

Information system for improving the process of managing the manufacture of organic products

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Abstract. Climate change and increased anthropogenic impact on the environment, leading to environmental problems, pose a threat to all countries of the world and require the development of effective solutions in the field of organizing production processes, ensuring the use of resource-saving technologies, increasing production volumes through the use of progressive scientific achievements in the field of digitalization, ecology, chemistry, breeding, etc. As a result, the development of organic agriculture and an increase in its production volumes becomes relevant. The purpose of this paper is to develop a hybrid intelligent decision support system for assessing the effective production of organic crop production in regions, municipal districts, as well as on individual land plots, where data on natural and climatic characteristics, agrochemical soil analysis, monitoring of air parameters, etc. act as input parameters. Within the framework of the article, the authors focused on the consideration of the information, behavioral model and the model of the intellectual system components. Thanks to the implementation of these models of the system for improving the process of managing the manufacture of organic products, the user receives the most optimal proposed solutions on the issue of production, changing parameters and conditions characterizing the level of region development, climatic conditions, socio-economic situation, etc. at the entrance to the system.

1 Introduction

Information technologies are an integral part of the efficiency of business entities, allowing them to automate processes, manage data, and improve interaction with various subjects of production processes. They are a key tool for achieving competitive advantages and ensuring success in current market. The agro-industrial complex of Russia is becoming an active participant in the introduction of the latest information technologies, which allows it to reach a competitive world level.

The success of the implementation and development of crop production as an agricultural industry depends on many factors and their optimal organization, including

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climatic conditions, soil quality, water supply, technical support, production management, etc. There is an urgent issue for agricultural producers to preserve the health of the country's population, in addition to providing food. Therefore, the problem of organic crop production development is a key high-tech area of agriculture.

Modern information technologies perform the tasks of automating processes, increasing productivity and improving efficiency in the activities of economic entities [4, 5, 10, 16, 29, 33]. This indicates the need and importance of their implementation in the activities of agricultural enterprises.

The works of many researchers, both foreign and domestic, are devoted to the study of the introduction of information technologies in the processes of managing the manufacture of agricultural products. Thus, a group of scientists from the Aristotle University in Thessaloniki, Ioannis M. Ifadis, Avraham Mavridis, Paraskevas Savvaidis, pay great attention to the issues of precision organic farming within the framework of research based on the geoinformation system (GIS) [46]. The GIS system under consideration by scientists allows managers of agricultural production to make managerial decisions. The authors of the work consider such necessary factors for the successful production of organic products as soil and climatic conditions, proximity to other plant species, the availability of sources of organic fertilizers in the form of neighboring agricultural producers, the development of the road network.

A group of Chinese scientists Xi Wang, Chun Wang, Xinzhong Wang, Weidong Zhuang from Heilongjiang Agricultural University of Baiyi in the study [42] consider the implementation of tracking the supply chain of organic soybean production. The proposed supply chain includes the process of production, processing, organic packaging of organic soybeans, etc. Product tracking will allow to keep records of data about each participant in production, thus reducing the frequency of counterfeits and contributing to improving product quality.

In Germany, the digital platform Kuratorium für Technik und Bauwesen in der Landwirtschaft (KTBL) has been developed, which constantly updates data on agricultural products markets, field experiments and research projects, as well as expert assessments and surveys of manufacturers on emerging production problems [36]. There is also the possibility of using free web services on this platform. One example of helping organic producers is an eco-conversion planner to assess the possibility of converting a farm into organic farming.

Climate FieldView can serve as an example of successful implementation of a digital platform for agricultural producers [47]. This is a unique American platform that gives you the opportunity to offer your solutions to farmers across the country and around the world. The platform provides farmers with the ability to collect, store, and view their field data on one easy-to-use digital platform that they can access from their site, office, or home, visualize and analyze yields using images and field data maps so that they can make the best initial decisions for their fields and optimize field involvement into circulation. In general, the platform can also be used by organic producers, but there are currently no separate services for them.

An example of successful implementation of interactive maps for assessing the quality of agricultural land is an interactive map developed by the US Department of Agriculture [45]. On the map, it is possible to estimate soil moisture, soil cover and other conditions for the manufacture of crop products. Nevertheless, there is no assessment of the possibility of manufacturing organic products.

