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# Экономические инструменты в программах устойчивого развития природопользования

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**Аннотация.** Статья посвящена исследованию экономических инструментов, которые могут быть эффективно использованы при разработке программ устойчивого природопользования. Целью исследования является изучение экономических инструментов, необходимых для разработки имитационных моделей решения задач в области устойчивого природопользования. Методы исследования: анализ, сравнение, обобщение и систематизация информации, апперцепция и описательный метод. Авторами поставлены цели, проведена их системная реализация и получены результаты, связанные с анализом экономического инструментария, используемого при разработке программ устойчивого природопользования, а также выбран экономический инструмент для формализации и количественного обоснования эффективности и реализуемости принимаемых управленческих решений и различных целей устойчивого природопользования. Актуальность темы и ее новизна определяются необходимостью разработки оптимальной системы управления природопользованием, наиболее подходящей для всех его участников. Выбор экономических инструментов осуществляется в процессе моделирования экономических систем. Обосновано, что имитационное моделирование является наиболее эффективным экономическим инструментом управления природопользованием. Имитационное моделирование применимо для решения различных задач устойчивого развития, устойчивого природопользования и оптимального управления территориями. Имитационное моделирование дает возможность анализировать массивы данных, разрабатывать модель, проверять ее эффективность и охватывать наиболее важные факторы. В статье описывается инструментарий, который авторы рекомендуют использовать для экономического обоснования программ устойчивого природопользования и учета наиболее значимых факторов в моделях при их разработке. Авторами установлено, что процесс моделирования не является статичным, современные подходы к анализу данных позволяют совершенствовать ранее разработанные модели и выбирать наиболее подходящие экономические инструменты для их анализа.

**Ключевые слова:** план, прогноз, модель, контроль, система, устойчивое развитие, природопользование, оптимизация, имитационная модель, эффективность, факторы, важность

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# Economic instruments in sustainable nature management development programs

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**Abstract.** The article addresses study of economic instruments, which can be effectively used in development of sustainable nature management programs. Purpose of the research is to study economic instruments required for development of simulation models for problem solving in the field of sustainable nature management. Research methods: analysis, comparison, generalization and systematization of

information, apperception and descriptive method. The authors had set the objectives, systematically achieved them and obtained the results related to analysis of economic toolset used in development of sustainable nature management programs, as well as selected an economic instrument for formalization and quantitative substantiation of efficiency and practicability of managerial decisions made and various objectives of sustainable nature management. Timeliness of the topic and its originality are defined by a need to develop an optimum nature management control system that will be the most suitable for all its participants. Selection of economic instruments is made within the process of economic systems modeling. Simulation modeling was substantiated as the most efficient economic instrument in nature management control. Simulation modeling is applicable to solution of various issues of sustainable development, sustainable nature management, and optimal territory management. Simulation modeling offers the possibility to analyze pools of data, develop a model, test its efficacy and cover the most important factors. The article describes a toolset that the authors recommend to use for economic justification of sustainable nature management programs and consideration of the most significant factors in models during their development. The authors have found out that modeling process is not a static one, modern approaches to data analysis make it possible to improve previously developed models and choose the most suitable economic instruments for their analysis.

**Keywords:** plan, forecast, model, control, system, sustainable development, nature management, optimization, simulation model, efficacy, factors, importance

## *Introduction*

Timeliness of the topic is that modern conditions of economic systems development require selecting the most effective economic instruments for their implementation into sustainable nature management programs.

This will help to extract the most probable trends, control problems, and to find a way to analyze and solve them. Selection of economic instruments for formalization and quantitative substantiation of effectiveness and feasibility of managerial decisions made, as well as solution of various issues of sustainable nature management has to be justified.

These problematics are covered in the researches of nature management control professionals, both national and foreign, including K.G. Gofman [7], M.Ya. Lemeshev [13], G.E. Mekush [15], G.M. Mkrtchian [9], A.L. Novoselov [16], I.M. Potravniy [17], N.F. Reimers [18], N.A. Chernykh [19] and others.

Economic system is formed under the influence of many factors. Some of them can be analyzed using standard economic instruments. But there are always hidden factors latent to the economic system. This is why economic instruments usually allow only to conduct an indirect analysis of factors. In order to solve the issues of control and sustainable nature management to the fullest extent possible, all factors affecting the economic system shall be taken into account.

It is impossible to solve such an issue completely. Economic instruments help to identify the most important significant factors when developing a model for sustainable nature management programs. These economic instruments may include “market balance model”, for example. Market balance model, also known as the model of exchange, is one of the commonest mathematical economic models used in analysis of interactions between economic system participants [2]. The model helps to find market clearing prices based on customer and manufacturer behavior analysis.

