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Problems in the methodology of assessing the value of the environment

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Original article

Abstract

The aim of this study is to optimize existing ecological-economic models used for assessing the value of the environment by integrating social and economic factors. Using a rigorous scientific methodology and systems analysis, the author synthesizes existing models of environmental valuation within the broader framework of global sustainable development. The proposed model incorporates mathematical algorithms that enable the quantitative estimation of environmental damage while also supporting the development of effective strategies to reduce the depletion of natural capital through its substitution with alternative resources. The study identifies significant shortcomings in existing ecological-economic models, particularly the omission of the social dimension and the lack of explicit consideration of critical natural capital as an essential component of total natural capital [1, 7, 8]. Such omissions are scientifically unjustifiable. The economic valuation model of natural capital proposed in this paper aims to refine and enhance existing methodologies through optimization.

Keywords

- model
- cost assessment
- natural capital
- technogenic development
- sustainability

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Introduction

Contradictions in environmental and economic development

Human economic activity, including activities in the field of logistics and the organization of transport processes, is directly or indirectly associated with environmental impacts. In some cases, these impacts are so significant that they lead to irreversible changes in parameters such as the chemical and physical composition of the atmosphere, its ozone layer, average

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annual air temperature, radiation levels, and others. In this context, the problem of ensuring the stability of environmental and physical parameters has extended beyond the scope of individual engineering programs and has acquired broader socio-economic significance. An evolution of the scientific worldview is currently taking place, marked by a transition from anthropocentrism to the theory of natural biotic regulation of the environment, and further toward a model of sustainable development.

Methodological approaches, mathematical frameworks, and practical applications have been developed in such scientific fields as industrial and transport ecology, environmental management, and related areas.

However, the problem remains unresolved due to contradictions between the desire to minimize production costs and reduce overall expenditures, on the one hand, and the increasing environmental burden, on the other. This article examines the causes and consequences of this contradiction using the modeling of ecological and technological processes.

Problem statement

The concept of scientific creativity makes it possible to integrate biological concepts of sustainability and evolution while also addressing the human drive for improvement and development. It should be noted that modern science dealing with complex self-organizing systems (synergetics) suggests that new structures emerge under conditions far from equilibrium. This postulate of synergetics appears to contradict the concept of sustainable development. There is reason to believe that this contradiction may be resolved over time, as society learns to transition between nonequilibrium states without causing destruction to itself or the natural environment.

At present, science seeks to answer the question of why the Earth's biosphere, composed of numerous organisms lacking intelligence, functions as a highly precise, balanced, and stable system, whereas human society, despite its high level of intelligence, does not exhibit these advantages. Moreover, due to its spontaneous organization, human society poses a threat to the very existence of the biosphere [9].

International climate conventions

Concern about threats to the biosphere is reflected in the Paris Agreement (2016). The agreement emphasizes the significant increase in the value of non-renewable natural capital, including vital resources such as the global climate, drinking water, and the ozone layer. A dangerous situation is emerging in which an ecological crisis may develop into an ecological catastrophe. Consumption has begun to exceed the regenerative capacity of natural systems. The main reason for this trend is the overexploitation of the non-renewable, critical components of natural capital.

The central message of the Paris Agreement is that resolving the contradiction between the economy and the natural environment within the framework of the modern concept of "sustainable development" remains extremely difficult. A shift in the overall paradigm of the relationship between humans and nature is therefore required [9]. The research presented in this article addresses the issue of greening the economy.

Structure of the article

The article presents the research methodology and methods, system analysis, justification of the problem, as well as process modeling that takes into account restrictive measures in the use of natural capital. The results of the study have been obtained and can be used in the development of scientific and practical programs for human interaction with nature.

Research method

Justification and characteristics of the method

The methodology adopted in the article is based on a philosophical approach to the objective reflection of reality. The main method used in the study is the systems approach, along with systems analysis of complex objects consisting of environmental, scientific, technical, economic, and social subsystems.

The so-called principle of alternative forecasting of relationships in ecosystems was also applied in the study [3], [7]. This approach combines two fundamental ideas: the principle of subsystem identification and the cybernetic principle of feedback. The method includes economic and ecological modeling as its mathematical framework. Within this framework, natural capital is considered as a subsystem, represented by its main critical components—such as non-renewable resources, the global climate, the ozone layer, and freshwater resources.

Analytical method

At this stage, the internal patterns of the system are identified. The internal structure of the object is examined, and the interactions between its elements are analyzed. However, this method also has its limitations: it does not account for the emergence of new properties in complex systems that exhibit self-organization. It should be noted that ecological systems are typically self-organizing.

