

Article

Mining Industry of the Republic of Sakha (Yakutia) and Problems of Environmental and Social Security of Indigenous Peoples

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Abstract: The Republic of Sakha (Yakutia; RS(Y)) is located in the northeast of Siberia (Russia) in the basins of the Lena, Yana, and Indigirka rivers, in the lower reaches of the Kolyma River. Yakutia is an industrial–agrarian republic with a developed mining, fuel, and energy industry. Indigenous peoples live mainly in the Arctic regions, where the large-scale development of mineral resources is planned, and South Yakutia, where the mining industry is well developed. The aim of this study is the development of methodological approaches to assessing the impact of the mining industry on the natural environment and the social sphere in the places of residence and traditional economic activities of the indigenous peoples of the North. We used the results of research work (R&D), materials of expeditionary work, and regulatory documents of the Republic of Sakha (Yakutia) and the Russian Federation (RF). The state of the environment (ES) was assessed on the basis of the analysis of indicators for three areas: (a) anthropogenic load, (b) environmental and social consequences, and (c) resistance of natural complexes to technogenic impacts. In total, 22 indicators were used for the 3 areas, for example, population density, person/km²; the volume of extraction of rock mass, million m³; and emissions, t/year. To bring dissimilar indicators into comparable ones, we used a methodological approach with the use of the social risk index (SRI). In Arctic regions (mainly agricultural), the ES is in a favorable and relatively favorable state: SRI 0.61–0.70; in the central regions (mainly agricultural), it is satisfactory and relatively satisfactory: SRI 0.71–1.0; in the southern and western regions with a developed mining industry, it is relatively tense and tense: SRI 1.01–3.0. An extremely tense state of environmental conditions has developed in the city of Yakutsk: SRI ≥ 3. Generally, the deterioration of the environmental situation and vital activity of the indigenous peoples in investigated Arctic region correlated with the impact of the mining industry.

Keywords: Arctic; sustainability; anthropogenic load; environment; indigenous peoples; quality of life; pollution; health



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1. Introduction

In the settlement and economic development of Arctic regions of Russia, indigenous peoples undoubtedly had the first experience. The concept of indigenous small-numbered peoples of the Russian Federation is given in Federal Law (FL) On Guarantees of the Rights of Small-Numbered Peoples of the Russian Federation no. 82 dated 30 April 1999 [1]: indigenous small-numbered peoples of the Russian Federation (small-numbered peoples) are peoples living on the territories of traditional settlement of their ancestors, preserving the traditional way of life, management, and crafts, numbering fewer than 50 thousand people in the Russian Federation, and realizing themselves as independent ethnic communities.

According to Decree No. 255 of 23 March 2000 “On a Single List of Indigenous Small-Numbered Peoples of the Russian Federation” [2], 45 peoples were included in the list of small-numbered peoples: Aleuts (Kamchatka Krai), Koryaks (Kamchatka Krai, Chukotka Autonomous Okrug), Mansi (Khanty-Mansi Autonomous Okrug), Nanais (Khabarovsk Krai, Sakhalin Oblast), Dolgans (Krasnoyarsk Krai), Nenets (Yamalo-Nenets Autonomous Okrug, Komi Republic, Krasnoyarsk Krai, etc.), Eskimos (Chukotka Autonomous Okrug, Kamchatka Krai), Tuvinians and Todzhins (Tyva Republic), etc. On the territory of the Republic of Sakha (Yakutia), this list includes five representatives of indigenous peoples: Evenks, Evens, Dolgans, Chukchi, and Yukaghirs.

According to the legislation of the Russian Federation, on the basis of appeals of the peoples of the North, the authorities form territories of traditional natural resource use (TTNRU), which are specially protected territories formed for traditional nature management by the peoples of the North, where activities of industrial companies are limited and only possible with the prior and informed consent of the aborigines [3]. In the context of the industrial development of the natural resources of the Russian Federation, the creation of the TTNRU plays an important role in protecting the interests and rights of indigenous peoples: on the one hand, it is a deterrent for the destruction of their original habitat; on the other hand, it stimulates socioeconomic development and an increase in the standard of living of associations of indigenous peoples [4]. The mining industry in Yakutia began to develop in 1924, when the first industrial enterprise in Yakutia, Yakzoloto, was organized in the Aldan gold mines. The main branches of the mining industry are gold (1924), diamond (1957), antimony (1972), coal (1928), tin (1941), and oil and gas (1967). Currently, Yakutia is an industrial–agrarian republic with a developed mining, fuel, and energy industry. With the emergence of the mining industry, environmental problems in the republic move to the territory of its development. In all its sectors, the extensive type of field development prevailed, without taking into account environmental and social priorities. Environmental problems are associated with large-scale disturbance of Earth’s surface, environmental pollution, mainly of water bodies, for example, the rivers of Vilyuy, Daldyn, Malaya Botuobiya, Adycha, Allah-Yun, Seligdar, and Khroma, and an increase in ecological diseases [5].

Currently in Russia, when making economic decisions, any pre-plan, pre-design, project documentation will not be accepted without EIA (environmental impact assessment) information. Ilya Gulakov and Frank Vanclay assessed [6] whether the requirements and practice of EIA in Russia comply with the basic principles of SIA (social impact assessments), civil society and democracy. To do this, they described the Russian regulatory framework for EIA and compared it with international standards (using the International Finance Corporation Performance Standards as a benchmark). At the same time, a specific project was investigated—the project for the extraction of coal Carmen in Russia (the Republic of Sakha (Yakutia), which makes it possible to compare Russian and international requirements. The EIA was carried out twice: once in accordance with the Russian requirements for obtaining a permit for environmental protection (hereinafter referred to as the national EIA), and the other with the international requirements for obtaining financing from an international bank (hereinafter international EIA). The International EIA, which was undertaken in accordance with the International Finance Corporation Performance Standards, is used as the benchmark against which the national EIA was assessed. By assessing the differences between national and international EIA, it was possible to identify shortcomings in the Russian EIA procedure. I. Gulakov and F. Vanklay [6] believe that the key weakness of the project is the subordination of social issues to environmental ones. This approach can lead to key social issues being easily overlooked or not sufficiently addressed in the assessment process.

