IRSTI 68.75.01
UDC 330.341.13 https://www.jpra-kazniiapk.kz
Research Article https://doi.org/10.46666/2025-2.2708-9991.03

BIG DATA ANALYTICS IN THE AGRO-INDUSTRIAL COMPLEX OF KAZAKHSTAN: EFFECTIVE TECHNOLOGIES

ҚАЗАҚСТАННЫҢ АГРОӨНЕРКӘСІПТІК КЕШЕНІНДЕГІ ҮЛКЕН ДЕРЕКТЕРДІ ТАЛДАУ: ТИІМДІ ТЕХНОЛОГИЯЛАР

АНАЛИТИКА БОЛЬШИХ ДАННЫХ В АГРОПРОМЫШЛЕННОМ КОМПЛЕКСЕ КАЗАХСТАНА: ЭФФЕКТИВНЫЕ ТЕХНОЛОГИИ

E. KALIYASKAROVA*[1]
Ph.D
***D. ILYASSOV*[2]**
C.E.Sc., Associate Professor
***I. SKOROBOGATYKH*[3]**
Dr.E.Sc., Professor
[1]Almaty Management University, Almaty, Kazakhstan
[2]Narxoz University, Almaty, Kazakhstan
[3]Marbella International University Centre, Marbella, Spain
** corresponding author e-mail: e.kaliyaskarova@almau.edu.kz*
Э.А. ҚАЛИАСҚАРОВА*[1]
Ph.D
***Д.Қ. ІЛИЯСОВ*[2]**
э.ғ.к., қауымдастырылған профессор
***I. SKOROBOGATYKH*[3]**
э.ғ.д., профессор
[1]Алматы Менеджмент Университеті, Алматы, Қазақстан
[2]Нархоз университеті, Алматы, Қазақстан
[3]Marbella халықаралық университет орталығы, Марбелла, Испания
** автордың электрондық поштасы: e.kaliyaskarova@almau.edu.kz*
Э.А. КАЛИЯСКАРОВА*[1]
Ph.D
***Д.К. ИЛЬЯСОВ*[2]**
к.э.н., ассоциированный профессор
***I. SKOROBOGATYKH*[3]**
д.э.н., профессор
[1]Алматы Менеджмент Университет, Алматы, Казахстан
[2] Университет Нархоз, Алматы, Казахстан
[3] Международный университетский центр в Марбелье, Марбелья, Испания
**электронная почта автора: e.kaliyaskarova@almau.edu.kz*

Abstract. The relevance of the topic is driven by the importance of digital transformation in agriculture. The application of big data technologies in the country's agro-industrial complex contributes to income growth, cost reduction, and increased efficiency of production processes. *The goal* is to identify the challenges of analyzing large volumes of information in the functioning of the agrarian sector in the context of global trends and challenges. The country's agro-industrial production faces a shortage of qualified personnel, high costs of digital transformation, and outdated solutions. A new challenge has emerged – the training of specialists in working with large data sets is complicated by the lack of sufficient practical experience among producers and integrators of innovative models. *Methods* – analytical, comparative analysis, and graphical methods were used to visualize materials and substantiate conclusions. The study includes analysis of case studies from Russia, the USA, Ukraine, Israel, and Kazakhstan, demonstrating practical adaptation of scientific approaches. *Results* – limitations restricting the interpretation of digital document flow in the agro-industrial complex were identified, and barriers hindering its

widespread adoption in the sector were highlighted. An expert assessment was given on the current state and prospects for the implementation of analytical tools based on a wide range of factual data in the agriculture of several foreign countries, with an emphasis on the potential for transferring successful practices to the agro-industrial complex of the Republic of Kazakhstan. The use of satellite monitoring and unmanned aerial vehicles (drones) was demonstrated, providing high-precision and real-time data on the condition of agricultural land. *Conclusions* – priority directions for the implementation of these nanotechnologies in the short term (5 years) were determined, and a conditional structuring of stages for the medium and long term (10 years) was proposed in the form of three sequential phases.

Аңдатпа. Тақырыптың өзектілігі ауыл шаруашылығындағы цифрлық трансформацияның маңыздылығына байланысты. Республиканың агроөнеркәсіптік кешенінде үлкен деректер технологияларын қолдану кірістердің өсуіне, шығындардың төмендеуіне және өндірістік процестердің тиімділігін арттыруға ықпал етеді. *Мақсаты* - жаһандық үрдістер мен сын қатерлер контекстінде аграрлық сектордың жұмыс істеуіндегі ақпараттың едәуір көлемін талдаудың проблемаларын анықтау. Елдің агроөнеркәсіптік өндірісі білікті кадрлардың жетіспеушілігіне, цифрлық қайта құрулардың қымбаттығына, ескірген әзірлемелерге тап болады. Жаңа міндет пайда болды – мәліметтер массивтерімен жұмыс істеу бойынша мамандарды даярлау инновациялық модельдер өндірушілері мен интеграторларында жеткілікті практикалық тәжірибенің болмауымен қиындайды. *Әдістері* – аналитикалық, салыстырмалы талдау, материалдарды визуализациялау және қорытындыларды негіздеу үшін графикалық. Зерттеу ғылыми тәсілдердің практикалық бейімделуін көрсететін Ресей, АҚШ, Украина, Израиль және Қазақстан жағдайларын талдауды қамтиды. *Нәтижелер* - агроөнеркәсіптік кешендегі цифрлық құжаттама ағынын түсіндіруді шектейтін шектеулер анықталды, оның салада кеңінен таралуын қиындататын кедергілер анықталды. Қазақстан Республикасының агроөнеркәсіптік кешеніне табысты тәжірибелерді трансферттеу мүмкіндігіне баса назар аудара отырып бірқатар шет мемлекеттердің ауыл шаруашылығына нақты материалдардың кең спектрін талдау құралдарын енгізудің жай-күйі мен перспективаларына сараптамалық баға берілді. Ауыл шаруашылығы алқаптарының жай-күйі туралы деректерді жоғары дәлдікпен және жедел алуды қамтамасыз ететін спутниктік мониторингті, ұшқышсыз ұшу аппараттарын (дрондарды) пайдалану көрсетілген. *Қорытындылар* - осы нанотехнологияларды қысқа мерзімді перспективада (5 жыл) іске асырудың басым бағыттары айқындалды және кезеңдерді орта мерзімді және ұзақ мерзімді перспективаға (10 жыл) қатарынан 3 фаза түрінде шартты құрылымдау ұсынылды.

