

# Automation of Environmental and Economic Systems Research Using Data Mining

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**Abstract** — The subject of the study is environmental and economic systems. The authors specified the concept of environmental and economic systems as the natural environment under the influence of human economic and social activities, including mutual influence, as well as the consequences resulting from it. The authors set a goal to develop a methodology for the study of environmental and economic systems that would adequately assess their current state and forecast changes. The approach to the study of such systems consists in the staged application of cluster analysis and data mining classification methods (random forest and support vectors method) and followed assessment of the quality of the model and choosing the best method. In presented research, the analytical procedures are automated in the R-Studio package. The analysis of the same indicators by two different methods confirmed the direct relationship between the costs and investments in environmental protection and the results of environmental protection: with the growth of investments in environmental protection, indicators of recycled water use, discharge of polluted wastewater, air emissions of pollutants were reduced.

**Keywords** — *environmental and economic system, environment, cluster analysis, random forest, data mining, support vector method.*

## I. INTRODUCTION

One of the most important areas of government regulation in many countries of the world is overcoming environmental problems, which are currently global in nature. Since the environmental consequences of gross economic activity and population growth far outweigh the restorative ability of the environmental system, the only effective way to solve this problem is to extend the government intervention. In the circumstances, the economic life of society and the environment are connected by close links, which leads to the need to develop management decisions regarding environmental and economic systems (EES) as regulatory

objects. So, first of all, it is necessary to clarify the concept of “environmental and economic system” as an object of statistical research, to determine its structure and trends. At the same time, making managerial decisions is inefficient without an adequate assessment of the current state of the EESs, trends and prospects for their development. The system of statistical indicators of the state of EES should be improved, and on its basis, a comprehensive analysis could be carried out. To differentiate regions according to the state of their environment and economic development, it is necessary to clarify the methodological approach to analysis, so we advise to use modern methods of Data Mining. The study of the impact of economic development on resources and the environment in environmental and economic systems will contribute to the construction of an effective sustainable development policy, however, it requires the enhancement of new methodological approach for the qualitative assessment of EES.

Thus, the purpose of this study is the development and automation of the basic principles and methodological approaches of statistical research of the state of EES at the regional level using Data Mining techniques. In accordance with this goal, the following research objectives are set:

- 1) to clarify the concept of EES as an object of study and determine its structure;
- 2) to improve the system of statistical indicators of the state of EES;
- 3) to develop a methodological approach to the analysis of the state of EES at the regional level using modern methods of Data Mining;
- 4) using the developed system of indicators and a methodological approach, to analyze the current state of EES in a regional context using the example of the Russian Federation.

II. LITERATURE REVIEW

The concept of an environmental and economic system is often used together with closely related concept of a “natural and economic” “natural and commercial” system. However, EES is a narrower concept than the natural and economic system and wider relative to the natural and commercial one. The main characteristic of the environmental and economic system, according to some scholars, is "the increased interconnection of economic, social, technological and natural processes in the surrounding world" [1]. As an example, in 1986 M.Ya. Lemeshev, a well-known scientist and economist, defined the ecological and economic system as “the integration of economics and nature, which is the interconnected and interdependent functioning of social production and the occurrence of natural processes in nature and the biosphere” [2]. It is no coincidence that property transformation, economic relations, and the restructuring of mechanisms associated with the functioning of industrial enterprises are recognized as the main problems of institutional support for environmental protection [3].

A number of authors call the environmental and economic system as “a set of interrelated economic, technical, social factors in the world around a person” [4]. Others see EES as “a combination of jointly functioning environmental and economic systems, the ecosphere and the anthroposphere” [5]. According to Akimova’s definition the environmental and economic system is “a part of the technobiosphere bounded by a certain territory, in which natural, social and industrial structures and processes are interconnected by mutually supportive flows of matter, energy and information” [6]. According to another point of view, EES is defined as a set of interconnections between ecology and economy, described by analyzing the flows and stocks of energy and matter, including their economic consequences for the social security processes and cultural development [7].

According to the author, the environmental and economic system should be understood as the natural environment under the influence of human economic and social activities, including mutual influence, as well as the consequences resulting from it (Figure 1).

