


The Prospects for the Intellectualization of Dairy Farming

T E Marinchenko ^a

Russian Research Institute of Information and Feasibility Study on Engineering Support of Agribusiness, the Federal State Budgetary Scientific Institution (Rosinformagrotekh FSBSI), 60, Lesnaya Str., Pravdinsky Township, 141261 Moscow Region, the Russian Federation
9419428@mail.ru

Keywords: Dairy farming, Digitalization, Artificial intelligence, Efficiency, Prospects.

Abstract: Digital technologies in the agricultural sector of many countries around the world have reached a high degree of penetration into business processes; the use of artificial intelligence technologies has shown their high efficiency, so they are being actively implemented. The use of artificial intelligence in the agricultural sector leads to more efficient and economical use of resources, increased productivity and improved product quality. At the same time, artificial intelligence has proven to be a powerful tool that combines advanced technologies and big data analysis methods to make effective decisions at all stages of agricultural production. To increase the efficiency of livestock farming, which is less advanced in matters of digitalization, the use of artificial intelligence technologies is very relevant. The purpose of the study is to analyze promising areas for the introduction of artificial intelligence technologies in dairy farming against the background of existing Russian projects. Government measures promoting these projects implementation, as well as domestic projects that are promising for implementation taking into account the identified effectiveness and potential for digitalization of business processes in dairy farming, are analyzed.

1 INTRODUCTION

Today, development within the framework of the Industry 4.0 concept based on the mass introduction of information technology (IT), automation of business processes and the spread of artificial intelligence (AI), is a global trend (Radun, 2021). According to McKinsey & Company, more than 50% of companies in the world are already implementing AI-based solutions into their business processes (Transforming Agriculture, 2022). The advantages of this approach are improved safety, increased productivity and competitiveness, and many other effects (The state of AI in 2021). This trend called AgriTech 4.0, is also typical for the agricultural sector. In addition to the introduction of the latest technological innovations, digital tools (AgTech) for automating and optimizing production processes at agricultural enterprises are becoming increasingly widespread (Marinchenko, 2023). Their implementation that leads to increased food production while making more efficient use of resources such as land, water, fertilizers and energy

resources, is a necessary element to ensure economic growth and global food security for a growing world population (Marinchenko, 2022, Regional Activity). Currently, the agricultural sector accounts for 4% of global gross domestic product (Sandu, 2019). To increase production efficiency in the agricultural sector, it is necessary to introduce innovative technologies. Leading consulting companies, such as Gartner Gartner, McKinsey & Company, Deloitte, etc., note that the most breakthrough technology is AI, which will change the agricultural sector and ensure sustainable development of crop and livestock production (Maosong, Y.In., 2023; Gartner, 2023; Agriculture's connected future, 2023).

Globally, digital solutions and AI have shown high efficiency in dairy farming (Braginets, 2022). Thus, the projects of CattleEye (from DairyOne, USA) and Piguard (Serket, UK), which use video analytics for herd management, are known (M. LI, 2023). Fertile-Eyez solutions (Verility, USA) are aimed at monitoring and improving the individual reproductive qualities of livestock and fertility management using laboratory tests for quality of semen and cow saliva for accurate diagnosis of

^a  <https://orcid.org/0000-0003-3721-112X>

ovulation (Shahinfar, 2021). The SMARTBOW system (Zoetis, USA) allows for precise monitoring of animals thanks to smart ear tags (Radun, 2021). The WUR Wolf computer system (Wageningen University, the Netherlands) based on AI allows you to assess the level of welfare of cattle by identifying 13 facial expressions that correlate with 9 different emotional states with an accuracy of 85%, which helps identify stressful and conflict situations and symptoms of deterioration, which allows for improving the quality and life expectancy of cattle (Gasser, 2023). The AI-powered Ida platform (Connecterra, Netherlands) helps farmers make management decisions that reduce carbon dioxide emissions from dairy farms while balancing other key metrics. The implementation practice on a Dutch dairy farm reduces emissions equivalent to 42 tons of carbon dioxide per 2 million kg of milk produced per year (Introducing Farm Emissions, 2023).

Russia lags significantly behind the level of implementation of AI technologies in the agricultural sector from the leading countries. For example, the number of robotic dairy farms in Europe already reaches 50%. More than 500 robots are installed in the USA and more than 700 in Germany annually (Corporate authors, 2021, Dairy industry). Otherwise, according to RoboTrends.ru, there were about 950 milking robots in 184 farms from 48 regions in Russia in 2021 (Milking robots, 2023).

