

Systematic approach to providing intelligent decision support whilst digital transformation of management processes in agro-industrial complex

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Abstract. Modern economic conditions, characterized by digitalization processes and the influence of geopolitical factors contributing to the development of domestic information technologies have made the issue of providing support for management decision-making by specialized systems important. In this regard, the purpose of the study is to analyze the logistics of information flows and identify problems associated with the digital transformation of management processes in the agro-industrial complex (AIC). A systematic approach was chosen as the main method. The logical analysis and synthesis were used as well. Based on the identified movements and interrelations of information flows, and limiting factors for its effective use, an automated information and analytical decision support system (AIASDSS) is proposed in the context of a unified digital platform. Its components are described and principles of operation are formulated. In the focus is the creation of an information platform module oriented mainly on agricultural producers who occupy a central place in the agro-industrial complex. It is noted that work is underway to ensure the intellectualization of decision-making processes in agricultural organizations through the use of mathematical, statistical and information tools. Particular solutions are given. The research materials are addressed to authorities and can be used in managing agricultural production.

1 Introduction

The agro-industrial complex (AIC) is considered as an inter-industry complex, which includes a set of industries. In modern economic conditions, determined by sanctions policy, rapidly changing requirements for the innovative component of a technological nature associated with the introduction of new equipment and technologies, including the digitalization of various processes, the requirements for the organization and implementation

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of management decision-making procedures change as well. This is reflected in the structuring of the flows of processed information, methods of its storage, retrieval, etc.

Besides, the effectiveness of managing the agro-industrial complex development depends on a wide range of factors. Let us note that the functioning of agricultural production, which occupies a leading role in the structure of the complex, is ensured by work with biological organisms (earth, animals) and is associated with random events (diseases, locust attacks, etc.); it is accompanied by low-predicted (especially in the long term) weather conditions (precipitation, temperature, etc.) and the presence of natural climatic factors, depending on the territorial location of a particular region (risky farming zone, intensive farming zone, etc.). Taking into consideration the complex geopolitical conditions (sanctions, rising prices, changing policies and market conditions, etc.), we presume that the decision-making in agriculture is clearly associated with their development in elevated uncertainty and risks.

In this regard, the use of decision support systems (DSS) is of particular relevance, their effectiveness depends on high-quality information, often obtained from various sources, that's why the decision maker (DM) must know a wide range of information technologies and technical and technological aspects of specific production systems. Therefore, the development of specialized domestic tools for the intellectualization of decision support in the context of management processes digitalization in the agro-industrial complex should be given serious attention.

2 Materials and Methods

Methods of a systems approach, logical analysis and synthesis were used to analyze data in the article.

The agro-industrial complex is considered as an intersectoral one, including a set of industries, which, according to classification characteristics, can be ordered and structured in different ways, depending on the conceptual approaches in the study of a particular author [1-4], with the central place given to agriculture, forestry and fisheries.

The main mission for the production of agricultural products is assigned to agriculture: crop production, livestock farming and their sub-sectors. The agro-industrial complex also includes processing (food, light, etc.) and supporting production industries (mechanical engineering, feed mills, etc.).

The third group consists of service industries, which represent in: production infrastructure (procurement and storage of agricultural products, agricultural technical maintenance, repair of equipment and machinery (combine harvesters, grain harvesters and transportation machines also owned by agricultural producers), etc.) and supporting infrastructure (transport, communications and etc., including delivery of the products to a consumer; the research institutes and educational organizations for personnel training are also included into the infrastructure). All identified groups are closely interconnected and are responsible for food security in regions and in the whole country. In turn, industries are divided into sub-sectors, thereby forming a complex structure of the agro-industrial complex with subordinate connections that influence management processes.

Today, in the context of the digital society [5], the development of software and information support to carry out a number of management [6, 7] and production processes [8, 9] is rapidly developing. Automated technologies, designed to provide decision-makers with the necessary tools for managing the processes of information collection, analysis, selection, planning, etc. in order to achieve the most profitable result of the agricultural enterprises' economic activity are in demand [10]. At the same time, the profitability of agricultural organizations depends on the provision of management processes with appropriate mathematical and instrumental tools [11, 12].