Systems approach method

With the development of scientific knowledge, purely analytical methods—based on decomposition and simple summation of results—became insufficient. These methods assume that system properties are determined solely by the properties of their elements. However, in some cases, systems acquire properties that are not inherent in their individual parts (a phenomenon known as emergence) [1].

It is now widely accepted that knowledge of objects in isolation is only basic and direct. This must be extended to systemic knowledge, where an object or phenomenon is understood as part of a broader system.

The emergence of systems research methods is driven both by the internal logic of scientific progress and by practical needs. The ecological approach is characterized by the presence of two major subsystems within an ecosystem. One is considered the central or "main" object, while the other represents the environment, which is evaluated in terms of its influence on the main object.

Systems research does not focus solely on the central object. Instead, the central object is treated as a subsystem within a larger system that includes the environment and the network of key relationships.

If the exchange of interactions is temporally ordered and linear, the ecosystem can be said to be in dynamic equilibrium. Otherwise, disruptions in this exchange lead to contradictions that drive changes and development within the ecosystem. Development implies increasing interaction between the ecosystem and its environment. If the ecosystem maintains equilibrium with the environment despite ongoing changes, it can be considered sustainable. Ecological sustainability can be defined as the preservation of the qualitative identity and stability of an ecosystem over an indefinite period.

In all research approaches, the principle of alternativeness may be applied—that is, the use of a wide range of scientific and practical methods to predict environmental changes in ecosystems.

The concept of sustainable development and its relevance

The concept of sustainable development, due to its significance, has become one of the most widely studied and influential theories today. It serves as a fundamental framework for understanding the future structure of the world.

The central issue within the concept of sustainable development is the need to account for the long-term environmental consequences of economic decisions made today. Researchers emphasize the importance of minimizing negative environmental impacts and future externalities for the benefit of future generations. Figuratively speaking, humanity cannot live at the expense of its children and grandchildren or exploit natural resources solely for present needs. Thus, the challenge of environmental constraints and the need to balance current and future consumption form the foundation for developing socio-economic development strategies in any country [8].

The experience of developed countries demonstrates that development projects which take natural laws into account are economically beneficial in the long term. Conversely, projects that ignore environmental consequences and externalities often prove to be unprofitable. Therefore, in the long run, the well-known principle applies: "what is environmentally sustainable is also economically efficient."

The issue of natural resource valuation examined in this article is considered an integral part of the sustainable development model, which is widely recognized as a model of progress that meets present needs without compromising the ability of future generations to meet their own needs [2, 5].

The analysis and resolution of this issue are based on achieving a balance between ecology, economics, and the social sphere, particularly in the context of climate change, resource depletion, and the transition to a "green" economy [6].

For the analysis and comparison of methods for valuing natural resources, this article refers to source [4], which also addresses sustainable development in relation to environmental values. However, the author of that source does not fully consider the role of institutional factors in environmental valuation.

In this article, calculation algorithm (1) incorporates the aforementioned institutional factor (I), which, alongside other factors, determines the social dimension of addressing environmental issues from the perspective of global sustainable development.

A multi-factor, enhanced assessment of natural resources within the framework of algorithm (1) improves the quality and objectivity of environmental and economic policies, regulations, and instruments, including taxation systems, fines, and administrative and criminal liability for environmental violations.

Model for assessing the value of the natural environment

In general, sustainable development over time, taking into account the main parameters, can be represented in the form of an algorithm expressed by inequality (1):

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

where:
$F_t(L,K,P,I)$, $F_{t+1}(L,K,P,I)$—sustainable development functions at time t ant $t+1$;
L—labor resources;
K—produced (man-made) capital;
P—natural capital;
I—institutional factor (e.g., public health , cultural traditions, science, and education)

To monitor changes in inequality (1) over time, the following cost-based assessment model is introduced:

$$C_s = C_p + \Sigma^4_{i=1} E_i + 1 \quad (2)$$

where:
C_s—total social costs;
C_p—private (individual) costs;
E_i—external costs of type i

with:

$$\Sigma^4_{i=1} E_i = E_c + E_h + E_f + E_r$$

and:
E_c—costs borne by entrepreneurs;
E_h—public health-related costs;
E_f—costs associated with resource degradation;
E_r—costs due to the loss of recreational value;
I—institutional factor (estimated based on statistical data).

Relations (1) and (2) indicate the need to maintain and increase production potential over time, primarily determined by three types of capital: L, K, and P.

