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SATELLITE SYSTEMS AND DIGITAL TECHNOLOGIES IN AGRICULTURE: STATE, PROBLEMS, PROFESSIONAL COMPETENCIES

АУЫЛ ШАРУАШЫЛЫҒЫНДАҒЫ СПУТНИКТІК ЖҮЙЕЛЕР ЖӘНЕ ЦИФРЛЫҚ ТЕХНОЛОГИЯЛАР: ЖАҒДАЙЫ, ПРОБЛЕМАЛАРЫ, КӘСІБИ ҚҰЗЫРЕТТЕРІ

СПУТНИКОВЫЕ СИСТЕМЫ И ЦИФРОВЫЕ ТЕХНОЛОГИИ В СЕЛЬСКОМ ХОЗЯЙСТВЕ: СОСТОЯНИЕ, ПРОБЛЕМЫ, ПРОФЕССИОНАЛЬНЫЕ КОМПЕТЕНЦИИ

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Abstract. *The goal* is to study the possibilities of using digital technologies in agriculture, economic efficiency on the example of digital product "Cropio" – a satellite monitoring system. *Methods* – analysis, synthesis, comparison and analogy, selection of data and their detailing. The article shows the conditions for the implementation of information processes in agro-industrial complex, considers the current state, problems, substantiates the need for the use of smart technologies, clarifies the concept of "precision farming". The authors analyze the benefits of the Cropio program, which is used in agricultural sector of developed countries. Its functionality allows not only to control the sowing work, but also to determine soil moisture, its saturation with nutrients. It is noted that the program generates information on climatic and weather conditions, calculates the savings in material resources. The software components, their functions, installation process, acquisition mechanisms, and information are presented. *Results* – calculations of the expected economic effect from the use of this automation system were carried out, profitability and expediency of applying the methodology for evaluating investment were determined. *Conclusions* – technical and information solutions of the Cropio precision farming project are becoming more and more popular every year, confirming their promise, they can reduce labor

costs, increase productivity of farmland, and therefore reduce cost of finished products. Observation of objects based on satellite navigation, computer technology and digital maps makes it possible to assess rationality and timeliness of financial resources, take into account a number of factors that affect market value and profitability of land, minimize various risks, optimize production activities through construction of new business processes.

Аңдатпа. *Мақсаты* – «Cropio» цифрлық өнімі-спутниктік мониторинг жүйесі мысалында ауыл шаруашылығында цифрлық технологияларды пайдалану мүмкіндіктерін, экономикалық тиімділікті зерттеу. *Әдістері* – талдау, синтездеу, салыстыру және ұқсастық, деректерді таңдау және оларды егжей-тегжейлі көрсету. Мақалада агроөнеркәсіптік кешенде ақпараттық процестерді енгізу шарттары көрсетілген, қазіргі жағдайы, проблемалары қарастырылған, ақылды технологияларды қолдану қажеттілігі негізделген, «нақты егіншілік» ұғымы нақтыланған. Авторлар дамыған елдердің аграрлық секторында қолданылатын «Cropio» бағдарламасының артықшылықтарын талдайды. Оның функционалдығы егіс жұмыстарын бақылауға ғана емес, сонымен қатар топырақтың ылғалдылығын, оның қоректік заттармен қанықтылығын анықтауға мүмкіндік береді. Бағдарлама климаттық және ауарайы жағдайлары туралы ақпарат қалыптастырады, материалдық ресурстарды үнемдеуді есептейді. Бағдарламалық жасақтама компоненттері, олардың функциялары, орнату процесі, алу механизмдері мен мәліметтері ұсынылған. *Нәтижелері* – осы автоматтандыру жүйесін пайдаланудан күтілетін экономикалық тиімділіктің есептеулері жүргізілді, инвестициялық салымдарды бағалау әдістемесін қолданудың рентабельділігі мен орындылығы анықталған. *Қортындылар* – «Cropio» нақты егіншілік жобасының техникалық және ақпараттық шешімдері жыл сайын танымал бола түсуде, өз перспективаларын растай отырып, еңбек шығындарын қысқартуға, ауыл шаруашылығы алқаптарының өнімділігін арттыруға, демек, дайын өнімнің өзіндік құнын төмендетуге мүмкіндік береді. Спутниктік навигация, есептеу техникасы және цифрлық карталар негізінде объектілерді бақылау қаржы қаражатының ұтымдылығы мен уақтылығын бағалауға, жердің нарықтық құны мен кірістілігіне әсер ететін бірқатар факторларды ескеруге, әртүрлі тәуекелдерді азайтуға, жаңа бизнес-процестерді құру арқылы өндірістік қызметті оңтайландыруға мүмкіндік береді.

