Digital land management: new approaches and technologies

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Abstract. The article analyzes problems of implementation of the “digital agriculture” program. The role of modern land management in implementing tasks of effective land management is described. Opportunities of modern departmental information systems when addressing issues of geographic information support of the agro-industrial complex are considered. New approaches and digital land management technologies providing a significant (up to 30%) increase in the efficiency of land use were suggested. The need for training the staff under digitalization of the industry was emphasized.

1. Introduction
In the agricultural industry, land is a spatial basis, a natural resource and a production tool whose rational use determines the efficiency of the industry and the state of the natural environment. Therefore, “smart land management” using “smart land management” methods should be at the core of digitalization of agriculture.

This indisputable fact is due to the following reasons:
1. The main issues of development of the industry (smart field, smart farm, smart garden, etc.) should not be considered in the overall system of the agricultural organization. The farming system is an element of an integrated economic system. It is determined by the need for the development of field crop and animal husbandry, fodder production, etc.
2. All the main agricultural branches are united by a single territory within its borders and connected by elements of the production and social infrastructures (roads, cattle routes, ameliorative networks) which requires the interconnected solution of the following issues:
   • streamlining of land and property relations (only 30% of land plots in the village are registered) which does not allow for the planned use and circulation of agricultural land;
   • accounting and assessing the quality of land in order to link the location of agricultural sectors to the territory by taking into account production and territorial properties of land (soil fertility, location of plots, land-reclamation, etc.);
   • designing the single interconnected system of land reclamation, anti-erosion and environmental protection measures whose boundaries coincide with catchment areas, basins of small rivers, areas of wind erosion, etc.

At the same time, smart land management should be both a means of obtaining and processing information, as well as a mechanism for making management decisions on land management regulation, fertility enhancement and soil protection.

The World Land Management Review prepared by the United Nations Economic Commission for Europe states that “... the level of civilization of society is determined by the level of land management and land use”. "... Due to the lack of land management in Russia, millions of hectares of previously
cultivated agricultural land are empty." The data of the National Union of Land Surveyors of Russia shows that more than 60 million hectares of land consisting of 6.2 million plots may be involved in agricultural circulation.

It is clear that for agriculture of Russia without using this reserve, assessing the land and resource potential, formalizing the ownership of rural land, it is impossible to achieve economic success.

Therefore, land management should be the main mechanism for implementing the agrarian policy, the main factor in improving the competitiveness of agriculture. It should be integrated into the overall system of economic management.

2. Materials and methods

Large arrays of processed information, complex and multivariant processes of land use, various branches of agriculture and the stochastic nature of production require the use of digital land management technologies, modern multi-level databases, variable software solutions, intelligent systems for solving production and design tasks, changing the land management system.

Digital land management is a system of geo-information support for agricultural territories, including the on-line processing of significant geospatial information flows (big geo data) and the issues of land ownership structure and systemic territorial development of farms.

Currently, the main information resource of digital land management is the Unified Federal Information System on Agricultural Lands.

This system provides the Ministry of Agriculture and subordinate organizations with up-to-date, relevant and reliable information on agricultural lands. The data are obtained during the state monitoring of these lands. The system collects, stores, processes and analyzes information about agricultural land, land accounting, land-improvement systems and hydraulic structures, systematic monitoring of the state and use of land, providing stakeholders with information about agricultural land.

The system contains information
- about the boundaries and areas of agricultural land and crops;
- data on land users;
- indicators of soil fertility;
- information on negative processes, land reclamation facilities and other information.

3. Information resource of digital land management

To create a modern, efficient land management system, this information base is not always sufficient. The data updating system is not operational, not relevant and reliable; it does not contain decision-making blocks. In particular, according to the Analytical Center, out of 83 agricultural regions, 22 ones did not report data to the UFIS. Out of the regions that reported the information, more than 70% do not have reliable information on crops in the sown areas (database completeness is less than 50%). The situation is similar with information about land users. In 42 regions of the Federation, the completeness of the land user database is less than 50%. There are significant errors in the cartographic provision of the UFIS AL. It is based on data from Landsat satellites with a 30 m spatial resolution which makes it impossible to construct accurate contours of lands and identify their purpose and actual application. Remote sensing materials from RapidEye satellites (6.5 m resolution) and ALOS / AVNIR-2 (10 m resolution) were applied on the territory of the current agronomic survey cycle (580 thousand km²).