Customer behavior is influenced by two major factors:

– Subjective utility of a certain item of goods to a customer, customer-related efficiency;

– Price of a purchased item of goods, determined by the best price-ultimate price ratio.

Another economic instrument is forecasting. Such a developed economic system as nature management requires long-term forecasts. Forecast has to consider system state changeability, including the state of uncertainty. Potential losses due to adverse scenarios of forming market conditions shall be taken into account in the forecast as well. Economic instruments of forecasting and modeling should consider risk and uncertainty, probable states of the medium where economic system is formed.

Mathematical modeling distinguishes two main approaches to modeling of economic systems with unidentified factors [11]. This leads us to the following approaches and economic instruments for description of nature management control models.

The first approach is as follows. Function relations of the model, modeled control system, are static. These models are called models with unidentified factors.

The second approach to economic systems modeling is based on a principle where variation interval of model input variable is known. These models are often called models with incomplete data [3].

This approach is used in international economic activity planning, when it is necessary to take country risks into account, but it is impossible to predict actions of foreign partners exactly. Unidentified factors of economic systems appear due to insufficient knowledge of processes, values etc., affecting the results of economic activity of economic system agents.

Assessment of managerial decisions efficiency in the field of nature management requires long-term consistent forecasts which will be able to show consequences of made decisions properly. Also, control models should allow for follow up. Follow-up instrument makes it possible to correct initial data and increase efficacy of economic instruments used, if necessary.

It is worth mentioning that forecasting models were used in many countries worldwide in order to assess macroeconomic decisions.

Basic instrument for analysis of sustainable nature management programs is mathematical modeling.

Mathematical modeling is the main instrument for economic systems analysis. Mathematical modeling includes a wide range of economic and other features for data analysis, uncertainty management, planning, forecasting etc. Long-term forecasting and assessment of efficiency of economic instruments use in the longer term are possible only with the use of mathematical modeling. For example, models of long-term macroeconomic forecasts can be used.

The main issue in the course of developing sustainable nature management programs is selecting the most suitable economic instrument for formulation of a control strategy for nature management subjects included into these programs. This requires preliminary selection of the most effective economic instruments.

## *Materials and Methods*

Modeling is related to description and study of economic systems, complexes of nature management, for example. As a part of the study, some separate enterprises may be analyzed to reveal the extent of influence of a wide variety of factors on their activities, interaction with environment, and economic system within the framework of sustainable nature management in order to find optimal and sustainable solutions.

Subject domain of the study is an economic toolset used in development of sustainable nature management programs.

Sustainable nature management is an integral economic, environmental and social system that uses natural resources to the fullest extent and makes it possible to reduce the amount of consumed resources by system participants, both resource suppliers and consumers.

The purpose of the research is to study economic instruments required for development of simulation models aimed at solving the issues of sustainable nature management.

The objectives of the research:

– Analysis of an economic toolset used in development of sustainable nature management programs;

– Selection of economic instruments for formalization and quantitative substantiation of efficiency and practicability of managerial decisions made and various objectives of sustainable nature management.

The authors used the following research methods: analysis, comparison, generalization and systematization of information, apperception and descriptive method.

Analysis method was used to divide features of economic instruments, and define their advantages and disadvantages.

Comparison method is based on comparison of resource management systems in order to define features in common and distinctions between them.

Generalization method is based on selection and recording of constant characteristics of economic instruments. As a result of generalization, the most important characteristics of economic instruments for formalization and quantitative substantiation of effectiveness and practicability of managerial decisions made from the authors' point of view were selected. The selection was made on the basis of cross-sectoral interactions, variable parameters of sector-specific and foreign trade policies.

Systematization method is based on development of a uniform system of economic instrument characteristics. This method helped to define required characteristics of variable parameters of sector-specific and foreign trade policies in the same manner as variables of economic policy and parameters of tax and financial policy are used in a macromodel.

Apperception method allowed the authors to complement research process with new information from various sources in line with the research trend.

Descriptive method conferred the possibility of concretization of thought process, definition of key words, prioritizing the most important research results.

## *Results*

The authors considered use of various instruments in development of nature management control programs, including use of market balance model, economic forecasting.

One of the areas where mathematical economic models are used in order to develop an optimal strategy of nature management control is forecasting of various economic processes.

Study of an economic system in the context of its external environment analysis is one of the guiding principles of systems theory.