Аннотация. Актуальность темы обусловлена значимостью цифровой трансформации в сельском хозяйстве. Применение технологий больших данных в агропромышленном комплексе республики способствует росту доходов, снижению затрат и повышению эффективности производственных процессов. *Цель* - выявить проблемы аналитики значительного объема информации в функционировании аграрного сектора в контексте глобальных тенденций и вызовов. Агропромышленное производство страны сталкивается с нехваткой квалифицированных кадров, высокой стоимостью цифровых преобразований, устаревшими разработками. Появилась новая задача – подготовка специалистов по работе с массивами сведений осложняется отсутствием достаточного практического опыта у производителей и интеграторов инновационных моделей. *Методы* – аналитический, сравнительного анализа, графический для визуализации материалов и обоснования выводов. Исследование включает анализ кейсов России, США, Украины, Израиля и Казахстана, демонстрирующих практическую адаптацию научных подходов. *Результаты* - идентифицированы ограничения, лимитирующие интерпретацию потока цифровой документации в АПК, выделены барьеры, затрудняющие ее широкое распространение в отрасли. Дана экспертная оценка состояния и перспектив внедрения инструментов аналитики широкого спектра фактических материалов в сельское хозяйство ряда зарубежных государств с акцентом на возможности трансфера успешных практик в агропромышленный комплекс Республики Казахстан. Показано использование спутникового мониторинга, беспилотных летательных аппаратов (дронов), обеспечивающих высокоточное и оперативное получение данных о состоянии сельскохозяйственных угодий. *Выводы* - определены приоритетные направления реализации этих нанотехнологий на краткосрочную перспективу (5 лет) и предложено условное структурирование этапов на среднесрочную и долгосрочную перспективу (10 лет) в виде 3 последовательных фаз.

Keywords: agriculture, agro-enterprises, digital technologies, big data analytics, investment support, sustainable development, competitiveness, food security.

Түйінді сөздер: ауыл шаруашылығы, агроқұрылымдар, цифрлық технологиялар, үлкен деректерді талдау, инвестициялық қолдау, тұрақты даму, бәсекеге қабілеттілік, азық-түлік қауіпсіздігі.

Ключевые слова: сельское хозяйство, агроформирования, цифровые технологии, аналитика больших данных, инвестиционная поддержка, устойчивое развитие, конкурентоспособность, продовольственная безопасность.

Received: 16.04.2025. Approved after Peer-reviewed: 12.05.2025. Accepted: 22.05.2025.

Introduction

Nowadays, Big Data issues are becoming crucially important everywhere and agriculture is not an exception. Moreover, already established foundation and global development of Big Data Analytics in the agro-industrial complex state a necessity of its development in Kazakhstan. The traditional assessment methods in agriculture are becoming less efficient due to a rapidly changing environment. A big emergence of data requires a quick process to make effective decisions. Based on global experience of Big Data Analytics in the agriculture sector, this study highlights the main challenges for the agro-industrial complex in Kazakhstan.

Agriculture is essential by doubled food consumption and increased demand of large number of industries for raw materials. According to Baseca C.C., Sendra S., Lloret J. et al. [1] the need for technology improvements increases the importance of Data Science.

The main aim of this study is to reflect the big data analytics challenges for the agriculture sector of Kazakhstan by analyzing international practice. As research methods, this study applies theoretical methods. More specifically, it includes literature review and statistical data analysis of international and Kazakhstani practice. Therefore, the local and international studies, the internet resources, and the data of the statistical agencies are the main sources of data collection. Today many companies applies Big Data Analytics in Kazakhstan. However, as noted by Tibbetts J. H. [2]. threefold increase of the number of companies in the USA and Europe reaching over 50 % of companies for the recent five years.

The world is changing rapidly. Today any company cannot be truly successful if it does not apply Big data technologies. Big Data as a socio-economic phenomenon associated with the emergence of technological upgrade, analyzes a huge amount of data globally, including possible consequences as well.

Anyway, traditional technologies can work with Big Data, but are slower at handling the large volume of data. Despite all the information available, many organizations do not realize that they are facing a Big Data problem or are simply not willing to think about these issues.

The united ecosystem of production is working by the Internet of Things (IoT) in agriculture. «Internet of Everything» is enhancing this process as well. This process requires any new products that will overtake existing ones by functional and other attributes. Biotechnology is opening many possibilities to build vertical urban farming. The smart cities combine these issues by exploring also space as the potential opportunity to expand food production.

The changes lead to crucial development of agriculture production in ecological, environmental, technological, industrial, economical and political terms. The research of these aspects open new challenges in Big Data Technologies to collect and analyze data even beyond the Earth. Robotics and automatized processes make easier to implement even hard tasks including agriculture production.

Literature Review

Boston Consulting Group and AgFunder interviewed fifty global agricultural executives and agritech investment specialists from venture capital firms. As mentioned by Bjerke L., Johansson S. the top five fields of agriculture are: Big Data and analytics; food safety and traceability; biotechnology; optimization hardware; sensors and communications equipment.