In general, the presented research and development of foreign studies are aimed at creating a sustainable and efficient production of organic products that can meet consumer demand and at the same time minimize the negative impact on nature.

It is necessary to highlight the works of domestic scientists dealing with the issues of improving the process of agricultural production management using information technologies, among which the works of A.I. Zavrazhnov, A.A. Zemlyansky, V.F. Fedorenko, et al. [11, 12, 31, 44]. Thus A.A. Zemlyansky proposes the introduction of space sensing for the study of the Earth's surface, aimed at the development of agriculture, the preservation of the environment, contributing to the reduction of anthropogenic impact on the environment by agricultural producers [11, 12]. V.F. Fedorenko, to manage agricultural machinery, greenhouses, livestock farms, etc., proposes the introduction of an Internet of Things platform [31].

The authors of this study propose to improve the process of managing the production of organic products by means of automated systems to effectively develop organic crop production [8, 30, 37]. Within the framework of this article, some models of the proposed hybrid automated system are considered, which, based on data on regions, municipal districts, and individual land plots, will allow receiving recommendations on possible cultivation crops, as well as improving production conditions.

The purpose of this work is to develop a hybrid intelligent decision support system for assessing the effective production of organic crop production in regions, municipal districts, as well as on individual land plots, where data on natural and climatic characteristics, agrochemical soil analysis, monitoring of air parameters, etc. act as input parameters. This system is endowed with the functions of an expert system and is based on the analysis of existing architectures and principles of organization of agricultural systems.

The relevance of this development is due to the fact that intelligent systems available on the Russian market (Agrointelligence, SmartFarm, EkoFarm, SAP S/4HANA, Oracle ERP Cloud, Trace Register, etc.) solve issues of enterprise management, production, digitalization of processes, automation of document flow and data analysis [1]. There is a contradiction between the need to introduce an information system for managing the manufacture of organic products, considering the features of rational placement and effective financial and credit mechanism for the production of organic crop production in the Russian Federation using digital systems, and the lack of available tools for processing and analyzing information in the subject area under consideration. The revealed contradiction caused the need to develop a hybrid intelligent system for improving the process of managing the manufacture of organic products. The implementation of the system models proposed by the authors of the article allows users to obtain the most optimal solutions for the manufacture of organic products, adjusting the parameters according to the socio-economic situation, climatic conditions, and the development level of the region.

2 Materials and Methods

The developed hybrid intelligent decision support system with the functions of an expert system will allow solving the tasks of the heads of the economic entities of the agro-industrial complex to assess the effective production of organic products from the point of view of the region, the municipal district, as well as the land plot.

The input parameters are the development level of the region, climatic and environmental conditions, agrochemical soil analysis, etc. Such a possibility of the system will make it possible to reasonably make managerial decisions by the heads of the economic entities of the agro-industrial complex. The key points of this article are information, behavioral models and models of system components.

The authors analyzed scientific and technical literature, conference materials on the use of information systems in obtaining and processing production data. A critical analysis of foreign literature on the rational placement of organic products based on territorial

characteristics and characteristics of farms was also carried out. The authors of the study presented information, behavioral models, and models of intelligent system components using UML, IDEF1X modeling notations and flowcharts. This system will allow to evaluate the possibilities of organic production from the point of view of regional placement, as well as to evaluate the possibilities of agricultural producers to place organic production, to receive recommendations on possible cultivation crops, to improve production conditions.

3 Discussion of the results

Intelligent information systems can be effectively used in a variety of different tasks. Nevertheless, their use in the framework of professional tasks implies in-depth knowledge and understanding of the processes of the subject area under consideration. When implementing the information system, we put forward the following business requirements, functional and user requirements. Thus, the business requirement for the development of a software product is aimed at improving the process of managing the production of organic products. Functional requirements for the system include the implementation of such features as multi-user operation, input and editing of data on existing indicators of the considered levels (regional, municipal, land), expert assessment of the efficiency of organic production within the considered level, the formation of accounting documents, information storage. Using the UML notation, the authors showed the user requirements for the system in the form of a diagram of use cases [2, 3]. So the user has the ability to work with data at all levels to analyze the possibility of manufacture of organic products (Fig. 1).

