Indicators of the seaport ecological state of a depressed industrial hub

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Abstract. The article presents the results of the seaport ecological condition indicators study of a depressed industrial hub. The traditional ranking of indicators of ecological condition on three levels is analyzed: international, national, regional. Based on the recommendations of Eco Port PERS, the requirements of ISO 14001 and environmental management and audit, EMAS analyzes the environmental indicators that are recommended for use. The scientific novelty is the justification of the necessity to use the territorial indicator of the seaport ecological condition due to the specifics of the territorial location - first, the nature of the seaport as a city-forming enterprise - secondly, the seaport - the third, deterioration of an ecological situation of an industrial site, in - the fourth. The ecological model of the seaport is based on its division into two subsystems: production and consumer, and the link between them is transport and transport processes. The necessity of maintaining the ecological and economic balance in the seaport and on the territory of the depressed industrial hub is substantiated according to the indicators of the cargo transportation intensity, the quality of transport services and the current ecological situation of the territory as a whole, which is provided by the System of ecological condition of European ports PERS.

1 Introduction

It should be noted that the topic of "ecology of activity" (meaning any activity: production, provision of services, including transportation, loading, reloading, unloading, storage, processing, etc.) since the 70s of the twentieth century has always been one of the most important in the world, in any international forum, the problem of ecology sounded

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particularly acute. Special attention is currently paid to the ecology of seaports. The explanation for the increased interest in the ecology of seaports is primarily due to the fact that according to historical, geographical and strategic criteria for any state, the seaport is always in the intersection center area of all transport routes and communications. An important component that explains the special attitude to seaports is due to the fact that they have always been created in industrial regions, in those places where raw materials, industrial and agricultural goods have accumulated. This has led to the fact that seaports are located in environmentally vulnerable areas; as a rule, are located within urban areas; handle large volumes of cargo that contain hydrocarbons, which inevitably affects the amount of carbon emissions and air quality. Another important circumstance that explains the increased interest in seaports, according to the authors, it is the largest volume of foreign economic activity of states is through seaports, which explains the increased level of requirements for the organization and implementation of production, economic, economic and environmental activities of seaports.

It should be added to the above mentioned that the fact that transportation through seaports is carried out using hydrocarbon fuel, as well as emissions from ships and in and their unloading, loading or reloading. Production activities and further development of seaports are directly related and interact with the air and water basin with soils, flora and fauna, as well as with the population of its territory.

2 Research methods

The theoretical basis of the work is the following fundamental provisions of the theories of transport systems, environmental safety, environmental management, transport risks, sets and the theory of environmental project management Relevance of the research. The well-known methods of differential computation are used as a mathematical apparatus.

3 Results and discussion

Apart from the above-mentioned negative environmental impact, seaports cannot properly provide environmentally friendly ship maintenance and cargo handling. Due to the active development of scientific and technological progress, the imperfection of most applied transshipment technologies, machinery, equipment and other objects of maritime transport, as well as their extremely negative impact on the environment, became especially obvious. Precisely because of the high cost of environmentally friendly cargo processing technologies, there are no opportunities for their use in production activities by Ukrainian seaports. However, as economic entities, seaports are required to comply with international and national environmental requirements.

The above circumstances, as well as issues of national security, the need to raise the image of Ukraine as a maritime power and determined the relevance of environmental indicators study of domestic seaports.

Currently, the approach to environmental indicators study of seaports is traditionally reduced to three levels, namely: international, national, regional.

The requirements of the international level of environmental safety of seaports are set out in the following documents: 17 Global Sustainable Development Goals for 2030 [1], which are supported by the UN Development Program, ratified by the Cabinet of Ministers of Ukraine in ISO 14001 [2] and Eco Port PERS [3], The International Convention for the Safety of Life at Sea SOLAS [4], the International Convention for the Prevention of Pollution from Ships MARPOL 73/78 [5], Environmental Management and Audit EMAS [6], the Strategy for the Development of Ukrainian Seaports until 2038 [7].

