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Ecosystem approach to strategic management on the example of agriculture

Vladimir I. Budzko
E-mail: vbudzko@ipiran.ru

Viktor I. Medennikov
E-mail: dommed@mail.ru

Federal Research Center "Computer Science and Control" of the Russian Academy of Sciences, Moscow, Russia

Abstract

This paper considers the transformation of methods and models of strategic management based on the ecosystem approach within the framework of the formation of a unified digital platform for management. The ecosystem approach to the socio-economic development of society is gaining popularity as a result of global social requirements for environmental protection and a careful attitude to use of limited natural resources. Environmental problems in the Russian agricultural sector are increasing, in particular due to the process of formation of agro-industrial associations, mainly in the form of agricultural holdings. In this case, there is a problem of a systematic approach to using of technologies for the integration of all types of resources involved in production, taking into account the growing number and importance of environmental factors. Mathematical modeling is proposed as the main method of strategic management research. Unlike most of the existing models, which are often iconographic, the model proposed allows us to consider a larger number of factors. This makes it possible to assess various options of the modeling objects development using a simulation approach. As a result of the research, a mathematical model of strategic management of agroholdings for sustainable development was developed. It is shown that the development strategy should be implemented considering an appropriate automated management information system. This will lead to a radical change in the whole system of management and production. It will allow the enterprise to apply strategic goal-setting, focusing first of all on quality, controllability and other components of competitiveness. The mathematical model proposed provides justification of unified methods of long-term digitalization applicable for large agricultural associations, as well as for small and medium-sized farms, which will be able to cooperate with agricultural holdings relying on the principles of outsourcing.

Keywords: strategic management, ecosystem, agriculture, digital management platform

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Introduction

The ecosystem as a scientific concept stems from biology, where a system is understood as a symbiosis of physical objects and biological organisms in some habitat in which they are interdependent and interact effectively [1–3]. The ecosystem approach is a concept based on new digital solutions aimed at improving the efficiency of control actions in the field of environmental protection. The ultimate goal is to transfer to the descendants as many natural resources as possible, while reducing the environmental burden on mankind and the natural environment.

A natural ecosystem can be defined as a system consisting of living and non-living elements interacting with each other in certain spatial areas [4]. When transferring the concept of ecosystem to socio-economic systems, the first part of this term ("eco") means the environment of some organizational structure, and the second part ("system") describes (from the point of view of the systems theory) the interrelation of elements functioning according to certain rules. Thus, in socio-economic research an ecosystem is defined through exogenously specified elements of the environment, as well as agents endogenously acting together according to the rules of the system, to the benefit of the participants of such interaction [5, 6].

Nowadays, research in the field of using the ecosystem approach regarding socio-economic development of mankind is becoming more and more important due to the rapidly increased global social demand for environmental protection, as well as for more efficient and environmentally friendly use of dwindling natural resources. This was confirmed by the establishment by the UN General Assembly (in 1987) of the International Commission on Environment and Development, which developed the concept of sustainable environmentally friendly development of the entire world community. In addition to the social demand mentioned above, the concept considers other complementary factors, including demographic, financial and social ones.

Environmental problems in Russia are increasing. In agriculture, the control by regulatory bodies over compliance with soil fertility preservation norms has decreased. The rules of crop rotation are not observed; chemical fertilizers and substances against diseases and pests are widely used, with the aim to increase the volume of production and its profitability. All this negatively affects not only harmful organisms but also beneficial ones interacting with them. Such external impact on ES and non-observance of some rules of the state of soil equilibrium, taking place over a quite long period of time, turns the soil into a warehouse of toxic chemicals with their further transmission through crops and animals to humans themselves. Thus, in [7] it is reported that in Russia about 2 million hectares of land are degraded per year, which leads to production losses of 3.9 million tons. Consequently, the fertility of chernozems in central part of Russia has almost halved over the last ten years.

Conducting crop rotation with ensuring the necessary level of an agricultural producer's profitability requires the development of long-term and current plans, as well as their subsequent regular adjustment and management, taking into account changing conditions. For each specific enterprise, it is impossible to develop an individual digital tool for solving this task, because of the increased number of internal and external environmental factors. Therefore, some analog of the computer aided design system is essential. An integrated management information system (MIS) should provide information support for such a process, and an ecosystem approach is fully applicable for its construction. At the same time, since market relations require seeking the most rational solutions while determining areas of activity, building the management information system is related with the best methods and approaches developed in the field of strategic management. The concept of sustainable environmentally friendly development, along with the political and economic instability worldwide during the last decade, has led to active research in the field of strategic management. Therefore, integrated crop rotation management requires creation of business ecosystems with elements of strategic management [8].