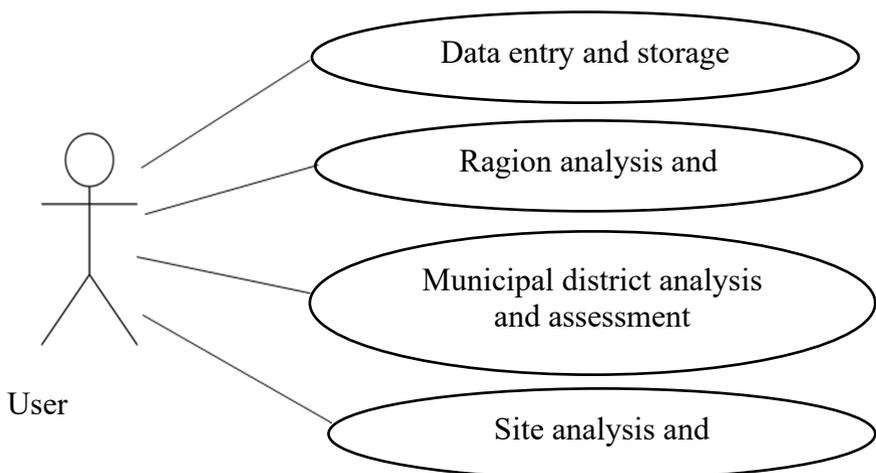


Fig. 1. Diagram of system use variants by user.

When creating an intelligent system, the authors pursue two main stages: firstly, to identify the basic principles of extracting knowledge from data that play an essential role in creating natural intelligence; secondly, to try to implement these principles on the basis of modern computer technologies.

Currently, a large number of approaches are used to build intelligent systems: production rules, neural networks, fuzzy logic, evolutionary methods, etc. [1, 9, 14, 15, 19, et al.]. The rapid development of this area has led to the emergence of "hybrid intelligent

systems" (HIS) [6, 7, 13, 17, 18, 35 et al.]. The HIS implementation is based on the principle of combining various methods of building systems.

The implementation of the developed system is based on the architecture of a hybrid intelligent system as one of the types of multicomponent intelligent systems [20-23]. It consists of a number of components aimed at storing knowledge about the state of land plots and related infrastructure at various levels, forming concepts and making decisions about the possibility of producing organic products within the considered production level.

It should be noted that the popularity of hybrid intelligent systems is constantly growing. This is due to a number of reasons. Among them, the ability of these systems to solve more complex tasks based on machine learning and deep learning, the widespread increase in the volume and availability of data, implemented intelligent solutions for automation and optimization of business processes of economic entities based on HIS, etc.

It should be noted that in the literature on the architecture of hybrid intelligent systems, the latter can be classified into the following types: combined, integrated, combined, and associative hybrid intelligent systems [18, 38]. There is also another type of hybrid intelligent systems – distributed, the appearance of which is due to the rapid growth of knowledge and data stored in distributed knowledge bases via the Internet. These HIS architectures are shown in Fig. 2.

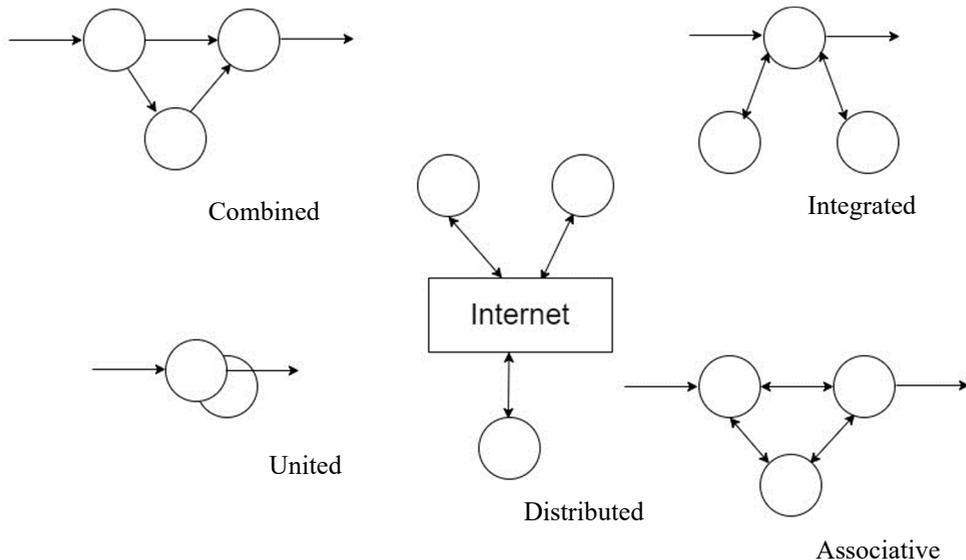


Fig. 2. HIS architectures.

