Providing Information Support for Decision-making in Agricultural Production through Implementation of Cross-platform Technologies

Irina Bolodurina
Federal State Budgetary Educational Institution of Higher Education «Orenburg State University», Orenburg, Russia

Rustam Rakhmatullin
Federal State Budgetary Educational Institution of Higher Education «Orenburg State University», Orenburg, Russia

Eugenij Speshilov
Federal State Budgetary Educational Institution of Higher Education «Orenburg State University», Orenburg, Russia

Petr Boldyrev
Federal State Budgetary Educational Institution of Higher Education «Orenburg State University», Orenburg, Russia

ABSTRACT
The development and implementation of platform service to provide the information support, that helps the agricultural producers to make decisions, are very important issues when forming the digital space in the Russian Federation within the framework of two projects «Digital Economy» (federal) and «Digital Agriculture» (ministerial). However, the development is fragmented and it requires much time to find them, and the commercial issue and high level of uncertainty regarding their quality increase the material risks for consumers. The research methods are system analysis, logical approach and synthesis, algorithmization, etc. The study under discussion proposes agricultural producers the development of a digital service «Agro-Exchange» to search software and innovative solutions (including digital technologies, services, raw materials, fertilizers, nanomaterials, etc.) in the information environment. The service offers the programme that is able to filter the information relying on requests (by specially organized search data structuring on agricultural production subsystems, which supports the implementation of step-by-step clarification of information). The composition of architectural components and the structure of the demo version of the digital service «Agro-Exchange» are presented together with the resource structuring on sub-platforms. An economic assessment of the project was carried out.

General Terms
Algorithms, Cross-platform Technologies, Information Support.

Keywords
Systems Approach, Analysis, Digital Transformation, Support For Management Decision-making, Cross-platform, Agricultural Production, Resources, Nanomaterials, Information, Data, Technology, Tools, Digital Service.

1. INTRODUCTION
Agriculture – a key link in the AIC – is entrusted with the mission of ensuring food security of the country and the production of essential consumer goods. Thus, within the framework of the program «Digital Economy of the Russian Federation», the Ministry of Agriculture of the Russian Federation has developed the project «Digital Agriculture». It is the basis for the digital transformation of the industry and is organized by regulatory documents. So far, the percentage of agricultural enterprises covered by the introduction of info-communication innovations is not very large, but their number is steadily increasing.

In accordance with the decree adopted by the Government of the Russian Federation on November 23, 2023, № 3309-r, a strategic direction for digital transformation in the agro industrial and fisheries complexes of the country until 2030 was determined. The main objective of this initiative is to ensure sustainable and accelerated growth in the field of digitalization of these industries. In modern geopolitical and economic conditions the implemented sanction policy forces countries to solve issues related to import substitution, promoting the active creation of various domestic software products and innovative technologies aimed at a wide range of tasks in agricultural production.

Currently the digital market offers products, including private Rospatent-registered goods, which in some cases don`t offer guaranteed results during implementation, the possibility of adaptation and support. Not all interesting and effective developments get to the advertising platforms are available to the user. One of the main problems that suppliers face is the search of the consumer, who can appear to be a fraudster offering an unreliable product.

The goal of this study is to develop methodological and software approaches to the implementation of the proposed digital service (organized as a marketplace based on the use of cross-platform solutions), which enables to search for specially structured information and present it to agricultural producers taking into consideration counter-partners` physical and digital resources aimed at increasing the efficiency of agricultural production.

To achieve the goal, it is necessary to analyze the advantages and disadvantages of the most popular digital products presented in the information environment; propose a scientifically based approach to structuring information for its placement in the service database in order to organize a targeted search; determine the composition of the digital service architectural components, conduct an expert assessment and determine the implementation and operation costs.

2. MATERIAL
The research works studying issues of digital transformation of management processes, software development,

informatization, etc., as well as the use of digital solutions in agricultural production form the methodological basis for the article. When writing the work, methods of a systemic approach, logical analysis and synthesis, and graphical presentation of the material were used.

The analysis shows that there is a wide range of scientific works by various authors [1]-[3] discussing the digitalization in the agro industrial complex and stating its necessity. Intellectualization of the decision-making process in agricultural production is presented in the article [4]. The introduction of artificial intelligence, digital environments and technologies into management and production processes in agriculture is described in [5]-[7].

