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Table of Contents

Econometric Assessment of Sustainable Development and Status of Health among the Population

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Abstract:

The Republic of Kazakhstan has achieved significant economic growth and significant results in the country's socio-economic development. However, the implementation of the Programs for Forced Industrial-Innovative Development, the Business Roadmap 2020 and others within the framework of the traditional production and consumption scheme causes a multiple increase in anthropogenic pressures on the regions. Thus, an increase in the seizures of mineral, hydrocarbon, water, land, energy resources, emissions and volumes of pollutants, the growth of new industries and infrastructures, determine their uneven development and increasing the degree of desertification of territories. Authors had considered in the regional aspect such a factor as the health of the population, taking into account the environmental problems and the environmental situation in the region. The article presents the economic and mathematical model of sustainable development management in the context of the regions of the Republic of Kazakhstan.

Keywords: econometric model; assessment, health; sustainable development

JEL Classification: C51; Q56; I15

Introduction

To date, a number of environmental problems remain unresolved in Kazakhstan, which requires a different approach to the development of state environmental policies and sustainable development management models.

There are many factors hampering the country's sustainable development: inefficient resource management; excessive consumption of natural resources (anthropogenic impact); commodity orientation of the economy; excessive urbanization of territories; deterioration of public health; human capital; imbalance of regional development; low productivity of economic sectors; increase in the number of industrial zones; deficiency of water resources and desertification of territories; environmental pollution; energy intensity of production; low land productivity and crop yields and other factors.

1. Research background

The issues of environmental and economic development of the regions within the framework of the transition of Kazakhstan to a "green" economy are engaged by foreign and domestic scientists: Grossman (2014), Krueger (2014), Kuznets (2013), Shabanova (2018), Agubaev (2018), Antonova (2014), Popov (2015) and others.

Many factors play a role in the implementation of the Concept of Sustainable Development of the Republic of Kazakhstan. Among others, we would like to note, such as: ineffective management of mineral, land, water and biological resources characteristic of our country will ultimately lead to an increase in the scale and rate of loss of

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the resource potential, which will accordingly limit the economic development and export potential of regions and the republic in whole. Specialists in the field of mineral resources have concluded that the growth in energy consumption will continue in Kazakhstan, and it has believed that in the next 50 years the volume of mining operations will increase more than five times, mainly due to new deposits with processing ores by old technology. Until 2025, there may be an almost complete exhaustion of the explored reserves of oil, gas and other energy resources.

The next, much important factor hampering sustainable development is the low productivity of land resources. The productivity of land and the yield of basic crops (wheat, barley) in Kazakhstan are three times lower than in Canada due to their considerable degradation. Half of the country's agricultural lands are degraded, of which 50% of arable land, because of which the yield of wheat fell by 36% (Shabanova and Agubaev 2018). Such a huge amount of land unsuitable for farming is caused by inefficient use, lack of water, anthropogenic impact.

Very low economic productivity of water use in agriculture, which is almost 5 times lower than in Russia, while the cost of water for irrigation of rice fields is 10 times higher than in Russia and Canada. Given the current assessment of water demand, Kazakhstan may face an acute shortage of water resources. According to the Committee of Water Resources, by 2030, less than 1/5 of the water resources will be available for economic use. According to international research, about 2 billion US dollars will be needed to meet water needs in cities, settlements, agrarian and industrial sectors.

In addition, a certain danger for Kazakhstan is the pollution of the environment by toxic substances. According to international experts, more than 40 thousand children under the age of 10 suffer from neurological disorders due to exposure and significant amounts of lead in the body. Kazakhstan ranks second among Central Asian countries and Eastern European countries in terms of environmental pollution by organic substances. Air pollution in Kazakhstan is the main cause of more than 6000 deaths per year.

The lack of a waste management system leads to uncontrolled landfills of more than 97% of household and construction waste. The problem of radioactivity remains very serious. The greatest pollution by toxic substances has observed in the cities of Zhezkazgan, Temirtau, Balkhash and Karaganda. This is due to the location in these settlements of the largest enterprises operating in the field of ferrous and non-ferrous metallurgy (JSC ArcelorMittal Temirtau and JSC Kazakhmys). Obsolete production technology, inefficient cleaning plants and equipment, poor quality of used fuel, and weak use of renewable energy sources have led to the fact that air pollution indicators are so high (Shabanova and Agubaev 2015).

For the Republic of Kazakhstan, the problems of atmospheric air pollution have been and remain relevant. Emissions to the atmosphere of harmful substances from stationary sources are about 2.5 million tons per year; transport emissions exceed 1 million tons / year. Today, about 5 million Kazakhstani people live in polluted atmospheric air, while at least 2 million people live in conditions of extremely high pollution levels. In addition, the layout of settlements, primarily because many cities and towns were formed as satellites of large industrial facilities, often lead to the inevitable pollution of the urban atmosphere by industrial emissions.

