Analytical assessment of social, environmental and economic indicators for the balanced development of the economy of the region

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Abstract. The article suggests an analytical evaluation of social, environmental and economic balanced development of the regional economy on the example of the Voronezh region. The assessment is based on a correlation analysis of indicators. The calculation of correlation coefficients revealed similarity and direction of the relationship of the studied parameters. Analytical assessment reflects the interrelation of indicators in the three main components of the regional economic sectors (economy, nature and society). Any development of economic activity causes significant harm to the environment by emissions of harmful substances into the atmosphere, discharges of polluted effluents into surface water bodies, formation of a huge amount of production and consumption waste. The measure of this impact are different in their strength, as well as the magnitude of the applied social, environmental and economic damage to the environment in different periods of economic development of the countries. The process of innovative development in production creation of new materials and other fields, (as well as any technogenic impact) can cause a negative, adverse impact on the environment. Environment protection becomes one of the priority tasks of modern eco-oriented economic development. This assessment can be further used in regional management to diagnose the current situation, identify cause and affect relationships between indicators and predict the parameters of balanced development.

1. Introduction

The development of a mechanism for regulating sustainable development aimed at the balanced development of regional economies and the achievement of socio-environmental and economic well-being with the capabilities of the environment is especially relevant recently. It is a viable concept for the territories with rich natural resources and unique nature objects, the conservation of which cannot be separated from conditions of development and regulation of business activities of economic agents. The increasing complexity of economic relations, manifested in the consideration of the environmental factor in managerial practice, necessitates the identification of institutional conditions and improvement of environmental policy instruments capable of ensuring the effective dynamics of positive changes in the economy. It happens in the face of deteriorating environmental conditions and increasing its negative impact on the nation's ability to work and health.

Conceptual ideas about the systems integrating the triad "nature-population-economy" began to form in the late 1970s-early 1980s in conditions when various imbalances of economic, social and environmental character sharply increased, special attention is deserved by the works considering the essence of balanced development from the position of regionalism.

Referring to the model of Pierce and Turner, in which natural resources and services (recreation, aesthetic impact, etc.) are considered as factors that have a direct impact on the level of welfare of the socio-economic system, the authors highlight its main drawback — anthropocentric approach.

A number of other models of the future world have been developed (E Laszlo, J Tinbergen, J Kaya and J Suziki, M Mesarovich and E Pestel, etc.). These models, despite some of their limitations, dealt a serious blow to the uncontrolled development of world production and were the impetus for the further revitalization of the club of Rome. We will dwell in more detail only on some of them. Thus, Japanese scientists Ya Kaya and Ya Suziki proposed a project in which they tried to find ways to reduce the existing gap in per capita income. They concluded that it was necessary to provide free aid to developing countries in the amount of 1 % of the annual income of developed countries. Other provisions of the draft are also of interest. Its authors believe that the share of light industry should be reduced in developed regions, and it should increase in developing regions [1].

These studies, including our recent publications, have shown that the socialization of the economy and the preservation of habitat gives a socio-ecological-economic system, which is the main form and conditions for the balanced development of the region. In addition, the analysis of international practice has shown that many problems of socio-economic and environmental imbalances originated primarily at the regional level and only later acquired national dimensions. Therefore, the research approach to the development of regions from the point of view of the system of ecology, economy and social sphere has become one of the methodological foundations of the study on the assessment of socio-ecological and economic indicators of the region.

