Digital control of the application efficiency of agricultural land and the involvement of retired territories into circulation

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Abstract. The economic instability of recent decades has various social consequences. One of which is the emergence of abandoned agricultural areas. Analytical studies have shown that geolocation, aimed at creating a digital image of agricultural areas, reveals exclusion zones. The government has set the task of developing programs to involve the agricultural turnover of unused land. It is proposed to carry out a system-architectural design of the target zoning of territories. The selection of the basic model within the architecture of the Database of agricultural lands in circulation is supplemented by a block of a digital image for recognizing resource opportunities. The problem of developing a formalized set of typed commands that structure knowledge about the state of territories and their functionality for expert programming systems is solved. The database is formed from declarative (factual), procedural, and control knowledge. To form the database, the state of unused agricultural land in the country was shown. A forecast was given by the Ministry of Agriculture of Russia for the involvement of fallow lands in the turnover by the end of 2030. The concept of the efficiency of involving unused agricultural land into circulation was presented. A mathematical description of the risks and a graphical presentation of ways to achieve the efficiency of returning unused land by a set of indicators of risk restrictions were given. The key advantage of the developed concept is the creation of a modular-type production infrastructure, which is modernized and filled according to the current needs of economic activity, which is flexible to changes in internal factors and does not require external resources.

1. Introduction

The strategic national priority, which is highlighted in the "Doctrine of Food Security of the Russian Federation" (January 21, 2020, No. 20), is the following "...improving the quality of life of Russian citizens by guaranteeing high living standards." Achievement of this goal is realized through the solution of many tasks, the key of which should be highlighted the following: "...restoration and improvement of the fertility of agricultural land, prevention of reduction of agricultural land, rational use of such land, protection and preservation of agricultural land from water and wind erosion and desertification" [1]. Significant changes in the social and economic state of Russia, the emergence of new external factors of risks and threats to food security require the creation in the agro-industrial complex of a consolidated highly scientific and productive sector based on modern technology and technology. The vector of sustainable development while ensuring food security should be aimed at...
expanding the production of agricultural products, raw materials, and food, as well as increasing the export potential, taking into account the priority of Russia's self-sufficiency in domestic agricultural products, raw materials, and food. Solving these problems requires a systematic approach in terms of increasing the efficiency of using agricultural land as the main means of agricultural production and the most important factor in ensuring the country's food security [2]. In this regard, for the development of the agro-industrial complex of Russia, tasks aimed at identifying unused agricultural land, primarily arable land, and their involvement in agricultural turnover, are becoming priorities [3-7].

The work aims to form the concept of involving unused agricultural land into circulation, based on the analysis of the dynamics of the implementation of strategic tasks of the development priorities of the Russian Federation.

2. Materials and methods
In this study, the following data were used for analysis and generalization: data from Rosstat and the governing bodies of the AIC of the constituent entities of the Russian Federation, the Report on the state and use of agricultural land in the Russian Federation in 2019, Internet resources, including the websites of the governing bodies of the AIC of the constituent entities of the Russian Federation, and other open sources. In 2019, within the framework of the departmental program "Development of the reclamation complex of Russia" and the federal project "Export of agricultural products", 324.6 thousand hectares of retired agricultural land were involved in the turnover due to cultural and technical measures (within the departmental program - 306 thousand hectares, the federal project - 18.6 thousand hectares) with the amount of financing from the federal budget for 1903.4 million rubles. (within the framework of the departmental program - 1,747 million, the federal project - 156.4 million rubles) [3]. The dynamics of the involvement in the turnover of retired (unused) agricultural land in the Russian Federation and some of its constituent entities due to cultural and technical work under the federal target program "Development of reclamation of agricultural land in Russia for 2014-2020" is shown in Fig. 1 [6].

![Figure 1](image.png)

**Figure 1.** Dynamics of the involvement of unused agricultural land in the Russian Federation due to cultural and technical work under federal target programs, thousand hectares.

The risks of the implementation of the program are mainly economic, although the SWOT analysis for the long term allows proposing a strategy to minimize the risks. The analysis of the problem highlighted internal risks that are not critical for the implementation of the presented project, in particular, human and economic factors can be eliminated by adjusting at the organizational level. At the same time, there are external risks that must be taken into account. In this regard, the risks were
considered in correlation with the list presented in section 4 "Doctrines" (Risks and threats to food security) [1].

**Economic risks [1]:**
- the possibility of a deterioration in the internal economic situation; - high inflation and a crisis of the banking system;

**Climatic and agro-ecological threats [1]**
- adverse climatic changes and abnormal natural phenomena; - the consequences of natural and man-made emergencies. It is possible to minimize external risks by applying technologies of scientific and technical support, which consist in building a digital image of agricultural territories, creating a platform for a predictive model of factor efficiency based on the developed digital content of the economic activity, with elements of predictive modeling of a risk change. Based on the analysis of the state of reclamation systems and reclaimed agricultural land, a roadmap has been developed that includes a list of priority technical measures aimed at restoring and improving the state of land [7, 8].