«Industry 4» robotic technologies are becoming very popular including agricultural complex. Big Data Analytics has significant potential to replace human data processing skills and improve decision-making processes. Special devices like drones assist in monitoring crop yield, plant health, and weather forecasts, providing real-time data to enhance agricultural practices.

According to Bjerke L., Johansson S. [3] SAP HANA, Hadoop, In-Memory Database, NoSQL, NewSQL and DBMS are broadly used platforms for data collection and analysis. The farmers use cloud based databases as well. Anyway for Big data processing it is actual to have appropriate database infrastructure.

According to Shameek M., Rohit K., Tinu J. [4] autonomous data collection and processing, visual assessment by images, prediction and optimization algorithms of Big Data Analy-

tics, reflection of unexpected natural anomalies, computerized decision making by precision algorithms are the main functions of AI in agriculture with descriptions.

As mentioned by Zayats O. A., Nazarova Yu. N., Strizhakova E. A. [5] Big Data Analytics and Artificial Intelligence (AI) transform the agricultural industry more efficient and effective with support of high-precision algorithms. Moreover, Departmental project «Digital Agriculture» [6] of Russia highlights the usage of Machine Learning and AI in a number of agricultural applications is increasing everywhere including the yield prediction and image recognition algorithms, smart machines and sensors. Farming is becoming more data driven.

According to RBK trend, precision agriculture is a technology that will feed humanity by quick and proactive adaptation to any changes including climate change (Technology that will feed humanity) [7]. Optimization of plant growth is important for higher productivity automated irrigation scheduling, for example «Rostselmash» and Cognitive Technologies conducted the first field trials of an unmanned combine harvester in Russia («Rostselmash" and «conscious technologies»…) [8].

According to Abdelkader A., Hafi da A. [9] farmland and greenhouse gases monitoring, production process management and crop security are important as well. According to Maya G., Bhargavi R. [10] Big Data comes to the farm by cost cut and in-vestment to new technologies. As mentioned by Vinay K., Hombaliah R. [11] agriculture is becoming smarter by modern information technology and systems that supports utilization of real time information.

Materials and methods

Big Data Analytics in agriculture affects production optimization, crop yields and productivity. Let's stay on case studies of Russia, Israel, Untied States and Ukraine as the large agricultural countries.

Russia is the largest bordered country with Kazakhstan has an enormous potential for agricultural development. By assessment of experts Russia's digitalization significantly less than western countries. Particularly, Europe's digitalization oversized by 7-8 times than Russia. The main barriers for Russia are staying a lack of proper infrastructure for digitalization and innovations. The state support for digitalization in Europe sufficient than in Russia as well. Digitalization solutions help to substitute human skills that is deficit in agriculture sector.

According to Kamilaris A., Augusti F., Francesk X. [12] advanced technologies support all hard manual work by automatize all production processes. As the main characteristic of agriculture mot processes are repetitive, machine learning and algorithms can easily substitute that.

Anyway, Russia's agriculture digital transformation is considerably high. As the evidence of that might be AI implementation in agriculture. Many companies in Russia are leading in this digitalization. One of them is Cognitive Pilot Company of Technologies applies AI for different industries including agriculture. This company introduced different kind of AI vehicles that work without human intervention.

In overall, as the main case study materials play experience of Russia in Big Data application as the largest bordered country with Kazakhstan with climate similarities.

Results

Today digitalization is navigation systems like Yandex navigators or others that are specialized on real fields of agriculture. Precise control of equipment is also becoming popular in agriculture. Some devices like sensors or drones in agriculture are getting actual data through monitoring on space or land. Approximately all big agricultural enterprises adapted Big Data Technologies. As previously mentioned IT companies like Yandex or others are crucially impact on that trend. Space Company Ctrl2GO uses satellite for agricultural research. Cloud movement for raining is one of the technology achievements today. This company also expands it field of activity in Big Data Analytics. It is helpful find for farmers to find some research results from open sources.

Nowadays a digital agriculture project is implementing in Russia with the size of Big Data over 6 billion US dollars. Big data size can be increased many times in coming years. The main of purpose of this program to sustain digitalization in all spheres of agriculture such as livestock, plantation, feed consumption and others. Smart farm and other devices based on AI can produce more products by growth of productivity.

One promising area for Big Data development is IT solutions in Russia that is becoming progressive. To collect data it is important to develop Big Data Technologies in agriculture by building new devices and equipment of data processing. Even some of them can provide analyzed data outputs that is very convenient for farmers. Some of them help to determine the exact harvest time to maximize output. Some devices also will implement watering and other processes. According to Sonka S. [13] many research institutions play a key role for digitalization of agricultural complex. For example, PWC is the one of leading companies for digital solutions in precision production.

Information systems is also applied for medicine of Livestock by monitoring its well-being. Each animal can be treated according to device signals that decreases cost from mortality. Another important thing is reflecting disease on time that has a good impact not only on sick one but also for other animals.

Today smart greenhouses are becoming popular. The advanced technologies protect plants from some negative pest or weed impact. Their prevention is also will be implemented effectively.

In overall, Big Data technologies started to introduce unmanned vehicles that show high productivity. The number and variety of them will be increased over time. According to Oussous A., Benjelloun F.Z., Lahcen A.A. et al. [14] Big Data Technologies testing shows also quality improvement that is very important for prevail preference.

