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MODELING OF TECHNOLOGICAL PROCESSES IN ECOLOGY

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ABSTRACT

The research work covers problems of complex approach and system analysis of technological process including influences of ecological factors. The object for the analysis is the influence of modern economic and social programs for long-term ecological further sequencing. The article presents a comprehensive complex system approach using mathematical models. The result of analysis is approve that the function of steady development should include a component in the form of critical natural capital.

Keywords: ecology, economics, modeling.

Introduction

Any economic activity of a person, including in the field of logistics and organization of transport processes, is directly or indirectly related to environmental impacts. In some cases, these effects are so large that they lead to irreversible changes in environmental parameters such as the chemical and physical composition of the atmosphere, its ozone layer, the average annual air temperature, radiation level, and others. In this regard, the problem of ensuring the stability of physical and environmental constants today has gone beyond individual engineering programs and has acquired a new socio-economic sound. There is an active evolution of the scientific worldview: the transition from anthropocentrism to the theory of natural biotic regulation of the environment and further to the society of sustainable development. Methodology, mathematical apparatus and practical applications are formed in such scientific areas as industrial and transport ecology, environmental management and other areas of national economic activity.

At the same time, the problem remains unresolved, which is caused by the contradictions between the desire to minimize production costs, reduce the cost of production - on the one hand and the excessive increase in environmental burden - on the other [1].This article is devoted to the study of this contradiction by the method of modeling environmental and technological processes, which constitute the concept of sustainable world development.

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Scientific foundations and practices

The concept of scientific work makes it possible to combine the biological concepts of sustainability and evolution, as well as to satisfy the human desire for improvement and creation. It should be noted that the modern science of complex self-organizing systems (synergy) claims that new structures are formed in conditions far from equilibrium, from stability. This postulate of synergy conflicts with the concept of sustainable development. There is reason to believe that over time this contradiction will be overcome and society will learn to transition from one non- equilibrium state to another, without destroying itself and the natural environment.

Today, science is looking for an answer to the question of why the Earth's biosphere, consisting of many diverse beings that do not possess reason, manifests itself as a system with a very accurate, balanced and sustainable organization. While the human society of carriers of high reason does not have the virtues of the biosphere. Moreover, by its spontaneous organization, society threatens the existence of the biosphere itself.

It is common knowledge that the highest ideal of scientific knowledge is the desire to obtain a holistic, synthetic picture of the world in mutual connection, movement and development of its components. Researchers achieve this goal in stages, by successive approaches to it. At the same time, they distinguish three main stages of scientific research [1].

The first step. Observing the input and the results at the output of such a "box", one can predict its behaviour without knowing how it actually works (Fig.1). Thus, traditional ecological thinking can be described by the same “black box” model representing the country's economy. Natural resources are supplied to the input of the "box", and the final product and various types of environmental pollution are taken as an output [2], [4], [5].

The black box model distinguishes between two types of system dynamics: functioning and development. Functioning is considered to be the processes that take place in a system that stably realizes a fixed goal. For example, city transport, logistics centre, etc. are functioning.

In the mathematical modeling of a certain process, its specific implementation is described as a correspondence between the elements of the set of inputs of the system X of “possible values” x and the elements of the ordered set T of “moments of time” t, i.e. as a display:

$$\mathbf{T \rightarrow X: \qquad x\,(t) \in X^T,\ t \in T.}$$

With the help of these concepts, mathematical models of systems are built. [2] Development should be considered what happens to the system when its goals change. A characteristic feature

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of development is the fact that the existing structure ceases to correspond to the new goal. To provide a new function, it is necessary to change the structure and sometimes the composition of the system, i.e. rebuild the entire system. Such systems are also possible, for the functioning of which some of its subsystems must be constantly in development.

According to traditional logic, when there is a shortage of manufactured products, it becomes obvious that more natural resources need to be fed in. At the same time, the question of how the “black box” itself, in this case, the economy, functions, remains beyond the scope of consideration.

The level of resource consumption in relation to the possibilities of their restoration by the natural environment is not considered. This can be seen in the example of the production function F, widely known in economic theory, which is a function of capital and labor resources:

$$F = f(K, L), \qquad (1)$$

where K is capital, L is labor resources

Here, in this approach, the consequences of economic development are left out of consideration, which manifest themselves in the form of environmental degradation, a decrease in the quality of life of the population, etc. Such an economic system in which natural resources are considered unlimited is called a frontal or "cowboy" economy.