From the point of view of possible health effects of the population, the most significant is the air pollution of populated areas with dust, sulfur dioxide, nitrogen dioxide, phenol, lead, formaldehyde, chlorine, hydrogen fluoride, ammonia, dioxin, furan, carbon monoxide, hydrogen sulfide and hydrogen chloride. It should be noted that each of these pollutants has its own specifics in terms of impact on public health.

Thus, Kazakhstan scientists estimated the damage to the health of the population due to the deterioration of the ecological situation, taking into account the overall costs of treatment, diagnosis and prevention of the pathology of the population, the average life expectancy, the cost of payments for sick leave, and the cost of retirement for disabled people. According to experts from the Center for Health Protection and Eco Projecting, Kazakhstan's losses amount to 55.7 US dollars per inhabitant per year or US $ 60 per tonne of air emissions. This means that the negative effect on the health of the population of Kazakhstan against air pollution is about 1.5 billion US dollars per year.

2. Methodology

Many factors play a role in the implementation of the Concept of Sustainable Development of the Republic of Kazakhstan. Among others, we would like to note, such as: ineffective management of mineral, land, water and biological resources characteristic of our country will ultimately lead to an increase in the scale and rate of loss of the resource potential, which will accordingly limit the economic development and export potential of regions and the republic in whole. Specialists in the field of mineral resources have concluded that the growth in energy consumption will continue in Kazakhstan, and it is believed that in the next 50 years the volume of mining operations will increase more than five times, mainly due to new deposits with processing ores by old technology. Until 2025 there may be an almost complete exhaustion of the explored reserves of oil, gas and other energy resources.

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In the Karaganda region, the largest volumes of pollutant emissions are observed in the Abai region, which can be explained by the existing production enterprises there (Abai Central Enrichment Plant, Coal Department of Mittal Steel Temirtau JSC, Kazakhmys State Regional Power Station, Abay Foundry-Mechanical LLP factory", PKF "Karaganda Textile Line", *etc*.).

Thus, under the strong anthropogenic press is Karaganda region, which is located within the region of Central Kazakhstan and covers an area of 4220.9 thousand hectares. Specificity of the region consists in the features of geomorphological characteristics - allocation of a special area of the Kazakh shield - Sary-Arka and high biodiversity of ecosystems. The region is unique in terms of the variety of soil types caused by zonal-provincial features of climatic conditions and relief, which determines the specificity of the diversity of flora, fauna and ecosystems. In Central Kazakhstan, 67 ecosystems have been identified, which characterizes a significant natural diversity. At the same time, the areas of disturbed territories and ecological risk zones, including habitat loss of rare plant species and ecosystems, are more than 50%. A high degree of danger in Central Kazakhstan, according to the data of ecological zoning, was noted for 32 ecosystems, on an area of 22,457.2 thousand hectares.

The analysis of the ecological risk zones of the Republic of Kazakhstan demonstrates a rather complex and diverse situation of ecosystem degradation in terms of hazard and risk of loss of species, ecosystems, tree and shrub thickets, the degree of internal danger of desertification of ecosystems, their soil cover under intense anthropogenic impact. In general, for Kazakhstan, according to the analysis of the developed map of ecological zoning, five degrees of danger have been identified, in principle corresponding to the degree of desertification - land degradation, ecosystems and, especially, soil and vegetation cover.

Because of the ecological zoning of Kazakhstan, the general picture of the current situation of desertification of ecosystems and the degree of danger in the further destabilization of the environment underlines the prevalence of a moderate degree of danger - 42.3% of the area of the republic. Nevertheless, even this is the ultimate limit of anthropogenic impact and further withdrawal of resources (soil and plant in particular) should be limited in a number of ecosystems. Reduction of the norms of use up to 10-20% is necessary for self-regulation of ecosystems and preservation of the reproducibility of resources. Moderate hazard conditions represent the limit of ecosystem resilience to a number of anthropogenic impacts, for example, to the removal of plant biomass. And with the additional factor of drought in arid years and seasons of rare species, the drying up of soils, the reduction of the species diversity of ecosystems, productivity and the change of ecosystems.

3. Application functionality

To assess the level of sustainable development, both at the regional and national level, as well as its modeling, a system of indices and indicators has used, which includes various components. In view of the enormous diversity in the definition of the term "sustainable development" in the interpretations of domestic and foreign scientists dealing with sustainable development management, we will mean sustainable development as a governance model that will ensure a decent level of the well-being of the population and the dynamic development of the economic and social system with the environment. Antonova (2014), with reference to the social and economic system, defines "stability" in the most general form as the ability of the system to return to the initial state relatively quickly or to reach a new, higher point on the trajectory of its development.