3 Results and Discussion

There are a lot of features inherent to the management of the agro-industrial complex, in particular, state regulation, which provides the interaction between government bodies (regional ministries of agriculture) and enterprises within the framework of multi-level development programs containing a wide range of incentive, investment and subsidy measures. The banking sector, leasing companies, insurance organizations, etc. are also involved in this process. To make effective decisions aimed at developing and increasing the efficiency of the agro-industrial complex in the regions and nationwide, it is necessary to have up-to-date, consistent, reliable information (coming from official sources), which is ensured through regular monitoring of territories' development (collection, accumulation, storage, statistical processing of data). However, in rapidly changing requirements for the innovative component of a technological nature connected with the introduction of new equipment and technologies, and digitalization of processes, the requirements for the organization and implementation of management decision-making procedures, which inevitably undergo digital transformation, also change. This is reflected in the structuring of processed information flows, methods of its storage, retrieval, etc. Ultimately, the decision maker should rely on a visually presented one (through tables, diagrams, models, dashboards, etc.), adapted both to the subject area and to the qualification characteristics. A decision maker is a set of data and established relationships, the use of which allows the intellectualization of the decision-making procedure.

In this regard, the issue of organizing the movement and processing information flows between all the «players» of the agro-industrial complex, government bodies, statistical organizations, etc. is of interest. This kind of process has a complex multi-level hierarchical nature. Thus, a generalized diagram of information flows movement when managing the agro-industrial complex at the top level is presented in Figure 1 (the diagrams at the levels of federal districts and regions are similar). Let us give a brief description of information flows content between the selected blocks.

