Study of Elements of System Analysis in Relation to the Development of the Territories of Megacities

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Summary

For any large territory, optimal and comprehensive development of the territories is important. All possible directions of such development should be taken into account: economic, social, demographic, transport, ecology, residential and selitebic zones and much more. All these directions (subsystems) are mutually connected and in the development of one of the subsystems, it is necessary not to forget about others. Thus, for the integrated development of the Territories, it is necessary to create a multi-purpose function that would lead to the optimal development of all subsystems. This is the purpose of the System Analysis. But, unfortunately, this analysis was hardly used for the development of the territories. The development of territories is understood to be the transformation of socio-economic conditions of life, ecology and other components in a certain direction. This direction is determined by the target system. The main, integral target and target for each subsystem are distinguished.

For example, the main, integral goal of socio-economic development of the Territories is to improve the quality of life of the population. This means raising real incomes (which makes it necessary to develop production and related employment of the population), improving the social infrastructure of cities and settlements aimed at increasing the opportunities of people to receive medical care, to be able to live comfortably, to learn throughout their lives, to be able to engage in sports, rest for their interests, and to develop transport accessibility.

Sub-goals are set for each of the above subsystems. Thus, from the point of view of system analysis, a multidimensional goal appears. However, since the subsystems are interconnected, it is not possible to fully achieve such a multidimensional goal. Therefore, it is necessary to identify the most important goals and to prioritize them. Understand which sub-goals can be implemented not completely, but partially. And to what extent partially. Thus, a task does not appear with a multidimensional target, but with some function from a multidimensional target. And this function should lead to the most optimal and effective result of the Territory 's development. It should be borne in mind that the modern interpretation of the development of the Territories indicates the need for harmonious and sustainable

development of the Territories.

Для любой крупной территории важно оптимальное и комплексное ее развитие. Следует учитывать все возможные направления такого развития: экономические, социальные, демографические, транспортные, экологические, жилые и селитебные зоны и многое другое. Все эти направления (подсистемы) взаимно связаны и при разработке одной из подсистем, надо не забывать о других. Таким образом, для комплексного развития территорий необходимо создать многоцелевую функцию, которая привела бы к оптимальному развитию всех подсистем. Это назначение системного анализа. Но, к сожалению, этот анализ практически не использовался для развития территорий. Под развитием территорий понимается трансформация социально-экономических условий жизни, экологии и других составляющих в определенном направлении. Это направление определяется целевой системой. Различают главную, интегральную цель и цель для каждой подсистемы. Например, главная, неотъемлемая цель социально-экономического развития территорий - повышение качества жизни населения. Это означает повышение реальных доходов (из-за чего необходимо развивать производство и связанную с ним занятость населения), совершенствование социальной инфраструктуры городов и поселений, направленных на расширение возможностей людей получать медицинскую помощь, иметь комфортное жилье, учиться на протяжении всей жизни, уметь заниматься спортом, отдыхать в своих интересах, развивать транспортную доступность. Подцели устанавливаются для каждой из вышеуказанных подсистем. Таким образом, с точки зрения системного анализа появляется многомерная цель. Однако, поскольку подсистемы взаимосвязаны, невозможно полностью достичь такой многоаспектной цели. Поэтому необходимо определить важнейшие цели и определить их приоритетность. Понять, какие подцели можно реализовать не полностью, а частично. И до какой степени частично. Таким образом, задача появляется не с многомерной целью, а с некоторой функцией от многомерной цели. И эта функция должна привести к наиболее оптимальному и эффективному результату развития территории. Следует учитывать, что современное толкование развития территорий свидетельствует о необходимости гармоничного и устойчивого развития территорий.

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1. The bases of the use of systems analysis for the development of territories.

System analysis - many scientific approaches, methods, techniques for solving complex problems in various spheres of human activity. Including problems of territory development. The system is considered as a set of interconnected objects (subsystems) aimed at achieving a common goal. It should be understood that the properties of an entire system may differ from those of its constituent subsystems. Therefore, the system is generally characterized by its own, specific parameters that are not determined by the characteristics and parameters operating in its subsystems (elements). System analysis is often applied in conditions of fuzzy initial data, fuzzy task setting. System analysis is a science that is closely related to decision-making theory.

