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# System Approach to Simulation of Sustainable Development of Regions

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**Abstract.** Applying the system analysis methods of agro-industrial region with the given known social-economic development indices, logical-mathematical structural model of sustainable development was offered and system analysis of the properties of the model was performed.

**Key Words and Phrases**: sustainable development, system analysis, mathematical model.
**2010 Mathematics Subject Classifications**: 36E48, 37A05

## 1. Introduction

The problems of transition to sustainable development of regions belong to the class of large -scale problems and their sound and timely decision play the basic role for providing long-term security of strategical and national interests of the country. By its structure, the decision of sustainable development of regions requires application of the methods of analysis and investigation of complex systems. In our days, the system analysis successfully applied in solutions of various problems and with wide spectrum of methods and means, by theoretical and applied methodology, is also used in studying complex systems [2,3]. System analysis entirely studies the problem under investigation and based on interaction of various alternative solutions enables to solve it with regard to uncertainties, information shortages and inexactnesses encountered in measuring. The first system analysis models for the developing economy was created in 1979 [4]. Thus, applying the system analysis methods, one can determine the mechanism of inner structural relations to forecast sustainability of the system to external effects and dynamics of activity of a complex system and based on this, to create effective methods and means for control of the system

## 2. Problem statement

By applying system analysis methods of agroindustrial region with known geographical characteristics and social-economic development indices given on certain time interval to create logical-mathematical structural model of sustainable development and applying this method based on complex interrelation of economical parameters of the region and to determine mechanism all possible influences.

 

## 3. Solution of the problem

Every region forms a complex social -economic system together with its natural-geographical features. Beingan open system, this system provides its economical, social sustainability by making information and metabolic exchange. Note that region develops by the influence of internal and external forces. Under internal forces we mean resources, possibility of using modern technology and existence of appropriate labour force, the opportunity of siting of production objects, ecological state, geological-morphological, physical-geographical, climate and ground properties of environment. The demand to production and consumption of natural resources, existence of energy and transport relations with other regions, etc. belong to external forces. In this case we can consider the region as a complex system of informative elements of interacting macroeconomical structures connecting the similar economical subjects.

Alternation of every informative medium is accompanied by change of material and financial balance. The material balance changes because of exchanges of regions resources between production exploitation and medium. In this case, the sustainable development function will be in the form:

$$\begin{cases} F_{sustainable\ development}(T+1) = f(X_{xar}(y_1, y_2, ..., y_m, T)) \\ \int\limits_0^T G\left(E_{cological}(t), E_{social}(t), E_{financial}(t)\right) \to \min \\ F_{sustainable\ development}(0) = F_0 \end{cases} \tag{1}$$

Here $X_{dax}(x_1, x_2, \cdots, x_n, t)$, $X_{xar}(y_1, y_2, \cdots, y_n, t)$ are vector functions formulated by the action of internal and external factors, $G(E_{cological}(t), E_{social}(t), E_{financial}(t))$ is ecological, social and financial balance equation based on similar criteria that ensure continuous development.

Each balance equation is constructed for specific region with regard to social, economical and ecological state.

The first equation of this system is a functions that determines the dynamics of sustainable development . At each moment $T$ as the indicator of ecological, social and financial features, this functional formulated under the action of internal and external factors in addition to individual features of the region is structured also with regard to regularities in the scale of the whole country. Various researchers offer different approaches for constructing this function.

For example, in [5,6] demographic development of population is taken as a main parameter and in "sustainable development" functional given by the Fehrlust equation is structured:

$$\frac{dN}{dt} = A \cdot N - B \cdot N^2.$$

Here, $N$ is the amount of population, $A$ is a factor formulated by mean indicators birth, of death, immigration and emigration, $B$ are the factors characterizing internal competition. In this model, the main assumption is to choose the main parameter, human resources for "sustainable development". But this factor (even if it is the main indicator)

can not cover on the whole dynamic picture of multiparameter system. In [7,8,9] this functional is given in the form of complex multiplicative relation expressed by periodically charging factors of ecological, social and economical development functional. There models enable to study dynamics of economical processes with regard to multifaceted complex relations. Difficulties of application of strong mathematical formulas and rules to creation of economic models is that the problems of investigation of economical relations belong to the class of unstructurized problems.

## 4. Conclusion

On the whole, by generalizing the existing approaches we can note the following common features of sustainable development models of a region.

1)The sustainable development model of a region should be constructed with regard to vector functions and balance equation of internal, external factors and the known initial state. The model should be constructed not separately for each subsystem, ecological, social and economical spheres, but with regard to their interrelations. As the model takes into account the time factor its usage time is determined by statistical stability of state and balance equations contained in the system.

2) The model should contain parameters that help sustainable development of the country. These parameters should consist of the complex of capital assets mechanism, human and natural resources providing long-term development of a region.

3)The mathematical model reflects the normal state of a region without cataclysms and jumps. New state and balance equations of the model are written for stabilization period. Initial conditions for these equations are structured according to new state.

4) The sustainable development models of a region by its form should be structured as a many- functional optimal control problem on each sphere.

5) As the parameters contained in the model are deterministic, probabilistic and fuzzy, have various nature, a different model should be created for each group of parameters, then they are connected by the universal scale and specified for a concrete region.

Thus, every region may be considered as a dynamic system that changes in space and time, and composed of functionally dependent components.

It this case, having considered one or several of these components as control parameters, we can get the predetermined state of the system within the restrictions formed under the influence certain internal and external factors.

The suggested model may be used to determine properly macroeconomical structural relations when creating sustainable development conception and project of a certain region based on real economical relations.

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