The authors of the system implementation are based on the architecture of integrated intelligent systems. Within the framework of this architecture, the integrator module plays a key role, which, depending on the tasks set by the user, selects certain intelligent modules for functioning. The methodology of building an information system for improving the process of managing the production of organic products is described in the works of V.V. Ignatiev [13].

Let us consider the information model of the system, which is the most important aspect of knowledge-based systems [24, 32, 34]. Considering the fact that the knowledge base of the system should contain information about land plots, municipal districts and regions of the Russian Federation, the authors identified the following entities: region, municipal district, land plot, the level of development of agriculture in the region, the level of development of the region, cluster, climatic conditions of the region, environmental conditions of the region, the standard of living of the region population. As a tool for

building a conceptual, logical and physical model of the knowledge base, the tool `app.dbdesigner.net` was used.

In this way, the entity "municipal district" contains attributes such as "id_Municipal district", "Region", "Number of trading places in the markets", "Local budget revenues actually executed, thousand rubles.", "Surplus, budget deficit of the municipality (local budget), actually executed, thousand rubles", "Turnover of public catering (excluding small businesses), thousand rubles", "Number of retail and public catering facilities", "The entire population, people", "Rural population, people", "Number of trading places at fairs (code KSP – 1351000010190)", "Current (operational) security costs environmental protection, including payment for environmental protection services, thousand rubles", "Share of the population living in settlements that do not have regular bus and (or) railway communication with the administrative center", "Average monthly nominal accrued wages of employees of large, medium-sized enterprises and non-profit organizations of the city district", "Share of profitable agricultural organizations in their total number (Crop production)", "Share of the length of public roads of local significance that do not meet regulatory requirements in the total length of public roads of local significance", "Length of public roads of local significance (at the end of the year) km", "Agricultural products in all categories, thousand rubles", "Sown areas of agricultural crops", "Total land area of the municipality, ha". So the entity "Region" contains attributes such as "Id_Region", "ID_Cluster", "ID_Level of region development", "ID_Level of agriculture development", "id_Climatic conditions", "id_Ecological conditions", "ID Population life development level". The "Field" entity contains the attributes: "Id_Field", "id_Municipal district", "Agrochemical composition of soils", "Remoteness from polluting emission sites", "Physical properties of soils". The Cluster entity contains the following attributes: "id_Cluster", "Cluster name", "Range_Region development level", "Range_Agricultural development level", "Range_Climatic conditions", "Range_Environmental conditions", "Range Standard of living". The attributes "id_Climatic conditions", "Name", "Year", "January standard temperature", "July standard temperature", "January standard precipitation", "July standard precipitation" are contained in the "Climatic conditions" entity. The essence "Environmental conditions" contains "id_Ecological conditions", "Name", "Year", "Air emissions per area", "Share of captured and neutralized air pollutants", "Environmental protection costs per area of the region", "Discharge of contaminated wastewater into surface waters water bodies per area", "Proportion of neutralized waste", "Availability of waste at the end of the reporting year per area". The entity "Standard of living" contains the following entities: "id_Standard of living", "Name", "Year", "Rural population in general, %", "Consumer spending on average per capita", "Median per capita monetary income of the population", "Population with monetary income", "Average per capita monetary income of the population", "Consumption of vegetables and food melons per capita", "Turnover of public catering per capita". The entity "Region development level" contains the following entities: "id_Region development level", "Name", "Year", "GRP per capita", "Density of public roads with a hard surface", "Proportion of households with broadband Internet access", "Costs of implementation and use digital technologies", "Internal costs for research and development in the fields of science". Let's consider another essence of the developed knowledge base "Agriculture development level". This entity includes such attributes as "id_Agriculture development level", "Name", "Year", "GVA of agriculture", "Turnover of organizations by types of economic activity per 1 hectare of agricultural land", "Net financial result of organizations by certain types of economic activity", "Specific gravity unprofitable organizations by certain types of economic activity", "Profitability of goods sold", "Number of agricultural organizations per population", "Number of peasant (farmer) farms and individual

entrepreneurs", "Agricultural land in total area, %", "Grain yield (average for 5 years)", "Deposits", "Application of mineral fertilizers per 1 hectare of sowing".