Studies show that at present digitalization is limited to the automation of accounting, support of the company's website, and the use of geographic information systems at 75% of enterprises in the agro industrial complex. Digital technologies are mainly used in agricultural production to automate processes in livestock complexes, as well as in organizing agro technological activities, while their use in the processing sector remains minimal [8].

The main factors hindering the digitalization process in the agro industrial complex include: lack of management culture for using technologies in strategic planning; low level of digital skills of employees; outdated technical equipment that hinders the implementation of new programs; limited access to credit financing that complicates the financing of digitalization, especially for small and medium-sized enterprises. The decision maker (DM) must rely on complete, reliable information at every step of the management process [9].

Special skills and various approaches aimed at intellectualizing the decision-making process are required to process large amounts of data [10]. The use of information technologies enables to provide the automation of certain procedures, narrowing the volume of the information processed, «running through» alternative solutions, etc. Digital platforms are also being created to obtain information data.

Currently, digital platforms aimed at increasing the efficiency of providing agricultural producers with various types of services are actively functioning and developing in the information space. Thus, consultations are provided, applications are accepted, payments are processed on the State Services portal. On the Rosselkhozbank website you can use the precise farming service, the map of agricultural technologies, the service for recording and monitoring farm animals, etc., as well as obtain a wide range of information for farmers. The Ministry of Agriculture website provides information on government support measures, preferential lending, agricultural machinery lessors, milk purchase prices at dairy processing plants, etc. The «Agrosolutions» digital platform is aimed at informing agricultural producers about the state of the soil, weather conditions, pest and disease infestations, technological crop losses, etc. It also selects standard digital technologies taking into account the type of a farm, climatic conditions, and other factors. The rapid development of Internet platforms has led to such a concept as «platform economy» [11]-[12], and the intelligent platform economy [13] can be considered to be a tool for ensuring the intellectualization of management decision-making at various enterprises.

3. METHOD

3.1 Architectural components digital service

Taking into consideration the concept of the agro-industrial complex development, there is a need to develop special digital products which will facilitate information support in order to increase the efficiency of decision-making for decision makers in the field of agricultural production. Therefore, the article proposes to create a digital service (organized as a marketplace based on the use of cross-platform solutions) that provides users` access from various digital devices and helps to search and provide information for agricultural producers on freely available and ready-to-purchase digital and physical resources focused on agricultural production. In our case, the architectural approach in our project is based on the relevant standards, for example, the conceptual model of formation and evolution of the TOGAF architecture is taken as a basis. Figure 1 shows the standard composition of architectural components proposed for a digital service.

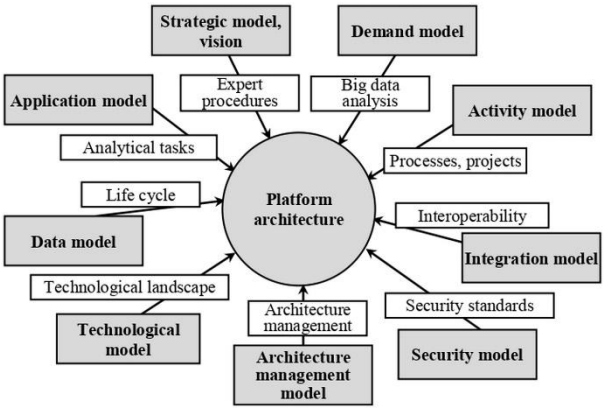

Fig. 1: Architectural components of the platform and their functional load

3.2 Structure of the digital platform «Agro-Exchange»

Since agriculture is a fundamental industry responsible for food security of both individual regions and the country as a whole, the integration of a digital service with the Internet platform of the regional Ministry of Agriculture can guarantee the reliability of the products offered for purchase.

For the sake of convenience, the structure of the digital platform is divided into corresponding sub-platforms (Figure 2), each is equipped with software modules (API) to help participants perform certain tasks. As is an innovative resource for ensuring efficient agricultural production, particular attention is given to nanomaterials, which pass through the content of all sub-platforms. Nanomaterials and nanotechnologies are used in almost all areas of agricultural production. The use of nanoparticles in nano-preparations as micro-fertilizers (to increase resistance to weather conditions and crop yields), additives to the feed ration of dairy cows (to increase milk yields), in the composition of preparations for the treatment and disinfection of agricultural premises, etc. has a high level of prospects.