Аннотация. *Цель* – изучение возможностей использования цифровых технологий в сельском хозяйстве, экономической эффективности на примере цифрового продукта «Cropio» - системы спутникового мониторинга. *Методы* – анализа, синтеза, сравнения и аналогии, подбора данных и их детализации. В статье показаны условия внедрения информационных процессов в агропромышленном комплексе, рассматривается современное состояние, проблемы, обоснована необходимость применения умных технологий, уточнено понятие «точное земледелие». Авторы анализируют преимущества программы «Cropio», которая используется в аграрном секторе развитых стран. Ее функционал позволяет не только осуществлять контроль за посевными работами, но и определять влажность почвы, ее насыщенность питательными веществами. Отмечается, что программа генерирует информацию о климатических и погодных условиях, рассчитывает экономию материальных ресурсов. Представлены программные компоненты, их функции, процесс установки, механизмы получения и сведения. *Результаты* – проведены расчеты ожидаемого экономического эффекта от использования данной системы автоматизации, определены рентабельность и целесообразность применения методики оценки инвестиционных вложений. *Выводы* – технические и информационные решения проекта точного земледелия «Cropio» с каждым годом становятся все более популярными, подтверждая свою перспективность, позволяют сокращать трудозатраты, повышать продуктивность сельхозугодий, а следовательно снижать себестоимость готовой продукции. Наблюдение за объектами на основе спутниковой навигации, вычислительной техники и цифровых карт дает возможность оценить рациональность и своевременность финансовых средств, учитывать ряд факторов, которые влияют на рыночную стоимость и доходность земли, минимизировать различные риски, оптимизировать производственную деятельность через построение новых бизнес-процессов.

Key words: agricultural sector, digital technologies, precision farming, satellite monitoring, economic efficiency, investment, profitability, profitability.

Түйінді сөздер: аграрлық сектор, цифрлық технологиялар, дәл егіншілік, спутниктік мониторинг, экономикалық тиімділік, инвестициялық салымдар, рентабельділік, кірістілік.

Ключевые слова: аграрный сектор, цифровые технологии, точное земледелие, спутниковый мониторинг, экономическая эффективность, инвестиционные вложения, рентабельность, доходность.

Introduction. In modern agriculture of Kazakhstan, there is an urgent need to modernize all processes and structures in order to form a new technological order based on new digital technologies, on the use of robotics, electronics, telecommunications, providing optimal solutions for agricultural analytics and automation. The new farming model is a smart farming solution that combines agriculture with modern information technology. It is now difficult to imagine new means of production used in agriculture without the presence of highly intelligent devices that minimize costs in the production process, as well as help increase the efficiency of the production process.

The results of the digitalization of agriculture will find expression in the creation of a single information space, improving the quality and efficiency of managerial decision-making through the use of modern analytical research methods, and reducing the response time to possible threats to the sustainable development of agriculture [1]. Obviously, the time has come for fundamental changes to implement the concept of creating a digital economy in agriculture.

The use of advanced technologies in crop production, known as precision farming, and its rapid emergence will provide revolutionary changes in the entire agricultural sector. Sensors, satellite photography and multispectral imaging are associated with the futuristic science of space and communications. Today, however, these technologies are increasingly seen as part of the agriculture future.

In this regard, in order to implement the strategy for the long-term development of the agricultural sector, the Ministry of Agriculture of the Republic of Kazakhstan has developed a specialized program of strategic tasks called E-AIC (electronic agro-industrial complex), the main goal of which is to introduce the most effective and affordable tools for digitalization of agriculture to increase productivity labor [2].

Material and methods of research. To achieve the goals and objectives of this study, in our opinion, it is more appropriate to apply the methods of formal logic, namely: analysis, synthesis, comparison and analogy. These methods make it possible to select and systematize material from a significant amount of information available in the scientific and research literature. The current state of the problem of integrating artificial intelligence and the system of the agro-industrial complex is analyzed using methods of non-linear data analysis, which made it possible to assess the state, dynamics and interdependence of various indicators, to identify key problems with a view to their further solution.

In the course of writing and conducting an analysis of the economic efficiency of the impact of digital technologies on the agro-industrial complex in the Republic of Kazakhstan, methods of studying and comparing, selecting data and detailing them were applied. A certain conditional, abstracted situation was applied, during which methods for calculating economic efficiency were applied. Based on the simulation of the situation, a forecast was built and the project was scaled up.

