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The Use of Statistical Methods in the Assessment and Monitoring of Institutional Transformations of Environmental Activities in Russia

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Abstract – **The article describes the aspects of decision making in the context of institutional transformations of environmental activities based on the use of a wide range of statistical methods. Their advantage is the ability to make and use models in the short term. Analysis and, on its basis, forecasting the phenomenon in the short term requires taking into account not so much the development trend of the phenomenon that has developed in the past, but the characteristics of the unevenness of the levels of the phenomenon and the ability to quickly adapt the structure and parameters of the series to changing conditions. As a rule, the amount of information on the phenomenon under investigation is extremely limited. Accordingly, in the practice of analyzing environmental activities, this methodology is extremely relevant. Using statistical methods, an assessment was made of the transformation of the quality of modern reporting on the approved forms in the aspect of institutional reform of the environmental protection system, as well as a quantitative assessment of the factors shaping the ecological situation, including in the North Caucasus Federal District.**

Key words – statristical methods, regional institutes, institutional transformation, environment monitoring

I. Introduction. Formulation of the problem

The current environmental situation in Russia as a whole and its negative trend require more and more comprehensive and extensive introduction of the institute of statistics for qualitative analysis, systematization, generalization of current information and the formation of objective forecast products for scientific purposes and in practical activities.

Based on the theory of institutionalism, statistics, as an institution in the information society, in the field of environmental management, should be considered in interaction with the institutional environment of environmental management structures and the environmental protection system as interdependent factors.

The state policy in the field of ecology, influenced by the awareness of the urgency of solving environmental problems and activating the social movement, is at the stage of major positive changes. The principles of supervision and control over the use of natural resources, accounting objects are being revised, environmental documentation and reporting are being improved. Statistical monitoring is carried out on the sources of anthropogenic impact associated with pollution of the environment, the channels of distribution of this pollution.

As a research object, now it is not the economic entity that is considered, but only an element of negative impact. All objects of this kind are divided into five groups (4 categories and no categories) according to the degree of environmental safety (NEI). As a result of these transformations, the routine part of ecological reality changes. Habitual environmental reporting is modified more and more and focuses on dependence on the category of environmental hazard [1].

Thus, quantitative assessment methods are acquiring importance, allowing a qualitative assessment of the air, water, soil, flora and fauna massifs, forecasting indicators of the natural state for the future and providing the most reliable information to the society about environmental changes [2].

II. The genesis of the basic concept of the development of environmental protection reform in the framework of the institutional development of the problem

Since 2019, environmental legislation introduces new rules for environmental reporting.

Table 1 presents the environmental documentation and type of reporting, which is necessary for all categories of economic entities.

TABLE I. COMPARATIVE ASSESSMENT OF ENVIRONMENTAL DOCUMENTATION AND REPORTING IN ACCORDANCE WITH THE GROUPING OF OBJECTS NEI [3]

Type of documentation	**Object categories NEI**				
	I	***II***	***III***	***IV***	***no categories***
Waste certification	yes	yes	yes	yes	yes
Accounting in the field of waste management	yes	yes	yes	yes	yes
Forms reports: No. 2-TP (waste)	yes	yes	yes	yes	yes
No. 2-TP (air), No. 4-OS[a]	yes	yes	yes	no	no
Reporting on the formation, use, disposal, disposal of waste	no	no	yes	no	no
Reporting on emissions of harmful (polluting) substances into the air	no	no	yes	no	no
Integrated environmental permit	yes	have the right[b]	no	no	no
Declaration of Environmental Impacty	no	yes	no	no	no
The program of industrial environmental monitoring and report on the organization and on the results of the implementation of the PVC	yes[c]	yes[d]	yes	no	no
Technological standards (standards for emissions, discharges of pollutants, standards for permissible physical effects)	yes[c]	no	no	no	no
Standards for permissible emissions, standards for permissible discharges	no	yes[d]	no	no	no
Standards of permissible emissions, permissible discharges for radioactive, highly toxic substances, substances with carcinogenic, mutagenic properties (substances of I, II hazard class)	yes[c]	yes	yes	no	no
Standards for permissible discharges of pollutants for the objects of the centralized water disposal system of villages and urban districts	yes[c]	yes[c,d]	no	no	no
Waste generation standards and limits for their placement	yes[c]	yes[d]	no	no	no
Environmental Performance Program[e]	yes[c]	no	no	no	no
Environmental Action Plan[e]	no	yes[d]	yes	no	no
Permission for harmful physical effects on atmospheric air (in the presence of such effects)	yes	yes	yes	no	no
Fee for negative environmental impact	yes	yes	yes	no	yes
Implementation of standards for recycling or payment of environmental fees, if the company is a manufacturer or importer of goods	yes	yes	yes	yes	yes
When implementing the use of water bodies: Report on the forms № 2-TP (water management); No. 2-OS; Information on forms 6.1, 6.2, 6.3, 3.1, 3.2, 3.3	yes	yes	yes	yes[f]	yes[f]

