Interregional inequality in environmental and economic development in the Russian Federation

Irina Zabelina[1,*]

[1]Institute of Natural Resources, Ecology and Cryology of Siberian Branch of Russian Academy of Sciences, 16A, Nedorezova str., 672014, Chita, Russia

Abstract. Using the most popular measures of inequality and recent statistical data, the authors estimate interregional inequalities in Russia. The specific aim of this study is to identify inequality in well-being indicators, which were calculated using a multiplicative model based on the A. Sen extended function. Our calculations have revealed that there is a significant interregional differentiation in the social well-being level. The environmentally adjusted well-being exhibits higher levels of inequality than the indicator that does not take into account the environmental component. The paper shows that from 2008 to 2018 the gaps between Russian regions had in some cases increased.

1 Introduction

Inequality of income distribution is one of the main problems in present-day Russia despite the comparatively fast economic growth during recent years, which could be an important factor in reducing poverty and inequality. The country is rich in natural resources, land and human capital. However, achieving fast economic growth had been the central goal of economic policy in the Russian Federation and had fixed the orientation of its economy on raw materials. Thus, almost all state documents on the development of the Far East are based on the strategy of increasing the intensification of natural resources use [1].

Inequality in the country is a result of continuous interaction of numerous economic, social, political and geographical factors. The benefits of rational income inequality include a positive influence on economic performance, national markets and economic growth. In contrast, the costs of excessive inequality include decreasing quality of life, negative effects on economic growth, political instability (especially in a large federal state) and the rise of conflicts between poor and rich population groups. As the biggest federal state, Russia has 85 sub-federal units (regions) with huge differences in economic, social and environmental conditions: 46 oblasts (regions), 22 republics, 9 krais (territories), 4 autonomous okrugs (districts), 1 autonomous oblast (region) and 3 federal cities. There are great differences between regions in welfare and poverty levels. The map (see Fig. 1) shows the spatial dynamics of poverty among the Russian regions.

*Corresponding author: i_zabelina@mail.ru

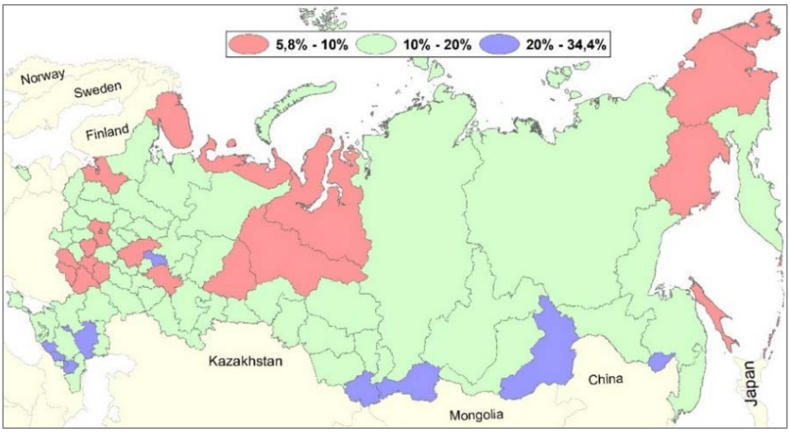

Fig. 1. Regional inequality in poverty distribution (share of people living below the national poverty line), 2018.

The Gini coefficient, a commonly used measure of income inequality, is calculated by the official statistical services of many countries. Table 1 shows the Gini coefficient as an income distribution metric in Russia and several other countries. The table demonstrates that a great degree of inequality occurs in the distribution of income. Such significant values of the Gini coefficient (more then 0.4) might be interpreted as crucial and demanding governmental efforts to reduce inequality. For comparison, Table 1 presents values of the Gini coefficient in 2019 for the following countries: Norway 0.25, Sweden 0.28 and Germany 0.30.

Table 1. Dynamics of the Gini coefficient (income per capita).

