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STRATEGIC ENVIRONMENTAL ASSESSMENT IN CONJUNCTION WITH ASSESSMENT OF IMPACTS ON ENVIRONMENT

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Abstract. The tool for supporting the strategic environmental assessment of large-scale territorial entities' and urban ecosystems' development projects is presented In the paper. The concept of environmental impact assessment is used for the development of this tool. The use of the industrial objects' ecological risk indicators for environmental safety estimation is suggested.

Key words: strategic environmental assessment, assessment of impacts on environment, environmental risk.

Introduction

Currently, the world community's significant efforts are directed at the environmental problems solution. The environmental laws become stricter. Preventive measures to minimize the environmental pollution's negative effects and natural resources depletion are implemented actively. The environmental aspects are taken into account when making practical decisions on achieving sustainable social and economic development of the society.

Whereas any planed economic activity is associated with using the natural resources and affects the environment, it is expedient to analyse its ecological danger before the strategic documents have been developed and evaluate all available alternatives comprehensively. Environmental assessment can be carried out both for the individual projects (environmental projects assessment) and for the strategic documents (strategic environmental assessment, SEA). As the international practice shows, SEA demonstrates high efficiency in solving such problems.

SEA is aimed at assessing possible environmental impacts (including the impact on public health), caused by forecast and program documents implementation and at the choice of an acceptable development alternative. It contributes to both improving the quality and efficiency of the planning system, and increasing the public confidence in the making decisions process.

1. Literature and previous research review

Subjecting to the SEA strategic documents include development plans of territories, sectors of the economy, programs, policies, strategies, etc. The basics for projects environmental assessment are set at a higher level due to the SEA. The European Directive 2001/42/EC of the individual plans and programs environmental consequences assessment is by far the most significant legislative document defining the minimum common procedures for the SEA [1]. The procedure for carrying out a systematic, preventive and open SEA is described in the Directive. The SEA Directive does not include the legislative acts consideration. The Directive is focused on the environmental report preparation.

The main provisions of the SEA Directive have formed the basis of the Strategic Environmental Assessment Protocol to the UN ECE Convention on Environmental Impact Assessment in a transboundary context [2]. However, there are some differences between the SEA Directive and the Protocol. The

Protocol includes legislative acts as SEA objects. Special attention in the Protocol is paid to the evaluation of the impact on the population health. The need for public participation and consultation with stakeholders in the process of conducting the SEA is also prescribed. Considerable material on conducting the SEA in different countries of the world has been accumulated; numerous monographs and guidance on the implementation of the SEA are published. The most effective approaches and methodology for conducting the SEA and involving the public are discussed.

According to the Protocol, the SEA means the evaluation of the possible environmental consequences, including the impact on the health of the population which comprises the determination of the scope of an environmental report and its preparation, public participation and the carrying-out consultations, and taking into account the environmental report and the results of public participation and consultations in the plan or programme development. [2–6]

In turn, the official representatives of Ukraine signed the SEA Protocol at the 5th Pan-European Conference of Environment Ministers "Environment for Europe" (Kyiv) in 2003. The protocol was ratified by Ukrainian parliament in 2015. It is important to note that many countries began to implement the SEA before there joining the SEA Protocol. Its main advantages are the precautionary nature of the procedures, and an integrated approach to the environment components assessment and human health. It allows integrating the summaries and avoiding the unwanted consequences. [8]. The number of countries, such as Canada, China etc., which are not signatories to the SEA Protocol, conduct similar assessments based on national legislation.

Ukraine tries to introduce certain EU environment protection directive, including the ecologization of territorial planning [9, 10]. On the other hand, the lack of modern full-scale territorial environmental situation assessment is the problem in Ukraine. Such assessments are not included in the construction projects, because the State city planning standards (SCPS) for environmental impact assessment (EIA) [11] are only applied to the construction sites and are limited to the infrastructure of the territory. Based on the strategic approaches to achieve goals in market conditions, EIA needs radical revision, in particular, complementing the rules and regulations for the development of territorial and strategic assessments.

The object of this study is the relationship between the SEA and EIA projects in the development of the algorithms for assessing the environmental risk of technogenic objects. The problem in this study is the descriptive nature of the SEA. At the same time, the intensive work for implementation the SEA is conducted in Ukraine.

The aim of the present research is the development of support tools for strategic environmental assessment of territorial formations development projects and urbanised ecosystem in conjunction with the EIA.

To achieve this aim, it is necessary:

– to explore implementation of the SEA in Ukraine;

– to establish a connection between the SEA and the EIA;

– to offer the procedure for territorial formations ecological safety estimation with the SEA.

2. Comparison and ways of combining the SEA and the EIA

The SEA impact to the process of developing strategic planning documents should be effective and timely. Therefore, it is important to coordinate the SEA itself with the development of such documents. According to [2] the possibility of full or partial integration of the SEA provisions into the design documentation process, as well as the carrying out the SEA separately, is envisaged.