In connection with this, the issue of public administration arises sharply in conditions of instability, *i.e.* creation of the Kazakhstan model of sustainable development management. Based on the analysis, it can be argued that environmental problems accumulated by more than one generation in the foreseeable future will lead to a deterioration in the living conditions of not only future generations, but also of current residents, the quality of their lives, an increase in morbidity in the RK regions, which cannot affect the social sphere of the country. In such conditions, the country's economic development cannot be sustainable. This is the triune unity of the economy, ecology and social sphere.

This has confirmed by the work of the American economist and Nobel laureate Simon Kuznets. In his work Economic Growth and Income Inequality of 1955, he argued that economic growth leads first to an increase, and then to a decrease in inequality (Kuznets 2013). About the ecological curve Kuznets started talking in the early 1990's with the filing of Princeton economists Gin Grossman and Alan Krueger, who studied the effects of free oil trade. Instead of an inequality in the ecological curve of Kuznets, pollution of the environment has substituted. The pattern is the same - the growth of GNP at first the ecology worsens: the factories are smoky and the forests are cut down. Then there is a turning point, which the World Bank report explains: "With the increase in revenues, the demand for improving the environment is rising and there are more resources that can be invested in it." In other words, wealthy citizens, firstly, are keenly interested in breathing clean air and swimming in clean water, and secondly, they can afford to spend extra money on the environment.

The ecological curve of Kuznets has something to love: in order to save the environment, it is necessary not to strangle the economy, but, on the contrary, to develop it as intensively as possible, without exchanging ecology. If the Kuznets curve works, then developed and developing countries will sacrifice part of their GDP. Not just for the sake of abstract humanism, but for the sake of further economic growth. The global economy will continue to develop, and greenhouse gas emissions will go down. A turning point will appear on the world ecological curve of Kuznets (Kuznets 2013). In our work, we attempted to analyze the relationship between the level of environmental pollution and the volume of GDP in Kazakhstan.

The simplified regression equation of the ecological curve has the form:

$$Y_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 GDP_{it}^2 + \beta_4 \overline{GDP}_{it} + \beta_5 \overline{GDP}_{it}^2 + u_{it}, \tag{1}$$

where: Y_{it} – polution; $\overline{GDP}_{it}$ - three-year moving average values of gross domestic product.

In this case, moving averages are usually included in the model to smooth out short-term fluctuations and highlight major trends or cycles. Estimate the coefficients of the regression equation by the least squares method. As a result of approximating the data on GRP volumes and air emissions of pollutants in 16 regions of Kazakhstan for the period from 2004 to 2017, the following equation was obtained:

$$Y_{it} = 81{,}47 + 0{,}13GRP_{it} - 0{,}00004GRP_{it}^2 + 0{,}03\overline{GRP}_{it} - 0{,}000005\overline{GRP}_{it}^2, \quad (2)$$

where: Y_{it} – emissions of pollutants emitted from stationary sources into the atmosphere, measured in thousand tons; GRP_{it} - GRP, billion tenge; $\overline{GRP}_{it}$ – three-year moving average values of gross regional product, billion tenge.

Since the coefficient $\beta_2 = -0{,}00004 < 0$, and the coefficient $\beta_1 = 0{,}13 > 0$, then we have a convex upward (∩-shaped) curve that changes its direction with respect to the point of inflection from growth to fall.

By differentiating the GRP index and equating the result to zero, we calculated the gross domestic product in Kazakhstan, for which the pollution volume reaches its maximum. We have received that the peak of pollution comes at a GRP level of 1677,05 billion tenge. Further increase of this indicator in the RK leads to a reduction in emissions of pollutants into the atmosphere.

However, this trend is not traced for a longer period. As a result of processing data on GRP volumes and air emissions of pollutants, it can be seen that in 16 regions of Kazakhstan for the period from 2004 to 2017, we obtained the following regression equation:

$$Y_{it} = 119{,}8 - 0{,}07GRP_{it} + 0{,}00001GRP_{it}^2 + 0{,}15\overline{GRP}_{it} - 0{,}00003\overline{GRP}_{it}^2, \quad (3)$$

In the equation, the coefficient $\beta_2 = 0{,}00001 > 0$, and the coefficient $\beta_1 = -0{,}07 < 0$, therefore, The curve is convex downward (U-shaped) and changes its direction with respect to the point of inflection from falling to growth.

In this case, using in the equation the moving averages of gross domestic product volumes, which are usually included in the model to smooth short-term fluctuations and highlight the main trends or cycles, we see a slightly different picture, analyzing the long trend. This, perhaps, is related to the cyclical development of the economy in the long run, which in itself does not contradict the principles of sustainable development.

Since economic growth reflects quantitative changes (in the form of gross domestic product); and sustainable development reflects qualitative positive changes aimed at growth, transformation and transition from one state to another.