1. Models and methods of strategic management

The theory of management leads to formation of strategic management as an independent integral scientific field [9, 10]. In these works, planning had a short-term annual horizon, the reason for which was the general economic stability in developed countries, in particular, in the relationship with the external world (environment) and provision of various resources. The extension of the planning horizon from one to several years was a consequence of the growing problems in the influence of various factors of the external environment on the work of businesses.

Accelerated development of science, technology and engineering, as well as the globalization of the economy (the appearance of production facilities with globally distributed assembly sites for individual product components) force most firms to engage in long-term planning and appropriate management. The development of the concept of strategic management became the result of such trends and research has surged in this area. Among the most famous foreign scientists who have worked in this field, we can mention Strickland and Thompson [11], as well as Mintzberg, Albert, Porter, Bowman, King, Drucker, Ansoff, Mescon, Khedouri, Cleland, Ahlstrand, Lampell, Chandler. It is also possible to distinguish such Russian specialists as Vikhansky [12], Shekhovtseva [13], Terekhova-Pushnaya [14] and some others.

For some time, the models of strategic management were subjected to various modifications [13]. As a result of the evolution, a large number of models based on graphics and flowcharts appeared. Quite often the difference between models was only in the number and content of consecutive stages of strategic management description. At the same time, all models have some common descriptions of the stages of SM, which include:

- goal setting of the firm's activity;
- allocation of a number of tasks aiming to achieve strategic goals;
- selection of tasks (from a certain set of options) that are the most important (optimal) from the point of view of strategy implementation;

- implementation of the tasks selected;
- monitoring, analysis and evaluation of the implementation of the approved trajectories focused on strategic goals.

In all the models, the most important function of strategic management (which is essential for our models) is analyzing internal resources, as well as features of the external environment that are significant for companies, including economic, social, political, environmental, technological and some other factors. Recent events show that the external environment is becoming more and more dynamic, forcing us to seek answers to a range of questions:

- what is the portrait of a prospective buyer of the company's products;
- to what extent can the company's products be substituted by products of other firms, considering the financial condition of buyers in the future;
- what is the price distribution of goods depending on regional wages, delivery volumes and the level of logistics development;
- what are the level and trends of product development in terms of public, business and regulatory requirements for quality, health safety, design and prospective characteristics;
- what are the conditions for obtaining loans and their impact on the cost of goods, the level of competition, its dynamics and expected forms;
- what is the degree and quality of adoption of digital technologies by expected competitors;
- what is the forecast of trends in the rulemaking of the state institutions affecting the company's interests.

As a result of attempts of different organizations to take into account most of the factors of the external environment listed above, the theory of business ecosystems was developed [8].

2. Methods of strategic management based on a single digital platform

James F. Moore, the founder of the theory of business ecosystems, gives the following definition of a business ecosystem [8]. By analogy with natural ecosystems, a business ecosystem is an economic community that includes (according to certain criteria, as is customary in system analysis) a group of interacting actors (organizations and individuals) from the business world. This means that an ecosystem of any organization includes both its own divisions and related entities, including customers, suppliers, intermediaries (participants of value added chains), as well as all kinds of departments, bodies and institutions which provide monitoring of compliance with standards, regulations and laws. Moreover, competitors that have or may have a significant impact on the ecosystem, as usual, are also included in the ecosystem. The influence of all these elements on the entire ecosystem should be considered at all management levels, relying on appropriate exchange of information.

In [7, 15, 16] a unified digital management platform (DMP) is studied for developing a typical MIS for multi-sector agricultural enterprises. In the light of the above mentioned arguments, this platform claims the role of a digital tool for implementing the concept of business ecosystems in practice. This solution also represents a basis for developing a strategic management system. The DMP consists of three main sub-platforms that could be adopted as digital cloud standards:

- collection, transmission and storage of primary accounting information (*Fig. 1*);
- database of technological information (*Fig. 2*);
- knowledge base reflecting the algorithmic support of management functions (in crop production, 240 typical algorithms are ontologically identified).

