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DIGITALIZATION OF AGRICULTURE IN THE REPUBLIC OF KAZAKHSTAN: EXPERIENCE AND PROBLEMS

ҚАЗАҚСТАН РЕСПУБЛИКАСЫНДА ЕГІНШІЛІКТІ ЦИФРЛАНДЫРУ: ТӘЖІРИБЕСІ ЖӘНЕ МӘСЕЛЕЛЕРІ

ЦИФРОВИЗАЦИЯ ЗЕМЛЕДЕЛИЯ В РЕСПУБЛИКЕ КАЗАХСТАН: ОПЫТ И ПРОБЛЕМЫ

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Abstract. The role of using digital technologies in the economy of agricultural sector of Kazakhstan is shown. A literature review based on a study of digitalization of agriculture and land cultivation is presented. It is proved that digital farming involves the promotion of new information systems. In particular, it was determined that agricultural engineering based on a digital instrument stimulates the optimization of production processes. An economic assessment of digital farms in Kazakhstan for 2018-2019 was carried out. The experience of implementing land use digitalization on the example of the activities of farms in the northern regions of Kazakhstan is analyzed. For example, in the North Kazakhstan, Akmola and Kostanai regions, electronic maps of agricultural fields have been introduced. Over the past three years, sowing and harvesting has been monitored online in the northern regions. The work focuses on equipping agricultural machinery with "GPS" monitoring systems via satellite navigation, this helps to quickly monitor crop ripening, irrigation level, plant disease, etc. Important attention is paid to the creation of an irrigated landfill on the example of agricultural activity of the Scientific and Production Center named after A.I. Barayev. This research center has achieved positive results in the implementation of the project "precision farming". The experience of spring wheat production using an integrated approach to managing soil productivity using computer and space nanotechnology, which contributes to high yields and resource savings, is shown. The main problems are identified and recommendations are proposed for stimulating the use of the digital farming system in agricultural sector of Kazakhstan.

Аңдатпа. Қазақстанның аграрлық секторының экономикасында сандық технологияларды пайдаланудың рөлі көрсетілген. Ауыл шаруашылығын цифрландыруды зерттеуге және жерді өсіруге негізделген әдебиетке шолу жасалды. Цифрлық егіншілік жаңа ақпараттық жүйелерді ілгерілетуді көздейтіні негізделген. Атап айтқанда, сандық құралдар базасындағы ауыл шаруашылығы машиналарын жасау өндірістік процестерді оңтайландыруды ынталан-дыратыны анықталған. Қазақстанда цифрлық фермаларға 2018-2019 жылдары экономикалық бағалау жүргізілген. Қазақстанның солтүстік өңірлерінің фермерлік шаруашылықтары қызметінің мысалында жерді цифрландыруды енгізу тәжірибесі талданған. Мысалы, Солтүстік Қазақстан, Ақмола және Қостанай облыстарында ауыл шаруашылығы алқаптарының электрондық карталары енгізілген. Солтүстік өңірлерде соңғы үш жыл бойы егіс және егін жинау жұмыстарын онлайн-бақылау жүзеге асырылуда. Жұмыста спутниктік навигация арқылы мониторинг жасау үшін ауылшаруашылық техникаларымен «GPS жүйелерімен» жабдықталуына көңіл аударылған, бұл егіннің пісуін, суару деңгейін, өсімдік ауруларын және т.б. жедел бақылауға көмектеседі. Ә.И. Бараев атындағы Ғылыми-өндірістік орталығында ауылшаруашылық қызметі мысалында суарылатын полигонды құруға маңызды мән берілген. Бұл ғылыми орталық «дәл егіншілік» жобасын жүзеге асыру бойынша оң нәтижелерге қол жеткізді. Жоғары өнімділікке және ресурстарды үнемдеуге ықпал ететін компьютерлік және ғарыштық нанотех-

нологияларды қолдана отырып, топырақтың өнімділігін басқаруға кешенді тәсілді пайдалана отырып жаздық бидай өндіру тәжірибесі көрсетілді. Негізгі мәселелер анықталды және Қазақстанның АӨК-де цифрлық егіншілік жүйесін қолдануды ынталандыру бойынша ұсыныстар жасалды.