Cyclical development of the economy can be defined as a form of its development, as a movement from one macroeconomic equilibrium to another, *i.e.* transition from one state to another. In this context, the U-shaped curve represents, on the one hand, the phases of the business cycle. However, since cyclicity itself is a form of economic development, the crisis (manifested at the point of recession), in turn, appears as a form of economic development.

Further, it is of practical interest to study the impact of economic development on the level of pollution in various regions of Kazakhstan. To do this, first we will cluster all regions according to two indicators: the amount of emissions of pollutants emitted from stationary sources (thousand tons) into the atmosphere, and the volume of the gross regional product (billion tenge). Table 1 presents all regions of Kazakhstan and indicators of the region's environmental and economic development in 2017.

Table 1. Ecological and economic development of the regions of the Republic of Kazakhstan in 2017

Regions	Amount of emissions into the atmosphere(thousand tons)	GRP volume (billions of tenge)
Akmola region	83,8	942,2
Aktyubinsk region	125,4	1816,3
Almaty region	68,4	1665,5
Atyrau region	138,4	3635,1
West Kazakhstan region	60,4	1845,8
Zhambyl region	33,6	864,0
Karagana region	572,6	2690,7
Kostanai region	115,4	1309,7
Kyzyl Orda region	31,2	1374,0
Mangistau region	77,5	1880,0

Regions	Amount of emissions into the atmosphere(thousand tons)	GRP volume (billions of tenge)
South Kazakhstan region	56,3	2062,6
Pavlodar region	650,4	1539,1
North Kazakhstan region	71,4	747,5
East Kazakhstan region	124,9	2050,3
City of Astana	60,6	3245,4
City of Almaty	12,4	6471,8

Source: compiled by authors

To classify regions, we use cluster analysis, which allows us to divide objects into homogeneous groups or clusters for a number of features. Uniform objects are considered, the observed signs of which are in close proximity to each other. The norm of proximity is the distance metric. To solve our problem, we used the usual Euclidean metric, according to which the distance between observations is calculated by the formula:

$$d_{i,j} = \sqrt{\sum_{k=1}^{p}(x_{ki} - x_{kj})^2} \tag{4}$$

Based on the Euclidean metric, the distance between regions 1 and 2 is:

$$d_{1,2} = \sqrt{(83{,}8 - 125{,}4)^2 + (942{,}2 - 1816{,}3)^2} = 875 \tag{5}$$

It is obvious that $d_{1,2} = d_{2,1}$, a $d_{1,1} = 0$.

Similarly, we find the distances between all 16 regions and build a distance matrix (Table 2 and Table 3).

Table 2. The matrix of distances between objects 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1		875	723	2693	904	93	1816	369	435	938	1121	823	195	1109	2303	5530
2	875		161	1819	71	957	982	507	452	80	256	594	1070	234	1431	4657
3	723	161		1971	180	802	1142	359	294	215	397	596	918	389	1580	4807
4	2693	1819	1971		1791	2773	1039	2326	2264	1756	1575	2158	2888	1585	397	2839
5	904	71	180	1791		982	988	539	473	**38**	217	665	1098	214	1400	4626
6	93	957	802	2773	982		1905	453	510	1017	1199	914	122	1190	2382	5608
7	1816	982	1142	1039	988	1905		1455	1424	950	813	1154	2007	781	755	3822
8	369	507	359	2326	539	453	1455		106	572	755	582	564	741	1936	5163
9	435	452	294	2264	473	510	1424	106		508	689	641	628	683	1872	5098
10	938	80	215	1756	**38**	1017	950	572	508		184	667	1133	177	1366	4592
11	1121	256	397	1575	217	1199	813	755	689	184		792	1315	70	1183	4409
12	823	594	596	2158	665	914	1154	582	641	667	792		981	733	1805	4974
13	195	1070	918	2888	1098	122	2007	564	628	1133	1315	981		1304	2498	5725
14	1109	234	389	1585	214	1190	781	741	683	177	70	733	1304		1197	4423
15	2303	1431	1580	397	1400	2382	755	1936	1872	1366	1183	1805	2498	1197		3227
16	5530	4657	4807	2839	4626	5608	3822	5163	5098	4592	4409	4974	5725	4423	3227	

