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Development of criteria of impact of the transportation facilities projected construction, exploitation, maintenance and reconstruction activities on the environment

O. Trofymchuk (Institute of Telecommunication and Global Information Space of NASU), **V. Khrutba** (National Transport University), **Y. Anpilova** (Institute of Telecommunication and Global Information Space of NASU), ***V. Lukianova** (National Transport University), **O. Barabash** (National Transport University)

SUMMARY

The aim of the work is to establish quantitative indicators of environmental impact assessment (EIA) of planned activities for construction, operation, repair and reconstruction of transport facilities.

The analysis has shown that there is no uniform system of EIA criteria in projects of construction and reconstruction of transport facilities, both in the system of environmental management and environmental safety, and in studies of design activities. These criteria depend on the specifics of the project, its environment and the problem the project aims to solve.

The environmental impact assessment at the motor roads construction and reconstruction (maintenance) method is used in the work based on the Leopold matrix, and the assessment of the project impact on the environment is carried out using the Harrington function on the example of the N-31 Dnipro - Tsarychanka - Kobelyaky – Reshetylivka.

Based on the Harrington function, conformity of the subjective assessment of an analyst and characteristics of the object (values of parameters) is set to determine the assessment of the impact of the motor road reconstruction (maintenance) processes. The general impact of the project on the environment is satisfying (lower-middle). The project is approved after a minor refinement.



Introduction. The development of road transport leads to a sharp increase in the problems of its impact on the environment (*EEA Report, 2015; Khrutba et al., 2021; Lukianova et al., 2020*), while at the same time being of important economic importance. In order to bring it closer to European standards, namely to control the degree of environmental pollution and to ensure the right of citizens to a safe environment, Ukraine adopted the Law "On Environmental Impact Assessment" in 2017 (*The Law of Ukraine "On Environmental Impact Assessment", 2017*). Given the above, there is a need to develop criteria for environmental impact assessment and a method to quantify them.

The aim of the work is to establish quantitative indicators of environmental impact assessment (EIA) of planned activities for construction, operation, repair and reconstruction of transport facilities.

The analysis has shown that there is no uniform system of EIA criteria in projects of construction and reconstruction of transport facilities, both in the system of environmental management and environmental safety, and in studies of design activities. These criteria depend on the specifics of the project, its environment and the problem the project aims to solve.

The environmental impact assessment at the motor roads construction and reconstruction (maintenance) method is used in the work based on the Leopold matrix (*Leopold et al., 1971*), and the assessment of the project impact on the environment is carried out using the Harrington function on the example of the N-31 Dnipro - Tsarychanka - Kobelyaky - Reshetylivka road of the IB technical category of the State importance on the plot of 11+400 km - 12+400 km in the boundaries of the Petrykivka district of Dnipropetrovsk region (*EIAR, 2018*).

The Harrington function and presented on the dimensionless scale of desirability. This scale establishes conformity of a subjective assessment of an analyst and characteristics of the objects (parameters values) that are researched.

An algorithm of carrying out stages of the environmental impact assessment in Ukraine has been analyzed in the work. Current legislation in Ukraine in the sphere of environmental impact assessment is found to comply with international requirements.

Based on the Harrington function, conformity of the subjective assessment of an analyst and characteristics of the object (values of parameters) is set to determine the assessment of the impact of the motor road reconstruction (maintenance) processes. The general impact of the project on the environment is satisfying (lower-middle). The project is approved after a minor refinement.

This work is a continuation of the Institute of Telecommunications and Global Information Space of NAS of Ukraine on geospatial information and ecologization of nature management taking into account risks of negative anthropogenic impact (*Trofymchuk et al., 2021a, 2021b; Anpilova et al., 2021*).

Method. Based on the Harrington function, conformity of the subjective assessment of an analyst and characteristics of the object (values of parameters) is set to determine the assessment of the impact of the motor road reconstruction (maintenance) processes. The general impact of the project on the environment is satisfying (lower-middle). The project is approved after a minor refinement.

Examples. On the basis of the criteria of the EIA in projects of construction and reconstruction of transport structures (*Khrutba et al., 2020*), a set of 10 groups of criteria for EIA and indicators for their assessment, as well as the features of the environmental impact of facilities during road reconstruction, presented in Fig. 1, are proposed.

