Economic and statistical analysis of environmental indicators in the Russian Federation

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Abstract. The problem of environmental pollution is acute and relevant at the present time. The article presents an economic and statistical analysis of indicators of air pollution, water and land resources. The analysis was carried out for 2009-2018. The process of predicting the level of atmospheric pollution according to the trend equation (the forecast was obtained until 2022) was carried out according to the time series, the level of water pollution was predicted using the multiple regression equation (a realistic, optimistic and pessimistic forecasts were obtained) and the level of reforestation was predicted based on average dynamics (until 2022).

1. Introduction
The issue of environmental protection and natural resources is so significant that there is almost no country on the planet that did not seek to find solutions to the problem. There are a large number of concepts, as well as ways to consider the impact of economic activities of agricultural and industrial enterprises on the natural environment.

Currently, the natural processes of reproduction and purification of nature have reached a striking scale: pollution and consumption of plant, energy and other raw materials have affected the state of the environment.

On average, several tens of billions of tons of ore and up to about 5 billion tons of fuel, various building materials, natural gas and oil are extracted from earth. This does not include the release of several hundred tons of carbon monoxide and sulfur dioxide into the atmosphere. Oil production also negatively affects the oceans: about 10 million tons of oil gets into the water. Each year, the area of soil suitable for agriculture shrinks due to such environmental problems. And this is not all indicators of violation of natural ecological balances and ecosystem overload.

2. Statement of problem
The impact of the economy on the state of the environment was conceived back in the eighteenth century. The French economist, F. Quesnay, suggested in 1758, when he was trying to develop methods for assessing macroeconomic flows, that economic activity has a direct impact on the environment and that nature must be restored. Unfortunately, this problem was forgotten due to the fact that all attention was focused on the analysis of the laws of the internal functioning of the economy [1]. But over time, starting from the twentieth century, when there was a clear threat to the
quality of life of people due to a lack of natural resources and pollution of the natural environment, the connection between the economy and the environment became visible [2].

3. Materials and Methods

Statistics of nature and natural resources is part of financial statistics, including general indicators describing the state of the environment, the availability and quality of natural resources, the relationship of man and the environment.

**Statistical analysis of air pollution**

Anthropogenic pollution of the atmosphere is only 0.5% of the total pollution by natural phenomena (dust storms, volcanic eruptions, forest fires, etc.). Nevertheless, it is this type of pollution that has the greatest negative impact on many living organisms, on the material values created by labor, and, of course, on human himself. Pollution of cities, mainly due to industry and transport, contributes to the development of many chronic diseases.

It should be borne in mind that as a result of the transfer of harmful impurities by air mass flows, transboundary air pollution occurs. Therefore, air pollution is a planetary problem.

The objects of statistical observation of technogenic effects on atmospheric air are the stationary sources of harmful substances polluting the air, their neutralization, capture and further disposal.

Table 1 shows the data for the last 9 years, showing how much, on the initiative of economic entities in the Russian Federation, substances hazardous to living organisms are released into the atmosphere.

| Table 1. Emissions of air polluting substances from stationary and mobile sources [3] |
|-----------------------------------|---------|---------|---------|---------|---------|---------|
| Indicators                        | 2009    | 2012    | 2015    | 2016    | 2017    | 2018    |
| Total                             | 19021   | 19630   | 17296   | 17349   | 17478   | 17068   |
| agriculture, hunting              | 127.5   | 162.5   | 197.3   | 218.2   | 248.1   | 219.5   |
| mining                            | 5238.6  | 6128.4  | 4754.7  | 4911.9  | 4919    | 4851    |
| processing industries             | 6353.5  | 6406.5  | 5968.6  | 5777.7  | 5803.5  | 3756    |
| food production including drinks  | 144.9   | 140.1   | 146.0   | 156.1   | 143.7   | 141.7   |
| chemical production               | 332.2   | 338.7   | 368.9   | 375.7   | 399.4   | 355.9   |
| manufacture of other non-metallic mineral products | 403.5 | 435.0 | 402.6 | 354.7 | 357.5 | 355.5 |
| other economic activities         | 1141    | 698.2   | 575.4   | 842.6   | 909.8   | 4759    |

According to Table 1, it can be said that in the studied period, the amount of pollutants emitted into the atmosphere in 2018 decreased in the Russian Federation by 1952 thousand tons compared to 2009, which is 10.3%. The data in the table show for 2018 that the first place in terms of emissions polluting the atmosphere of the Russian Federation is mining (4851 thousand tons), the second is other economic activities (4749 thousand tons), and the manufacturing industry is third (3756 thousand tons).

But it is worth highlighting that the amount of pollutant emissions into the atmosphere is decreasing every year, which has a positive side in the problem of protecting air. It should be emphasized separately that a high concentration of these substances in combination with other organic substances is the cause of acid rain and environmental degradation over a large area.