Among the environmental indicators by the authors of the article [8] the use of the Pigouvian tax is proposed, which is calculated at the cost of bringing the ecosystem to zero. In accordance with this approach, a large number of enterprises have effective negative indicators of adverse environmental impact. It should be noted that the use of the Pigouvian tax in the scientific community of both economists and ecologists is controversial. The very essence of the Pigouvian tax comes down to the fact that when the marginal public interest does not coincide with the marginal interest of the enterprise owner, the latter has no incentive to reduce the value of marginal social costs; and vice versa, according to Pigou, if an enterprise provides marginal social benefit, the persons who receive it have no motivation to pay for this benefit [9]. With such a discrepancy between the ultimate interests of the owner of the enterprise and the social interests of society, the following consequences are obtained. The first consequence the party receiving social assistance does not pay for it, and the person who causes social harm does not pay for it. The second consequence is when the marginal social cost exceeds the marginal private benefit, the cost producer overproduces the product. Thus, external effects of a non-monetary nature exceed the social value (absence of environmental pollution, clean air basin, absence of soil and ground pollution), but lead to overproduction. To solve the problem of overproduction, Pigou recommended levying taxes from the violating producer, thus obliging him to pay the moral external harm he created, but at the same time it is necessary to correctly and reasonably determine the amount of this tax, i.e. it is necessary to determine the value of social costs.

Developing this idea further, it turns out that the Pigou tax controls only the scale of a particular enterprise, and not the entire number of such enterprises in the industry. If the number of polluting enterprises increases, the level of pollution and negative impact on the environment will also increase. It should also be said that it is extremely difficult, and sometimes impossible, to correctly measure social costs, since most of them are either psychological or purely individual in nature: how, for example, to measure the social benefit from the fact that the territory of a seaport is contained in cleanliness, or has well-groomed green spaces? Of course, seaports provide jobs and this effect can be measured by the number of workers and the level of their wages, but how to measure the effect when most of the seaports of Ukraine are city-forming? The way out of this situation, apparently, is to determine the specific amount of payments by enterprises, in this case, the seaport, a specific amount for a specific period of time for the use of natural resources and environmental pollution, which is currently being used.

The modern approach to the organization of environmental management in seaports is reflected in the ESPO report. The Environmental Report is an important tool of the ESPO Ecoports Network together with the Self-Diagnostic Method (SDM) and the Port Environmental Assessment System (PERS) [8]. SDM is a short checklist by which port managers can self-assess the environment. Aggregate data from SDM form the basis of annual environmental reports. Developed by the ports themselves, PERS has thoroughly established itself as a standard of environmental management for the port sector. The PERS certificate is indeed evidence of the port's voluntary compliance with environmental requirements, which it carries out independently. PERS is an EU research initiative that connects the port network, research universities and industry. More than a fifth of EU ports - EcoPorts members are PERS certified ports.

The proposed indicators of the ecological condition of the seaport in the EU include the following indicators: *A Environmental management indicators, B Environmental monitoring indicators, C Top 10 Environmental priorities, D Green services to shipping* [8]. According to the requirements of PERS, the indicators are weighed according to their significance for the environment. Significance is determined by the method of interviewing port employees and organizations working in the port, shippers' enterprises and surrounding

institutions. Such certification demonstrates to a wide range of stakeholders that the seaport is competitive and meets modern ESPO requirements.

The authors consider it necessary to note that EcoPorts PERS is the only industry standard of environmental management, it is in constant open access and is becoming increasingly recognized in business circles and international organizations outside Europe.

The seaport is characterized by high compactness, density of territory development and communication saturation. The ecological and economic model of a seaport is understood as a set of interconnected economic, technical, technological, social and natural factors. The economic space of the seaport can be divided into two subsystems: production and consumption, and their connecting factor is transport, both internal transport of the seaport and external transport.

Each of these subsystems and their associated transport use environmental resources. The product of such interaction are:

- waste, which includes all types of material substances that can be disposed into the atmosphere, discharged into water (sea), buried in the ground or placed on it;
- emissions, namely emissions in the form of heat, magnetic fields, radiation, vibration.

It is impossible to consider separately the ecological situation of the seaport from the ecological situation of the city, the territory where the port is located and it is impossible not to take into account the ecological principles and approaches professed by shippers and shipping companies. The link between the seaport and the companies is transport. After all, cargo arrives at the seaport by vehicles. Mainly, road and rail transport are used for these purposes. Such an irrational by today's standards configuration of transport communications is explained by the choice of the shortest route and minimization of transport tasks, which was inherited from the socialist way of management. These principles have been used in the past when laying routes along sea coasts, beach and park areas. However, it is impossible to move the railway, which transports goods to the seaport, and no one will build bypass roads for the same purposes. Therefore, it is necessary to look for other options for a favorable solution to the existing situation.