The current Russian model of technological development provides for the development and modernization of the economy through the widespread development of IT (Kuzmin, 2021). The use of AI in the process of digital transformation of the agricultural sector allows making operational and strategic decisions without human participation, since its algorithms allow simulating human thinking to form conclusions and make effective decisions based on a large amount of data (Marinchenko, 2021, Digital Technology).

More innovatively, active agricultural holdings today perceive AI not as a technology of the future and an exclusive product, but as a necessary technological reality (Letyagina, 2021).

Despite the increase in the number of agricultural enterprises implementing digital technologies in recent years, already about 20% of agricultural areas were processed using digital solutions in 2021. The size of investments in AgroTech projects in Russia is relatively small, while the level of costs for innovation lags behind the leading countries (Digital transformation of the agribusiness, 2023).

The purpose of the study is to search and analyze domestic AI projects for dairy farming that are ready for replication.

2 MATERIALS AND METHODS

The material for the study was: information from the Ministry of Agriculture of Russia, data from analytical agencies, scientific publications on the digitalization of agricultural production and dairy farming, as well as data on Russian projects in the field of AI in this area. Research methods such as monographic, comparative and system analysis ones, as well as idealization and mental modeling methods were used.

3 RESULTS AND DISCUSSION

In Russia, following developed foreign countries, innovative technologies of AI, automation and digital platforms are being introduced at an accelerated pace, but the implementation of these projects is not fast enough and is localized mainly in agricultural holdings (Marinchenko, 2022, Transformation of the Service Sector).

IT budgets of the Russian companies rarely exceed 1% of annual revenue, while they reach more than 4% in many Western countries. This has led to the fact that, by the beginning of 2023, more than 90% of large Western agricultural companies had already completed building a digital foundation and moved on to building digital platforms, profiles of equipment, machinery, animals and process optimization using machine learning and AI technologies. This complicates the competitiveness of Russian enterprises with them (Corporate authors, 2023, Effective domestic practices; Korolkova, 2020).

The Russian government is taking measures to increase competitiveness. Since 2021, the development of the state One-Stop information system for collecting and analyzing industry data has continued, which will become the core of the agricultural sector in the country (Marinchenko, 2022, Support for Innovative Activities). The main objective of this platform is the verified collection of information at various levels from agricultural producers. Storage, processing and analysis of this information will facilitate the adoption of optimal management decisions (Nemenushchaya, Bolotina, 2021). To provide for the import substitution of

digital developments and to increase the availability of domestic technologies, the Russian Ministry of Agriculture has created three industrial competence centers in the Crop production, Livestock production and Food and Processing Industry sub-sectors. The state support is provided for the acquisition and implementation of software products, including those having AI algorithms (Marinchenko, 2021, Automation of dairy cattle breeding). To stimulate the implementation of the latter, the issue of applying the criterion for using AI in production to receive government subsidies is being considered. The creation of optimal conditions for the development of AI in Russia is facilitated by the activities of the Artificial Intelligence federal project to be implemented within the framework of the Digital Economy national program that have been implementing since 2021 (Braginets, 2022). In 2021, the Federal Agency on Technical Regulation and Metrology also approved the first national standard for the use of AI in agriculture. This is GOST R 59920-2021, which regulates the main specifications of the operational safety of smart systems and the criteria for its confirmation (Corporate authors, 2023, Effective domestic practices).

In the interests of dairy farming, it is planned to create unified digital registers of breeding farm

animals in 2026–2028, into which digital profiles of animals of all enterprises will be integrated. Registry completeness target will be 95% of breeding animals with genomic profiles by 2030.

Currently, genomic profiles are already successfully used at individual breeding enterprises in the country. Thus, a system of digital animal profiles in the Perm region from CROC is known. AI technologies make it possible to interpret large amounts of genomic data and annotate large volumes of genomic sequence elements in a short time, while reducing research costs. KSITEST is engaged in the RHC genomic selection. Based on the collected training sample and the BLUP and ss-gBLUP algorithms, the startup analyzes the breeding value of the herd and provides processed information in a user-friendly format (Milking robots, 2023).

Despite existing projects, the level of penetration of AI in the agricultural sector is two times lower (11.9%) as of the beginning of 2022 than the national average (20.8%), while 28.6% of the total number of enterprises implementing AI technologies independently develop them for themselves (Corporate authors, 2023, Effective domestic practices) (Table 1).

Table 1: Level of AI implementation in Russian economic sectors.