Another country as the case of example Israel is known for its desert regions, where it was previously thought impossible to grow fruits and vegetables successfully due to the arid conditions. However, a solution was found through the development of drip irrigation systems. These modern systems water crops directly at the roots, ensuring that every drop of water is used efficiently and only where it is needed. They can operate both underground and on the surface of the soil. To address the issue of moisture scarcity, Israel has also implemented a method known as «aquacu-lture». Also such a method leads for new fishing. The economic part of watering is very important in terms of water scarce as well.

Farmers also use mobile applications for detecting plant diseases. Such apps help to diagnose diseases and offer their treatment ways. Moreover, it helps to monitor progress.

These apps utilize artificial intelligence to detect plant diseases. A farmer simply needs to take a smartphone or tablet, install the application, and scan the leaves of their crops. With the help of optical character recognition (OCR) technology and previous data analysis, the program can quickly identify specific diseases affecting the plants.

Big Data is proving to be a valuable tool for generating profits in agriculture. For instance, Taranis secured $20 million in Series B funding from the Israeli fund Viola Ventures to develop technology that employs spatial scanning and deep learning techniques to identify potential crop issues. The system is continually being improved to enhance its effectiveness

In the United States, numerous companies are leveraging Big Data in the agricultural sector. For instance, FarmLogs offers user-friendly analytics and applications designed to help plan and optimize agricultural operations. This application can generate illustrations of crop conditions in the field, soil moisture levels, and fertilization needs. It processes data on weather and solar activity for further analysis.

The company has developed tools that analyze historical data to determine the best plants for cultivation and the appropriate amount of fertilizer required. Users can also plan their crop profits effectively.

Some database systems is existing for farmers to help find proper chemicals as fertilizer with instructions. Farmers use these chemicals following all procedures by simple instructions.

This approach allows farmers to consolidate data on a single platform, eliminating the need to search through multiple sources for information. The system integrates the data into a practical guide, enhancing decision-making in agriculture.

In Ukraine, the agro-industrial complex is actively utilizing innovations and Big Data, with drones serving as a notable example. In agriculture, these drones help manage resource use, apply fertilizers, and monitor crops through agromonitoring of fields. This technology provides a comprehensive overview of crops, including the detection of weeds and assessment of yield potential.

The development of precision agriculture is a priority, enabling average savings of 15% on fertilizers, fuel, and plant protection products while optimizing field management. The second priority is innovation in accounting and field analytics. Thirdly, the implementation of ERP systems for business management is crucial, as these systems allow for the management of territorial areas spread across the country and coordination of a large workforce. While no technology can replace the need for rain, these innovations can help mitigate the harmful effects of drought. Ukrainian companies are also making strides in agricultural technology.

Some companies focus on data collection and processing technologies. Their goal is to develop a remote sensing project for land areas and create a system capable of analyzing data and making autonomous decisions. Nowadays data has emerged as a valuable global resource. Data provides insightful information. Based on that experts make assumptions or real findings for artificial development.

Proper Data usage is becoming as the one of the strong competitive advantages. In addition, it plays a key role for food security of a country. The importance of Big Data Analytics

is rising in terms of climate change. Contemporary biotechnology studies apply Big Data Technologies as well.

For Ukraine and Kazakhstan, global warming has significant changes for agricultural sectors. Due to this, it is expected decline of productivity for coming years. The impact of that can be revealed by Big Data Technologies.

Another big issue to consider is carbon emission that has also negative impact on weather and ecology. This problem exists everywhere. However, the importance of this problem is rising in big cities and their neighborhoods of Kazakhstan. People are moving to big cities. Few people are staying in agrarian sector. That also highlights the importance of unmanned vehicles that existing in some countries.

Customer preferences are also evolving. Some beliefs, values and preferences shape demand that also should be taken into account for farmers. The importance of food production is rising as well. All these circumstances require new approaches for agrarian production.

The location of Kazakhstan as largest land locked country emphasizes the importance of agrarian production. The development of logistics in Kazakhstan is important for agrarian development. Industrialization of populated China might increase the food demand from agrarian sectors. To stay competitive for agrarian sector of Kazakhstan Big Data Analytics and AI development play a key role.

According to Naess L.O., Thompson J., Allen-O'Neil B. [15] Big Data Technologies are staying as innovation in response to Climate Change. Climate change problem is staying as the actual for all countries for coming years.

As mentioned by Ilyassov D.K., Kitapova G., Kench T. [16] understanding tradeoffs in the context off machine learning and statistics of decision support tools for assessing climate smart agriculture is important.

To conclude all above data table 1 shows issues based on comparative analysis. Among all countries, Russia has an ambitious challenge to be a leader in terms of implementing artificial intelligence (AI) systems.

Table 1 - Comparative Analysis of implemented actions and challenges among Russia, Israel, USA, Ukraine and Kazakhstan

Countries	The implemented actions	The challenges
Russia	Build infrastructure for the full use of digital solutions, pilot production facilities for testing innovative technologies	May find itself among the leaders, for example, in terms of implementing artificial intelligence (AI) systems
Israel	OCR technology and analysis of the experience accumulated	Apps use artificial intelligence to identify plant diseases
United States of America	Application to prepare an illustration of the crop conditions in the field, soil moisture, and fertilization. The systems transmit weather and solar activity data for further analysis	Applications for planning and optimizing agricultural work
Ukraine	Manage resource usage, fertilizer application, and crop control through agromonitoring of fields	Precision production of agriculture by agromonitoring devices
Kazakhstan	Digital transformation leads to cost cut and unmanned production	To increase competitiveness in agro climatic map
Note: adapted by the authors from source (Zayats O.A., Nazarova Yu.N., Strizhakova E.A.) [5]		

To conclude, similarly to other countries Kazakhstan has its own barriers of Big Data Analytics development in Kazakhstan: a lack of digital infrastructure; difficulties in logistics that has also affect agriculture development; the lack or high cost of Big Data processing systems; a lack of Big Data Analysts specialized on agriculture; disbelief of consumers due to data privacy.