[a] enterprises with wastewater treatment plants, carrying out environmental protection measures in the amount of more than 100 thousand rubles. in year.
[b] in the presence of ITS (information and technical reference).
[c] as part of the EEC (integrated environmental permit).
[d] in the composition of DVOS (declaration of environmental impact).
[e] in case of failure to comply with the standards for permissible emissions, standards for permissible discharges, technological standards.
[f] if there is use of water bodies.

Statistical reporting in most categories allows for regular monitoring of the environmental situation. If the object does not have the assigned category NEI or has the 4th category, reporting is provided in the prescribed forms for water bodies (when used). In the course of their activities, state statistics bodies, like any other institutions, bear costs. In accordance with institutional theory, total costs include transaction and transformational costs. If transformational costs are in the form of costs and are embodied in the cost of goods (services), then transaction costs are associated with the improvement of the system of relations [4, 5]. This is a theoretical indicator that is not reflected in accounting and management documents.

The growth of transaction costs in accordance with the changes occurring is caused by the formation of new relationships between environmental actors.

Improving the regulatory framework and the expansion of state regulation measures in the field of environmental protection (depending on the category of the object of negative environmental impact assigned to such an object when it is registered with the state) is aimed at saving transaction costs in this area.

In the area of statistical accounting for environmental protection, in order to minimize all types of costs, including transactional ones, it is important to identify types of transactions whose regulation will help, using the environment, to preserve it as much as possible with a minimum of costs [6, 7].

The main types of transactions are:

- improvement of the system of indicators in accordance with international standards for the organization of statistical monitoring of the construction and operation of environmental facilities;
- Adaptation of recommendations on the use of statistical guidelines for economies based on natural resources in the Russian state statistics system (developed by the Ulan Bator Group) in terms of production plans and forecasts, quality management;
- modernization of the methodology for building a system of macroeconomic indicators characterizing the productivity of natural resources, the use of new technologies in this area, the improvement of technical operations, which is directly related to information processing [8];
- selection of an adequate econometric methodology for analyzing and predicting the situation.

Thus, the reform of environmental protection activities, including several stages, introduces new reporting rules (differentiated by object categories NEI) and the use of econometric methods, allowing to quantify the environmental situation, identify factors and indicators that have a negative and positive impact on the environment.

III. METHODS AND RESULTS OF THE STUDY

The focus of statistical monitoring of agriculture and the natural environment is aimed at collecting and recording information on specially protected natural areas, on forest reproduction and afforestation, current expenditures on environmental protection, on forest protection, air protection, etc.

Particular attention is focused on enhancing the protection of atmospheric air. This problem is of relevance in most regions of the Russian Federation, including the North Caucasus Federal District (NCFD). To assess the current situation, the main indicator is used – emissions of pollutants into the air coming from stationary sources (Table 2).