Economic sector	Share of enterprises using AI in production, %
Financial services	56.8
Information and communication technologies	46.6
Fuel and energy complex	29.1
Trade	19.2
Healthcare	16
Agricultural sector	11.9
Economy average	20.8

The potential for using AI in the agricultural sector is highly assessed. According to the National Research University Higher School of Economics, the demand of Russian agricultural enterprises for AI and neurotechnologies amounted to 3.9 billion rubles in 2020. Thirty-six percent of enterprises plan to implement them in the near future. Due to the great potential, demand for AI is expected to grow more than 20 times (up to 86 billion rubles) by 2030, (Abdrakhmanova, Vishnevskiy, Gokhberg, 2021).

AI technologies in dairy farming also have a high potential for increasing production efficiency, since they allow monitoring the health and physiological state of cows, monitoring their fertility, identifying and proactively responding to symptoms of deteriorating health, forming a diet, and also

identifying new relationships between housing conditions, feeding and health as well as productivity. Such monitoring is especially important in large-scale livestock production where animals are kept in close quarters (Marinchenko, 2021, Scientific support and advanced research).

In particular, AI is able to systematize the collected data on animals to diagnose and predict the results of their treatment without the participation of veterinarians, which makes it possible to increase the speed of response to the first symptoms and the effectiveness of measures taken. Thus, Big Data analysis allows farmers to make informed and reasonable decisions and optimize the company's performance (Marinchenko, 2021, Digital Technology).

A number of Russian enterprises have positive experience in implementing AgroTech projects, which have shown high efficiency and can be scaled and replicated at other enterprises (Table 2). Thus, livestock enterprises located in the Tambov and Tver regions have implemented the animal feed accounting system from CROC Inc. The AI-based system analyzes data on the receipt, consumption and remainder of feed in each container from the harvester through to the storage facility, predicts feed consumption depending on the type and physiological state of individual animals for planning purchases and

adjusting the diet depending on the stage of cultivation, which significantly reduces feeding costs. Agrobot LLC has developed an Agrobot intelligent robotic system for remote animal care, which maps livestock by temperature, detects the presence of dead animals, increases the accuracy of veterinary interventions, monitors microclimate indicators, increases the activity of animals, etc. (Corporate authors, 2023. Effective domestic practices; Marinchenko, 2021, Automation of dairy cattle breeding).

Table 2: Efficiency of using AI technologies in dairy farming.

AI solution provider	Customers of AI solutions	Effects
CROC Inc. CJSC	Damate Group	Reducing the time to determine the beginning of calving to several minutes Reduce errors in product accounting by up to 100% Increase in livestock productivity by 10 -15%
Alan-IT LLC, ER-Telecom Holding JSC	Borodulinskoe LLC	Reducing the risk of decreased milk production during the transition period and in hot weather by 90% Reduce feeding costs by 25% Reducing the risk of silage loss by 2 times
Digital Consulting Solutions (DCS) LLC	Zelenaya Dolina Agricultural Holding	Improving the accuracy of cattle population forecasts by up to 10%
Alan-IT LLC	Borodulinskoe LLC, Voshchazhnikovo Agricultural Enterprise JSC	Increase in average milk yield by 26-30% per 1,000 dairy cows
		Reducing milk rejection twice
		Additional profit per 1,000 heads, from 46 million rubles on average
		Reduce feeding costs by 25%
Agrointellekt LLC	Avangard-Agro JSC, Doronichi Agricultural Holding	The accuracy of forecasting feed costs is 97-99% on average
		Growth in gross milk yield per cow is over 3 years by an average of 7.5%
		Reducing the time to clarify the reasons for the drop in milk production from 2-3 days up to 15 min. Savings due to notification of a decrease in milk production are 25.8 million rubles on average
Maslov.ai LLP	Kuzminsky Agricultural Production Artel (Co-Operative), Green Agro Khankai Agroindustrial Complex, Don LLC	Reducing mortality and morbidity by 2-4%
		Increasing 1.5 times in the productive life of cattle
		Increase in milk production by 11-17%
		Reducing the period of time between calving by an average of 10-20 days
		Reducing feeding costs by 5-10%
Increasing in enterprise productivity by 5-10%		

According to CROC, 73% of companies in the agricultural sector set the goal of digital transformation to reduce operating costs, 66% of them make it a point to increase the speed and flexibility of business processes, 53% of them contemplate to increase productivity, and 21% set objective to increase revenue. CROC survey has shown that the main goals of digitalization are related to the optimization of production and business processes (Russian IT companies, 2023).

There are a wide range of business processes that can be significantly optimized in dairy farming using AI. The agricultural sector business processes can be divided into 3 categories, namely basic, supporting, and management ones. Within each of these categories there are processes that have great application potential.