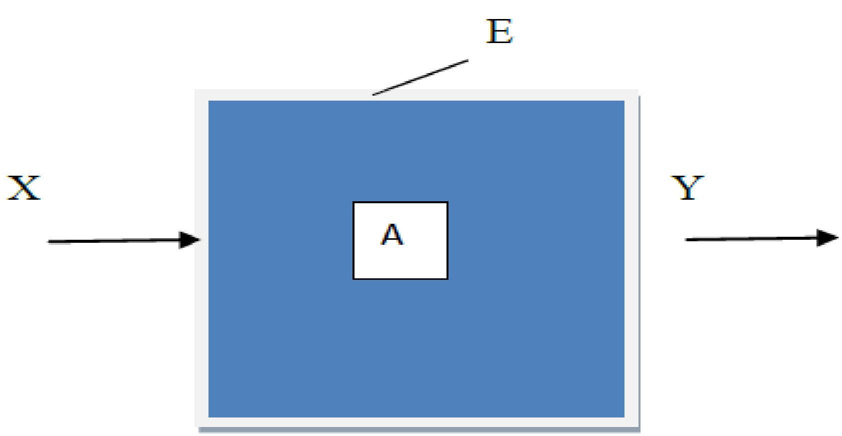

Fig. 1. Conditional diagram of the functional approach.

A - "black box";
X - information at the entrance;

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Y - output information,
E - economy

For a real solution to environmental problems, it is necessary to "open" the "black box", assess the effectiveness of economic structures from an environmental standpoint and make the necessary adjustments. It is necessary to understand why our "black box" is so gluttonous and to reduce its appetite for nature. That is, one should understand the reasons for the colossal nature-intensiveness of the economy and fight against these reasons, and not with the consequences. In this case, it is necessary to evaluate natural resources, the environment and the resulting products as a single complex, a single system. It is this approach that is considered at the second and third stages of scientific research.

Second stage Analytical

At this stage, the internal patterns of the “black box” object are revealed (Fig. 2).