We also believe that the social problems of the population are insufficiently covered in the EIA. In particular, for projects where indigenous peoples live and conduct economic activities (Evens, Evenks, Yukagirs), social problems are not considered at all. From this point of view, in these territories, along with the EIA, another procedure is currently being carried out the AIEE (assessment of the impact on ethnological expertise). In 2010, a law

of the Republic of Sakha (Yakutia), On Ethnological Expertise in Places of Traditional Residence and Traditional Economic Activity of the Indigenous Small-Numbered Peoples of the North, was issued [7]. Ethnological expertise in places of compact residence of the indigenous peoples of the North is necessary for the following:

- Solving the issue of fair compensation for losses from a decrease in the volume of products of reindeer husbandry, hunting, fishing, and gathering in connection with the provision of TTNRU for industrial and other needs;
- Developing proposals and recommendations aimed at the socioeconomic and cultural development of small-numbered peoples, the protection of their original habitat, and traditional way of life and management;
- Compensating for the costs of arranging new territories and the implementation of social measures to adapt the aboriginal population to new living conditions.

To date, 15 examinations have been carried out in ethnological expertise at the request of industrial companies to assess the impact of industrial projects on the peoples of the North. All questions or problems that arose were resolved on the public platform of the authorized body of the government of the region during the examination. The Republic of Sakha (Yakutia), as one of the leading regions from the point of view of legal support concerning the rights of the indigenous small-numbered peoples of the North (ISPN), is also of particular interest to Arctic researchers. Many works are devoted to the study of the problems of traditional nature management in the Arctic regions, in particular in the Republic of Sakha (Yakutia) [8–14]. They above studies note that the experience of Yakutia in terms of the interaction between indigenous peoples and industrial enterprises, the effect of the law on ethnological expertise, republican programs to support traditional sectors of the economy, nomadic families, and nomadic tribal communities all show a positive example for other regions with indigenous peoples not only in Russia, but also other Arctic countries.

Study purpose: assessing the environmental and social problems of indigenous peoples in connection with the industrial development of the territory of Yakutia. To achieve this goal, we set the following tasks:

1. Giving a brief description of the development of natural resources in Yakutia.
2. Carrying out a comprehensive assessment of the state of the environment of the Republic of Sakha (Yakutia).
3. Analyzing the integral assessment of the state of the operating system in three areas: (a) anthropogenic load; (b) environmental and social impacts; (c) stability of natural complexes: climatic, biotic, and lithogenic factors.

2. Materials and Methods

2.1. Data for Analysis

For our study, we used official documents and results of complex research studies:

(1) R&D Comprehensive Assessment of the Impact of Climate Change and Industrial Development of the Arctic on the Livelihoods of the Indigenous Population of the Nizhnekolymsky Ulus of Yakutia, 2016; (2) R&D Assessment, Main Trends of the Natural and Socioeconomic State, Human Potential of the Arctic Economic Zone of the Republic of Sakha (Yakutia); (3) Scheme for the Integrated Development of Productive Forces, Transport and Energy in Yakutia Until 2020; (4) Strategy for Socioeconomic Development of the Republic of Sakha (Yakutia) Until 2030 With the Definition of a Target Vision Until 2050; (5) Strategy for the Development of the Arctic Zone of the Russian Federation and Ensuring National Security for the Period Until 2020; (6) Integrated Development of South Yakutia Investment Project; and (7) Materials of Expeditionary Work in Ust-Yansky (2018, 2019) and Anabarsky Districts of Yakutia (2018, 2019).

2.2. Comprehensive Assessment of the Environmental Conditions in the Republic of Sakha (Yakutia)

The general methodology of interdisciplinary research is represented by a complex of methodological approaches: legal, historicogeographical, economic, ecological, analyt-

ical and synthetic, statistical, and the assessment of the state of objects. The conceptual idea of this study is based on analysis of the development of the mining industry, and its positive and negative consequences. To identify the attitude of the indigenous population towards megaprojects (construction of the Eastern Siberia–Pacific Ocean oil pipeline, cascade of hydroelectric power plants, Elkon Mining and Metallurgical Combine), we surveyed 90 households in the villages of Khatystyr, Ugoyan, and Verkhnyaya Amga. Most respondents (99.1% of the representatives of indigenous peoples) expressed concern that the implementation of megaprojects would violate the natural ways of animal migration, reducing the area of reindeer pastures and worsening environmental conditions.

For a comprehensive assessment of the environmental conditions in the Republic of Sakha (Yakutia), we used the methodological approach proposed by Burtseva E.I. [15], which is a universal quantitative indicator widely used in practice—the percentage of a feature in the estimated system of parameters. This is the social risk index (SRI), which is a deviation from the average state of an object in relative terms. The ranking procedure can be divided into two stages. At the first stage, all indicators of the estimated factors for each area are brought into comparable ones by converting absolute values into relative ones. For this, the SRI is determined, which is calculated as the share of the characteristic in the average republican indicator. For the convenience of calculations, a better perception of the results and the release of the index from the dimension, instead of 100%, we use the number 1. Moreover, all indicators of the assessed factors and indices calculated for them are presented in their average values. SRI is determined by the following formula:

$$SRI_i = \frac{a_i}{M}$$

where *SRI* is the social risk index, *a_i* is the absolute value of the *i*th indicator, and *M* is the absolute average value of a set of indicators.

A comprehensive ecological and economic assessment of the state of the environment of the republic includes three major sections: anthropogenic load, environmental and social consequences, and vulnerability of natural complexes to technogenic impacts. A detailed description of this methodology is presented in the supplementary file. Table 1 shows the structure of indicators for a comprehensive assessment of the state of the environment.

2.3. Survey of Households

One of the main structural components of the quality of life are the living conditions of the population. We assessed the standard of living of the indigenous peoples of the North using the example of the Aldansky district of South Yakutia. We also carried out a sample survey of households in the villages of Khatystyr, Ugoyan, and Verkhnyaya Amga of the Aldansky district. We collected data on subsistence income, personal subsidiary plots (PSP), hunting, fishing, reindeer husbandry, and picking berries. In the surveyed settlements, 356 people were surveyed, and the size of households averaged 4 people.

