Review of modern technologies intellectual decision support in the reclamation of agricultural crops

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Abstract. According to the "Strategy for scientific and technological development of the Russian Federation" and within the framework of the "Digital agriculture" program, in the coming years, one of the priority areas of development is the transition to highly productive agro-aquatic farming. The key vector for the development of scientific and technological progress in the agro-industrial complex is to improve the management of irrigated agriculture, increase productivity on reclaimed land and resource conservation through the development of intelligent decision support systems, digital information technologies and mathematical models of agricultural reproduction. The theoretical and methodological basis of the research is the works of domestic and foreign scientists in the field of information technologies for decision support, mathematical modeling and programming, optimization of technical parameters for the operation of reclamation systems. Relevance of the review of the theory and technologies of crop irrigation management using mathematical models and intelligent technologies at the stage of agricultural digitalization. this is due to the need to create a new generation of reclamation systems that use modern achievements of scientific and technological progress, which will make it possible to practically implement the ideas of highly efficient and environmentally friendly agriculture on irrigated lands.

1. Introduction
Irrigated land is a key factor in ensuring food security and stability of agricultural production worldwide. The problem of ensuring high productivity of agricultural production in the Russian Federation, where more than 75% of all agricultural land is located in areas of insufficient or unstable natural moisture is possible due to irrigation of agricultural land. One of the basic assets of improving the efficiency of irrigation management is to increase the efficiency of operational planning of irrigation by optimizing the technical and operational parameters of sprinklers and irrigation modes of agricultural crops, taking into account soil and climate factors.

As part of the main direction of development of the domestic reclamation complex, a program for the development of reclamation from 2021 to 2030 is being developed, which is based on the following main tasks:
- restoration of the existing reclamation complex (reclaimed land, reclamation systems and hydraulic structures), including technical re-equipment of currently functioning reclamation systems,
reconstruction of obsolete and physically worn-out reclamation systems, conservation and (or) elimination of systems and structures that are unsuitable for effective use;
- further development of the reclamation complex through the priority construction of new generation reclamation systems using high-tech innovative technologies that minimize the specific water and energy consumption per unit of production;
- ensuring the safety of the functioning of hydraulic structures, preventing the possibility of emergency situations in the zone of influence of large hydraulic structures;
- introduction of retired reclaimed land into agricultural circulation by conducting agrotechnical, cultural, chemical, agroforestry and phytomeliorative measures to increase soil fertility and the stability of agricultural landscapes;
- increasing water availability of territories by using local runoff, underground water, livestock runoff and waste water for irrigation, taking into account their treatment, and subsequent waste disposal, as well as local redistribution of river runoff;
- ensuring environmental safety and preservation of the natural environment through the creation and implementation of innovative environmental technologies to increase the fertility of agricultural land;
- increasing the role of digital technologies in the management of land reclamation activities, based on modern technologies of data mining and computer modeling methods that contribute to the quality and speed of management decision-making.

2. Materials and methods
According to the modern ideas of leading Russian scientists L. V. Kireycheva, V. M. Yashina, G. V. Olgarenko, A. A. Uryumova, M. A. Bandurina, I. F. Yurchenko, A. L. Buber and etc., the sphere of melioration involves the development of measures to preserve and increase the renewable natural resource potential of the agricultural landscape and environmental protection, as well as the formation of an adequate set of agromeliorative measures to increase the productivity of agricultural land and preserve the natural environment. Integrated land reclamation is designed to form and maintain a high level of bio-productivity, soil fertility reproduction and environmental sustainability in land reclamation systems [1-7].

In the scientific works of A. S. Ovchinnikov and V. S. Bocharnikov, mathematical and computer models of soil water regime optimization were developed, in particular, an optimization model of soil water regime management under irrigation conditions was proposed, which allowed us to assess the need for the next vegetation irrigation, the likely date of the next irrigation, draw up irrigation schedules and develop a water use plan for short, medium and long-term periods. In contrast to the well-known solutions, the model proposed by the authors provides for the possibility of determining the current state of soil moisture by calculations, as well as using an information management system, which features the use of different methods for determining evapotranspiration during forecast and retrospective calculations [8-10].