**Statistical analysis of water resources**

The objects of statistical monitoring of water resources are water users of various sources that produce water for industrial, agricultural needs, as well as for domestic, drinking and other needs.

Statistical monitoring units are individual enterprises (organizations, institutions) of all sectors of the economy, regardless of water supply sources and wastewater receivers. The volume of water...
withdrawal from natural sources is subject to statistical accounting, that is, the amount of water withdrawn from surface water bodies (sea, river, lake) and underground horizons for further use.

Russia has huge water resources and ranks first in Europe in terms of its reserves. Thus, the total volume of water only in lakes (including those that border countries outside the Commonwealth of Independent States) is more than 106 trillion cubic meters. Water reserves in fresh lakes amount to 25 trillion m$^3$, of which 91% falls on Lake Baikal. At the same time, the problem of pollution and depletion of water resources in Russia is extremely urgent.

For further analysis of water resources protection, we use data from the Federal State Statistics Service and present them in Table 2.

**Table 2. Use of fresh water in the Russian Federation**

| Years | Total [m$^3$] | including irrigation and agricultural water supply | including manufacturing needs for household and drinking needs |
|-------|---------------|---------------------------------------------------|----------------------------------------------------------|
| 2009  | 57.7          | 8.4                                               | 34.9                                                     | 10.6 |
| 2012  | 56.9          | 7.7                                               | 33.9                                                     | 9.0  |
| 2015  | 54.5          | 7.1                                               | 31.4                                                     | 8.2  |
| 2016  | 54.6          | 7.0                                               | 31.0                                                     | 7.9  |
| 2017  | 53.5          | 7.1                                               | 30.0                                                     | 7.7  |
| 2018  | 53.0          | 7.0                                               | 29.3                                                     | 7.6  |

Over nine years, due to a decrease in water consumption for industrial needs, irrigation and agricultural water supply, the use of fresh water decreased by 4.7 billion cubic meters (8.2%).

It is worth highlighting that from 2009 to 2011 the level of fresh water use had been growing, but already from 2014 to 2018 this indicator decreased.

Apparently from Table 2, most of the water resources go for industrial needs. It averages 57.7% of the total fresh water used.

**Statistical analysis of land resources.**

Forests have a significant impact on the climatic conditions, the circulation of heat in the atmosphere, the moisture supply in the soil, water in rivers and lakes of different geographical zones and regions [4].

Forest stands significantly complicate the spread of water and wind erosion. The destruction of forests is everywhere accompanied by an increase in the area of surface soil erosion, which leads to the formation of ravines. Based on this fact, we consider the analysis of land resources based on forestry statistics and the protection of forests from pests.

**Table 3. Forestry and the provision of forestry services in the Russian Federation**

| Year | Reforestation | Forest protection from pests |
|------|---------------|------------------------------|
|      | Total         | including artificial reforestation | biological | chemical |
| 2009 | 836.7         | 181.0                        | 150.4       | 15.5     |
| 2012 | 841.7         | 184.9                        | 255.2       | 73.5     |
| 2015 | 802.9         | 182.2                        | 196.1       | 36.6     |
| 2016 | 839.9         | 178.7                        | 379.9       | 20.6     |
| 2017 | 961.8         | 176.6                        | ...         | ...      |
| 2018 | 940.4         | 171.8                        | ...         | ...      |

Work on reforestation and on the protection of forests from pests in the Russian Federation has a positive trend. Almost the same amount of work is being done from year to year to protect forests.
from pests and diseases by the biological method, but there has been an increase in the amount of work to protect forests from pests by the chemical method. This leads to the fact that over the studied 10 years, the area of reforestation has increased significantly. This suggests that protecting forests from pests and artificial reforestation have a positive impact on the environment [5].

Figure 1. Protection of forests from pests in the Russian Federation in 2009-2016

From the data on the dynamics of protection of forests from pests in the Russian Federation over 2009-2016, the following conclusions can be made:

1) Over the studied nine years, work in the field of forest protection from pests by the chemical and biological method in the Russian Federation for 2009-2016, in general, is inconsistent, i.e. indicators raise and fall;

2) In 2011, there was a strong decline in efforts in the field of forest protection compared to 2010 by 64.9 thousand ha, which could lead to risks of destruction of a large number of forest territories;

3) In 2012, this indicator increased, especially with respect to work on the protection of forests biologically by 93.5 thousand ha. A chemical method also shows an increase of 59.7 thousand ha.

4) But already from 2013 to 2015 inclusively, there was a decrease in the protection of forests from pests by the biological method. And the chemical method in this period rose to 2013, but already in 2014 it also went down.

5) The highest indicator of the protection of forests from pests by the biological method was shown in 2016, when there is a sharp increase in relation to 2015 by 183.8 thousand ha. The chemical method continues to decline.

Thus, we can say that work on reforestation and on protecting forests from pests is ongoing. The state allocates money for these works. Reforestation work continues to grow. As for the work to protect forests from pests, this is a very inconsistent issue.