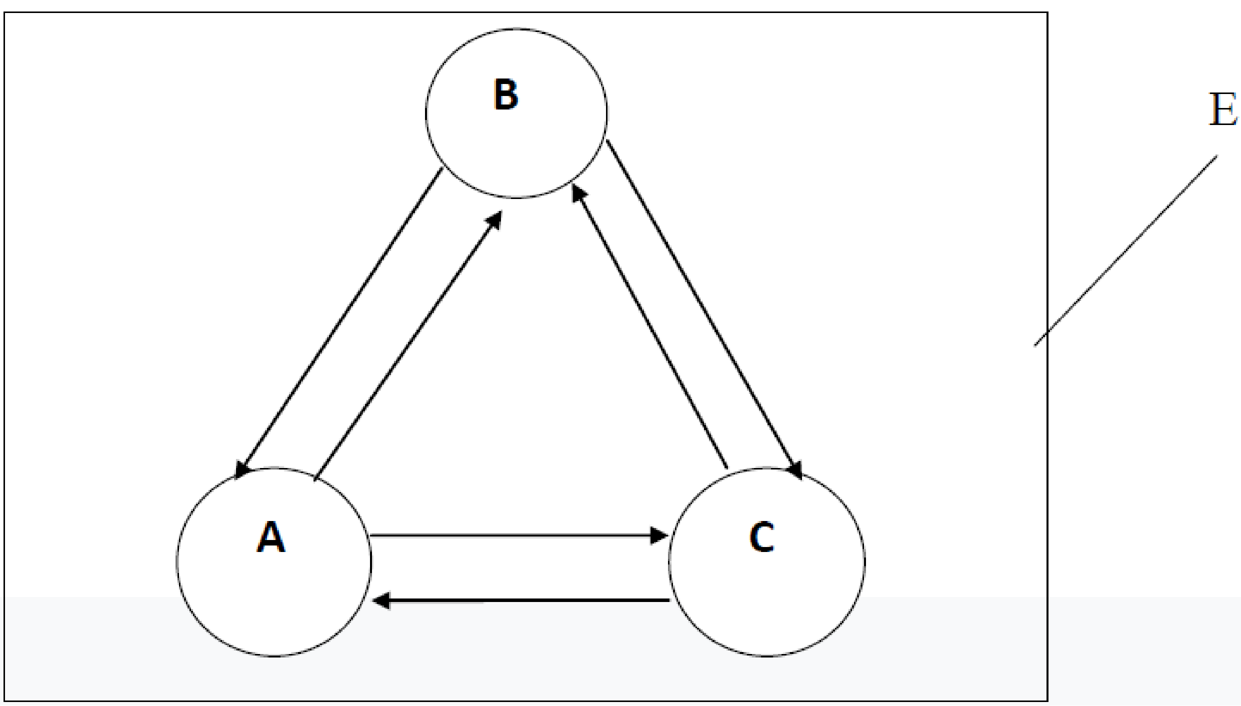

Fig. 2. Conditional scheme of the analytical approach.

E - system; A, B, C - system elements.

Here the internal structure of the object is studied, interactions of the structure elements are revealed. However, this method also has its drawbacks. It does not take into account the

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emergence of new qualities of such a system, which has a complex structure and has the so-called self-organization. Note that ecological systems, as a rule, are self-organizing.

The third step Systems approach

With the development of scientific knowledge, analytical methods, methods of division into parts and simple summation of results did not begin to satisfy researchers. For these methods considered systems in which the properties of the elements determined the properties of the system. But in some cases, the system receives properties that are not inherent in its individual parts (the property of emergence).

It has now become generally accepted that knowledge about objects, as such, is only direct, simple knowledge. From this knowledge it is necessary to pass to the essential or systemic, when an object, a phenomenon appears as an element of a wider system (Fig. 3).

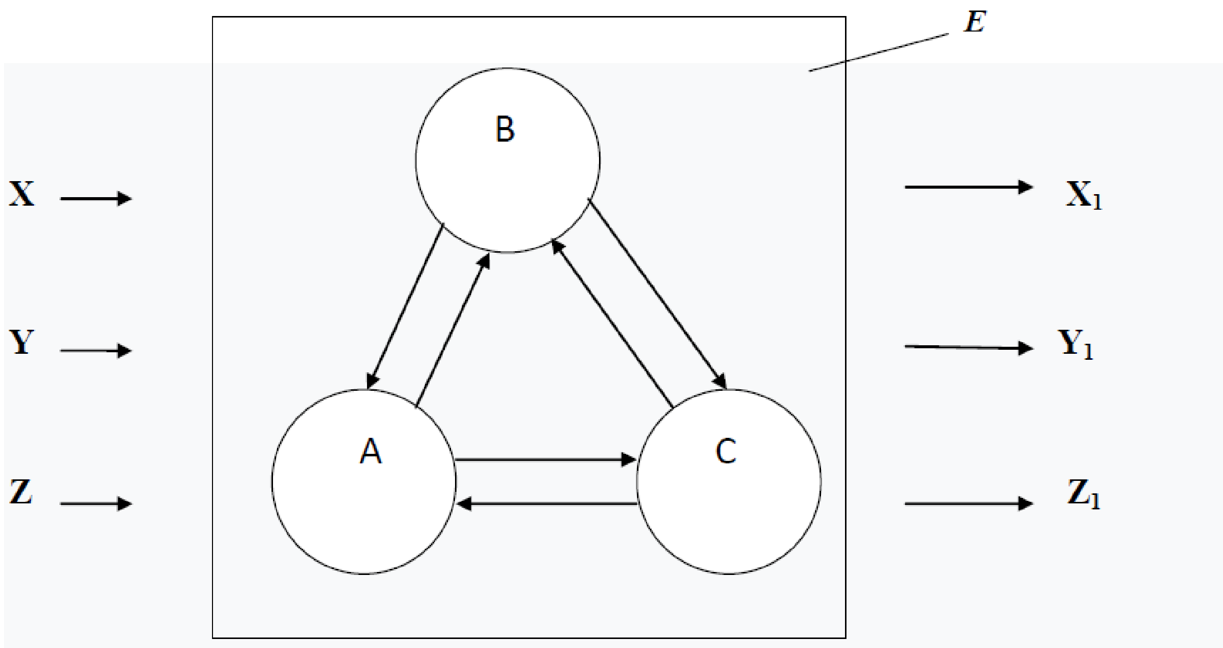

Fig. 3. System approach diagram.