For a quantitative assessment of the level of impact (amplitude) of the significance of the ecosystem changes (importance) for each criterion, a numerical score of a criterion (C_{sc}) is defined using a supporting table (Table 2.) (*Olekh et al., 2013a; 2013b*). The final numerical score of a criterion (C_{sc}) is calculated on a formula (1):

$$C_{sc} = (R + L + C + S + F + T + D)M, \quad (1)$$

where R is the assessment of the risk of impact; L is the assessment of legal requirements and standards fulfilment; C is the assessment of civil discourse; S is the assessment of the impact scale; F is the assessment of financial costs to recover from impact; T is the usage of new innovative technologies; D is time or duration of impact; M is the assessment of management capabilities.



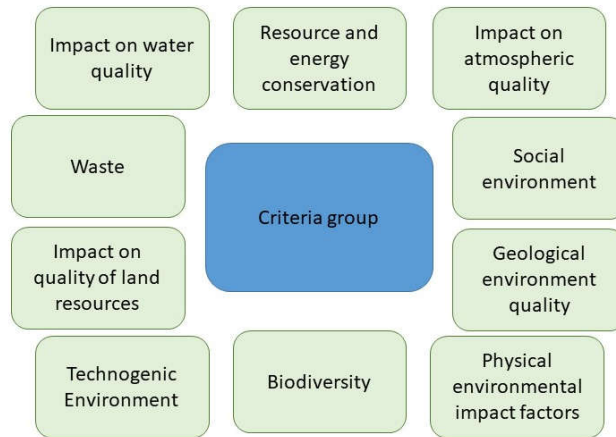


Figure 1 Environmental impact criteria for road reconstruction.

During the project, emission of pollutants in the ambient air lower layer is created in each defined process from the emission of construction vehicles engines (lifting jib cranes, excavators, etc.), emission of pollutants during the transportation of materials, equipment and workers.

A fragment of the Leopold matrix for conducting the RIA for the project “Building of the N-31 Dnipro - Tsarychanka - Kobelyaky - Reshetylivka motor road of State importance from Loboikivka village to the Dnipropetrovsk region boundary” during the construction phase is shown in Fig. 2.

	Parameters				Arrangement of roadbed		Road dressing		Fortification of kerbs	Crossing and abutment, arrangement of a traffic interchange on a given road section				$\sum_{i=1}^n Z_i$	Significance of impact Y_i	Severity of impact F_i	Sum of influences	Local assessment of impact V_i
	Impact on the ambient air lower layer	Mass concentration of a pollutant in the ambient air lower layer	Sulfur oxide	On the road axis 50 m	Roadbed filling		Removal of a vegetation layer			Arrangement of road dressing for the fortification of kerbs	Acceleration and deceleration lanes	Arrangement of the road dressing of a "broker" ring road	Arrangement of the road dressing with the highway					
Air					Impact on the ambient air lower layer	Mass concentration of a pollutant in the ambient air lower layer	Sulfur oxide	On the road axis	2					2	3	3	2	2
	50 m	2	1	2				2	1	1	2	2	1	14	11,11	155,54		
	Nitrogen oxide	On the road axis	2	2			3	3	2	2	3	3	1	21	11,11	233,31		
		50 m	2	1			2	2	1	1	2	2	1	14	11,11	155,54		
	Carbon dioxide	On the road axis	1	1			2	2	1	1	2	1	1	12	11,11	133,32		
		50 m	1	1			1	1	1	1	1	1	1	9	11,11	99,99		
	Benzol(a)pyrene	On the road axis	0	0	3	3	2	2	2	2	0	14	16,67	233,38				
		50 m	0	0	2	2	1	1	1	1	0	8	16,67	133,36				
	Mass concentration of solid pollutants (dust)	PM ₁₀	On the road axis	2	2	3	3	3	3	3	3	1	23	11,11	255,53			
			50 m	2	2	2	2	2	2	2	2	1	17	11,11	188,87			
		PM _{2,5}	On the road axis	2	2	3	3	3	3	3	3	1	23	11,11	255,53			
			50 m	2	2	2	2	2	2	2	2	1	17	11,11	188,87			

Figure 2 A fragment of the Leopold matrix fragment for carrying out the EIA of the “Building of the N-31 Dnipro - Tsarychanka - Kobelyaky - Reshetylivka motor road of State importance from Loboikivka village to the Dnipropetrovsk region boundary” project on the construction stage.