In conclusion, Kazakhstan has a big potential for agriculture development by Big Data Technologies in effect of e-government and other digitalized industries. The successful experience of digital banking system and digital tenge stays as a benchmark for agricultural digitalization.

Big Data Analytics application in agriculture has some similar algorithm of development based on international practice. The initial stage is automatic data collection by using sensors and other equipment. Then, satellite and drone imagery helps to visualize time series data and provides the snapshot of real conditions. Machine learning algorithms make forecasting and optimization focused on collected data. AI as the powerful tool of analytics supports anomaly and problem detection. In addition, AI helps farmers and agronomists opti-

mize production processes, manage resources, and improve efficiency through automated decision making processes. The description and tasks are provided in table 2.

Table 2 – Usage of AI in agriculture

Functions	Description	Tasks
Automatic data collection	AI systems can be configured to automatically collect data from sensors installed in fields or on equipment	They can continuously monitor parameters such as soil moisture levels, temperature, nutrient content, and other factors, collecting valuable data for further analysis
Image analysis	AI has the ability to analyze satellite and drone imagery	It assesses crop health, detect plant diseases, determine weather conditions, and more
Forecasting and optimization	Using machine learning algorithms	AI can analyze historical data on weather, soil conditions, crop yields, and other parameters to predict future events and optimize production processes
Anomaly and problem detection	AI can be used to detect abnormal patterns	Indicate potential problems such as plant diseases, underutilization of resources, or soil degradation
Automated decision-making processes	Based on data collected and analyzed using AI, automated decision-making systems can be developed	To help farmers and agronomists optimize production processes, manage resources, and improve efficiency
Note: adapted by authors from (Shameek M., Rohit K., Tinu J.) [4]		

By considering experience of Big Data Analytics development in agriculture of Russia, Israel, USA, Ukraine the proposed solutions for overtaking barriers in Kazakhstan.

The main barrier is a lack of digital infrastructure. State support for digitalization and AI development programs should allow farmers open access to databases of countries with advanced digital agriculture. Secondly, difficulties in logistics that has also affect agriculture development. As one of the solutions, logistics development map should be created for agricultural complex. Funding of new projects for experimentation and own equipment testing is important to solve the lack or high cost of Big Data processing systems.

Digital modernization of research and educational institutions in agriculture should help to solve a problem of lack of Big Data analysts specialized on agriculture. Finally, cybersecurity and state support of small enterprises of agriculture eliminate disbelief of consumers due to data privacy.

Additionally, the dynamics of innovative activities among agricultural enterprises in Kazakhstan is rising by state support. The further research on Big Data Analytics in Kazakhstan's agriculture is crucial for highlighting pathways to innovative development.

The rural economy of Kazakhstan, which is defined by agricultural development, plays a crucial role in supporting the country's overall economic sustainability. However, the level of digitalization in agriculture remains low. This can be attributed primarily to the lack of a systematic approach to agricultural development that focuses on Big Data Analytics and digital technologies.

The state program «Digital 2 («New Agriculture») is not yet functioning effectively. One significant challenge is the poor internet access in some regions, which hinders digitalization efforts. Strengthening the relationships between the government, agribusinesses, and scientific institutions could accelerate the adoption of new technologies.

These programs will continue funding projects aimed at implementing Big Data solutions in agriculture. The framework of purposes, tasks and actions for Big Data Analytics Development in Kazakhstan for coming ten years. Conditionally 10 years consist of four periods:

Period I - The starting 3-year period from 2025 to 2028. Cost cut and yield increase by Big Data applications need modern information technology and systems.

Period II - The next 2 years (2028-2030). Automate the process of data acquisition highlights privacy and security. Evaluating the impact of new technologies and climate adaptation strategies.

Period III - The following 3 years (2030-2033). Imaginary data processing requires data visualizations by satellite or drones. Data storage and processing is actual.

Period IV - For the last 2 years (from 2033 to 2035). Dealing with climate change issues lead to unmanned production development. To survive it is important to create sustaining competitive advantages in agroclimatic map.

According to table 3 the identified challenges determine the periods with the pur-

poses, tasks and actions. During ten years, it is real to implement Big Data technology adaptation in agriculture of Kazakhstan with the output of automated decision-making processes.

Table 3 - Further development of Big Data Analytics in Kazakhstan for coming 10 years

Periods	Purposes	Tasks	Actions
Up to 3 years (2025-2028)	Cost cut and yield increase	Big Data applications	Modern information technology and systems
3-5 years (2028-2030)	Automate data acquisition	Ensure privacy and security	Assessing impact of new technologies and climate adaptation
5-7 years (2030-2033)	Illustrative analysis	The users do not want models, but they need information they can produce	Data transmission technologies
7-10 years (2033-2036)	Access to model outputs	Food safety and traceability	Automated decision-making processes
Note: compiled by the authors based on the source (Ilyassov D.K., Kitapova G., Kench T.) [16]			

The identified challenges determine the periods with the purposes, tasks and actions for 10 years based on international experience of Big Data Analytics adaptation for Kazakhstan.

Discussion

The use of Big Data is one of the most promising areas of agriculture. The applications of Big Data Analytics in the agri-food sector are many. Management of enterprises of the agro-industrial complex based on Big Data allows to reduce production costs, increase the efficiency of most processes and thus create competitive advantages over enterprises that do not digitize their production.

