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Development of cartographic materials for optimal placement of objects and lands using the information logical system of automated land management design

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Abstract. This article analyzes the main problems and prospects of land management automation. It presents a flow chart of preparing a cartographic digital basis for an automated land management project using an information-logical system. The authors proposed new software solutions for obtaining a high-quality geospatial basis for a land management project and software solutions for varied approaches to optimal land organization and management methods. All developed solutions have been tested at real agricultural facilities and have shown a significant (up to 40%) increase in land management efficiency. The article notes the need to prepare new personnel for the industry in the context of digitalization of the agricultural sector and the widespread use of on-line technologies.

1. Introduction

The Digital Economy of the Russian Federation program approved by Decree of the Government of the Russian Federation No. 1632-r dated July 28, 2017, according to the Decree of the President of the Russian Federation "On the Strategy for the Development of the Information Society in the Russian Federation for 2017-2030" No. 203 dated May 09, 2017, determined vector development of digital agriculture in the coming years. The program aims to create an ecosystem of the digital economy of the Russian Federation with digital data as a key factor of production in all areas of socio-economic activity and with insurance of effective interaction, including cross-border, business, the scientific and educational community, the state and citizens.

The action plan in the Information Infrastructure direction approved by the Government Commission on the use of information technologies to improve the quality of life and the conditions for doing business on December 18, 2017, lists the tasks within the framework of the program. They include section 4.03.016 “Create domestic digital platforms for collecting, processing and disseminating spatial data and remote sensing data from space, providing the needs of citizens, business and government”.

The implementation of the project will ensure the filling of the state information system of the Ministry of Agriculture of the Russian Federation with the Information System of Earthquake Detection and its subordinate organizations with the data of remote sensing of the Earth (GIS for providing consumers with RSD), which ensures interaction with the information systems of regional executive authorities and municipal authorities, other regional consumers.

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With the planned development of the domestic satellite segment within the framework of the Sovereign's Eye project and the development of the remote sensing industry as a whole, it is important to consider the preparation of relevant industry solutions (services, geoportals, etc.) in advance, considering the provision of three large-scale levels: cadastral, resource and meteorological. More and more users are switching from purchasing surveys to using online services both for access to archives and for solving specific problems in various areas of the economy, including the agricultural sector.

Based on this, it is important to understand that it will be difficult today to ensure the current needs of the state in the implementation of the digital economy, without making appropriate adjustments to the training of specialists. And it is important to introduce the latest digital technological solutions into the educational process for graduates of universities to successfully cope with the tasks set for a decade [1].

2.Materials and methods

In land management, planning and cartographic material can take the form of dashed contour plans (or photoplans), thematic maps and diagrams, as well as laser scanning rasters, and RSD photographs [2, 3].

Depending on the type and quality of the source material and their processing programs, there are various technologies for the post-processing and presentation of the planning and cartographic material in digital display, which fit into the system "land management scheme - land management project - working draft". The general technological scheme of the work sequence for automated land management design is presented in [4].

The main part of the information-logical model, its functional structure is the design subsystem, which includes the following elements:

- automation of environmental and economic assessment of the territory;
- automation of the business plan of the economy;
- automation of the development of inter-farm land management projects;
- automation of the development of integrated projects for on-farm land management;
- automation of working design;

automation of the economic feasibility of design decisions and determination of the economic efficiency of the project.

3. Technological solutions

The State University of Land Management has developed the basic elements of automation of a land management project.

The MEZHA program aims at preparing land surveys in an automated mode based on processing data from field measurements of geodetic surveys.

The program provides the following features:

1. calculate theodolite stroke;
2. calculate picket coordinates;
3. calculate the area of land, their parts, real estate;
4. prepare land management documents.

Figure 1 gives an example of the program at a specific production facility.