The EIA procedure also needs to be reworked considering both insufficient consideration of territorial issues in the EIA methodology and the lack of the EIA in the development of plans, programs and policies at both local and state levels in the construction industry [12, 13]. In our opinion, the EIA prospect lies in differentiating the sections into:

– EIA of the designed objects (object EIA);

– EIA of engineering-assimilated territories, which is necessary for the implementation in district planning, general cities plans, industrial facilities, regional development projects etc. (territorial EIA);

– EIA for plans, programs and policies at both local and state levels in the construction industry (strategic EIA).

The development and enactment of state building regulations regarding object, territorial and strategic EIA is considered expedient in conjunction with the SEA concept In terms of the human-environment interaction harmonization.

Object EIA should contain: information about the documents which is the basis for developing the EIA materials as a part of an investment program or a

construction project; the list of potential impact sources for the planned environmental activity with the alternative options; a list and a brief description of the planned activity influence types to the environment; the list of environmental, sanitary-epidemiological, fire and urban constraints; the data on the attitude of the public and other stakeholders to the planned activities; the list of used normative-methodical documents; the description of methods for forecasting the environmental indicators dynamics and forecast periods justification; the data about the performer and the list of organizations and specialists who performed the EIA; the list and brief analysis of previous approvals and expert assessments, including public examination. The list of information sources used in the EIA development is also required [14].

The purpose of the territorial EIA is objective definition of acceptability and expediency of territory planning or placing of a single environmentally dangerous project by the environmental safety criterion and fixing objective environmental aspects of planning in the legal field. In the territorial EIA, it is necessary to foresee maximally possible provision of acceptable living conditions for the population and serviceability of the existing sites; to consider the ecological state of the territory and determine its unauthorized changes for the estimated construction period. Only with a positive result, the planned projects should be placed so as not to violate the acceptable sanitary norms [14].

In the strategic EIA, it is necessary to foresee assessment of the impact on environment, made by the developed plans, programs and policies at the local or state levels in the construction industry [14].

The combination of the basic provisions of the SEA and the improved EIA procedures will make it possible to create the procedure of evaluation of ecological safety of territorial formations to conduct strategic environmental assessment. It is advisable to use an ecological risk indicator for technogenic projects as a basic of environmental safety indicator, which is substantiated by the authors of the paper [15].

3. The tools for maintaining strategic environmental assessment

The previously developed "index-risk" method was adapted for taking into account the main provisions of the SEA for assessing the environmental safety of territorial entities. The implantation of a new industrial facility into an industrial-ecological system leads to the changes in the state of the environment. According to the concept of the EIA and the specifics of the industrial objects designing, the mathematical dependencies for the risk of this changing are proposed (1)–(3) [16]:

$$R_E = \sum_{i=1}^{m} r_i, \tag{1}$$

$$r_i = a_i \cdot \exp\left(b_i \cdot I_i\right), \tag{2}$$

$$r_{i,k} = c \cdot \exp\left(d \cdot I_{i,k}\right), \tag{3}$$

where r_i – the risk of changes in the state of the *i*-th environmental component; I_i – index of assessment of the level of environmental hazard of the impact on the *i*-th environmental component; $r_{i,k}$ – risk of changes in the state of the *i*-th environmental component of the *k*-th substance (for assessment of individual impact of every substance); $I_{i,k}$ – index of assessment of the level of environmental hazard of the impact of the *k*-th substance on the *i*-th environmental component. The empirical constants *a, b, c, d* are connected with the specifics of the individual environmental components and determined in [16].

The assessment of the risk of *i*-th environmental component changes is carried out in accordance with the proposed scale in table 1.

Table 1

Levels of risk of changing in the emergency state

Level	Value of risk
Unacceptable	$>10^{-6}$
Conditionally acceptable	10^{-6}–10^{-7}
Acceptable	10^{-7}–10^{-8}
Unconditionally acceptable	$<10^{-8}$

Using an object-based approach, which takes into account the specifics of industrial objects and their location, risk-based dependencies can be used for environmental safety assessment (4). These dependencies are valid both for designing and for the standard mode of operation [16]:

$$\overline{p} = \overline{y} \times m_{ij} \tag{4}$$

where p – environmental risk probability; m_{ij} – the coefficient indicating the connection between the object and the ecosystem; $\overline{y}$ – vector of indicators that takes into account the features of an industrial object in the *i*-th form of the influence of environmental constituents [16].

An important task is to find the elements of the $\overline{y}$ vector, which depends on the object's features

and allows taking into account the magnitude of risk. The mathematical dependences of the risk and the index of environmental hazard assessment are used to solve this problem as proved in [15]. From (4) we take (5):

$$I = \frac{1}{b}\ln\left(\frac{r}{a}\right), \quad (5)$$

and taking into account the risks and the rating index we have (6)

$$I = 1 - \exp\left(-\exp\left(-y'\right)\right) \quad (6)$$

The indicator for taking into account the characteristics of an industrial object (7):

$$y' = \ln\left(\ln\left(1 - \frac{1}{b}\ln\left(\frac{r}{a}\right)\right)\right), \quad (7)$$

On the other hand, based on the mathematical dependence of the indices, values can be represented in general terms [15]:

$$y' = k_1 y + k_2, \quad (8)$$

where y' – relevant indicators of environmental components.