Аннотация. Показана роль использования цифровых технологий в экономике аграрного сектора Казахстана. Представлен обзор литературы, основанный на исследовании цифровизации сельского хозяйства и возделывания земли. Обосновано, что цифровое земледелие предполагает продвижение новых информационных систем. В частности, определено, что сельскохозяйственное машиностроение на бае цифровых инструментов стимулирует оптимизацию производственных процессов. Проведена экономическая оценка цифровых ферм в Казахстане за 2018-2019 годы. Проанализирован опыт внедрения цифровизации землепользования на примере деятельности фермерских хозяйств северных регионов Казахстана. Например, в Северо-Казахстанской, Акмолинской и Костанайской областях внедрены электронные карты сельскохозяйственных полей. В северных регионах на протяжении последних трех лет осуществляется онлайн-контроль посевных и уборочных работ. В работе сделан акцент на оснащенности сельхозтехники «системами GPS» мониторинга через спутниковую навигацию, это помогает оперативно отслеживать созревание урожая, уровень полива, заболевание растений и др. Важное внимание уделено созданию орошаемого полигона на примере сельхоздеятельности Научно-производственного центра им. А.И. Бараева. Этот научный центр достиг положительных результатов по реализации проекта «точного земледелия». Показан опыт производства яровой пшеницы с использованием комплексного подхода к управлению продуктивностью почвы с применением компьютерных и космических нанотехнологий, способствующего высокой урожайности и экономии ресурсов. Выявлены основные проблемы и предложены рекомендации по стимулированию применения системы цифрового земледелия в АПК Казахстана.

Key words: agro-industrial complex, agricultural products, digital technologies, digitalization of agriculture, farms, electronic field maps, online control, satellite navigation..

Түйінді сөздер: агроөнеркәсіп кешені, ауыл шаруашылығы өнімі, сандық технологиялар, егіншілікті цифрландыру, фермерлік шаруашылықтар, егістіктің электрондық карталары, онлайн-бақылау, спутниктік навигация.

Ключевые слова: агропромышленный комплекс, сельхозпродукция, цифровые технологии, цифровизация земледелия, фермерские хозяйства, электронные карты полей, онлайн-контроль, спутниковая навигация.

Introduction. Today, all the leading countries of the world orient their development strategy based on the introduction of digital technologies. It is estimated that at least 25% of the global economy will become digital in 2020. Research shows that digitalization will lead to increased productivity on a global scale. Much attention is paid to the digital development of agriculture in the world.

Agriculture is on the verge of a "Second green revolution". Experts estimate that thanks to precision farming technologies, a surge in yields may follow.

Digitalization and automation of the maximum number of agricultural processes is included in the development strategies of the largest agro-industrial and machine-building companies.

Data and advanced data management systems (data: science & management) are becoming a key resource for further growth of agricultural productivity, ensuring stable results and increasing competitiveness on a local and global scale. Automated agricultural management systems allow controlling 2/3 of crop loss factors.

According to «J'son&Partners Consulting», the total economic effect of the transition of rural households to business models based on ICT and digitalization may amount to 5-7% of GDP growth. Within the framework of the European Association of agricultural engineering, we have developed the concept of agriculture 4.0, which means the transition from precision agriculture to digital agriculture [1].

At the end of December 2019, Kazakhstan adopted the Program of industrial and innovative development for 2020-2025, where considerable attention is paid to the formation of the manufacturing industry. At the same time, the focus is on increasing access to world markets and increasing the export-oriented economy with high added value.

Increasing the competitiveness of the manufacturing sector will occur due to the organization of the technological industry. At the same time, it is important to implement the digitalization of fixed assets of companies and enterprises, including in the agricultural sector.

