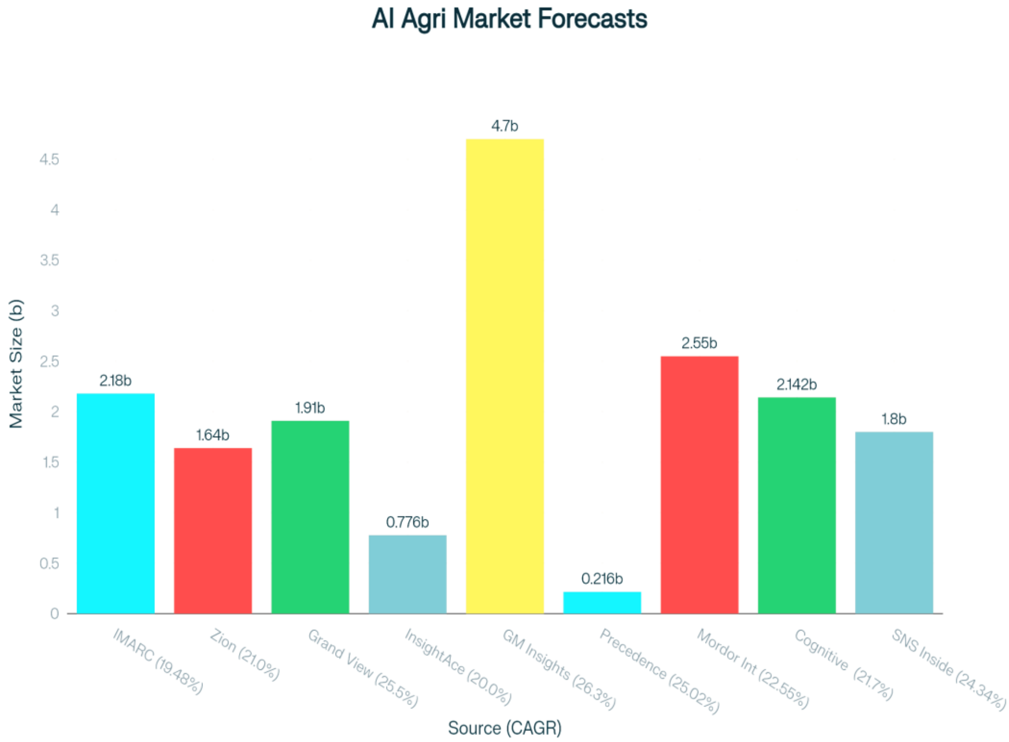

Fig. 1. Comparison of AI market size forecasts in agriculture from various research companies

Regional distribution. North America dominates the market with a 34.7-36.8% share in 2024, driven by its advanced technology infrastructure, large farms, and high levels of investment in agtech. The US leads in agtech investment ($4.2 billion) and the number of startups (850).[1, 6].

Europe ranks second with a 30% market share, demonstrating a projected CAGR of 22%. The region is focusing on sustainable technologies and Green Deal compliance. Germany leads Europe in AI adoption in agriculture, with a 38% adoption rate.[6].

The Asia-Pacific region shows the highest projected CAGR of 24.4-25.5%, driven by government digitalization programs in China and India, as well as growing populations and the need for increased agricultural productivity.[1, 6].

MATERIALS AND METHODS.

The study utilized various open-source analytical materials. Using methods of analysis and synthesis, induction and deduction, we processed these materials, allowing us to draw conclusions about the main leaders in AI in agriculture and the prospects for development in this area.

RESULTS AND DISCUSSION.

We will conduct research on the development of artificial intelligence implementation in Russia. The Russian agritech industry is demonstrating a moderate but steady pace of AI adoption. According to the Russian Government's National Center for Artificial Intelligence, 12-15% of agricultural companies are already using AI solutions, and another 37% are planning to implement them in the near future.

The Minister of Digital Development called agriculture one of the leaders in the implementation of artificial intelligence in Russia. According to the Minister of Agriculture, 40% of agricultural enterprises in the country are using AI and digital solutions.

Domestic companies and their solutions

Russian agritech companies are developing innovative solutions tailored to the specific needs of domestic agriculture. Cognitive Pilot is a shining example of the successful implementation of AI in the Russian agricultural sector. The company has developed an autopilot system for grain harvesters based on computer vision and artificial intelligence.

The results of implementing Cognitive Agro Pilot are impressive: in 2020-2021, the system was installed on combine harvesters in more than 30 regions of Russia, processing over 200,000 hectares and harvesting over 1 million tons of crops. The company's revenue increased from 64 million rubles in 2020 to over 180 million rubles in 2021, demonstrating the high demand for such solutions.

Sber Business Soft has created video analysis systems for greenhouses that help predict yields and minimize losses using computer vision data. K2Tech has developed an intelligent feed accounting system for livestock and poultry that tracks the entire feed supply chain from production to distribution.
Maslov.aipresented a robotic dairy farm where AI recognizes cows by their external characteristics and analyzes individual feeding and milking data, allowing for a 15% increase in milk yield. Erlab LLC developed a greenhouse monitoring robot that detects parasites and diseases at an early stage, reducing crop protection costs by up to 95%.
The stated results of the implementation of AI in agriculture are a factor in increasing economic security at the enterprise level, as it allows for countering various threats arising during the production activities of enterprises.

