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REGIONAL ISSUES

Environmentally Adjusted Evaluation of Regional Economic Growth

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Abstract—Issues in the construction of sustainable development indicators for the constituent members of the Russian Federation are discussed. To this end, the value of environmental pollution damage and the value of natural resource rent for all the constituents of the Russian Federation are defined. Environmental pollution damage and natural resource rent are viewed as two types of "unearned" income. The calculation of indicators of the gross regional product cleared of such incomes made it possible to evaluate more correctly the economic results and to define the level of innovative development of regional economies.

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The discrepancy between the existing measures of economic growth and the low level of territorial development has a long history not only in Russia. O.S. Pchelintsev drew a vivid example in [1]: between 1944 and 1954, the per capita gross regional product (GRP) in the United States decreased 5%, while industrial production remained at the same level. At the same time, dozens of very large enterprises were built, and mass production industries and housing construction were growing rapidly; that is, a real industrial revolution took place in the United States during this period. However, macroeconomic indicators responded very poorly to it.

In Russia, examples of this discrepancy were revealed as a result of clustering the Russian regions by their economic development [2]. The results of interregional comparisons have shown that highly developed regions are those where value added is formed by the consumption of natural resources, located on their territories. And vice verse, regions where value added is created only by using labor and capital resources are poorly developed in the majority of cases.

The use of natural resources in economic activity, whether it is the extraction of natural resources or industrial waste discharges into the atmosphere and water bodies, leads to their gradual depletion: mineral and fuel reserves are depleted and the assimilation capacity of ecosystems is reduced. According to the concept of sustainable development, the degradation of the natural environment during economic activity reduces its capacity to reproduce and develop further and entails the increased costs of future generations to meet their needs. To evaluate the current level of economic development of an economic system in terms of its sustainability, the traditional system of indicators must be supplemented with indicators that show the consumption of the natural potential during economic activity.

One of the most well-known systems of environmental–economic indicators is the System of Integrated Environmental and Economic Accounting (SEEA), proposed by the United Nations Statistics Division. Out of the many SEEA indicators, we selected those of the environmentally adjusted gross regional product (GRP^E) and the environmentally adjusted net regional product (NRP^E) to account for the environmental factor in the development of the regional economies.

The GRP^E indicator is a gross regional product minus the consumption of natural resources (including the assimilation potential):

$$GRP^E = GRP - \text{the consumed stock of natural resources} = GRP - \text{the qualitative depletion} - \text{quantitative consumption} = GRP - \text{damage} - \text{rent}.$$

The NRP^E indicator supplements GRP^E reflecting the consumption of both natural and basic capital during economic activity:

$$NRP^E = GRP - \text{basic capital consumption} - \text{the depletion of natural resources}.$$

However, the calculation of the absolute values of environmentally adjusted indicators does not always allow us to evaluate objectively the level of the environmentally balanced development of a region. More important is the comparison of these indicators with the traditional indicators of regional development, GRP and NRP. The following indicators may be used as comparison indicators: specific environmental capacity, the intensity of resource consumption, and per capita resource consumption.

To calculate the above environmental–economic indicators for each of the 86 constituent members of the Russian Federation, we calculated environmental damages resulting from economic activity on the territory of a region and rent incomes from the extraction and export of this territory's natural resources, as well as the depreciation of the basic production assets over the accounting period.

Rent income evaluation by region. To evaluate the quantitative consumption of natural resources in this

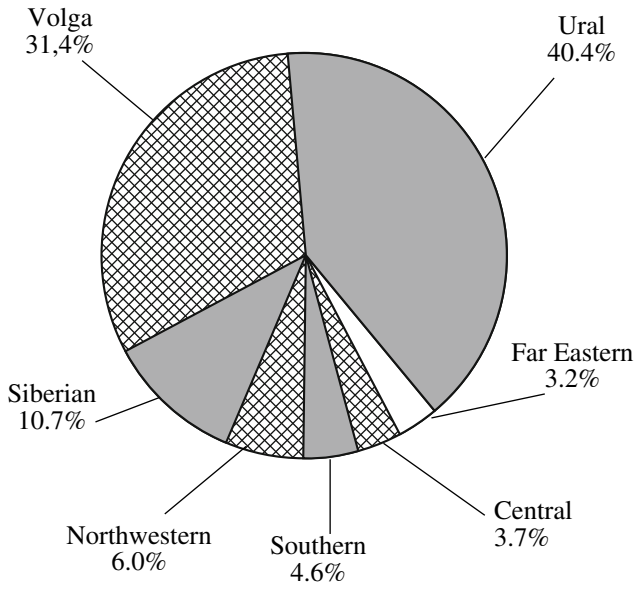

Fig. 1. Russia's rent-income structure by federal district.

paper, we selected the "resultant" approach, namely, the rent evaluation of resources used.

The evaluation of the rent income by region was based on the methodology proposed in [3, 4]. According to this methodology, the calculation of the rent income is based on comparison of the income obtained by nature management industries with the size of the normal or average income. Note that, to calculate the natural resource rent, it is necessary to use not the profit indicator, derived after paying the VAT, excises, the mineral extraction tax, and other taxes, but the primary income indicator, i.e., income before these payments. The methodology uses the income indicators of processing industries that do not receive the natural resource rent as the average income.

The authors treated the oil and gas industries and ferrous and nonferrous metallurgy as the main rent-forming industries. For each of these industries, the rent income was evaluated on the federal level.

In our paper, we used the share of the rent income in the output of a rent-forming industry, calculated by the authors of the above methodology, to evaluate the rent income of each region. This share was 58.4% for the oil industry, 61.9% for the gas industry, and 3.9 and 31.3% for ferrous and nonferrous metallurgy, respectively.