Big Data technologies are innovations that allow companies to increase their competitiveness by making informed management decisions based on high-quality analytical information obtained through Big Data research. The factors influencing the development and acceleration of the implementation of Big Data Technologies in Kazakhstan are: investor funding and the status of projects to promote Big Data Technologies; openness of companies that successfully apply Big Data Technologies; regular dialogue between business, as creators of tools for working with Big Data, and the government, as a data provider; ensuring an influx of qualified managers, analysts and engineers who can properly work with Big Data. Big Data can already be successfully used in agriculture.

To do this, entrepreneurs need to be able to work with modern technologies (and not only in the IT field) and process data. As a result, by receiving and processing data from GPS navigators, seed sensors, soil moisture sensors, etc., they will be able to calculate the optimal route for moving equipment, calculate the required amount of fertilizers, and determine the optimal irrigation scheme. Big Data processing has enormous potential for agriculture. There are now services that do not require users to have specific skills in data processing; the main thing is to set up the task correctly and the system itself will present possible solutions. The various processing, analytical tools as well as dynamic visualization support Big Data platforms in agriculture. Hence, usage of Big Data Technologies sustains profitability and productivity of agriculture business.

Based on literature review on international practice of Big Data application in agricultural industry of global markets cost cut and yield increase is one of challenges staying for Kazakhstani agricultural industry as well. It needs investing money on new technologies that use detailed data on soil type, seed variety and weather. Big Data applications lead to developments of Cloud based platform, Hadoop file system and their hybrid system make appropriate technological infrastructure using sensors, open data, biometric sensing genotype information.

Another issue is setting a benchmark in agriculture sector with modern information technology and systems that has advanced innovative architecture and frameworks, algorithms, analytics improvements. It can be implemented by automate data acquisition. Some data virtually no costs, but some of them remaining privately. Therefore, it is necessary to have a common pool infrastructure to transfer and integrate data by making Data exchange facilities.

Developing applications by privileged access to Big Data and building trust with farmers is staying as ongoing development process. However, ensure privacy and security is one of the key issues for Big Data Analytics on state and local level.

The global trends dictate the necessity of Big Data Analytics development in Kazakhstan. In particular, climate change and global warming lead to development of new technologies for climate adaptation. The popular movement is climate smart agriculture by forward

looking and technology impact assessment. Most studies carry out agricultural technology impact assessment after technologies have been disseminated. For instance, illustrative analysis provides how climate change may impact dry-land wheat producing farmers.

Improved contract design and creative usage of satellite allow to extend insurance coverage that is actual for farmers to mitigate risks. Data predictions on crop yield or loss allow governments or insurance companies to respond to catastrophes in a timely manner.

Governments protect the health of citizens by using network analysis approach and science tools and respect environmental sustainability. For this purpose, farmers and researchers share information based on a wide range of factors such as: location, crop, management practices, mechanization level, irrigation type, farm size and soil type. These help about the different choices of cultivation and take necessary measures.

To sum up, the application of Big Data Technology in agriculture, with a certain approach and the necessary knowledge, will ensure the growth of business income, ultimately leading to the progress of agricultural activity. Informed decision-making based on Big Data will not only help increase the profitability of individual enterprises, but also, through the expansion of trade and the development of effective supply policies, ensure food security in the country.

Conclusion

1. The prospective way of agriculture development is adaptation of Big Data Technologies and AI. It allows the usage of unmanned vehicles that can substitute human hard work. The lack of workforce in agriculture is obvious today. Its deficit increase for coming years explained by migration of population to big cities from rural areas. The main prospective solution is sustaining competitive advantage during global warming by increasing productivity and quality of produced products.

2. For plantation sector, farmers are able to take advices and instructions for any kind of problem solutions from open sources. AI consultation allow access for getting any kind of data for decision-making. The usage of robotics has unlimited possibilities to simplify hard work of agrarians and farmers. Devices also can determine the effective time for yield. The visualization by images make direction for proposed actions. Farmers might have a strong set of tools not just for making decisions but also for actions.

3. Big Data Technologies for livestock allows decreasing mortality by monitoring well being of animals. Taking proper actions in the case of animal sickness might be implemented by instructions of Big Data Analytics.

4. In overall, Big Data Technologies help to increase profitability of farmers by cost cut, higher productivity and efficient work. Big Data Analytics applications might be costly for small enterprises. State support might help to generate profit of them to become bigger. Agricultural digital centers and incubators might implement training of farmers. In addition, they can provide open database sources for increasing the use of Machine learning and AI. Development of Big Data Analytics infrastructure should be done by combine work of state and digital agencies.

5. International cooperation in adapting Big Data Technologies help to motivate farmers to adapt Big Data Technologies. Ongoing grants and subsidies for digital projects enhance digitalization of agriculture. Collaboration work for joint projects with international digital centers might have a positive impact on digitalization of agriculture. The digital centers might help for the finding beneficial cooperation for farms. To conclude, digitalization of agriculture in Kazakhstan has a big potential by leading strong digitalized other existing industries and support from Government to develop agriculture for coming years.

Authors' contribution: Kaliyaskarova Elmira: literature review on the research topic, analysis and collection of information, calculations; Iyassov Didar: development of research methodology, editing and revision of the publication; Skorobogatykh Irina: interpretation of the research results.

Conflict of interest: the authors declare no conflict of interest.

References

[1] Baseca, C.C. A Smart Decision System for Digital Farming / C.C. Baseca, S. Sendra, J. Lloret, J. Tomas // Agronomy. -2019.- Vol.9.-N 5.- P.1-19. https://doi.org/10.3390/agronomy905 0216

[2] Tibbetts, J.H. Agricultural Disruption: New technology, consolidation, may yield production gains, job upheaval / J.H. Tibbetts // Bioscience.- 2019.- Vol. 69.-Issue 4.-P. 237-243.

