GIS as a tool for creating a global geographic information platform for digital transformation of agriculture

E V Kotsur\textsuperscript{1,3}, M N Veselova\textsuperscript{1}, A V Dubrovskiy\textsuperscript{2}, V N Moskvin\textsuperscript{2} and Yu S Yusova\textsuperscript{1}

\textsuperscript{1}Omsk State Agrarian University named after PA Stolypin, 1 Institutskaya squ., Omsk, 644008, Russia
\textsuperscript{2}Siberian State University of Geosystems and Technologies, 10 Plakhotny str., Novosibirsk, 630108, Russia
\textsuperscript{3}E-mail: ev.kotsur@omgau.org

Abstract. The article highlights the issues of digitalization of the economy of the Russian Federation, in particular, “Digital Agriculture” state program. The goals and objectives of digitalization of agriculture in Russia are discussed. The main point is made about the fact that it is impossible to create digital agriculture, which implies the introduction of “smart land use” bypassing the creation of “digital land management”. The analysis of "Digital Agriculture" project concept is given; its goals and directions are considered. “Digital land use and land management” direction has been studied in details. The authors of the article suggest introducing “Smart Agrolandscape” land information system (ZIS “Smart Agrolandscape”). The basis of this system includes a scheme of ecological and economic zoning, taking into account the suitability of agrolandscapes for arable land and fodder land use. The article presents the structure of the proposed system, its goals, objectives, purpose, and algorithm of work in the system. In conclusion, the authors of the article recommend the inclusion of ZIS “Smart Agrolandscape” into the Digital Land Use and Land Management project, due to the fact that the process of making recommendations on the efficient use of land in municipalities using this system is fully automated and does not require time, labour and financial costs; its use is maximally simplified and accessible to unlimited interested parties.

At the moment, the agro-industrial complex of Russia is ready for introduction of various kinds of innovations. This need arose with the understanding that farming by out-dated methods does not allow achieving even stopping of raising prices for agricultural products. The introduction of modern digital technologies in Russian agriculture is aimed at ensuring its intensification; moreover it will help optimize the use of agricultural land [1].

Agriculture has always had characteristics that are not attractive to investors, which are as follows: a long production cycle, dependence on natural factors, out-dated production technologies, yield losses on all production cycles. But, despite this fact, such countries as the USA, China, India, Canada, Israel have been able to attract the attention of investors by introducing digital farming technologies [2, 3].

The adoption of the Digital Economy of the Russian Federation program, approved by the Decree of the Government of the Russian Federation of July 28, 2017 No. 1632-r, can be considered the stage of digitalization in Russia. It should be noted that in preparing this program, agriculture was not included in the list of priority sectors, but by the end of 2017, the Ministry of Agriculture proposed the creation of “Digital Agriculture” state program. Along with this, the Analytical Centre has appeared in the
Ministry of Agriculture, which monitors the condition of agricultural land. The largest agricultural universities of the country opened special departments to train qualified personnel in the field of digitalization of agriculture.

The Analytical Centre for obtaining information on agricultural lands and for making managerial decisions has developed and is implementing the Unified Federal Information System on Agricultural Lands (UFIS AL). Such data as information on cultivated crops for each field, the name and identification number of the land user, information on objects and structures of land reclamation are entered into the system. The system systematizes the results of agrochemical surveys conducted by the institutions of the agrochemical service of the Ministry of Agriculture of Russia, provides automatic plotting of the crop rotation and the progress of vegetation indices, and allows determining fields with a low level of fertility. It is planned to expand the functions of the module using remote sensing data: identification of crops grown, identification of unused land, assessment of the degree of land overgrowing with shrubbery. All of the above data will be displayed in the federal state information system, which is called Functional subsystem "Electronic Atlas of Agricultural Lands", which will provide free access for agricultural producers and investors.