An example of enlarged modular information model of crop production in agricultural farms is given in *Fig. 2.*

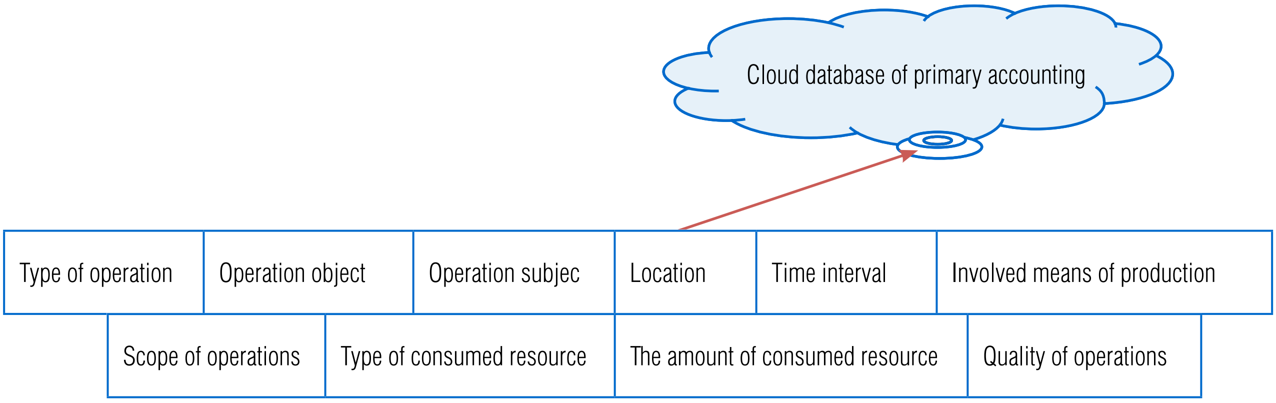

Fig. 1. Modules of the sub-platform for collecting, transmitting and storing primary accounting information.

