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Economic-Mathematical Modeling of Social and Environmental Risks Management of Projects of Urbanized Territories Development

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Abstract

The article covers the problem of development of management methods of social and environmental risks of urbanized territories development. The main purpose of research is a development and scientific substantiation of economic-mathematical model, allowing to increase the efficiency of risk management of urban development and selection for the practical implementation of the most efficient investment and town-planning projects. During the investigation the conditions and possible consequences of socio-environmental violations of natural and antropogenic environment in urban areas were examined, the characteristics of the information base of the assessment and objects of socio-ecological and economic risks of urban development were identified, the peculiarities of the negative occurrences of the deterioration of environmental quality were distinguished. As a base for the source data array composition, the authors propose to use the common system of integral parameters of sustainable development and environmental indicators. As basic function of socio-ecological damage is proposed to use the direct dependency of the health level of the population from the most significant parameters of the environment, expressed in the econometric equation. For formal description of the dependency of economic-mathematical models, the whole complex of factors affecting the value of socio-ecological damage were studied, the drawbacks of simple regression models for description of interaction between the mentioned factors were examined, the assumption about the need to include in a formal description the factors of socio-economic risks of the interrelated equations system was made. The main result of the study is developed economic-mathematical model describing the process of formation of socio-environmental risk during implementation of investment and construction projects of urbanized territories development. The main conclusion of the study is the justification for the need to identify environmental and social risks and due to their presence the economic damage in the process of developing programmes and projects of urban territories development. The use of the proposed model assists with pictorial rendition of the correlation between environmental problems and development of city economy, as well as more objective substantiation of efficiency of investments in the urban environment development.

Keywords: modeling, risk, project, development, urbanized territories

1. Introduction

Modern urbanized environment of urban areas in Russia is characterized by a severe socio-ecological violations (Murzin, 2012), due to the lack of control of ecological parameters of investment and construction projects (Borisov & Marshalkovich, 2012) and as a result large-scale pollutions of atmospheric air, surface & deep soil and water objects (Qian et al., 2013).

The deterioration of ecological environment parameters, intensification of construction and anthropogenic impact on the environment contribute to a violation of the natural-anthropogenic sustainability (Murzin, 2013) and increase the probability of negative socio-economic consequences in the scale of urban agglomeration (Taroun, 2014), exhibited in the increasing incidence, growth of economic losses and on-budget expenditures (Murzin, 2012).

At the same time, many researchers use the official publications of the environment pollution as an information basis of data, which, as a rule, do not consider unauthorized discharges and emissions, which leads to poorly objective character of the obtained results and reduces the practical significance of the conclusions (Borisov and Marshalkovich, 2012). Constellations of criteria used for assessment of the ecological state of the environment

often reflect only the degree of anthropogenic impact of human activities, and does not take into account the risks of social damages (Murzin, 2012).

The objects of ecological and economic risks of the realized investment and construction projects of urbanized territories development are individuals, urban population, economic entities (enterprises, organizations, companies), territorial and environmental systems and territorial-production complexes of different levels (Murzin , 2013).

The process of deterioration in environmental quality can be as relatively evolutionary in nature, for example, prolonged accumulation of the pollutants in the specific field of the environment, and also can have catastrophic rate, for example, in consequence of technogenic accidents, catastrophes or natural disasters (Wang et al., 2009).

In connection with the indicated circumstances the modeling of processes of social and environmental risks management in the process of planning the directions and realization of investment projects of urbanized areas development is relevant and affects interests of the city community, defining long-term priorities of the environment security of urban areas.

2. Materials and Methods

An important issue of economic-mathematical modelling is to determine the criteria characterizing the state of the studied object. When studying the socio-ecological environmental parameters, as a rule, can be used two or three key indices, for example: the volume of natural resource, absolute discharge (emission) of polluting substances, their concentrations in the environment and so on. However, it is obvious that the assessment of socio-ecological parameters of the investment and construction projects of urbanized territories development must be accompanied by considering the significantly larger number of figures. In other words, it's talking about the integrated assessment of the consequences of the condition, quality, safety and sustainability of the natural environment of a certain territory. Most known systems of ecological indicators of the environment is a system of criteria for sustainable development, elaborated by the United Nations Commission on Sustainable Development (UN CSD) and the system of environmental indicators proposed by the Organization for Economic Cooperation and Development (OECD) (Bossel, 1999).

Despite intensive nature and a great variety of socio-ecological and ecological-economic risks emerging in the process of realization of urban areas projects and regions development, researches on the degree of their influence on the socio-economic condition of the city and the heterogeneity of the development are practically absent.