Information on leading rent-forming industries' output and the approximate evaluations of the rent-income shares were used to obtain the rent income in 2003 for each region and for the country as a whole (Appendix).[1] The rent income is obtained by the formula:

$$R = \sum_i (r^i V^i),$$

where R is the sum of rent incomes formed in the main rent-forming industries on the territory of a region, V^i is the output of the ith rent-forming industry, and r^i is the rent-income share in the output of the ith industry.

Data on the national structure of industrial production in 2003 allowed us to obtain the approximate evaluation of rent incomes from the extraction and export of mineral resources in the country as a whole. It was about 1.1 trillion rubles.

Rent incomes differ greatly by region, depending on the availability of mineral reserves and the intensity of their development in the region. Regions like the Ust–Orda Buryat and Komi–Permyak autonomous districts have very small rent incomes. The largest rent incomes are in regions that are the richest in natural resources, such as the Yamalo–Nenets Autonomous District and the republics of Bashkortostan and Tatarstan. Their rents in 2003 were 54 billion, 63 billion, and 76 billion rubles. The highest rent income in the main nature management industries was in the Khanty–Mansi Autonomous District, reaching 207 billion rubles, which is one-fifth of the total rent income on Russian territory.

The analysis of the territorial structure of the rent income of the main rent-forming industries in Russia revealed regions with the highest exploitation of natural resources (Fig. 1). More than 70% of all rent incomes falls on the regions of the Ural and Volga federal districts. In addition, more than half of the country's rent income is formed on the territory of five regions: the Khanty–Mansi and the Yamalo–Nenets autonomous districts, Orenburg oblast, and the republics of Tatarstan and Bashkortostan.

More representative in evaluating the quantitative depletion of the natural potential is the ratio of the calculated rent income to the gross product. In general, the country's rent income is 8.5% of Russia's GDP. This may imply the low quantitative depletion of natural resources. However, the cluster analysis results [2] led us to the conclusion that the basis of Russia's contemporary economic development is the extraction and export of mineral resources. Indeed, the distribution of the regions by the average per capita GRP showed that the highest values of this traditional indicator of economic growth correspond to higher rent incomes from the exploitation of natural resources.

In 10% of the regions with the lowest economic growth, the average rent incomes are 2.2% of the GRP (Table 1).

In 10% of the most developed regions, this indicator is 14 times higher: the average share of the rent from the extraction and export of mineral resources in the group is more than 30%. Three regions, the raw-material leaders—the Khanty–Mansi, Nenets, and Yamalo-Nenets autonomous districts—have a monoindustry structure: their share of the oil and gas industry is more than 90% of all industrial output. These regions' rent incomes are 39–65% of the GRP.

[1] Hereinafter, we cite statistical data by [5].

The evaluation of the natural capital with the rent income from the consumption of natural resources in each region and in the country as a whole allows us to make the following conclusion. Natural resources are most actively consumed in some regions of the Ural and Volga federal districts with rich mineral reserves and advantageous geographic locations relative to the main thoroughfares. The extraction and export of raw materials play an important role in the economic development of these regions. More than one-third of their regional incomes are of a rent "unearned" nature.

Evaluating damage from environmental pollution by region. A consequence of nature management is the qualitative depletion of the assimilation potential of the environment. It is degradation resulting from the extreme human impact on the main ecosystemic functions, among which is the ability of the biosphere to assimilate various negative impacts and pollutions within certain limits without significant changes in its main properties.

For the cost estimation of the assimilation potential's qualitative depletion, it is advisable to evaluate damage to the economy resulting from environmental pollution. The cost estimation of damage in each federal constituent of Russia, when the availability of regional statistics is limited, was based on the temporary typical methodology [6].

The main problem in damage evaluation was the absence of indicators of industrial damage from pollutions that characterize damage from the industrial production of a value unit. Such indicators were defined in [7, 8], which is a laborious process, requiring the knowledge of the product structure of industries and the environmental characteristics of each process. As a result, damage from air and water pollution was evaluated in the ratios of damage rubles to product rubles (Table 2).

Unit production in the electric-power and coal industries causes the largest damage. The output worth 1000 rubles in these industries causes damage worth 367 and 340 rubles, respectively. The least damage is characteristic of machine building and metalworking: the cost of the damage caused is slightly more than 5% of the product cost.

The economic evaluation of damage from industrial pollution on a region's territory is calculated as follows:

$$D = \sum_i d^i V^i,$$

where d is the cost of damage to the economy from environmental pollution, V^i is the output of the ith polluting industry, and d^i is the ratio of pollution damage by the ith polluting industry.

The available ratios and statistics on the output by volume and by industry in 2003 allowed us to calculate total economic damage incurred by industrial production in Russia, which is 1.3 trillion rubles.

Table 1. Comparing growth indicators and rent incomes

Group of regions by per capita GRP (by 10% groups)	Per capita GRP, thou. rubles	Rent income, % of GRP
1st (lowest GRP)	20.0	2.2
2nd	30.9	1.5
3rd	35.5	1.3
4th	38.6	1.6
5th	42.7	3.4
6th	48.4	6.9
7th	52.1	5.3
8th	60.0	15.8
9th	68.3	13.5
10th (highest GRP)	112.3	30.8

Table 2. Cost ratios of damage from industrial production in Russia

Industry	Damage ratio
Electric power	0.367
Oil extraction	0.189
Oil processing	0.117
Natural gas	0.152
Coal	0.340
Ferrous metallurgy	0.169
Nonferrous metallurgy	0.100
Chemical and petrochemical	0.113
Machine building and metalworking	0.053
Forestry, woodworking, and paper	0.246
Building materials	0.250
Light	0.289
Food	0.081
Other industries	0.033

Since the products of the fuel and energy industries, as well as ferrous and nonferrous metallurgy, have the highest damage ratios, dominating in the structure of the country's industrial products, the share of damage incurred by production in these industries is about 70% of the total damage cost (Fig 2). In addition, specific production damage in machine building is much smaller (7%) and even smaller (4%) in the chemical and petrochemical industry.