2.4. Brief Historical Outline of the Development of the Natural Resources of Yakutia

The concept of the “North” includes the Arctic, the Subarctic, the forest–tundra zone, the northern light-coniferous sparse taiga, and part of the middle light-coniferous taiga with the participation of dark-coniferous species. The North was zoned by the Canadian economist and geographer Hamlen L.E. [16], who identified three zones: the Middle, Distant, and Far North. In Russia, the territory of the North is conditionally divided into two zones: the regions of the Far North and the areas equating them. The entire territory of the Republic of Sakha (Yakutia) is included in the Far North [17]. Yakutia is located in the northeast of Siberia in the basins of the Lena, Yana, and Indigirka rivers, and in the lower reaches of the Kolyma River. The territory of the Republic of Sakha (Yakutia) stretches from north to south for 3000 km, and from west to east for 2500 km. The area of Yakutia (3103.2 thousand km²) is 1/5 of the territory of the Russian Federation (Figure 1).

Table 1. Structure of indicators for a comprehensive assessment of the state.

Groups of Factors Determining the State of the ES	Assessment Objects	Assessment Indicators
Anthropogenic Load	Population	Population density, people/km ² ; settlements by population
	Mining Industry	Volume of rock mass production from the beginning of field development to 2000, million m ³ ; environmental hazard of waste
	Forestry	Volume of timber harvesting, thousand m ³ /year
	Agriculture	Number of farm animals, livestock, sown area, ha
	Transport	Specific freight turnover, t-km/S ulus; passenger turnover, passenger-km/S of the ulus; number of vehicles per person
Groups of Factors Determining the State of the ES	Assessment Objects	Indicative indicators of assessment
Environmental and Social Consequences	Air Pollution	Emissions, t/year
	Surface Water Pollution	Discharges, t/year
	Disturbance of the Earth's Surface	Disturbed land, ha/km ² of territory
	Medical and Demographic Situation	Fertility per 1000 people
		Total mortality per 1000 people
		Infant mortality rate per 1000 people
		General morbidity per 1000 people
		Primary access to disability per 10,000 people
	Environmentally Caused Diseases	Malignant tumors and neoplasms, cases per 100,000 people
Stability of Natural Complexes	Climatic Factors	Average annual air temperature, °C
		Sum of temperatures above 5 °C
		Long-term average precipitation, mm
	Biotic Factors	Average timber stock, m ³ /ha
		Species diversity of mammals, number
		Rare species of mammals, number
	Lithogenic Factors	Depth of seasonal thawing of soils, m
		Ice content of permafrost, points

During the period 1632–1640, the vast territory of Yakutia was annexed to the Russian state and declared sovereign land. During these 400 years of being part of Russia, Yakutia specialized in two industries in the all-Russian economy: until the 20th century, the fur trade, and from the 20th century, the mining industry. In the taiga zone, before the arrival of the Russians, the Yakuts were mainly engaged in cattle breeding. Moreover, in the 17–18th centuries, horse breeding prevailed, and only in the 19th century did cattle breeding begin to more intensively develop. By the time that the first Russians explorers appeared, the Yakuts occupied lands only in the middle part of the Lena basin, along the middle Aldan, along the lower Vilyuy, and near the mouth of the Olekma, and were engaged in cattle breeding and herd horse breeding. The rest of the territory of Yakutia in its western and southern parts was inhabited by Tungus, and in the northeastern part by Lamuts (ancestors of modern Evens), and Yukaghirs. In the tundra and forest–tundra zone, the population (Evens, Evenks, Yukaghirs, and Chukchi) was engaged in reindeer husbandry, hunting, and

fishing [17]. With the arrival of the Russians, people living in the Lena Krai (Yakutia) were declared yasak subjects, i.e., paid tribute in the form of yasak (in russ.—tribute). The main part of the yasak was sable; fur became the main trade of the Russian currency, and Yakutia provided up to one-third of the goods. The fur was supplied to replenish the treasury of tsarist Russia and was also exported to Europe and China. The tightening of the yasak regime and the intensification of fur harvesting led to the predatory extermination of the resources of the fur trade, their depletion, and up to the threat of extinction of some species. The first fur-bearing animal of Yakutia, the natural reserves of which were undermined in the 17th century, was the sable. The reduction in the sable resources of the region continued during the second half of the 18th up to the mid-19th centuries. In the North and Northeast of Yakutia, it disappeared as early as the 18th century. In the 1830s, the sable began to disappear in the basin of the Vilyuy River, in the Kolyma Okrug [18]. The extermination of sables peaked in the first quarter of the 20th century. The history of the development of fur-bearing animals in Yakutia is a clear example of the predatory use of natural resources: irregular taking and the direct pursuit can lead to the extinction of certain species.



Figure 1. Location of the Sakha Republic into Russian Federation.

Since the 20th century (during the Soviet period), Yakutia has specialized in the mining industry in the all-Russian economy. The beginning of the industrial development of Yakutia is considered to be the development of a placer gold deposit at Aldan in the 1920s. During this period, environmental problems in the republic shifted to developing the mining industry. Environmental problems were associated with the large-scale disturbance of Earth's surface and environmental pollution, mainly of water bodies: the rivers Vilyuy, Daldyn, Malaya Botuobiya, Adycha, Allah-Yun, Seligdar, and Khroma, and an increase in ecological diseases [5].

The expansion of diamond production required a high rate of increase in electricity generation; in 1960, the construction of the Vilyuy hydroelectric power station began, the first stage of which was commissioned in 1967. During the construction of the Vilyuy hydroelectric station, an area of 196.14 thousand hectares was flooded, including settlements of indigenous small-numbered peoples: Tuoi-Khaya, Synsyktaakh, Chokhchuolu, and Ust-Chona. There was coverage of the tragedy of migrants who had forever left

their ancestral lands in the book *Goodbye Forever, Tuoi-Khaya* (published in 2006) based on archival materials, official documents, and media publications [8]. In addition, large areas of forests (131.5 thousand hectares)—30 mln3 standing forests—were flooded, which led to an increase in the content of phenols along the entire length of the Vilyuy Rivera and agricultural land. The total cost of damage from lands flooding under the reservoir, according to the calculations of employees of the Institute of Regional Economics of the Academy of Sciences of the Republic of Sakha (Yakutia), amounted to RUB 56.3 billion as measured in 1992 prices [15]. In addition, deposits and manifestations of vilyuite, grossular, and akhtarandite were flooded under the reservoir, the value of which amounted to RUB 250 trillion in 1992 prices. However, due to the complexity of the economic and legal mechanism for regulating natural resources, no practical compensation was produced. In the period of the development of the diamond industry until the 1980s, the state of the environment deteriorated sharply in some areas, in particular along the tributaries of the Vilyuy River. It was proposed to allocate the status of an ecological disaster zone to the rivers Irelyakh, Malaya Botuobiya, Daldyn, and Markha [19]. The development of the diamond mining industry is also associated with underground nuclear explosions (UNE), which became known only since 1989 in connection with the declassification of many materials on the ecology. In Yakutia, 12 controlled underground nuclear explosions (UNEs) were carried out from 1974 to 1987 in the Bulunsky, Verkhnevilyuisky, Kobyaysky, and Mirninsky Districts [19]. Of these, two explosions were officially recognized as emergencies: Kristall and Kraton-3. The first UNE (Kristall, 1974) occurred just 2.5 km from the town of Udachny to create a tailings dam for the concentrating plant. The second emergency UNE (Kraton-3, 1978) was intended for seismic sounding of Earth's crust and occurred 40 km east of the Aikhal village [19].