Under the ecological and economic risks we understand the risks of economic losses and damages emerging within economic entities of different levels of social organization due to the deterioration of the quality parameters of the environment state. The economic part of this term defines the involvement of objects that have ecological and economic risks to the general economic subsystem of the city and reflects the economic characteristics of their losses. The environmental part reflects the causes of the environmental and economic risks.

In most studies of domestic and foreign scientists as a function of damage are used simple linear or exponential functions, and as an assessment tool is used the method of econometric modeling (Murzin, 2012). It also assumes a direct dependence of the health level of the population from a number of factors, the most significant of which is determined by the quality of the environment. This relationship can be represented in the form of econometric equations:

$$y_i = f\left(x_{ij},\ldots,x_{in}\right)+ e_e,$$

where: f: form of dependence, y_i: dependent variable, x_{ij}: independent variables, e_e: error of the equation.

3. Results

In this regard, to estimate the potential socio-economic damage from pollution of the environment during the implementation of investment and construction projects of city urbanized territories development, we suggest a model based on the ideas of Freeman (Freeman, 1979), which presumes that:

- indicator of socio-economic damage (incidence rate) (M) is a function of the impact of a pollutant on the environment (P), and other variables of a system of simultaneous equations are the availability of qualitative medical attendance (D) and average of income level (Y);
- availability of qualitative medical attendance is dependent on the average income level;

- the level of income directly depends on the extent of the damage to the recipient, as the high incidence causes the loss of working time and wage cut.

Thus, the proposed model can be presented as:

$$\begin{cases} M = a_0 + a_1 D + a_2 P + u_1, \\ D = b_0 + b_1 Y + u_2, \\ Y = c_0 + c_1 M + u_3, \end{cases}$$

where u_1, u_2, u_3: residual terms of equation; it is assumed that the free variables must meet the following conditions: a_0, a_2, b_1, $c_0 > 0$; a_1, $c_1 < 0$.

Criteria for the level of morbidity, access to medical attendance and average income levels are endogenous regarding to the system even taking into account that each one of them acts as the independent variable in one of the system equations. The assessment of these equations by the least squares method (Ordinary Least Squares, OLS) can produce contradictory results, moreover, in this case they cannot be identified. Building a model of simultaneous connections with multiple structural equations adequately reflecting identified relationships, allows to use special statistical methods of their assessment, for example, a two-step OLS that helps to overcome these shortcomings.

Analysis of methodological approaches to economic assessment of possible damage from a pollution of the environment during the implementation of investment and construction projects of development of urbanized territories showed that the most appropriate are the methods of objective group, and in particular, the method of valuation impact, based on an econometric damage function.

4. Discussion

An important task of the research of this relationship is to determine the degree of influence of the whole complex of factors on the amount of possible damage (Nasirzadeh at al., 2014). It should be noted that the estimation of the contribution of a particular factor in the formation of the identified dependencies is very difficult, due to the multitude of combinations of mutual influence and interaction of risk factors, real conditions and restrictions of risk manifestations, inaccurate forecasts of the amount of damage and environmental pollution (Qian et al., 2013).

The main group of factors of a damage formation from pollution are the socio-economic factors, which are also characterized by the presence of complex relationships (Wang at al., 2014). This circumstance causes the lack of adequacy of the models of simple regression based on the cross-comparison of the values of a certain amount of damage and the related indicators of environmental quality (Shinkareva and Plahov, 2010). This is explained by the following circumstances:

1. Most of the economical, ecological and social processes are too complex to describe in one equation linking dependent parameter and set of independent variables.
2. The independent variables may have multicollinear connections.
3. Regression due to its reduced form often cannot fully describe the true nature of the studied system.

Therefore, we conclude that the formalized description of the factors of socio-economic risks caused by the realization of investment and construction projects of urban territories development, must include a system of equations in which the exogenous variables of some equations will be endogenous with respect to the entire system, in other words act as dependent in other equations system (Aleksandrova, 2007). However, we noted that in the majority of the empirical studies of damage from environmental violations is not taken into account the possibility of describing the dependencies of the type «natural damage and environmental pollution» (Lapteva & Morozova, 2011).

To determine the most acute issues of sustainable urban areas development in the region, it is proposed to use the model of «pressure-state-reaction» indicators system (Indicators, 1994). An important feature and advantage of this model is the logical interconnection between the indicators of «pressure», reflecting the level of negative human impact, indicators of «state», reflecting the currently existing quality of the environment components and the «reaction» indicators that characterize the public response to the current pressure level.