The qualitative, unlike quantitative, depletion of natural capital is typical of all the country's regions without exception, because industry, which is the main source of hazardous environmental pollutants, is present in all the regions to a greater or lesser degree. Thus, a great economic damage is incurred on the most industrially developed regions (Fig. 3).

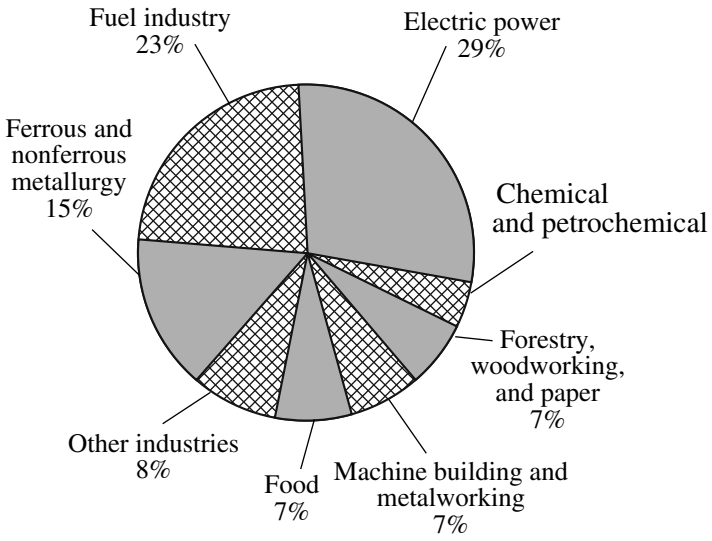

Fig. 2. Structure of damage from environmental pollution by industry in Russia.

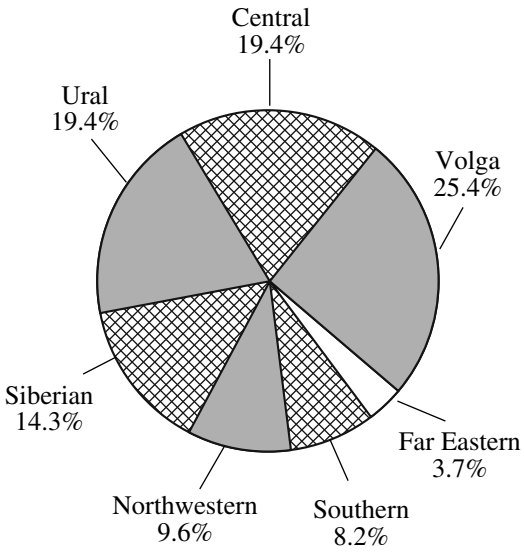

Fig. 3. Structure of damage from environmental pollution by federal district.

More than one-fourth of total damage to the economy comes from industrial discharges in the Volga Federal District. This region forms about 30% of Russia's total industrial output. Among regions that lead in damage are the republics of Bashkortostan and Tatarstan and Perm and Samara oblasts. One-third of the damage is related to the hazardous discharges of raw-material industries. The Ural and Central federal districts are also characterized by high industrial development. In the Central Federal District, the largest damage is incurred by electric power production, more than 35% of the district's total damage. The largest damage from industrial production is registered in Lipetsk and Moscow oblasts. The Ural Federal District, whose industry is mainly represented by raw-material industries takes 70% of the total damage cost. A large part of damage falls on Sverdlovsk oblast and the Yamalo-Nenets and the Khanty–Mansi autonomous districts.

Table 3. Comparing development and environmental damage

Group of regions by per capita GRP (by 10% groups)	Per capita GRP, thou. rubles	Damage cost, % of GRP
1st (lowest GRP)	20.0	4.0
2nd	30.9	12.5
3rd	35.5	11.1
4th	38.6	14.3
5th	42.7	12.7
6th	48.4	18.0
7th	52.1	14.9
8th	60.0	13.9
9th	68.3	15.6
10th (highest GRP)	112.3	17.0

Returning to the most demonstrative comparison between the damage cost and the GDP volume, we may say the following. The cost of damage to the economy by environmental pollution with hazardous industrial discharges is comparable to 10% of the value added created in the national economy. However, in Russia's regions that lead in development, the intensity of the natural potential's qualitative depletion is much higher (Table 3).

Damage from industrial discharges is sufficiently high in all the regions. In 10% of the regions with the least developed economies, damage is comparable to 4% of the GRP. In 10% of the most developed regions, this indicator is more than four times higher: the cost of damage to the economy from industrial production is 17% of the GRP cost.

This interrelation between development and the qualitative depletion of natural capital in contemporary Russia is due to the fact that its economic development depends on the level of industrial development, primarily, its raw-material sector. The largest damage from pollution is registered in regions where industrial output consists more than 60% of the products of the electric power, fuel, and metallurgical industries. (Table 4).

Environmentally adjusted indicators of development of the Russian regions. The calculation of the cost of industrial damage, the rent incomes from the extraction and export of mineral resources, the depreciation of basic production assets for each region and for the country as a whole allows us to obtain the approximate evaluation of the depletion of natural resources and to calculate the environmentally adjusted growth indicators GRP^E and NRP^E.

The approximate evaluation of the total consumption of the country's natural potential in 2003 was

2.4 trillion rubles. About 60% of the total consumption of natural resources falls on the Ural and Volga federal districts, where rich oil and gas deposits are developed (Fig. 4).

The consumption of the main production capital in 2003 was 414 billion rubles, and the GDP was 13.2 trillion rubles. The approximate evaluation of the GDP^E in 2003, based on the above data, was 10.8 trillion rubles, and the NDP^E, 10.4 trillion rubles.

To compare these indicators with the traditional growth indicator GDP, we can use the following indicators: specific environmental capacity and the intensity of resource consumption.

The specific environmental capacity indicator of income is a ratio of the consumption of natural resources to the GDP. The contribution of the environmental factor to GDP creation, or the specific environmental capacity of the GDP, in 2003 was 18.2%. The next indicator, the intensity of resource consumption, reflects the consumption of both natural resources and basic capital during income creation, being the indicator of sustainability of economic development. The intensity of resource consumption of the Russian economy is 21.3%.