The concept of sustainable social, environmental and economic development of the territory, in our opinion, should be based on the principles of: optimal matching of society and natural environment; the natural balance of the biosphere; compensation according to the values of the measures taken from nature, environmentally oriented human activities, complexity and environmental soundness of the decisions made, ensuring the priority of public interest over private one. In essence, this means that economic development can not and should not be accompanied by dangerous pollution and environmental degradation. In accordance with the Federal Law 172 “On Strategic Planning in the Russian Federation”, the achievement of the strategic goals of sustainable development of social, environmental and economic system is achieved through the development and monitoring of the implementation of three groups of documents [2]:

1) Strategic planning documents developed in the framework of goal-setting (strategies for the socio-economic development of the Russian Federation in general, macroregions, regions, municipalities in particular);

2) Documents of strategic planning developed in the framework of planning and programming (plans for the implementation of strategies for socio-economic development of the constituent entities of the Russian Federation, municipalities; state programs of constituent entities and municipalities; territorial planning schemes for constituent entities of the Russian Federation);

3) Strategic planning documents developed in the framework of forecasting (long-term and medium-term forecasts of the socio-economic development of the country, macro-regions, subjects, municipalities of the Russian Federation; long term budget forecast of the regions, municipalities ; forecast of the socio-economic development of the constituent entities of the Russian Federation for the medium term) [3].

It is the system of strategic tools for managing the resource base that coordinates with each other. It can most significantly affect the sustainable development of the region [4].

Sustainable development of the region is a process of both positive and negative changes, ensuring systemic social, environmental and economic balance and the achievement of goals and priorities over a long-term (strategic) period of time. Realization of the goals is achieved by competent

management of this process. Management of sustainable development of the region, in our opinion, is ensured through the implementation of a strategic management mechanism based on analytical assessment of balanced indicators.

The novelty of these scientific and methodological foundations is in the allocation of their main theoretical components in the assessment of socio-ecological and economic indicators for the balanced development of the economy of the region. Such development is seen as a system of targeted functions that allow for economic sustainability, taking into account environmental constraints, on the basis of social surveys. The application of the framework will contribute to the achievement of the goals through a consistent movement from adaptation to innovation and therefore to a balanced development associated with the solution of social, economic and environmental problems.

The main purpose of the study is to form an economic mechanism for the implementation of legislation, which would provide the following: creation of conditions for the activation of the investment process aimed at solving social and environmental problems; rational use of natural resource potential.

2. Statement of the problem

It is necessary to implement a set of measures aimed at strengthening the sustainability potential to ensure sustainable development of social, environmental and economic balance:

1) To analyze the structure of industry markets in the regions, identify the highest priority ones that affect the sustainability potential; to ensure the integrated development of industry markets based on the observance of optimal proportions for the development of social reproduction;

2) To make the maximum use of the employment policy of the population in order to effectively develop the socio-economic potential of the regions;

3) To increase the resource self-sufficiency of the regions, including food factor, in connection with the implementation of policies aimed at supporting local agricultural producers and gradually reducing food imports;

4) To implement environmental management with the use of effective methods of economic and administrative impact on the environmental pollutants;

5) To strengthen the regional budget and create a qualitatively new system of environmental and economic interregional relations and relations between the regions and the center;

6) To increase the level of energy independence of the regions as the basis for the rational development of its ecologized socio-economic (social, environmental, and economic) system [5].

The development of socio-economic system formations is impossible without effective external regulation and management, including government intervention or the intervention of private and other governing structures. The first priority is given to the regulation by government agencies, since small business is of almost no interest to social and environmental issues due to the lack of a profitability factor. In order to ensure the effectiveness of public administration in social, environmental, and economic regional formations, it is necessary to use an integrated systems approach, including the development of strategies and tactical measures for the government influence in this area. The fundamental basis of state regulation should be the synthesis of the interests of all interested spheres of the territories. It should include the organizational and economic mechanism, the environmental component, and the social effectiveness of the reforms. It is impossible to determine the main role of any of the selected aspects, since the systematic approach is characterized by the complexity and interconnection of all the constituent elements. For example, in addition to the classification of state regulation by industry, it must also be differentiated by vertical elements and be practically implemented at the federal, regional and municipal levels. It should take into account the variability of market mechanisms.

