EVALUATION AND GENERALIZATION OF MULTI-PARAMETER INFORMATION FOR COMPARISON OF INDICATORS OF QUALITY OF VARIANTS OF HIGHWAY PROJECTS

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Abstract

A method is proposed for generalizing multiparameter information about the properties of projected natural-technogenic geoecosystems that are transformed by a dense network of highways. The method is based on formalizing the properties of individual parameters of the projected objects using the double exponential function. After obtaining estimates of the properties of individual project parameters, they are generalized using the integral parameter in the form of a geometric mean.Despite the pure empirical nature of the proposed method of generalization of the estimated parameters of the projected natural and technogenic geoecosystem, its use seems to be quite promising from the point of view of choosing the optimal project and the subsequent prediction of the processes of transformation of natural and territorial complexes.

Key words: project parameters, multiparameter information, project evaluation, "desirability" function, integral properties, geometric mean, quality prediction.

Actuality of work. The dynamics of the transformation of the natural-territorial complex [1, 3, 4] under the influence of the motor transport infrastructure causes the flow of nonstationary processes, which in general can be described as:

$$S_p(t) = x_S^p(t) + x_p(t) \qquad p = 1, 2, \dots, m; \tag{1}$$

where $S_p(t)$ – the value of the p-th controlled parameter variables in time;

$x_S^p(t)$ – the deterministic component of the process;

$x_S^p(t)$ – stochastic component of the process;

m – number of controlled parameters (attributes).

Material and results of research. If we evaluate the studied variants of the system (project) in terms of generalization of its parameters (attributes), then formula (1) takes the form:

$$S_p{}^{(*)}(t) = \sum_{t=0}^{t} m_S^{p(*)} + \int_{t=0}^{t} x_p{}^{(*)} \cdot dt \qquad (2)$$

where $S_p{}^{(*)}(t)$ – формалізоване значення оцінюваного параметру (ознаки).

For a numerical generalization of multi-parameter information about a system (project), all its properties (attributes) considered must be represented in some intensive form, which presupposes the relativity of the numerical expression of the evaluated sign in a dimensionless form with respect to some "norm" or a selected (predefined) base value of the same signs that are given in the extensive form (in the form of an absolute value with a definite dimension). In this case, provided that the absolute (extensive) values of the boundaries of variation (maximum and minimum) of the feature under consideration are determined, any numerical values of the same sign in an intensive form will be determined by a range of 0 ... 1.

Thus, the integral property of an evaluated system (project) for a selected group of individual properties of this system (project) can be defined as [2]:

$$K = f\begin{pmatrix} X_1^+, \dots, X_a^+, X_{a+1}^-, \dots, X_b^-, Y_{b+1}^+, \dots, Y_c^+, Y_{c+1}^-, \dots, Y_d^-, \\ X_{d+1}^0, \dots, X_m^0, Y_{m+1}^0, \dots, Y_n^0, Z_{n+1}, \dots, Z_k \end{pmatrix} \qquad (3)$$

where $X_1^+, \dots, X_a^+$ – positive continuous attributes of the system (project), which, with an increase in the numerical value of the parameter characterizing this attribute, leads to an increase in the quality index of the system (project) as a whole;

$X_{a+1}^-, \dots, X_b^-$ – negative continuous properties of system attributes, which, with an increase in the numerical value of a parameter that characterizes this property, leads to a decrease in the quality index of the system (project);

$Y_{b+1}^+, \dots, Y_c^+$ – positive discrete properties of system signs (project), which, with an increase in the numerical value of the parameter characterizing this attribute, leads to an increase in the quality index of the system (project) in general;

$Y_{c+1}^-, \dots, Y_d^-$ – negative discrete properties of system attributes, which, with an increase in the numerical value of a parameter that characterizes this property, leads to a decrease in the quality index of the system (project).

$X_{d+1}^0, \dots, X_m^0$ – numeric value of the parameter (attributes) of a continuous property with a double-sided constraint;

$Y_{m+1}^0, \dots, Y_n^0$ – numeric value of the parameter (attributes) of the discrete property with a double-sided constraint;

$Z_{n+1}, \dots, Z_k$ – properties (attributes) of comparable variants of systems (projects) which are characterized by the terminological category and which can be assigned a numerical value in the form of a certain score, which purely subjectively determines the degree of conformity of the considered feature (property) to the quality level of the evaluated object or system in general.

f – the function of the generalization of the properties of the system, which must satisfy the following requirements:

$$\begin{cases} \dfrac{df}{dX_a^+} > 0; \quad (a = 1, \dots, a); \\[2ex] \dfrac{df}{dX_b^-} < 0; \quad (b = a + 1, \dots, b); \\[2ex] \dfrac{df}{dY_c^+} > 0; \quad (c = b + 1, \dots, c); \\[2ex] \dfrac{df}{dY_d^-} < 0; \quad (d = c + 1, \dots, d); \\[2ex] \dfrac{df}{dX_m^0} \to opt; \quad (m = d + 1, \dots, m) \\[2ex] \dfrac{df}{dY_n^0} \to opt; \quad (n = m + 1, \dots, n) \\[2ex] Z_k \ni \begin{cases} min \\ max \end{cases}; \quad (k = n + 1, \dots, k) \end{cases} \tag{4}$$