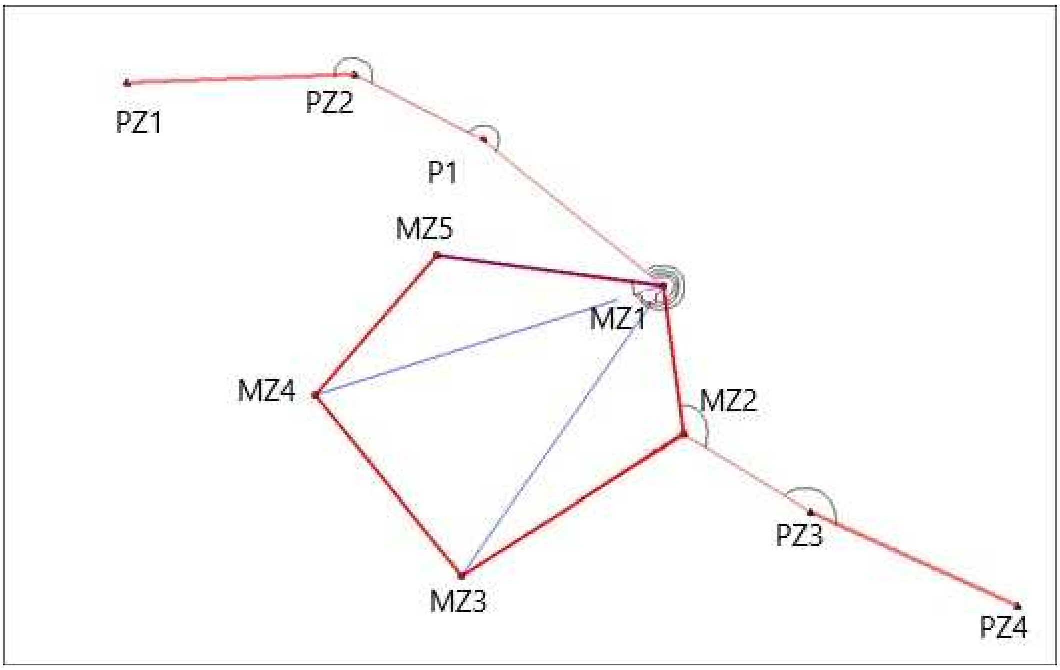

Figure 1. Example of the program at a specific production facility.

The program automatically calculates the coordinates of the turning points of the course, considering the calculated angular and linear residuals.

The KOLOS program allows to quickly and reasonably solve the issues of organizing production and territory in case of any changes in business conditions and forms of ownership.

In many cases, in the process of land planning, there is a need to analyze various options for organizing the territory and make operational decisions to improve it. At the same time, it is important to know what impact the introduced organization of the territory will have on the economy of the agricultural enterprise, the output of gross and marketable crop production, the state and level of land fertility, and the use of agricultural machinery.

As a rule, the designer considers a few options for organizing the territory due to the complexity and a large amount of calculation of indicators to choose the best solution. It is advisable to solve this problem using **KOLOS AS** to reduce the time for calculating and analyzing the planned options for organizing the territory and justifying the business plan of the enterprise, considering the quality and location of the land assigned to them.

The solution to this problem is relevant when creating new land tenure and management, new land relations because in this case, it is important not only to choose the best option for organizing the territory but also to justify the production program (business plan) of the enterprise, considering the quality and location of the land assigned to it.

The solution to these issues not only increase the economic feasibility of on-farm land management projects but also raises their informational significance, which increases the interest of agricultural enterprises in them.

The scope of **KOLOS AS** functioning is agricultural organizations. The system helps to quickly resolve issues of organization of production and territory in case of any changes in the business environment and forms of ownership and make operational decisions to improve it. At the same time, it is important to know what impact the introduced organization of the territory will have on the economy of the agricultural enterprise, the output of gross and marketable crop production, the state and level of land fertility, and the use of agricultural machinery.

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KOLOS AS is a local software tool, its implementation used general theoretical approaches, which allows us to consider it as one of the elements of the ASP structure in land management and integrate it into a single system for automating land management.

The software and methodological support of **KOLOS AS** include:

- the methodology of the automated economic feasibility study for on-farm land management projects;
- technological scheme of an automated system;
- application package.

The development of mathematical models of the economic feasibility of land management projects included the principle of rational and reasonable combination and consideration of state and private interests of landowners and land users. High income should not result from reducing the productive properties of the land, environmental degradation, and disturbance in the stability of the agrolandscape. In this regard, there is a need for a comprehensive solution of environmental, social and production problems in the rational use of land, labour and material resources, intensification of production, the involvement of unused lands in agricultural circulation, solving organizational, economic, environmental and social issues, determining the need for material and technical resources, machinery, equipment, organic and mineral fertilizers, capital investments.

The calculation of the economic justification of crop rotation and the arrangement of their territory is based on multivariate land management design, which is part of a subsystem of automated assessment and selection of the best land management option for the economy.

The figure shows the technological scheme of an automated system of economic feasibility of on-farm land management projects and the selection of the optimal project option.

