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CONCEPTUAL MODEL OF INFORMATION SYSTEM FOR SUPPORTING DECISION MAKING IN THE AGRARIAN SPHERE

Food production needs are constantly increasing. The use of extensive methods of increasing yields and meat production is unacceptable in developed countries. Therefore, there is a need to apply intensive methods, in particular to improve the efficiency of agricultural management. The rapid development of information technologies in agriculture is observed. There is a transition of technologies from the start-up stage of their implementation by creating information systems. A considerable amount of investment is directed towards informatization of agriculture.

The problem of decision making in the activity of agricultural enterprises in the conditions of ecological uncertainty is formulated as a multicriteria problem of conditional optimization. The peculiarity of this statement is that the factors are considered as dynamic and fuzzy quantities. The choice of the best alternative is made from a finite set of alternatives defined in advance. On the basis of this formulation of the problem, we formulate the requirements that the method of solving it must satisfy. The decision-making process is broken down into stages. A set of basic tasks is formulated, the solution of which is to provide the information system of decision support. The structure of the decision support system of four subsystems is proposed: user interaction, data storage, model management, operation and calculation. A conceptual model was developed, which defined the functions of each of the subsystems and the information interactions between them. In the implementation of the system involves the use of microservice approach. In this approach, it is possible to extend and modify each of the subsystems independently of the others. Also, the microservice structure enhances the stability and flexibility of the system.

Keywords: decision-making, agrarian industry, multicriteria problem, information system.

1. Introduction. Agrarian sphere is a strategically important sphere of functioning of any state. Food production needs are constantly increasing. Extensive methods of increasing harvesting and growing meat cause significant environmental damage. Therefore, their use is unacceptable in developed countries. As a result, there is a need for intensive methods of increasing harvesting and meat production. One way to achieve this is to improve the efficiency of agricultural management.

2. Review of sources. A great deal of research has been devoted to the problem of management effectiveness in the agricultural sector [1-3]. The authors note that the main ways to improve management effectiveness are to use monitoring information systems and to use new approaches to decision making. The last few years have seen the rapid development of IT in agriculture. Currently, a significant bank of innovative technologies in this field has been formed. Gradually,

agricultural production moves to their introduction. In other words, there is a transition of technologies from the stage of start-ups to the implementation of real information systems. According to BI Intelligence, by 2034, the proliferation of IT systems for the collection, storage, processing and delivery of information will increase tenfold and reach the level of use of 5 million Data Points [4]. This will create the basis for the widespread use of decision support systems (DSS) in the agricultural sector. It is also possible to note a considerable amount of investments aimed at informatization of agriculture by both state and private entities. This is confirmed by projects such as EU-PLF project, Anemon (Switzerland), eCow (UK), Connected Cow (Medria Technologies and Deutsche Telekom), Sensorfish (EU) and others [5]. The mutual influence of agriculture and environmental factors, which necessitates decision-making to improve the efficiency of use of natural resources and the application of new approaches to agriculture, is shown in [6, 7].

Therefore, the task of developing an information system to support decision-making in the agricultural sector, taking into account the uncertainty conditions that cause the mutual impact of agriculture and environmental factors is extremely important.

3. Statement of the decision making problem in the activity of agrarian enterprises in conditions of uncertainty. Consider the activities of a certain agrarian company. Let certain know about the history of the company, the state of the environment in the region and the economic market. This information may not be complete and inaccurate, so we will assume that the company's activities are carried out under conditions of uncertainty and risk.

Suppose that a certain number of alternatives are described that describe the further functioning of $s_1, s_2, \ldots, s_n$, where n is the number of alternatives. A set of criteria $c_1, c_2, \ldots, c_m$ has also been formed, on the basis of which alternatives can be evaluated, m is the number of criteria for evaluating alternatives.

The task of decision-making is to choose a certain alternative $s_j^* \in \{s_1, s_2, \ldots, s_n\}$ to the company's future operation, which is the best in a certain sense. It should take into account existing resource, financial and legislative restrictions. Let $x_1, x_2, \ldots, x_k$ are factors that affect the functioning of the agrarian company, k is the number of factors.