TABLE II. DYNAMICS OF POLLUTANT EMISSIONS INTO THE AIR FROM STATIONARY SOURCES IN THE NORTH CAUCASUS FEDERAL DISTRICT (THOUSAND TONS)

Indicator	2005	2010	2014	2015	2016	2016 in% by 2005
The Republic of Dagestan	27	18	13	11	14	51.9
The Republic of Ingushetia	1	1	0.4	0.4	1	100.0
Kabardino-Balkaria	2	3	2	3	4	50.0
Karachay-Cherkess Republic	16	20	16	15	17	106.3
Republic of North Ossetia - Alania	6	6	3	5	5	83.3
Chechen Republic	58	25	31	21	21	36.2
Stavropol region	75	66	79	85	88	117.3
Emission dispersion, σ^2	854.2857	833.4762	1112.066	1207.023	1252.286	146.6

[a] * calculated by authors based on www.gks.ru

For the period from 2005 to 2016 in terms of emissions of pollutants into the air coming from stationary sources, dispersion increased by 46.6 %, which in turn indicates an increased risk of pollution.

The methodology of statistical data processing requires verification of their homogeneity. This stage is important because the information is selected for different periods of time and, accordingly, the sum of data for each year should be considered as a separate sample.

The independence of statistical data, their belonging to a single, normally distributed general population is determined using the Fisher criterion and the hypothesis about the equality of the corrected variances [9]. The maximum value is the ratio of the corrected variance for 2016 to the corrected variance for 2010 (1.502). At a significance level of 0.05 and degrees of freedom in this case, $n_1 = n_2 = 6$ $F_{крит.}$ equals 4.28. Condition $F_{факт.} < F_{крит.}$ is fulfilled, and the hypothesis of equal corrected variances is accepted [10].

The value of the random variable t for testing the null hypothesis H0 on equality of the means is determined as follows:

- if the general σ_x^2 and σ_y^2 are the same (it is possible using the Student's distribution in this case to construct a criterion for testing the hypothesis H0 about equality of the expectation values of X and Y using a random variable)

$$t = ((\bar{x} - \bar{y}) \cdot (\sigma^2)^{-1}) \cdot \left(\frac{n_x \cdot n_y}{n_x + n_y} \right)^{1/2},$$

where

$$\sigma^2 = \left((n_x - 1) \cdot \sigma_x^2 + (n_y - 1) \cdot \sigma_y^2\right) \cdot \left(n_x + n_y - 2\right)^{-1}$$

- if the increase in the error due to the replacement of the general dispersions by the corrected sample, leads to an increase in the error in determining the acceptance area of the hypothesis H0, determine the interval of the critical value of the random variable t ($-t_{кр}$; $t_{кр}$). The acceptance area of the hypothesis H0 in this case will be in the range of p ($-t_{кр} < T < T_{кр}$) =1-α with probability 1-α.

The data obtained as a result of the calculations are presented in Table 3.

TABLE III. THE MATRIX OF THE VALUES OF THE RANDOM VARIABLE T OF TESTING THE HYPOTHESIS H0 ABOUT THE EQUALITY OF THE AVERAGE IN TERMS OF THE INDICATOR - EMISSIONS OF POLLUTANTS INTO THE AIR COMING FROM STATIONARY SOURCES [A]

years	Years to be compared			
	2005	*2010*	*2014*	*2015*
2010	2.21053			
2014	0.95082	0.12245		
2015	0.89738	0.02740	0.15444	
2016	0.66667	0.20408	0.17778	0.54857

[b.] [a] Calculated by the authors

The maximum value is t = 2.21. The tabular value of the Student's t-test at a 5 % significance level is equal to 2.447, which is greater than the maximum actual. Thus, the hypothesis that all observations belong to a single general population is accepted. The greatest equality of average values of indicators of emissions of pollutants into the air coming from stationary sources was observed in 2005 and 2010. In 2014, the environmental situation tended to worsen.

The main regions that most pollute the atmospheric air in the district include the Stavropol Territory, the Kabardino-Balkaria and Karachay-Cherkess Republics (Table 4). Their

share for the period 2005–2016 in total emissions grows. This is primarily due to the development of industrial production. The Republic of Dagestan and the Chechen Republic have reduced emissions. The share of other regions (they have a small share in the total amount of emissions) practically does not change.