4. Results and Discussion

Prediction of indicators of the atmospheric air state according to the trend equation.

Initially, according to the data in Table 1, we determine the equation of the trend of the state of atmospheric air of the Russian Federation in 2018-2022. Based on the data obtained, the polynomial trend is the best, since it has the highest $R^2$. The trend equation is as follows: $y = 0.0409x^2 - 0.5476x + 33.527$. $R^2$ equals 0.6116, which indicates that the type of trend line is selected correctly.

In dynamics, there is a forecast for a decrease in pollutant emissions starting in 2009. The smallest value is observed in 2014, then there is a gradual increase in atmospheric emissions of polluting
substances of the Russian Federation. The forecast shows that air emissions of pollutants are gradually decreasing in the future, starting from 2019.

Table 4 presents the calculation of the upper and lower confidence limits of the forecast, the confidence boundary of the forecast for 2018-2022.

| Years | Forecast | Lower confidence limit | Upper confidence limit |
|-------|----------|------------------------|------------------------|
| 2018  | 32327    | 32327                  | 32327                  |
| 2019  | 32296.029| 31507.39              | 33084.67              |
| 2020  | 32265.073| 31095.06              | 33436.35              |
| 2021  | 32235.376| 30732.03              | 33738.72              |
| 2022  | 32205.05 | 30387.61              | 34022.49              |

This means that the trend in 2020 will pass through the point with ordinate 32265.1, through the point 32235.4 in 2021, and the point 32205.1 in 2022. However, trend parameters calculated over a limited period are only sample estimates of the general parameters.

**Correlation and regression analysis of the state of water resources in the Russian Federation**

A large number of factors affect the state and environmental protection. Let us try to study the relationship between the level of water resources and other economic phenomena occurring in the Russian Federation.

To conduct correlation and regression analysis, we use the following factor signs:
- $L$ is current costs for the collection and treatment of wastewater, mln rubles
- $V$ is production and consumption waste generation, mln tons
- $Z$ is the total number of natural emergencies that occurred on the territory of the Russian Federation.

Let us conduct a regression analysis. Based on the results of the regression analysis, the following regression equation was obtained:

$$y = 17,056 + 0,149L + 4,499V - 0,094Z$$

\[1.97\] \[1.53\] \[2.89\] \[4.19\]

The multiple regression coefficient is 0.996. This means a strong relationship between the indicators. The determination coefficient is 0.992, therefore, 99.2% of the state of water resources in the Russian Federation.

Let us perform forecasting (Table 5).

| Forecast | Prognostic value |
|----------|------------------|
| Pessimistic | 91.45             |
| Realistic   | 74.16             |
| Optimistic  | 74.32             |

Thus, with the average value of the factors included in the protection of water resources, while the current trend is unchanged, it can reach 74.16 million tons. With the minimum values of water protection factors, it can reach 74.32 million tons. At maximum values protection of water resources can reach 91.45 million tons.

**Forecasting based on average reforestation rates**

In addition to building a point and interval forecast for the trend for modeling and forecasting the level of reforestation, let us make a forecast based on absolute growth.

Based on the predicted values, provided that the trend in the state of reforestation in the Russian Federation will continue to grow, may reach 951.9 thousand hectares in 2019, 963.4 thousand hectares in 2020, 974.9 thousand hectares in 2021 and 986.4 thousand hectares in 2022.
Table 6. Forecast values of the level of reforestation in the Russian Federation in 2018-2022

| Forecasting year | L | Promising reforestation level |
|------------------|---|------------------------------|
| 2019             | 1 | 951.9                        |
| 2020             | 2 | 963.4                        |
| 2021             | 3 | 974.9                        |
| 2022             | 4 | 986.4                        |

5. Conclusion
Due to air pollution, the number of chronic diseases increasingly raises. Work on the protection of atmospheric air as a whole has positive results. Over the study period from 2009 to 2018, the amount of pollutant emissions decreased by 10.3%. Particularly obvious were efforts to reduce emissions in manufacturing by 1.5 times.

Water resources in general also demonstrate a positive trend. Between 2009 and 2018, the use of fresh water or the discharge of wastewater and polluted water decreased. The following indicators have decreased: water consumption for industrial needs, irrigation and agricultural water supply. But it is still worth highlighting that most of the water resources are consumed by production sector.

When analyzing the state of land resources, an indicator of reforestation was taken. This indicator has a direct impact on the state of many other indicators: soil, air, biological cycle. In general, this indicator also has positive results. It has been revealed that there is an increase in reforestation work and protection of the forest from pests. However, the protection of the forest from pests is inconsistent: one year the process of protecting the forest has high rates, when in a year it can decrease.

It is worth paying attention to the modernization of the economy, which will be focused on the creation of industries without having a strong influence on the state of the biosphere. Humanity expects a long and very difficult process of the joint transformation of nature and society, and the formation of a civilization that meets the new human needs, consistent with the new realities of the surrounding nature, will be crucial in its duration.

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