Country	2012	2013	2014	2015	2016	2017	2018	2019
Russia	0.42	0.42	0.42	0.41	0.41	0.41	0.41	0.41
Germany	0.28	0.30	0.31	0.30	0.30	0.29	0.31	0.30
Norway	0.23	0.23	0.24	0.24	0.25	0.26	0.25	0.25
France	0.31	0.30	0.29	0.29	0.29	0.29	0.29	0.29
Italy	0.32	0.33	0.32	0.32	0.33	0.33	0.33	0.33
Sweden	0.26	0.26	0.27	0.27	0.28	0.28	0.27	0.28
China	0.47	0.47	0.47	0.46	0.47	0.47	0.47	0.47

The Gini coefficient estimated by statistics from Russia, illustrates the level of individual income inequality, but it does not reflect the inequalities in regional development. Comparative analysis of the main economic indicator (Gross Regional Product per capita) shows significant differences between the Russian regions. There are some regions that have GRP per capita several times higher (or lower) than the mean value for Russia as a whole. The gap between the rich and poor regions is very large: the richest have an economy that is 62 times that of the poorest (according to GRP per capita in 2018).

The efforts of some Russian regions to achieve the growth rates of national economy, which in most cases are formed at the expense of regions with raw-material economy, can lead to depletion of mineral resources and significant degradation of ecosystems in these regions. If volumes of air pollutant emissions and waste water exceed assimilative capacity of territory, its ability to absorb pollutants respectively decreases. The high level of environmental pressure can lead to degradation of territory and reduce the quality of life for people living there. Thus, the differences in environmental pressure caused by economic activity are a natural extension of inequality in economic development across the regions. Additionally, a comparison of main indicators of ecological conditions illustrates significant differences between Russian regions and large gaps in environmental pressure distributions. Thus, an estimation of inequality of regional development with environmental factor is, of course, an important issue.

Although the inequalities in income are relatively well studied by the Russian and foreign researchers, comparatively little attention has been paid (at least to date) to the inequalities in the consumption of environmental services. There are several studies devoted to exploring the estimation of non-monetary measures of well-being by standard measures of income inequality, such as the Gini coefficient and Atkinson index [2]. For example, Ruitenbeek [3] used these measures to compare market income distribution and the distribution of income that includes the value of ecological functions. Styme and Jackson [4] also used traditional methodology to estimate national sustainable welfare. The study [5] assessed inequality for regional development and environmental indicators. Hedenus and Azar [6] examined distributions of income and resource consumption including the use of paper, electricity, energy, carbon, animal food and the food across the globe. Most of literature focused on the distribution of the CO_2 emission only as a main global warming factor and has not paid attention to other types of environmental pollution. Thus, the contribution of this paper to the literature on environmental inequality presents an analysis of the interregional distribution of well-being indicators taking into account such an important component as the quality of the environment.

2 Materials and methods

The purpose of this work is the estimation of interregional inequality for the level of well-being, which can be measured using a multiplicative model [7] based on the A. Sen extended function [8]. This model has been expanded to include the environmental component. An assessment methodology is described in detail in the article [9]. Here we will give only a brief description of the five-component multiplicative model factors (Table 2).

Table 2. Factors of the multiplicative model, based on the A. Sen extended function.

Factor	Designation of factor in the formula	Characteristic of model factors
GRP per capita of the region	$\frac{Y}{N}$	GRP per capita is converted into 2008 constant prices in conjunction with official GDP growth rates
Share of personal incomes in GRP of the region	$\frac{D}{Y}$	It is calculated as the ratio of the population income to GRP (both economic values are converted into 2008 constant prices)
The cost of living index in the region	$\frac{\overline{CI}}{CI}$	It is calculated as the ratio of the cost of a fixed set of consumer goods and services in the entire country to the cost of this set in the region
An indicator that takes into account income inequality in the region	(1-G)	It is calculated as 1-G, where G – the Gini coefficient in region
The integrated environmental index characterizing the ecological conditions in the region	E	It is defined as the average of specific ecological indices, calculated on the basis of the following indicators: the share of the tests of air, water and soil exceeding maximum permissible concentration in a total number of the studied tests. The value of coefficient E varies in the range from 0 to 1: the higher it is, the better the state of the environment in region.