To justify the effectiveness of the proposed innovative project for the implementation of the Cropio precision farming system, methods of absolute and comparative investment efficiency were used. Namely, a methodology for evaluating real investments based on a system of indicators for evaluating real investments: net present value; profitability index; internal rate of return; discounted payback period (term); accounting Rate of Return.

Results and their discussion. It is generally recognized that agricultural production is the most important industry in the world, as it ensures social stability and economic security. The problem of overcoming the contradiction between the population explosion and the limited production of grain, meat and other vital products motivates the implementation of an increasing number of research projects in the smart agriculture field, combining agriculture and modern information technologies.

It should be noted that there are a sufficient number of publications on this issue, which largely reflect the state, nature and level of problem solving depending on the country's agricultural economy. In the latest publications of authors from developed countries, we are talking about the transition to agriculture 5.0. According to the Spanish scientists Verónica Saiz-Rubio and Francisco Rovira-Más, this is agriculture that is controlled using robotic solutions, includes artificial intelligence methods, and allows reaching a new level of labor productivity [3].

Smart agriculture, which combines data management with the well-known concept of precision farming, improves the accuracy of operations and the intelligence of management [4]. New technologies in smart agriculture based on the Internet of things are described in the work of the authors [5], and are also considered in the article "Recent achievements and problems of the Internet of things in smart agriculture: a review" [6]. The theoretical and methodological foundations of the digitalization of agriculture are disclosed in the studies of Russian authors [7].

The problems that hinder the development of digitalization in agriculture are considered in the article [8]. Kazakh authors Smagulova Sh.A. and others, Abraliev O.A. and others characterize digitalization as the basis of the innovative potential of agricultural production in Kazakhstan [9,10]. And others consider the current state, features of the implementation and development of the problem, the experience of individual agricultural enterprises in digitalization in Kazakhstan [11].

It should be noted that most of the work is theoretical in nature. In our opinion, this topic deserves a closer and more detailed discussion: it is necessary to study the conditions and effectiveness of IT implementation in the development of the agricultural sector in Kazakhstan from a practical point of view.

Precision farming is a management strategy that uses detailed site-specific information to accurately manage production costs. According to analysts at the investment bank Goldman Sachs, with the help of precision farming, it is possible to increase agricultural yields by up to 70% on existing farmland.

The advantages of introducing precision farming are as follows:

• increase in productivity by 10-20%;

• reduction the consumption of fertilizers by 10-30%, seeds by 10-15%, fuels and lubricants by 5-10%, plant protection products by 15-60%;

• reduction of equipment depreciation by 10%;

• reduction of equipment downtime by 15-20%.

There is a brief description of some programs that are currently used in agriculture (table 1).

Table 1 – Programs engaged in the development of agro-monitoring and telematics using satellite systems

Application name	Year	Manufacturer counrty	Description
Farm-Logs	2012	USA	It is a comprehensive program that allows farmers to manage all aspects of their operations. Allows you to easily keep a job log and view field activities in one place. Recordings will be organized, protected and accessible from any desktop or mobile device.
Farmbrite	2013	USA	The app allows you to map fields, use seed order estimator and harvest reports, do online marketing and sales, track income and expenses, field and pasture rotation, equipment maintenance, important contacts, multiple users - all from a mobile device or computer.
Diary of an agronomist	2015	Russia	A simple and convenient program for maintaining an electronic book of the history of crop rotation fields. The application allows you to work with an electronic fields map, keep a history of crop placement, a diary of technological operations and see the consumption of materials in each field. The brand focuses on the simplicity and accessibility of using all the features of the platform.
Agro-Stream	2017	Kazakhstan	This is a unified information automated system that allows you to plan, model, analyze and determine the company's management system in terms of increasing efficiency, limited by logistical, regional capabilities and crop history.
SoftFarm	2017	Ukrain	Provides information on NDVI vegetation indexes, creates task maps for machinery, creates cartograms of soil properties, analyzes weather from weather stations and surveys crops for pests or diseases using a mobile application, improves work efficiency by monitoring location and fuel consumption using GPS monitoring of equipment.
Cropio	2017	USA	Cropio is a monitoring system aimed at optimizing the fertilization and irrigation of the soil and thus reducing the amount of fertilizer and water used. Cropio, together with weather and satellite data, also makes it possible to monitor crops and predict yields.
OneSoil	2018	Belarus	OneSoil is a digital products company that provides a platform to help farmers and agricultural companies be more profitable and sustainable.
Egistic	2019	Kazakhstan	The program is based on the implementation of an integrated solution for monitoring and managing crop areas using remote sensing technologies, high-precision satellite navigation, geographic information systems and machine learning technologies.
FarmPad	2019	USA	The application consists of a set of highly specialized programs, each of which relates to a specific type of farmer's daily activities. The con-

			venience of the platform lies in a single interface for each product of the “package” of the FarmPad brand.
Note: compiled by the author according to sourcesx [lk.2,4,8;15]			