Authors of the material [10] analyze the use of indicators of inclusive development in state (meaning country, from the word country) indicators. The main emphasis in this publication is made on the formation of the suppositions for inclusive nature management in socio-economic and environmental practices and their subsequent methodological support.

It should be noted that the concept of inclusive growth (*inclusive sustainable growth*) was nominated by the European Union Growth and Development Commission back in 2008. The concept of inclusive growth based on the "green economy" differs from the previously used strategies, provisions and principles in complex content and full involvement in government reforms, on the basis of which the diversification of national economies takes place. The European Commission included in the content of the Europe 2030 strategy the following as mandatory items: expansion of goals and growth indicators, and not just the indicator of gross national product; reducing inequality and poverty; active participation not only in the distribution of income, but also in the economic life of the country; receiving not only profits and benefits of individual ruling circles, but also noticeable improvements for all segments of the population, especially people of the "silver age", children, women; careful use of natural resources, increasing the share of renewable energy sources; widespread in all sectors of the national economy, and not only in high-tech industries with the obligatory involvement of most of the working-age population; equal opportunities for all members of society to access markets and resources; minimization of risks associated with climate change, global epidemics, massive infectious diseases and crises associated with a shortage of water resources. As it was noted above, among the environmental indicators, special attention is paid to: scarcity of water resources, careful

use of natural resources, an increase in the share of renewable energy sources; an increase in the dynamics of wooded areas, the quality of the environment and the air basin, namely: the concentration of particulate matter in the atmospheric air, the intensity of carbon dioxide emissions. The solution of these tasks is possible with the creation and use of innovative ideas and products, which provides material for the development of business and scientific research, and the latter, in turn, make it possible to develop the education of the population and increase the number of jobs. Consequently, the result of introducing the concept of inclusive growth to solve environmental problems will improve the quality of life of people and their additional employment. Inclusive growth requires an accurate and thorough analysis of the environment, which can be achieved by introducing new indicators and indicators of the value of resources in projects and regional development programs.

In most scientific approaches, the criteria for the efficient operation of transport are traditionally: ensuring the efficiency of territorial logistics, maximizing profits, expanding the market segment of the business. However, nowhere is there a different approach to environmental performance indicators, which is based on a balanced, balanced approach to the organization of the transportation process, with mandatory consideration of specific priorities for resource conservation and environmental safety of vehicles and the transport process itself, which approach would take into account the existing level of pollution environment and degree of satisfaction with the quality of transport services.

Theoretically, to ensure effective regulation of the environmental situation, which is the result of the interaction of the seaport with the components of the environment to the ecological models and criteria, the following requirements are imposed:

- availability of objective and complete information on the ecological situation in the seaport, the territories surrounding the port;
- truthful identification of causal links and determination of the patterns of functioning of the system (seaport - transport - shipper) and its impact on the environment;
- development of a sufficiently complete set of scenarios for the development of the situation, which are formed on the basis of the forecast of the development of the existing environmental situation, and an integrated assessment of the results of this forecast;
- development of science-based solutions and implementation of rational regulatory measures to reduce and prevent the negative impact of the seaport system on the environment.
- constant monitoring of the state of the environment [11].

The need to maintain the ecological and economic balance in the system "seaport - transport - cargo owner (manufacturer)" is associated with a sharp deterioration of the environmental situation, which has the following features:

- increase in the volume of industrial and household waste, the size of which violates natural natural and biological processes;
- pollution of natural reservoirs and coastal sea waters with industrial and household waste;
- pollution of the environment by products of spent fuel: ash, oxides of sulfur, nitrogen, spent oil products: resins, fuel oil;
- use of materials and products containing harmful and toxic substances that are detrimental to geochemical and biological life processes;
- the presence in the environment of an increased concentration of various types of noise, vibration, radiation [13].