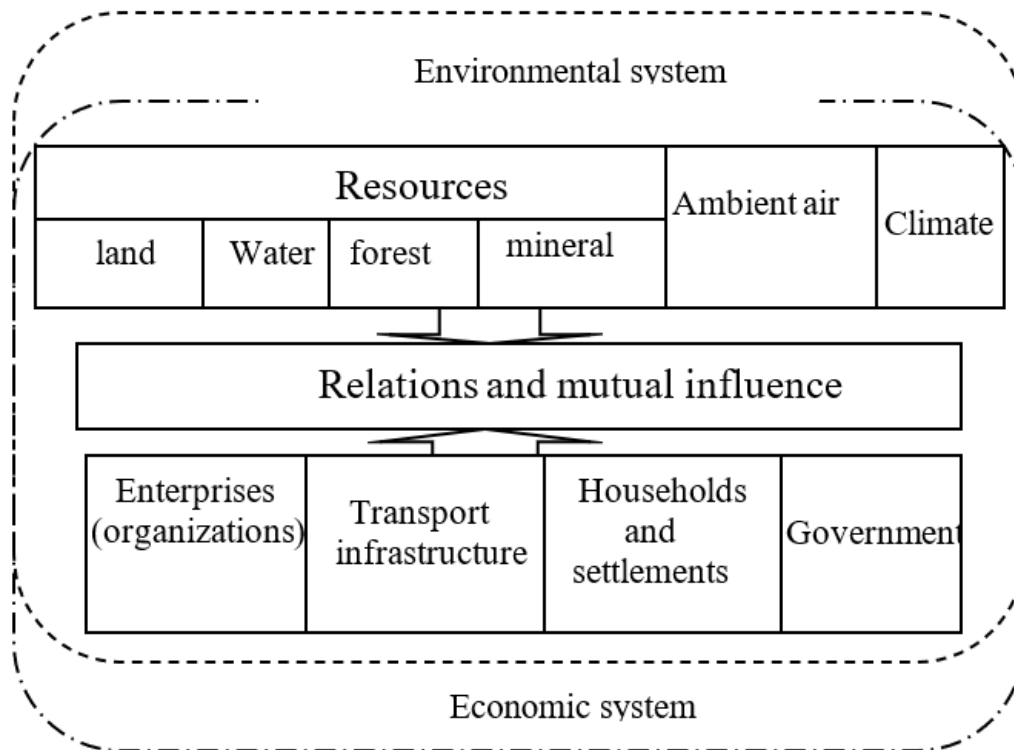


Fig. 1. The structure of the environmental and economic system.

At the same time, environmental and economic processes include economic processes that affect the natural environment (NE), as well as processes that arise in the NE and affect economic activity. Based on these provisions, for the purposes of this study, biological resources are not included in the elements of the environmental system, because, being part of the natural environment, they are indirectly connected with the economic system. This issue

was considered in more detail in previous studies of the authors [8].

A complete understanding of the interconnected environmental and economic systems requires the integration of various theoretical foundations and assessment methods. Statistical studies in the field of environmental and economic systems have recently gained particular popularity. This is largely due to the increased

interest in the environmental situation in the world and the so-called "environmental boom". Today, economic activity has reached such proportions that it can be considered a geological and climate-forming factor that can significantly change the human conditions [9]. Currently, an important area in the field of sustainable development of environmental and economic systems, known as the "green economy", is developing significantly [10]. The main feature of this research area is the study of the long-term dynamics of the environmental and economic system, taking into account the interaction of key economic agents. In addition, recently, most developed and developing countries of the world have received an unprecedented opportunity to access, record, store and analyze environmental data at various spatiotemporal scales. Environmental and economic systems are complex in content and structure, as economic, social factors, resources and environmental factors interact in them, etc. It is no coincidence that researchers propose applying a systematic approach to the assessment and analysis of EES. In particular, there is proposed a concept that combines environmental accounting and assessment of ecosystem services, and allows identifying three main indicators that need to be studied when focusing on the provision and operation of ecosystem services: (1) sustainable economic and environmental costs, (2) benefits received and (3) created impacts [11]. In a recent study by Chinese scientists, the mutual influence of economic growth and environmental government regulation on the river system of China, in particular, on water quality (as one of the elements of OPS) was studied [12]. The authors note that the conflict between economic growth and environmental pollution has become a serious obstacle to the future development of China. In the study, they conclude that, firstly, administrative regulation of the ecological system is not effective, and secondly, it is not consistent with economic development at the municipal level. This once again confirms the need to analyze EES as an integrated whole.