Material and methods of research. In order to study the scientific works of foreign authors, empirical methods were used in this work. In particular, it has been considered by the scientific and practical results in the application of foreign experience of digital agriculture.

The use of methods for collecting, processing and evaluating statistical data made it possible to analyze the state of the agro-industrial complex in Kazakhstan.

A systematic approach was used in the economic analysis. This allowed us to identify patterns in the process of interaction between the introduction of new achievements in science and technology and the volume of agricultural output.

It is determined that the use of digital technologies and digital agriculture can ensure the growth of labor productivity and efficiency of agribusiness.

Digital farming uses Precision Farming technology and also implements smart networks and data management tools. Based on statistical processing of experimental data, the number of digital farms in the country was calculated.

Based on the methods of observation and comparative analysis of the practical experience of agricultural enterprises in the northern regions of Kazakhstan, it was proved that digitalization of agriculture has a direct impact on increasing productivity and improving the quality of the crop.

The methodology of synthesis and generalization made it possible to make recommendations and offer reliable conclusions on the prospects of applying digital farming technology in the republic.

Results and their discussion. According to Ahlmann & al (2016), precision agriculture (PA), or Smart Farming, is the most modern management strategy used in crop production. Its methodologies can be applied at the vegetative stage of sowing, agricultural operations, tillage, fertilization, and crop monitoring [2].

Korotchenya and Leachman noted that the progress of digital agriculture implementation depends on the success of the 3 levels of the system. For example, an insufficient number of agricultural machinery indicates a weak development of mechanized technologies. The slow introduction of precision agriculture means that most agricultural enterprises have no experience with these technologies [3].

Precision farming (PF) is now fully recognized for its potential to increase crop yields in the fields. In addition, costs are reduced and the impact of agricultural activities on the environment is minimized [4].

Small farmers in rural areas do not have wide access to agricultural resources, finance and credit, storage and professional advice. And, consequently, they have problems with optimal management and use of innovative technologies in agriculture [5].

Global positioning system (GPS) and mapping through geographic information systems are key elements of many precision farming applications. These technologies allow the use of guidance systems and controlled movement during field operations such as tillage, harvesting, and the use of resources such as nitrogen, seeds, and pesticides [6].

Smart farming (SF) is a concept that originated from software engineering and computer science, which emerged with the addition of computing technologies and data transfer from agriculture in a common environment of almost ubiquitous computing [7].

The review of the literature suggests that the use of the «digital farming» system in the world economy is a promising direction for the development of agriculture.

So, for 10 months of 2019, 379.4 billion tenge of investments were attracted to the agro-industrial complex, which is 37% higher than the level of the marked period of 2018. In general, over the past five years, the industry attracted 1.3 trillion tenge of investment, while the private sector has invested about 80% of the investment. A total of 758 projects were financed as part of investment project financing. Including in 2019, 39 projects were financed for a total of 46.1 billion tenge in priority areas – creation and development of dairy farms, greenhouses, poultry farms, intensive gardens, projects for processing agricultural products. About 29 thousand jobs are provided here.

In 2019 the total area of irrigated land in the country is approximately 1.4 million hectares. By 2021, it is planned to increase this figure to 2.0 million hectares.

It should be noted that the scientific and innovative sphere of the agro-industrial complex is not yet fully evaluated in Kazakhstan. There are problems with the application of digitalization in the manufacturing industry, including in the agricultural sector.

This leads to stagnation in the development of science and technology, and

the lack of demand for scientific and technical products. There are shortcomings in the reproduction of soil fertility and quality use of land. Together, this leads to a decrease in the growth of production of high-quality agricultural products in Kazakhstan. The volume of gross agricultural output for the 10 months of 2019 decreased by 0.2% and amounted to 4.5 trillion tenge. The decrease in production is due to a decrease in crop production by 3.2%. Thus, according to preliminary data, crop production has seen a 13.5% decrease in the gross harvest of grain crops.

