Ecological Safety as a Factor of Sustainable Development of Industrial Areas

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Abstract: The purpose of the article is to study ecological safety as a factor of the sustainable development of industrial areas. The methodological approach consists in using the basic principles of the concept of sustainable development as a basis for integrating economic development strategies and ecological policy and determining the principles of ecological safety of an industrial area, focused on balanced eco-economic development. The main structural elements and parameters of the industrial area as an eco-economic system are determined, an integrating factor is proposed, that determines the possibility of economic development under the condition of ecological safety. The problem of choosing criteria for the ecological safety of an industrial area, focused on sustainable development, is solved and a system of indicators is proposed, that characterizes the level of ecological safety of an industrial area from the standpoint of the use of resources in production systems, an assessment of the ecological state and initiative activity, aimed at preventing degradation and restoring the environment.

1 INTRODUCTION

Ecological systems play a fundamental role in maintaining life on Earth at all hierarchical levels, are the source of all resources, and provide the possibility as itself of human existence.

Ultimately, economic growth and prosperity are possible only if ecological systems function sustainably.

In 1987, the Brutland Commission's report, "Our Common Future", was published, which for the first time attempted to link economic development and ecological sustainability and define sustainable development as “development, that meets the needs of the present without compromising the ability of future generations to meet their own needs” (United Nations General Assembly, 1987).

Despite the fact, that this formulation of the concept of sustainable development is not specific enough, it is obvious, that it is aimed at maintaining economic progress only if the long-term environmental value is preserved (Cerin, 2006).

However, throughout the 20th century, scientists stated, that there is no need to make a compromise between ecological sustainability and economic development.

Using economic instruments, a number of scientists suggested, that environmental policy can also contribute to the innovation development and provide economic growth. In "Welfare Economics", published in 1920, Arthur Pigou noted, that the discrepancy between marginal private costs and benefits and marginal social costs and benefits creates so-called "neighborhood effects" and acts as a barrier to achieving balance in the market (Pigou, 1920). These neighborhood effects - the availability of additional free services or public goods - are considered costs and benefits, not included in the price of the good or service. Components of a healthy environment, such as clean air and water, are considered public goods in the sense, that they are not competitive or excluded from turnover.

The continued possibility of using these public goods for present and future generations fails with the help of the traditional market mechanism. To regulate

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the market mechanism, Pigou proposed to adopt a tax on those activities, that cause negative neighborhood effects, at a rate, equal to these external costs. As a result of this tax collection, the market price will more accurately reflect the total costs and benefits of producing and consuming a good or service. Recently, many states have taken on an introduction of such market-based instruments to assess the costs of negative impacts and ensure long-term environmental stability.

Michael Porter and Klaas van der Linde (Porterandvander Linde, 1999), stating, that competitive advantage depends on the ability to improve, believed, that "ecological norms can actually increase competitiveness by stimulating innovation" (Porter and van der Linde, 1999). In other words, ecological policy, using market-based instruments, can stimulate the introduction of new technologies and reduce production waste. However, market-based ecological instruments have traditionally been perceived as more "business-friendly" than strict ecological management (Cooper and Vargas, 2004).

Understanding, that the compromise between ecological sustainability and economic development is impossible, sustainable development policy are directed to eliminate sources of environmental degradation, not just consequences, while providing opportunities and creating incentives for economic progress. This internal interdependence between long-term environmental stability and economic growth is the conceptual framework for sustainable development.

2 RESEARCH METHODOLOGY. SUSTAINABLE DEVELOPMENT: DEFINITION AND PRINCIPLES

The key principle, that determines other principles in the framework of sustainable development, is the integration of ecological, social, and economic issues into all aspects of decision-making - it is this concept of integration, that distinguishes sustainability from other forms of policy (Stoddart, 2011).

As noted above, the most commonly used definition of sustainable development is one, that addresses the importance of conserving resources for future generations and is one of the main features, that distinguish sustainable development policy from traditional ecological policy, which is based on the internalization of neighborhood effects of environmental degradation. The overall goal of sustainable development - long-term stability of the economy and the environment - is achievable only through the integration and recognition of economic, ecological, and social issues in the decision-making process.

Using this definition of sustainable development raises the problem of capital interchangeability. Aggregate capital stock priority: recognizing, that artificial or produced capital is an adequate alternative to natural capital, means poor development sustainability. On the other hand, strong development sustainability recognizes the unique properties of natural resources and goods (natural capital), that cannot be replaced by artificial capital (Stoddart, 2011).