TABLE IV. DYNAMICS OF EMISSIONS OF POLLUTANTS INTO THE ATMOSPHERIC AIR FROM STATIONARY SOURCES IN THE NCFD (%) [A]

Region	2005	2010	2014	2015	2016	Absolute change (+, –) in 2016 compared to 2005, pp.
North Caucasus Federal District (NCFD)	100.0	100.0	100.0	100.0	100.0	x
The Republic of Dagestan	14.6	12.9	9.0	7.8	9.3	–5.3
The Republic of Ingushetia	0.5	0.7	0.6	0.1	0.7	0.2
Kabardino-Balkaria	1.0	2.2	1.4	2.1	2.7	1.7
Karachay-Cherkess Republic	8.7	14.4	11.0	10.7	11.3	2.6
Republic of North Ossetia - Alania	3.2	4.3	2.1	3.6	3.3	0.1
Chechen Republic	31.5	18.0	21.4	15.0	14.0	–17.5
Stavropol region	40.5	47.5	54.5	60.7	58.7	18.2

[c.] [a] Calculated by authors based on data www.gks.ru

In the structure of emissions of pollutants into the air coming from stationary sources for the period 2005–2016. There have been changes. This is also proved by the VM Ryabtsev index calculated by us (0.23), which according to the scale of assessment of the measure of materiality of differences in structures, suggests a significant level of differences. However, the structure of emissions of pollutants into the air coming from stationary sources for the period 1995–2016. across the regions of the North Caucasus Federal District did not change significantly (according to the VM Ryabtsev criterion, the indicator was only 0.14).

These changes are due to the strengthening not only of control, but also the volume of investment flows in environmental protection and rational use of natural resources (Table 5).

TABLE V. DYNAMICS OF INVESTMENTS IN FIXED ASSETS AIMED AT ENVIRONMENTAL PROTECTION AND RATIONAL USE OF NATURAL RESOURCES IN THE REGIONS OF THE NORTH CAUCASUS FEDERAL DISTRICT (IN ACTUAL PRICES, MLN. RUBLES) [A]

Years	Stavropol region	RSO – Alania	Karachay – Cherkess Republic	Ingushetia	Kabardino-Balkaria	The Republic of Dagestan	Chechen Republic
2010	628.1	229.2	276	–	292.9	548875	76.5
2015	845.1	123.9	252	–	382.2	58551.0	576.6
2016	1178.4	138.5	180	20.8	106.1	20841.8	531.2
2017	761.2	287.7	171	–	…	20381	94.3

[d.] [a] Site data www.gks.ru

Most regions in the period 2010–2017 characterized by stable investment flows. However, in 2017, their size is sharply reduced except for the Republic of Ingushetia (information about the investment flow is limited to the data of 2016) and the RNO-Alania (there is an increase in investment).

Based on an economic analysis of the possible influence of individual factors on the amount of pollutant emissions into the air coming from stationary sources, statistical models were constructed considering those factors that are publicly available (Table 6).

TABLE VI. THE RESULTS OF THE CORRELATION AND REGRESSION ANALYSIS OF THE DEPENDENCE OF THE GROWTH RATE OF EMISSIONS OF POLLUTANTS INTO THE ATMOSPHERIC AIR, COMING FROM STATIONARY SOURCES OF THE TOTALITY OF THE REGIONS OF THE NORTH CAUCASUS FEDERAL DISTRICT (ACCORDING TO 2016 COMPARED TO 2015) [A]