As you can see, the United States is the main supplier of software for managing agricultural production. In the Republic of Kazakhstan, according to the Bureau of National Statistics of the Agency for Strategic Planning and Reforms, the number of agricultural units engaged in crop production in 2021 amounted to 17 672 farms. The total area of cultivated land by these formations amounted to 22 925 hectares. Based on the given data, the potential capacity of the Cropio market is determined by more than 17 thousand customers [12].

The Cropio program [13] is engaged in one of the new areas in agribusiness – satellite monitoring of agricultural land. By the nature of its activity, the company belongs to the operators of satellite monitoring services for crops. The system allows you to control the level of crop vegetation, nutrient content and soil moisture, receive up-to-date information about the weather and price dynamics, and receive notifications of significant changes in the fields [14]. The system is suitable for monitoring all grains and oilseeds without exception.

The system was created by New Science Technologies, which specializes in processing information from remote sensing of the Earth for the purpose of scientific, geological, meteorological and other research. It was created in 2013. Representative offices and technical support centers are located in North America, Europe and CIS countries.

In August 2017, the company launched a new iOS application Cropio, which helps to track the forecast of crop yields in the company's fields and monitor the progress of the harvesting campaign online, not only through computers, but also through gadgets (tablets or smartphones).

The system is based on the ability to track the situation in the fields with crops, including the level of vegetation, the content of a number of minerals, accurate weather conditions and other parameters. The work of the system is aimed at identifying the indi-vidual characteristics of each individual field in order to increase efficiency in yield and save costs in the process of processing the field.

Thanks to the spectral properties of chlorophyll, the pigment that causes the green color of plants, it is possible to determine the level of plant vegetation. Satellites take pictures in different spectral ranges, which makes it possible to fix the level of chlorophyll and, with the help of special processing, calculate the level of vegetation at each point of the picture.

The Cropio system automatically analyzes and presents the finished processing result in the form of electronic vegetation maps and graphs. The vegetation level is calculated for each pixel in the received satellite images. Photographs of the fields are processed and analyzed by the Cropio system according to the prescribed algorithm. The results of the analysis of each field are presented in the form of an electronic vegetation map.

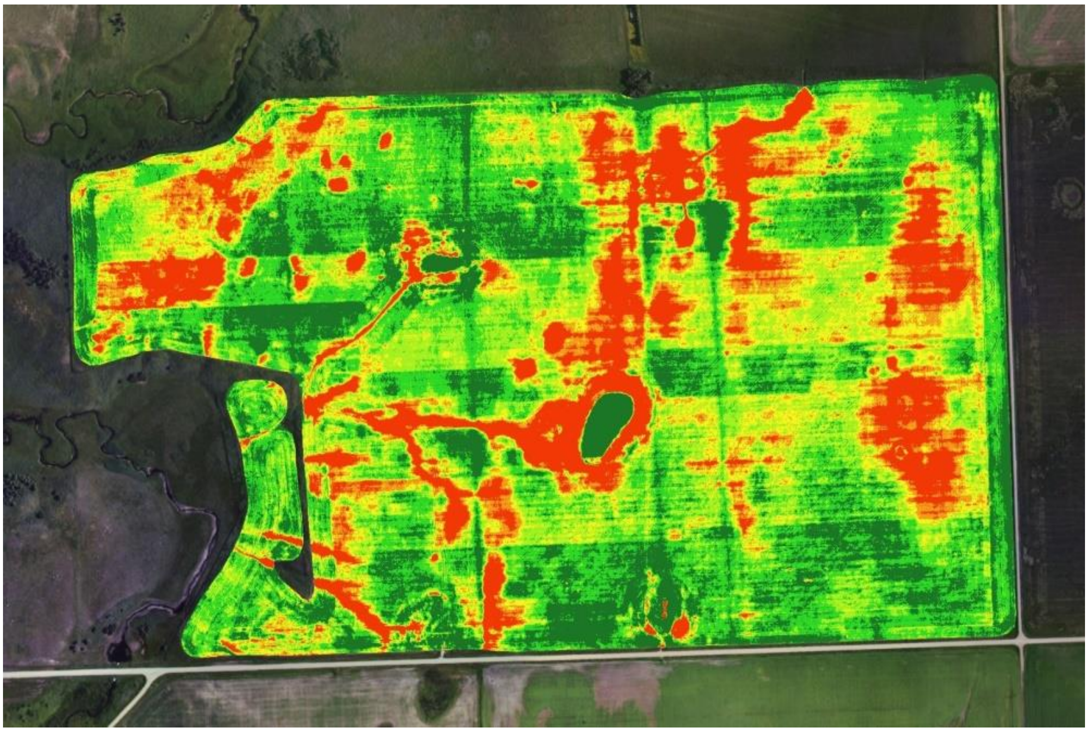
Figure 1 shows an example of an electronic three-color map of the field vegetation:

- red color indicates the immaturity of the crop in this area of the field;
- yellow color - incomplete maturation of the culture;
- green - the full level of maturation of the culture.

Cropio uses images from more than 10 different satellites. These are satellites of such systems as MODIS, Landsat, Sentinel-2, Iconos and GeoEye. Pictures are taken on a daily and weekly basis. Some images are historical and are updated no more than once a year. The system uses vegetation images with a resolution of 10, 15, 30 and 250 meters per pixel. These snapshots are updated by the system on a daily and weekly basis. More accurate images are also used, the resolution of which is 50 centimeters.

The functionality of the Cropio field satellite monitoring system consists of several blocks:

- field monitoring (monitoring the status of fields in real time);
- preciseweather (updated weather forecast with reference to the location of each field);
- field analytics (field state analysis);
- field zoning (determination of the field structure with the allocation of problem areas);
- field tasking (creating tasks to perform work in the field);
- n-deficit (calculation of the recommended dose of nitrogen fertilizers);
- active control (alert system about significant changes in the state of crops);
- news&prices (information about events in the markets of agricultural products, as well as up-to-date data on price dynamics);
- reports (weekly and monthly reports on the state of crops, summarizing information for each field, crop and farm as a whole).



Compiled by the author according to sources 15

Figure 1 - Electronic map of the field vegetation

The Cropio system has two main areas, the functions of which are presented in table 2:

▪ agro is a system of remote control of agricultural land, which includes operational monitoring of the state of sown areas, auto documentation, forecasting and planning of agricultural operations;

▪ telematics - allows you to track hourly and daily work, productivity and movement of equipment. The system can send automatic alerts in situations such as work without a plan, no signal, and others.

Table 2 – Functions of the main directions of the Cropio system

Cropio			
Agro		Telematics	
History of fields	up to 10 years of vegetation, precipitation, humidity and weather history	automatic alerts	notifications about the speed of movement, work without a plan, departure from the plan and others
Reminders	weather, vegetation and forecast change notifications	daily plan	hourly and daily plan for each machine
Vegetation map	vegetation maps of all fields	movement	map and movement report for each machine and field for one day or a separate period
Weather forecast	updated weather and forecast for each field separately	harvest weighing	weighing report for each machine
Precipitation	soil moisture at different depths	field card	all field data in one place, accessible from anywhere where there is Internet coverage
Reports	reports on productivity, inspections, slopes, weather and more	cars	complete list of vehicles and equipment
Nitrogen deficiency	nitrogen deficiency for each field and its part	hourly payed job	transport hourly report on the map
Inspection of the fields	draws attention to problem areas in the fields	progress	complete history of movement, speed, fuel consumption and crops in one place

Soil tests	soil test results on the map	flexible sensor configuration	setting up sensors on equipment for collecting and analyzing information
Harvest forecast	crop forecast already in the early stages of growth	translation of field processing	the ability to view the processing of your fields and the movement of vehicles in real time
Note: compiled by the author according to sourcesx [lk.13;15]			

Let us describe the installation process of the system. First, an official request is sent, in response to which a license agreement comes, which must be signed. After signing the contract, a login with a password comes: you need to register on the site (there are no settings). Following the instructions given in the instructions, the coordinates of the fields are entered into the system. There are two options: either upload the shape files (the site lists valid formats - it's quite a long list that includes all or at least almost all popular formats), or you can use Google Maps to highlight the field outlines.