We utilize annual data on GDP, personal income, cost of a fixed set of consumer goods and services, share of the tests of air and water exceeding maximum permissible concentration for the 2008-2018 period, as reported in annual volumes of the Russia Statistical Yearbook and obtained by the Federal State Statistics Service of Russia. In order to take into account the soil state in Russian regions, we used the available official data of the Federal Service for Surveillance on Consumer Rights Protection and Human Wellbeing. Traditionally, the autonomous okrugs' (districts') data are combined with the data from specific regions within the borders of which they are situated. We consider this data separately from the data of the regions because these areas are the main oil producing territories in Russia and have specific characteristics for inequality analysis. We exclude Republic of Crimea and the city of federal importance Sevastopol from the evaluation because the required data prior to 2014 are unavailable. Thus, using a multiplicative model we will evaluate the following social welfare indicators for Russian regions:

• Indicator S (without the environmental component E) for the period from 2008 to 2018;
• Indicator SE (the environmental component E is defined as average of specific indices that take into account the air and water bodies state) for the period from 2008 to 2018;
• Indicator SE_s (the environmental component E is defined as average of specific indices that take into account the air, water bodies and soil state) for 2012, 2015-2018.

There are several inequality metrics. Traditionally, researchers use different inequality indices and compare results caused by differences in origin, sensitivity to changes in scale and other aspects of the calculations. To estimate income distribution, such measures should satisfy some properties postulated in the economic literature [10]:

• "The Pigou-Dalton Transfer Principle" suggests that inequality should decrease in the case of a transfer of income from a rich person (region) to a poor person (region) and vice versa;
• "Scale Independence" means that an index should not change if there is a multiplication of income for every person (region);
• "Principle of Population" states that inequality is independent from the number of people (regions) in an economy;
• "Anonymity" says that inequality is independent from a person who owns some part of the distribution;
• "Decomposability" means that inequality can be calculated as the sum of inter-group inequality and inequality within each individual group.

The last property is additional, and an index should satisfy it only if the index is used to study interregional and intraregional inequality, for example. This paper utilizes the two most common measures (see Table 3) that have all the main properties described above: the Gini coefficient and the Theil index [11]. The last index also has the decomposability property.

Table 3. Properties of inequality measures.

Properties	The Gini coefficient	The normalized Theil index
Range	From 0 to 1	From 0 to maximum entropy. Can be normalized in the range from 0 to 1.
Sensitivity to zero values	Can be evaluated.	Zero values must be replaced or excluded.
Satisfaction basic axioms	Transfer Principle, Scale Independence, Principle of Population, Anonymity	Transfer Principle, Scale Independence, Principle of Population, Anonymity, Decomposability
Sensitivity to changes in the different parts of the scale distribution	Center	Neutral

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The Gini coefficient is a popular index based on the Lorenz curve. It evaluates the overall inequality but is influenced by outliers and the method of grouping regions. The Gini coefficient can also be defined as follows:

$$G = \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} x_i x_j \left|\frac{y_i}{y} - \frac{y_j}{y}\right|, \quad (1)$$

where n is the amount of regions, x_i is the share of i^{th} region in the total population of the country, y_i is the average income per capita in the i^{th} region, y_i is the average income per capita in country.

The Theil's inequality measure is referred to as an entropy metric, and its value is sensitive to zero values. The Theil index is calculated as follows:

$$I_T = \sum_{i=1}^{n} x_i \frac{y_i}{y} ln\left(\frac{y_i}{y}\right) \quad (2)$$

Value of the Gini coefficient can be easy interpreted because they range from 0 (total equality) to 1 (total inequality). To compare the Theil index, we normalize it following the standard technique. The operation $I_{TN} = 1 - e^{-I_T}$ is to be performed to converse its values in the interval [0, 1]. The result of the conversion is called the normalized Theil index.

3 Results

In most cases, inequality measures find different trajectories of interregional inequalities (Fig. 2-3). However, measurements show that the level of interregional inequality in the distribution of environmentally adjusted well-being is higher than the inequality in social well-being without the environmental component. Both inequality measures demonstrate the convergence dynamics of the Russian regions in terms of well-being indicators from 2008 to 2012. The Gini coefficient illustrates essential increasing in the well-being inequality during the period of economic crisis in Russia (2014-2016). This measure shows more rapid growth in inequality than the normalized Theil index, the values of which vary in this period but do not show a clear convergence or a divergence of regions.