However, specification and correction of the system data were fragmentary and of poor quality. As a result, 60-70% of the data do not correspond to the real boundaries of the fields and contain erroneous information about the areas and location of agricultural land plots in Russia. This is confirmed by selective comparisons with the data of current UAV flights made by university specialists in Tambov, Yaroslavl, and Smolensk regions (Figure 1) [1, 2].
Figure 1. Comparative analysis of remote sensing data of the UFIS AL and UAV survey data

We have suggested adaptive technologies for the development of integrated land management projects, allowing to study the state of lands, predict individual indicators and production results, and manage land resources solving important agricultural problems. The main ones are as follows:

- assessment of agricultural lands;
- identification and involvement of unused lands into circulation;
- registering valuable productive agricultural lands;
- development of zone-based agricultural regulations;
• drafting of adaptive landscape farming and land management projects. Special software and unique equipment, including robotic geodetic total stations, ground-based and airborne laser scanners, unmanned aerial vehicles with multispectral imaging equipment in the visible and infrared ranges, space monitoring data with a spatial resolution of up to 10 cm, cloud geo-information systems processing a large amount of geospatial information, automated land management on-line design systems are required. The use of digital land management systems will allow to

1. create an information computer-based system for assessing the quality and location of agricultural land plots based on the assessment of their productive and territorial properties (analogues of the American LESA system - Land Evaluation and Site Assessment System and the Soviet system of intra-farm land assessment) [3].

2. form land ownership in the agricultural industry, carry out these processes ensuring the delimitation of all forms of ownership, register all agricultural land plots. This will attract additional financial resources to the agricultural industry against security of land plots and increase the taxable base.

3. plan the land management at the federal, regional and municipal levels as in the European Union, the USA and China [4], which will link the development of agriculture with socio-economic and natural conditions of the country and regions and business opportunities.

4. develop agricultural (land management) regulations, measures against land degradation and soil fertility reproduction, enhance the efficiency of land use.

5. develop regional business-oriented projects of adaptive-landscape land management in order to link the farming system (crop cultivation technologies: a processing system, fertilizers, soil reclamation, plant protection, seed production, a system of machines) to the land, and improve the efficiency of its use.

Evaluation and planning (programming) of crop yields based on the intra-field organization of the territory is the most important component of these projects.

Currently, the methods for evaluating and planning crop yields are based on the analysis of data on obtained as a result from aerospace observations, taking into account weather conditions possibilities for various types and volumes of field work on crop processing, fertilization, harvesting, etc.

They are rather accurate, but take into account the existing situation which characterizes optimal location of crops and their structure regarding the soil quality based on the suitability of crops and the location of economic centers. This makes it impossible to obtain large yields focused on the maximum possible and rational use of arable land resources (soil fertility) and does not allow for proper management of production of high stable yields.

To solve this problem, we have developed and tested methods for estimating and planning crop yields based on the multivariate analysis of geospatial information in the context of crop rotation fields, taking into account their field organization and separation into homogeneous areas.

This will solve the following issues:
• improvement of the accuracy of estimation and prediction of crop yields with a probability of up to 95%;
• an increase in the yield by 25-30% by optimizing the location of crops on the optimal land plots;
• reduction of production costs for the cultivation of crops by 15-20% by taking into account technological properties and location of land plots;
• coordination of cultivation technologies and specific areas of arable land;
• development of a system of anti-erosion and environmental protection measures within the boundaries of fields and working plots (agrotechnical, forest reclamation, hydrotechnical, organizational and economic) [5, 6] (Figure 2).
4. Conclusion

Thus, using the example of pilot projects in several regions, it was shown that:

1. In the agricultural industry, the technological breakthrough based on digital transformation is possible only by creating optimal soil-agrotechnical and organizational-territorial conditions that ensure a significant increase in crop yields on the basis of planning and programming, production output per one worker, a decrease in material costs of fuel, electricity, soil protection means, plants, labor, etc..

2. Modern digital technologies can optimize key parameters affecting crop yields: soil fertility; technological land properties; location and structure of land.

3. For the widespread use of digital technologies in the agro-industrial sector, it is necessary to train staff. A single online platform "Open Agrarian Education" can be created. This educational platform will be part of a unified national system of online education linked to information systems of the Ministry of Agriculture of Russia: “Electronic Atlas of Agricultural Lands”, the System for Monitoring and Forecasting Food Security, the Federal System of Information on Agricultural Lands.

4. It is necessary to make proposals to the draft Federal Law “On Land Planning” in order to create a digital system of land use and land management.

5. The most significant scientific areas of digital land use and land management are development of projects aimed at improving technologies, methods and algorithms for collecting, processing and managing information support for the most important digital technologies, including:

   - Development of an information hardware-software system for involving agricultural land plots into active economic circulation, including in connection with their use not for the intended purpose or in violation of the legislation of the Russian Federation based on the developed digital criteria and modeling of agricultural production efficiency taking into account long-term development of the agro-industrial sector and ensuring food security of the Russian Federation;

   - Development of a system for automating zoning of agricultural territories under the influence of technological development of the agricultural industry based on integrated aerospace information in order to update information state resources for the sustainable development of agricultural lands.
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