One of the priority tools in the analysis of environmental and economic systems is mathematical modeling. In particular, the Japanese scientist Takuro Uehara, exploring the ecological and economic threshold, developed an environmental and economic model, based on the model of population and resource dynamics of Brander and Taylor [13]. The author obtained a number of important results on the controllability and adjustability of environmental and economic systems; however, as noted in the study, due to the complexity of the model, it was not possible to interpret all conclusions definitely.

We have analyzed a long-term dynamic growth model that endogenously links biophysical and economic variables such as natural resources, population flows, resources, and money [14]. This model allows exploring the interdependencies between the rates of extraction and

depletion of resources; accumulation of population, capital and debt; as well as the distribution of cash flows in economy. However, it does not take into account variables related to environmental resources and sinks, such as land, greenhouse gas emissions and types of pollution, which do not directly contribute to or limit economic production. In this connection, it does not allow adequate assessment of the current state of EES.

The complexity of the search for optimal scenarios for the long-term development of the ecological and economic system is due not only to the scale of such systems and their elements, but also to the presence of internal non-linear multiple feedbacks that are balanced and reinforcing, that leads to the appearance of a difficultly predicted multiplicative effect [15]. In connection with the above, we believe that ecologist's tools can significantly benefit from the inclusion of statistical methods that process accessible databases and contribute to the adoption of managerial decisions taking into account economic constraints [16]. However, it is difficult to conduct a comprehensive and consistent analysis of the interaction between factors from a systemic point of view, using traditional statistical and econometric approaches [17]. As Cristina García notes, the use of R packages makes it possible to put into practice statistical tools to reveal the effects of ecosystems on environmental changes. [16]. Supporting this point, the authors of this study implement the methodological approach for the analysis of environmental and economic systems using R-Studio.

### III. METHODOLOGY

The authors used general scientific research methods (analysis, synthesis, induction, and deduction), methods of econometrics and statistics, as well as datamining. In the course of the research work, a methodological approach was presented, the scheme is given in Figure 2.

The authors developed a comprehensive approach, expressed in the phased application of cluster analysis and data mining classification methods (random forest and support vector machine), subsequent assessment of the quality of the model and choosing the best method. This is a distinguishing feature of this study from previously published works in this field.

According to the author's approach, the analysis process contents of six stages, the main part of which (the most labor consuming and time-consuming) assumes automation. The first stage is to calculate a system of indicators characterizing the environmental load and economic condition of the regions. The selection of indicators on the basis of which the study and analysis of the environmental and economic system will be carried out, involves consideration of the state of the environment and the possibilities of its government and economic regulation. Groups of such indicators are presented in Figure 3.