For assessing the effects of pollutants, the y' values and the corresponding coefficients k_1, k_2 are represented in Table 2, for assessing the impact on the environmental component in general – in Table 3.

Table 2

y' values for assessing the effects of pollutants

Environmental component	y', k_1, k_2	Conditional designations
Atmosphere (i = 1)	$y' = -2 \cdot PS_k + 1$ $k_1 = -2$, $k_2 = 1$	$PS_k = C_k / (BRC_k \cdot K_k)$, PS_k is the indicator of pollution of the k-th substance; C_i is the mean daily concentration of the k-th substance, mg/m^3; BPC_k is the boundary permissible concentration, mg/m^3; K_k is the values of coefficients that consider the hazard class of the k-th substance.
Surface waters (i = 2)	$y' = -2 \cdot I_k + 1$, $k_1 = -2$, $k_2 = 1$	$I_k = C_k / BPC_k$, I_k is the index of the k-th pollution indicator; C_k is the substance concentration (in a number of cases, values of physical-chemical parameter are used), mg/l; BPC_k is the found magnitude of standard for corresponding type of water site, mg/l
Soils (i = 3)	$y' = -2 \cdot Kc_k + 1$, $k_1 = -2$, $k_2 = 1$	$Kc_k = C_k / Cb_k$, Kc_k is the coefficient of chemical substance concentration; C_k is the factual content of pollutant in soils, mg/kg; Cb_k is the background content of pollutant in soils, mg/kg

Table 3

y' values for the impact on the environmental component in general

Environmental component	y', k_1, k_2	Conditional designations
Atmosphere (i = 1)	$y' = -0.25 \cdot ME + 1$ $k_1 = -0.25$. $k_2 = 1$	ME is the multiplicity of excess of standards
Surface waters (i = 2)	$y' = -0.33 \cdot I_E + 1{,}33$, $k_1 = -0.33$. $k_2 = 1$	I_E is the integral ecological index
Soils (i = 3)	$y' = -0.016 \cdot Z_c + 1$ $k_1 = -0.016$. $k_2 = 1$	Z_c is the total pollution indicator

Equating both expressions of the magnitude *y'* and find the required value of y for the estimation of the influence of the environmental component in general.

$$\ln\left(\ln\left(1-\frac{1}{b}\ln\left(\frac{r}{a}\right)\right)\right)=k_1 y+k_2,$$
$$y=\frac{1}{k_1}\left(\ln\left(1-\frac{1}{b}\ln\left(\frac{r}{a}\right)\right)\right)-\frac{k_2}{k_1}. \quad (9)$$

In order to estimate the impact in general, empirical constants *a* and *b* (3) are used. To estimate the impacts of each pollutant, the constants *c*, *d* (3) are used. The consolidated table of empirical constants *a*, *b*, *c*, *d* and coefficients k_1, k_2 is represented in table 4.

The coefficients of interactions m_{ij} can be calculated according to mathematical dependence:

$$m_{ij}=\bar{a}\times y_{ij},\ \bar{a}=\begin{pmatrix}0\\1\end{pmatrix}, \quad (10)$$

where $\overset{\mathbf{r}}{a}$ – the information matrix of parameters of a project, considering the specifics of location of industrial project on certain territories [15]. The elements of matrix $\overset{\mathbf{r}}{a}$ may take values of 0 and 1, which indicate the impact absence or presence respectively; indices *i*, *j* indicate the environmental component and a pollutant respectively.

Table 4

Empirical constants and coefficients

Environmental component		Constants				Coefficients	
		a	*b*	*c*	*d*	k_1	k_2
Atmosphere (*i* = 1	by pollutants	-	-	$1\cdot10^{-8}$	4.931	-2	1
	in general	$5.17\cdot10^{-9}$	11.29	-	-	-0.25	1
Surface waters (*i* = 2)	by pollutants	-	-	$1\cdot10^{-8}$	4.931	-2	1
	in general	$4.84\cdot10^{-13}$	21.054	-	-	-0.33	1.33
Soils (*i* = 3)	by pollutants	-	-	$1\cdot10^{-8}$	4.931	-2	1
	in general	$6.08\cdot10^{-8}$	5.48	-	-	-0.016	1

Conclusions

Research in the field of strategic environmental analysis to establish SEA and EIA relationships was n conducted. It was found that it is a challenge that the SEA bears only a descriptive character, however, at present, the intensive work on drafting laws on implementing the SEA in Ukraine is in process.

Based on methodology for calculating indices and environmental risks, previously developed by the authors, the tool of supporting strategic environmental assessment of territorial formations development and urbanised ecosystems of different scales along with the EIA is proposed. This tool was developed for assessing the ecological safety of territorial entities for conducting strategic environmental assessment based on the EIA. The applied objective approach allows establishing a connection between the estimates of the object, ecosystem and territory.

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