The digitalization of agriculture has two main objectives: increasing productivity and reducing losses. And if the task of developed countries is to maximize agricultural productivity, then Russia faces the task of accelerating agricultural productivity, as recent world events have shown that the effectiveness of domestic agriculture is not at a high level. Thus, it is necessary to look immediately for solutions to problems that impede the increase in agricultural productivity. One cannot disagree with the opinion of T.V. Papaskiri [4] that it is impossible to create digital agriculture, which implies the introduction of “smart land use” bypassing the creation of “digital land management”. Agriculture on the basis of adaptive-landscape approaches cannot be carried out without effective planning and rational use of land resources. This could be a crucial mistake in the strategy to increase agricultural productivity, which at the moment does not have the right to take risks.

In our opinion, the introduction of “Digital Agriculture” is necessary; and at the moment more relevant than ever, but without taking into account the suitability of land for use, the implementation of “smart farming” is impractical. This can lead to insignificant short-term results, but it will not lead to a steady increase in productivity.

In the Russian Federation for the period from 2005 to 2018 land management projects were not developed enough. They were mainly aimed at agricultural organizations only (on-farm land management). The exception is Belgorod Region, where the development of on-farm land management projects was widespread (123 projects from 2007 to 2014) and, in the development of on-farm land management by 2015, 10 projects of the adaptive-landscape system of agriculture and soil protection were drawn up [5]. These 123 agricultural organizations are ready to carry out the “Digitalization of Agriculture” for conducting “smart farming”. In Belgorod Region nowadays highly efficient agriculture is being carried out, and the introduction of precision farming would raise the indicators even to a higher level.

At the moment, the Ministry of the Russian Federation, the Russian Academy of Sciences, Federal State Budgetary Institution “Soil Institute named after V.V. Dokuchaev”, Federal State Budgetary Educational Institution of Higher Education “State University of Land Management” developed a draft concept of “Digital Agriculture”, which indicates that the issues of effective planning and rational use of land resources will be taken into account when digitalizing agriculture.

The main goal of the concept is to increase labour productivity at agricultural enterprises. Achieving this goal is proposed by mean of the following technologies:

- use of digital technologies;
- creation of information and reference systems in the field of land relations;
- improvement of the Unified Federal Information System on Agricultural Lands;
- formation of a unified platform for monitoring the protection of agricultural land from negative anthropogenic and natural influences;
creating computer-aided design and workstation automation systems for agricultural producers to apply digital farming methods;
creating digital methods and technologies to optimize land use;
stimulating the transition to digital agriculture by simplifying the processes of lending and insurance of agricultural production, reducing the timing of subsidies, subsidies, etc.
providing high-speed communications to rural areas, etc.

It is proposed to carry out the digitalization of agriculture in three stages (up to 2024 inclusive) in the following areas: Digital technologies in the management of the agro-industrial complex, Smart land use, Smart field, Smart garden, Smart greenhouse, Smart farm.

The project of “Digital Agriculture” Concept has developed the main directions, but their technical component requires elaboration. One of the priority projects of scientific and technological development of digital products and technologies for agriculture is “Digital land use and land management” direction. The purpose of this area is to create an intelligent multi-level system for planning and forming sustainable agrolandscapes. The introduction of such a system is designed to increase the productivity of agricultural producers and reduce the cost of agricultural products as a result of the efficient use of land resources. To achieve the goal in the framework of the implementation of this project, it is necessary to do the following:

a) develop and implement a digital information and reference system of legal regulation in the field of land relations;
b) create a system of automated planning for adaptive landscape land use, consisting of nine blocks:
  Block 1 “Information about the site”;
  Block 2 “Monitoring and updating”;
  Block 3 “Assessment of suitability”;
  Block 4 “Potential yields”;
  Block 5 “Prediction of productivity”;
  Block 6 “Digital farming”;
  Block 7 “Cadastral valuation and collateral value”;
  Block 8 “Visualization of analysis results”;
  Block 9 “Data storage”.

c) create an end-to-end platform for monitoring agricultural land protection processes;
d) create centres of competence for the introduction of adaptive-landscape systems of land use and land management.

e) create centres of excellence and training of specialists to work in centres of competence;
f) fulfil approbation of the system on pilot projects of adaptive landscape agriculture and land management.