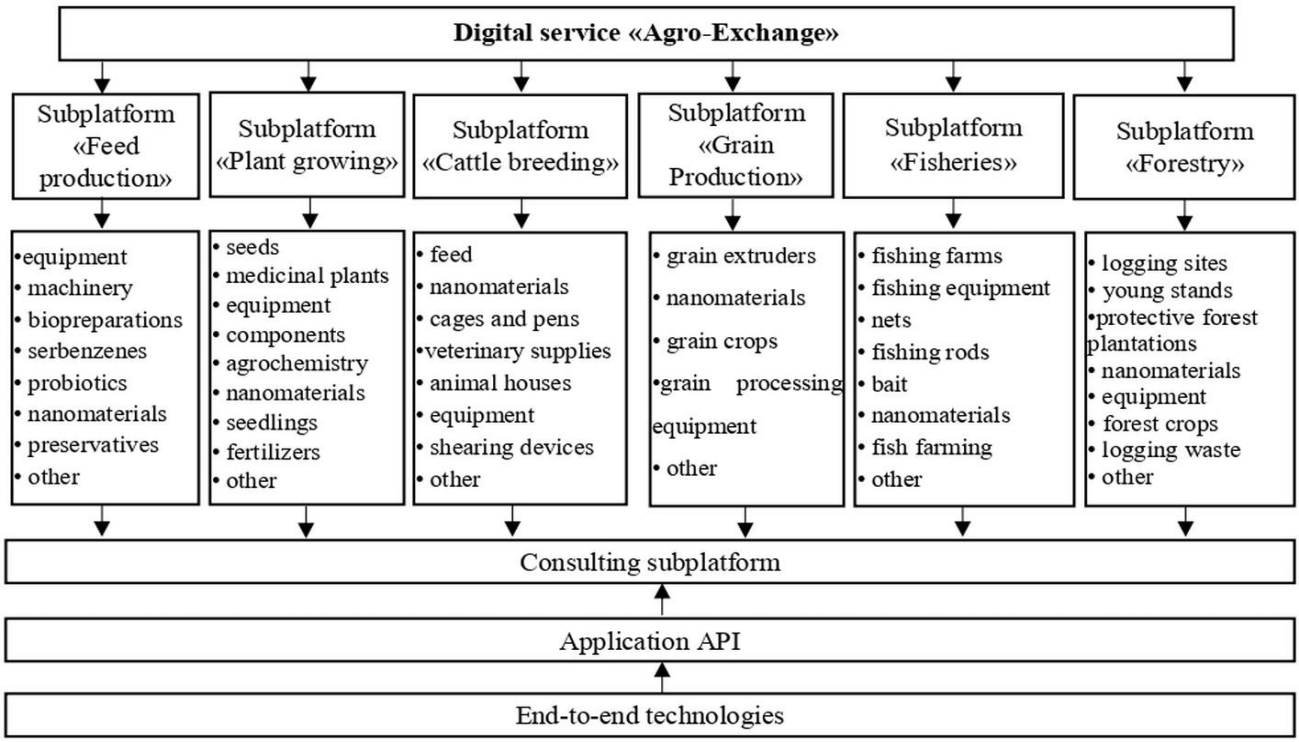

Fig. 2: Subplatforms included in the digital service «Agro-Exchange»

3.3 Development assessment

At this stage the expert method was used to evaluate the proposed development. Six people were selected as experts: two representatives from the regional Ministry of Agriculture, three heads of agricultural organizations, and one head of a peasant farm. The evaluation was carried out on the processing of data obtained during the survey using the interview method. The formulas of the source [14] were used to evaluate the efficiency of the service. The weight of the *i*-th object was calculated based on the assessments of all experts:

$$w_i = \frac{\sum_{j=1}^{m} w_{ij}}{m}, \quad (1)$$

$$w_{ij} = \frac{x_{ij}}{\sum_{j=1}^{m} x_{ij}}, \quad (2)$$

where x_{ij} is the assessment of expert j for factor i; m is the number of experts; w_{ij} is the weight of the i-th factor, calculated on the assessments of the j-th expert; n is the number of factors.

The consistency of expert opinions was assessed on the calculation of the concordance coefficient W [14] using the formulas:

$$S_e = \sum_{i=1}^{n} \left(\sum_{j=1}^{m} x_{ij} - \frac{1}{2} m(n+1) \right)^2, \quad (3)$$

$$W = \frac{12 * S_e}{m^2 (n^3 - n)}. \quad (4)$$

The coefficient W varies in the range from 0 to 1. Its equality to one means that all experts assigned the same ranks to the objects, and the closer it is to zero, the less consistent the experts' assessments are.