If we assume that the main characteristics of freight traffic in the system "seaport - transport - cargo owner" are cargo flows and the type of rolling stock that is chosen for their transportation. According to the monitoring of the state of the environment, using statistical results at a specific time t it is possible to calculate the level of marginal saturation of certain values of environmental indicators of the state of this system. The total

cost of delivery of goods in the port area for a certain period of time will be presented as follows: [12]

$$\sum_{i=1}^n s_i = \sum_{i=1}^n (b_i \times z_i + d_i) \quad (1)$$

where: s_i - total cost of transportation of the i -th cargo, monetary units; b_i - volumes of cargo flows to the seaport, t; z_i - costs of industrial enterprises for the transportation of 1 ton of cargo, monetary units ; d_i - costs of the i -th enterprise for environmental measures, according to regulations and legislation, monetary units [12].

The required level of environmental safety during transportation is denoted by h_i . The current level of the current environmentally safe situation of transportation of the i -th type of products is denoted by r_i [12].

Taking the amount of fines for environmental degradation for Q_i , we obtain:

$$d_i = Q_i(h_i, r_i) = \begin{cases} Q_i(r_i), & \text{provided } r_i < h_i \\ 0, & \text{provided } r_i \geq h_i \end{cases} \quad (2)$$

The amount of deductions for violation of environmental requirements during the transportation of cargo is defined as the difference between the required and current levels of environmental safety. Therefore, the costs of organizing the transportation process taking into account the reimbursement of environmental contributions can be represented by expression (3) [12].

$$\sum_{i=1}^n s_i = \sum_{i=1}^n (b_i \times z_i + Q_i(h_i, r_i)) \quad (3)$$

In the absence of freight, no environmental charges for violations (4) [12].

$$r_i(0, d_i) = 0 \quad (4)$$

With the growth of traffic volumes, taking into account the fact that permanent environmental deductions and fees do not change and are made in a timely manner, the amount of environmental deductions does not decrease (5) [12].

$$\frac{dr_i(b_i, d_i)}{db_i} \geq 0 \quad (5)$$

At constant volume of cargo transportations and with growth of expenses for environmental protection the level of ecological deductions does not increase (6) [12].

$$\frac{dr_i(b_i, d_i)}{dd_i} \leq 0 \quad (6)$$

If freight volumes do not change, remain constant, each subsequent investment in environmental measures reduces the reduction of environmental risk (7) [12].

$$\frac{\partial r_i^2(b_i, d_i)}{\partial d_i^2} \geq 0 \quad (7)$$

Consider the possibility of damage from emergencies during the transportation of goods to the seaport. The possible total damage of the i -th load is denoted by F_i . The weighted average of the results of all possible emergencies in the transportation of goods to a seaport can be expressed by a mathematical expectation (8) [12]:

$$M(F) = \sum_{i=0}^n M(F_i) \quad (8)$$

Therefore, the ecological and economic system "seaport - transport - cargo owner (manufacturer)" must take into account the contradictions that arise in this system in a particular period of time between the needs of shippers and the constraints and capabilities of natural resources, and determine the rational relationship between consumption level, production development and environmental factors.

The share of modes of transport that participate in the transportation process can be determined by expression (9):

$$k = \frac{T_i}{\sum_{i=0}^n T_i} \quad (9)$$

where: T_i - number of units of vehicles of the i -th mode of transport, pieces; n - number of modes of transport, pieces [12].

The load factor of roads and access roads to the seaport can be determined by the ratio of the intensity of the i -th mode of transport to the capacity of roads (10).

$$I = \frac{G_i}{J} \quad (10)$$

where: G_i - intensity of the i -th mode of transport, pieces / hour; J - capacity of roads and access roads to the seaport, pieces / hour [12].

The following indicators can be used for the indicators "level of transport safety and ecology": the amount of emissions of harmful substances by the vehicle, the toxicity factor for the car engine.

For indicators of "quality of transport service" it is recommended to use indicators: duration of the period of delivery of freight, timeliness of arrival of the vehicle.

4 Conclusions

The research article proposes the use of ecological efficiency indicators of the ecological and economic system "seaport - transport - cargo owner (manufacturer)" which are based on a balanced approach to the organization of the transportation process, taking into account specific priorities for resource conservation and environmental safety of vehicles and the transportation process itself. This approach takes into account: the current level of environmental pollution and the degree of satisfaction with the quality of transport services.

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