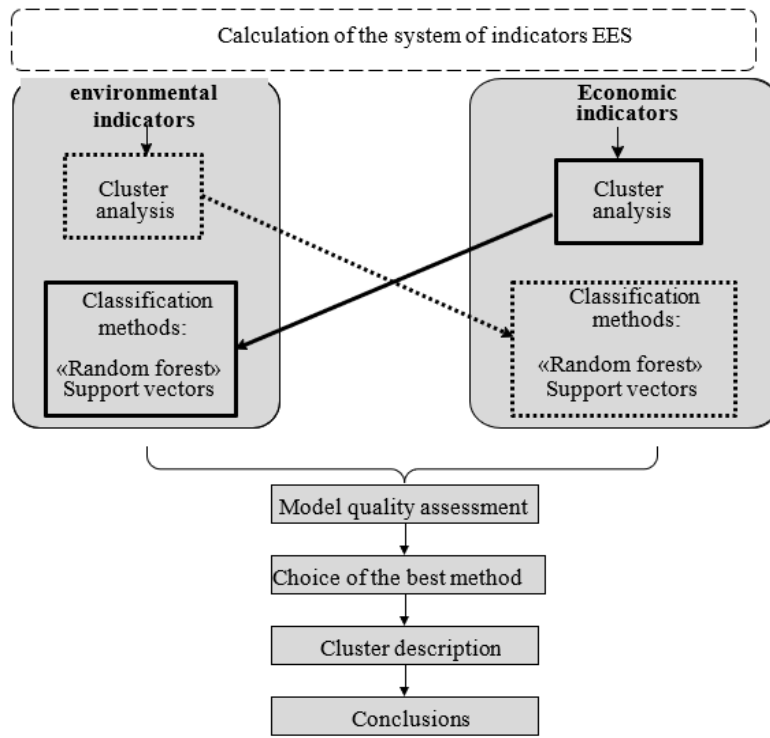


Fig. 2. Scheme of a methodological approach to the analysis of EES

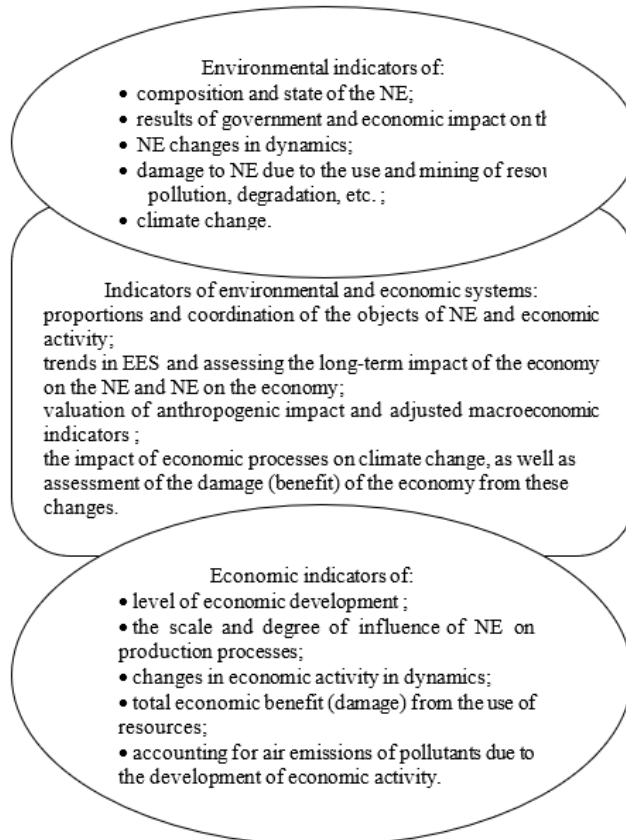


Fig. 3. Groups of indicators of the environmental and economic system

Based on official statistics (data provided by Federal State Statistic Service (FSSS)), the system of indicators of the environmental and economic system should be considered in three areas: land resources, water resources and weather conditions. In the framework of the ecological and economic system, first of all, those resources were considered that are directly involved in economic activity and are subject to the influence of the economic system. Therefore, bioresources in this case were not considered. The system of indicators is presented in Table 1.

TABLE I. THE SYSTEM OF INDICATORS OF EES

Physical Indicators	Cost Indicators
<i>Water Resources</i>	
Water withdrawals from natural water bodies for use, th.m <sup>3</sup> Recycling and sequential use of water, th.m <sup>3</sup> Discharges of polluted waste water, th.m <sup>3</sup>	Investments in fixed assets aimed at the protection and rational use of water resources, th. RUB. Current costs for sewage collection and treatment, th. RUB. Current costs for the protection and rehabilitation of land, surface water and groundwater, th. RUB.
<i>Land Resources</i>	
	Investments in fixed assets aimed at the protection and rational use of land, th. RUB. Capital expenditures for the protection and rehabilitation of land, surface water and groundwater, th. RUB.
<i>Weather Conditions</i>	
Air pollutant emissions from stationary sources, th. ton Air pollutants captured and decontaminated, th. ton	Costs of air protection and mitigation of climate change, RUB. Investments in fixed assets aimed at protecting atmospheric air, RUB. Current costs for air protection and mitigation, RUB.
<i>General Indicators</i>	
The share of the population with cash incomes below the subsistence level, % (the indicator of cash income was used by the authors based on the fact that it is officially published by the statistical department of the Russian Federation; information on non-monetary incomes of the population is not presented) Industrial production index, percentage of the previous year The number of enterprises and organizations per 1000 km <sup>2</sup>	Average consumer spending per capita (per month), th. RUB. Gross regional product per capita, th. RUB. (when considering indicators in a regional context) Agricultural products - total, th. RUB. Current environmental and waste management costs, th. RUB. Current costs for biodiversity conservation and protection of nature areas, th. RUB. Investments in fixed assets aimed at protecting the environment from the harmful effects of production and consumption waste, th. RUB.