In 1992, samples taken at the Kraton-3 explosion site, analyzed by the specialists of the V.I. Khlopin Radium Institute (St. Petersburg), contained isotopes of plutonium with content exceeding the background concentration from 6 to 35,000 times. Decontamination of the Kristall UNE was carried out in 1992, 16 years after the explosion, by filling the epicentral part of the Udachny open-pit mine with waste rock. Decontamination at the Kraton-3 facility, the largest emergency underground nuclear explosion in Russia with a capacity of 22 kilotons (the bomb dropped on the city of Hiroshima had a yield of 15 kilotons), began in 1981, three years after the explosion remediation work on the contaminated area of the Kristall facility was carried out by ALROSA JSC in 2006, during which the dead forest and vegetation were taken outside the sanitary protection zone. Additional filling of the contaminated area was carried out, and five control and observation wells were installed. On the basis of radiation and environmental monitoring results, the St. Petersburg Institute of Radiation Hygiene gave an expert opinion on the compliance of the modern radiation and hygienic situation in the Kristall UNE area with the requirements of radiation safety standards and basic sanitary rules for ensuring radiation safety [19]. Experts recommend that the site of the explosion be considered as a place of burial of radioactive waste, since despite the large-scale isolation and decontamination measures taken, an unknown part of the stock of radioactive contamination remained at the site of the explosion and could pose danger to humans and the environment [15]. In 2007 at the Kraton-3 facility, the Aikhal Mining Complex of ALROSA carried out the main rehabilitation work on the contaminated area. The work included strengthening the repository by adding five 0.3 m thick layers of soil, erecting a drainage protective shaft with a height of 0.9 m, and drilling and constructing three control and observation wells with a depth of 3 m. At the final stage, a technology for the construction of a protective barrier based on zeolite from the Honguru deposit is to be proposed. The need for further rehabilitation measures is determined by the results of radiation and environmental monitoring of the facility, which are provided by the measures of state program Environmental Protection of the Republic of Sakha (Yakutia) for 2007–2011.

The basis of the republic's economy is now composed of subsoil use industries: non-ferrous metallurgy, and the fuel and energy industry. The current state of the environment

is characterized by an increase in the technogenic load on the natural environment, manifesting public dissatisfaction with an increase in the incidence rate, especially cancer. In most regions of the republic, the ecological situation is satisfactory. The tense category of the state of the environment was identified in 10 regions with a developed mining industry.

3. Results

3.1. Anthropogenic Load

At the beginning of the 20th century, 251.5 thousand people lived in Yakutia; in 1959, 487.3 thousand people; and in 1989, 1094 thousand people [20]. The rapid growth of the population since the 1930s was associated with the industrial development of the territory of Yakutia. The population of the Republic of Sakha (Yakutia) is now 971,996 people, including the urban population of 642,708 people (66.1%) and rural population of 329,288 people (33.9%). In 2020, compared with 2010 census data, the population of the republic increased by 1.5%: the urban population increased by 3.1%, and the rural population decreased by 1.7% (Table 2). The decrease in the rural population was facilitated by the internal migration of the rural population to cities and large worker settlements of the republic.

Table 2. Population at beginning of the year, thousand people.

Indicators	2005	2006	2007	2008	2010	2020
Republic of Sakha (Yakutia)	950.7	949.9	950	951.4	958.0	972.0
- urban population	610.8	610	613.1	619.5	623.1	642.7
- rural population	339.9	339.9	336.9	331.9	334.9	329.3

The basis of the economy of the Republic of Sakha (Yakutia) is the mining industry, the leading industries of which are nonferrous metallurgy, and the fuel and energy industry. Nonferrous metallurgy is represented by the diamond, gold, and tin mining industries. More than 60 large mining companies operate in the republic, including ALROSA OJSC, Yakutugol JSC, Polyus Zoloto OJSC, Neryungri-Metallik LLC, Surgutneftegaz OJSC, Sakhatransneftegaz OJSC, and Rosneft OJSC [21]. RS(Y) is one of the leading gold mining regions of Russia: in 2013, it ranked third after the Krasnoyarsk Krai and the Amur Oblast. Deputatskolovo OJSC is the leading tin mining enterprise of the Russian Federation, as more than 40% of Russia's reserves are concentrated there; production is 50% of Russia's total [20]. ALROSA globally ranks first in terms of diamond production in carats, mining 95% of all diamonds in the Russian Federation.

The main gas production and fuel enterprise in Yakutia is the PJSC Yakutsk Fuel and Energy Company (YATEK), a Soviet and Russian company with an 86% share in industrial gas production. Founded in 1967 as Yakutgazprom State Enterprise, in 1994 it was transformed into an open joint stock company, and in 2010, it received its present name. It conducts the industrial development of the Srednevilysky and Mastakhsky gas condensate fields. This is the only enterprise that supplies gas to the central regions of the republic; the needs of Yakutsk are fully satisfied by the company's resources.

3.2. Environmental Implications

The current environmental state is characterized by an increase in the technogenic load in the republic, its further deterioration in the territories of the mining industry, and an increase in the incidence rate, especially cancer. The republic accumulated much information on environmental, social, and economic problems [5,22–24]. To select the most informative indicators, previously selected to characterize the ES and identify statistical relationships between them, we calculated pairwise Pearson correlation coefficients (Table 3).

Table 3. Correlation coefficients between environmental state indicators *.