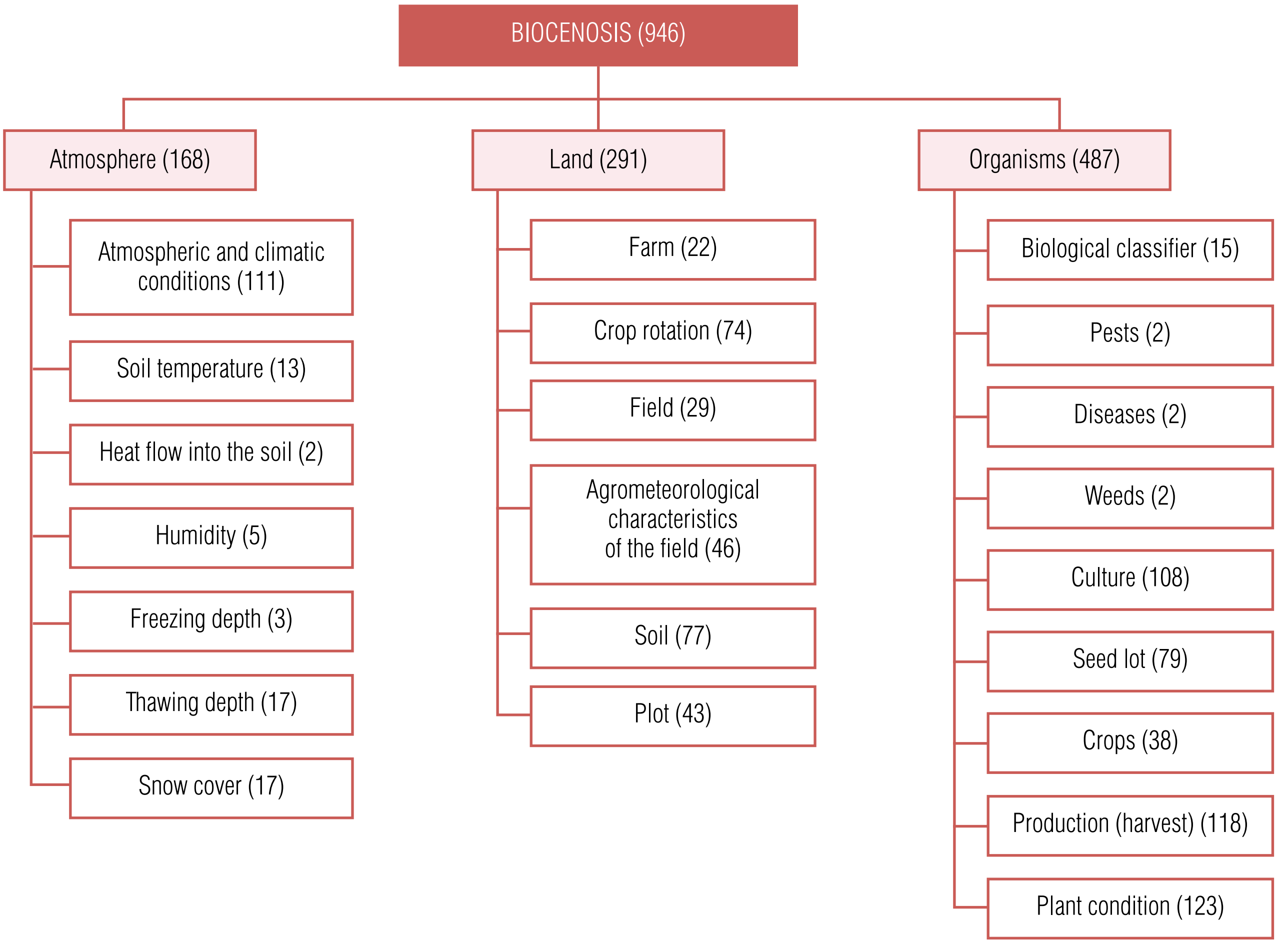

Fig. 2. Large-scale modular information model of crop production.

The sub-platform for collecting, transmitting and storing primary accounting information has an inter-industry universal nature for the main production sectors. Two other sub-platforms represent digital standards of a specific industry. DMP also contains all the master data and classifiers that are necessary for management algorithms. It should be noticed that the universality of the first sub-platform, implemented as an appropriate toolkit, is related with storing all the technological operations performed and all the information collected using the Internet of Things. This may explain the argument advanced by academician Glushkov in favor of the OGAS project ("to overtake without catching up") since conceptually the DMP is far ahead of the overseas approach to the digitalization of the economy [17, 18]. This is related with the statement of J'son & Partners Consulting that at present in the US agricultural sector there are only two types of specific sub-platforms: aggregators collecting and accumulating primary data and sub-platforms of applied tasks [19].

Let us consider the expected results of the application of the MIS implemented on a single DMP regarding the development of various strategic management systems.

As noted above, the business ecosystem of any enterprise includes many economic agents in contact with it, as well as government and regulatory institutions that provide compliance regarding laws and standards. Growing integration trends of the digital economy significantly strengthen this relationship. It is possible to note the emerging requirements of market agents and private buyers to receive online information about various characteristics of goods (for example, in Russia the Honest Sign system is actively developing). Such requirements based on digital economics integration technologies have been realized in the concept of traceability of goods and services. A digital tool implementing the traceability concept allows us to provide suitable information about the manufacturer, composition of the goods (with quality, price, cost indicators), production date and expiration date, and other data, not only to participants of production and logistics chains, but also to all stakeholders, including regulatory authorities. As a result of the spread and improvement of this tool, customer behavior patterns in digitally developed countries is changing towards choosing higher quality and safer goods, medicines and food products. As follows from the considered characteristics and capabilities of the DMP, an ideal tool for providing traceability of goods and services is MIS developed on the DMP basis [20], which also includes a digital platform of logistics management [21] (*Fig. 3*).

Moreover, it can be concluded that DMP, in combination with a number of other digital technologies, such as artificial intelligence allows us to make reliable and objective calculations of the individual contribution of each participant in the value chain to the cost of production. This allows us to draw the following conclusion: the business behavior of all participants in the chain will undergo a radical transformation caused by full awareness of the real contribution of each of them when transferring their products to the chain [20]. We forecast that in 15 to 20 years, when DMP will be recognized due to its practical efficiency, it can be predicted that this platform will become an instrument for changing the service model of socio-economic relations to a product model of behavior for the whole society [22].

3. Methods of strategic management of an agro-industrial association based on a single digital platform

Scientific interest in strategic management in Russian agriculture sector is explained (behind tasks of a general nature) by growing environmental problems and declining soil fertility. This interest is also facilitated by ongoing structural reforms, which leads to rapid increase in agricultural holdings bringing together enterprises from different industries and regions with different levels of development. The