It should be noted that, first, the factors considered are dynamic quantities. That is, their value changes over time. Secondly, factors may contain uncertainty, so fuzzy values can be used to describe them. Thirdly, among the factors may be factors that depend on the alternatives to the operation of the enterprise in previous periods of time. So $x_i =< X(E, t, s_{j_1}^*, s_{j_2}^*, \ldots, s_{j_p}^*), \mu(X) >$ for $i = \overline{1,k}$, where E is a description of the state of the external environment of the agricultural firm, t is some point in time, $s_{j_q}^*$ for $q = \overline{1,p)}$ are alternatives for which the agrarian enterprise operated at previous times $t'_1 < t'_2 < \ldots < t'_p < t$, p is the number of moments in time, X is some really significant function, and μ is a membership function therefore $\mu(X) \in [0, 1]$. Given the significant dependence of the activities of agricultural enterprises on weather conditions, it is natural to use periods of time that correspond to seasonality. So $t'_q = t_0 + q * \Delta t$, where t_0 is the initial moment of time, Δt is the season of operation of the agricultural enterprise (usually is equal to 1 year, but may be equal to 6 or 3 months).

Then the problem of decision-making can be formally written as a multi-criteria

problem of conditional optimization.

$$c_1(s_1(x_1, x_2, \ldots, x_k), s_2(x_1, x_2, \ldots, x_k), \ldots, s_n(x_1, x_2, \ldots, x_k)) \underset{s}{\rightarrow} \max; \quad (1)$$

$$\ldots$$

$$c_1(s_1(x_1, x_2, \ldots, x_k), s_2(x_1, x_2, \ldots, x_k), \ldots, s_n(x_1, x_2, \ldots, x_k)) \underset{s}{\rightarrow} \max; \quad (2)$$

$$G_1(x_1, x_2, \ldots, x_k) = 0; \quad (3)$$

$$\ldots$$

$$G_r(x_1, x_2, \ldots, x_k) = 0, \quad (4)$$

where r is a number of restrictions and G is a set of functional restrictions that determine the feasibility of implementing a suitable alternative to the functioning of an agricultural company in terms of available resources, legal and cultural constraints, etc. In order to accomplish this task, given the multi-criteria decision making methods [8], it is necessary to develop such a method or methods that would satisfy the conditions:

1) To operate in conditions of uncertainty, that is, methods should work with fuzzy values.
2) Evaluation criteria and alternatives should adequately reflect the activities of the agrarian enterprise and its interaction with the environment.
3) Functional constraints should take into account all available constraints on resources, resources and natural opportunities.
4) Decomposition of the method in stages, with the possibility of combining and modifying the methods that implement each stage.
5) Simplicity and clarity in the interpretation of the results of the evaluation of alternatives, that is, the creation of appropriate scales and descriptions of the results of evaluation, which would facilitate the work of the decision maker.
6) Opportunity of the person who decides to choose other alternatives, if the proposed ones do not suit him. The fulfillment of the requirement can be ensured by guiding the solution of the problem not as one optimal alternative, but a ranged set of feasible alternatives.

In [9, 10], it is proposed to evaluate alternatives in terms of risk minimization. In general, the decision-making process can be divided into 5 stages:

1) Formation of the set of alternatives and criteria for their evaluation.
2) Determination or evaluation of the factors for the appropriate period of time for which it is necessary to make a choice of alternatives.
3) Screening of inadmissible alternatives.
4) Evaluation of alternatives. Numerical calculation of criteria for each of the alternatives for the fixed value of the factors (found in step 2).
5) Construction of a certain convolution of the criteria for determining the optimal solution.

4. Construction of a conceptual model of the information system of decision-making support in the agricultural sphere. In accordance with the task of organizing the effective activity of agrarian enterprise on the basis of multi-criteria methods of analysis of decisions under uncertainty, it is necessary to develop an information system for supporting decision making. The article [11] proposes a DSS structure consisting of four subsystems: user interaction subsystem, data management subsystem, system management subsystem and model managment subsystem.

In accordance with this structure, we will develop a conceptual model of a system consisting of 4 subsystems (Fig. 1).