Then an Excel template is downloaded for historical information. It is filled and loaded back into the system. After starting the system, we go to the Monitoring Center page, where you can see the crop structure and a convenient map with all fields painted in different colors, which indicates a different level of vegetation in the fields.

Clicking on a specific crop brings up a drop-down list of fields with individual crops, as well as all other areas, while the fields with individual crops are shaded on the map. As a result, you can easily select fields under a certain crop, see where they are and sort them according to the level of vegetation.

After entering the basic information, the Monitoring Center is self-updating: at any time you can log in and see the status of the crops and the current value of the crop. This is especially convenient when agronomists prepare a forecast, and any specialist, if necessary, can access information on the Internet.

"Expected Yield" is a column that is empty by default. The instructions say that you need to go to each individual page and enter the expected yield based on the information in the Forecast Assistant. The Forecast Assistant is a page that compares the growing season of a particular field with the historical growing graph of the same crop in the same or similar areas; you can use the graph that is next to the line representing this year and select its indicators in the form of expected results. Of course, it is possible to correct the data.

The feature is very useful for farmers and companies as it allows business decisions (forward sales, insurance, cash management) and production decisions to be made by different people. Ideally, this should help avoid a situation where the director or manager is surprised at the level of crops in the fields, and the agronomist says that this was expected.

The next stage is the transition to the "culture" fields. This page is focused primarily on the agronomist. The page has a section, separate for each crop, where there is information related to the current state of the crops in the fields and about the changes for the current week. All fields are automatically sorted by vegetation level, which allows detecting unused fields.

In the help section, you can find more information on how to use the data: during the growth stages, short reports are reviewed; fields with low levels of vegetation are selected and checked what is going wrong and what can be done to improve the situation if the fields are at maturity.

The next step is to go to the individual fields level. There's quite a bit of information out there regarding different field specifications (different measures may have different priority levels for different users): field card; vegetation; the soil; weather and precipitation; grade; sowing date; crop rotation; field history.

The highest resolution for photos is 15x15 - the image is very detailed, the stripes are clear. At the same time, the supplier draws attention to the possibility of obtaining additional high-resolution images for an additional fee.

Soil moisture. Information is available on the moisture level at three different depths. Although the data is taken from a 10 km satellite image, it is more accurate than similar data from weather stations with an average coverage of 50 miles.

It is also possible to integrate your own weather stations where you can choose your own weather station and integrate it into the system. The weather forecast is based on the GPS coordinates of a particular field.

The vegetation page provides a detailed graph of crop development compared to average and historical vegetation data for the same crop. In fact, this is almost the same information that is used in the Prediction

Assistant. On the page, you can clearly see how a particular field is developing compared to fields under the same crop in the current season and previous results in that field.

The Set Field page allows you to create files for VRA depending on the level of vegetation. It looks very simple: you need to select a mesh (depending on the VRA equipment) and save the file in the appropriate format. Note the very useful Field Data page, where you can set parameters such as fields with a specific crop, area, specific vegetation level, to sort all fields according to vegetation level, and etc.

The rationale for the project of integrating satellite systems with technologies of the agro-industrial complex is to increase the volume of finished products, optimize funds and further reduce the cost of production. The implementation of this innovative project will solve the following tasks:

* introduction of innovative technology for growing grain crops;
* increase the profitability of production;
* increase in wages;
* staff development;
* increase in labor productivity and its profitability.

The investment and innovative proposal is the installation or, in other words, the use of the Cropio precision farming system (installation is not required, only registration on the site with access to satellites is required). The installation of this system involves reducing the cost of fuels and lubricants, fertilizers, plant protection products and seeds, as well as increasing the yield of grain crops. This technology is actively used in Europe, Ukraine and Belarus, South America and Australia.

After applying the Cropio system, farms record cost reductions for items such as: fuels and lubricants (- 26%); depreciation charges (- 32%); volume of applied fertilizers (- 18%); volume of plant protection products used (- 15%); the overall effect of reducing production costs - 23%.

If these percentages are applied on conditional indicators, then we will obtain the indicators presented in the calculation table 3.

Table 3 – Comparative analysis of the main indicators for the project

Basic indicators	Existing technology	New technology
Purchase costs tg/ha	600.4	1 273.7
Service life, years	3	3
Depreciation tg/ha	14 000.8	9 520.6
Maximum production volume, tg/ha	121 264.0	148 851.5
Other fixed costs, tg/ha	7 979.0	6 163.8
Salary, tg/ha	15 284.9	11 807.6
Raw materials, tg/ha	64 662.1	56 073.1
Other variable costs, tg/ha	2 340.6	1 808.1

Even without analyzing the efficiency and payback, according to the presented indicators, one can see a beneficial reduction in fixed and variable costs, and, consequently, a reduction in the cost of production.