It is common to assess the effectiveness of the management of the development of the territories by the dynamics of the level of socio-economic development of the territorial entity. There are various approaches and methods for assessing the level of socio-economic development. They are conditionally divided into international, federal, regional, local.

In planning the development of territories there are situations in which it is not possible to present all parameters in numerical form. There are only some qualitative characteristics on which decisions must be taken in order to achieve the Goals. Within the framework of system analysis, various mathematical disciplines are used at its various stages, among them: system theory, graph theory, information theory, probability theory and others. The overall system analysis structure can be represented as the following diagram.

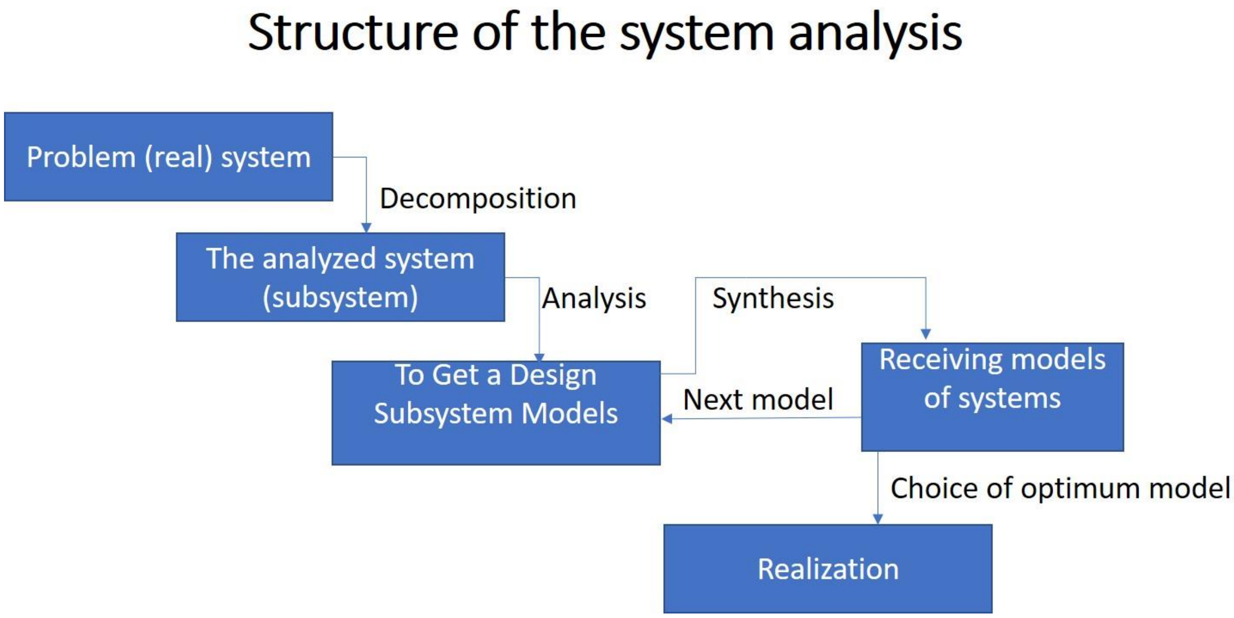

Fig. 1 Structure of the system analysis

In decision theory, decision criteria are very important. These criteria are related to the targets selected for each subsystem and are actually functions from the parameters of a particular subsystem. For example, on housing. It is possible to set the goal - to put into operation in five years a certain amount of living space. It is possible to limit the number of floors of buildings under construction, thus reducing the population density. Hence, the goal can be set to provide housing for all residents of the city without exceeding a certain value of population density. It is clear that this parameter must be consistent with the parameters of other subsystems. In particular, the production capacity of the region should be calculated on the basis of population size. A general diagram of the relationship between the main target and the sub-goals can be presented as follows.