[3] Bjerke, L. Innovation in agriculture: An analysis of Swedish agricultural and non-agricultural firms// L.Bjerke, S. Johansson // Food Policy.-2022.-Vol. 109.- P. 1–14. https://doi.org/10.1016/j.foodpol.2022.102269

[4] Shameek, M. Developing big data enabled Marketing 4.0 framework / M. Shameek, K. Rohit, J.Tinu // International Journal of Information Management Data Insights. – 2024. -Vol. 4.- Issue 1.- P. 1-11. https://doi.org/10.1016/j.jjimei.2024.100214

[5] Заяц, О.А. Big Data технологии в сельском хозяйсстве / О.А. Заяц, Ю.Н., Назарова, Е.А. Стрижакова // Фундаментальные исследования.- 2022.- № 7.- С. 35–40. https:// doi.org/ 10.17513/fr.43280.

[6] Ведомственный проект «Цифровое сельское хозяйство».- М.: Росинформтех, 2019.- 48 с.

[7] Технология, которая прокормит человечество [Электронный ресурс].- URL: https:// www.trends.rbc.ru/trends/industry/6221f6aa9a79 47184f151d22 (дата обращения: 17.03.2025).

[8] «Ростсельмаш» и «сознательные технологии» впервые в России провели полевые испытания беспилотного комбайна [Электронный ресурс].- URL: https://www.agbz.ru/news/ rostselmash--i-CognitiveTechnologies-vpervyie-v-rossii-proveli-polevyie-ispyitaniyabespilotnogo-kombayna/ (дата обращения: 17.03.2025).

[9] Abdelkader, A. Predictive Analysis for Big Data: Extension of Classification and Regression Trees Algorithm / A. Abdelkader, A. Hafi da // International Journal of Computer and Systems Engineering.- 2019.-Vol. 13.- N 8. - P. 450–454.

[10] Maya, G. Big Data Challenges and Opportunities in Agriculture / G. Maya, R. Bhar-gavi // International Journal of Agricultural and Environmental Information Systems.–2020.–Vol.11.- Issue1.– P.48-65. https://doi:10.4018 /IJAEIS.20 20010103

[11] Vinay, K. Paradigm change in Indian agricultural practices using Big Data: Challenges and opportunities from field to plate / K. Vinay, R.Hombaliah // Information Processing in Agriculture. - 2020. - Vol.7.- Issue 3. – P. 366-368. https://doi.org/10.1016/j.inpa.2020.01.001

[12] Kamilaris, A. The Rise of Blockchain Technology in Agriculture and Food Supply Chains / A. Kamilaris, F. Augusti, X. Francesk // Trends in Food Science & Technology. -2019. – Vol. 91(9).– P. 1-34. https://doi: 10.1016/j.tifs. 2019.07.034

[13] Sonka, S. T. Digital Technologies, Big Data, and Agricultural Innovation / S.T. Sonka //The Innovation Revolution in Agriculture.- Luxembourg: Springer, 2020. – P. 1-8. https:/doi:10. 1007/978-3-030-50991-0_8

[14] Oussous, A. ASA: A framework for Arabic sentiment analysis / A. Oussous, F.Z. Benjelloun, A.A. Lahcen, S. Belfkih / Journal of Information Science.-2019.-Vol.46.-Issue 4.-P.544-559. https://doi.org/10.1177/0165551519849516

[15] Naess, L.O. Agricultural innovation and climate change adaptation: a framework for analysis / L.O. Naess., J. Thompson, B. Allen-O'Neil // Handbook on Climate Change and Technology, 2023. – P. 324-337. https://doi.org/10.4337/ 9781800882119.00035

[16] Ilyassov, D.K. Overview and Advantages of Machine Learning in Statistics / D.K. Ilyassov, G.Kitapova, T.Kenc // Bulletin of the Karaganda University.- 2023.-N1(109).- P. 59–66. https://doi.org/10.31489/2023ec1/59-66

References

[1] Baseca, C.C., Sendra, S., Lloret, J., Tomas, J. (2019). A Smart Decision System for Digital Farming. *Agronomy*, 9(5), 1-19. https://doi.org/10.3390/agronomy9050216 [in English].

[2] Tibbetts, J.H. (2019). Agricultural Disruption: New technology, consolidation, may yield production gains, job upheaval. *Bioscience*, 69(4), 237-243 [in English].

[3] Bjerke, L., Johansson, S. (2022). Innovation in agriculture: An analysis of Swedish agricultural and non-agricultural firms. *Food Policy*, 109, 1-14. https://doi.org/10.1016/j.foodpol.2022. 102269 [in English].

[4] Shameek, M., Rohit, K., Tinu, J. (2024). Developing big data enabled Marketing 4.0 framework. *International Journal of Information Management Data Insights*, 4(1), 1-11. https:// doi.org/10.1016/j.jjimei.2024.100214 [in English].

[5] Zayats, O.A., Nazarova, Yu.N., Strizhakova, E.A. (2022). Big Data technologies in agriculture. *Fundamental'nye issledovaniya – Fundamental Research*, 7, 35-40. https://doi.org/ 10. 17513/fr.43280 [in Russian].

[6] Vedomstvennyy proekt "Tsifrovoe sel'skoe khozyaystvo" [Departmental project "Digital Agriculture"] (2019). Moscow: Rosinform-tekhnika, 48 [in Russian].

[7] Tekhnologiya, kotoroe prokormyat chelovechestvo [Technology that will feed humanity] (2025). Available at: https://www.trends.rbc.ru/ trends/industry/6221f6aa9a7947184f151d22 (date of access: 17.03.2025) [in Russian].