The technological scheme of **KOLOS AS** reflects the main stages of work that require automation to select the optimal project for the organization of the farm.

The essential land management tasks of the agro-economic substantiation of land management projects that can be solved by the **KOLOS AS**:

– compilation of the annual turnover of a herd of cattle; sheep; pigs;
– calculation of feed requirements;
– calculation of the need for green fodder for each grazing group of cattle;
– calculation of the green conveyor;
– calculation of sown areas of fodder crops;
– optimization of the structure of sown areas on the farm;
– distribution of crops on the territory depending on the erosion and soil quality;
– calculation of gross production in physical and value terms;
– calculation of production costs;
– calculation of the output of manure on the farm;
– calculation of the yield of organic fertilizers in the household;
– calculation of the balance of nutrients in the soil;
– calculation of costs for idle moves of agricultural machinery;
– calculation of the costs of maintaining soil fertility;
– determination of product losses due to violation of the terms of field work (according to variants);
– calculation of losses of field crop production from the area occupied under roads, triangles and wedges, headlands;
– calculation of additional output by reducing the cost of field mechanized work;
– calculation of the reduction in the cost of mechanized fieldwork by the increasing headland, reducing downtime for organizational and technical reasons, reducing biases in work areas;

– definition and analysis of consolidated estimated indicators of field cultivation according to project options;
– determination of the need for fixed and current assets;
– selection of the best farm option for the integrated indicator;
– determination of the economic efficiency of agricultural production of land management.

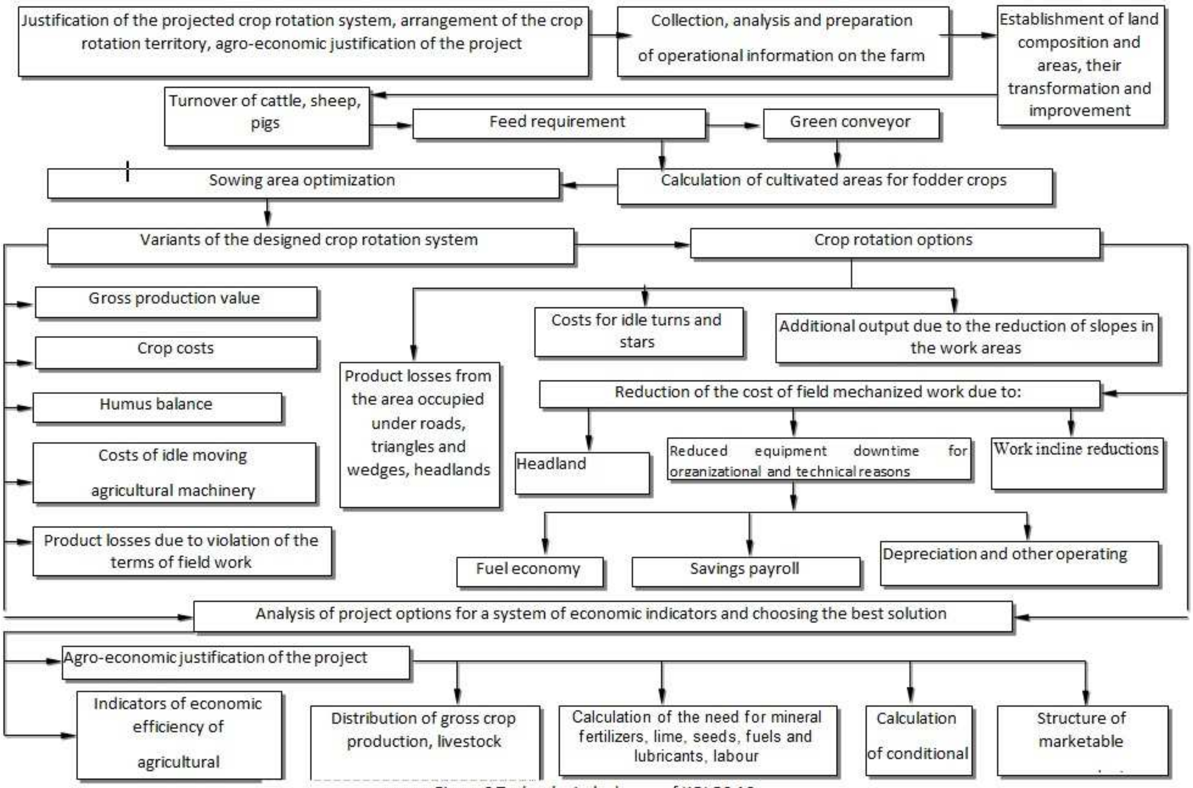

Figure 2. Technological scheme of KOLOS AS

The generalized block scheme of KOLOS AS illustrates the process of obtaining the optimal design option for on-farm land management.