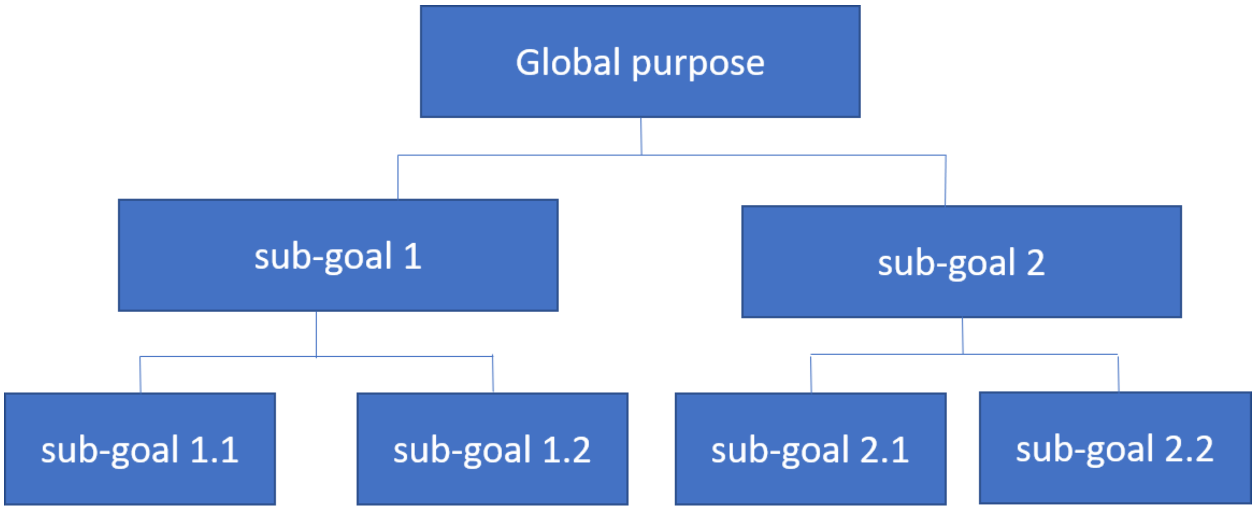

Fig. 2. The goals tree

The figure shows how a global target is generated from a sub-goal hierarchy. Some target formation techniques involve analysis by comparing and evaluating sub-goals. If a complex system such as territorial development is considered, it will be seen as a dynamic system that changes its parameters over time. Therefore, sub-goals at various times may, depending on the state of the system, be transformed.

In the dynamic version, a scenario is constructed of a sequence of events arising from a particular solution that may occur in the future.

In case of insufficient population, temporary workers of other regions will have to be invited. If the number of inhabitants is significantly higher than the demand for productive capacity, the unemployment rate in the region will increase. Thus, production facilities and housing are closely linked to each other. At the same time, all these subsystems affect the environmental situation. And this influence can be expressed in different ways. For example, harmful emissions of production will exceed the permissible standards for some parameters. For example, waste-processing or waste-burning plants will not cope with the flow of emerging garbage. As we can see, all components of the system subsystem are closely interconnected. In developing subsystems, it is therefore necessary to have criteria for each objective and their priority. The goals themselves must be interrelated too. In addition, you must have rules by which you can choose the best solution options. In this step, the analysis obtained from decompression of the constituents is performed.

One decision method is the minimax method. Minimax is a decision method that is used when a solution needs to be selected from a variety of options. These variants are hierarchical and arranged in the form of a tree. I.e. In the first stage, the first level option is considered. When selected, a plurality of next-level events occur, etc. Each stage (variant) is pumped by a situation that can be evaluated. To find out how effective this option is. Let us consider that the estimate is a number obtained according to certain, pre-adopted rules. Final position estimates of all possible (across all subsystems) variants are information that can be used to determine the desired variant. The minimax method describes how, using estimate of information about finite position, to make decisions about the variant that will be best.

There is another method of determining the best option, the ranking method. In this case, the procedure is used to arrange of all variants. Ordering is done based on categories such as better, worse, equivalent, significantly better, and significantly worse. The option is chosen on the basis of own knowledge, experience, skills, skill. On the basis of which, the expert has the options presented in order of preference, usually based on only a few selected comparison indicators.

2. Types of ranking

There are several types of ranking:

2.1 **Direct ranking**.

Direct ranking requires the decision maker to rank the variants that are part of the evaluated group by some indicator. For example, if you select a production object.