In modern conditions, the study and management of social, environmental, and economic activities of the regional systems is implemented only by the state authorities, through the provision of production and development quotas, the issuance of licenses, certificates, etc. In the conditions of market relation development, it is quite expedient to form alternative commercial structures that have

all the powers to carry out environmental certification, to conclude transactions for the purchase and sale of rights to permissible pollution, to conduct environmental and economic audits, and consulting. World experience clearly demonstrates the effectiveness of such organizations. In this case most of the tax burden for servicing these structures is fully self-sustaining. The activities of such institutions are certified in a mandatory established manner in order to avoid lobbying for their own interests on the part of these structures, as well as in order to prevent monopolization of the market of environmental services by these structures or exceed their powers [6].

3. Materials and methods

Analytical assessment of social, environmental, and economic indicators for balanced development is an eco-integrated systemic development over a long time. It is based on the interaction of economic, environmental and social elements, as well as leading factors and a new model of development of the region's economy.

The methods of regression analysis are often used in modern sources. Using these methods enables to:

1) Obtain a correlation-regression model of relationships in the phenomenon under study;
2) Form conclusions about the impact of one or another factor on the resulting value;
3) Predict the result of managerial influence on the change of factors of this model.

The information base was statistical data on the Voronezh region, posted on the pages of official sites.

Economic and geographical position of the Voronezh region is advantageous. The Voronezh region is situated on the East European Plain in the center of the European part of Russia. In the south it borders with the Ukraine and the Rostov region, in the west with the Belgorod region, in the north-west – with the Kursk region, in the north – with the Lipetsk and Tambov regions, in the east – with the Saratov region, in the southeast with the Volgograd region. The capital of the republic is the city of Voronezh. This region is the largest after the Moscow region by territory, population, and economic potential among the regions of the European part of the country. The region extends from north to south for 277 km; from west to east – 352 km. The total area of the territory is 52.2 thousand km^2. It is slightly less than 0.31% of the area of the Russian Federation (the 51st place in terms of area among all the Russian regions). The population of the region is more than 2330 thousand people. This is almost 1.63% of Russia's population. The average population density in the region is 44.6 people per 1 km^2. The Voronezh region is located in the European part of the south-east of the Central Black Earth economic region. It has favorable agri-climatic opportunities for agricultural production, located on the border of two natural zones – the forest-steppe (most of the northern part) and the steppe (area in the south). The land fund of the region is equal to 5221.6 thousand hectares. Agricultural lands occupy 81.2% of the land. Today, agricultural production in the Voronezh region creates more than 20% of the gross regional product. 34% of the total population lives in rural areas, which is significantly higher than the national average (27%).

In connection with the multiplicity and complexity of the observed social, environmental, and economic phenomena and processes, data about them are multidimensional and diverse in their nature. Under these conditions, the problems of building groupings and classifications based on multidimensional data come to the fore. It is possible to optimize this construction from the point of view of the best correspondence of the obtained result to the final classification goal.

The grouping method is used to distinguish homogeneous populations. Grouping of indicators similar in their characteristics, in other words, clustering, is an important component of social, environmental, and economic assessment of the development of the municipal territories.

Analytical analysis is a generic name for a sufficiently large set of algorithms used to create a classification. The main task of the analytical analysis is to identify compact groups of objects. Cluster analysis enables to consider a sufficiently large amount of information. It drastically reduces and compresses large arrays of social, environmental, and economic information, make them compact and intuitive [7].

Indicators of three blocks are selected by the method of expert assessments as the main indicators of the level of regional development: social, economic, environmental. The following indicators are

proposed for the social block: demographic indicators; indicators of housing provision, health care, education, deviant behavior; provision of the population with personal vehicles. Indicators of population employment, wages and social benefits, production indicators; financial and investment indicators are proposed for the economic block. Indicators of waste disposal, water and air pollution, soil and terrain disturbance, and the environmental security of the territory are accordingly proposed for the environmental block.

Statistical information was collected on the indicators for the Voronezh region.