The architecture of the proposed intelligent system includes three main blocks: an executive system, a set of intelligent interface tools, a knowledge base about the factors of organic production (Fig. 3). The principle of the system implementation used is reflected in the works of a number of researchers [25-28]. It is within the framework of the intelligent interface that concepts are formed that allow the user to make a decision about the possibility of producing organic products within the considered level of land plots. These concepts are placed in the concept storage. The latter interacts with the executive system and the intelligent interface. Python has become the main language for data processing within this module. The integration module is used to communicate with other systems, it is not a mandatory component of an intelligent system. The executive system also includes components of visualization, search for associative rules and statistics.

The concept extraction module extracts basic data, including the name of the region, cadastral numbers of individual land plots formed considering the data of natural and climatic characteristics, monitoring of various air parameters and agrochemical soil analysis, etc.

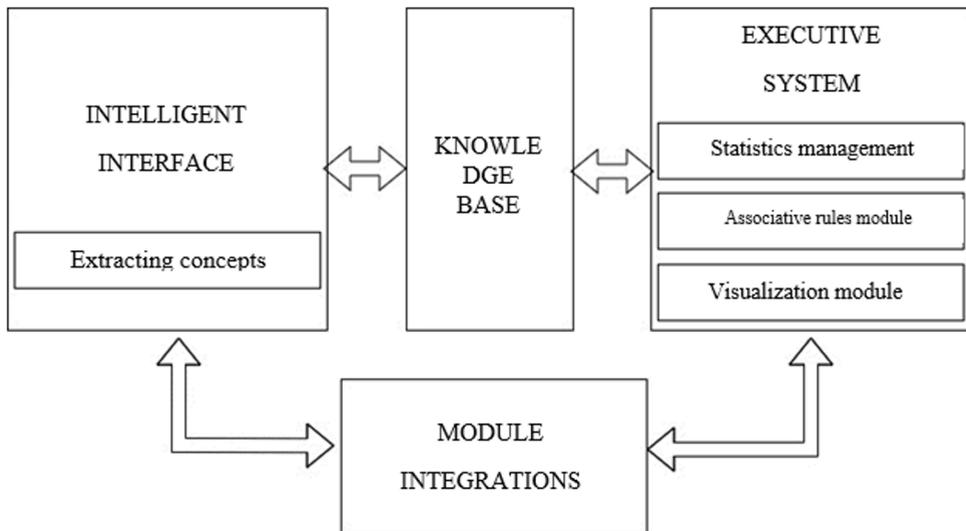


Fig. 3. Hybrid intelligent system architecture.

Within the framework of the executive system in the statistics module, it is possible for the considered levels of land plots to assess the possibilities of growing organic products according to various parameters. The parameters of each level are shown in Fig. 4.