This level of resource consumption during income generation could indicate a sufficiently high level of sustainability of the Russian economy. However, owing to the extremely high heterogeneity of Russia's regions by development, geographical characteristics, and many other conditions, these indicators do not allow us to come to unambiguous conclusions about the nature of the country's economic development and sustainability. It is advisable to calculate environmentally adjusted indicators for each region and then to determine the sustainability of economic development of a group of homogeneous territories. The distribution of the federal constituents by such groups was based on the cluster analysis, described in [2]. The calculation of the GRP, GRP^E, NRP^E, the specific environmental capacity of the GRP, and the intensity of resource consumption by region is presented in the *Appendix*.

The interregional comparisons of per capita GRP^E and NRP^E showed that the Russian regions are more homogeneous by these environmental–economic indicators of development than by the traditional indicator of an average per capita GRP. The coefficient of variation of the average per capita GRP, even with account for price differentiation, was 81.7%. This indicates the extreme heterogeneity of the regions by development. Variations for the average per capita GRP^E and NRP^E indicators decreased to 44.25 and 42.6%, respectively. The number of federal constituents in the totality of regions under study where the per capita GRP^E exceeded the Russian average more than two times decreased from four to one (Fig. 5).

A higher homogeneity of the regions during the analysis of environmentally adjusted indicators was due to the elimination of the environmental factor in regional income creation. This indicates that the use of the labor and capital factors in all of the country's regions has a more or less similar efficiency, and the strongest differentiation in economic development among the regions is largely predetermined by the presence or absence of rich natural resources on the territory of a region.

Table 4. Regions with the highest pollution damage

Region	Damage cost, % of the GRP	Share of raw-material industries in industrial output, %
Khanty–Mansi AD	20.67	87.9
Nenets AD	21.73	97.7
Chelyabinsk oblast	22.72	66.5
Lipetsk oblast	27.14	64.1
Vologda oblast	28.69	62.8
Kemerovo oblast	33.32	69.9

Regions with the highest indicators of environmental–economic development are still the Khanty–Mansi, Nenets, and Yamalo-Nenets autonomous districts, because the methodology used in this paper to calculate GRP^E and NRP^E produces an approximate and lower values for the depletion of natural resources and damage. Even after adjusting the regional income by the consumption of natural resources and the basic capital, the level of development in these regions exceeded the Russian average level 1.5 times. Therefore, further analysis of the sustainability of regional economic growth included both absolute and relative indicators of regional development and supplemented the cluster analysis of traditional macroeconomic indicators of regional development (Table 5).

Cluster I. "Very low level. The raw-material sector." The regions that form this cluster retain the lowest

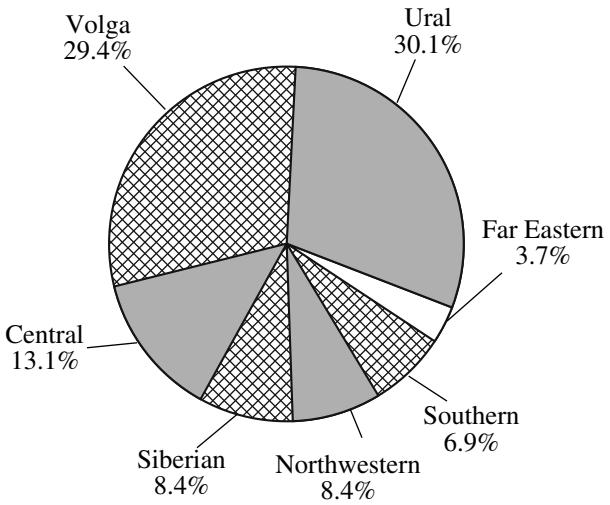

Fig. 4. Structure of natural resource consumption by federal district.

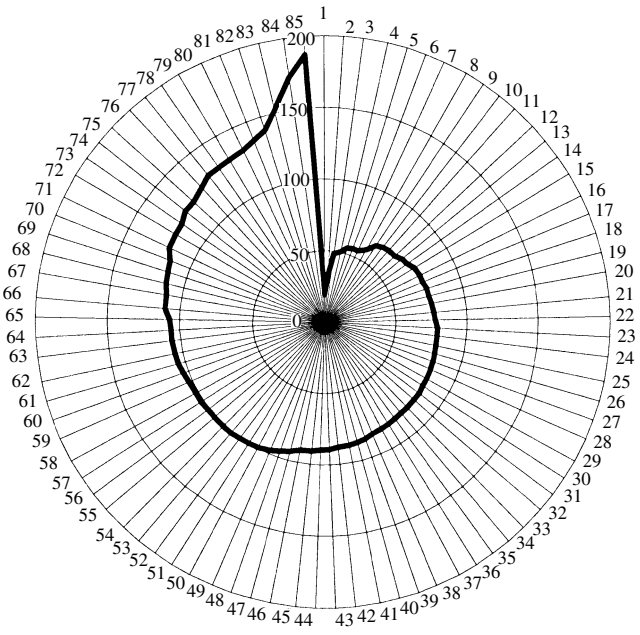

Fig. 5. Distribution of regions by average per capita GRP^E, % of Russian average.

growth level in terms of the environmental adjustment of economic indicators. They are characterized by the lowest depletion of the natural potential: the cluster's average intensity of resource consumption is 6.7%. This is due to a relatively low scale of industrial activity, which is the main source of depletion of mineral resources and basic capital. However, small production that is present in the regions is related to the raw-material sector of the economy: oil and coal extraction and nonferrous metallurgy. Economic activity in other industries is not efficient and does not make it possible to create a regional income sufficient for sustainable economic growth. Thus, by the nature of development, the cluster I regions may be referred to the inefficient resource-consuming type. The most vivid example is the Republic of Ingushetia, where, under extremely low average per capita GRP and NRP of 8700 and 7500 rubles, oil extraction officially comprises more than 50% of the republican industry.