NN variants	Parameters of estimation of an object					
	The number of the involved workers		Energy demand factor (0 to 1)		How much the enterprise will replenish the budget of the region	Impact on the region 's ecology. Pollution coefficient
		place		place		
1	2000	3	0,7	2	25% of budget 3	0,5 1
2	4000	1	0,8	3	40% of budget 1	0,6 2
3	2500	2	0,6	1	30% of budget 2	0,8 3

Assuming that the effect of each parameter on the choice of option is the same, we will obtain:

NN	place parameter No. 1	place parameter No. 2	place parameter No. 3	place parameter No. 4	Sum of places	Place of variants
1	3	2	3	1	9	3
2	1	3	1	2	7	1
3	2	1	2	3	8	2

Thus, in the first place in the ranked row will be the second option. Second place is the third option. And on the third position there was the first option. It should be borne in mind here, of course, that we have accepted each of the four parameters as equivalent. But, the decision-maker can attribute to each parameter its weight, which determines its importance. In other words, from the best option to the worst option, from the most effective to the minimum effective. Such a method is good when the proposed objects are compared on several indicators at once. In this case, each evaluation criterion is considered separately, and all collected results can be tabulated.

2.2 The alternating ranging.

In this case, several criteria are also considered. But, the choice of options is made by the expert. He determines the best and worst option based on his perceptions. At the same time a table of the following kind is drawn up (a number of six variants are ranked:

NN of variants	The first iteration	The second iteration	The third iteration Final ranging
1	3	3	3
2		4	4
3			2

4			6
5		1	1
6	5	5	5

Here, the first iteration determines the best option from the point of view of the expert (the second is written in the top line) and the worst (it is written in the bottom line). In the second iteration, the best and worst option from the remaining is selected. There are only two options left in the third iteration. They are recorded by the expert, in accordance with his submission to the third and fourth positions.

2.3 **Method of pair comparison.**

This method uses a pair comparison matrix that is written to the following table.

№ of variants	1	2	3	4	5	6	Sum
1		+	+	-	+	-	3
2	-		+	-	-	+	2
3	-	-		+	-	-	1
4	+	+	+		+	+	5
5	-	-	-	-		-	0
6	+	+	+	-	+		4

Here, the variant numbers are written to the first column and duplicated in the first row. Plus, in the i row means the advantage of this variant, over the variant shown by the j column. The last column shows the sum of the row benefits. The more pros in the row, the better the option and stands higher in the ranked row. From the table you can see that the Best Option is the 4th Option, which has 5 pros. I.e. in method of pair comparison with each option it turned out to be the best. Next in the row is the 6th option. In the last place the 5th option.

The number of comparisons can be determined by formula for the process of comparing pairs. The number of comparisons K = N (N - 1)/2, where N is the number of variants. In this example, 6 variants. The number of comparisons is equal

To =6(6-1)/2=15. And in the table, the number of pros and the number of cons is the number of comparisons.

3. Some methods of system analysis in the development of territories

System analysis has a wide range of mathematical approaches to solving specific problems. Let 's look at some possible approaches of system analysis in relation to the development of territories. The basic concepts of territory development are described above.

Let us approach this concept as some complex system consisting of many subsystems, which can also be decomposed into subsystems. This is the first step in using system analysis - decomposition. It should be noted at once that it is advisable to distinguish between new territories (free), built-up and partially built-up. For example, the development of territories for built-up territories is associated with many conditions that arise from existing and functioning objects. For example, an existing transport network that cannot be constructed as a new object. For its development it is necessary to come from already built network. For example, Moscow has historically developed a road network in the form of rings - garden ring, 3rd transport ring, MKAD. And radial roads running from the center to MKAD - Leningrad highway, Warsaw highway, Yaroslavsky highway, Shelckovsky highway, Dmitrevsky highway, etc. Therefore, further development took place in the construction of chords of these circles. In the construction of non-built-up areas, the network is usually built in the form of rectangles. So, what processes (subsystems) are involved in the development of territories. Subsystems: Region Economics, Social Conditions, Energy, Demography, Transport, Industry, Housing, Underground Communications, Other Real Estate, Ecology, Selitebic Zones, Natural Park, Road Network, Informatization Infrastructure, and many others. These subsystems are closely interrelated and dependent on each other.

The next step. It is a synthesis stage. In our case, for the sake of clarity, the subsystem data can be represented as a set (synthesis) of information layers.