Therefore, the next economic instrument of interest is simulation modeling. Simulation modeling identifies the most probable trends, potential problems etc. The purpose of modeling is also to create an instrument for formalization and quantitative substantiation of managerial decisions made within economic systems. Simulation models are powerful forecasting instruments [2].

Simulation model is a character representation of real objects and processes. Study subject has a large number of characteristics, properties. Formal representation of a model in the form of equations, set of equations is unable to show all of them. During modeling, a set of key properties is identified, which is a challenging task as well.

Challenges of character representation of processes studied in economics should be mentioned. Interpretation of modeling results also expressed in symbols is called desymbolization. At this stage, character and object cannot be assigned to its numerous properties and characteristics. Economic unit studied in a simulation model has not only economic, but also extraeconomic characteristics - social, political, national, cultural, technical, environmental etc. - which cannot be expressed in characters while preserving the level of model complexity acceptable for interpretation. Character representation in simulation modeling will lead to data loss and reduction of data quality and validity of results.

In this regard, let us specify a set of requirements to an economic model: thoroughness and realism of rationales used and assumptions made, ability to verify and provide information support, data aggregation based on primary indicators etc.

The problem when developing a model is to select several factors having the strongest influence on economic system out of an infinite number of factors. Other factors are ignored; their influence is considered as random disturbance and the extent of this random disturbance influence on the modeling results is deemed negligible.

The problem arises if the extent of some factor's influence was mistakenly underestimated and the factor was identified as negligible. In this case, the model will turn out invalid, and calculations and conclusions made according to it - incorrect.

This may be related to changes in properties of the modeling subject or the model itself, for example, during transition from microstate to macroenvironment. Microeconomic models give no consideration to influence of macroeconomic, global factors when studying the behavior of agents. However, transition of modeling subjects from micro- to macrolevel is possible. And the reason for this is globalization processes.

Economy globalization is characterized by significant changes in the extent of global factors influence on behavior of separate economic agents. In particular, it requires improving many developed models, creating instruments for transition from local to global control models.

Model classes include balance models and simulation models. Balance models describe system condition at a time with system parameters being known. Their application is effective in cases when a set of factors having influence on the system condition can be described explicitly. Complex systems, such as nature management, include characteristics of sectors having human impact on environment, and balance models as a modeling instrument and a basis for managerial decision-making are inefficient.

The impact of multiple interactions accumulates and changes the condition of separate system components. Decision-making based on a certain subset of factors or even one factor makes it impossible to classify these models as efficient for nature management.

Forecasting has a significant role in good strategic decision-making in the field of nature management. Advantages of simulation models for forecasting are their relative simplicity, flexibility, ability to modify input data, as well as consideration of planning horizon. This modeling method makes it possible to describe separate interactions between system components. Description of complex and implicit interactions between system components in a simulation model comes down to characterizing relatively simple processes, the totality of which defines the ultimate result. This makes them an efficient mean for economic systems description, including in the field of sustainable nature management.

Non-linear character of relations in complex economic systems makes it difficult, and sometimes even impossible, to find an optimal control strategy. Here, control strategy can be interpreted as a functional that includes a set of parameters required for achievement of an objective. Development of this functional is quite a challenging task.

In simulation modeling, instrument for construction of a set of strategies can be distinguished. According to it, a set of strategies is developed that potentially should lead to the set goal. Implementation results of each strategy are defined using simulation model, and the one with the result closest to the set goal is selected. When this approach is used, the economic system is considered open. The issue with analyzing open systems is to define boundaries between the system and external environment. It is necessary to set a boundary for internal interactions defining the nature of system functioning. Professionals note that it is difficult to define system boundaries.

The system constructed within the selected boundary should be able to generate any situation or difficulty, which may require analysis. Closeness principle assumes that behavior of studied system is not imposed on it from the outside. This approach allows for using an optimal set of instruments for analysis and development of sustainable nature management programs.

It is suggested to select an instrument that considers cross-sectoral interactions as the most efficient economic instrument of nature management control. Nature management development planning model considers variable parameters reflecting sector-specific and foreign trade policy as economic policy instruments, in the same

way as macromodels use variables of economic policy and parameters reflecting tax and financial policy.