Moreover, natural capital P may decrease, provided that this reduction is compensated by an increase in produced capital K (e.g., advanced technologies, infrastructure) and improvements in human capital L (e.g., education and skills). This substitution perspective has led to the concept of critical natural capital.

Critical natural capital refers to those natural assets essential for life that cannot be replaced by artificial means, such as the ozone layer, atmospheric air, and the global climate. This type of capital must be preserved under all economic development scenarios. The remaining natural capital may be partially substituted by produced capital. This applies to renewable resources and, to some extent, non-renewable ones (e.g., replacing fossil fuels with renewable energy sources such as solar and wind energy). Taking critical natural capital into account, the sustainable development function F_t should include constraints on its depletion.

Supporters of the technogenic approach argue for virtually unlimited substitution of natural capital through market mechanisms and technological progress. In contrast, proponents of weak sustainability support substitution but emphasize maintaining the overall stock of natural capital, based on its prior valuation.

The application of the research results, conducted within a rigorous methodology and a systemic approach, allows for:

a) the development of an environmental program for the optimal use and preservation of critical non-renewable natural capital;
b) the promotion of standardized institutional approaches to the concept of sustainable development.

Conclusions

The article provides a systematic analysis of existing models of sustainable development, taking into account the valuation of the natural environment. As a result of the analysis, shortcomings in the structural content of the methodologies were identified. In particular, these models do not specify or distinguish between approaches to the use of the non-renewable component of critical natural capital. The author has developed and presented a new model incorporating logistics, accounting techniques, and the use of specific types of natural resources, including their valuation.

The proposed model is supported by mathematical algorithms for assessing the effectiveness of reducing the consumption rate of non-renewable natural resources. The model confirms that an important direction in the development of the concept of sustainable development is a comprehensive economic, ecological, and social approach that includes the valuation of natural capital.

The article also provides a systematic analysis of existing methods for assessing natural resources and identifies shortcomings in their structural content.

Existing models do not define approaches to incorporating institutional factors in the assessment of social costs.

- The author presents a model in mathematical form that includes a factor related to social costs.
- The proposed model represents a comprehensive approach to the economic and social assessment of the environment, taking into account all types of internal and external externalities.
- The practical significance of the article lies in its potential use in analyzing institutional support, as well as in developing plans to ensure environmental safety and protect human health.

Taking into account the scientific analysis, including the findings of this article, it is necessary to promptly optimize national strategies for the transition to a low-carbon economy, decarbonization of production, technological modernization, and adaptation to climate change. In this context, methods for assessing the value of natural resources and environmental damage are of primary importance.

References

[1] Askarov RA, Lakman IA, Sadikova LF, Karelin AO, Askarova ZF. Spatial modeling of mortality and air pollution in the Republic of Bashkortostan. Human Ecology. 2019;4:4–9. https://doi.org/10.33396/1728-0869-2019-4-4-9.

[2] Castro CJ. Sustainable development: Mainstream and critical Perspectives. Organization and Environment. 2024;17(2):195–225. Available at: https://www.jstor.org/stable/26162866.

[3] Chugunov A, Vinnitsky V, Nafikova G. Extraction of valuable components from artificial waters. Ecology and Industry of Russia. 2020;24(12):4–10. [in Russian]. https://doi.org/10.18412/1816-0395-2020-12-4-10.

[4] Collste D, Pedercini M, Cornell SE. (2017). Policy coherence for achieving the SDGs: Using integrated simulation models to evaluate effective policies. Sustainability Science. 2017;12:921–931. https://doi.org/10.1007/s11625-017-0457-x.

[5] Vargas CM, Cooper PJ. Implementing Sustainable Development: From Global Policy to Local Action. Lanham: Rowman and Littlefield Publishers; 2004.

[6] Du Pisani JA. Sustainable development – historical roots of the concept. Environmental Sciences. 2006;3(2):83–96. https://doi.org/10.1080/15693430600688831.

[7] Kolk A. The social responsibility of international business: From ethics and the environment to CSR and sustainable development. Journal of World Business. 2016;51(1):23–34. https://doi.org/10.1016/j.jwb.2015.08.010.

[8] Weiss P, Bentlage J. Environmental Management Systems and Certification. Upsala: Baltic University Press; 2018.

[9] Retchless DP, Brewer CA. Guidance for representing uncertainty on global temperature change maps. International Journal of Climatology. 2016;36(3):1143–1159. https://doi.org/10.1002/joc.4408.