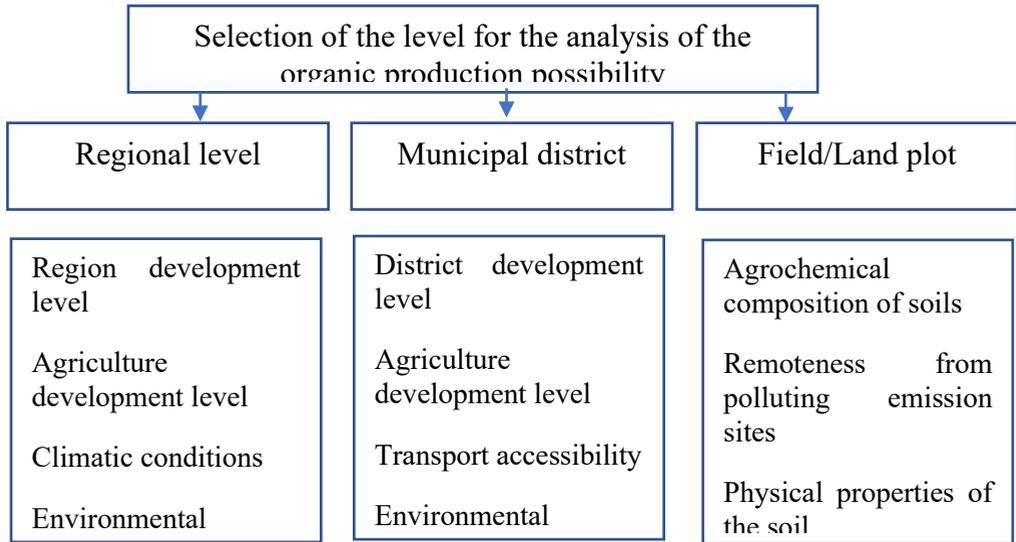


Fig. 4. Groups of indicators for each level under consideration.

The visualization module of the executive system allows to display statistical data in a graphical form.

In general, depending on the level under consideration, groups of indicators change. Indicators may also differ within each group.

To study the placement of organic production in the regions of Russia, the following groups of indicators were identified: the region development level, the agriculture development level, climatic conditions, environmental conditions, the standard of living.

To study the possibility of manufacture and sale of organic production by municipal districts, groups of indicators may also differ from the characteristics of the region. Thus, in regions where it is not recommended to grow organic products, the level of agricultural development and environmental conditions will not be considered. For them, the primary factors will be the ability to transport and sell products. In general, the following groups of indicators are identified: the level of municipal district development, the agriculture development level, transport accessibility, environmental conditions, the number of outlets for sale.

We also note the indicators for a specific land plot. Among them:

- agrochemical composition of soils – characterizes the possibilities of growing organic products, such as the content of organic matter, the presence of heavy metals, the content of trace elements, etc.
- remoteness from polluting emission sites – characterize the location of sites relative to stationary sources of polluting emissions;
- physical properties of the soil – such as structure, density, air permeability and moisture retention capacity. The optimal values of these parameters allow for the good development of the root system of plants and the preservation of moisture in the soil.

The sequence of user actions within the system when evaluating the efficiency of organic production is presented using a flowchart (Fig. 5).