The second stage involves the division of the general system of indicators into two groups that characterize the environmental and economic burden separately from each other.

At the third stage, the researcher has two tasks: conducting a cluster analysis, first for one group of selected indicators, and then for another. The goal of this stage is to divide the regions into groups (clusters) with a similar ecological state for analysis by environmental indicators and with a similar economic development for analysis by

indicators characterizing the economic condition of the regions. Such a "cross" approach allows a bilateral assessment of EES.

The fourth stage of the analysis also involves several tasks. First we need to study the methods for classifying the elements of each cluster into new groups. When using the methodological approach, 2 methods are implied: "random forest" and the support vector method. The "random forest" method consists in constructing many decision trees. The purpose of this method is to construct a model that predicts the value of the target variable depending on the values of the determining variables at the input. Moreover, thanks to the tree voting algorithm, a set is built under the condition of parallel machine learning and the work of classifiers.

The support vector method, previously referred to as the "generalized portrait" algorithm, was developed by the Soviet mathematician V.N. Vapnik and A.Ya. Chervonenkis in 1974 and since then has gained wide popularity [18]. This method belongs to the group of boundary ones defining classes using the boundaries of regions. The essence of the method is to separate all points of the population by the classifier plane. There can be several such planes, but one that will be as far away from points as possible will be optimal.

The next task of this stage is to classify elements by two methods. At this stage, one peculiarity is noted: according to the results of the cluster analysis for a group of indicators characterizing the ecological state of the regions, it is necessary to calculate indicators characterizing the economic load. And according to the results of a cluster analysis for a group of economic indicators one should calculate the indicators characterizing the environmental load. Then the two classification methods described above should be applied to the groups according to the newly calculated indicators.

The fifth stage involves assessing the quality of the resulting classification models, on the basis of which the best classification method is subsequently selected. After that, the initial clusters should be described.

At the sixth stage, general conclusions are drawn that should reflect a qualitative assessment of the constructed models, which will serve as a justification for choosing the best classification method. Also at this stage it is necessary to illuminate the ecological state of the regions and its relationship with the economic load.

The developed methodological approach can be represented as an information system. The context diagram of the main process is shown in Figure 4.

At the entrance, the system receives official data of national statistical agencies or intermediate results of the analysis, and at the output, an assessment of the state of the environmental and economic system. For a more detailed consideration of the main function, it must be decomposed using the methodology of functional modeling IDEF0. The decomposition diagram of the first level of the main function of the information system is presented in Figure 5.