Key business processes directly related to AI production can optimize processes during procurement of feed, vaccines, embryos and semen, selection and breeding work, as well as obtaining,

primary processing, transportation, sales and marketing of products. In Russia, companies for this category of business processes are successfully operating. KSITEST offers a service for the genomic selection of cows, CROC has implemented an automated production planning system for perishable dairy and meat products, as well as a video analytics and cattle life cycle monitoring system, Maslov LLC uses intelligent feed supply and milking system. The laboratory of mathematical modeling and artificial intelligence (MathLab) and the laboratory of innovation (InnovationLab) at Damate Group work in the field of predictive analytics in the agricultural sector based on BigData. They are developing fully automated solutions for forecasting sales and balancing orders based on mathematics and machine learning (Corporate authors, 2023, Effective domestic practices). An accurate forecast of orders allows planning production, ordering the required volume of packaging, optimizing schedules for slaughter, freezing, promotions, etc., which will allow the company to use production capacity as efficiently as possible and build long-term relationships (Russian IT companies, 2023).

AI solutions that ensure business processes to support a company's infrastructure can help with office management, veterinary and sanitary services, waste management, control and maintenance, human resources, safety and security, as well as IT and communications. Digital Consulting Solutions LLC offers systems for predicting equipment failure and optimizing the purchase of equipment and spare parts. Alan-IT LLC provides for analytics and forecasting services for dairy production and for data collection, and monitoring, analysis and management of IoT devices.

Management business processes that ensure management, competitiveness and development of the enterprise include strategic planning, internal audit and control, quality management of agricultural products, finance, marketing, risks and personnel management as well. To provide these processes, a system for monitoring the implementation and evaluation of the effectiveness of procedures by employees using video analytics from Connectom-Service LLC and Mattler LLC, an analytics and forecasting service for dairy production from Alan-IT LLC, and an employee performance monitoring

system from Mattler LLC in areas, where manual labor is used, will be useful.

Automation of processes in dairy farming in combination with AI, which provide operational management based on BigData analytics, can increase the efficiency of dairy farm production by reducing costs of both main production processes and others that ensure the efficiency of farms (Marinchenko, 2021, Digital Transformations). Identified domestic projects that use AI have shown high efficiency in dairy cattle breeding in such areas as breeding, housing and feeding. Providing and management business processes can also be optimized by identified AI solutions. The next logical stage is the construction of digital platforms with integrated profiles of equipment, machinery, animals and further optimization of processes using AI technologies.

4 CONCLUSIONS

The digital transformation of the agricultural sector remains the focus of increased government attention, and the formation of high-tech infrastructure continues. The development priority is the transition to advanced digital, intelligent production technologies and robotic systems. AI technologies in the Russian agricultural sector are currently perceived by large enterprises as a necessary technological reality.

In the main areas of application of AI technologies developing in the world, domestic projects exist in Russia that are tested and proven effective. They optimize production processes in the areas. which directly affect the productivity of cattle, e.g. in selection work, breeding, feeding and others. This experience needs to be replicated more widely, including at mid-level enterprises. Areas for the use of AI technologies in dairy farming have been identified and some Russian AI technologies have been proposed for implementation in support and management business processes that accompany the activities of any enterprise. Research in the field of increasing the efficiency of using AI technology in dairy farming is extremely promising for further research.