Additionally, the average weighted score was calculated:

$$S_{awe} = \sum_{i=1}^{n} (w_i * \bar{x}_i), \quad (5)$$

where $\bar{x}_i$ is the average value of all experts' scores for criterion i.

The following scale of assessment criteria for experts was established: unexpressed – 1 point; weakly expressed – 2 points; expressed moderately – 3 points; well-expressed – 4 points; clearly expressed – 5 points.

4. RESULTS AND DISCUSSION

4.1 Digital service «Agro-Exchange»

The demo version of the digital service «Agro-Exchange» was developed ([15], Figure 3). It was created in the application development environment Visual Studio Code in HTML, CSS, JavaScript.

Fig. 3: The start window of the digital service «Agro-Exchange»

Information support for the decision-making process in this case consists of using the result of a «smart» search query, organized as pre-structured information through collection, processing and placement in the database according to agricultural production subsystems and necessary for increasing the efficiency of agricultural production management at the planning stages, resolving issues of resource provision, etc.

Currently, methodological approaches to the formation of blocks, principles for filling structural components have been developed, and the internal content of the digital service «Agro-Exchange» has been partially defined. Also, specialized software, various IT solutions aimed at increasing the efficiency of agricultural production, digital products for agricultural producers can be offered on sub-platforms in accordance with the sub-industry affiliation, and access to the user and the selection of digital technologies should be strictly monitored by government agencies (as part of the work of departments of the Ministries of digital development and / or agriculture). The demo version of the digital service «Agro-Exchange» already provides the user with pictures, thus clients can easily, using step-by-step filtering, select the product they need (for example, feed, fertilizers, nanomaterials, etc.), and also find something that may interest them with the prospect of introducing it into production.

4.2 Expert assessment

The experts' assessments and calculated weighting indicators (formulas (1)-(2)) are presented in Table 1.

Table 1: Data of criteria service effectiveness assessments

Assessment criteria	Indicator weight	Experts' assessment					
		1	2	3	4	5	6
Convenience of digital service in terms of structured information	0.167	4	2	3	2	2	2
Importance of the service for agricultural producers	0.300	5	4	5	4	4	5
Ease usage of the service with the demo version as an example	0.289	3	5	4	5	5	4
Ease of product maintenance for the system administrator	0.167	1	3	2	3	3	3
Functional completeness	0.078	2	1	1	1	1	1

According to formulas (3) and (4), the coefficient of concordance is equal to 0.789; it shows a good degree of agreement between the experts' opinions. Although the experts came to similar general conclusions, the calculated value also reveals a certain number of differences in their assessments, which can be explained by the fact that the demo version was discussed as the product is under development and has not yet been completed. Then the average and average weighted assessments were calculated with the formulas (1), (5), which made it possible to obtain summary data (Table 2).

Table 2: Summary table of experts` assessment

Evaluation criteria	Indicator weight	Average assessment	Average weighted assessments
Convenience of digital service in terms of structured information	0.167	2.500	0.417
Importance of the service for agricultural producers	0.300	4.500	1.350
Ease usage of the service with the demo version as an example	0.289	4.333	1.252
Ease of product maintenance for the system administrator	0.167	2.500	0.417
Functional completeness	0.078	1.167	0.091

As a result of summing up the average weighted assessment, a value of 3.526 was obtained. According to a five-point scale, the value indicates the experts` positive perception of the service (using the demo version as an example). However, there are areas which require improvement. The highest average scores were received by such criteria as «Importance of the service for agricultural producers» (4.500) and «Ease usage of the service with the demo version as an example» (4.333). These results prove the high level of the service importance and profitability. Besides, the weight of these criteria (0.300 and 0.289, respectively) emphasizes their importance for the overall assessment of the product. The criteria «Convenience of the digital service in terms of structured information» and «Ease of product maintenance for a system administrator» have the same average rating of 2.500. At the weight of 0.167 this rating determines the positions of the criteria as satisfactory, but requiring further development in the full version. The «functional completeness» of the service was rated significantly lower – at 1.167 points, which indicates the need to expand the product's functionality. Work in this direction will be a key step to improve the perception of the service and increase its efficiency, which will improve, in its turn, other assessment indicators. When considering the importance of the product and possible interest in further scaling of its development, a positive decision was made.