	** 1	2	3	4	5	6	7	8	9	10	11
1			0.07	0.99	0.21	−0.07	0.67	−0.21	−0.23	−0.03	0.81
2			−0.27	0.10	0.72	−0.61	0.56	−0.50	−0.03	−0.53	0.59
3				−0.04	−0.33	0.36	−0.12	−0.24	−0.63	−0.24	−0.20
4					0.28	−0.11	0.67	−0.16	−0.16	−0.01	0.85
5						−0.65	0.48	−0.25	0.08	−0.34	0.69
6							−0.47	0.26	−0.26	0.22	−0.45
7								−0.51	−0.07	−0.38	0.81
8									0.48	0.61	−0.33
9										0.54	−0.07
10											−0.23
11											1

* With a confidence level of 0.95 (significance level 0.05), the threshold of significant correlation coefficients is ± 0.33 . ** 1–4, anthropogenic load: 1, population; 2, industry; 3, agriculture; 4, transport; 5–7, environmental consequences, 5, environmental violation (pollution), 6, medical and demographic situation, 7, malignant diseases; 8–10, vulnerability to technogenic impacts by environmental factors, 8, climatic; 9, biotic, 10, lithogenic; 11, the environmental state by a set of factors.

A close positive correlation ($r = 0.59–0.85$) was found among the indicators of anthropogenic load (population, industry, transport), environmental pollution, malignant diseases, and the state of the environment by a set of factors, which indicates the dependence of the latter on the former, and they negatively impact the ecological situation in the republic. The state of the medical and demographic situation in the republic is determined mainly by socioeconomic and sanitary–hygienic factors, as evidenced by a positive relationship with agriculture (0.36) and the opposite, with industry and environmental pollution (-0.61 ; -0.65), i.e., in rural areas, the medical and demographic situation is worse, and in industrial areas it is better. An opposite relationship is observed for ecologically caused diseases: the incidence of malignant neoplasms of the population is closely related to the indicators of industrial urban nature use—population, industrial load, transport press, and environmental pollution ($r = 0.48–0.67$). In general, when the indicator of malignant neoplasms is included in the overall assessment of the health status of the population (the official medical and demographic characteristics do not take it into account), there is a close relationship between the technogenic impact and the state of human health (0.72) [15]. To characterize the levels of the state of the environment, we used the following structure of definitions of the ecological situation (Table 4).

Table 4. Definitions of ecological situation [15].

Definition		Environmental Situation							
Generalization	Prosperous	Satisfactory				Tense		Crisis	
Details	Prosperous	Relatively prosperous	Satisfactory	Relatively satisfactory	Relatively tense	Tense	Extremely tense	Critical	Catastrophic

Figure 2 shows a comprehensive ecological and economic assessment of the state of the environment in Yakutia. In most regions of the republic (mainly agricultural), the ecological situation is favorable and satisfactory.

A tense ecological situation is inherent in areas with developed industrial production (Mirninsky, Lensky, Neryungrinsky, and Aldansky). An extremely tense ecological situation has developed in the city of Yakutsk with its subordinate territory [15].

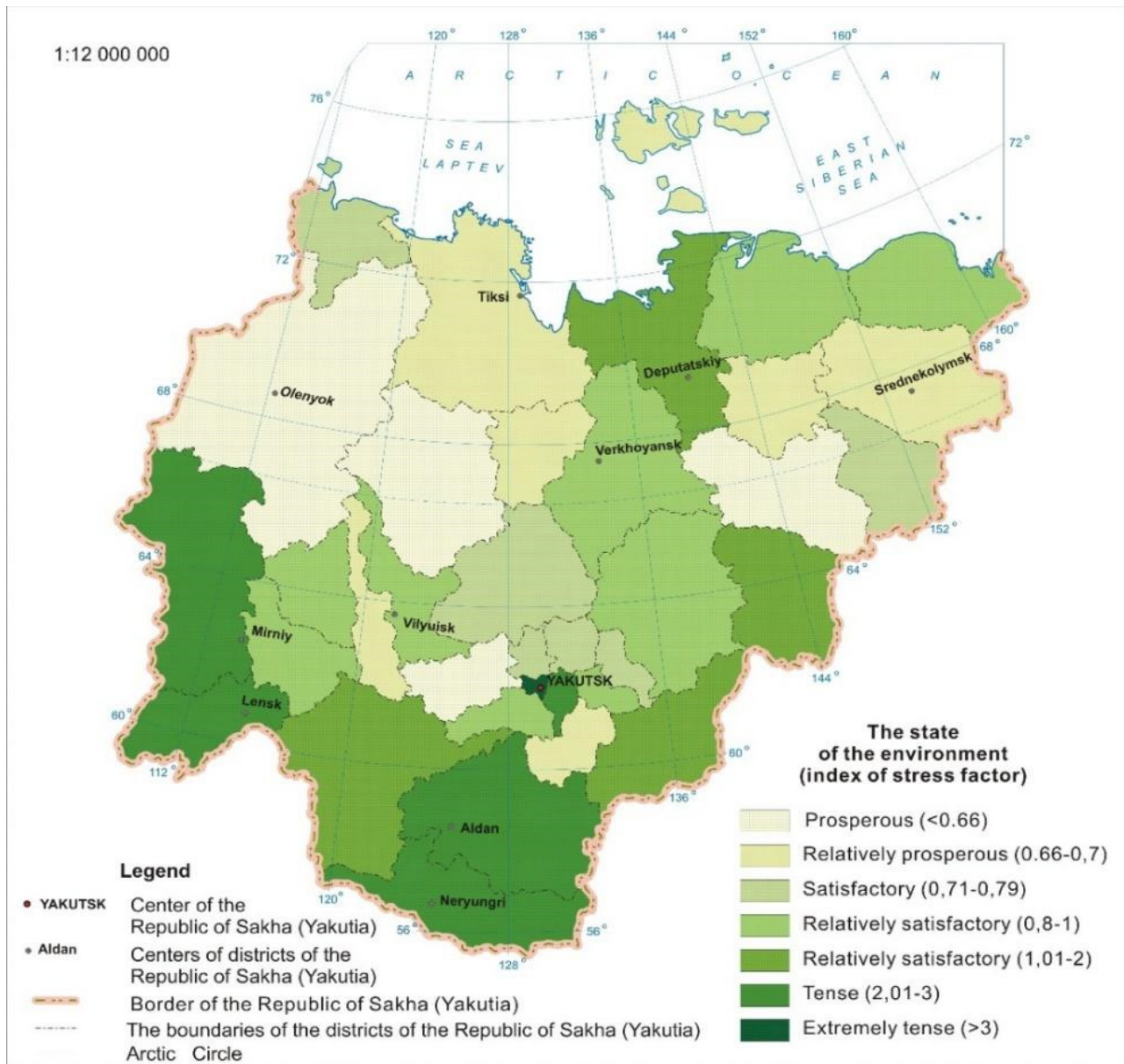


Figure 2. Comprehensive ecological and economic assessment of Yakutia's environmental state.