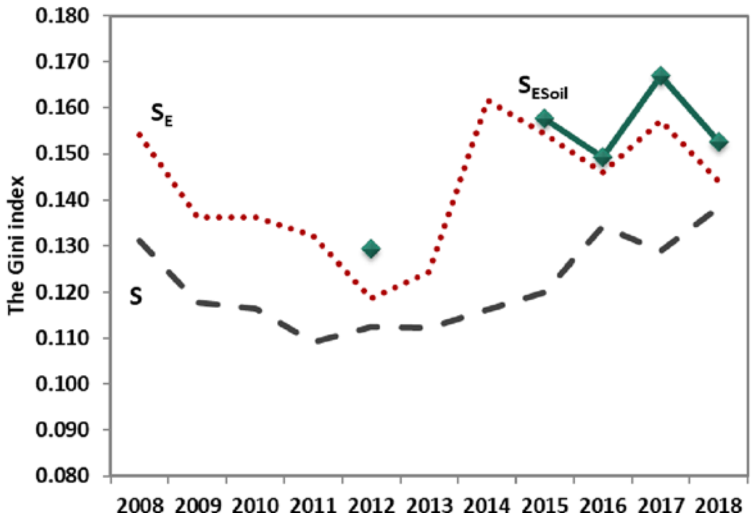

Fig. 2. The Regional inequality in social well-being according to the Gini index, 2008-2018.

The value of the Gini index for the indicator calculated on the basis of the four-component model (without the environmental component) had increased by 5.6% over the period from 2008 to 2018 (see Table 4). A noticeable increase in interregional inequality was also observed for the environmentally adjusted well-being indicator SEs, which takes into account the state of the air, water bodies and soils (18.1% for the period from 2012 to 2018).

Table 4. Inequality metrics for the well-being indicators of Russian regions.

Indicator	Inequality metrics					
	Gini coefficient			The normalized Theil index		
	2008 / 2012	2018	Change, %	2008 / 2012	2018	Change, %
Indicator *S*	0.131	0.138	5.6%	0.027	0.019	-29.5%
Indicator *SE*	0.154	0.144	-6.6%	0.034	0.020	-40.2%
Indicator SE_s	0.129	0.153	18.1%	0.024	0.019	-23.4%

Figure 3 shows the dynamics of the normalized Teil index for all the analyzed well-being indicators, weighted with the population. According to the results of the calculations, the most significant differences between the Russian regions are observed for the environmentally adjusted well-being indicator *SE*, which takes into account the state of the air and water bodies. During the analyzed time period, there was a decrease in the inequality for all the considered social well-being indicators.

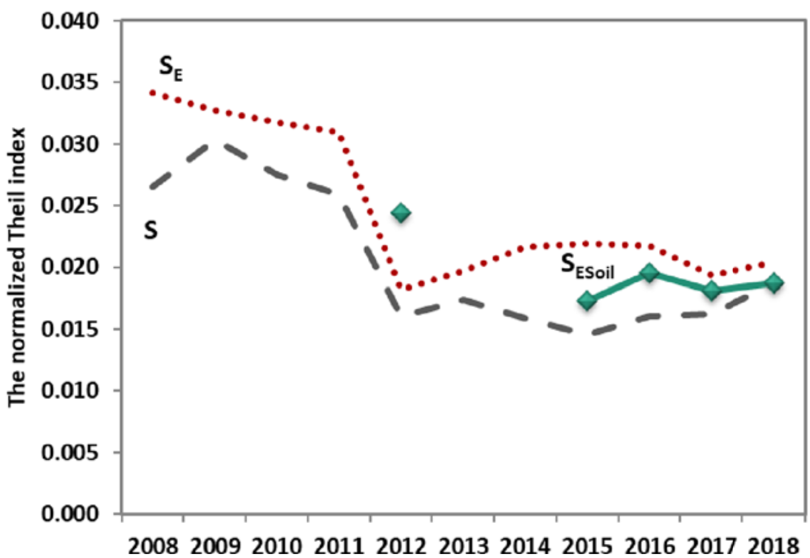

Fig. 3. The Regional inequality in social well-being according to the normalized Theil index, 2008-2018.

Figures 4-5 present the spatial patterns of social welfare indicators according a multiplicative model, based on the A. Sen extended function.