Instruments of this model makes it possible to define the state of equilibrium in production industry, when final output of goods in the amount required for ultimate consumption is ensured under existing amount of industrial consumption of each type of resources by each branch. In the simplest case, the model describes cross-sectoral balance. In general terms, the model is described by relations of formula 1-3 [4]:

$$\eta_j = \xi_j - \sum_i \alpha_{i,j} \times \xi_i \quad (1)$$

$$\sum_j \xi_j \times \beta_j \to min \quad (2)$$

$$\sum_i \alpha_{i,j} \times \xi_i \leq \xi_j \quad (3)$$

where $\eta_j$ – ultimate consumption of the goods, manufactured by j branch;

$\xi_i$ – the amount of commercial production of i branch;

$\alpha_{i,j}$ – intermediate consumption by j branch of a product manufactured by i branch;

$\beta_j$ – non-manufacturing costs of j branch.

Cost relationships in the control model are described by formula 4 and 5:

$$r_j = p_j - \sum_i \alpha_{i,j} \times p_i \quad (4)$$

$$p_j = \sum_i \alpha_{i,j} \times p_i + w \times \beta_j \quad (5)$$

where $r_j$ – profit of j branch;

$p_i$ – cost of i branch product;

w – wage rate.

In this model, natural resources are not production factors, because the product of other branches is used during their extraction and production factor is labor. Natural resources are limited. They are either excluded from the model or considered as a product of one of the branches. As a result, the model in this state is not completely suitable for description of sustainable nature management programs and has to be clarified. When modeling, it is necessary to take peculiarities of natural resources utilization in business processes into account. Any source of resources has natural constraints, which prevent increasing the amount of its utilization at discretion. This applies both to renewable and non-renewable natural resources. For non-renewable resources, a deposit can provide an output of a certain amount of resources in a certain time period.

## *Discussion*

Mathematical simulation modeling in economy started to develop in the 20th century. One of the first applications of mathematical models was modeling of population size,

changes in its dynamics. Mathematical, simulation models of open systems are the most commonly used. Hypotheses of kinetic properties of processes (growth rate, reproduction, death, interaction intensity, damage etc.) are introduced into a mathematical model. The model processes the information and helps to study space-time structure formed in real and hypothetic system qualitatively and quantitatively, reveal cause-and-effect relations. Mathematical modeling and study of processes at the level of biogeocenosis are of particular interest and form a basis for studying the nature management processes in the works of I.M. Avramenko [2], T.F. Gurova [8], N.F. Remers [18], N.A. Chernykh [19]. The main principles laid down by professionals into modeling are universal conservation laws, balance mathematical equations of particle number, matter, energy conservation, as well as principles of transference, transboundariness. These provisions are reflected in the works of A.N. Beshentsev [6], K.G. Gofman [7], N.G. Komarova [12], M.Ya. Lemeshov [13], E.R. Magaril and V.N. Lokket [14], G.E. Mekush and A.A. Panova [15], A.S. Novosielova and A.V. Faleeva [16], I.M. Potravniy [17] et al. Methods of stability theory and bifurcation theory are used for research. This does not mean that models require no improvement. Modern data processing instruments on the basis of big data technology allow for improving even conventional models and suggesting improved models for sustainable nature management. They were reviewed in researches of I.M. Avramenko [1], O.E. Astafieva and A.V. Petriuk [5], K.G. Gofman [7] et al.

The instruments recommended by the authors for economic substantiation of sustainable nature management programs and consideration of the most significant factors in models during their development were used by researchers in order to solve local modeling issues, including P.C. Annes [3], I.N. Dubina, G. M. Mkrtchyan [9], O. V. Gritskevich, V.A. Pavlenko [10], M. Kerf , A.K. Izaguirre [11], E.O. Ushakova, S. A. Vdovin, A.V. Dubrovsky [20]. In the model presented by authors, natural resources are not production factors, because the product of other branches is used during their extraction and production factor is labor. Results obtained in this research confirm the results specified in the works of G.M. Mkrtchyan [9], M. Kerf [11]. The authors have found out that modeling process is not a static one, modern approaches to data analysis make it possible to improve previously developed models and choose the most suitable economic instruments for their analysis, which is supported by the results of P.C. Annez [3], O.V. Gritskevich [10].

## *Conclusion*

The most suitable instrument for making optimal managerial decisions in regard to economic system is simulation modeling. Usually, sustainable nature management programs cover certain territories. Control includes a large number of components, factors of significant influence on development of territories. Interrelations of internal components, as well as internal and external components, are complex and only the simulation modeling instrument can take their impact into account and suggest a set of optimal control and development strategies in sustainable nature management programs. Simulation modeling under specified initial conditions helps to define system development direction providing for cross impact of all factors and follow-ups, assess quality of control model, which covers all factors influencing the sustainable nature management program.

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