Cluster II. "Low level. The processing sector." The low level of economic development of the regions in this cluster is due to the prevalence of low-efficient processing industries in their industrial structure. The depletion of resources is mainly due to pollution damages, which are comparable with 11% of the average regional income in the cluster. The highest environmental capacity of the GRP is registered in Ivanovo and Kostroma oblasts and in the Republic of Mari El. Inefficient technologies, which pollute the environment but do not create a sufficiently high income, bring the damage cost up to 20% of the GRP of these regions. If we take the cluster as a whole, the role of the environmental factor in the formation of the regional income is low, since the majority of the regions that form cluster II are not rich in mineral resources. The economic activity of the regions in this cluster does not create the foundation for further sustainable development.

Cluster III. "Mean level. The raw-material sector." The regions in this cluster have the mean level of growth in terms of both traditional macroeconomic and environmentally adjusted indicators. More than one-fourth of the regional income is the depletion of resources. A large part (16.6%) is damage resulting from industrial pollution. The quantitative depletion of natural resources takes a smaller part (7.7%) of the GRP. This is because raw-material industries that do

Table 5. Indicators of environmental–economic accounting by cluster

Cluster	Number of regions in a cluster	Per capita GRP, thou. rubles	Per capita GRP^E, thou. rubles	Per capita NRP^E, thou. rubles	GRP's specific environmental capacity, %	Resource consumption intensity, %
I. Very low level. The raw-material sector	4	18.8	18.1	18.0	6.0	6.7
II. Low level. The processing sector	34	35.7	32.8	32.2	13.4	15.0
III. Mean level. The raw-material sector	18	48.5	36.8	35.7	24.2	26.5
IV. Mean level. The processing sector	5	46.3	38.5	37.6	16.1	18.2
V. High level. The raw-material sector	15	68.0	43.8	42.0	34.9	37.6
VI. High level. The processing sector	4	62.0	49.0	47.9	16.0	17.9
VII. Very high level. The raw-material sector	3	264.5	89.3	73.8	67.9	73.5
The 86 regions' average	86	53.0	39.0	37.7	26.5	28.9

not form high rent incomes but whose production incurs significant damage prevail in the industrial structure of the regions in the cluster. Among these industries are ferrous metallurgy and the coal industry. The most vivid examples of such regions are Kemerovo, Chelyabinsk, and Sverdlovsk oblasts, where the environmental capacity of the GRP is about 30%. The environmental factor's contribution to the development of these regions is high enough to refer the development of the regions in cluster III to the resource-consuming type.

Cluster IV. "Mean level. The processing sector." The reduction of the environmental capacity of the regional incomes in this cluster indicates economic growth better than an increase in environmentally adjusted indicators. In the absence of mineral resources in the regions of cluster IV, the environmental factor's contribution to economic activity is reduced to 16% of the GRP on average. A large part of it is damage from environmental pollution. About 40% of the total damage cost falls on the electric power industry. The processing sector prevails in the industry of these regions. Since production versatility is higher here, the profitability of this sector is sufficiently high. Economic growth here is constructive rather than resource-consuming, since economic activity results in a relatively high regional income.

Cluster V. "High level. The raw-material sector." This cluster is characterized by a high level of the environmental capacity of the GRP. This cluster comprises regions with sufficiently rich mineral resources. Primary industries—oil and gas extraction and ferrous and nonferrous metallurgy—are in the lead here. The rent-forming nature of these industries and high damages that they incur result in high regional incomes. At the same time, more than one-third of the regional income in the cluster is formed due to the environmental factor. In some regions, such as the republics of Tatarstan and Bashkortostan, the Koryak Autonomous District, and Orenburg oblast, the environmental factor's contribution to the GRP reaches 40–50%, and two-thirds of this contribution fall on the rent from the extraction and export of natural resources. This indicates a low sustainability of economic growth in the regions of cluster V, referring it to the resource-consuming type.

Cluster VI. "High level. The processing sector." The economies of these four regions are characterized by the highest sustainability. The environmental factor's contribution to regional income creation does not exceed 16% of the GRP. The quantitative depletion of natural resources is 4%, and the qualitative depletion is 12%. Industrial production in the electric power and machine building industries incurs large damages on the economy. The backbone of economic growth is leading high-tech processing industries: the automotive industry, instrument making, the manufacture of home appliances, pharmacology, etc. The high profitability of these industries is ensured by the introduction of new technologies and the increased efficiency of the labor and capital factors. Constructive development, characteristic of the economies of Samara, Yaroslavl, Nizhni Novgorod, and Moscow oblasts, provides sustainability for the economic system under the significant depletion of natural resources.

Cluster VII. "Very high level of development. The raw-material sector." This cluster comprises three regions with the highest growth indicators, both traditional and environmentally adjusted: the Khanty–Mansi, Nenets, and Yamalo-Nenets autonomous districts. However, the growth sustainability analysis uses not only absolute but also relative environmental–economic indicators. This cluster's average intensity of resource consumption is 73.5%. The environmental factor's contribution to regional income creation is close to 70%. These indicators reflect, in fact, the low efficiency of the labor and capital factors; therefore, the economic development of the cluster VII regions may be characterized as highly resource-consuming.

The investigation of traditional and environmentally adjusted indicators of growth led us to the following conclusions. The lowest contribution of natural resources to economic growth is registered in clusters with low and very low development. This is because inefficient production prevails in these regions. Output costs in these regions do not create enough incomes for sustainable development.

The low contribution of the environmental factor to value added creation is registered in regions with the high and mean levels of industrial development in the processing sector. Production in these regions has a relatively high profitability, because their high-tech products find a ready market. Sufficiently high indicators of regional development are due to the growing efficiency of the use of the labor and capital factors, as the achievements of science and technology are introduced into industrial production. This growth is sustainable, since it creates the basis for economic growth in the future.