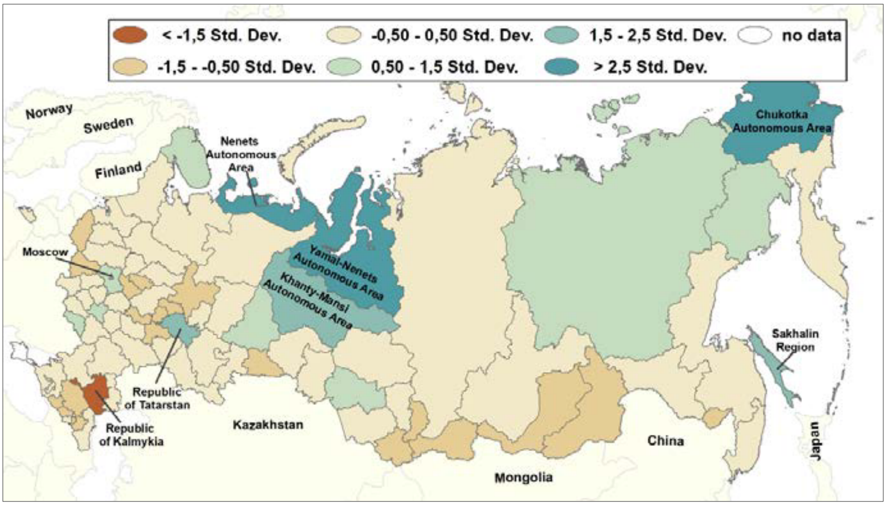

Fig. 4. Spatial patterns of social welfare according to four-component model (S) in 2018.

We employ the standard deviations from the mean as a measure, which allows us to classify Russian regions into several different groups (see Table 5).

Table 5. Statistical characteristics of the studied indicators distribution in Russian regions (Russian Rubles per capita, in 2008 prices), 2018.

Characteristics	Social well-being according to		
	four-component model (without the environmental component *E*), *S*	five-component model, *SE*	five-component model, SE_s
Minimum	5756	3381	4559
Maximum	21087	14932	17872
Mean	9189	7355	7483
Standard deviation	2464	1720	1849

Analyzing the regional indicators of social well-being shows that most of the Russian regions (approximately 63 percent) lag behind, with an indicator *S* of less than 9189 rubles per capita. In the least prosperous group were some border regions of the Russian Far East: Trans-Baikal Territory, Jewish Autonomous Region and Republic of Buryatia. The value of the indicator *S* in them did not exceed 7929 rubles per capita (see Table 6).

Table 6. Distribution of Russian regions by groups and range boundaries (Russian Rubles per capita, in 2008 prices), 2018.

Standard deviation	Indicator *S*	Indicator *SE*	Indicator SE_s
< -1.5 Std. Dev.	5756-5800 1 region	3381-4775 3 regions	4559-4710 1 region
-1.5 – -0.5 Std. Dev.	5800-7929 20 regions	4775-6495 18 regions	4710-6559 25 regions
-0.5 – 0.5 Std. Dev.	7929-10057 46 regions	6495-8215 38 regions	6559-8407 37 regions
0.5 – 1.5 Std. Dev.	10057-12186 9 regions	8215-9935 18 regions	8407-10255 14 regions
1.5 – 2.5 Std. Dev.	12186-14314 4 regions	9935-11654 2 regions	10255-17872 4 regions
> 2.5 Std. Dev.	14314-21087 3 regions	11654-14932 2 regions	–

Only 31 regions have a level of social well-being above the mean value. The above-the-mean groups commonly include the territories rich in natural resources (mainly oil and natural gas). According to the Federal State Statistics Service of Russia, during 2000 to 2018 time period, the extraction of primary energy resources had been growing in Russia: crude oil by 72% (556 million tons, 2018), coal by 70% (439 million tons, 2018) and natural gas by 31% (726 billion cubic meters, 2018). The mining sector is one of the main consumers of energy while also being the predominant cause for the environmental pollution. Only during the 2015-2018 time period alone, the consumption of energy producing minerals in the mining industry sector had increased by 10.4%. In addition, the share of "Mining and quarrying" in the total volume of air pollutants and generated waste had been 28% and 94%, respectively, in 2018. Thus, the above-mentioned regions with a raw-material oriented economy are characterized by high levels of environmental pressure.