Source: compiled by authors

Table 3. The matrix of distances between objects 2

	1	2	3	4	5+10	6	7	8	9	11	12	13	14	15	16	
1		875	723	2693	938	93	1816	369	435	1121	823	195	1109	2303	5530	1
2	875		161	1819	80	957	982	507	452	256	594	1070	234	1431	4657	2
3	723	161		1971	215	802	1142	359	294	397	596	918	389	1580	4807	3
4	2693	1819	1971		1791	2773	1039	2326	2264	1575	2158	2888	1585	397	2839	4
5+10	938	80	215	1791		1017	988	572	508	217	667	1133	214	1400	4626	5+10
6	93	957	802	2773	1017		1905	453	510	1199	914	122	1190	2382	5608	6
7	1816	982	1142	1039	988	1905		1455	1424	813	1154	2007	781	755	3822	7
8	369	507	359	2326	572	453	1455		106	755	582	564	741	1936	5163	8
9	435	452	294	2264	508	510	1424	106		689	641	628	683	1872	5098	9
11	1121	256	397	1575	217	1199	813	755	689		792	1315	**70**	1183	4409	11
12	823	594	596	2158	667	914	1154	582	641	792		981	733	1805	4974	12
13	195	1070	918	2888	1133	122	2007	564	628	1315	981		1304	2498	5725	13

	1	2	3	4	5+10	6	7	8	9	11	12	13	14	15	16	
14	1109	234	389	1585	214	1190	781	741	683	**70**	733	1304		1197	4423	14
15	2303	1431	1580	397	1400	2382	755	1936	1872	1183	1805	2498	1197		3227	15
16	5530	4657	4807	2839	4626	5608	3822	5163	5098	4409	4974	5725	4423	3227		16
	1	2	3	4	5+10	6	7	8	9	11	12	13	14	15	16	

Source: compiled by authors

From the distance matrix (Table 2) it follows that regions 5 and 10 are closest to each other $d_{5,10} = 38$, so we combine them into one cluster and proceed to the next partition. The distance between the clusters is determined by the principle of the "far neighbor", which is described by the formula:

$$d_{r,q} = \frac{1}{2}d_{l,q} + \frac{1}{2}d_{m,q} + \frac{1}{2}\left|d_{l,q} - d_{m,q}\right|, \quad (6)$$

where: $d_{l,q}$; $d_{m,q}$ - geometric distances between the corresponding clusters.

Thus, the distance between region 2 and the cluster (1 + 8) is:

$$d_{1,(5+10)} = \frac{1}{2}d_{1,5} + \frac{1}{2}d_{1,10} + \frac{1}{2}\left|d_{1,5} - d_{1,10}\right| =$$

$$\frac{1}{2}\cdot 904 + \frac{1}{2}\cdot 938 + \frac{1}{2}|904 - 938| = 938. \quad (7)$$

Carrying out similar calculations, we get a new distance matrix (Table 3). Again, we find the minimum distance between the objects$d_{11,14} = 70$, combine them into a cluster and, by the principle of "far neighbor", determine the distance between clusters. Thus, we again construct the distance matrix. Calculations continue as long as we do not get one final cluster. The sequence of clustering is presented in the form of a scheme:

{1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16}
↓
{1,2,3,4,5+10,6,7,8,9,11,12,13,14,15,16}
↓
{1,2,3,4,5+10,6,7,8,9,11+14,12,13,15,16}
↓
{1,2+(5+10),3,4,6,7,8,9,11+14,12,13,15,16}
↓
{1+6,2+(5+10),3,4,7,8,9,11+14,12,13,15,16}
↓
{1+6,2+(5+10),3,4,7,8+9,11+14,12,13,15,16}
↓
{(1+6)+13,2+(5+10),3,4,7,8+9,11+14,12,15,16}
↓
{(1+6)+13,(2+(5+10))+3,4,7,8+9,11+14,12,15,16}
↓
{(1+6)+13,((2+(5+10))+3)+(11+14),4,7,8+9,12,15,16}
↓
{(1+6)+13,((2+(5+10))+3)+(11+14),4+15,7,8+9,12,16}
↓
{((1+6)+13)+(8+9),((2+(5+10))+3)+(11+14),4+15,7,12,16}
↓
{((1+6)+13)+(8+9),(((2+(5+10))+3)+(11+14))+12,4+15,7,16}
↓
{((1+6)+13)+(8+9),(((2+(5+10))+3)+(11+14))+12,(4+15)+7,16}
↓
{(((1+6)+13)+(8+9))+((((2+(5+10))+3)+(11+14))+12),(4+15)+7,16}
↓
{((((1+6)+13)+(8+9))+((((2+(5+10))+3)+(11+14))+12))+((4+15)+7),16}
↓
{(((((1+6)+13)+(8+9))+((((2+(5+10))+3)+(11+14))+12))+((4+15)+7))+16}

Based on the schematic representation of the results of cluster analysis, it can be concluded that all regions of the Republic of Kazakhstan for environmental and economic development are divided into four clusters:

1 - Akmola region (1), Zhambyl region (6), Kostanay region (8), Kyzylorda region (9), North-Kazakhstan region (13);
2 - Aktobe region (2), Almaty region (3), West Kazakhstan Oblast (5), Mangistau region (10), South-Kazakhstan region (11), Pavlodar region (12), East Kazakhstan region (14);
3 - Atyrau region (4), Karaganda region (7), Astana (15);
4 - Almaty city (16).