This model allows to identify cause-effect interconnections between economic, environmental and social conditions that provides the basis for decision–making in the sphere of environmental–economic policy, and also allows the public to trace interconnection of such phenomena and to develop the arising issues solving policy.

The following specific set of indicators to assess the sustainable development of socio-ecological-economic system can be offered (Table 1).

The system of indicators contains a rather well-known indicators, most of which are included in range of indicators calculated by the Federal State Statistics Service and its regional departments:

1. «Pressure» Indicators
   1.1. Emissions of air pollutants from stationary sources and vehicles
   1.2. Proportion of trapped and neutralized pollutants in the total emission volume
   1.3. Volume of wastewater discharges to surface waters
   1.4. The pollutants mass dumping
   1.5. Generation of waste
2. «State» Indicators
   2.1. API – Air Pollution Index
   2.2. SI – Standard Index – index for the concentration of impurities in terms of maximum allowable concentrations
   2.3. HF – The Highest Frequency of exceeding the maximum permissible concentration
   2.4. Specific weight of waste water samples that don't meet hygienic standards
   2.5. The water quality of 2-nd category reservoirs of water use (recreation area)
   2.6. Natural increase (loss) of the population
   2.7. Climate change (average annual temperature and precipitation, humidity, level of water bodies)
   2.8. Gross regional product (GRP)
   2.9. Human Development Index (HDI)
3. Reaction» Indicators
   3.1. The costs of environmental protection
   3.2. Collection of payments for negative impact on the environment
   3.3. Penalties for violation of environmental laws
   3.4. Investments in fixed capital, aimed to protect the environment
   3.5. The share of GRP accounted by environmentally clean goods and services

The first group of indicators – «pressure indicators» – includes indicators that reflect the parameters of human impact on the basic components of the environment: air, water bodies, land and forest fund, as well as on the fundamental properties of ecosystem: production of bio-resources and pollution assimilation, which are considered through the indicators of a biodiversity and waste accumulation.

The second group of indicators – «state indicators» – contains the basic parameters of environmental quality and its major components that are reflected by various indicators of the pollution level. In addition, indicators, reflecting the general prosperity of the region's population, dependent on the quality of the environment and resources, reflecting the general level of economic development and differentiation of society in terms of economic development are included here.

Besides, in order to reflect the level of environmental region economy it is advisably to use GRP energy intensity, reflecting the general state of economy from the point of using the energy efficient technologies in it (which are also environmentally clean). Despite the seeming simplicity of such an indicator, its use is necessary, as it most completely reflects the efficiency of existing regional policy in the field of ecological economics and in fact without going into excessive detalization by an assessment of concrete instruments and mechanisms used for it, and reflects the final «output» result of the system.

Human development index (HDI), which reflects the general picture of modern society development and the possible heritage for future generations is also included in the second group of indicators.

The third group – indicators of «reaction» – includes a number of indicators that characterize different courses of the implemented in a region environmental–economic policy: implementation of costs for environmental protection, Collection of payments for negative impact on the environment, measures related to pollution prevention, etc.

The choice of concrete indicators was determined by the following conditions: the presence of a comparable official data over a sufficiently long period of time (5–10 years), the possibility of an adequate assessment of the overall region situation (Bossel, 1999). In general, this set of indicators may be expanded at the expense of their concrete definition in different directions depending on the realizable goal, as well as the specifics of a particular region, by including more detailed information on municipal entities, types and substances effects; sectoral sign,

more detailed segmentation of the environment components, regulatory institutions of the impact on environmental (Visvaldis at al., 2013).

For the most trustworthy assessment effectiveness of implemented in the area environmental–economic policy, it is needed to consider these indicators in the long–term dynamics, that will trace the measures taken in the field of environmental protection, and their effects, that are coming out in the parameters of human impact on the environment and quality characteristics of its main components.

5. Conclusion

Thus, we can conclude that the toolset for comprehensive socio-economic impact assessments of investment and construction projects of urbanized territories development are not fully formed. Restriction: as a base for forming an array of source data we used a system of commonly integral parameters: the system of criteria of sustainable development elaborated by the United Nations Commission on sustainable development and the system of environmental indicators proposed by the Organization for economic cooperation and development. However, in order to further improve the methods, more specific systems of integral indicators may need to be developed.

Nevertheless, the accounting of possible socio-ecological-economic damage from pollution must accompany the development of programs and projects of urban territories development. Estimation of such harm, first of all, reflects the relationship of environmental problems and municipal economy, and secondly, it promotes a more objective substantiation of efficiency of investments in the development of the urban environment.

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