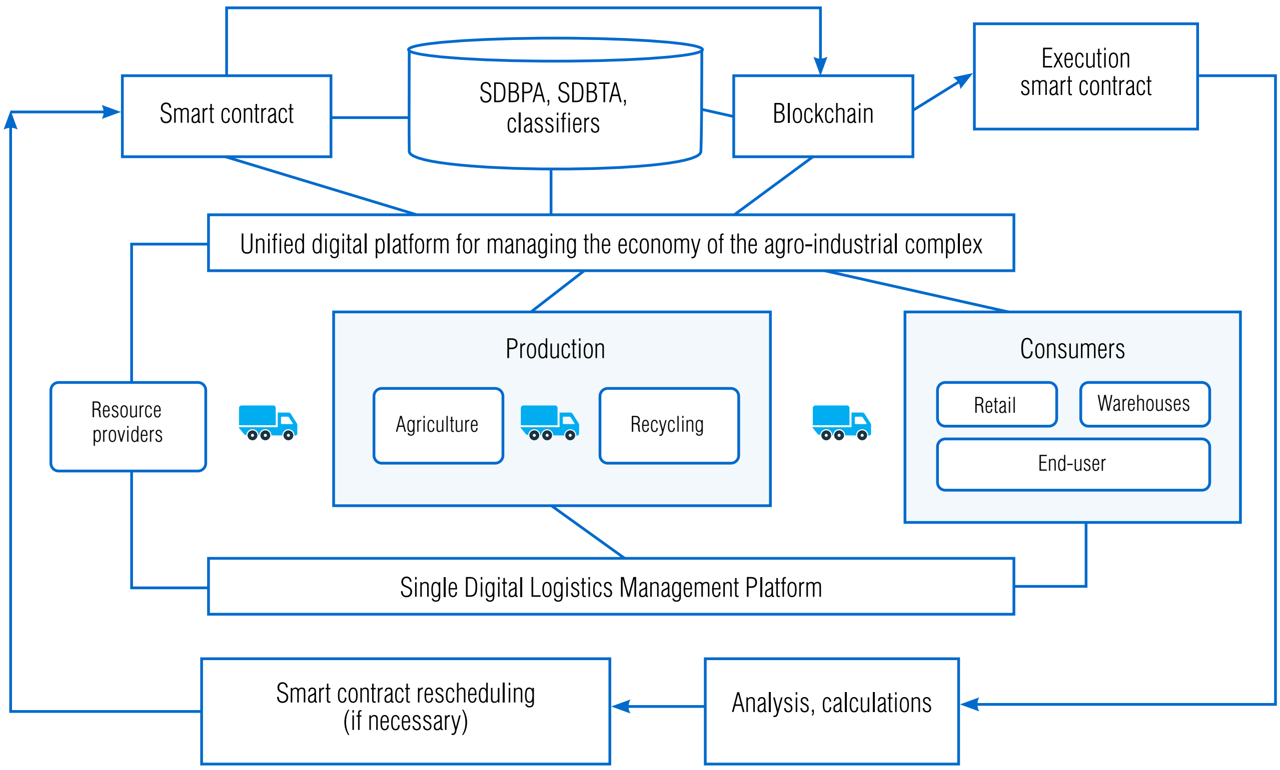

Fig. 3. Scheme for implementing product traceability within a single automated control system based on the DMP.

main dominant motive for this is the need to integrate agricultural organizations with more profitable livestock processing enterprises. For these enterprises, such relationships guarantee the access to relatively cheaper (comparing with market process) raw materials and essential technological stability. Often these enterprises act as initiators of such integration. This leads to reduction of market intermediaries' participation in supply chains and, in the case of organizing own retail chains – to implementing the principle "from the field to the counter" (this principle is similar to appropriate trends in foreign countries).

The creation of holdings gives rise to a number of problems associated with the alignment of production facilities, as well as providing effective integration of all the resources (material, labor, financial and digital resources essential in the era of digital economy) while forming optimal logistics chains.

To resolve the problems listed above, let us discuss the strategic management model of an agricultural holding, considering its integration trends.

As in has been mentioned, holdings include the crop, livestock and processing industries of the agro-industrial complex. To shorten the model, we do not consider secondary industries that carry out auxiliary functions, and we take into account their impact on total costs within the main industries. However, in the future (considering that the holding has completely switched to the DMP) it is mandatory to include in the model the logistics block, as an important element of the integration processes. Further, we assume that only crop and livestock products serve as raw materials for processing enterprises, and only crop products serve as raw materials for the livestock industry (although, in practice, some processing waste is included in the feed ration of some animals). Due to quite strict crop rotation requirements, to produce such a set of plant crops only for the needs of the livestock and processing industries is not possible. Therefore, additional products should be supplied either to the market or to processing. The scheme of factors taken into account when developing a strategic management system for an agroholding is shown in *Fig. 4*.

Considering the assumptions described, there is a problem of defining an optimal prospective structure for the production of the holding's final products. This makes it possible to maximize profit, using effective integration technologies regarding all the resources used in production. Moreover, it is essential to take into account investments in the economy, production technologies, as well as mechanisms for achieving the required level of product competitiveness (*Fig. 5*). The next stage of strategic management will allow us to introduce a program for transition from the initial state of the agroholding to the final state obtained as a result of strategic planning of the first stage [23].