The results of the cluster analysis can be represented in the form of a dendrogram, which is depicted in Figure 1. After breaking all the regions of Kazakhstan into four clusters, we conducted a regression analysis of the dependence of the level of pollution on the economic development of the regions, as a result of which the following equations were obtained:

For the 1st cluster:

$$Y_{it} = 196{,}8 - 0{,}345\text{ВРП}_{it} - 0{,}00002\text{ВРП}_{it}^2 - 0{,}006\overline{\text{ВРП}}_{it} + 0{,}0003\overline{\text{ВРП}}_{it}^2, \tag{8}$$

For the 2nd cluster:

$$Y_{it} = 98{,}4 + 0{,}08\text{ВРП}_{it} - 0{,}00005\text{ВРП}_{it}^2 + 0{,}106\overline{\text{ВРП}}_{it} - 0{,}00005\overline{\text{ВРП}}_{it}^2 \tag{9}$$

For the 3rd cluster:

$$Y_{it} = 76{,}5 + 0{,}65\text{ВРП}_{it} - 0{,}00013\text{ВРП}_{it}^2 - 0{,}198\overline{\text{ВРП}}_{it} - 0{,}00001\overline{\text{ВРП}}_{it}^2, \tag{10}$$

For the 4th cluster:

$$Y_{it} = 11{,}36 - 0{,}032\text{ВРП}_{it} - 0{,}000007\text{ВРП}_{it}^2 + 0{,}034\overline{\text{ВРП}}_{it} - 0{,}000008\overline{\text{ВРП}}_{it}^2, \tag{11}$$

Thus, the first cluster has represented by the most prosperous, from the ecological point of view, regions - Akmola, Zhambyl, Kostanay, Kyzylorda and North-Kazakhstan regions. For this cluster, the Kuznets curve does not work - there is no maximum point here, but there is a minimum point, i.e. before it increases with GRP, the amount of emissions decreases, and after this point, with an increase in GRP, the amount of emissions will increase.

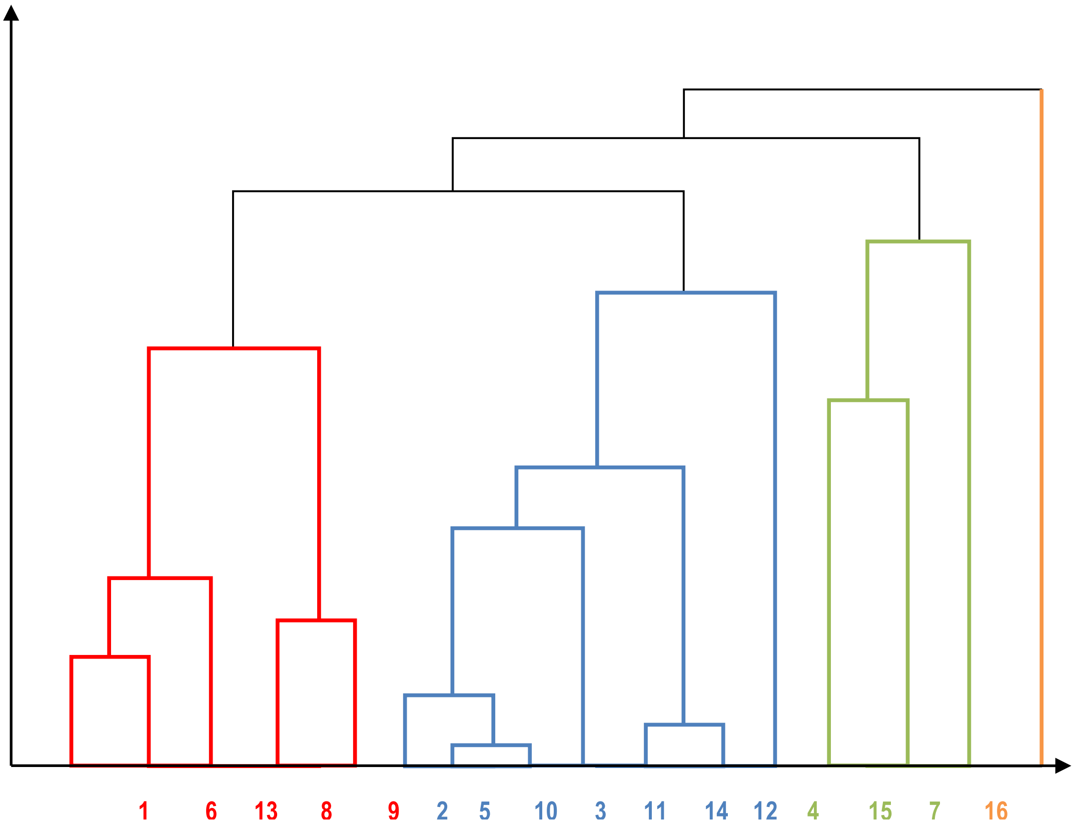
The second cluster has represented by regions that are less favorable from the ecological point of view: Aktobe oblast, Almaty oblast, West Kazakhstan oblast, Mangistau region, South Kazakhstan oblast, Pavlodar region, East Kazakhstan region. The Atyrau Oblast, the Karaganda Region, and the city of Astana represent the third cluster. The city of Almaty stands out as an independent fourth cluster.