Currently, there are a number of problems in the sector that hinder the development of the agricultural sector in Kazakhstan. This is a low yield of agricultural crops from 7 to 12 quintals per hectare and low productivity in animal husbandry.

The deterioration of agricultural machinery and equipment is up to 80%, there are questions about the availability of borrowed funds.

In order to solve these problems the republic, in our opinion, should pay significant attention to the development of the "Digital Farming" process.

The goal of «Digital Farming» (DF) is to use all available information and expertise to automate technological processes in agriculture. Digital farming began when GPS signals became available to the consumer. Combined with telematics (vehicle fleet monitoring) and data management, it improves the accuracy of operations and allows you to manage fertility within the field. The goal is to give each plant what it needs for optimal growth, while reducing costs (producing more products at a lower cost).

The next step is the improvement of map-tasks for the targeted application of fertilizers with the help of algorithms. This is based on data from several fields, such as seed characteristics and environmental conditions [8].

At the same time, DF uses GPS navigation systems for managed agriculture, precise fertilization, plant protection measures, etc.

One of the industries that serve farmers and agricultural contractors is agricultural engineering. It fully meets the idea of implementing DF and constantly improving and developing it. In other words, the industry focuses on developing machines that are compatible with the digital infrastructure of the farm and can make the necessary contribution to optimizing production processes [9].

Digital intelligent agricultural machines must:

- to be able to send and receive information using sensors and communication equipment;
- to ensure optimal use of machinery and equipment;
- to help the machine operator to perform high quality technological processes optimize the design of machinery to improve efficiency;
- to collect data from management systems for the purpose of drawing up application maps for sowing seeds, applying fertilizers and plant protection products;
- to use the data obtained to document the work done, for example, through yield maps and current crop status maps.

This means that attention has now gradually shifted to the optimal integration of the agricultural machine into the production system (process optimization).

We will note, the Ministry of agriculture is included in the implementation of the state program "Digital Kazakhstan" on the implementation of automated systems in the agro-industrial complex of the country.

In particular, according to the Ministry of agriculture of Kazakhstan, in 2019 there were 16 farms that became "digital". 6 smart farms have been created in the livestock sector. In 2018, 12 farms and 3 poultry farms received digital status. In addition, 12 more livestock farms have become smart farms.

Thus, the total number of Kazakh agricultural enterprises where production is automated using computer systems has reached 49 units (table).

Table - Number of digital farms in Kazakhstan, 2018-2019

Years	"Digital" farms, units	Smart farms, units	Total
2018	15	12	27
2019	16	6	22
TOTAL	31	18	49
Source: according to the Ministry of agriculture of Kazakhstan / In access mode: https://moa.gov.kz/ru/posts-list/post			

For the first time, employees Of the Kazakh Agrotechnical University named after Seifullin (KATU, Nur-Sultan) conducted a cartogram in the best farms of Northern and Central Kazakhstan. A soil sample was taken from each hectare. It turned out that even in the best farms, 77 percent of fields have low nitrogen content. However, 88 percent of the fields have

very low phosphorus content, and almost half of the fields have low humus content.

Therefore, the yield and quality of Kazakh wheat in our country is falling every year. The project also includes the installation of weather stations and the introduction of a weather service. They will allow farmers to predict the optimal timing of field work.

Let's consider the experience of implementing digitalization of agriculture in Kazakhstan. For example, nine farms in the Northern regions of Kazakhstan are implementing a precision farming system in a pilot mode, which involves using a combination of several IT solutions. 9 best farms were selected in four regions: in North Kazakhstan, Kostanay, Akmola and Karaganda. For example, these are rural formations such as "Chagala agro", "Peterfeld agro", "Dihan plus", "Troyana", etc. Digital agriculture will be developed on their basis, starting with cartography and ending with the forecast of yield.