It is known that the main processes of agricultural production are determined by the structure of scientifically justified crop rotation [24]. The choice of crop rotation determines technologies of land processing and caring for plantings, the scope of measures

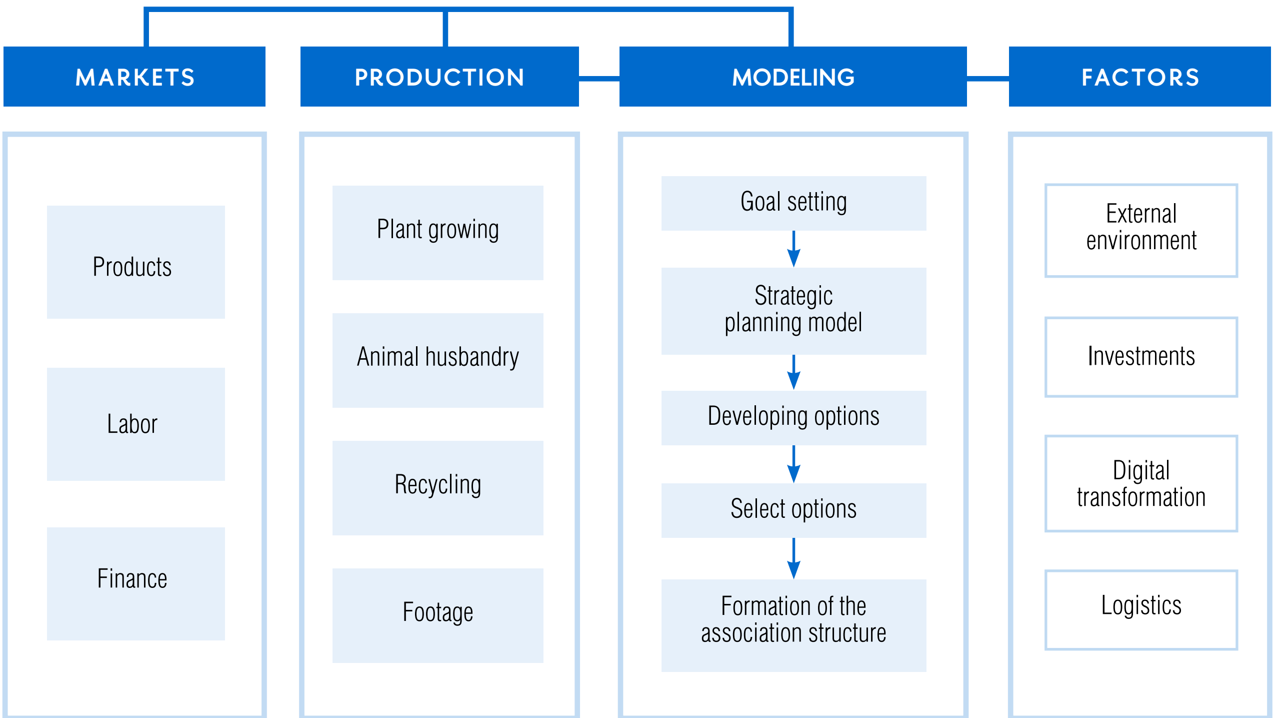

Fig. 4. Factors taken into account in the strategic management of an agricultural holding.