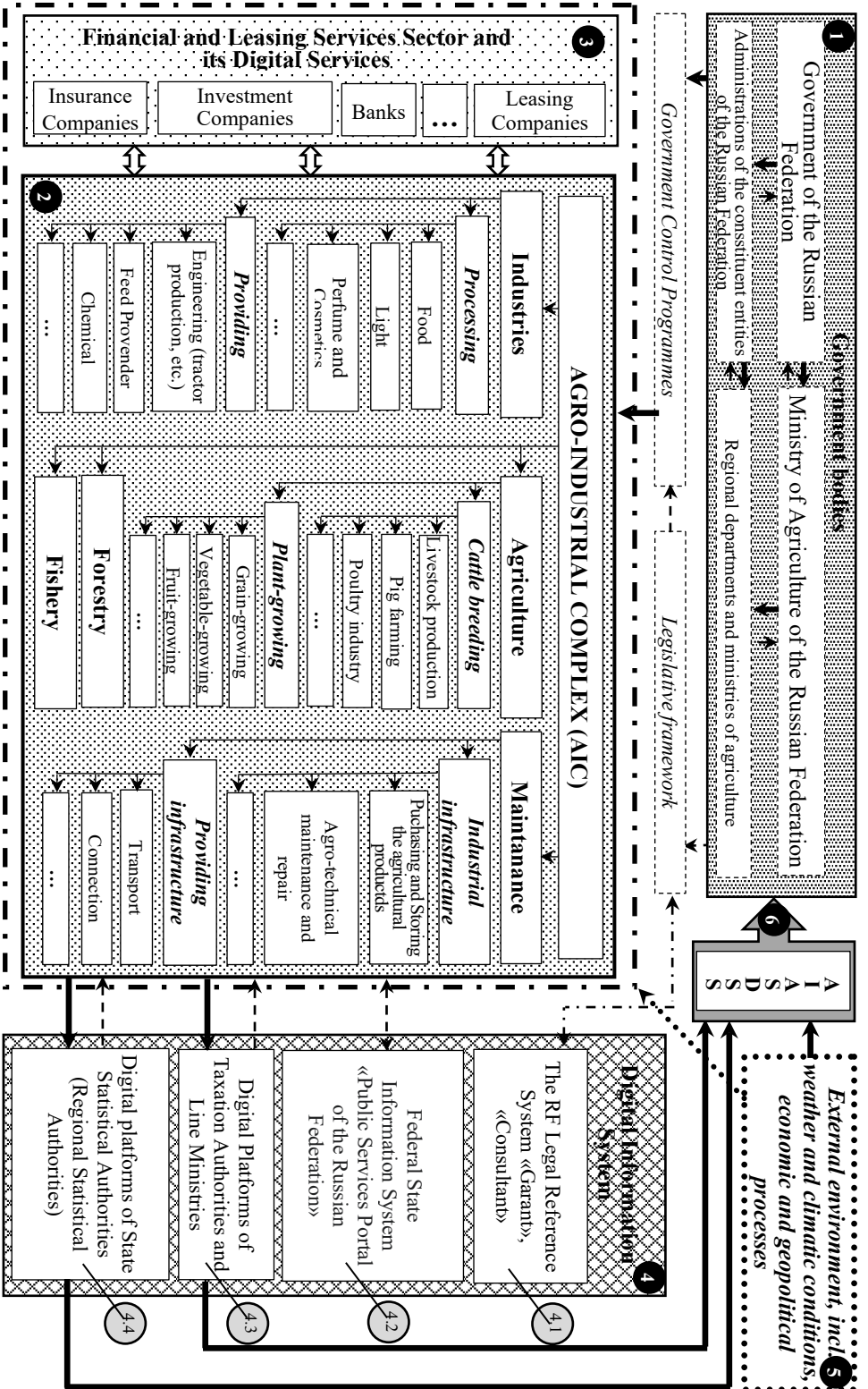


Fig. 1. The outer contour of the information flows logistics when controlling AIC (compiled by the authors).

As noted above, government bodies (block 1), through the development of various sets of government regulation programs (based on the legislative framework (block 4.1)), influence the development of the agro-industrial complex (block 2), which is closely related to the financial and leasing services sector functioning (block 3). Thus, documents focused on agriculture contain information on target indicators, the achievement of which is expected by increasing the agricultural producers' efficiency with the help of prescribed guaranteed measures such as a subsidiary, incentive, price, etc. Currently in effect: the state program of the Russian Federation «Development of agriculture and regulation of markets for agricultural products, raw materials and food», approved by the decision of the Government of the Russian Federation of December 23, 2021, No. MM-P11-19122; state program for the effective involvement of agricultural land in circulation and the development of the reclamation complex for the period from 2022 to 2031, approved by the Decree of the Government of the Russian Federation of May 14, 2021, No. 731; state program of the Russian Federation «Integrated development of rural areas», approved by the Decree of the Government of the Russian Federation of May 31, 2019, No. 696; Federal scientific and technical program for the development of agriculture for 2017-2025, approved by the Decree of the Government of the Russian Federation of August 25, 2017, No. 996, etc. [13].

State Programs contain subprograms (including those taking into account the specific features of the regions) and also provide for measures within which the regulation of interaction is prescribed both between industry enterprises within the agro-industrial complex (block 2), and between them and financial sector organizations and leasing companies (block 3), most of them have their own independent digital services in the form of websites or electronic platforms, thanks to them the information can be obtained and a number of processes can be automated. Thus, the website of Rosselkhozbank [14] presents material on raising loans for purchasing of machinery, equipment, farm animals, for constructing milk and meat production complexes, as well as for remodeling facilities for production, storage, processing of agricultural products with grant support. Special lending programs with state support and preferential rates are aimed at developing small businesses in agriculture. That is, the state acts as a guarantor of program activities, thereby stimulating and regulating the development of the agro-industrial complex in conjunction with the financial sector.

As for block 4.2, it is used to automate the submission of various types of applications, payment for services (a separate section for utility bills) and taxes (interaction with the portal of the Federal Tax Service of Russia is ensured) by the subjects of block 2, as well as for obtaining various types of up-to-date reference information and providing internal and external electronic document management through the use of an electronic signature [15].

Thanks to monitoring indicators received in blocks 4.3 (reports on the activities of organizations, including various forms of support in interaction with organizations of block 3) and 4.4 (statistical data according to established forms) about territories and aggregation of the information received, decisions are made on adjustments current programs, the amount of funding for specific areas, prolongation of documents with respect to the current situation and projected parameters.

However, the information currently circulating in the management circuit of the agro-industrial complex (both global and local levels) is mainly of a reference and analytical nature, requiring additional processing, the use of mathematical and econometric tools to justify the applied management decisions.