Government support and infrastructure

The Russian government actively supports the implementation of AI in the agricultural sector through various mechanisms. The Russian Ministry of Agriculture offers preferential loans for the purchase and implementation of AI-based software, the retrofitting of equipment with automated systems, and the procurement of drones. As part of the national project "Digital Economy," the federal project "Artificial Intelligence" is being implemented. It includes the development of human resources, the stimulation of scientific research, and financial support for the development of AI solutions.

International experience in applying AI in agricultural engineering

John Deere is the undisputed leader in the application of AI for precision agriculture. The company has invested $20 billion in AI technologies for agricultural machinery by 2024. By 2025, more than 60% of new John Deere equipment will be equipped with integrated AI systems for precision agriculture.[6, 7].
Results from implementing John Deere technologies include a 25% increase in yield, a 30% reduction in water and fertilizer use, a 20% increase in seeding efficiency, and a 15% reduction in fuel consumption. The See & Spray system from Blue River Technology (a John Deere subsidiary) reduces herbicide use by 90% using computer vision [7].
Through its Climate FieldView platform, Bayer provides farmers with decision-making tools based on satellite imagery, soil analysis, and yield forecasting. Implementing Bayer AI solutions, such as the Croptimus system, can result in savings of up to $25 per acre per season and a significant reduction in pesticide use [8, 9].

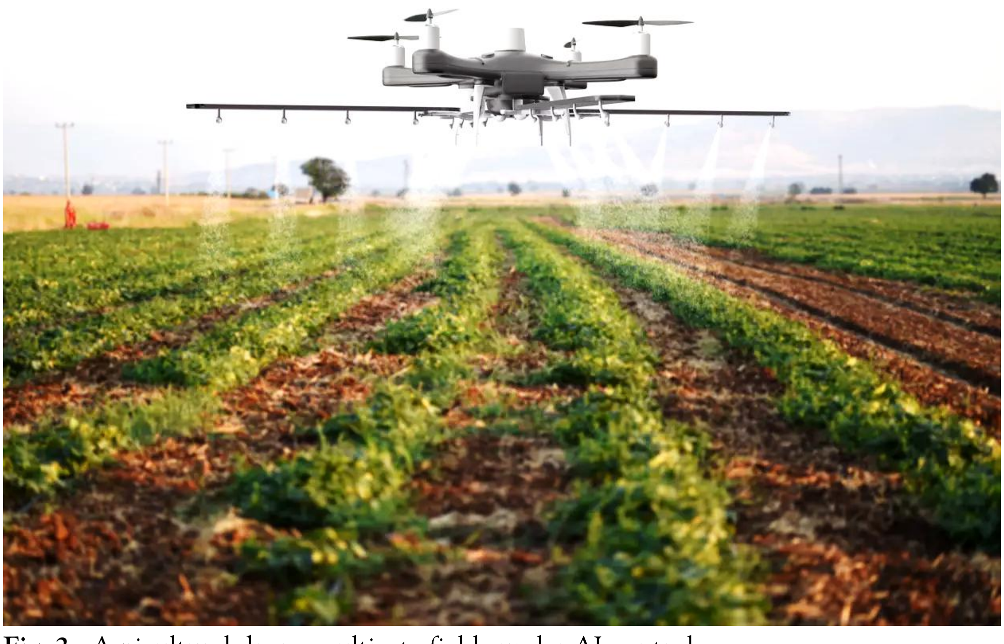

Fig. 2. Agricultural drones cultivate fields under AI control

IBM Watson Decision Platform for Agriculture integrates weather data and remote sensing to optimize resource use and prevent over-fertilization. Microsoft Azure Farm Beats offers cloud solutions for integrating IoT data and satellite analytics.

Regional Features of AI Application

In the US, the focus is on large-scale precision farming using autonomous equipment and drones. American farmers using AI report a 20% increase in operational efficiency and yield, ensuring their economic security [10].

Germany and the Netherlands are leading the way in AI-based greenhouse technologies. The EUR 30 million AgrifoodTEF project in Europe is building 5G hubs to test robotic sprayers aimed at halving pesticide use [6].

In China, Fujian Newland has developed a greenhouse robot for plant health analysis and pest control. India has launched the National Pest Surveillance System (NPSS) AI system for 140 million farmers [1].

The technological landscape of AI in agricultural engineering

Distribution of technologies

An analysis of the technology landscape shows that machine learning dominates with a 47% market share in 2024 and a projected CAGR of 22%. This technology is used for yield analysis, forecasting, and processing large amounts of agricultural data [3,6]. Computer vision ranks second with 25% of the market but demonstrates the highest growth rate of 28.7% CAGR. This technology is used for crop monitoring, plant disease detection, automated sorting, and product quality control [3].

AI-enabled robotics is growing at a 35% CAGR with a current market share of 4%. This includes autonomous agricultural machinery, robotic harvesters, and automated processing systems.