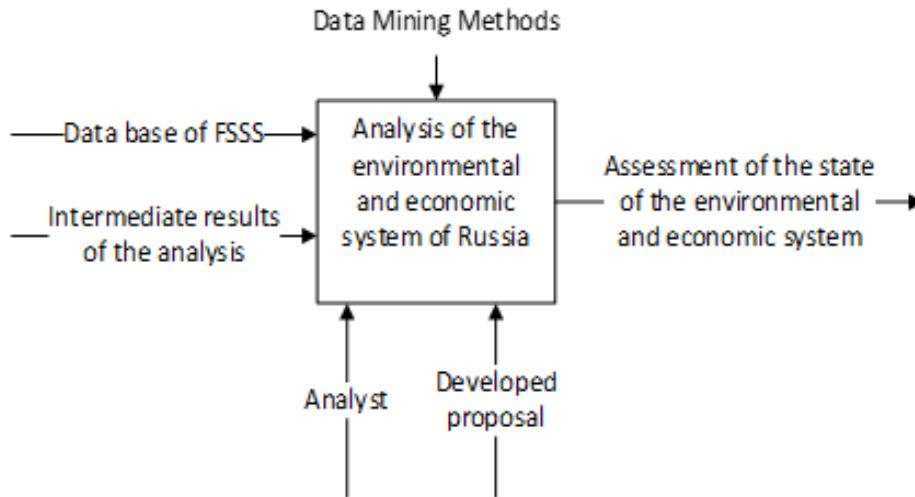


Fig. 4. Context diagram of the main function of the information system

Thus, the scientific novelty of the proposed methodological approach does not lie in the concept of any particular component, but in the design and integration of a combination of data mining components. The use of the proposed methodological approach is focused on a comprehensive assessment of the country's environmental and economic system, and the synergy of the used methods of data mining in the presence of disadvantages of each separately allows obtaining the most reliable and objective results, which are the basis for making specific management decisions.

IV. RESULTS

It should be noted that in general, in recent years, the state of the environmental and economic systems of Russia has been improving, but the measures taken to restore the quality of natural resources are not enough. In a number of regions, the state of environmental and economic systems is not stable in terms of compliance with the country's average level of indicators. The need for differentiation of regions is due to the ability to regulate the environmental and economic status of several regions with similar characteristics of regional environmental and economic systems at once.

As a result, to identify the regions according to the state of the EES, a cluster analysis was carried out according to indicators characterizing the state of the environment. The data was taken for 2017 as they were current and the most complete at the time of the study. When conducting cluster analysis using the k-means method, the data were standardized. As a result, 4 clusters were identified and the indicators characterizing the environmental impact of economic activity were calculated by the clusters (table 2).

TABLE II. TYPOLOGICAL GROUPING ACCORDING TO THE RESULTS OF CLUSTER ANALYSIS

Indicators	Clusters				
	I	II	III	IV	Average
The number of regions	9	27	42	4	
Per 100 people:					
water withdrawal from natural water bodies for use, mln.m3	47.6	28.9	39.1	146.6	41.7
recycling and sequential use of water, mln.m3	174.8	132.1	40.8	183.7	93.9
discharges of polluted waste water, mln.m3	15.7	11.2	7.0	19.8	10.0
emissions of pollutants into the atmosphere from stationary sources, th. ton	40.4	9.8	3.7	46.3	11.8
air pollutants captured and disposed, th. ton	158.2	27.9	11.5	25.7	33.5
current environmental costs, th. RUB	437.5	225.0	92.1	772.1	208.8
investments in fixed assets, th. RUB	171.0	93.5	38.0	515.9	95.2

In general, it can be seen that the selected clusters differ in indicators characterizing the environment.

The regions that made up the first cluster are characterized by high values of all indicators, compared with the second and third cluster. These regions are characterized by low water withdrawals from natural water bodies and discharge of polluted wastewater, and, as a result, high recycling and sequential use of water. If we separately consider the costs of protecting the environment, then the prevailing costs are the collection and treatment of wastewater and waste handling. It also explains the high rates of recycled water use. As for investments, in the regions of the first cluster the greatest attention is paid to investments in the protection and rational use of water resources and in the protection of atmospheric air.

The regions of the second and third clusters are characterized by average values of indicators. Since among the current expenditures on environmental protection the costs of collecting and treating wastewater prevail, and the same is for investments in the rational use of water, the indicators of recycling and sequential use of water are quite high compared to other indicators of the 2nd and 3rd clusters.

The regions of the 4th cluster are characterized by the highest values of indicators. The costs of environmental protection in these regions are dominated by the costs of protecting atmospheric air and preventing climate change, the collection and treatment of wastewater, as well as the protection and rehabilitation of land, surface water and groundwater. As to investments, the most of them is in the protection of atmospheric air and the rational use of water resources. An approximately equal amount of funds is invested in the protection and rational use of land and in protecting the environment from the harmful effects of production and consumption waste. In the regions of 4th cluster, the environmental load is the highest, however, more measures are being taken to restore the state of the EES.

Thus, it should be noted that cluster analysis allows identifying qualitatively heterogeneous groups of regions. In order to be able to classify regions into clusters using indicators characterizing economic development, data mining methods were used in the R Environment: the support vector method and "random forest", the results are presented in Tables 3 and Table 4.