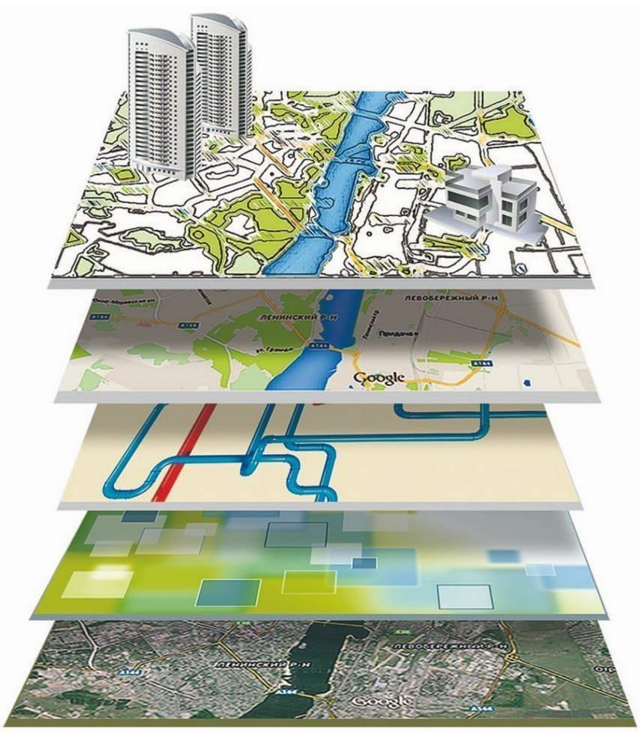

Fig. 3. Information layers (subsystem)

For example, a layer of buildings and structures (housing and other real estate), Road network, energy layer, underground communications layer, etc. Hence, some general models of territory development must be synthesized. From these models one, best by any parameters and criteria is selected. And this best model must be implemented. This is the next step in the system analysis structure. As a mathematical apparatus of modeling, in our opinion, it is convenient to accept the theory of mass service, and as models of systems (the system of development of territories) at this level to use the system of mass service (SMS). The SMS has the concept of simulation's modeling when events are reproduced with time in mind. Dynamic modeling. In this case, it is convenient to use graph theory, but taking into account the dynamics of all processes. This possibility is provided by so-called PETRI networks. The Petri network is an apparatus for simulating dynamic discrete systems (mainly asynchronous parallel processes). This is exactly what we are seeing in the development of territories. A Petri network is defined as a quartet < P, T, I, O > where P are finite sets of positions (states), T are multiple transitions, I input and O-output functions (actions that lead to a new state). As a mathematical apparatus of modeling, in our opinion, it is convenient to accept the theory of mass service, and as models of systems (the system of development of territories) at this level to use the system of mass service (SMS). In other words, a Petri network is a be-fraction oriented graph in which the positions (states) correspond to vertices represented by circles and the transitions correspond to vertices represented by thickened strokes; I - functions correspond to arcs directed from positions to transitions, and O - functions correspond to arcs directed from transitions to positions.

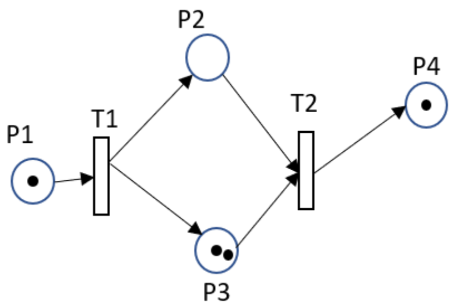

Fig.4. The Petri network. Example.

Vertices of the same type cannot be connected directly. Positions can contain labels (markers) that can move through the network. A petri network event is a network transition in which labels from the input positions of that transition are moved to the output positions. Events occur instantly, or at different times, when certain conditions are met. Here the fat line is the time stage of transition to a new state. Such as commissioning of a facility. For example, underground communications of an area or a fragment of a road network or other object.

The Petri network, in this case, is a dynamic model. But, considering that we are dealing with a system with quite a lot of parameters, goals, which, in fact, are connected with random processes, especially at the stage of task setting, goals, it is possible to build some many such models! For example, taking as a basis how the main goal is socio-economic well-being, we will build one model. If we take, as the main goal of ecology, its stability, the model will be slightly different. Therefore, the next step will be to select the best model to be implemented in the future. The following approaches can be used to select the best model.