Land manager-designer performs *the work of collecting, analyzing and preparing information* for automated processing.

In determining the composition of the source data, he uses a comprehensive system of indicators which are the basis for the justification of design land management decisions.

We tested the operability and capabilities of KOLOS AS on the experimental calculations to justify on-farm land management projects [5,6].

We implemented control examples of checking the correct operation of the system at the facilities: the Borets collective farm of the Moscow region, the Bolshepolyanskoye LLP of the Nizhny Novgorod region, the Kuzminichi LLP of the Kaluga region.

We measured the time spent on the traditional and automated justification of the design solution with the simultaneous calculation of test cases for the Mir collective farm of the Kirov region, the Rassvet state farm of the Krasnodar Territory, the Uteshkovo agricultural cooperative of the Kaluga Region.

KOLOS AS allowed us to justify pilot production experimental design in the following enterprises: KP Zarya in Medynsky District of Kaluga Region, Kuzminichi LLP in Kuibyshevsky District of Kaluga Region, organized on the basis of two Risk and Kuzminichnoe partnerships, the small enterprise Central, cooperatives Passages and Uteshkovo in the Kuybyshevsky district of the

Kaluga region, farms on the lands of collective agricultural enterprises of the Kamennobrodskoye Olkhov LLP district of the Volgograd region. The latter has been organized in the form of an agricultural cooperative and has been operating since 1996. On the territory of the unit, there are seven settlements and 125 residents, including 48 able-bodied residents. The total area of the project is 2,976 hectares, of which 1,375 hectares (46.2%) are agricultural land, which is indicative of the average development of the area for that zone. Ploughed agricultural lands amounted to 82.3%, arable land was 1132, hayfields was 122 hectares, pastures was 121 hectares.

It requires the unification of its structure when determining the types and volumes of stored information, developing methods for storing, searching and making changes to data arrays and keeping them up to date. We have identified informational relationships between the tasks of the economic feasibility of on-farm land management projects, established links between the elements of **KOLOS AS**, and determined the flows of input and output information.

Analyzing the relationships between the source (input) and calculated (output) data, it turned out that the same information is the source when solving many problems.

The calculated and output data for solving some problems are the source for others. Therefore, the information once entered into the **KOLOS AS** is repeatedly used when substantiating the components and elements of a project.

Developed design solutions can be used with cloud technologies, however, they require significant advanced training for specialists in the agricultural industry.

Table 1. The list of programs included in the KOLOS AS

No.	***Program name***	***Name Programs***
1	***2***	***3***
1.	Calculation of turnover of cattle herd	KRS_OB
2.	Calculation of the turnover of the herd of pigs	SV_OB
3.	Calculation of the turnover of the flock of sheep	OV_OB
4.	Calculation of livestock feed requirements	KORMA
5.	Calculation of green feed requirements	ZEL_KORM
6.	Calculation of the green conveyor	CONVEER
7.	Calculation of areas of forage crops	KORM_PLO
8.	Determination of transport costs in the economy associated with the cultivation of crops in crop rotation	GRUZ
9.	Calculation of costs for single moving units	HOLPER
10.	Determining the value of gross crop production	VAL
11.	Determination of net income from leased land	INCOME
12.	Solution of optimization land management problems of linear programming by the simplex method	SIM
13.	Solving linear transport programming problems	RASP
14.	Definition of regression equations for production functions:	PROFUN
15.	Selection of the best land management option based on the economic and environmental assessment of the organization of arable land	KOLOS AS

4. Conclusion

1. The authors developed an information-logical diagram of land management planning using multilevel geospatial information, obtained both by automation of traditional topographic and geodetic measurements and remote sensing data.

2. They formed technical requirements and developed software for key elements of the automation of a land management project that determines the optimal location and structure of the land.

3. Researchers provided a brief description and functionality of the MEZHA and KOLOS software systems, as well as examples of their testing at several agricultural enterprises in various regions of the Russian Federation.

4. They showed that the effectiveness of the use of automated systems for land management design increases the efficiency of land use and agricultural production up to 30 - 40%. The widespread adoption of digital technologies in the agro-industrial complex requires the training of qualified personnel who can use modern software, including based on cloud technologies.

5. Acknowledgments

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