4.3 Material costs

Next, the preliminary costs for the development (Table 3) were calculated and support (Table 4) of this service was provided that it becomes integrated into the website of the regional Ministry of Agriculture (hosting rental is not considered in this regard). To count the expenses the data on the labour-consuming estimated cost for setting up and maintaining websites from the Internet public domain of various companies are taken.

Table 3: Estimated costs for service implementation

Expenditures	Description	Price range, ruble
Development		
Back-end-development	Creation of the service server (algorithms, integration with the databases of the Ministry of Agriculture)	200 000 – 300 000
Front-end development	Development of User`s Interface	150 000 – 250 000
Current site integration	Connecting the service to an existing platform	50 000 – 100 000
Requirements gathering	Define functional and non-functional requirements for the system	150 000 – 200 000
Projecting	Creation of system architecture, interface prototypes, and documentation for development	200 000 – 250 000
Testing		
Functional testing	Performance check of all functions	30 000 – 50 000
Load testing	Performance evaluating under high load	40 000 – 60 000
Correction of errors	Troubleshooting elimination	30 000 – 50 000
Implementation and Training		
Deployment onto a real server	Deploying the service in a real environment	20 000 – 40 000
Personnel Training	Training site administrators to work with the new service	10 000 – 30 000

The development and implementation of a digital service will require investments in software and services in the amount of 880 000 to 1 330 000 rubles. Moreover, the further support for the product life cycle will also be necessary.

Table 4: Estimated costs for operating the service

Cost item	Support and updates	Price range, ruble
Technical support	Emerging problems solving, service maintenance	10 000 – 20 000 (per month)
Upgrading and Updating	New functions revision, updating in accordance with market requirements. Search for information and its reliability check, sorting, filling and maintaining the database	20 000 – 30 000 (per month)

The project can be financed from the funds of the Digital Agriculture program. Current costs can be recouped by receiving funds from product sellers (provided that the relevant agreements are made) selected by a specialist (responsible for filling in the database) for placement on the service platform for agricultural producers to find this information. It is important for the counter-partners to provide the partners with the required package of documents confirming the quality and guaranteeing the implementation efficiency when making an agreement on deployment. The issue must be carefully worked out.

The development was approved by senior officials of the regional Ministry of Agriculture. It was noted that nowadays the protection of agricultural producers from purchasing low-quality raw materials including innovative ones (in particular nanomaterials) deserves close attention. This digital product is relevant in the context of the development of a unified digital platform for agricultural production.

4.4 Prospects

This project has a significant potential for further development, which will ensure its sustainability and efficiency in the long term. One of the key opportunities is the scaling of the service, which will enable to integrate new modules and adapt the contents to the needs of various agro industrial complex segments, including both production, maintenance and processing. This will provide the platform with the flexibility and multifunctionality, meeting the demands of a wide range of users. In addition, it is planned to expand the target audience by developing a mobile application, which will make the service available to farmers and small farm owners working in the field. The implementation of such a technology will increase the number of users and boost the project popularity.

An equally important prospect is the integration of the service with other digital platforms. The inclusion of analytical tools and the ability to exchange data with government systems and commercial platforms such as yield forecasting, market accounting and resource management systems will create a single information space for agricultural producers. This will not only simplify the work of the users, but also increase the value of the platform by offering comprehensive solutions.

5. CONCLUSIONS

The agro-industrial complex faces a number of challenges related to the implementation of innovative and digital technologies. A systematic approach to solve these issues can create a reliable basis for the agro-industrial complex digitalization, which, in its turn, will increase its competitiveness and efficiency. Automation of business processes in the agricultural sector contributes to higher efficiency. The development of IT infrastructure at agricultural enterprises will increase their productivity and decrease the number of errors arising due to the human factor.

Cross-platform technologies, adapted and applied to solve a number of relevant digitalization problems at the agro-

industrial complex, are important for implementation of management processes in agriculture. Digital products support the process of the managerial decision-making. The systems approach and information logistics can significantly improve the access of agricultural producers to the necessary information and contribute to more efficient cost management in agriculture. To achieve these goals it is proposed to create and implement a special full-fledged digital service «Agro-Exchange» (a corresponding demo version has been developed and assessed to show the prospects of the service). The service ensures a quick and effective search for innovations (both digital and physical, aimed at improving efficiency of management and production processes in the agricultural sector). It also compares the innovations according to a number of criteria and selects the most acceptable ones, with a quality guarantee provided by government authorities through the integration of this cross-platform solution with its digital platform.