Traditionally, when it comes to assessing the negative impact level of economic activity on the environment in the Russian regions, the main environmental indicators (pollutants emissions, sewage water and solid waste generation) are used. However, Ryumina E.V notes that these ecological characteristics only ambiguously determine the real ecological conditions of the population's life [12]. In particular, they do not take into account the influence of background concentrations of pollutants in the environment, climatic conditions and many other factors. Therefore, the author proposes to characterize the state of the environment by an indicator of the share of the tests of air and water exceeding maximum permissible concentration in a total number of the studied tests. In our study, we also included in the analysis an indicator that takes into account the state of residential area soil. It allowed us to perform a more comprehensive assessment of the ecological situation in the Russian regions.

The Russian regions are largely differentiated by the indicator «share of the negative tests of air, water and soil in a total number of the studied tests». The greatest variation is observed in the number of negative water tests (see Table 7). In 2018, this indicator varied in the following ranges: from 0% (in most of the Republics of the North Caucasus and the Murmansk Region) to 81.7% (Khanty-Mansi Autonomous Area) in terms of sanitary-chemical indicators and from 0% (Orenburg Region) to 84.6% (St. Petersburg) in terms of microbiological indicators. The most unsatisfactory condition of the atmosphere was observed in Chukotka Autonomous Area, and soil in Primorye Territory (according to sanitary-chemical indicators), Nenets Autonomous Area (microbiological indicators) and Astrakhan Region (parasitic indicators).

Table 7. Share of the negative tests of air, water and soil in 2018.

Value	Share of the negative tests (%)					
	air	water according to		soil according to		
		sanitary-chemical indicators	microbiological indicators	sanitary-chemical indicators	microbiological indicators	parasitic indicators
Minimum	0	0	0	0	0	0
Maximum	35.9	81.7	84.6	34.7	40.0	6.6
Russian Federation	0.7	20.3	20.2	4.7	5.8	0.9

Figures 5 present the spatial patterns of social welfare indicator according a five-component multiplicative model (SE_s) in 2018. The values on the map show the difference between the S and SE_s well-being indicators (red indicates values that exceed the average Russian level). It can be seen that in the group of the most prosperous regions (indicator SE_s falls in the range 10255-17872 Russian Rubles per capita), Yamal-Nenets and Khanty-Mansi Autonomous Areas, Republic of Tatarstan and Sakhalin Region still remain. In the Far East of Russia, Magadan Region, Kamchatka Territory and Sakhalin Region are distinguished by the SE_s well-being indicator.

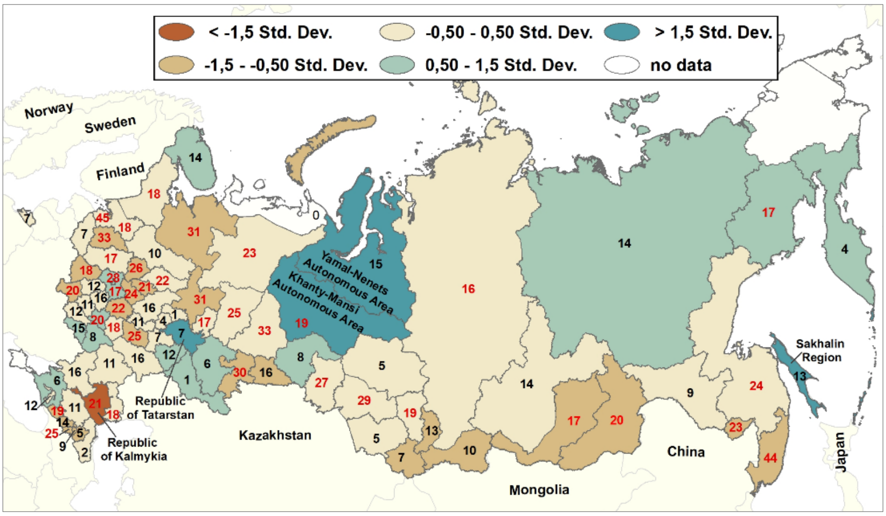

Fig. 5. Spatial patterns of social welfare according to five-component model (SE_s) in 2018.

The group of the least prosperous regions included 26 territories located mainly in Central and North Caucasus Federal Districts (SE_S changes from 4559 to 6559 Russian Rubles per capita). The above-mentioned eastern border territories retained their position in the group of less prosperous ones. After the inclusion of the environmental component E in the assessment of well-being, Primorye Territory also joined them. It was the second (after St. Petersburg) in the rating in terms of the difference between S and SE_s indicators (in 2018, the difference was 44%).