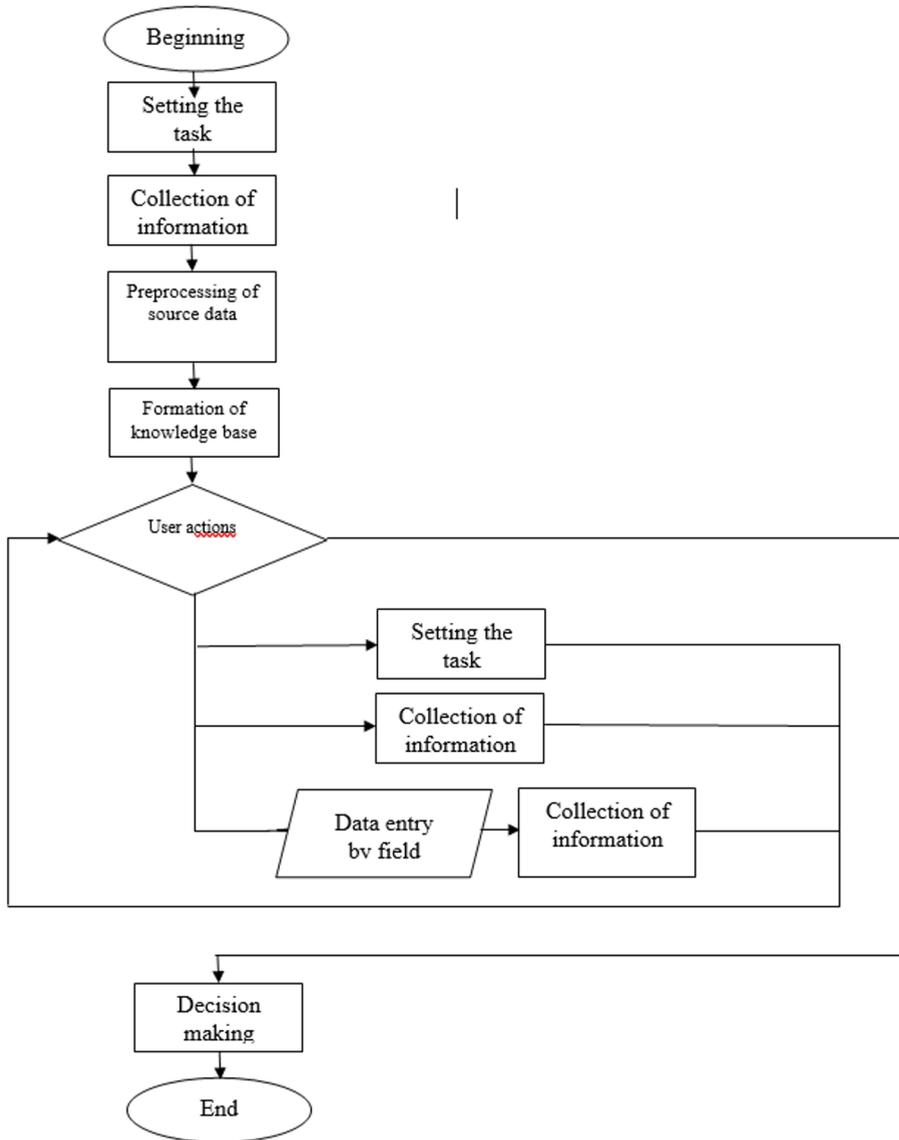


Fig. 5. Flowchart of solving the problem within the framework of an intelligent system.

It makes easy to understand the main steps and the relationships between them [39-41, 43].

Let's consider the main features of the user interface of the information system for improving the manufacture of organic products. When the system starts, the user switches to an interactive map of the regions of the Russian Federation, which allows switching to such forms as "Assessment of the region", "Assessment of the municipal district", "Assessment of the field" (Fig. 6).

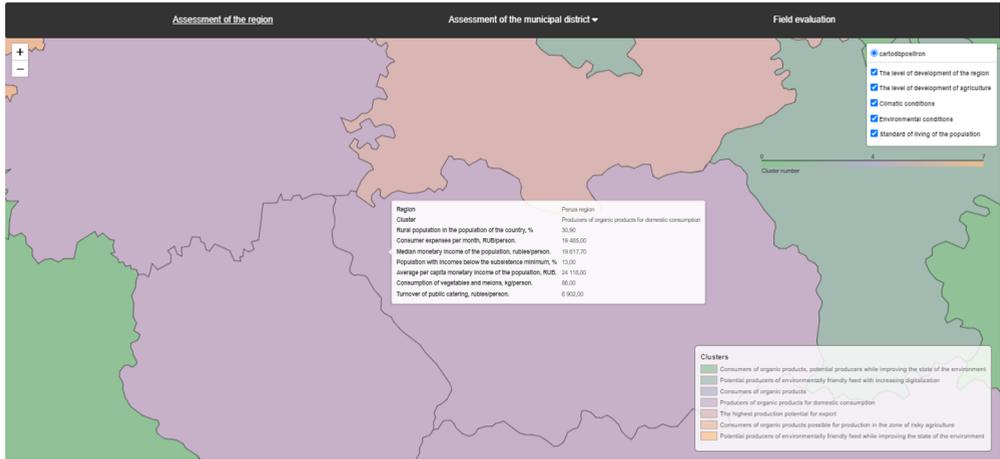


Fig. 6. The main window of the intelligent system.

When a user evaluates regions from the point of view of the efficiency of organic production, seven different clusters of regions can be seen in color: from consumers to manufacturers of products.

By hovering the mouse, the user can navigate to the required region to evaluate its municipal districts (Fig.7).