6. ACKNOWLEDGMENTS

The study was carried out with the support of a grant in the form of a subsidy for the implementation of a large scientific project in the priority area of scientific and technological development 23-075-67362-1-0409-000301.

7. REFERENCES

[1] Bashilov, A. M., Korolev, V. A. 2023. From hierarchical management of an agricultural enterprise to a group network-centric one. Bull. of NGIEI. 8, 147, 74-85. Available at https://doi.org/10.24412/2227-9407-2023-8-74-85

[2] Panova, A. V. 2020 Agriculture 4.0: Problems and Prospects. Intern. Res. J. 7-3(97), 160-164. Available at https://doi.org/10.23670/IRJ.2020.97.7.100

[3] Peshkova, G. Yu., Fedorov, K. F. 2022. Current trends and problems of agro industrial complex digitalization. Intern. Res. J. 4-4 (118), 150-153. Available at https://doi.org/10.23670/IRJ.2022.118.4.139

[4] Pechlivani, E. M., Gkogkos, G., Giakoumoglou, N. et al. 2023. Towards Sustainable Farming: A Robust Decision Support System's Architecture for Agriculture 4.0. 24th International Conference on Digital Signal Processing (DSP). Rhodes, Greece, 1-5. Available at https://doi.org/10.1109/DSP58604.2023.10167922

[5] Fedotova, G. V, Slozhenkina, M. I., Mitrofanova, I. V. et al. 2021 Artificial intelligence as an innovative vector of regional agro industrial complex management. Reg. Econ. South of Russia. 9, 1, 152-162. Available at https://doi.org/10.15688/re.volsu.2021.1.13

[6] Nagoev, Z. V., Shuganov, V. M., Bzhikhatlov, K. Ch. et al., 2021. Prospects for increasing the productivity and efficiency of agricultural production using an intelligent integrated environment. Bull. of the Kab.-Balkar. Sci. Cen. of the Rus. Aca. of Sci. 6 (104), 155-165. Available at https://doi.org/10.35330/1991-6639-2021-6-104-155-165.

[7] Timakova, R. T., Ilyukhin, R. V. 2023. Digital technologies: new approaches to traceability of grain flows in Russia. Digital models and solutions. 2, 2. Available at http://dx.doi.org/10.29141/2782-4934-2023-2-2-6

[8] Tokarev, K. E., Rudenko, A. Yu., Kuzmin, V. A., Chernyavsky, A. N. 2021. Theory and digital technologies of intelligent decision support for increasing the bioproductivity of agroecosystems based on neural network models. News of the Lower Volga Agrarian University Complex: Science and Higher Professional Education. 4 (64), 421-440. Available at https://doi.org/10.32786/2071-9485-2021-04-42

[9] Provost, F., Fawcett, T. 2013. Data science and its relationship to Big Data and data-driven decision making. Big Data. 51-59. Available at https://doi.org/10.1089/big.2013.1508

[10] Katzenbach, C. 2019. Defining concepts of the digital society. Internet Policy Review. 8, 1-6. Available at https://doi.org/10.14763/2019.4.1430

[11] Anselin, L., Gallo, J. L, Jayet, H. 2008. Spatial panel econometrics. The econometrics of panel data. Series: Advanced Studies in Theoretical and Applied Econometrics (Chapter 19). 46, 625-660. Available at http://dx.doi.org/10.1007/978-3-540-75892-1_19

[12] Parker, G. G., Alstyne Marshall, W. V., Choudary, S. P. 2016. Platform Revolution: How Networked Markets Are Transforming the Economy and How to Make Them Work for You. Business, Economics, Computer Science, 256. Available at http://dx.doi.org/10.33077/uw.24511617.ms.2017.68.418

[13] Vasilenko, N. V., Babkin, A. V., Grigorieva, E. A. et al. 2023. Intelligent platform economy: development trends: monograph. SPb.: POLYTECH-PRESS, 547. Available at https://doi.org/10.18720/IEP/2023.2

[14] Danelyan, T. Ya. 2015. Formal methods of expert assessments. Statistics and Economics. 1, 183-187. Available at https://doi.org/10.21686/2500-3925-2015-1-183-187

[15] Bogach, E. V., Rakhmatullin, R. R., Speshilov, E. A. 2025. Web service «Agro-Exchange». Certificate of state registration of computer program 2025615053, Rospatent 02/28/2025.