Next, we conduct an analytical assessment of social, environmental, and economic indicators for the balanced development of the region's economy. The authors determine the relationship between the studied indicators using mathematical modeling of social, environmental and economic phenomena. This is a characteristic of a huge number of factors affecting the studied social, environmental and economic value (model output), and the calculated (in relation to the number of factors) volume of observations of specific factors used in the modeling. In total, about 50 indicators were identified, the values of which are known for the studied region over the past three years. Since there are a lot of indicators, it is rather difficult to single out those that have the most significant impact on the level of innovative potential. In addition, if the problem is solved by means of regression analysis, it is necessary to have a large amount of the training sample for a large number of explanatory variables (indicators). It is impossible in this problem. Scientist A G Ivakhnenko developed the group method of data handling (GMDH) to solve such problems. It provides an acceptable model quality in terms of the multifactorial nature of the controlled object and the limited size of the training sample [8-10].

The inductive algorithm for determining the model of an effective structure is based on the following important steps.

1. If a given sample, $D = \{(x_n, \gamma_n)\}_{n=1}^{N} \quad x \in R^m$ is divided into training and test one.

2. The base model is determined. This model characterizes the relationship between the dependent variable y and free variables x. For example, the Volterra functional series is used also called the Kolmogorov-Gabor polynomial:

$$y = w_0 + \sum_{i=1}^{m} w_i x_i + \sum_{i=1}^{m}\sum_{j=1}^{m} w_{ij} x_i x_j + \sum_{i=1}^{m}\sum_{j=1}^{m}\sum_{k=1}^{m} w_{ijk} x_i x_j x_k + \ldots \quad (1)$$

In this model $x = \{x_i i = 1,\ldots,m\}$ – multitude of free variables and w – direction of parameters (weight coefficients):

$$w = (w_i, w_{ij}, w_{ijk}, \ldots i, j, k, \ldots = 1,\ldots,m). \quad (2)$$

3. Based on the tasks to be solved, a target function (external criterion) is formed that determines the quality of the model.

4. Candidate models appear inductively. In this case, a restriction on the capabilities of the polynomial of the base model is determined. For example, the polynomial degree of the base model cannot exceed a certain number R. Then the basic model is reflected in the form of a linear combination of a certain number of multiplications of free variables F_0:

$$y = f(x_1, x_2, \ldots, x_1^2, x_2, x_2^2, \ldots, x_m^R), \quad (3)$$

where f – linear combination. The arguments to this function are expressed as follows:

$$x_1 \to a_1 \; x_2 \to a_2 \; x_1^2 \to a_a \; x_1 x_2 \to a_\beta \; a_\beta x_m^q \to a_{F_0} \quad (4)$$

That is $y = f(a_1, a_2, \ldots, a_{F_0})$.

Single indexing is found for linearly determining coefficients $w = (w_1, w_2, \ldots, w_{F_0})$. Then the model can be given in the form of a linear combination:

$$y = w_0 + \sum_{i=1}^{F_0} w_i a_i \tag{5}$$

Each created model is determined by a linear combination of components: $\{(w_i, a_i)\}$, in which many indexes $\{i\} = S$ are defined by subset $\{1,...,F_0\}$.

5. Formed model parameters. For the formation of an internal criterion – the criterion calculated using the training sample. Each element of the direction x_n (the sample element *D*) is expressed in submission to the vector a_n. The matching algorithm is indicated above. A matrix A_w (a set of column vectors a_i) is formed. The matrix A_w is divided into submatrices A_l and A_c (for training and test samples). The smallest discrepancy $|y - \hat{y}|$, where $\hat{y} = A\hat{w}$, is determined by the value of the parameter direction $\hat{w}$, which is calculated by the method of the least squares.

Moreover, the root mean square error is determined as an internal criterion:

$$\varepsilon_G^2 = |y_G - A_G w_G|^2 \tag{6}$$

In accordance with the criterion $\varepsilon_G^2 \to \min$, the parameter setting w is determined. The calculation of the error on the test subsample expressed by G is made. Here $G = l$. When improving the model, the internal criterion does not determine the minimum for effective complexity models. Therefore, it is not needed for model selection.