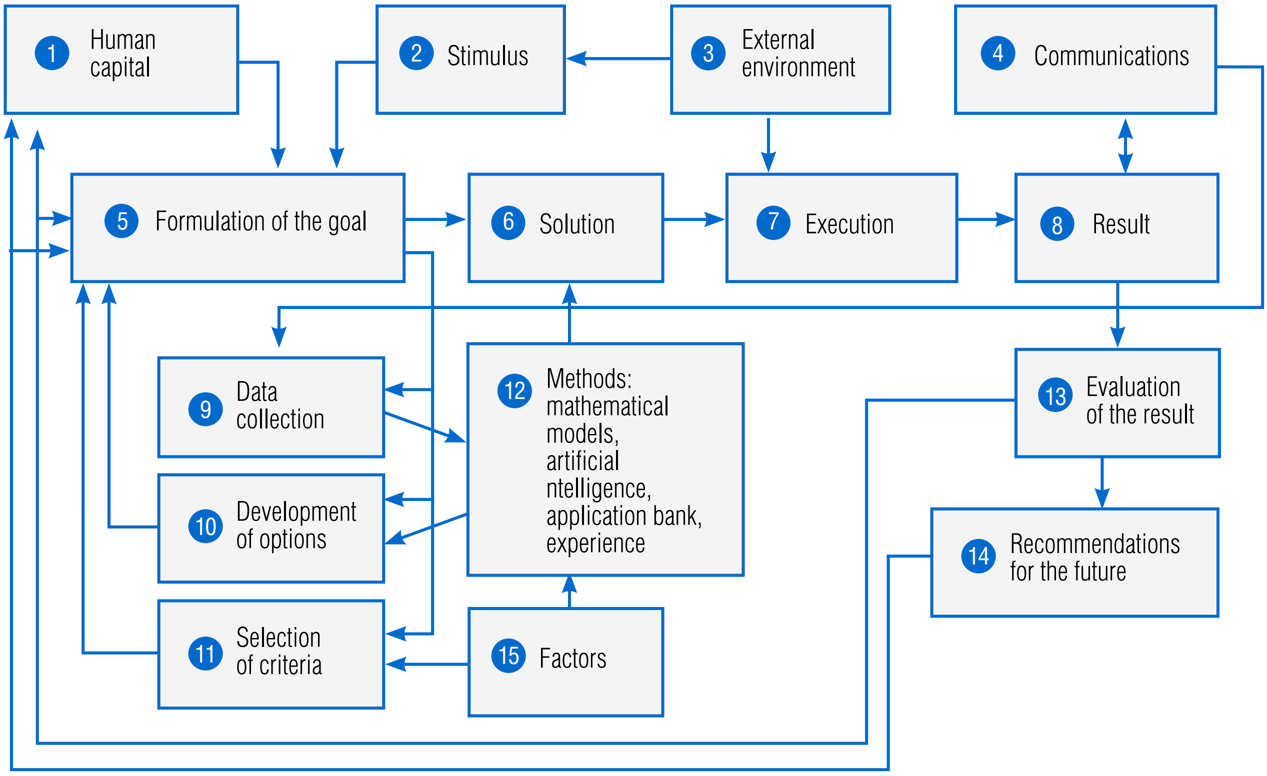

Fig. 5. Block diagram of strategic management of the holding.

for cultivated plants protection, the list of chemicals planned for use, the brands and nomenclature of technical means, the structure and territorial distribution of warehouses and production buildings, etc. It can be said that the final result of agricultural production as whole depends on the selected structure of crop rotation, in which land is the main resource. Crop rotation provides rational and efficient use of other resources applied for growing crops. Therefore, the formation of strategic management systems of agroholdings should be preceded by the development of scientifically approved crop rotation, the mathematical model of which is presented in [25].

For this reason, all the technological processes must be informationally and algorithmically interconnected in accordance with the integration principles. The same is relevant to logistics, the digital technologies of which must act as a link between all crop rotation elements – suppliers of materials, fuel and chemicals, temporary storage points (warehouses, silo tanks, haylage towers, grain threshing floors), all kinds of consumers of plant products (livestock farms, processing and feed mills, elevators, traders), as well as transportation entities themselves. The relevance of considering logistics as an element of crop rotation for the purpose of its optimization is confirmed by data on the huge costs for it in Russia – about 20% of GDP [21] (for comparison, in the EU these costs are 2.5 times lower).

Let us consider the mechanism for integrating the logistics block into the strategic management model, since it has a significant impact on the interregional and intra-farm life of the agricultural holding. Due to the nonlinear behavior of the logistic model, it seems reasonable to use the logistics block when designing crop rotation in the simulation mode (*Fig. 6*), one of the variants of which is described in [21].

The mathematical model of strategic management considered in [25] refers to static linear models, which, due to the existing powerful mathematical apparatus, are used in the overwhelming majority of studies in the field of strategic planning. Although agriculture is a weakly structured system with significant nonlinear dependencies, their formalization is quite complex. For example, the Liebig principle, published by the German scientist Justus von Liebig back in 1840, is still in use, and neither artificial intelligence, nor mathematical nonlinear methods can improve it. In practice, according to academician Dorodnitsyn, over 98% of mathematical models are linear. For example, back in 1970 to refute the statement of Nobel laureate Robert Solow about the absence of an economic effect from the computerization of the economy, the Economist Intelligence Unit used a simple Cobb–Douglas function, which becomes linear after taking its logarithm.

However, while using such an approach, the most serious problem in strategic management modeling tasks is finding the optimal process of transition from a known initial state of the system to the target state determined by strategic planning. Most works consider strategic management only as developing a long-term plan. A mathematical model of the second stage of the transition processes optimization is given in [25].