[8] "Rostselmash" i "Soznatel'nye technologii" vpervye v Rossii proveli polevye ispytaniya bespilotnogo kombayna ["Rostselmash" and "Conscions Technologies"for the first time in Russia conducted field tests of an unmanned combine] (2025). Available at: https://www.agbz.ru/ news/ rostselmash-i-Cognitive-Technologies-vpervyie-v-rossii-proveli--polevyie-ispyitaniyabespilotnogo-kombayna/ (date of access: 17.03. 2025) [in Russian].

[9] Abdelkader, A., Hafida, A. (2019). Predictive Analysis for Big Data: Extension of Classification and Regression Trees Algorithm. *International Journal of Computer and Systems Engineering*, 13(8), 450-454 [in English].

[10] Maya, G., Bhargavi, R. (2020). Big Data Challenges and Opportunities in Agriculture. *International Journal of Agricultural and Environmental Information Systems*, 11(1), 48-65. https://doi.org/10.4018/IJAEIS.2020010103 [in English].

[11] Vinay, K., Hombaliah, R. (2020). Paradigm change in Indian agricultural practices using Big Data: Challenges and opportunities from field to plate. *Information Processing in Agriculture*,

7(3), 366-368. https://doi.org/10.1016/j.inpa.2020.01.001 [in English].

[12] Kamilaris, A., Augusti, F., Francesk, X. (2019). The Rise of Blockchain Technology in Agriculture and Food Supply Chains. *Trends in Food Science & Technology*, 91(9), 1-34. https://doi.org/10.1016/j.tifs.2019.07.034 [in English].

[13] Sonka, S.T. (2020). Digital Technologies, Big Data, and Agricultural Innovation. In *The Innovation Revolution in Agriculture*, 1-8. Luxembourg: Springer. https://doi.org/10.1007/978-3-030-50991-0_8 [in English].

[14] Oussous, A., Benjelloun, F.Z., Lahcen, A.A., Belfkih, S. (2019). ASA: A framework for Arabic sentiment analysis. *Journal of Information Science*, 46(4), 544-559. https://doi.org/10.1177/0165551519849516 [in English].

[15] Naess, L.O., Thompson, J., Allen-O'Neil, B. (2023). Agricultural innovation and climate change adaptation: a framework for analysis. In *Handbook on Climate Change and Technology*, 324-337. https://doi.org/10.4337/9781800882119.00035 [in English].

[16] Ilyassov, D.K., Kitapova, G., Kenc, T. (2023). Overview and Advantages of Machine Learning in Statistics. *Bulletin of the Karaganda University*, 1(109), 59-66. https://doi.org/10.31489/ 2023ec1/59-66 [in English].

Information about authors:

Kaliyaskarova Elmira - **The main author**; Ph.D; Senior Lecturer; Almaty Management University; 050060 Rozibakiyev str., 227, Almaty, Kazakhstan; e-mail: e.kaliyaskarova@almau.edu.kz; https://orcid.org/0000-0002-7131-9444

Ilyassov Didar; Candidate of Economic Sciences, Associate Professor; Associated Professor of EP "Marketing»; Narxoz University; 050035 Jandosov str., 55, Almaty, Kazakhstan; e-mail: didarilyassov@gmail.com; https://orcid.org/0000- 0001-6150-6492

Skorobogatykh Irina; Doctor of Economic Sciences, Professor; Professor of the Department of International Business; Marbella International University Center; 29601 Avenida Don Jaime de Mora y Aragón, s/n Finca El Pinillo, Marbella, Spain; e-mail: iskorobogatykh@gmail.com; https://orcid.org/0000-0002-1206-4509

Авторлар туралы ақпарат:

Қалиасқарова Эльмира Асетовна – **негізгі автор**; Ph.D; сеньор лектор; Алматы Менеджмент Университеті; 050060 Розыбакиев көш., 227, Алматы қ., Қазақстан; e-mail: e.kaliyaskarova@almau.edu.kz; https://orcid.org/0000-0002-7131-9444

Ілиясов Дидар Кабидолданович; экономика ғылымдарының кандидаты, қауымдастырылған профессор; «Маркетинг» ББ бағдарламасы қауымдастырылған профессоры; Нархоз университеті; 050035 Жандосов көш., 55, Алматы қ., Қазақстан; e-mail: didarilyassov@gmail.com; https://orcid.org/0000- 0001-6150-6492

Skorobogatykh Irina; экономика ғылымдарының докторы, профессор; «Халықаралық бизнес» кафедрасының профессоры; Marbella халықаралық университет орталығы; 29601 Avenida Don Jaime de Mora y Aragón, s/n Finca El Pinillo, Марбелла қ., Испания; e-mail: iskorobogatykh@gmail.com; https://orcid.org/0000-0002-1206-4509

Информация об авторах:

Калияскарова Эльмира Асетовна – **основной автор**; Ph.D; senior lecturer; Алматы Менеджмент Университет; 050060 ул. Розыбакиева, 227, г.Алматы, Казахстан; e-mail: e.kaliyaskarova@almau.edu.kz; https://orcid.org/0000-0002-7131-9444

Ильясов Дидар Кабидолданович; кандидат экономических наук, ассоцированный профессор; ассоцированный профессор ОП «Маркетинг»; Университет Нархоз; 050035 ул. Жандосова, 55, г.Алматы, Казахстан; e-mail: didarilyassov@gmail.com; https://orcid.org/0000- 0001-6150-6492.

Skorobogatykh Irina; доктор экономических наук, профессор; профессор кафедры «Международный бизнес»; Международный университетский центр в Марбелье; 29601 Avenida Don Jaime de Mora y Aragón, s/n Finca El Pinillo, г.Марбелья, Испания; e-mail: iskorobogatykh@gmail.com; https://orcid.org/0000-0002-1206-4509