The leaders of sustainable development are the cluster VI regions: Samara, Nizhni Novgorod, Moscow, and Yaroslavl oblasts (Table 6). They have no rich potential of natural resources, but their geographic location and the presence of the scientific and engineering potential allowed their economies to enter the high-tech sector of the processing industry.

The significant contribution of the environmental factor to economic development was registered in regions with high macroeconomic indicators, whose economies are based on the raw-material sector. The rent-forming nature of its industries and high damages owing to the depletion of resources allow regions to receive high incomes. However, the significant part of their GRPs is not an "earned" income of the economic system but the consumption of natural resources and basic capital, which the economy has to compensate for in the future.

The leaders in wasting their resources are the regions of cluster VII with a very high level of development (Table

Table 6. Regions leading in sustainable development

Region	Per capita GRP, thou. rubles	Per capita GRP^E, thou. rubles	Per capita NRP^E, thou. rubles	GRP's specific environmental capacity, %	Resource consumption intensity, %
Samara oblast	70.2	54.6	52.8	22.2	24.9
Nizhni Novgorod oblast	57.6	49.3	48.3	14.3	16.0
Yaroslavl oblast	69.9	59.4	58.3	15.0	16.6
Moscow oblast	50.5	43.8	43.1	13.1	14.6

Table 7. Regions leading in unsustainable development

Region	Per capita GRP, thou. rubles	Per capita GRP^E, thou. rubles	Per capita NRP^E, thou. rubles	GRP's specific environmental capacity, %	Resource consumption intensity, %
Nenets AD	210.3	27.3	12.8	87.0	93.9
Khanty–Mansi AD	267.0	67.3	50.8	74.8	81.0
Yamalo-Nenets AD	316.1	156.5	143.7	50.5	54.5

7). The adjustment by resource consumption reduced the growth level 3.5 times on average in the cluster.

For Russia as a whole, the environmental factor ensures more than one-fourth of the GDP. The comparatively low indicator of the GDP's environmental capacity does not reflect the actual contribution of the environmental factor to the country's income generation. The analysis of the dynamics of the physical volume of Russia's total GRP over the past few years shows that the main gross product growth occurs in a small group of regions that are the leaders. They include the Khanty–Mansi and Yamalo-Nenets ADs; the republics of Bashkortostan and Tatarstan; and Samara, Nizhni Novgorod, and Moscow oblasts.

The structure of the growth of the total GRP's physical volume from 2000 through 2003, calculated by cluster (Fig. 6), reveals the following.

The largest growth of the total income is contributed by 15 regions of the cluster "High level. The raw-material sector." In addition, 34 regions that form the cluster "Low level. The processing sector" contribute only one-fifth of the income growth. Three regions that are leaders in wasting resources create more than 11% of the growth, and four regions that are leaders in sustainable development create about 13% of the growth of the physical volume of Russia's total GRP.

In recent years, more than 60% of the GDP growth fell on 40 regions whose economies are based on the raw-material sector within clusters with different levels of development. Thus, the main growth in the country's value added is created in regions with the highly developed raw-material sector, high specific environmental capacities of regional incomes, and high intensities of resource consumption. We may conclude that the environmental factor plays a tremendous role in Russia's economic development in general. The consumption of natural resources reaches 34% of the GDP. The intensity of resource consumption in the regions that constitute the core of the country's economic development is 37% of value added.

These relative and environmentally adjusted indicators do not allow us to evaluate the general nature of the development of the Russian economy as constructive. The scale of involvement of natural resources in the economic turnover is enormous: rent incomes from the main raw-material industries and the damage from industrial discharges are 17% of the country's total income. Such a high dependence of national economic growth on natural resources may with time result in a sharp deterioration in the economic position of the regions if the global market situation changes or natural resources deplete. All these factors characterize the contemporary development of the Russian economy as resource-consuming and unsustainable.

To improve the sustainability of development, it is necessary to orient the economy not at the consumption of natural resources but at the creation of value added through the efficient use of the labor and capital factors. The introduction of scientific and technological achievements into production improves the efficiency of these factors. The most vivid examples of regions whose development is sustainable and constructive were identified among the constituent members of the Russian Federation. They include Samara, Yaroslavl, Moscow, and Nizhni Novgorod oblasts. These regions are the leaders in the country's processing sector, because the implementation of high-tech processes allows them to create competitive products with a large share of value added.

The contribution of these regions to the sustainable and environmentally balanced development is higher than the findings obtained through the analysis of traditional macroeconomic indicators. As a result, their share in the environmentally adjusted total GRP

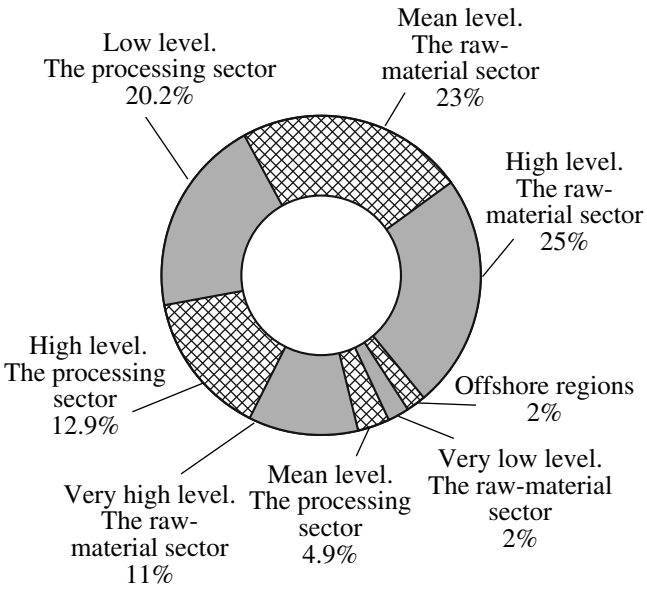

Fig. 6. Structure of growth of Russia's total GRP by cluster.

increased to 15% instead of 13% in Russia's total GRP in 2003 (Fig. 7).