Within the general definition of sustainable development, the principle of equity recognizes the long-term perspective of sustainability to meet the needs of future generations (Stoddart, 2011). The "polluter pays" principle means, that economic agents with negative impacts on the environment, bare the costs and liabilities, related to these impacts, and do not impose these costs on others, the environment or future generations. State ecological policy and ecological management must ensure, that the negative impact on the environment as a result of economic activity is taken into account and compensated for.

The precautionary principle states, that when serious or irreversible damage is threatened, a lack of full scientific certainty should not be used as a reason to postpone cost-effective measures to prevent environmental degradation (United Nations Conference on the Human Environment, 1992). This means, that the initiator of actions, with a risk of serious or irreversible damage to the environment, bears the burden of proof, that such an action would not cause substantial harm.

The principle of common, but differentiated liability recognizes, that each nation must play a proportionate role in realizing the concept of sustainable development. This principle recognizes the different contributions of developed and developing countries to environmental degradation, in general, developed countries bear a greater responsibility due to the large volume of resources they consume and the pressure they put on the environment (Brodhag and Taliere, 2006).

The system of state ecological management works quite effectively and allows to implement a number of principles of the concept of sustainable development, in particular, the "polluter pays" principle, but does not ensure the necessary integration of economic, ecological, and social goals

for different sectors and industries, areas, and generations.

The technosphere and biosphere are usually considered as separate systems: industrial facilities, municipal facilities, and the environment - it is necessary to eliminate such fragmentation, that is, ecological, social, and economic issues must be integrated into a single decision-making process in order to move towards truly sustainable development. This is possible if the industrial system and the sociosphere are considered as a special form of ecosystem - the processes of production and consumption of goods and services consist of material, energy and information flows, just like natural ecosystems, but unlike natural ecosystems, they are open.

Unlike closed material flows in the natural environment, waste and by-products, generated as a result of economic activity, do not always return to economic turnover and become a resource for other activities. Recycling of production and consumption wastes should ultimately make up a significant part of the resources, used in industrial processes, which brings the functioning of industrial and socio-systems closer to ecosystems, ensuring the integration of ecological, social, and economic issues into a single decision-making process and creating conditions for the sustainable development of a single eco-economic system.

3 RESULTS OF RESEARCH. INDUSTRIAL AREA AS AN ECO-ECONOMIC SYSTEM

Considering an industrial area as an eco-economic system, we determined two main structural elements and an integrating factor (Fig. 1).

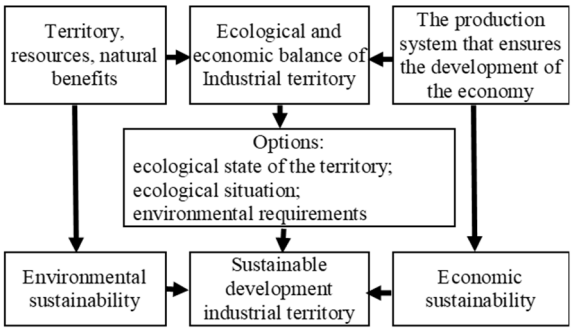

Figure 1: Industrial area as an eco-economic system.

Structural elements of an industrial area as an eco-economic system:

- Area, resources, natural goods of the region as a basis for living and satisfying vital needs;
- A production system, that ensures the development of the region's economy.
- Eco-economic balance of the industrial area

The eco-economic balance of the industrial area performs a function of a necessary integrating factor of the industrial area as an eco-economic system.

To describe the eco-economic balance of the industrial area, the following parameters are proposed:

- Ecological state of the area is the state, in which ecosystems and their components are in a specific period of time;
- Ecological situation is a combination of conditions, processes and circumstances of a natural and technogenic nature, that determine the state of natural or natural-technical systems;
- Ecological requirements are a set of restrictions on the use of natural resources and conditions for the preservation of the environment in the process of economic and other activities.

The sustainability of the production system of an industrial area or economic sustainability is defined as a production system, that satisfies the current level of consumption without affecting future needs.

The environmental sustainability of an industrial area is defined as the ability of natural systems to preserve their structure and functional properties under the anthropogenic impact, providing a harmonious combination of natural resources, goods, and ecological safety as the basis for living and meeting the vital needs of the population.