Analysis of digitalization showed that many farms have imported seed complexes, for example, "John Deere". They have the functionality to automatically change the seeding rate. In other words, these are doses of mineral fertilizers, according to the tasks of electronic maps, that is, differentiated dosing. These complexes were used for differentiated application of starting doses of mineral fertilizers during sowing and main doses during pre-sowing treatment. In addition, in farms, the park of sowing machines is made up of "Bourgault" complexes that do not have the function of dose differentiation.

In 2019 North Kazakhstan agricultural entrepreneurs planted 4.2 million hectares. At the same time, the North Kazakhstan region is a zone of risky agriculture. And much depends on weather conditions. However, you can learn and prepare in a timely manner by adjusting the action plan. Here you can use elements of precision farming technology.

For example, agricultural holding "Grain industry" in Kostanay region and JSC "Atameken agro" in North Kazakhstan region has introduced electronic maps, performs online monitoring and control of sowing and harvesting operations. This reduces unproductive costs and work time, and increases productivity. For example, fuel sensors allow you to save about 1 million tenge per season from one unit of equipment by reducing losses and theft of fuel.

«Karkyn» agrofirm in Kostanay region has been implementing smart technologies since 2014. On average, 70% of the agricultural machinery fleet is equipped with GPS monitoring systems via satellite navigation. A 100% digitized field maps, the structure of crop rotations.

The online mode tracks the arrival and consumption of grain from the field to the Elevator, as well as the consumption of fuel.

It should be noted that Akmola region is one of the drivers of agriculture in Kazakhstan. Here, digitalization and precision technologies are promising areas for improving productivity. In 2019, there are about 95 farms in the region that use elements of precision agriculture.

Until 2022, it is planned to use its individual elements in 194 farms in the region. For example, "Khleborob" LLP in Akmola region, using elements of «precision agriculture», reduced the cost of herbicides in 2018. Thus, the use of a modern sprayer in LLP allowed processing only weeds. The company received savings of 15 million tenge.

The main elements of digital farming are parallel driving and auto piloting. They help to accurately observe the distance between the aisles of machines when performing field work. When using them, technological operations are performed with minimal overlap. This saves working and machine time, fuel, seeds, fertilizers and plant protection products. Also, the advantages of parallel driving systems are the accuracy of the movement of units, driver unloading, and the ability to work in the dark and in poor visibility conditions.

As a result of this great work in the Akmola region for the seven months of 2019 the volume of gross agricultural output increased by 11.4% to the level of 2018 to 100.7 billion tenge. In particular, crop production - 100% or 4.3 billion tenge, livestock - 112% or 96.2 billion tenge. All categories of farms produced 80 thousand tons of meat (an increase of 29% to the level of 2018), 237 thousand tons of milk (an increase of 3.2%), 519 million eggs (at the level of 2018). This led to an increase in the supply of products to the market of the city of Nur-Sultan.

The group Scientific-production center of grain farming named after A.I. Barayev (SPCGF) is already in active work on the creation of irrigated smart polygon in the framework of the State program of development of agroindustrial complex of Kazakhstan for the years 2017-2021. This work is carried out jointly with the Ministry of agriculture of Kazakhstan. To do this, the SPCGF has signed an agreement with the American company TNC "Valmont", and today cooperates with them in the field of precision irrigation. The project is aimed at demonstrating new innovative

agricultural technologies for crop cultivation and irrigation systems, as well as monitoring and control technologies. The company will supply the research center with three new-generation sprinkler systems that will increase productivity and save water resources.

In this regard, in 2018 as part of digitalization a pilot project for the implementation of "digital farming" was launched on the basis of the noted Research and Production Center. On the example of spring wheat production, the efficiency of using resource-saving technology with digitalization elements was considered.

According to the results of 2018 using "digital farming", a high yield of 25.4 *quintal* per hectare was obtained. And also there is a saving of resources by an average of 5-15% in comparison with resource-saving farming. The profitability of the production of spring wheat with precision farming elements reaches 38.5% per year.