Conclusion about the intensity of impact on the environment according to the variants of projected activity is carried out by matching corresponding cells in matrices that comply with the alternative variants of the project. The general assessment of the project impact on the environment is made using the Harrington function. The mentioned generalized function allows determining an integral parameter of the assessment of the impact on the environment which is a qualitative, unambiguous, universal parameter of the researched object quality and can be used as a criterion of the assessment of the environmental impact during a motor road construction and reconstruction (maintenance) due to its adequacy, efficiency and statistical sensitivity.



To build an integral parameter of the environmental impact assessment, a generalized Harrington desirability function and its graphic representation are used ((*EIAR, 2018*). Accordingly, the integral parameter of the environmental impact assessment (Y) equals:

$$Y = m \sqrt{\prod_{i=1}^m Y_i} \quad (2)$$

Where Y_i is the level of local impact of the motor road reconstruction (maintenance) process on the environment; m is the quantity of local parameters of impact on the environment.

The environmental impact assessment of the motor road reconstruction (maintenance) processes is done based on the Harrington function and presented on the dimensionless scale of desirability. This scale establishes conformity of a subjective assessment of an analyst and characteristics of the objects (parameters values) that are researched and presented in Table 1.

Table 1 Graduation of the intensity of the impact level of motor road construction and reconstruction (maintenance) processes on the environment

Harrington scale	Intensity of the impact level scale, Y	Graduation of the intensity of the impact level	Conclusion about the EIA result
0 - 0,20	0 – 1,0	Very (extremely) low	The projects is approved
0,21 - 0,37	1,01 – 1,85	Low	The project is approved
0,38 - 0,63	1,86 – 3,15	Satisfying (lower-middle)	The project is approved after a minor refinement
0,64 - 0,80	3,16– 4,0	High	The project is approved after significant refinement and implementation of ecological safety measures. Reassessment is carried out
0,81 - 1,0	4,01 – 5,0	Very high (extremely high)	The project is not approved

Thus, the lower is the value of an integral parameter during the motor road construction or reconstruction (maintenance), the less the impact on the environment and the safer the project will be. Results of the assessment of the impact on separate components of the environment near the “Building of the N-31 Dnipro - Tsarychanka - Kobelyaky - Reshetylivkamotor road of State importance from Loboikivka village to the Dnipropetrovsk region boundary” project are given in Table 2.

Analysis of the table shows that the impact on most parameters of the environment is satisfying (lower-middle). However, a significant negative impact is done on the air due to a high level of dust formation during the motor road construction processes.

Table 2 Assessment of impact on separate components of the environment

Environmental component	Parameter value	Conclusion
Air	2,3318	Satisfying (lower-middle)
Land	1,6974	Low
Waste	1,3719	Low
Water	1,7831	Low
Flora and fauna	1,5546	Low
General impact of the project on the environment	1,9081	Satisfying (lower-middle). The project is approved after a minor refinement

Thus, a carried out EIA of the “Building of the N-31 Dnipro - Tsarychanka - Kobelyaky - Reshetylivka road of the IB technical category of the State importance with 4 traffic lanes (2 traffic lanes in each direction) avoiding Loboikivka, Petrykivka, Mohyliv, Kytaihorod, Tsarychanka, Liashkivka localities” project have shown that the project doesn't have a significant impact on the environment and can be approved after a minor refinement.

Conclusions. An algorithm of carrying out stages of the environmental impact assessment in Ukraine has been analyzed in the work. Current legislation in Ukraine in the sphere of environmental impact assessment is found to comply with international requirements.



The Leopold matrix is built for the assessment of the impact of the N-31 Dnipro - Tsarychanka - Kobelyaky - Reshetylivka road of the IB technical category of the State importance with 4 traffic lanes avoiding Loboikivka, Petrykivka, Mohyliv, Kytaihorod, Tsarychanka, Liashkivka localities construction project on the environment. It is convenient for a developer of the project that they can modify the matrix in correspondence with specific tasks of the motor road construction and reconstruction (maintenance) project.

Based on the Harrington function, conformity of the subjective assessment of an analyst and characteristics of the object (values of parameters) is set to determine the assessment of the impact of the motor road reconstruction (maintenance) processes. The general impact of the project on the environment is satisfying (lower-middle). The project is approved after a minor refinement.

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