3.3. Social Impact

According to the 2010 All-Russian Population Census, there are representatives of more than 140 nationalities living in the republic: the indigenous population, Yakuts (48.6%), Evens (1.6%), Evenks (2.19%), Dolgans (0.2%), and Yukaghirs (0.13%); Russians, 36.9%; and Ukrainians, 2.12% [19]. Large-scale industrial development of the territory of the republic affects the vital interests of the population living in the places of industrial development, primarily the indigenous peoples of the North, whose livelihoods are fully associated with the use of renewable natural resources (reindeer pastures, hunting, fish, plant). Many works are devoted to the study of the problems of traditional nature management in the Arctic regions, among which we can note the works of the following authors [8–10,25,26].

To assess the dependence of health status on the social environment, statistical medical and demographic indicators of the Yakutsk Republican Medical Information and Analytical Center of the Republic of Sakha (Yakutia) for 30 years (1982–2011) for tuberculosis were analyzed. In a ranked series of tuberculosis prevalence among the population in ascending order of indicators, morbidity (newly diagnosed patients), morbidity (registered

patients) and mortality, the Arctic and northern regions have high and increased levels of infection [27]. The conceptual idea of the study is based on the analysis of the situation of the indigenous peoples of the North and their interaction with industrial companies from the standpoint of legal anthropology within the framework of the methodology of legal pluralism [27]. This is considered the coexistence of two or more legal systems, when human behavior, as defined by Griffiths J. [27], corresponds to more than one legal order.

According to the Strategy of Socioeconomic Development of the republic until 2030 with a Vision for 2050, one of the tasks of preserving and protecting the indigenous habitat of the indigenous peoples is guaranteed compliance with the participation of industrial companies in the socioeconomic development of territories inhabited by indigenous peoples. At present, the question is being raised about the division of the benefits from the development of mineral deposits on the TTNRU between industrialists and indigenous peoples [28]. According to the 2010 census, only 39,936 ISPN live on the territory of the republic of Sakha (Yakutia), who live compactly in the villages of twenty districts of the republic. The highest proportion of indigenous peoples in the total population is observed in the northern regions, Oleneksky, Zhigansky and Eveno-Bytantaysky, and the smallest are mainly in the central regions of the republic, Megino-Kangalassky, Ust-Aldansky, and Tatta.

It is believed that the contribution of indigenous peoples to the social and environmental harmonization of human existence is enormous. For example, the current global financial crisis, from which many people (individuals, social groups, and entire states) greatly suffered, has practically not affected those who live off the traditional subsistence economy. In a crisis, this life support model turned out to be effective, even lifesaving.

3.4. Resistance of Natural Complexes to Technogenic Impacts

All factors affecting the resistance of permafrost landscapes to technogenic impacts can be combined into three large groups: climatic (solar radiation, air temperature, precipitation, etc.), biotic (nature of vegetation, biological productivity, biodiversity, etc.), and lithogenic (presence of permafrost, ice content of soils, depth of seasonal thawing, etc.). According to the results of research by employees of the Institute of Regional Economics of the Republic of Sakha (Yakutia) in the 2000s, the vulnerability of natural complexes to technogenic impact doubled from south to north. Certain violations of this pattern were observed in terms of the ice content of the permafrost (azonal phenomenon) and the Red Data Book species of mammals, which primarily reflect the degree of anthropogenic pressure [15]. In total, more than half of the territory of Yakutia (North of 62° N) is characterized by the high (varying degrees) vulnerability of natural complexes to technogenic impact (Figure 3).

The territory of middle taiga forests is more resistant to technogenic impact. Relatively high stability is characteristic of the southern part of the republic (Lensky, Olekminsky, Aldan regions), with an average annual air temperature of −7 to −9 °C, and one in Central Yakutia (Amginsky), where we noted weak surface sensitivity to lithogenic factors. Average stability is mainly characterized by the regions of Central and Western Yakutia, where the average annual air temperature is −10 °C. The territory of the northern and northeastern part of the republic, where the average annual air temperature reaches −15.5 °C, is more vulnerable to technogenic impact, and the surface sensitivity to lithogenic factors is characterized as strong and relatively strong. Extremely high vulnerability of natural complexes to technogenic impact (southern border up to 70° N) is characteristic of the Arctic regions of Yakutia [15].