A, B, C - elements of the object in the relationship

X, Y, Z - the impact of the external environment on the object

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X1, Y1, Z1 - the impact of the object on the external environment.

Figure 3 shows the interaction of individual elements with each other, as well as the mutual influence of the environment on the system and systems on the environment. The emergence of systemic research methods is due to both the logic of the development of science and the needs of practice. The peculiarity of the ecological approach is determined by the fact that the ecosystem includes two large subsystems. One of them is placed in the center and considered as the "main object", and the other - as the environment (Fig. 4). All connections (in the figure they are indicated by numbers 1,2,3) are assessed by their effect on the installed object.

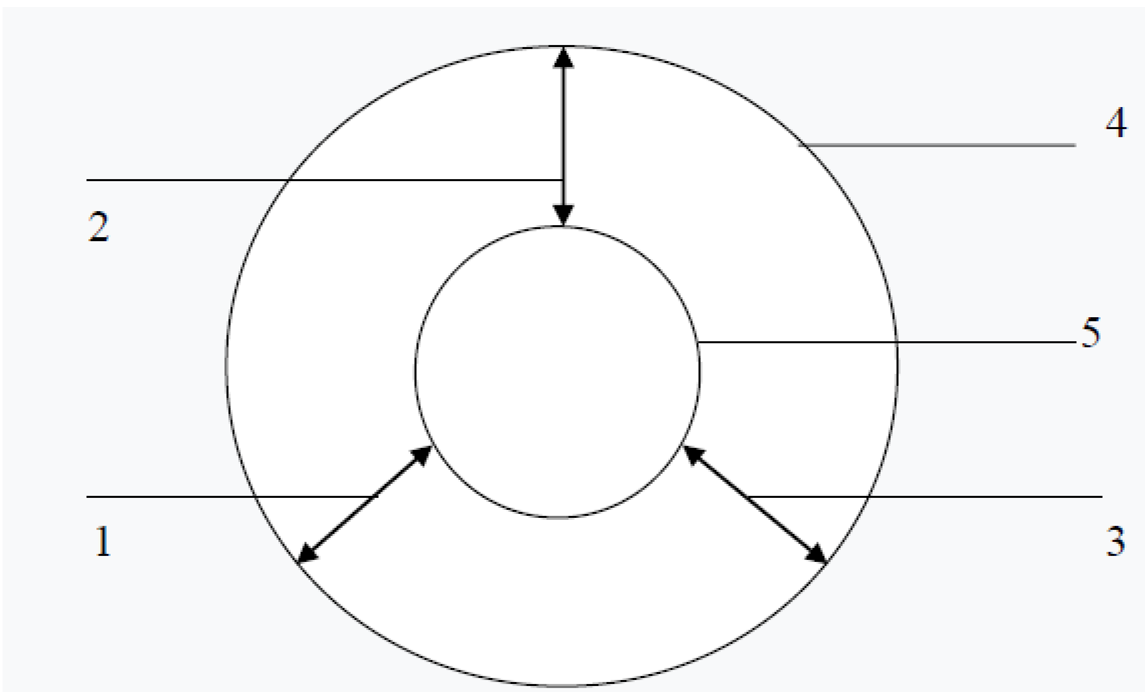

Fig. 4. Integrated ecological approach diagram

1 - energy exchange;

2 - material exchange;

3 - information exchange.

4 – Environment;

5 - The main object of research.

Systems research deals not only with the analysis of the central object. Here, the central object is

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a subsystem, i.e. part of a larger system that includes the environment with the contours of the main interrelationships. If the exchange process of mutual relations is ordered in time and has a linear character, then we can talk about dynamic equilibrium in the ecosystem. Otherwise, in case of violation of harmony in the exchange process, contradictions arise that determine the change and development of the ecosystem. Development implies strengthening the interaction of the ecosystem with the environment.

If an ecosystem maintains equilibrium with the environment during all changes, it can be considered stable.

Environmental sustainability can be represented as a concept that characterizes the preservation of the qualitative certainty of an ecosystem and its stability over an indefinitely long time.