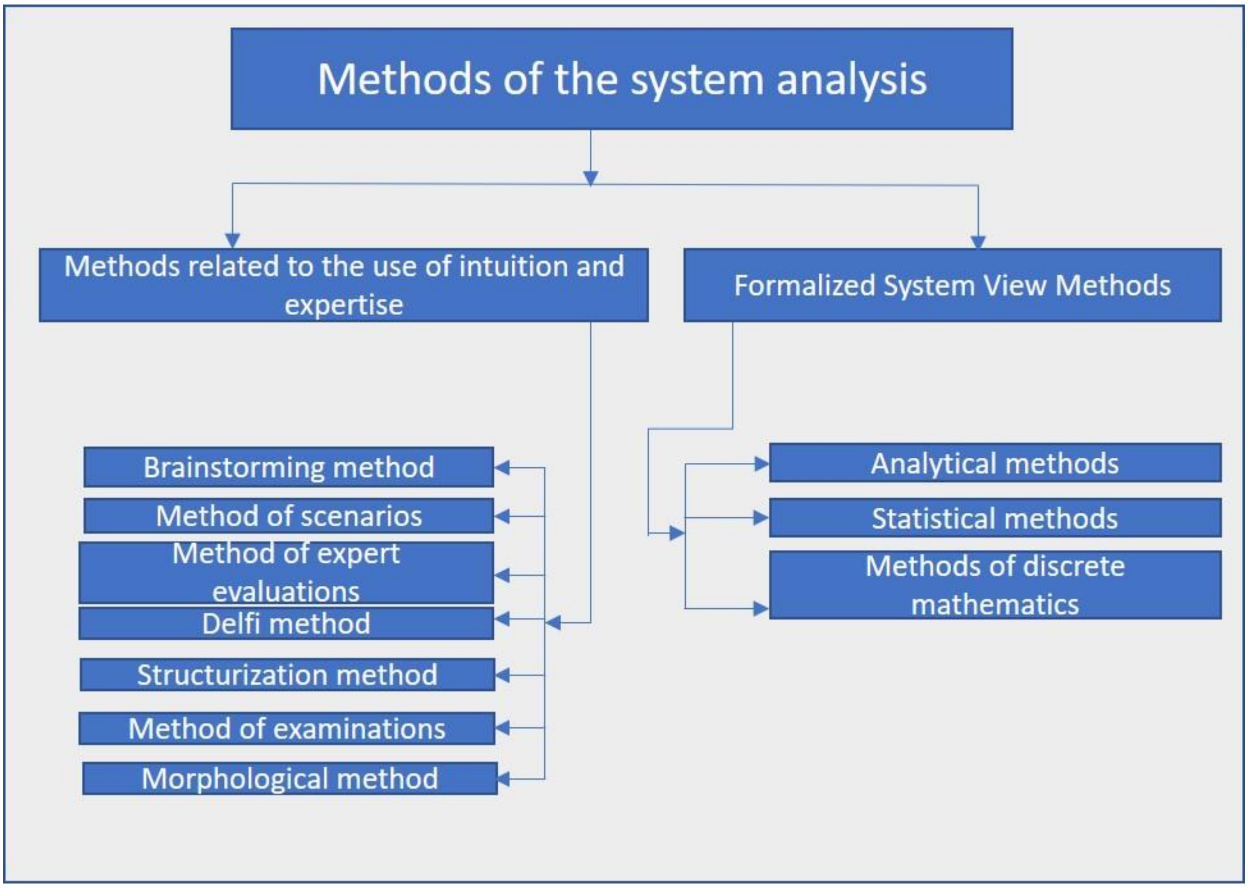

Fig. 5 Classification of system analysis methods

As we can see, methods are divided into two main groups. Methods related to expert evaluation when models are selected based on expert experience. And methods based on the formalization of systems. In the latter case, purely mathematical approaches are used. Statistical methods, discrete mathematics, analytical methods. Based on this approach, the best model that we believe can be implemented with Petri networks is determined.

4. Conclusion.

Analysis of the method of system analysis, its structure, mathematical apparatus, showed that this approach can be used to solve multipurpose problems belonging to the class of dynamic. This is the task of sustainable development of the Territories. But since such an approach, in this area, has hardly been applied in an integrated manner for all subsystems of territory development, it requires serious preliminary preparation of the use of system analysis at each stage. This report only outlines ways to implement this approach. Implementation of it, determination of the optimal structure of use of system analysis, formalization of all stages of territory development requires further scientific research, careful theoretical study of possible use of certain methods and approaches of system analysis to solve the identified problem. In addition, many practical experiments will be required to confirm the optimality and effectiveness of the proposed approaches, techniques and schemes. The task of this report was to draw attention to this approach in solving the identified problem of territory development. We hope that the study will be further developed.

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