**TABLE III.** INTERRELATION OF THE ELEMENTS OF THE MODEL PREDICTED BY THE METHOD OF SUPPORT VECTORS WITH ELEMENTS OF CLUSTERS

Predicted clusters	Initial clusters			
	1_kl	2_kl	3_kl	4_kl
1_kl	1	0	0	0
2_kl	6	17	6	2
3_kl	2	10	36	1
4_kl	0	0	0	1
The share of correctly distributed elements, %	11	70	16	25

**TABLE IV.** INTERRELATION OF THE ELEMENTS OF THE MODEL PREDICTED BY THE RANDOM FOREST METHOD WITH CLUSTER ELEMENTS

Predicted clusters	Initial clusters			
	1_kl	2_kl	3_kl	4_kl
1_kl	9	0	0	0
2_kl	0	27	0	0
3_kl	0	0	42	0
4_kl	0	0	0	4

Based on the results presented in Table 3, we can conclude that the quality of the forecast is not high enough. Despite the fact that in the second cluster 70 % of the elements were correctly classified, in the first, second, and third clusters, the forecast accuracy does not exceed 30 %. Let us compare the results of the classification of elements by the method of "random forest".

As it can be seen from the table on economic indicators, it is possible to predict the environmental load of the regions without errors.

Similarly, clusters were identified by the level of economic development. The results of the classification of regions according to environmental indicators are presented in Table 5 and Table 6.

**TABLE V.** INTERRELATION OF THE ELEMENTS OF THE MODEL PREDICTED BY THE METHOD OF SUPPORT VECTORS WITH ELEMENTS OF CLUSTERS THAT CHARACTERIZE ECONOMIC DEVELOPMENT

Predicted clusters	Initial clusters				
	1_kl	2_kl	3_kl	4_kl	5_kl
1_kl	0	0	0	0	0
2_kl	0	6	0	0	0
3_kl	1	0	43	5	21
4_kl	0	0	0	0	0
5_kl	0	0	0	0	6
The share of correctly distributed elements, %	0	100	100	0	22

Table 5 shows that in the third and fourth clusters all elements of the second and third clusters were correctly classified. However, in the first and fourth clusters, not a single element was distributed correctly. In the fifth cluster of 21 elements, only six were correctly distributed.

**TABLE VI.** INTERRELATION OF THE ELEMENTS OF THE MODEL PREDICTED BY THE RANDOM FOREST METHOD WITH CLUSTER ELEMENTS CHARACTERIZING ECONOMIC DEVELOPMENT

Predicted clusters	Initial clusters				
	1_kl	2_kl	3_kl	4_kl	5_kl
1_kl	1	0	0	0	0
2_kl	0	6	0	0	0
3_kl	0	0	43	0	0
4_kl	0	0	0	5	0
5_kl	0	0	0	0	27

The results of the classification of elements by the "random forest" method are completely different, they are presented in Table 6.

From the data, it follows that the model built on the system of indicators of the NE predicted by this method is fully consistent with the composition of the clusters according to the system of economic indicators.

Summarizing the conclusions made, we can say that according to the results of the analysis of the same indicators by two different methods, the composition of typical groups and clusters is not the same. The number of regions in groups and clusters also differs. But despite these differences, a direct relationship between the costs and investments in protecting the NE and the results of the protection of the NE is confirmed. So, the more investments are made in environmental protection, the better are the indicators of recycled water use, discharge of polluted wastewater, pollutant emissions into the atmosphere, etc.

In addition, it should be noted that in order to choose the best classification method, it is necessary to compare the composition of models constructed using two different

methods with the composition of clusters. Thus, we can say that since the results of the analysis revealed a direct dependence of the ecological state of the regions on the level of their economic development, in the future it is possible to use only economic data to describe the EES and correctly predict the ecological state of the regions. Similarly, the economic development of the regions can be predicted only by indicators characterizing the load on the NE.

## V. CONCLUSION

The solution of global environmental problems requires medium and long-term sustainable development and transformation strategies. They are often driven by politics and are aimed at production and consumption of resources [19]. In that regard, such transformations are related not only to the environment, but also to the economy, and public administration must adapt to such an object as an environmental and economic system.

In the framework of this study, the authors developed the basic principles and methodological approach for the statistical study of the state of EES at the regional level using data mining techniques.