The authors of the article propose to include the “Smart Agrolandscape” ZIS into the third block “Suitability Assessment” of “Digital Land Use and Land Management” project as a technical component. The proposed system will help reduce the time and cost of evaluating usability and restoring the fertility of the country’s agrolandscapes.

The purpose of the “Smart Agrolandscape” ZIS is to inform state authorities and local governments, legal entities and individuals about the ecological state of agrolandscapes and their suitability for use.

The basis of the proposed system includes the scheme of ecological and economic zoning, taking into account the suitability of agricultural landscapes for use for arable land and fodder land.

The purpose of the system is visual access of all categories of users, which include public officials, individuals and legal entities to the graphic and semantic data of the scheme of ecological and economic zoning for improving agricultural systems.

The software used is “MapInfo Professional” geographic information system. The structure of “Smart Agrolandscape” ZIS is presented in figure 1.
Figure 1. The structure of “Smart Agrolandscape” ZIS.

The basis for ecological and economic zoning (EEZ) and the formation of agricultural EEZ is a digital landscape model (DLM) of municipal districts with a set of indicators contained in a database [6]. Such indicators include graphical and attributive (semantic) data on rural settlements, human settlements, business entities, fields, forage lands, geomorphological zones, soil differences and non-agricultural lands.

After conducting an EEZ [7, 8], the DLM database is updated with information on subclasses of agrolandscapes, field and forage species of agrolandscapes, suitability groups for arable land and forage lands, types of agrolandscapes and ecological and economic zones. Ecological and economic zones, as a result of the EEZ and the key link of the “Smart Agrolandscape” ZIS are shown by shading for better visual perception.

To make recommendations on the efficient use of land in agrolandscapes of economic entities, it is necessary to do the following:

- make the layer with a grid and fields visible (figure 2);
- load the layer “Ecological and economic zones” to the layer with the grid and fields (figure 3);
- conduct a visual analysis,
- go to the tab with the attribute database of the "Ecological and economic zones" layer;
- familiarize with land use regimes in the zones of interest;
- make recommendations on the efficient use of land in the agrolandscapes of the studied economy on the basis of land use regimes.
Thus, the process of making recommendations on the efficient use of land in municipalities using “Smart Agrolandscape” ZIS is fully automated and does not require time and labour costs. The use of “Smart Agrolandscape” ZIS is maximally simplified and accessible to unlimited interested parties; therefore, it can be recommended for inclusion into “Digital Land Use and Land Management” project.

References
[1] Vershinin V V, Kovaleva T N, Demidova M M and Lebedev P P 2018 Geo-information projects of agricultural development of agricultural enterprises as a basis for digitalization of agriculture Moscow economic journal 5 16-27
[2] Liang Y, Lu X, Zhang D, Fu L and Zhi-bo R 2003 Study on the framework system of digital agriculture Chinese geographical science 1 15-9
[3] Duan Yn 2011 Research and Analysis about sistem of Digital Agriculture Based on a Network Platform Computer and computing technologies in agriculture 2 274-82
[4] Papaskiri T V 2018 On the concept of digital land management Land management, land monitoring and cadaster (Moscow: Publishing House “Panorama”, Publishing House “Athena”) vol 11 pp 5-11
[5] Khusainov A 2015 Promotion of work on on-farm land management in the Belgorod Region International Agricultural Journal 3 8-10
[6] Karpik A P and Musikhin I A 2016 Research and practical trends in geospatial sciences International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences 6 177-84
[7] Kotsur E V and Veselova M N 2015 Ecological and economic zoning of agricultural landscapes of the Pavlograd district of the Omsk region Omsk Scientific Bulletin 144 186-90
[8] Kotsur E, Kapitulina N and Yusova Yu 2019 Creation and use of the module “Sustainable agrolandscape” in the framework of the digital transformation of agriculture Advances in Intelligent Systems Research 167 93-7