6. The quality of new social, environmental, and economic models is calculated for the development [11,12]. It is important to use this method for the forest complex [13-15].

This applies the control sample and a certain external criterion:

$$\Delta^2(H) = \Delta^2(H/G) = \left| y_H - A_H \hat{w}_G \right|^2, \tag{7}$$

where $H \in \{1, c\}$, $H \cap G = \otimes$. This means that the error is calculated on the subsample H with the model parameters used on the subsample G.

4. Results and discussion

A model that defines the minimum of the external criterion is considered to be effective. If the value of the external criterion does not form its minimum with increasing complexity of the model or the value of the quality function is unsatisfactory one, then the best model is built from the models of the existing complexity. The complexity of the model refers to the number of configurable model parameters.

The following functional dependency is obtained:

$$P = \sum_i \bar{a}_i w_i \tag{8}$$

where $\bar{a}_i$ – fuzzy coefficients and w_i – generalized variables shown in Table 1.

The social, environmental and economic indicators influencing the balanced development of the regional economy fell into the functional dependence. The values of fuzzy dependency coefficients are presented in Table 2. Only those coefficients whose values exceeded 0.001 are given here.

With a balanced development of social, environmental and economic indicators, the expected value of the indicators for the different variants of probability is shown in Table 3.

A strong direct relationship is observed between the population size and the natural increase (decline) of the population, the average salary and the population. A strong unbalanced relationship can be traced between the volume of paid services to the population and the number of unemployed people. Since the balanced development of a region implies a relationship and interdependence

between social, environmental and economic indicators, the proposed analysis can be further used in regional management for adequate diagnostics of various spheres of the region.

Table 1. The coefficients of functional dependence, reflecting the impact of social, environmental, and economic indicators on the balanced development of the regional economy.

Summand W_i	The value of the membership function of fuzzy coefficient $\tilde{a}_i$			
	0	0.1	0.2	0.3
$X_{1,6}$	0.043	0.156	0.2788	0.01
$X_{3,25}$	0.0137	0.081	0.065	0.023
$X_{2,14}$	0.0231	0.003	0.0921	0.0321
$X_{1,6}\ X_{2,14}$	0.064	0.0491	0.0067	0.0275
$X_{2,14}\ X_{4,6}$	0.0047	0.0036	0.0063	0.046
$X_{1,6}\ X^2_{3,25}\ X_{4,14}$	-0.032	0.065	0.0473	0.040
$X_{4,14}\ X_{8,8}$	0.023	0.0754	0.0254	0.254
$X_{8,8}\ X_{4,6}$	0.0236	0.0320	0.0045	0.0573
$X_{2,14}\ X^2_{3,11}$	0.0142	0.0365	0.0625	0.0329
$X^2_{8,8}\ X_{2,13}$	0.0352	0.0863	0.0354	0.032
$X^2_{2,14}\ X_{2,13}$	0.0256	0.0560	0.0812	0.0147
$X_{4,14}\ X^2_{3,25}\ X_{2,14}$	0.0365	0.0665	0.0454	0.0241
$X_{4,5}\ X_{3,25}\ X^2_{3,11}\ X_{4,14}$	0.0320	0.0582	0.0241	0.004
$X_{8,9}\ X_{3,25}\ X_{3,11}\ X^2_{4,14}\ X_{2,13}$	0.0050	0.0123	0.0045	0.0024
$X^2_{8,9}\ X_{3,25}\ X_{3,11}$	0.0652	0.0891	0.841	0.0351
$X_{8,9}\ X^2_{1,6}\ X_{2,14}$	0.0541	0.0682	0.0674	0.0354
$X^2_{2,14}\ X^2_{1,6}$	0.0085	0.0214	0.0351	0.0012
$X^2_{2,13}\ X^2_{3,11}\ X_{8,8}$	0.0954	0.1240	0.2451	0.0489
$X^2_{4,5}\ X^3_{8,9}$	0.0023	0.0754	0.0512	0.0015

Table 2. Social, environmental and economic indicators influencing the balanced development of the regional economy.