For the last three clusters, the curve is ∩-shaped, i.e. there is a point of maximum GRP, after which the emissions are reduced. Thus, according to the environmental curve of Kuznets, along with economic development, emissions of pollutants into the environment are also reduced. For the same for the first cluster that is most environmentally friendly in Kazakhstan, the Kuznets curve does not work.

This can be explained by the fact that the growth of economic activity has a negative impact on the quality of the environment, in contrast to changes in the per capita GRP income, whose influence on the environment is positive and linear, which contradicts the results of Grossman and Kruger. A variable that measures the impact of trade is not significant in regression equations, since it can have a contradictory effect on the environment. The level of pollution increases if there is an excess of capital in the country (since in this case capital-intensive and environmentally dirty industries develop), and falls with the growth of labor-intensive industries.

In general, in countries with low income, per capita GDP produces environmentally dirty products, and the public is not yet so concerned about the state of the environment that the state carries out environmental activities. As pollution increases, the pollution reaches a critical point. Then the state, under the pressure of the public, on the one hand, begins to formulate a system for regulating the use of natural resources, and on the other hand, with the help of macroeconomic instruments, to stimulate the transition of the economy from environmentally polluting industries to high-tech industries, where modern technologies and the human factor play an important role. As a result, pollution begins to decrease.

Figure 1. Cluster analysis of the ecological and economic development of the regions of the Republic of Kazakhstan from 1995 to 2017



Source: compiled by authors

From the point of view of the incidence of the population in the least prosperous cluster - the third, it can be noted that the leader among the regions in terms of the number of occupational diseases is the Karaganda region.

According to the data of the Committee for the Protection of Public Health of the Ministry of Health of the Republic of Karelia, the incidence of occupational diseases in industrial enterprises has registered in the Karaganda region.

Thus, the indicator of occupational morbidity for 6 months of 2017 for 10 thousand workers was 12.8% (in 2016 - 7.9%) or 175 cases, which is 64 cases more than in 6 months of 2016 (111 cases). And it makes 69.2% of occupational diseases registered in the Republic.

The growth of occupational morbidity is noted in the non-ferrous metallurgy industry for 46 cases, coal industry for 15 cases, in other industries for 3 cases. The indicator of occupational morbidity per 10 000 employees for 6 months of 2017 was 12.8 (for 6 months in 2016 - 7.9). The growth of occupational morbidity is caused by unsatisfactory working conditions, which is confirmed by the results of laboratory-instrumental studies.

So at industrial enterprises there is an excess of the maximum permissible concentrations (hereinafter - MAC) of dust and aerosols, vapors and gases in the air of the working area. Dust can have fibrogenic, toxic, irritating, allergenic, and carcinogenic effects and leads to diseases of the upper respiratory tract, pneumoconiosis and chronic bronchitis.

In the first half of 2017, Karaganda Oblast registered 61 cases of silicosis (24 cases in the same period in 2016), 20 cases of bronchitis (15 cases in the same period in 2016). There is a discrepancy between the microclimate parameters (air temperature, air speed, humidity) to the maximum permissible levels (hereinafter - the remote control). Therefore, the parameters of the microclimate above the average values of the border of comfort zones can lead to uncomfortable thermal sensations, a considerable stress of thermoregulation processes, and with a high thermal load and a violation of health (overheating). The cooling microclimate causes an uncomfortable thermal sensation and stresses in the processes of thermoregulation of the body, which can lead to heat deficiency and hypothermia, which in turn can lead to diseases of the respiratory system.

The noise levels at workplaces exceed the remote control, which in turn leads to a decrease in speech intelligibility, unpleasant sensations, development of fatigue and a decrease in labor productivity and to progressive hearing loss by type of cochlear neuritis, *i.e.* to sensorineural hearing loss.

In the first half of 2017, 40 cases of hearing loss were registered in the Karaganda region (23 cases for the same period in 2016). Exceeding the levels of vibration in the workplace, combined with a set of unfavorable production factors, can lead to the development of vibration pathology with the defeat of the neuromuscular, musculoskeletal system and vascular disorders. In the first half of 2017 in the Karaganda region, 3 cases of vibration sickness were registered (5 cases for the same period in 2016).

Also at the workplaces of industrial enterprises, inconsistencies in the normative requirements for illumination are revealed, which in turn can lead to injuries. After all, one of the factors that determine the safe working conditions and contribute to higher labor productivity and production culture is a favorable light climate.