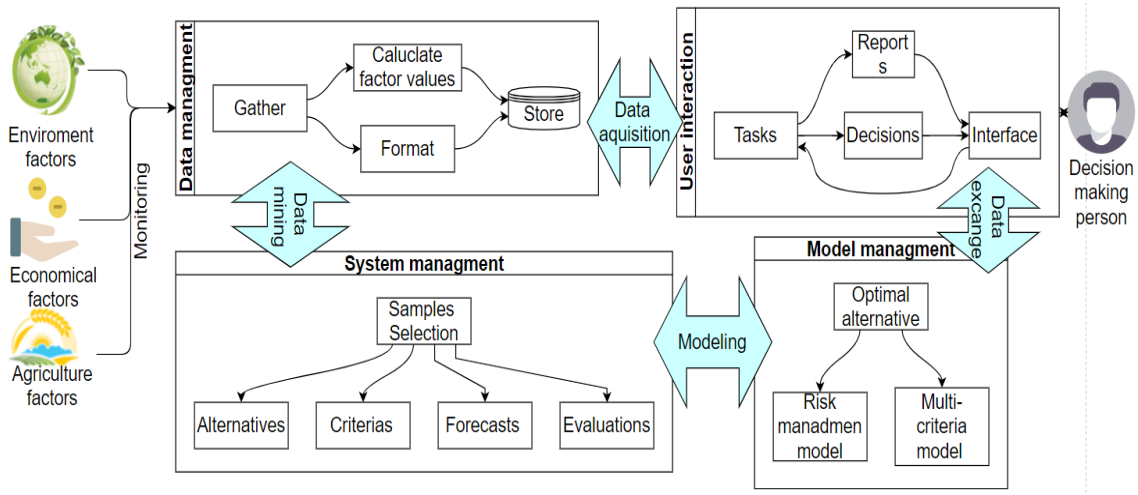

Fig. 1. Conceptual model of information system for supporting decision making in the agrarian sphere

1) Data management subsystem provides collection, including data on soil in the region, weather forecast, information on sowing material, price situation and demand for products, etc. Data obtained from sensors, information systems, analysis of aerospace images [12] and other open sources in different formats should be brought to a single format. Their values should be calculated in a fuzzy format. The subsystem also stores the factors in the database.
2) System management subsystem provides the formation of many alternatives and multiple criteria. The subsystem also collects data for the required period, on the basis of which it occurs, forecasting the values of factors for the desired period, evaluating alternatives by criteria, etc.
3) Model management subsystem provides functioning models for choosing the optimal alternative, taking into account relevant models (multicriteria model, risk management model, etc.) and appropriate decision-making methods.
4) The user interaction subsystem must present the information in a convenient form. In particular, to show the value of the criteria for the optimal alternative to the functioning of the enterprise, and to justify its selection by a report on the expected results of the functioning of the agricultural enterprise. The user should request data from the dialog.

The statement of multicriteria optimization problem (1)-(4) determines the structure of System management subsystem. Also, the model that fits it is one of the many models that are implemented in the Model management subsystem.

5. Conclusions and prospects for further research. The article deals with the development of a conceptual model of the decision support system in the agricultural sector. To this end, the decision-making problem is formalized as a multicriteria optimization problem. Consideration of the problem in this formulation makes it possible to apply multicriteria optimization methods to select the best alternative. A conceptual model consisting of 4 subsystems is proposed. The functions of each subsystem and the information interactions between the subsystems are defined. Each subsystem can be considered as a separate module. The modular structure of the system will allow to expand and modify the capabilities of each of the modules independently of others. Also, the modular structure increases the stability and flexibility of the system. And given the modern approach to software development, the modular approach allows us to implement a micro-service approach when a system consists of a set of independent microservices.

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Цзі Ч., Андрашко Ю. В. Концептуальна модель інформаційної системи підтримки прийняття рішень в аграрній сфері.

Потреби у виробництві продуктів харчування зростають постійно. Використання екстенсивних методів збільшення урожайності та вирощування м'яса є неприпустимим в розвинених країнах. Тому виникає потреба в застосуванні інтенсивних методів,

зокрема підвищення ефективності управління сільським господарством. Спостерігається бурхливий розвиток інформаційних технологій в сільському господарстві. Відбувається перехід технологій від стадії старт-апів їх впровадження шляхом створення інформаційних систем. Значний обсяг інвестицій спрямовується на інформатизацію сільського господарства.

В роботі сформульовано задачу прийняття рішень в діяльності аграрних підприємств в умовах екологічної невизначеності як багатокритеріальну задачу умовної оптимізації. Особливістю даної постановки є те, що фактори розглядаються як динамічні і нечіткі величини. Вибір найкращої альтернативи здійснюється серед визначеної наперед скінченної множини альтернатив. На основі цієї постановки задачі сформульовано вимоги, яким повинен задовольняти метод її розв'язування. Процес прийняття рішень розбитий на етапи. Сформульовано набір основних завдань, вирішення яких повинна забезпечити інформаційна система підтримки прийняття рішень. Запропонована структура системи підтримки прийняття рішень із чотирьох підсистем: взаємодії з користувачем, зберігання даних, керування моделями, забезпечення функціонування та обчислення. Побудовано концептуальну модель, в якій визначено функції кожної із підсистем та інформаційні взаємодії між ними. В реалізації системи передбачається застосування мікросервісного підходу. При такому підході можливе розширення та модифікація кожної з підсистем незалежно від інших. Також мікросервісна структура підвищує стійкість та гнучкість системи.

Ключові слова: прийняття рішень, аграрна галузь, багатокритеріальна задача, інформаційна система.

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