The contribution of regions that are the "raw-material" leaders to the creation of the environmentally adjusted net value added has, on the contrary, decreased to 3%, compared to their 8% share in the total value added.

Regional economies, as well as the country's economy as a whole, should be reoriented from the prevalence of raw-material industries to the development of high-tech and science-intensive industries. This would benefit from the introduction of accounting for consumed natural resources into the process of territorial administration at various levels.

The developed method of calculating environmentally adjusted indicators can be used to coordinate the economic policy of a region to maximize its GRP^E. It is also necessary to determine the environmental factor's contribution to the development of a territory when evaluating the investment appeal of regions for the implementation of international projects, which require an environmental review. The cost accounting for the consumption of natural resources is obligatory for the development of rational nature management programs and the formation of penalty and compensation systems related to the depletion of natural resources.

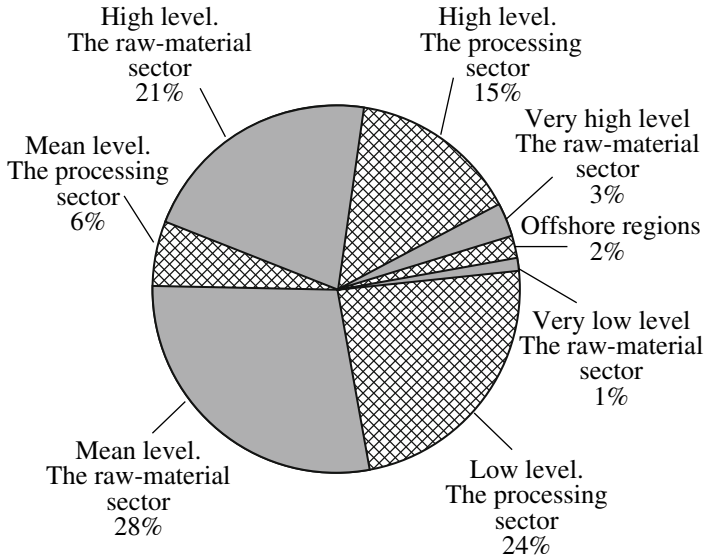

Fig. 7. Contribution of clusters to the creation of an environmentally adjusted net value added.

APPENDIX

Table A. Environmental–economic indicators of regional economic development

Constituent member of the Russian Federation	Total depreciation of fixed assets, million rubles	Total damage, million rubles	Total rent, million rubles	GRP^{E}, million rubles	NRP^{E}, million rubles	GRP's specific environmental capacity, %	Resource consumption intensity, %
A	1	2	3	4	5	6	7
Aginsk Buryat AD	2.7	19.0	2.9	1539.4	1517.6	1.4	1.6
Altai krai	1406.1	10372.9	368.1	87499.6	76758.6	12.1	13.7
Amur oblast	547.3	3811.9	1214.9	37342.1	32315.4	13.3	14.7
Arkhangel'sk oblast	1500.3	9244.8	7018.9	56622.5	40358.8	28.0	30.6
Astrakhan oblast	1497.0	4858.1	11253.8	47770.0	31658.1	32.7	35.7
Belgorod oblast	1683.6	15541.6	1520.7	80463.0	63400.7	20.8	22.8
Bryansk oblast	718.8	5357.6	9.4	49688.7	44322.0	10.6	12.1
Vladimir oblast	1307.6	9021.2	590.4	60195.4	50583.8	15.6	17.8
Volgograd oblast	2719.6	19271.0	12765.0	129368.5	97332.5	24.3	26.3
Vologda oblast	2428.0	25078.8	3591.6	84981.3	56310.9	32.8	35.6
Voronezh oblast	1722.6	12053.7	73.8	102647.4	90519.9	11.6	13.3
Jewish Autonomous Oblast	50.3	450.0	34.4	5444.8	4960.4	8.8	9.7
Ivanovo oblast	598.1	6096.3	5.4	29982.0	23880.2	20.0	21.9
Irkutsk oblast	2550.6	20477.0	11967.5	126151.2	93706.8	25.2	27.2
Kabardino–Balkaria	235.2	1715.4	157.6	30800.0	28926.9	6.0	6.8
Kaliningrad oblast	697.1	4336.5	2463.3	36842.8	30043.0	18.1	20.0
Kaluga oblast	844.5	6070.0	87.0	40867.3	34710.3	14.8	16.8
Kamchatka oblast	232.9	1786.3	389.4	12319.4	10143.6	17.3	19.2
Karachay–Cherkessia	175.3	1412.0	78.4	12804.6	11314.2	11.5	12.8
Kemerovo oblast	7400.1	47871.0	4407.4	136271.3	83993.0	36.4	41.5
Kirov oblast	1009.7	7803.8	691.8	55972.2	47476.7	14.9	16.7
Komi–Permyak AD	15.0	114.8	0.2	3048.3	2903.3	4.7	5.2
Koryak AD	33.7	287.5	383.3	1659.5	988.6	39.6	41.6
Kostroma oblast	720.4	5515.5	87.0	29552.8	23950.2	18.5	20.9
Krasnodar krai	2356.4	18328.6	4761.4	260754.6	237664.6	8.8	9.7
Krasnoyarsk krai	3423.3	25883.5	41933.8	189568.0	121750.7	35.1	36.9
Kurgan oblast	547.8	3229.9	46.3	32489.0	29212.8	9.9	11.6
Kursk oblast	1364.7	10285.6	361.0	44873.2	34226.6	23.0	26.0
Leningrad oblast	2102.4	19520.0	11368.2	97716.3	66828.1	30.9	33.1
Lipetsk oblast	2389.2	24287.5	3833.4	87090.8	58969.9	31.4	34.1
Magadan oblast	219.2	1614.4	2262.3	12390.9	8514.2	30.7	32.5
Moscow oblast	4795.9	37931.1	5942.9	329095.2	285221.2	13.1	14.6
Murmansk oblast	1014.6	7428.9	4094.7	42141.1	30617.5	26.7	29.1
Nenets AD	608.1	1919.4	5769.4	8225.7	536.9	87.0	93.9
Nizhni Novgorod oblast	3537.0	24821.2	4080.7	198841.3	169939.4	14.3	16.0
Novgorod oblast	702.9	5895.0	167.7	32551.7	26489.1	18.2	20.3
Novosibirsk oblast	1471.3	10768.3	2775.4	118775.3	105231.5	11.3	12.5
Omsk oblast	1197.6	8913.7	5033.8	95655.9	81708.4	14.4	15.6
Orenburg oblast	4296.7	20368.6	34733.5	114624.8	59522.7	46.3	49.9
Orel oblast	549.9	4301.1	194.1	47614.3	43119.0	9.3	10.5
Penza oblast	736.7	5106.3	592.4	52671.7	46973.0	10.7	12.0
Perm oblast	5312.1	30375.5	30777.5	175665.1	114512.0	33.8	36.7
Primorskii krai	1055.4	7678.0	471.1	72949.9	64800.8	11.0	12.4
Pskov oblast	414.8	3122.2	198.8	28586.3	25265.3	11.5	12.9