### 3. Results and discussions

The implementation of the tasks set in the "roadmap" was presented through the introduction of digital systems for collecting, processing, and managing data on specific territories involved in economic activities. Taking into account the fact that the problem posed can be typified and has a cyclical solution, at the first stage, the problem of structuring knowledge about the state of territories in general and in the context of their involvement in economic circulation was solved, taking into account various strategies, in particular, knowledge for expert systems, not only knowledge “What to do”, but also the knowledge of the answers “how to do”. In this paper, the core of the expert system was proposed to represent "frames" (a frame is a large structured unit of knowledge based on facts or procedures). The database was formed from declarative (factual), procedural and control knowledge, such as

- declarative (factual) knowledge. This is information about specific facts collected through communication with the operator, a priori accepting the truth of the information based on the experience and professionalism of an expert; as well as a scenario description of the state of the territories and the factor influence on the effectiveness of their involvement in economic activity.

- procedural knowledge. This is a list of rules, including information on methods of narrowing the area of its search, rules according to which declared knowledge can be transformed in the system under consideration, for example, according to the “if-then” rules;

- management knowledge. It is a set of decision optimization strategies based on the system’s metaknowledge about its work, structure, memory, and reasoning scheme. Management knowledge determines the level of competence of the system. They contain information regarding the ways of using knowledge and its properties.

Since the database is usually formed by an expert in a specific professional field relying on intuition and experience, and the declared and procedural knowledge constitutes a fairly voluminous information apparatus, the task under consideration is detailed, highlighting individual frames and the logic of their interconnection. Thus, the "frame" becomes the key, and the unity of the system is realized with the help of additional information contained in each frame. Promising is not only the accumulation of generalized knowledge formalized in frames but also the ability to use them meaningfully, for which they are organized into hierarchical structures linked into a single whole with the help of various relationships between informative elements. The system remains "open", i.e. capable of accumulating new knowledge. Such a model ensures the consistent operation of different levels of the problem representation hierarchy.
As an example, we can cite the UgCS hardware and software module, into the software shell of which recognition frames are embedded, based on the photogrammetry method, and in practice, information is collected by surveying the territory with unmanned aerial vehicles - quadcopters, a fragment of visualization is shown in Fig. 1.

The applied methodology for creating a knowledge base on the state of territories and the rules for their involvement in economic activities will provide computers with the ability to learn, which in turn creates a platform for a flexible (intelligent) system capable of choosing any program from its memory or several programs to create a new one and form goals for based on the standard algorithms for the effectiveness of sustainable agriculture. Modal Analysis of the Effectiveness of Involving Unused Agricultural Lands in the Turnover Based on the Set of Risk Constraint Indicators

Scientific support for the concept of involving unused agricultural land in circulation involves the creation of a system for monitoring regional territories in real-time, as an additional structure in the EFIS ZSN using digital technologies. Certification of territories with augmented reality in the digital environment makes it possible to form a stable platform for control of use, taking into account the sustainability of prospective profitability, to coordinate measures to reduce the environmental load on the environment and preserve the identity of the biobalance [14-13]. The following three ways of implementing the concept of drawing unused agricultural land into circulation were established:

- **intensive (Int).** This is an implementation in the shortest possible time with maximum financial investments, which is not very acceptable for territories located in a region with a dispersed social structure and makes this option difficult to implement. At the same time, such a variant of the development of territories cannot be ignored, since getting a return on investment in a 2-3 year time period can be considered an ideal option;

- **extensive (Ef).** This is the most acceptable option, receiving profitability in 5-8 years, during the period of the project. The attractiveness of this option lies in the fact that it provides for a parallel solution to the issue of expanding the functional use and reducing the anthropogenic load on the territory. In this case, there is a possibility of smooth involvement of natural resources and their recovery from human activities.

- **complex (Opt).** This is a time lag of profitability of 3-4 years, which fully reflects the economic reality and the real possibilities of investors. The mathematical model for monitoring the effectiveness of bringing unused agricultural land into circulation. To control the efficiency of investments applied technologies, and attracted technical means, the concept of the competitive status of the territory (KSt) was introduced, expressed in the following form:

\[
KSt = \frac{I_T - I_K \cdot S_T \cdot C_T}{I_o - I_K \cdot S_o \cdot C_o},
\]

where \(I_T\) is the level of strategic capital investments in territorial development; \(I_o\) is the optimal amount of capital investments, taking into account risk restrictions;

\(I_K\) - critical volume of capital investments, taking into account risk restrictions;

\(S_T, S_o\) - respectively, the current and optimal strategy for the development of territories;
\( C_{T}, C_{O} \) - respectively, the available and optimal capabilities of the region. For the calculation, the first element of formula (1) has a quite definite quantitative value, while the other two indicators should be considered as arithmetic mean points (a scale from 0 to 1) of the degree of correspondence between the factors of the current strategy or the available opportunities to the factors of the optimal strategy or optimal opportunities.