Besides, the effectiveness of managing the agro-industrial complex development depends on a wide range of factors (Figure 1, block 5). It should be noted that the functioning of agricultural production, which occupies a leading role in the structure of the complex, is accompanied by unpredictable (especially in the long term) weather and climatic conditions (precipitation, temperature, etc.); the presence of natural and climatic factors depending on the territorial location of the region (zone of risky farming, zone of intensive farming, etc.).

Moreover, work with living organisms is always associated with random events (diseases, locust attacks, etc.); and if we consider complex geopolitical conditions (sanctions, rising prices, changing policies and market conditions, etc.), then decision-making in agriculture is clearly related to their development under conditions of uncertainty and risks. In turn, this clearly affects other components of the agro-industrial complex, connected, among other things, by logistics supply chains.

Therefore, we consider it necessary to develop and implement an automated information and analytical decision support system (AIASDSS) (block 6 in Figure 1), which has a hierarchical structure for storing and processing information, including the formation of a knowledge base focused on the choice of methods for ensuring the quality and reliability of the results obtained. The system contains the solutions for problems of a predictive type (analysis of the interdependencies of factors and processes formalized through the use of statistical, econometric methods and models; production problems, including those of an optimization nature, for example, determining optimal solutions that allow to achieve criterion parameters while minimizing costs, etc.) for the efficiency of ensuring digital transformation of management processes in the agro-industrial complex. This development fits into the general concept of the informatization development in the agro-industrial complex and at the same time it is a DPS (decision support) module at the external level.

The organization of the data warehouse should be based on the following principles:

- 1) unification of basing information into various structures (or using tools to standardize its presentation in the extraction process) for subsequent analysis and use in making management decisions at various hierarchical levels;

- 2) block-by-block placement according to the source and further processing, including grouping of detailed and aggregated data, as well as metadata and analytical materials;

- 3) ensuring the protection of information by access levels for information security and confidentiality;

- 4) the structure of the advisory decisions obtained as a result of data analytics for target queries.

As for the components of the AIASDSS, attention should be paid to the creation of a module of a single information platform, which also contains a block-by-block hierarchical structure, which reflects: 1) state regulation and development programs; 2) existing proposals and requests for interaction between structures and enterprises; 3) created and tested digital solutions for the agricultural organizations' management, including developments in software for management and technological processes, mathematical and information optimization tools for planning and organizing agricultural production, etc. The resource can be implemented through the use of cloud technologies and must be available (with appropriate and specially organized registration) at the request of agricultural producers and other participants of the agro-industrial complex.

Thus, to fill the third group of the information platform, we can offer the currently growing range of available domestic developments for digital support of agricultural production. The accumulation of information of this type significantly reduces the search, and its inclusion in a special register ensures quality and reliability for agricultural producers.

Currently, we are solving a set of problems to ensure the intellectualization of decision-making processes in agricultural organizations through the use of mathematical, statistical and information tools.

In particular, developments on application of mathematical and statistical methods to solve the task of resource management in agricultural production with reference to uncertainty and risk [16] and the regression models for assessing and predicting the qualitative composition of the crop are underway [17]. Creation of a digital model for assessing the influence of agro-ecological factors on wheat grain yield [18] and algorithms for solving production optimization problems for decision support system software in

agriculture [19], etc. are also being developed. All these solutions are offered to fill AIASDSS modules and information platform, and can be used by regional agricultural producers.

4 Conclusion

The effective functioning of the agro-industrial complex in general and agricultural production in particular is not possible in modern conditions without the use of digital technologies for management decision-making. At the same time, there are problems in the area of quality and comparability of the information to be processed, methods of its extraction and storage.

The development of the automated information and analytical decision support system (AIASDSS) is considered as the opportunity to ensure intellectualization of the management decision-making support. The system is to be installed into the logistics of information flows at different hierarchical levels of agro-industrial complex management. Thus it provides for managing the complex with modern digital tools through a specially organized repository of generated databases and specifically selected and accumulated knowledge bases.

Currently, intense work is underway on mathematical and instrumental support for the blocks that are part of the subsystems responsible for increasing the efficiency of agricultural production management within the framework of a prototype information and analytical system in the region with all its specifics.

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