Table A. (Contd.)

Constituent member of the Russian Federation	Total depreciation of fixed assets, million rubles	Total damage, million rubles	Total rent, million rubles	GRP^E, million rubles	NRP^E, million rubles	GRP's specific environmental capacity, %	Resource consumption intensity, %
A	1	2	3	4	5	6	7
Adygeya	74.2	680.0	17.7	10742.5	10044.8	6.5	7.1
Altai	15.0	139.9	52.0	6454.7	6262.9	3.0	3.2
Bashkortostan	5788.2	35019.0	54155.2	252843.0	163668.8	34.5	36.7
Buryatia	650.6	4109.4	865.3	34658.7	29684.1	14.1	15.9
Dagestan	319.9	1778.9	1272.1	53374.0	50323.1	5.7	6.3
Ingushetia	50.2	227.5	290.8	4013.7	3495.4	12.8	14.0
Kalmykia	102.2	520.9	456.6	16343.7	15366.1	5.9	6.6
Karelia	797.8	7605.7	739.5	35969.9	27624.7	22.7	24.9
Komi	2481.6	12979.0	12838.8	68232.8	42415.1	36.5	40.0
Mari El	461.7	3619.3	763.3	22694.4	18311.9	18.9	20.9
Mordovia	645.0	4287.0	5.3	27989.5	23697.2	15.0	17.2
Sakha (Yakutia)	1347.9	8984.6	12377.3	65615.4	44253.5	31.9	33.9
North Ossetia–Alania	236.5	2075.0	795.2	23157.8	20287.5	12.3	13.3
Tatarstan	11722.4	49877.9	76412.6	306379.4	180088.9	39.7	43.4
Tyva	49.3	329.6	120.7	6142.1	5691.8	7.3	8.1
Khakassia	577.9	3929.6	2702.6	23638.3	17006.1	27.4	29.8
Rostov oblast	2892.0	21111.5	2486.5	157923.7	134325.6	14.7	16.5
Ryazan oblast	1133.6	10468.3	12087.3	59996.7	37441.0	36.9	38.8
Samara oblast	6096.4	31093.2	19280.6	221042.6	170668.8	22.2	24.9
Saratov oblast	2355.9	16925.2	13249.3	108628.4	78453.8	27.2	29.3
Sakhalin oblast	792.0	3653.0	5015.2	30297.2	21629.0	27.9	30.4
Sverdlovsk oblast	5523.4	44532.1	24995.4	237139.6	167612.0	28.7	30.9
Smolensk oblast	1187.0	8513.5	280.7	51136.7	42342.5	16.8	19.1
Stavropol krai	1624.2	10350.2	2088.3	91743.7	79305.2	13.3	15.1
Taimyr (Dolgano–Nenets) AD	12.9	56.6	52.4	1508.0	1399.1	7.2	8.0
Tambov oblast	615.5	4091.8	3.2	49312.7	45217.8	8.2	9.4
Tver oblast	1426.3	10070.1	6.7	59688.2	49611.4	16.5	18.8
Tomsk oblast	1750.4	7791.7	13410.3	68144.6	46942.6	30.3	32.8
Tula oblast	1948.8	14973.1	900.5	79605.3	63731.7	19.5	21.9
Tyumen oblast	1722.6	5683.4	15236.0	87415.6	66496.2	23.5	25.4
Udmurtia	2733.2	12763.7	15498.0	87296.6	59034.9	31.4	34.4
Ulyanovsk oblast	1138.9	6866.1	889.1	54563.1	46808.0	13.9	16.0
Ust-Orda Buryat AD	5.7	46.9	0.0	3436.0	3389.1	1.4	1.5
Khabarovsk krai	1321.3	9068.1	3336.6	69085.1	56680.5	17.6	19.5
Khanty–Mansi AD–Yurga	23700.6	79375.0	207863.5	360268.6	73030.1	74.8	81.0
Chelyabinsk oblast	4573.3	43634.1	12113.6	187507.0	131759.2	29.0	31.4
Chita oblast	406.5	2754.6	1610.1	34904.7	30539.9	12.4	13.5
Chuvashia	979.0	6661.1	26.4	47428.0	40740.5	13.8	15.8
Chukchi AD	62.9	413.4	159.6	4374.6	3801.6	12.9	14.3
Evenki AD	15.8	72.3	133.7	406.4	200.4	48.8	52.5
Yamalo-Nenets AD	6477.3	18626.2	62616.9	154409.5	73166.4	50.5	54.5
Yaroslavl oblast	1475.2	10729.6	3568.1	93824.8	79527.1	15.0	16.6

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