With all variants of research, it is possible to use the so-called principle of alternativeness, i.e. involvement of all scientific and practical methods for predicting environmental changes in ecosystems.

The concept of sustainable development, due to its relevance, is becoming the most researched and popular theory today. It becomes the basic ideology in understanding the future structure of the world.

Central to the concept of “sustainable development” is the problem of taking into account the long-term environmental consequences of those economic decisions that are made today. Researchers believe that for future generations, it is imperative to minimize negative environmental impacts, future externalities. Figuratively speaking, you cannot live at the expense of your children and grandchildren, you cannot waste the natural pantry only for yourself. That is, the problem of environmental restrictions, a compromise between today's and future consumption becomes the basis for developing a socio-economic development strategy for any country [3].

The practice of advanced countries shows that those development projects that take into account natural laws are economically profitable for the long term. And vice versa, projects without taking into account the economic consequences, externalities most often turn out to be unprofitable. Therefore, for a long-term perspective, you can safely apply the well- known phrase - "what is environmentally friendly is economical.

In order to analyze and substantiate the prospects for the concept of sustainable development, four main criteria can be distinguished. The first. The amount of renewable natural resources should not decrease, in other words, the reproduction regime should be ensured.

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The first. The amount of renewable natural resources should not decrease, in other words, the reproduction regime should be ensured. These four criteria require them to be taken into account when developing the concept of sustainable economic and social development. Such accounting will preserve the environment for future generations and will not worsen the ecological living conditions.

In the concept we are considering, its global nature is obvious. It takes into account the most complex environmental, economic and social problems in the relationship. In general, sustainable development over time, taking into account the main parameters, can be represented by the algorithm [3]:

$$\mathbf{F_t (L, K, P, I) \leq F_{t+1} (L, K, P, I),} \qquad \mathbf{(2)}$$

where F_t (L, K, P, I); F_{t+1} (L, K, P, I) - functions of sustainable development; L - labor resources;

K - means of production (artificially created capital);

P - natural resources;

I - institutional factor (cultural traditions, religion, etc.);

$\mathbf{t} \geq 0$ - a period of time for the future.

Sustainable development function

Ratio (2) shows the need to preserve and increase in time some production potential, which is determined mainly by three types of capital ***L, K, P***. Moreover, here natural capital ***P*** can decrease to such an extent until this decrease is compensated by an increase in the means of production ***K*** (high technology, good roads), as well as advanced training of ***L***.In connection

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with the problem of the need to replace natural capital with artificial, the concept of "critical natural capital" arose. Let's consider what is the essence of such a concept. It is generally accepted that critical natural capital is such natural goods necessary for life that cannot be replaced by artificial means: the ozone layer, atmospheric air, global climate, etc. Critical natural capital must be preserved in all economic development scenarios.

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Taking into account the critical natural capital, the sustainable development function Ft will be supplemented by a restriction on the depletion of critical natural capital, i.e.:

$$\mathbf{F_t (L, K, P^*, J) \leq F_{t+1} (L, K, P^*, J),} \qquad \mathbf{(3)}$$

where natural capital $\mathbf{P^*}$ is represented by two components: irreplaceable critical $\mathbf{P_{kr}}$ and replaceable $\mathbf{P_{zm}}$

$$\mathbf{P^* = P_{kr} + P_{zm},} \qquad \mathbf{(4)}$$

moreover, it should be so that

$$\mathbf{P_{kr} \leq P_{kr} + 1,} \qquad \mathbf{(5)}$$

The last expression (5) indicates that the critical natural capital should not decrease over time. A significant difference between these three approaches (concepts) lies in the answer to the question: how should one treat the possible replacement of natural capital with artificial (anthropogenic)? In other words: "To what extent is it possible to replace natural resources with man-made means of production?"

Proponents of the technogenic approach advocate endless possibilities for replacing natural capital through the development of a free market and technological progress. Supporters of soft sustainability are in favor of the broadest possibilities of such a replacement, but while maintaining the general stock of natural capital [4].

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Conclusions

1. In the concept of strong sustainability, only a minimum of replacement of natural capital by artificial one is allowed.
2. The idea is confirmed that an integral ecological and economic approach should become an important direction in the economic development concepts.

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