Characteristic	Influence
Balanced development indicator	
$X_{1,6}$ – natural population growth	+
$X_{2,13}$ – average annual production growth	+
$X_{2,14}$ – provision of the population with personal vehicles	+
$X_{3,11}$ – conservation of biological species	+
$X_{3,25}$ – the financial potential of the region	+
$X_{4,14}$ – average annual salary	+
$X_{8,8}$ – gross profit	+
Imbalanced development indicator	
$X_{4,5}$ – dilapidated and emergency housing area	–
$X_{4,6}$ – inflation rate	–
$X_{8,9}$ – indicators of water and air pollution	–

Obtaining information has a certain practical significance for the development of the regional economy. The influence of indicators on the balanced development is determined based on the results of the analysis. It is made on the basis of fuzzy quantitative assessment on the basis of which you can make a managerial decision on the allocation of resources.

Table 3. The value of indicators in a balanced development of the region.

Indicator	Probability								
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Natural population growth, %	51	51.5	52	51	51	51	53	53	53
Average annual production growth, %	26.5	28.3	27.6	27.8	26.7	26.3	27.3	27.3	27.4
Provision of the population with personal vehicles, %	15	17	17	18	17	17	17	18	18
Conservation of biological species, %	27.6	29.3	29.6	30.1	29.3	29.1	29.4	29.3	29.4
Financial potential of the region, %	1.5	1.3	1.2	1.4	1.3	1.4	1.4	1.3	1.5
Average annual salary, %	20	20	22	20	20	22	22	22	23
Gross profit, %	0.31	0.36	0.37	0.39	0.36	0.37	0.34	0.36	0.36
dilapidated and emergency housing area, %	11	12	12	15	12	13	13	12	13
Inflation rate, %	6.8	6.8	7.2	7	6.8	6.7	6.8	6.7	6.8
Indicators of water and air pollution, %	3.6	3.1	3.9	3.8	3.0	3.2	3.5	3.5	3.5

5. Conclusions

Thus, the combination of effective and interdependent economic measures aimed at obtaining a specific result constitutes the organizational and economic mechanism for managing social, environmental and economic well-being. It ensures the optimization of resource-saving nature management, based on the principles of sustainable economic development and further providing of digital space [15]. The assessment of the potential of sustainable development of the regions is also a reliable criterion for the ability of the system to restore a steady state.

The Genesis of the formation of economic and mathematical methods of complex research of social, economic and environmental phenomena showed that the existing directions of their complex assessment in the most General form require a rational combination due to the impossibility of performing interdisciplinary calculations on the actual available information. Socio-ecological-economic system as an object of management has some features. This circumstance, in accordance with Godel's theorem on the incompleteness of a deductive system, requires its own language of description and control. From the incompleteness of our knowledge about the socio-ecological and economic system, wrong decisions are made. The proposed assessment includes the human being as a necessary element and is therefore a complex targeted system. Managing a targeted system requires knowledge not only about the environment, but also about the system itself. This knowledge is formed in the model of the system and its environment, as well as the model creates a mechanism for generating new knowledge about the system and a mechanism for finding solutions for balanced development of management decisions [16].

The state development programs of the country as a whole, its macro- and micro-entities in particular, determine the main points of the transition to the model of sustainable development. The following elements are identified as the key areas of regional development: a) development of economic mechanisms for managing the social and economic development of a subject; b) implementation of environmental measures in residential and undeveloped areas; c) progressive development of the social sphere and infrastructure aimed at improving the population; d) stimulating the development of the agricultural industry through the use of new technology and advanced technologies; e) reconstruction of the regional industrial ecosystem taking into account the economic capacity of local ecosystems.

In general, regional development should be based on building up and effectively using the potential of the subject by reducing state intervention and creating a rational management mechanism in the regions.

The implementation of the above proposed tools for managing the sustainable development of the social, environmental and economic system of the region (in many respects) enables to solve a number of social, environmental and economic problems.

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