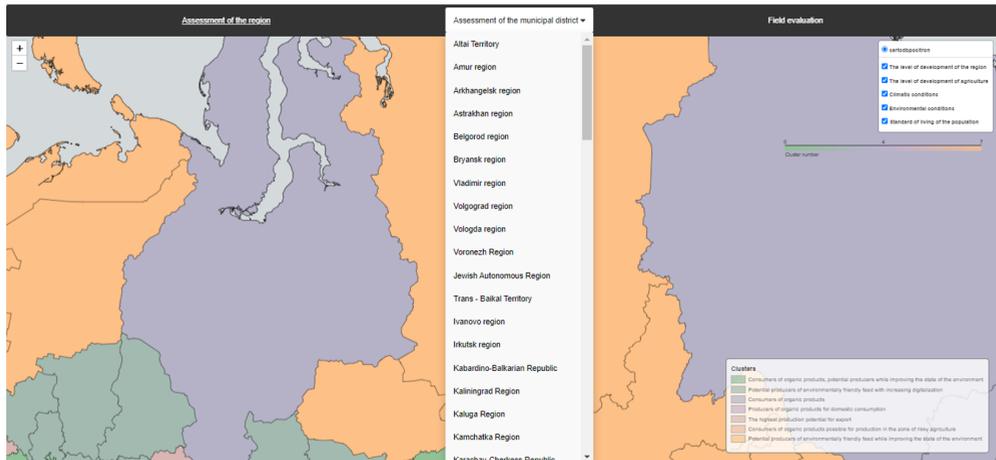


Fig. 7. List of regions for assessment of municipal districts.

An example of a user's transition to the required region for evaluating its municipal districts is shown in Figure 8. Thus, Figure 8 shows an assessment of the municipal districts of the Penza region, where, based on the available parameters of the region, clusters of municipal districts are determined by the degree of organic production efficiency.

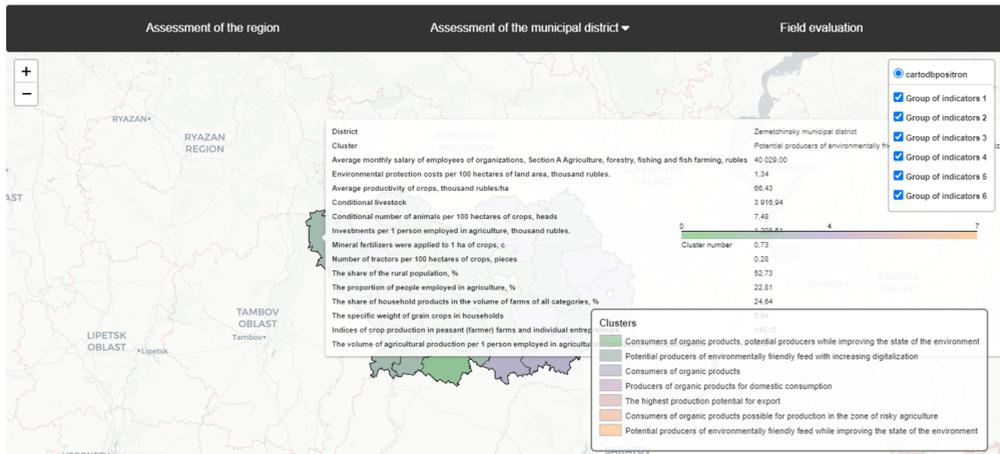


Fig. 8. Assessment of municipal districts of the Penza region.

The implementation of the described intelligent system models for improving the process of managing the manufacture of organic products makes it possible to determine the possibilities of manufacturing organic products considering regional location. The user also has the opportunity to receive recommendations on the cultivation of possible crops and improvement of production conditions on the necessary request. The described functionality of the system allows to assert that it has the functions of an expert system. Thus, by adjusting the input parameters according to climatic conditions, socio-economic situation, according to the conditions of the region, commodity producers receive the most optimal solutions for the manufacture of products.

4 Conclusion

The models of the information system described in the article by the authors, focused on improving the management process of agricultural production of organic products, are based on the principles of implementation of hybrid intelligent information systems.

It is reasonable to build a generalized system structure on the basis of executive system modules, knowledge base, intelligent interface, and module for integration with other systems. Data processing within the intelligent interface is based on high-level programming languages. The formation of concepts for effective decision-making and the possibility of producing the products in question is carried out within the framework of an intelligent interface. The concepts obtained are placed in the knowledge base. Statistics, their visualization, and search for associative rules of these factors of production are carried out within the framework of the executive system.

Thus, it can be noted that the intellectual system proposed by the authors to improve the process of managing the production of organic products will contribute to the development of the crop industry as a globally competitive direction of agriculture that meets the requirements of "green" production in Russia.

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