In recent years, there has been a progressive degradation of the soil cover and the depletion of the resource-assimilation potential of nature. This problem is associated with a sharp deterioration in the material, technical and resource support of agricultural production, the unjustified use of regional systems of adaptive landscape farming and modes of operation of reclamation systems.

The use of modern information technologies and high-tech computer tools for intellectual analysis of data on the natural and ecological state of irrigated lands opens up broad prospects in the field of regulating technologies for cultivating crops, improving the efficiency of agriculture on reclaimed lands and rational use of water resources.

Scientific justification of the use of intelligent information systems based on known and developed mathematical models of crop irrigation management will improve the quality of operation of reclamation systems, prevent degradation of irrigated land, and allow efficient and rational use of natural resources. Solving the problems of degradation of agricultural land reclamation landscapes and ensuring their stable ecological and meliorative state requires taking into account the characteristics of
each irrigated area, which requires the use of automated information technologies for monitoring fertility management in irrigated areas.

Information support for mathematical models includes geoinformation systems, database management systems (DBMS) and intelligent decision support systems (information and reference, information and advice, and information management), simulation environments and various service models that allow determining the choice of the type and parameters of technological operations, taking into account changes in logical and technical and economic constraints, and also determine the need to develop automated technologies for managing crop cultivation in irrigation conditions based on artificial intelligence. Special attention should be paid to the use of automated GIS (geoinformation systems) technologies that use satellite monitoring and remote sensing data. The use of geoinformation systems for reclamation areas is due to the territorial dispersion of objects, the possibility of building digital models that take into account spatially distributed factors, calculating and measuring the geometric characteristics of agricultural water supply facilities, as well as analyzing actual and model calculation data with subsequent visualization on the map, which will allow performing situational analysis and monitoring of the state of irrigated and drained lands. S.M. Vasiliev conducted research on the problems of monitoring agricultural land in the Russian agro-industrial complex using the satellite service "VEGA-Science", which allows you to set boundaries and solve research problems for each specific field, as well as identify areas of changes in soil properties for certain crops, as well as monitor the state of irrigated land, identify and control the development of degradation processes and develop measures to combat them.

Research by A. F. Rogachev and E. V. Melikhova is devoted to the problems of using unmanned aerial vehicles and artificial neural networks in agricultural production. As part of their research, they developed and implemented software systems for binary classification of the state of agricultural crops based on high-resolution color aerial images, management of programmed agricultural production based on long-term retrospective data on crop yields in arid conditions, obtaining and processing results, as well as subsequent analysis of the image set and calculation of vegetation indices. The use of specialized GIS for the implementation of precision farming technologies allows us to consider each agricultural field as a heterogeneous array, dividing it into a conditional number of homogeneous areas (management units), each of which forms its own reclamation regime, and introduces a differentiated and strictly standardized dose of fertilizers, taking into account the specified indicators of quality and volume of agricultural products [11-14].

In V. V. Borodychev's scientific works, the possibilities of managing the reclamation of agricultural crops with the use of modern GIS technologies for monitoring the work of irrigation equipment in real time, implying the formation of a specialized list of interactive interaction segments, as well as the use of multifunctional software systems for data analysis and intellectual support for managerial decision-making, are studied. In addition, the authors designed and implemented an information system for monitoring and operational management of irrigation based on global satellite positioning technologies and preprocessing determination of the optimal management decision area, which allows simulating the presence of an operator directly at the control object and making decisions analyzing the behavior of the object [15-17].

I. F. Yurchenko's works are devoted to the problems of information support for decision-making on the management of agricultural land reclamation and water management complex:

- the possibilities of using intelligent systems, methods of technical Cybernetics, control automation and mathematical modeling to optimize the management of technological processes in irrigated agriculture are investigated.