To determine the numerical estimates of d (in the intensive form) of the individual properties of the evaluated system (project) we use a narrower class of functions [2], Which is reduced to exponential and index functions. The first of these functions, which is determined by the double exponent for the evaluation of continuous and discrete positive and negative properties, and for the evaluation of properties with double-sided restrictions, this function will have the form of exponential-index function:

– double exponential function (fig.1):

$$d_i = e^{-e^{-R_i}} = exp[-exp(R_i)]; \qquad (5)$$

– exponential-index function (exponential-exponential function, fig.2):

$$d_i = e^{-(|R_i|)^n} = exp[-(|R_i|)^n]; \qquad (6)$$

where, the power exponent *n* is a positive number for computing which is calculated by a certain value |*m*|:

$$|m| = \frac{2R_i - (R_{max} - R_{min})}{R_{max} - R_{min}} \qquad (7)$$

after which the power index *n* can be calculated if you set the estimated property *R* of some value *d* (best in the interval $0,37 < d < 0,99$), calculate accordingly (7) the value |*m*|, and then use the expression:

$$n = \frac{ln\left(ln\frac{1}{d}\right)}{ln|m|} \qquad (8)$$

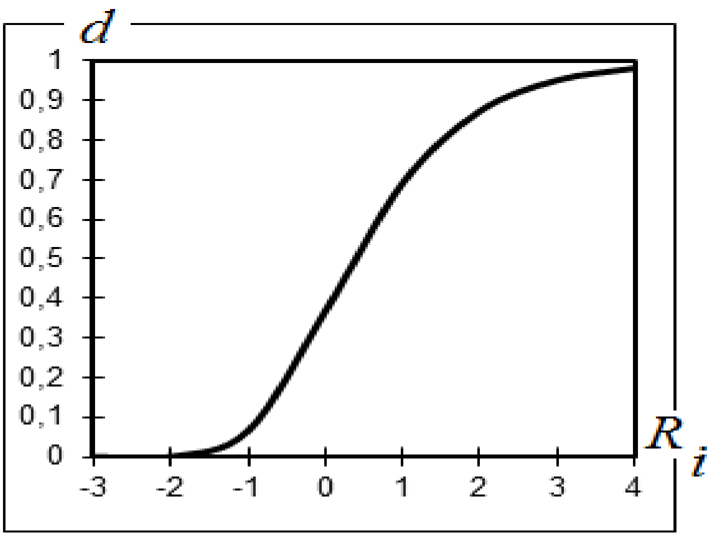

Fig.1. Double exponential function

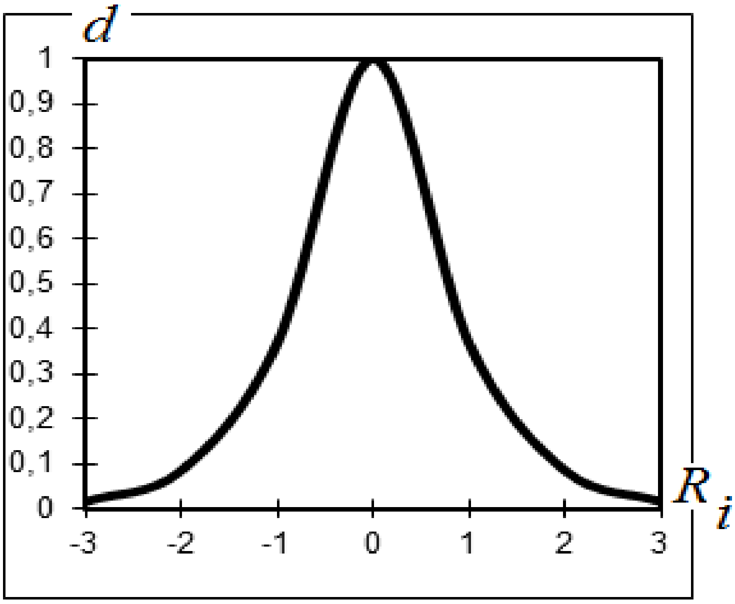

Fig.2. Exponential-index function (exponential-exponential function

By choosing different values of *n*, a different curvature of the curve can be given for the estimation (fig.2). This allows to take into account a special rank (by degree of importance) of individual properties (attributes) of a projected natural-technogenic geoecosystem with a developed motor transport network. In this case, for such properties, the index *n* will have more value and a sharp (contrast) change in their estimation will correspond to the small numerical changes of the estimated parameter of the sign near the bounding boundaries. The final generalization of numerical parameters (estimates) d_i of separate properties (attributes) of the system (project) is carried out by their averaging with the mean geometric [2]:

$$D = \sqrt[q]{\prod_{i=1}^{q} d_i} = \sqrt[q]{d_1 \times d_2 \times \dots \times d_q} \tag{9}$$

де D – generalized (integral) estimation of the system (project) of a natural technogenic geoecosystem with a developed motor transport network.

Conclusion. Despite the pure empirical nature of the proposed method of generalized estimation of parameters of a projected natural-technological geoecosystem during the construction or reconstruction of the road network infrastructure, its use is quite promising in terms of choosing the optimal project and further predicting the processes of transformation of natural-territorial complexes.

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