Practical application

Precision farming remains a key application of AI, using data analysis to optimize the application of fertilizers, seeds, and water according to the specific needs of different areas of a field. Drone-based crop monitoring can detect early signs of plant stress, disease outbreaks, or nutrient deficiencies, enabling farmers to take proactive measures. AI-powered yield forecasting analyzes historical yield data, weather conditions, soil data, and satellite imagery to create accurate forecasts. Risk management involves using AI to predict droughts, frosts, floods, and other natural events, allowing farmers to adjust planting and harvesting schedules.

Economic effects of AI implementation

Quantitative performance indicators

The implementation of AI technologies in agricultural engineering demonstrates significant economic benefits. Crop yield increases average 15-20%, with improvements ranging from 10% to 25%. Water cost reductions typically reach 25%, with improvements ranging from 20-30%. Particularly impressive are the results in reducing pesticide use – typical reductions are 75% with maximum values of up to 90%, achieved through computer vision systems for targeted application of chemicals. Labor cost savings average 40%, with a range of 30-50%, which is especially important in the context of a shortage of skilled labor in agriculture.

Payback periods

Most AI solutions in agricultural engineering demonstrate a rapid payback. Systems for reducing pesticide use pay for themselves within one year, while solutions for increasing yields and reducing harvest losses pay for themselves within one to two years. More complex systems, such as product quality enhancement, require 2-4 years to fully pay for themselves, which remains attractive to most farmers.

Barriers and challenges to AI implementation

Main obstacles

A study of barriers to AI adoption reveals several key issues. High initial costs remain the primary barrier, influencing 85% of adoption decisions. In Russia, the severity of this problem is rated as "very high," while in other countries it is "moderate." A shortage of qualified personnel influences 75% of implementation decisions and is a pressing issue both in Russia and abroad. Limited IT infrastructure is particularly critical in Russia, where poor internet access in rural areas poses significant barriers.

Regional differences

Russia faces more serious infrastructure challenges than developed foreign markets. Problems with IT infrastructure and internet access in rural areas are rated as "very high," while in other countries these issues are less critical. Industry conservatism remains a significant factor in Russia, influencing 65% of implementation decisions, necessitating demonstration projects to overcome mistrust of new technologies.

Promising areas of development

Short-term prospects (1-2 years)

Predictive analytics and precision farming technologies are expected to see widespread adoption in the next one to two years. Automated equipment control and crop monitoring systems will become more accessible thanks to the reduced cost of sensors and computing power. The development of agricultural drones and their integration with AI systems will enable more effective monitoring of large areas with automatic detection of problem areas.

Medium-term prospects (3-5 years)

The widespread adoption of robotic and self-driving vehicles is expected within 3-5 years. The development of 5G networks in rural areas will provide the necessary infrastructure for real-time control of autonomous systems [6]. Generative AI will find wide application in creating personalized recommendations for farmers, especially in developing countries, where it will help smallholder farmers gain access to expert knowledge.

Long-term prospects (5+ years)

In the next five years or more, AI-based biotechnology is expected to develop, enabling the creation of new plant varieties with improved characteristics based on genetic data analysis. Fully autonomous farms with minimal human intervention will become a reality thanks to the integration of various AI systems: from crop planning to automated harvesting and logistics.

CONCLUSION

The use of artificial intelligence in the work of domestic and international agricultural engineers is demonstrating dynamic growth and significant potential for transforming agriculture. The global AI market in agriculture is growing at an average rate of 20-26% per year, reaching $2-5 billion in 2024 and projected to reach $7-13 billion by 2030-2034.

Despite lagging behind global leaders in adoption rates (15% versus 45% in the US), Russia is showing positive momentum, with 37% of companies planning to implement AI. Domestic companies such as Cognitive Pilot, Sber Business Soft, K2Tech, and others are developing competitive solutions tailored to the specific needs of Russian agriculture.

International leaders, including John Deere, Bayer, IBM, and Microsoft, are setting industry technological standards, demonstrating results such as a 25% increase in crop yields, a 30% reduction in water use, and a 90% reduction in pesticide use. Machine learning and computer vision remain dominant technologies, with market shares of 47% and 25%, respectively.

The economic impact of implementing AI in agricultural engineering is significant: typical yield increases are 15-20%, labor savings are 40%, and payback periods are 1-3 years for most solutions. The main barriers remain high initial costs (accounting for 85% of the impact on implementation decisions) and a lack of qualified personnel (accounting for 75% of the impact).

The industry's development prospects are linked to the further improvement of machine learning, computer vision, and robotics technologies, as well as overcoming infrastructure barriers through the development of 5G networks and satellite communications. Successful digital transformation of agriculture requires coordinated efforts by the government, business, and the scientific community to create a favorable innovation ecosystem and support the implementation of advanced technologies. This set of measures means that artificial intelligence in agricultural engineering is becoming a factor in ensuring the economic security of enterprises, countering various threats specific to the agricultural sector.

Conflict of interest. The authors declare that there is no known conflict of interest associated with this publication.

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