In almost half of the Russian regions (39 out of 81), the difference between the studied well-being indicators was higher than the average Russian level – 16.4%. According to the value of the integrated environmental index, the most unfavorable environmental conditions are observed in next Russian regions: Arkhangelsk Region, Kirov Region, Novgorod Region, Sverdlovsk Region, Primorye Territory and St. Petersburg (see Fig. 6).

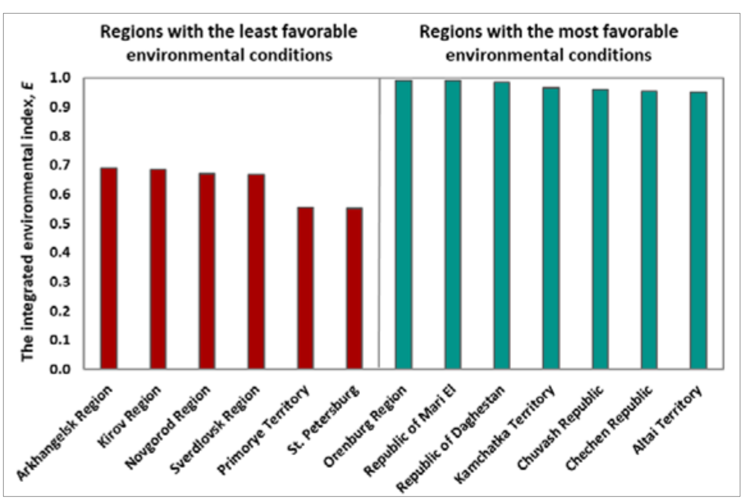

Fig. 6. The integrated environmental index in some Russian regions in 2018.

All these territories are characterized by poor quality of water and soil in residential areas. St. Petersburg is the leader in the number of negative water tests according to microbiological indicators, and Primorye Territory is the leader in the number of negative soil tests according to sanitary-chemical indicators.

The highest values of the composite ecological index (E>0.95, which means the best ecological living conditions) are observed in the following regions: Orenburg Region, Republic of Mari El, Republic of Daghestan, Kamchatka Territory, Chuvash Republic, Chechen Republic and Altai Territory.

4 Discussion and Conclusion

The results of this study have proved that there is an interregional differentiation by the well-being indicators, which has slightly increased over the analyzed time period. The value of the Gini index for the indicator calculated on the basis of the four-component model (without the environmental component) increased by 5.6% over the period from 2008 to 2018. A noticeable increase in the interregional inequality was also observed for the environmentally adjusted well-being indicator SE_s, which takes into account the state of the air, water bodies and soils (18.1% for the period from 2012 to 2018).

Environmentally adjusted well-being exhibits higher levels of inequality than the indicators that do not take into account the environmental component. Observed increasing inequalities in the distribution of environmental intensity [5] can signify the development of an “environmental colonialism” policy with respect to some Russian regions. Additionally, these inequalities may raise the danger of interregional and interpersonal conflicts and lead not just to economic but also to social crises. Such conflicts are already taking place in some regions, where projects are being implemented with the involvement of foreign capital [13]. Current intensive mining extraction leads to fast resource depletion and other components of natural capital in some regions of Siberia and Far East which can be preserved for the future generations. In the recent years Chinese companies have been actively investing in the development of mining extraction and lumbering enterprises situated in the near-border territories. Special interest is attached to the export of extracted mineral and energy resources and energy which are necessary to satisfy the domestic demand for a rapidly growing economy.

The observed increase of interregional disparities in Russia is dangerous and demonstrates a necessity for governmental regulation. Presently we can recommend to use the set of widespread inequality indexes to monitor and analyze the inequality in well-being indicators distribution in order to develop adequate tools to reduce the overall degree of divergence in consumption of environmental services within a nation. Estimation of the main inequality measures in distribution of environmentally adjusted well-being indicators is an important application to policy of government regulation addressed to soften cross-regional differences by reduction of environmental degradations first of all in with the regions with unfavorable environmental conditions as the first priority.

Acknowledgements

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