- classical and modern approaches to the development, implementation and adaptation of information management systems in agro-industrial production are analyzed.

- priority directions for the evolution of automated process control systems in land reclamation are proposed;
- the most important directions of development of automated intelligent systems for managing agricultural production processes based on cloud technologies, processing large data sets, the use of computer systems for neural network modeling and deep machine learning are highlighted.

- innovative directions for the development of further research in the field of precision control automation of agricultural systems within the framework of the "Digital agriculture" program.

Foreign developments in the field of control of irrigation procedures that ensure the implementation of a rational irrigation process, control of soil parameters and meteorological conditions in online mode are widely presented by JohnDeere, Acromag SM, LindsayCorp.’s. Cropx humidity sensors successfully transmit data on the moisture availability of agroecososes to a smartphone. Equipping sprinkler systems with Sprinkl controllers allows saving water due to a differentiated approach to irrigation, providing monitoring of irrigation needs for specific areas of the field based on soil moisture data. Review of foreign developments shows that there are numerous agricultural technology information support regulate watering for the transmission to mobile devices online the relevant recommendations, the formation of which is implemented on the basis of the mining and processing of geoinformation monitoring and remote sensing. Smart technologies for precise irrigation involve automation of field configuration accounting, analysis of irrigation needs in various areas, optimization of water supply methods, which contributes to rationalization of water consumption and overall resource saving. The developed PMDI precision mobile irrigation system and variable-speed irrigation technology allow to eliminate the slipping of the sprinkler, reduce the running time and waste water, as well as solve the problem of achieving uniformity of irrigation taking into account differences in soil structure and humidity. Trimble has developed a system for automatically turning on/off sprinklers to improve irrigation of corners and protrusions of the field, which eliminates unproductive water consumption and over-watering of problematic areas of the field. Developments in the field of intelligent monitoring of soil conditions, weather conditions, control of circular and frontal sprinklers, water guns, as well as the formation of statistical data on the consumption of irrigation systems resources are presented by Tevatronik and FieldNET. The automated information systems include an irrigation management module with implemented technological operations that allow reducing operating costs through efficient use of time, optimizing labor resources, electricity, and increasing the level of resource saving.

3. Conclusion
The review of domestic and foreign research in the field of decision support for crop irrigation management using information technologies and mathematical modeling has shown that the priority trends in the development of agricultural reclamation techniques and intelligent technologies for the Russian Federation within the framework of the "Strategy for scientific and technological development of the Russian Federation" and the "Digital agriculture" program, including in the field of digital irrigation, are:

- ensuring the development of innovative information and control systems for managing the reclamation situation in real time;
- software implementation of intelligent decision support systems that provide information support for agricultural production on irrigated land, biotic reclamation, precision farming technology;
- modernization of digital shells for the use of cloud technologies, systems processing large amounts of data and machine learning;
- development of software systems based on neural network modeling and deep machine learning technologies;
- using of universal mobile telecommunications tools for solving auxiliary tasks of agricultural production based on intelligent information systems and simulation technologies;
- development of software systems for simulating the development of agricultural plants taking into account soil-climatic and agrobiological conditions, equipped with an ergonomic web interface,
- application of remote sensing and satellite monitoring results using multispectral cameras for operational control of agroecososes state based on vegetation indices NDVI;
- improvement of methods for increasing the productivity of agricultural land, taking into account soil-climatic, agro-ecological factors in the conditions of land reclamation, based on the operational results of satellite monitoring of territories and remote sensing data;
- using of remote sensing data obtained using unmanned aerial vehicles to monitor the reclamation status of agrocenoses online;
- development of intelligent models and methods of information processing that take into account the specifics of land conservation, resource conservation and increased reproduction of agricultural crops in the conditions of optimization of irrigation regimes.

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