This service can be used by specialists directly related to sowing operations (agronomists, director, dispatcher, and etc.), as well as persons who have access to the system with the permission of the director and who have certain rights to avoid incorrect adjustments. To manage and work in the system, no additional employees are required: it is enough to have your own programmer or system manager at the enterprise.

Having shown the features of an innovative project and its scope, let's move on to calculating the expected economic efficiency from the introduction of an automation system.

The economic effect from the introduction of automation tools can only be indirect, since the implemented automation systems are not a direct source of income, but are either an auxiliary means of organizing profits or helping to reduce costs.

The main economic effect of the introduction of an automation system is to improve economic performance of the enterprise, primarily by increasing the efficiency of management and reducing labor costs for the implementation of the management process, that is, reducing management costs or reducing the time to complete work. For most enterprises, the economic effect is in the form of savings in labor and financial resources obtained from:

- reduction of the complexity of calculations;
- reduction of labor costs for the search and preparation of documents;
- savings on consumables;
- layoffs of specialists.

Reducing labor costs at the enterprise is also possible by automating the work with documents, reducing the cost of information search.

The criterion for the effectiveness of the creation and implementation of new automation tools is the expected economic effect. It is determined by the formula:

$$E = Er - En * Cp, \quad (1)$$

Where, *Er* is the annual savings;

En – normative coefficient (En=0.15);

Cp – capital costs for design and implementation, including the initial cost of the system.

Annual savings (*Er)* are made up of savings in operating costs and savings due to improved user productivity. Thus, we get the formula:

$$Er = (C_1 - C_2) + \Delta Rp, \quad (2)$$

Where, C_1 and C_2 are, respectively, operating costs before and after the implementation of the system;

*ΔR*p – savings from increasing labor productivity.

The calculation of savings due to an increase in the productivity of a specialist is also the main indicator in calculating economic efficiency. If the user saves ΔT_j, hours, while saving the j-type using the program, then the increase in labor productivity P_i (%) is determined by the formula:

$$P_i = \left(\frac{\Delta T_j}{F_j - \Delta T_j}\right) * 100, \quad (3)$$

Where, F_j – the time that the user planned to perform the j-type work before the implementation of the program (hours).

From the calculation table 4, it can be seen that after the implementation of the Cropio system, the time savings for performing basic reports will be 81%.

Table 4 – The main types of specialists time work

Type of work	Before automation, min. Fj	Time saving, min. ΔTj	Increase in labor productivity P_i, %
Information entry	60	55	1 100
Carrying out calculations	120	100	500
Preparing and printing reports	20	15	300
Data analysis and sampling	40	25	167
Total, hours	4	3.25	81

Savings associated with an increase in the productivity of a specialist - P, is determined by the formula:

$$\Delta P = Z_п * \sum_i \frac{P_i}{100}, \quad (4)$$

где $Z_п$ – worker's average annual salary.

$$\Delta P = 159\ 167 * \sum_i \frac{1100 + 500 + 300 + 167}{100} = 3\ 289\ 444 \text{ tenge}$$

Having calculated the savings associated with increasing the productivity of specialists, which amounted to 3 289 444 tenge per year, you can proceed to the calculation of annual savings:

$$E\text{p} = (9\ 005\ 300 - 9\ 552\ 830) + 1\ 910\ 000 = 1\ 362\ 480 \text{ tenge}$$

$$E = 1\ 362\ 480 - 0.15 * 19\ 105\ 650 = -1\ 503\ 370 \text{ tenge}$$

The annual savings for the maintenance of the new automated system amounted to 1 362 480 tenge, while the expected economic effect in the first year of implementation is negative – minus 1 503 370 tenge, this is due to the high costs of implementing the new system. For the final conclusion on the effectiveness of the innovation project, an additional calculation of indicators is required.

The most widely used method for evaluating real investments is based on a system of indicators for evaluating real investments:

- Net present value - NPV;
- Profitability index - PI;
- Internal rate of return – IRR;
- Discounted payback period (term) - DPP;
- Accounting Rate of Return – ARR.