It is proposed to determine the eco-economic balance of an industrial area as an eco-economic system through the achievement of positive economic and social effects of economic development and social sphere, under the condition of sustainable functioning of ecological systems.

In general, sustainable development of an industrial area is defined as economic development, corresponding to current and future consumption levels, subject to ecological safety.

4 THE DISCUSSION OF THE RESULTS. CRITERIA AND INDICATORS OF THE ECOLOGICAL SAFETY OF AN INDUSTRIAL AREA, FOCUSED ON SUSTAINABLE DEVELOPMENT

The ecological safety of an industrial area is defined as a set of conditions, processes, and actions, that ensures an ecological balance in the environment and does not lead to vital damage (or threats of such damage) to the natural environment and humans.

The principles of ecological safety, focused on sustainable development are described below.

The principle of strong sustainability recognizes the unique properties of components of the natural environment, that cannot be replaced by artificial capital. Such components include the constituent parts of ecosystems: air, surface and underground waters, bowels, soils, flora, and fauna.

The principle of equitable distribution of natural resources and goods between generations recognizes a long-term period of sustainability to meet needs. To comply with the principle of equity, the value of the use of natural resources or technogenic impact on ecosystems and its individual components should be determined, in which the functional and structural characteristics of ecosystems do not go beyond the limits of natural changes.

The “polluter pays” principle intends a quantification of the anthropogenic load as the value of the direct and indirect negative impact of human activities on natural complexes and components of the natural environment and compensation for the consequences of such impact.

The precautionary principle states, that lack of full scientific confidence should not be used as a reason to postpone effective measures to prevent environmental degradation. To comply with the precautionary principle, it is necessary to determine the ecological hazard - the probability of degradation of the quality indicators of the natural environment (states, processes) under the impact of natural and technogenic factors, posing a threat.

Ecological safety criteria, focused on sustainable development, are specified in Table 1.

Table 1: Ecological safety criteria, focused on sustainable development.

Sustainable development principles	Ecological safety criteria
Strong sustainability principle	Conservation of biodiversity, air purity, water supply sources and other natural objects, public legacy
The principle of equity	Rational use of natural, material, fuel and energy and labor resources; eco-friendly consumption
The "polluter pays" principle	Minimal damage to the environment with the sustainable socio-economic development of areas
The precautionary principle	Introduction of high-performance low-waste or waste-free technological equipment and machines

The criteria for the formation of a specific set of ecological safety indicators are, as a rule, social significance, scientific certainty, and the possibility of practical monitoring (Elgert and Krueger, 2012).

Ecological safety indicators can be determined and presented at different scales and for specific ecosystems (Fan et al., 2010; Maiorova and Ponomareva, 2015). For example, as part of the implementation of programs for the socio-economic development of the area in order to achieve rational use of natural resources and ensure ecological safety - indicators can be used, ensuring the quality of atmospheric air and water bodies in accordance with regulatory requirements, reducing the negative impact of waste on the environment (Maiorova and Belik, 2018; Maiorova et al., 2018).

In accordance with the criteria, corresponding to the principles of sustainable development (Table 1), it is proposed to use the following groups of indicators to determine the level of ecological safety of an industrial area:

Indicators of resource use in production systems of the area and in the process of consumption:

- Total and specific energy consumption;
- Total and specific consumption of freshwater; the proportion of reused water in the total volume of water consumption;
- A load of discharge and emission of pollutants into the atmosphere and water bodies;
- Number of significant accidents with ecological damage.

Indicators of the ecological state of the area:

- Concentration of pollutants in the atmosphere;

- Concentration of pollutants in water bodies;
- Concentration of pollutants in the soil;
- Land size for waste disposal;
- Degraded land size;
- Biodiversity indicators.

Indicators of activities, aimed at preventing degradation and restoring the environment:

- Initiatives to cushion the environmental impact;
- Investments in objects of environmental protection and restoration.

5 CONCLUSIONS

The ecological safety criteria, formulated on the basis of the basic principles of the concept of sustainable development, determine the conditions for the preservation of the structure and functional properties of natural systems and the economic development of an industrial area as an eco-economic system.

The proposed indicators of ecological safety can be used by authorities of different levels of governance, including territorial, non-governmental organizations, public groups, and research institutions to determine ecological requirements in the process of economic and other activities, to determine the level of ecological safety, to inform the public and decision-makers about the degree of sustainability of the functioning of ecological systems, and also as a diagnostic tool for identifying the ecological state and ecological situation of the area.

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