REFERENCES

- Agriculture's connected future: How technology can yield new growth. Retrieved in <https://www.mckinsey.com/~media/McKinsey/Industries/Agriculture/Our%20InsightsAgricultures%20connected%20future%20How%20technology%20can%20yield%20new%20growth/Agriculturesconnected-future-How-technology-can-yield-new-growth-F.pdf> (accessed on 30.11.2023).
- Braginets, S.A., et al., 2022. Neural Networks and Artificial Intelligence in Stockbreeding and Forecasting Dairy Cattle Productivity. In: *AgroTech. Springer, Singapore*, vol. 13(3), pp. 292-301.
- Corporate authors, 2021. *Dairy industry 2021. A Handbook*, National Union of Milk Producers, Moscow.
- Corporate authors, 2023. *Effective domestic practices based on artificial intelligence technologies in agriculture. An analytical report*, Digital Economy, Moscow.
- Digital transformation of the agribusiness. Retrieved in <https://nnov.hse.ru/news/645573799.html> (accessed on 12.10.2023).
- Gartner, G., Top 10 Strategic Technology Trends for 2023. Retrieved in <https://www.gartner.com/en/articles/gartner-top-10-strategic-technology-trends-for-2023> (accessed on 10.10.2023).
- Gasser, L., et al., 2023. Can meteorological data improve the short-term prediction of individual Milk yield in dairy cows? In *Journal of dairy science*, vol.106, Is.8, pp. 5501-5516.
- Introducing Farm Emissions Optimization model — Ida helps a farmer reduce CO2 emissions by 42 t per year. Retrieved in https://www.connecterra.io/feo_model/ (accessed on 07.10.2023).
- Korolkova, A.P., et al., 2020. Factors of influence on the innovative activity of agricultural enterprises. In *IOP Conf. Ser.: Earth Environ. Sci.*, vol. 604, p. 012005.
- Kuzmin, V.N., et al., 2021. Mechanism for increasing innovative activity in agriculture in Russia using programing. In *IOP Conf. Ser.: Earth Environ. Sci.*, vol. 723, p. 032055.
- Letyagina, E., et al., 2021. Innovative processes and modernization in the agroindustrial complex of the Russian Federation: results and prospects. In *E3S Web of Conferences*, vol. 247(93), p. 01062.
- M. LI, et al., 2023. A time series analysis of milk productivity in us dairy states. In *Journal of dairy science*, vol. 106, I. 9, pp. 6232-6248.
- Maosong, Y.In., et al., 2023. Non-contact sensing technology enables precision livestock farming in Smart farms. In *Computers and Electronics in Agriculture*, vol. 212, p. 108171.
- Marinchenko, T., 2021. Scientific support and advanced research in dairy farming in the Russian Federation. In *E3S Web of Conferences*, vol. 282, p. 02001.
- Marinchenko, T., 2023. Improving the infrastructure for the transfer of innovations in the agribusiness. In *E3S Web of Conferences*, vol. 371, p. 03001.
- Marinchenko, T.E., 2021. Automation of dairy cattle breeding. In *IOP Conf. Ser.: Earth Environ. Sci.*, vol. 624(1), p. 012080.
- Marinchenko, T.E., 2021. Digital Technology in Agricultural Sector. In *IOP Conf. Ser.: Earth Environ. Sci.*, vol. 666(3), p. 032024.
- Marinchenko, T.E., 2021. Digital Transformations in Agriculture Studies in Systems. In *Decision and Control*, vol. 283, pp. 409-418.
- Marinchenko, T.E., 2022. Regional Activity in Agriculture Digitalization. In *IOP Conf. Ser.: Earth Environ. Sci.*, vol. 988(3), p. 03007.
- Marinchenko, T.E., 2022. Support for Innovative Activities in the Russian Agricultural Sector. In *IOP Conf. Ser.: Earth Environ. Sci.*, vol. 1069(1), p. 012034.
- Marinchenko, T.E., 2022. Transformation of the Service Sector as Part of the Agribusiness Digitalization. In *IOP Conf. Ser.: Earth Environ. Sci.*, vol. 988(4), p. 042007.
- Milking robots. Statistics and forecasts around the world. Retrieved in <https://robotrends.ru/robopedia/doilnye-roboty.-statistika-i-prognozy-po-miru> (accessed on 12.10.2023).
- Nemenushchaya, L.A., Bolotina, M.N., 2021. Innovations for milk production. In *Equipment and technologies in animal husbandry*, vol. 3 (43), pp. 43-47.
- Radun, V. et al., 2021. Implementing artificial intelligence as a part of precision dairy farming for enabling sustainable dairy farming. In *Экономика Польонпривреде*, vol. 68(4), pp. 869-880.
- Russian IT companies will provide farmers with "smart" technologies. Retrieved in https://www.croc.ru/press_releases/rossijskie-it-kompanii-obespechat-agrarijev-umnymi-tekhnologiyami (accessed on 12.10.2023).
- Sandu, I., et al., 2019. Scientific basis for forecasting the innovative development of the agricultural sector of the region's economy. In *Perm region IOP Conf. Ser.: Earth Environ. Sci.*, vol. 274, p. 012016.
- Shahinfar, S. et al., 2012. Weigel Prediction of Breeding Values for Dairy Cattle Using Artificial Neural Networks and Neuro-Fuzzy Systems. In *Computational and Mathematical Methods in Medicine*, vol. 4, p. 127130.
- The state of AI in 2021. QuantumBlack AI by Mckinsey. Retrieved in <https://www.mckinsey.com/capabilities/quantumblack/our-insights/global-survey-the-state-of-ai-in-2021> (accessed on 25.10.2023).
- Transforming Agriculture through Digital Technologies. Retrieved in https://www2.deloitte.com/content/dam/Deloitte/gr/Documents/consumer-businessgr/Transforming_Agriculture_through_Digital_Technologies_noexp.pdf (accessed on 30.11.2022).