Options	growth factors				
	GRP	***GVA s.-h.***	***Labor Resources Economy***	***Employed in S.-H.***	***Investment in the protection of natural resources***
a_0	7.62079	-1.29369	-0.11769	0.725264	2.007015
a_1	-6.03802	2.318178	1.2468	0.39513	-0.87248
σ_{a1}	0.030198	0.115101	0.385207	1.218266	0.454143
t_{a0}	1.071794	-0.70323	-0.69223	8.781664	7.594814
t_{a1}	-2.300683	1.430778	8.942681	9.310209	-2.98525
R^2	0.51424	0.290491	0.560969	0.645462	0.64059
F_{fact}	5.293141	2.047125	6.388722	8.667999	8.911695
$\sigma^2_{remains}$	0.296576	0.243448	0.02019	0.018713	0.123321
AIC Criterion	-0.64402	-0.84142	-3.33112	-3.40711	-1.52153
Schwartz Criterion	-0.65948	-0.85688	-3.34658	-3.42256	-1.53699
The forecast of the increase in emissions of pollutants into the air coming from stationary sources (t at a significance level of 0.05)					
Spot forecast	X	X	X	1.223128	1.623124
Interval (min)	X	X	X	0.846299	0.636655
(max)				1.599957	**2.609593**

[e.] [a] Calculated and compiled by the authors

The results of the analysis indicate that not all statistical models are adequate, since the tabular value of the F-test is 6.61 (at a significance level of 0.05). In addition, not all regression coefficients are significant at the 5 % level of significance ($t_{table.} = 2.57$).

The greatest influence on the growth of emissions of pollutants into the air is exerted by factors of growth in the number of people employed in agriculture and investments in the protection of natural resources, which is understandable. The increase in the number of employed workers in agriculture suggests an increase in the anthropogenic load on the surrounding natural habitat. The relationship between investment and emissions is multidirectional.

As a measure of the relative quality of the statistical model for this data set, the criteria of Akaike and Schwartz were used. The advantages of these criteria are: the possibility of a qualitative fit of the model, considering the number of observations and the number of variables. According to these criteria, you should choose a model with the lowest value. Therefore, in our case, we can assume that the last two models are of the highest quality.

Using data, the average growth rate for the independent variables, a point and interval predictions were made for the growth rate of pollutant emissions to the air coming from stationary sources [11]. Of concern is the forecast for investment flows, as the data in Table 5 show a sharp decline in investment resources in almost all regions in 2017, which suggests a deterioration in the environmental situation.

It should be noted that the amount of statistical information in the open access system does not provide opportunities for comprehensive and more detailed factor analysis, including economic and statistical modeling.

IV. CONCLUSION

Thus, the reform of accounting institutions, providing statistical information on environmental monitoring and environmental protection is the result of the transformation of the system of state control over the use of resources [12]. Through such a reform of accounting and statistics, economic actors are involved in the global global monitoring system for the rational use of natural resources. As a result of the research, the internal institutional use of modern norms by categories of HBOC objects was revealed. In April 2014, the Government of the Russian Federation approved subprogramme 9 "Official Statistics" as part of the implementation of the program "Economic Development and Innovative Economy" (as amended up to March 31, 2018), which should provide, among other things, an increase in the amount of information in the system access on the website of the Federal Statistics Service on the Internet information and telecommunication network. The total funding for its implementation in 2018 will be 1,652,376.6 thousand rubles; for 2019 – 17227567.3 thousand rubles; for 2020 – 33112732.7 thousand rubles.

Reforming environmental protection activities involves several stages with the introduction of new reporting rules differentiated by categories of objects of the National Environmental Protection, and the use of econometric methods allows to quantify the environmental situation and identify factors and indicators that have a negative and positive impact on the natural environment.

In a study using statistical methods for analyzing the indicator of emissions of pollutants into the air coming from stationary sources, it was revealed that for the period from 2005 to 2016 46.6 % increased the square of deviations from the average value, which in turn indicates an increased risk of pollution. A hypothetical assessment of all observations belonging to a single general population showed that the greatest equality of average values of pollutant emissions to air from stationary sources was observed in 2005 and 2010. By 2017, the environmental situation has changed for the worse and the forecast estimate is not positive. Therefore, in the regions, attention should be paid to the search for additional financial sources for nature protection and the development of programs to mitigate the negative human-induced human influence.

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