To calculate the above indicators, it is necessary to provide initial data. The total investment costs for the project are 19 105 650 tenge. The amount is calculated depending on the country, the location of the fields, the terrain, and so on. Financing of the project is planned to be carried out both at the expense of the project initiator's own funds (13 373 960 tenge) and at the expense of borrowed funds (5 731 700 tenge).

We will conduct a comparative analysis of technologies before and after the introduction of the Cropio system and identify the profitability of investments. The costs of the investment project are carried out in 2023. The estimated implementation period is 1 month (since registration in the system will take a little less than a month), and the payback period is 3 years.

In addition to the proposed software satellite upgrade, businesses need to pur-chase a GPS system for all tractors and combines, as well as fuel consumption sensors.

To analyze the effectiveness of the project, we take the following indicators: the income shown in the calculation table is presented as gross income relative to 2022 with a forecast increase over the future period. It can be seen from the calculations carried out, that NPV 7 > (greater than) zero, therefore, the project should be accepted. Graphically net cash flow with NPV accu-mulation. Net cash flow already from the first year of commissioning begins to bring positive cash flows, in other words, these investments will not keep you waiting.

Imagine that the company does not have an increase in net profit in subsequent years, but reaches the indicators of 2022. Even in the situation considered, NPV > (greater than) zero, therefore, the project should be accepted.

Calculate the return on investment:

$$IRR = \frac{PV}{IC} = \frac{429\ 887.4}{19\ 105.7} = 22.50$$

Since the return on investment is more than one, the project must be accepted. The internal rate of return (IRR) at which NPV=0 for an innovative project is 27.63.The average annual cash flow amounted to 5 110 800 tenge. The payback period of the project is 3 years and 8 months. Of course, the company is able to repay the loan in 1 year, given the opportunities for making a profit, but then the project will be unprofitable for the lender, since investors or banks earn on interest from the loan.

The payback period is the minimum time interval (from the beginning of the project), beyond which the integral effect becomes and then remains non-negative.

As a development of the digital direction of the agro-industrial complex of the Republic of Kazakhstan, a program is proposed to introduce a new precision farming system to automate the work of specialists, as well as save their working time. But the main purpose of introducing this system is to help reduce the cost of production. The project was considered fewer than two conditions: an increase in the gross profit of the enterprise and the unchanged net profit in subsequent years. All calculation norms were met. The results of this innovative proposal are quite promising.

Given the fact that these measures will be implemented in the agro-industrial complex of the Republic of Kazakhstan, simultaneously or even point wise, we can confidently say that their effectiveness will increase. It can be assumed that their impact on GDP will be at least 10% of growth; therefore, household incomes will also begin to grow.

Conclusion.

1. The practice of foreign and domestic enterprises of the agro-industrial complex shows that strategic and tactical initiatives are most fully disclosed when they are implemented simultaneously. But this does not mean that it is necessary to allocate labor resources to ongoing projects literally at once. Thus, it is preferable to start operating activities from weak points, since they are the constraints in economic growth.

2. Through the use of online and offline communication tools, the most favorable situation is achieved in terms of predicting the conversion rate (both the first and second levels). In turn, the developed software focuses on the internal optimization of the enterprise, which is expected to lead to an increase in the efficiency of business structures. These measures are an innovation and have not been used before.

Therefore, it will be difficult and subjective to draw a conclusion about the proposed economic effect. However, based on the practice of applying similar measures to other CIS agricultural holdings operating in the same industry, we can analyze the economic efficiency based on their quantitative data.

3. As a final recommendation in the development of this direction for agro-industrial enterprises, in accordance with their financial capabilities, it is necessary to develop a business plan that will help assess the additional risks and effectiveness of the proposed system, the level of profitability of individual departments or specialists (who will directly work with this system, and how it will affect the performance of their duties) also involves staff development. All this is aimed at increasing production in the cultivation and cultivation of

crops, and increasing the income of the agricultural sector of the country's economy.

4. Based on the calculations made at the micro level in the conditional values of one enterprise, it can be concluded that it is possible to scale and implement this project as a whole in the industry. Obviously, to implement this idea, state support is needed, which is not even considered in this direction now. If we are talking about subsidizing projects in the agro-industrial complex of the Republic of Kazakhstan, we see that they support the construction of facilities, materials for growing, feed components in animal husbandry, but there is not a single project with digitalization. But this would serve as a great incentive for the breakthrough development of innovations in agriculture.

5. Thus, if the public sector pays attention to the development of digital technologies in the agricultural sector and develops state support, in particular subsidies for the acquisition of these technologies in agriculture, then the economic effect will not be long in coming.

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