To implement the project on typical soils of the Akmola region, an experimental training ground was organized on an area of 3 000 hectares, where various technological innovations were tested. For example, digitization of fields, agrochemical examination of elementary plots of arable land from 5 hectares of area, cartograms of the distribution of nutrients, nitrogen and phosphorus fertilizers, etc. Crop yields at these landfills exceeded regional values by 2.5 times.

Engineers and agronomists observe what is happening in the fields from the project management center. "Digital farming" is able to increase grain productivity to 25 *quintal*s per hectare and increase labor productivity by 2-2.5 times.

This means that the total cost savings from the use of precision farming elements is about 16-20% compared with the traditional system.

In general in the Akmola region, digitalization in the livestock industry is mainly used in dairy farms – «Astana Onim» JSC, «AF Rodina» LLP, «Esil Agro», «Kamyshenka», «Enbek», «Khamze». In these enterprises, herd management processes are automated. For example, the process of milking, reproduction and feeding, monitoring the clinical condition of animals and the integration of individually tuned systems for calculating milk production. This allows you to optimize the process, increase productivity and reduce the cost of production.

It should be noted, that in 2019, 25 million tenge was allocated from the Akmola regional budget for space monitoring, which allows you to promptly make optimal decisions on agricultural techniques for conducting field work.

Despite bringing some experience in applying the digital farming system, Kazakhstan farmers in this area have the following problems:

● in most of the studied farms in the northern regions of the country there is a low nitrogen and phosphorus supply. This is the result of the uncontrolled use of leguminous crop rotation and the annual addition of ammonium nitrate and ammophos. All this leads to a decrease in the quality of the crop; labor shortages, declining soil fertility, trade wars, product spoilage, lack of access to pricing and Internet data in rural areas; sensors that are mounted on combines, tractors and other agricultural machinery, as a rule, require calibration and verification; there is a lack of subsidized costs for the introduction of digital farming technologies. Currently, in the agricultural space there are obstacles associated with the absence, collection and exchange of publicly available data [10]. That is, machine learning, artificial intelligence and the development of advanced algorithms are advancing quickly, and the collection of significant agricultural data at a low level. Farm managers in the Republic of Kazakhstan are restrained in modern technology because of the high cost. In addition, they are worried about the high time spent on the development of these technologies and the cost of retraining personnel. The limiting factor in resolving issues of digital farming is the high cost and lack of necessary equipment for subsoil fertilizing;

● in our opinion, the most popular and sought-after areas of agricultural digitalization for the agro-industrial complex will be: integrated design of production data processing solutions; creation of an information base received from sensors; differentiated watering and sowing, fertilizing, crop forecasting; sensor for monitoring soil temperature and humidity, monitoring systems for agricultural machinery and personnel; fuel quantity control, aerospace images, aerial mapping, accurate weather data, space monitoring; improving production processes through automated data collection and targeted data analysis to increase transparency; training highly qualified personnel who are skilled in automation, robotics and digitalization.

Conclusions.

1. In the agro-industrial complex, the focus will be on stimulating the deep processing of agricultural products. In the global trend of digitalization in all spheres of life and the economy, the introduction and

wide dissemination of digital technologies is becoming a key competitive factor.

2. In the next two to three years, the active introduction of digital farming processes will increase the production of food products by an average of 5-7%. This leads to the filling of the local market, as well as a decrease in the import of foreign food products. In addition, Kazakhstan, within the framework of the State Agribusiness Development Program (2017-2021), plans to increase the export of processed agricultural products to $ 2.4 billion in 2021.

3. Due to modern digital technologies, it is possible to increase labor productivity, as well as the profitability and competitiveness of agricultural enterprises.

4. The above experience of using digital farming technology by Kazakhstani farmers demonstrates the positive dynamics of agricultural production growth. This allowed agricultural companies to optimize the process, improve the organization and working conditions of workers, increase labor productivity by 20%, reduce the cost of inventory by 10-15%, improve the use of agricultural chemistry, seed production, sensors and weather factors. This together will reduce agricultural losses by at least 25% and manage record and analyze expenses online.

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