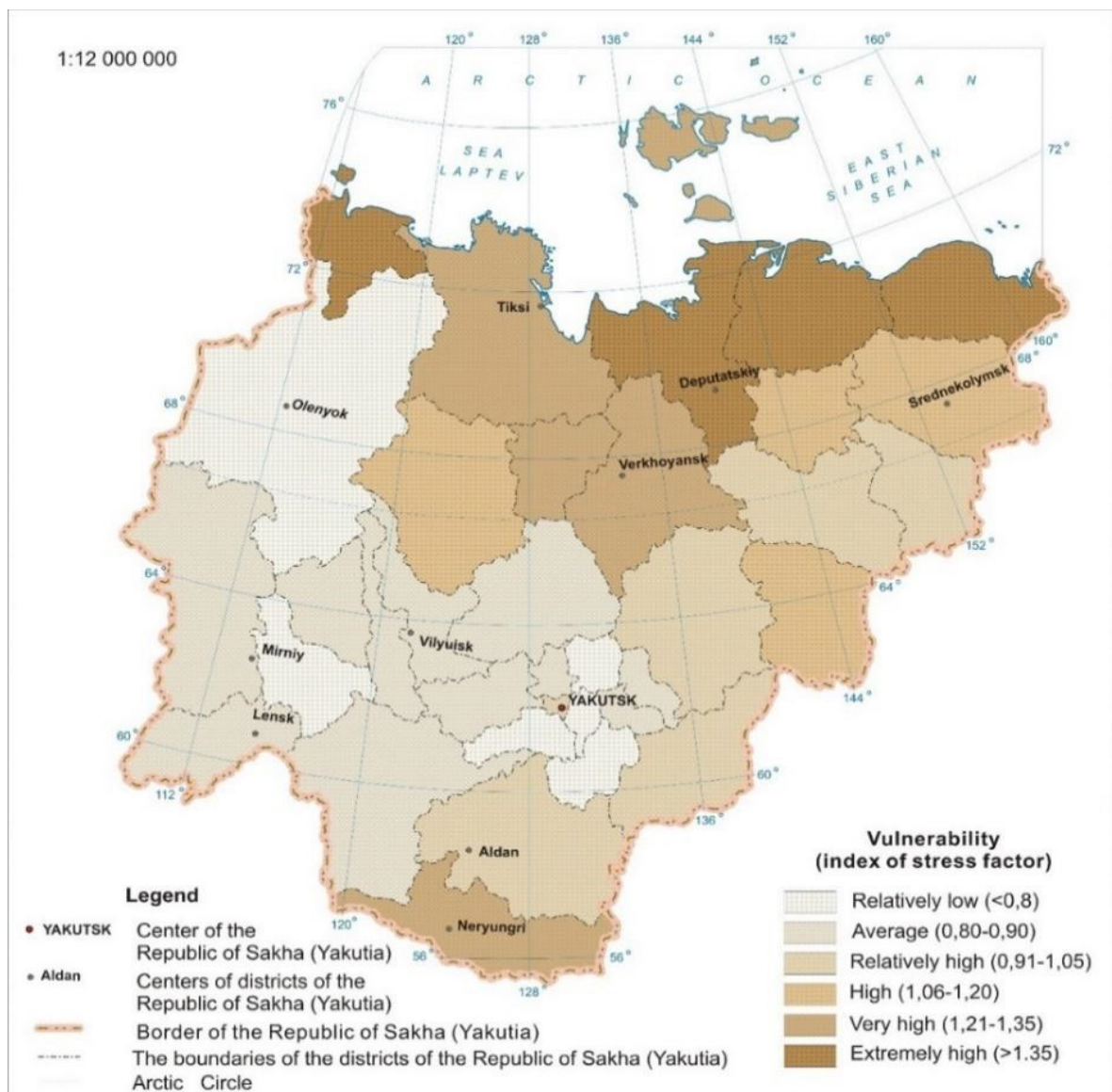


Figure 3. Comprehensive assessment of vulnerability of natural complexes to technogenic impact.

4. Discussion

Indigenous minorities compactly live mainly in the Arctic and South Yakutia, where the large-scale industrial development of mineral resources is planned: in the Arctic, diamonds, gold, coal; in South Yakutia, the construction of the South Yakutian hydropower complex, the Elkon mining and metallurgical plant of uranium ore, the Tarynnakh and Taiga mining complexes for the development of iron ore deposits, and the Inaglinsky coal complex [29]. The Arctic is one of the regions of global atmospheric processes on the planet, a regulator of oxygen and methane, and a drainage area for many chemical compounds. Russia is the largest Arctic power. To the north of the Arctic Circle lies 20% of the territory of Russia (3 million km²). This is more than half of the entire world's Arctic territory. It is home to about 1.5 million people, which is 1% of the country's population and about 40% of the world's Arctic population. This territory creates 12%–15% of the country's GDP and provides about one-quarter of Russia's exports. The Arctic zone of Yakutia includes 13 administrative regions. More than 70,000 people live in the Arctic zone of the republic, of which 20,000 are indigenous peoples (Evens, Evenks, Yukaghirs, Chukchi, and Dolgans).

The industrial development of the Arctic and northern regions on the territory of Yakutia began with the development of a coal deposit in the Verkhnekolymsky region in 1936. The development of the Ese-Khaisky tin deposit in the Verkhoyansky region began in 1941, and in 1951, the Depututsky mine was opened in the Ust-Yansky area. In the 1960s, the development of diamond deposits began with the Aikhal quarry (1961) in the Mirny region, and with gold mining in the lower reaches of the river (Yany: Kular mine (1963) in the Ust-Yansky region [8]). Diamond mining in the Anabarsky, Oleneksky, and Bulunsky regions is carried out by ALROSA OJSC (Verkhnemunsky primary deposit since the end of 2017) and its subsidiary, Almazy Anabara JSC, at placer deposits. In addition, more than 80 kg of placer gold is simultaneously extracted from the tailings of diamond sand processing. Placer gold (more than 500 kg/year) is mined in Arctic Yakutia by Yanzoloto LLC and Yakutskgeologiya JSC in the Ust-Yansky region, Khotu LLC in the Momsky region, Sever LLC in the Verkhoyansk region, and Anzhu LLC in the Bulunsky region. Coal mining (more than 150 thousand tons/year) at the Nadezhdinsky deposit in the Verkhnekolymsky region is carried out by Zyryansky Coal Mine JSC.

Changes in the natural environment of the Arctic zone as a result of global warming and accelerated industrial development are mostly negative for the traditional way of life of the northerners. The indigenous peoples themselves believe that the main threat to them is not climate warming, but the industrial development of territories. The main ethnopreserving branch of the indigenous peoples of the North is reindeer herding [15]. The catastrophic reduction in the number of reindeer continues; in 2016, it numbered to 11,208 reindeer in the republic, that is, it decreased by 33.9 times compared to that in 1981. In 2001, if there were 20 areas with more than 500 thousand reindeer heads; in 2016, there were only 6 such areas in the republic. As a result of 75 years of artificial pressure on the Arctic and northern territories of industrial facilities, an unfavorable environmental situation has developed. The most acute environmental problem is the pollution of surface waters. In 2019, the water of the Yana River was assessed as Class 4, Category A, and was characterized as dirty. The basin of the Indigirka River is Class 3, Category B (very polluted). The qualitative composition of the river basin water of Kolyma was assessed as Class 3, Category B (very polluted). The quality of water in the reservoirs of the Lena River (Neelova Bay (Lena Delta) in 2019 was assessed as Class 3, Category B (very polluted).

The territory of South Yakutia is the original habitat of the indigenous peoples of the North, for which the Land Code of the Russian Federation provides a special legal regime for the use of lands of all categories. On the territory of South Yakutia, the indigenous peoples of the North are mainly represented by the Evenks, and separate tribal communities of another small-numbered people of Siberia, the Evens (Lamuts), are registered here. Reindeer husbandry is the first type of traditional nature-resource use in terms of importance for the life of the indigenous population. In the Neryungri region, the number of deer decreased in 2010 by 1.8 times, and in the Aldan Region by 1.2 times compared to 1991. The second most important type of traditional nature management for the life of the indigenous population is hunting. A feature of the hunting industry in the region is its narrow specialization, with over 95% of the cost of purchased fur being sable skins.

