Complex technical modeling of the spatial-territorial system aimed at searching for an integral development indicator

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Abstract. The article discusses the use of complex technical modeling to determine the level of capitalization of territories. An analysis of 17 UN goals for achieving sustainable development is carried out. These goals are achieved following the spiritual and moral principles that ensure the rational use of land and a socio-economic balance between the participants in projects at developing territories. Violation of the "reference" distribution of resources of the model layers causes losses of system stability, which involves the formation of an excess or insufficiency of resources in a particular layer, thereby determining the subject of management of the territory. The materials make it possible to supplement the theoretical provisions of land management, including the introduction of an indicator of socio-economic development of the territory into the theory and practice of land management; capitalization coefficients of some components of the territory, which form the nature of the territory as a land resource with improvements, taking into account the share of each participant in the reorganization of the territory, which allows for integrating the harmonious state of the territory, determining the development of the spatial-territorial system.

1. Introduction

The sphere of interaction between society and nature, within the boundaries of which reasonable human activities become a determining development factor, participates in the reorganization of territories and organizational and technical systems that form a spatial-territorial system together with the territory [1].

Development of the spatial-territorial system is determined by the goal of society. If the goal of the system is defined as sustainable development, in the “nature-society-man” system, the territorial management scheme “... should be subordinated to the creation of conditions for the chrono-integral process of meeting the needs of the present and future generations, while observing the laws of development of Nature ...” [2, p. 48] This requires an integrated approach to the study of the spatial-territorial system using the achievements of various sciences to analyze properties and relationships of all its components.

The UN Sustainable Development Goals can be achieved through the monitoring of the following areas:
1. Zero poverty
2. Zero hunger
3. Good health and wellbeing
4. Quality education
5. Gender equality
6. Clean water and sanitation
7. Inexpensive, sustainable and clean energy
8. Decent work and economic growth
9. Industrialization, innovation and infrastructure
10. Reduced inequality
11. Sustainable cities and towns
12. Responsible distribution (consumption) and production
13. Combating climate change
14. Conservation of marine ecosystems
15. Conservation of terrestrial ecosystems
16. Peace, justice and strong institutions
17. Partnership for sustainable development

These goals cover all areas of human life and determine the purposeful development of the spatial-territorial system. Each of the goals requires research and quantification that allows for the monitoring, management and dynamics of their changes. The application of the "goals-means tree" method [4] made it possible to analyze these goals, reveal their interrelation and interdependence. In turn, the result of the analysis confirmed the need for the development of an integral indicator that allows for tracking the dynamics of goal achievement. The choice or determination of such an indicator will require the identification of relations between the differential parameters of the spatial-territorial system, which are characterized by different quantitative indicators and different dimensions.

2. Results and Discussion

The article discusses the use of complex technical models aimed to determine the ways to search for an integral indicator of sustainable development of a spatial-territorial system.

The UN goals to achieve sustainable development define a set of "values" for humanity. The category “value” means social significance of an object or phenomenon. The history of the development of the “value” preserves its significance to people in various historical and economic conditions, thereby forming the inner world of the individual, and creates positive prerequisites for its further spiritual development and self-improvement.

Humans use natural resources, absorbing them by involving four natural elements: fire, air, water and land. These elements interact under the influence of space and are present in the harmonious state of land, thereby defining it as a generalized indicator of natural harmony.

Land is the main natural element that reflects human activities. In the land management process, "the Earth is a land surface, eventually inhabited by living organisms, surrounded by oceans and airspace, forming a single system" [3, p. 20].

Any human activity requires land as an irreplaceable and only natural resource to achieve the goals. The variety of land properties is reflected in the results obtained. The complex indicator of value that unites all this diversity is reflected in the level of land capitalization; this indicator can be represented as a response of the land to land management activities [5].

A human using land in his activities absorbs its resource:
- in agriculture, land is the main means of production, the level of unrecovered absorbed resource depends on scientific and technological progress in agriculture. This land property determines the second and third goals set by the UN and depends on the parameters related to the ecology of climate and natural resources;
- in forestry, land also plays the role of the main means of production and serves to preserve or recreate natural complexes. This property determines the achievement of the sixth, thirteenth, fourteenth and fifteenth goals of the UN and depends on the eco-culture of humanity;
- in the extractive industry, land is a subject of labor, and a spatial operating basis for the location of non-mining enterprises. Replenishment of this resource depends on the level of technology for the extraction of minerals and environmental restoration works. These properties of land determine the ninth goal set by the UN and affect the achievement of the thirteenth, fourteenth and fifteenth goals;
- in the manufacturing industry, land plays the role of a spatial operating basis, replenishment of the resource depends on the efficient use of engineering infrastructure, an appropriate level of production ecology and living conditions of people;
- in the housing and communal sector, land serves as a material basis of life for a person, land reproduction depends on the environmental friendliness and energy efficiency of buildings. This property reflects the seventh and eleventh goals of the UN;
- in the transport sector, land is the material condition for the location of linear objects, reproduction of depends on the environmental friendliness of transport systems.

The analysis of land properties shows that the spatial-territorial system must be considered as a constantly changing complex under the influence of a human, i.e. it is a dynamic system. The equilibrium is ensured by a rational system of resource allocation in a harmonious structure of this system which determines the achievement of the first, tenth, twelfth and seventeenth UN Sustainable Development Goals.

In terms of the economic approach, the usefulness of social institutions and a creative personality is determined by the results of practical impacts on the population through creative products and services of workers in the sphere of culture, art, education, sports and religion. This impact is reflected in the corresponding spiritual transformations aimed at meeting social needs of people and reflects the fourth, fifth, eighth and sixteenth goals of the UN.