In particular, four research tasks have been completely solved, they are as follows:

1. In the framework of this study, the authors clarified the concept of "environmental and economic system" as an object of statistical research, which should be understood as the natural environment under the influence of economic and social activity of a person, including mutual influence, as well as the consequences resulting from this, determined its structure and trends. That all led to improvement of the quality of the analysis from the perspective of the essential content of this category.

2. Based on the substantive analysis of EES, the system of statistical indicators of the EES state integrated and developed in the author's analysis technique is generalized and improved. In particular, such indicators are grouped in four areas: the economic system, land resources, water resources and weather conditions.

3. As the most important element of the scientific novelty of the research of environmental and economic systems, the authors developed a methodological approach using modern methods of data mining ("random forest" and the support vector method) and adapted it to EES. It allows differentiating regions according to the level of environmental load based on indicators characterizing economic development, and vice versa. The application of this approach can be used to monitor the environmental and economic situation and operational data processing in the digital economy. The approach is aimed at optimizing the process of collecting and processing information in the field of economics and environmental protection, it allows reducing the time and material resources spent on analysis, to improve its quality and accuracy of forecasts.

4. Presented methodological approach was automated and tested using the programming language R. As a result,

there was chosen the best method for classifying regions - "random forest", which allows classification of regions according to environmental load and economic development without errors.

The analysis makes it possible to conclude that the negative impact on the NE is lower not only in those regions where production volumes are very small ("non-productive regions"), but also in the constituent entities of the Russian Federation with the most developed material production ("economic developed regions"). At the same time, it was noted that in economically developed regions much more attention is paid to the degree of negative impact and protection of NE. With regards to the above, we believe that an effective solution to environmental problems can only be achieved through economic growth based on restoring the country's production potential, increasing production intensification, conducting systematic land reclamation and drainage processes to increase fertility, and actively introducing new innovative "Environment-friendly" products.

The results of the study can be used to develop and improve measures of state regulation of economic and environmental policies. From the point of view of macroeconomic regulation, the authors proved the following conclusion: a high level of economic development of a country's region ensures the formation of a stable environmental situation in its territory. It is no coincidence that the Environmental Doctrine of the Russian Federation includes the low technological and organizational level of the economy, the high degree of deterioration of fixed assets as the main factors of environmental degradation of the Russian Federation; as well as the consequences of the economic crisis and the low standard of living of the population. The authors revealed a significant differentiation of Russian regions according to the state of the EES. While not pleading with the doctrinal thesis about the need for a unified state policy in the field of ecology, we consider it appropriate to differentiate approaches to state regulation of the region's ecology by economic methods on the basis of diversification of types of economic regulators - regulatory instruments, in particular by dividing them into direct and indirect [20].

In economically developed regions (clusters 1 and 4), emphasis should be placed on indirect tools for the economic regulation of environmental processes (tax incentives, preferential lending systems for investments in social insurance schemes, preferential insurance and reinsurance systems). The high level of economic development of such entities allows concluding that it is possible for them to finance independently the costs of protecting the environment, and therefore it is only necessary to indirectly affect the EES of the entities of these clusters. It is no accident that in the study "Actual Problems of Ecological Insurance in the Subsurface Use Sphere" it is noted that flexible tax policy and insurance can become an effective element of environmental management in the country [21].

In the regions of cluster 2 and cluster 3, taking into account the lack of opportunities for full self-financing of



expenditures for environmental protection, due to their economic status, it is necessary to actively introduce direct tools for the economic regulation of environmental processes (budget subsidies to economic entities, subsidized financing of regional and local budgets, public-private partnerships with partial financing of "environmental" costs). Such tools are more "voluminous" (in terms of support sizes) and targeted, and therefore appropriate for these regions. To a large extent, this proposal is consistent with the results of a study by Chinese scientists who proved on the basis of an analysis of data from Chinese companies for 2007–2017. sensitivity of environmental indicators and financial indicators, as well as substantiating the need for expanded financial support for the environment in financially insolvent economic entities [22]. In addition, the presented approach is justified by significant differences in the level of economic development of territories within the country. For this reason, it can be used not only by the Russian Federation, but also by a number of other countries of the federal structure, the distinguishing feature of which is the strong economic differentiation of regions.

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