One of the main structural components of the quality of life is the level and living conditions of the population. The standard of living of the indigenous peoples of the North in South Yakutia was assessed using the example of the Aldan region. At the same time, in 2006 we carried out a sample survey of households in settlements where indigenous minorities live: villages of Khatystyr, Ugoyan, and Verkhnyaya Amga of the Aldan region [5,8]. In the surveyed settlements, 356 people were covered; the size of households averaged 4 people. On average, the value of income per 1 member of the household was RUB 3253.7, and the total amount of income per 1 member of the surveyed household was RUB 6956.1 (i.e., almost twice lower than the average per capita income for the surveyed families of the Aldan Region (11,051 rubles per month). In general, the socioeconomic living conditions of the indigenous minorities in the region are low: according to the association of indigenous peoples of the city of Tommot, there are

235 Evenki with low income comprising 71.5%, the unemployed, 16.2%, and the homeless, 23.8% (Table 5)

Table 5. Socioeconomic situation of the Evenki in Tommot. Source: data of the association of indigenous peoples of the city of Tommot for 2006.

Total Evenki Population	235	100%
- Children under 18	43	18.3
- Low-income	168	71.5
- Unemployed	38	16.2
- Homeless	56	23.8
- Of them the destitute	26	11.1
- In need of improving living conditions	40	17.0
- Disabled Group 1	3	1.3
Group 2	9	3.8
Group 3	33	1.3

The implementation of megaprojects would generally improve the socioeconomic living conditions of the population of the district: unemployment would decrease as a result of the creation of new jobs, real incomes would increase, and transport, consumer, and trade services would improve. However, for the indigenous peoples engaged in traditional natural resource use, the construction of large industrial facilities may also have negative socioeconomic consequences. To identify the attitude of the indigenous population to megaprojects (construction of the ESPO, cascade of hydroelectric power plants, EMMC), we surveyed 90 households in the villages of Khatystyr, Ugoyan, and Verkhnyaya Amga. The majority of respondents (99.1% of the representatives of indigenous peoples expressed concern that the implementation of megaprojects would violate the natural ways of animal migration, reduce the area of reindeer pastures, and worsen environmental conditions, with revenues from traditional industries being fewer, and the social situation worsening.

One of the indicators of the quality of life of the population is the state of health of the population. Official statistics do not take into account the morbidity of the population by ethnic composition, and it is impossible to assess the state of health according to the statistics of indigenous minorities in this period. The expected technogenic pressure in South Yakutia may lead to negative consequences in relation to the health status of indigenous minorities [15]:

- Increase in the frequency of births of children with congenital malformations;
- Increase in the number of malignant neoplasms of various localizations;
- Increase in the incidence rate of the population with multifactorial diseases (autoimmune, cardiovascular, and infectious diseases, endocrine disorders, diseases of the central and peripheral nervous system, and mental disorders).

The analyzed enterprises that provide financial and sponsorship assistance are republican enterprises. Megaprojects would be built and operated by private enterprises, for which the main goal is to profit (a property of any economy). Under these conditions, compensation for social damage to the population from the deterioration of the environmental situation is possible only with mutual cooperation of the governments of the Russian Federation and the Republic of Sakha (Yakutia), and scientific and public organizations and companies that conduct economic activities in the republic. At the same time, all social and environmental problems should be resolved on the basis of agreements and treaties. The enterprises themselves are also interested in carrying out such a policy, as their highly effective economic development is only possible if the territory in which they conduct economic activity creates social and environmental sustainability [30–34].

5. Conclusions

1. To evaluate the operating state, we used a quantitative indicator, the social risk index (SRI), which is the deviation from the average state of the object in relative terms. At the same time, all 26 heterogeneous indicators for the three areas (anthropogenic load, environmental and social consequences, stability of natural complexes) are comparable by converting absolute values into relative ones. For this, the SRI was determined, which was calculated as the share of the characteristic in the average republican indicator.
2. The economy of the Republic of Sakha (Yakutia) is based on the mining industry (share in the volume of industrial production is 88%). Of the 35 administrative units, the mining industry is developed in 18 districts, including the TTNRU. These are the Arctic and northern regions (Bulunsky, Nizhnekolymsky, Allaikhovsky, Anabarsky, Zhigansky, etc.), Western Yakutia (Mirninsky), and South Yakutia (Aldansky, Neryungrinsky, Lensky, Olekminsky). A high level of load ($SRI \geq 3$) on the environment was noted in Mirninsky (diamond mining) and Neryungri (coal mining); an increased level ($SRI 1.01\text{--}3.0$) was noted in Oymyakonsky (gold mining), Aldansky (gold mining), and Ust-Yansky (tin mining), which are the original habitat of the indigenous peoples of the North.
3. The current state of the environment is characterized by an increase in the technogenic load and further deterioration of the environmental state. In 25 predominantly agricultural regions of the republic (of which TTNRU are organized in 17 regions), the state of the environment is favorable and satisfactory ($SRI \leq 0.66$; $0.66\text{--}0.10$). In 5 regions with developed industry, a relatively tense state is characteristic, where, with the leading role of agriculture, the mining industry is also developing ($SRI 1.01\text{--}2.0$). A tense state ($SRI 2.01\text{--}3.0$) exists for 4 regions with a developed mining industry, which is the original habitat of the indigenous peoples of the North; an extremely tense state exists for the city of Yakutsk ($SRI \geq 3$), where indigenous minorities partly live.
4. The level of human health is the clearest indicator of the quality of life of the population. According to the results of the medical and demographic situation in the life of the population (indicators such as fertility, total mortality, infant mortality, general morbidity, and primary disability), a low level is typical for industrial regions: Neryungrinsky, Mirninsky, Ust-Maisky, and Lensky. An increased level (above the level of the republic) was established for agricultural regions ($SRI 1.06\text{--}1.15$), Ust-Aldan, Tattinsky, Momsky, etc., and a high level for three northern agricultural districts remote from the centers, Anabarsky, Oleneksky, and Eveno-Bytantaysky, with a mainly indigenous population.

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