Thus, all the UN sustainable development goals depend on land properties. Of all the listed properties, one can see an energetic relation and an exchange of creative human energy of man and land energy. It is most likely that the harmony of this interchange contributes to the sustainable development of the spatial-territorial system. This reveals the wave nature of development of the "nature-society-man" system.

By creating real estate objects, the human person involves the land into socio-economic relations. He involves land into property relations in the form of land plots which are the basis for investment processes, the lever for the socio-economic development of the spatial-territorial system.

The mechanism of reproduction of resources involved in human life and distribution of the results of this activity depends on the form of ownership. Therefore, the basis for sustainable development is the state structure and the adopted structure of territorial management, taking into account the prevailing forms of ownership of land plots and principles of distribution of resources. The dominant owners should develop the spatial and territorial system.

As an object of socio-economic relations, land plots play a multifunctional role in the development of the spatial-territorial system. Their wear determines the possibility of development of the spatial system. Therefore, the state of the spatial-territorial system should be considered only when disclosing the specifics of the impact of human activity on the rational use of land plots.

The “value” of land is determined by the factors that contribute to its rational and efficient use, therefore “value” is a characteristic reflecting the diversity of land properties, depending on human activities.

Depending on the efficiency of human activities aimed to create artificial objects - real estate objects, tools and industrial products, the flow of energy to the land changes. This flow causes a reverse reaction of land, which can be numerically expressed (as a coefficient), reflecting the efficiency of the land plot and indirectly characterizing the state of scientific, technical and social communication. The dynamics of changes in this coefficient should present a non-decreasing function subject to the sustainable development of the spatial-territorial system.
In countries with market economies, management of the spatial-territorial system is based on changes in the market value. The market value calculation is based on the price information prevailing under certain economic conditions. However, both the price and the economy undergo significant changes due to external factors. Therefore, the market value cannot reflect the dynamics of changes in the system. In addition, when calculating the market value, human impacts on the environment and costs for the restoration of natural resources are not taken into account.

Thus, we can conclude that the exchange of goods, determined by the efficiency of exploitation of land plots, contributes to the social communication; the ability of a human to utilize products with the maximum return rate of land energy reflects the development of earthly life.

An analysis of factors that determine the development of the spatial-territorial system shows that individual components of the system, having the same purposefulness, are multidirectional in relation to resources; there are components that absorb the resource and components that create the resource. In addition, among those creating the resource, one can distinguish components that stimulate creative activities and components that are constructive. This state of the spatial-territorial system does not allow us to apply a systematic approach based on the unidirectionality of components.

A distinctive feature of the complex technical modeling is that it presupposes the presence of components whose functionality is opposite in terms of resource consumption and production [6]. The harmonious state of the complex system is determined by the equilibrium ratio of the multidirectional resources of the components subordinate to one goal. In addition, complex engineering includes an active element - a human who changes the structural equilibrium of the system due to the scientific and technological progress. The fundamental principles of complex technical modeling correspond to peculiarities of the integrated spatial-territorial system.

Taking into account the evolution of urban development [7], a comprehensive model was developed for built-up areas. In [8], the model of a complex object was formed, properties of the model were determined for a land plot.

The scope of this model was expanded, and [9] shows the functionality of this model and the significance of the "territory" layer in ensuring the structural homogeneity of the model.

This model was based on the recurrent dependence of its layers in mutual directions, both from the bottom up, from the abstract to the concrete, and from the top down, from specific needs of the inhabitants to peculiarities of territories. As a consequence, the criterion for the rational integrated development of territories depends on the level of its capitalization. Using this model, functional dependencies of the model elements in the market valuation method, relationships and interdependencies of economic parameters characterizing the spatial-territorial system, and a method for calculating the capitalization ratio for a land plot were developed [8]. These works showed that changes in each system layers affect the efficiency of land management, and determine the level of land capitalization, being indicators of the investment project expediency.

To develop objective methods for assessing the value of agricultural land by the calculated value of the capitalization ratio, a comprehensive model of land management was developed [5]. Unlike the model of a complex reorganization object, which considers a territory with an already formed land plot (the "territory" layer of this model is considered as a single component (geographical location, natural resources, climate, human resources, etc.), in this land management model, this layer is dismembered into two components ("land" and "land management") [5]. Depending on the functional purpose of the territories, the content of this model changes, preserving the structure and functional significance of each system layer [5].

As a result of these works, a generalized complex triple model of the territory was developed. It includes an organizer of the territory reorganization, a model of land management and a model of the system of executors of the territory reorganization project.

The mutual influence of the layers is evident when implementing the system of ecological building construction [10].

The arrangement of the territory is entrusted to the organizer, who must manage the interaction of project executors, thereby structuring the model [8]. The model contains a recurrent dependence of
eight system layers, which make up four pairs with different orientations to resources. One layer has a stimulating effect on the second constructive layer [8].

Having determined the weight of each layer of the model, the method of economic analysis described above allows us to calculate the capitalization ratio of the land plot and all layers of the models, provided that the system is in a harmonious state ("reference" state). Changes in the deviation of the real state from the "reference" value give information about the development or degradation of the system. Since the capitalization ratio is dimensionless, it becomes possible to compare the use of various land plots and track the dynamics of changes in the effectiveness of individual layers of the model in the territory capitalization.

3. Conclusion

All land properties reflect the nature of human existence and a set of values that are inherent in society. The models reflect the state of territories and their individual components. Scientific and technological progress and innovations change the ratio in resource provision and reproduction of the land resource, creating a disequilibrium in the elements of the system which determines its development. Violation of the "reference" distribution of resources of the model layers causes losses of its stability, which involves the formation of excessive or insufficient resources in a particular layer, thereby determining the subject of territory management.

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