The condition for achieving the optimal value of the coefficients is as follows: the optimal value of the coefficient of functional use is characterized by 100% readiness for use for its intended purpose, with a high level of development of the territory and is taken: \( K_{fi} = 1 \). Nowadays, the regional territories of unused agricultural land have the lowest value of the coefficient of functional use of 0.2. The qualitative characteristic of the coefficient through an indirect assessment and its relationship with the quantitative value is presented in the table of ranks (Table 1).

It was found by calculation that with an extensive development path, a change in the value appears within the following limits: 2022 - 0.43, 2027 - 0.71, and the maximum workload by 2030 - 1. A positive trend in the change in the coefficient of functional utilization is observed with an increase in the value indicator. For the coefficient of anthropogenic loading of the territory, an optimal value of 100% is taken if the load provides a balance between the natural environment and human economic activity: \( K_{i} = 1 \).

| Coefficient value | 1    | 0.8  | 0.6  | 0.4  | 0.2  |
|-------------------|------|------|------|------|------|
| Percentage        | 100% | 80%  | 60%  | 40%  | 20%  |
| Qualitative characteristic | high | above average | average | acceptable | low |

Table 1. The coefficient values of the functional use of the territory.

At present, regional territories claiming to be returned to agricultural use are located in a natural complex with a fairly high value of the anthropogenic load factor of 0.6. The qualitative characteristic of the coefficient through an indirect assessment and its relationship with the quantitative value is presented in the table of ranks (Table 2).

| Coefficient value | 0.2 | 0.4 | 0.6 | 0.8 | 1  |
|-------------------|-----|-----|-----|-----|----|
| Percentage        | 20% | 40% | 60% | 80% | 100%|
| Qualitative characteristic | optimal | average | acceptable | above average | unacceptable (high) |

Table 2. The coefficient values of anthropogenic loading of the territory.

By calculation, it was found that when the extensive development path is implemented, the change in value varies within the following limits: 2022 - 0.55; 2027 - 0.5 and minimum workload by 2030 - 0.4. These values indicate the risks of both technical and natural restrictions to reduce the anthropogenic congestion of the territory, which does not make it possible to reduce the indicator to the optimal value of 0.2. Accordingly, the positive dynamics of change in the coefficient of anthropogenic congestion of the territory is observed with a decrease in the value of the indicator. To determine the average assessments of the strategy and the possibilities of the \( S_{T}/S_{O} \) and \( C_{T}/C_{O} \) ratios, a set of typical factors and the nature of their influence on the efficiency of drawing unused agricultural land into circulation were selected. The calculation results for better visualization are presented in the form of a graph (Fig. 3).
Figure 3. The calculation of the way to achieve the efficiency of the return of unused agricultural land was made based on the combination of the following indicators of risk restrictions: Kant is the coefficient of anthropogenic loading of the territory; $K_{tr}$ is the infrastructure coefficient for the example of vehicles, $K_{fi}$ is the coefficient of functional use. Implementation ways: $I_{int}$ - intensive; $E_{ext}$ - extensive; $O_{pt}$ - complex.

The carried out both modal analysis and theoretical studies have shown the consistency of the results. Based on this, a qualitative description of the costly and environmental risks of bringing unused agricultural land into circulation was presented in the format of a positioning scale such as the following: $0 < KST \leq 0.4$ - weak; $0.5 < KST \leq 0.7$ - average; $0.8 < KST \leq 1.0$ - strong. The combination of factorial studies of territories, supplemented by calculated results, allows one to give a scientifically grounded assessment of the competitive status of the territory and make a long-term forecast for the model of their involvement in agricultural turnover without damaging the natural environment.

4. Summary
The concept of the efficiency of involving unused agricultural land into circulation was presented. A mathematical description of the risks and a graphical presentation of ways to achieve the effectiveness of involving agricultural land in circulation were given.

The key advantage of the developed concept was the creation of a modular-type production infrastructure, which is modernized and filled according to the current needs of economic activity, which is flexible to changes in internal factors and does not require external resources.

It was found that the efficiency of capital investments is ensured by a personalized account of the natural and climatic conditions for the use of land plots, as well as scientific justification of financial investments with a predictive model of break-even functioning and payback of agricultural activities.

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