The evaluation of occurrence of the situations provoked by economic activities, technogenic failures and accidents with human casualties or infringements in functioning of geotechnical systems prevails among applied works. Thus, geologic geomorphological con dictions usually act as the factor defining the probability of extreme situations. At presence of multiple observations or the historical data the probability of emergencies of this or that degree is estimated quantitatively, as a number of possible situations in a year or as an inverse value – possibility of an extreme situation occurring once in a certain number of years. The combination of natural and technogenic components of possible catastrophes allows estimating the ecologic geographical position of specific objects and the ecological risk for the corresponding territories.

As a result of the water erosion influence in the given area the size of ecologic economic risk is defined under the expression:

$$R = \sum_{i=1}^{n} \left(P\ P_0\ P\left(\frac{q}{y}\right) P\ (IS))i \right) Y_t \tag{12}$$

where: P is the probability of a fallout of the atmospheric precipitation forming a superficial water flow (the discharge of water with probability of excess is less than 10%) and erosion; P0 is the probability of unfavorable meteorological conditions (rains few days straight) promoting the occurrence of dangerous natural phenomenon; P(q/γ) is the conditional probability of the developed situation for ecological objects (q) in view of quality of the environment (γ); P (IS) is the probability of potential losses depending on social conditions, scale of influence and destructive force of erosive processes in the area; Yi are losses (damage) in the cost expression depending on a degree of erosion influence on ecological objects.

Quantitative characteristics of rain are: the layer, du ration and intensity of precipitations, which are random variables in time and space. The factor of the eroding ability of rains assumes revealing of the correlation connection with quantity of the eroded soil or plotting of the probability distribution curves for volume of soil washout (discharge of mudflows) (Talanov 2017, 53–61).

Unfavorable meteorological conditions (UMC), when precipitations fall out during a long interval of time (two days straight), is a very rare event (P0) but such cases is possible to at tribute to the erosion hazardous. For plain territory the value is P0=0,3, for intermountain valleys and foothills P0=0,35, and for mountains P0=0,5. The probability that two independent events can happen simultaneously (by the quantity of the fallen out precipitations of today and tomorrow) is the product of probabilities of each of these events, *i. e.* P1=P·P0. Thus, characteristics of a storm rain with probability 0,0693 at UMC in the foothill territory (P0=0,35) can be expected at their joint realization with probability 0,0243, and in mountains at (P0=0,5) – 0,0346.

For cartography of ecologic economic risk in territory of economic development of Almaty area are used:

- The soil erosive map of Kazakhstan (scale 1:2500000), made in the Institute of Soil Science NAN RAC (Alimbaev 2016);
- The map of land utilization (scale 1:1000000), made by the Kazakh branch of VISHAGI;
- The map of the mudflow danger of the territory of Republic of Kazakhstan (scale 1:1000000), made by Kazakh Scientific Research Institute of Environment and Climate Monitoring (Talanov *et al*. 1996). On the soil erosive map of Republic of Kazakhstan, the non-eroded and non-deflated territories are allocated, as well as: water erosion, deflation, joint display of water erosion and deflation.

On the map of land utilization, the natural zones (subzones) and agricultural lands on the plain (A), in mountains (B) and in intermountain valleys (Ba) are all located. In our case, the arable land sites, irrigated area ble lands, pastures upland and flooded, hayfields upland and flooded, forests and other which are widely used in economic activities, are of special interest.

The map of ecologic economic risk for the territory of Almaty area (scale 1:2500000) can serve as the basis for planning and management of nature with introduction of the system of insurance in order to compensate the damage caused by the natural spontaneous phenomena, ecological and social factors of risk and the dynamic of diseases.

Conclusion

Thus, the prediction of the transition to "sustainable" development made by our macroeconomic model is very favorable for the Republic of Kazakhstan from the economic, ecological, and social point of view. In our model, it was shown that "sustainable development" not only leads to economic development of the country as a whole, but also provides higher GRP growth rates, unevenness in regional development, and promotes self-development - one of the main indicators of the country's well-being.

At the present stage of its development, the Republic of Kazakhstan has not yet reached this point of maximum on the ecological curve of Kuznets, which explains the degradation of the environment and the aggravation of the ecological situation and the subsequent increase in the incidence of the population of the regions of the Republic of Kazakhstan. One of the most disadvantaged regions in terms of environmental quality is the Karaganda region.

The transition to sustainable development and its management is a very long process, since it requires solving unprecedented social, economic and environmental tasks. As we move towards sustainable development, the very idea of it will change and be refined, people's needs, will be rationalized in accordance with environmental constraints, and the means of meeting these needs will be improved. Therefore, the implementation of the principles of sustainable development should be considered in stages.

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