Conclusion

The approach to optimization of strategic management in agricultural production is discussed in this work. The basis of this approach is a management information system, which should be created in each agricultural holding on the basis of a single DMP of production. After the implementation of the DMP in the selected holdings this approach can be extended to other enterprises and farms, which could act as some additional links in the global supply chains of holdings on the principles of outsourcing. The construction of an MIS of enterprises on a single DMP will allow an entire agro-industrial complex to arrange an effective transition to organic farming with minimization of environmental risks caused by the harmful effects of natural and human factors on the products.

Successful implementation of the solutions implemented in DMP requires the availability of structured and ontologically verified information: on completed technological operations (for example, using the Internet of Things), on monitoring results, on the state of cultivated and harmful plants and soil, on the required volumes of equipment and chemicals applied, as well as other information stored in the DMP database that is essential for implementation of farming technologies. Thus, in crop production almost all cultivated plant experimental technologies for the introduction of nutrition and protection of products are being developed. All this information should be collected

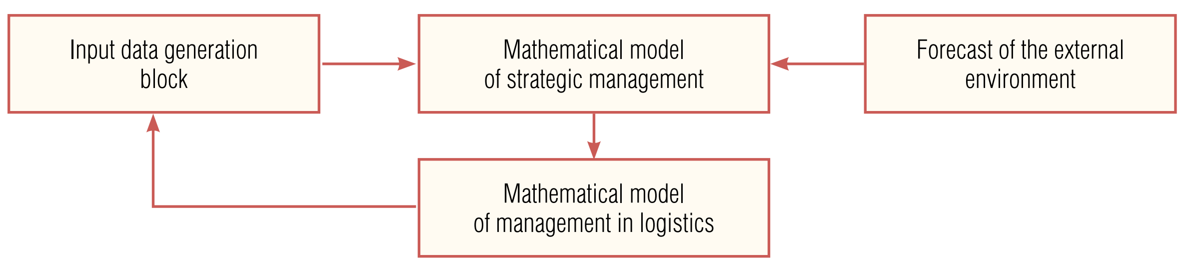

Fig. 6. Scheme of embedding the logistics block into the strategic management model.

and used, however the problem is complicated by the refusal of large enterprises to provide the necessary information even to the Ministry of Agriculture. This fact was manifested in attempts to test the model in practice, taking into account the accumulated experience within the framework of the "Electronization of Agriculture" program, in collaboration with experts from the Kuban Research Institute of Agriculture, which has large long-term experimental material on the formation of crop rotations.

The model was tested for adequacy on one of the farms in Krasnodar Region, which has over 7 thousand hectares of land (with two groups), for which recommendations for the use of crop rotation were available. The implementation, confirmed by the State Committee for Science and Technology document, showed the economic effect of increasing the yield of grain and leguminous crops by 4 c/ha without additional costs.

This experience has shown that violations of crop rotation in Russia and the lack of necessary accounting of technological operations do not allow collecting the initial information required for the model. Although the highly developed agriculture of Kuban Region significantly surpasses other regions in terms of information, it was not possible to collect all the information necessary to implement the full model, so a significantly simplified model was implemented. In this case, the necessary data had to be restored by statistical methods based on data from other farms. This is evidenced by studies showing that over 85% of the industry information is stored either on paper, or in spreadsheets. Moreover, in many farms important information is not stored at all.

This was the reason for the lack of sensitivity studies of the model. It was important to check its behavior when forming crop rotations for the choice of fields depending on the continuous or scattered method of fields placing, since this significantly affects fuel consumption, time characteristics and overall production efficiency. The continuous method is used in the case of large areas of land of one agro-ecological group located on a geographically uniform array and claiming to accommodate one of the crop rotations. Such geography and the physical and chemical properties of the soil suggest placing all fields directly next to each other. The scattered method is used in the case when fields belonging to one agro-ecological group are placed on land plots geographically isolated from each other. Simulation calculations have shown the importance of this point, so work is being carried out regarding an optimization model, which is reduced to a variation of the problem of packing in containers. ■

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About the authors

Vladimir I. Budzko

Doctor of Sciences (Technology), Academician of Cryptography Academy of Russian Federation;

Chief Researcher, Federal Research Center "Computer Science and Control" of the Russian Academy of Sciences, 44-2, Vavilova St., Moscow 119333, Russia;

E-mail: vbudzko@ipiran.ru

ORCID: 0000-0002-8235-0404

Viktor I. Medennikov

Doctor of Sciences (Technology);

Leading researcher, Federal Research Center "Computer Science and Control" of the Russian Academy of Sciences, 44-2, Vavilova St., Moscow 119333, Russia;

E-mail: dommed@mail.ru

ORCID: 0000-0002-4485-7132