Arctic and North. 2024. No. 55. Pp. 60–80.
Original article
UDC [330.564.2:316.342.6](045)
DOI: https://doi.org/10.37482/issn2221-2698.2024.55.72

New Opportunities and New Risks for Sustainable Development of the Russian Arctic in the Context of Climate Change

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Abstract. The Arctic climate has been changing dramatically in recent years. This external condition, on the one hand, increases the risk of sustainable development of the Arctic; on the other hand, in combination with the management factors of the Russian Federation's Arctic zone, it provides new development opportunities. Based on the authors' methodology, the paper assesses the efficiency of sustainable development management of the Arctic by comparing the costs of environmental protection and the volume of pollutants entering the Arctic ecosystems. The study showed that, despite the growth of current expenditures on sustainable development management in the Arctic, their use cannot be considered fully effective and efficient: financial investments do not always lead to a reduction in pollution; investments in sustainable development are uneven and depend on the current conjuncture. Changes in the Arctic climate were assessed by comparing indicators for the period from 1971 to the present, characterizing air temperature, precipitation, snow cover, sea and river ice, permafrost, etc. The analysis revealed an accelerated growth of Arctic climate change indicators. The impact of climate change on new opportunities and new risks for the sustainable development of the Russian Arctic was determined on the basis of authors' research and correlated with the opinion of authoritative Arctic researchers. Based on the results of the study, the positive and negative effects of the implementation of new opportunities for the Arctic territories in the context of climate change have been identified.
Keywords: *climate change, risk, new opportunities, sustainable development, Arctic territories*

Acknowledgments and funding

The study includes the results obtained through the state task of the FSBIS FRC KSC RAS 123012500057-0.

Introduction

Historically, most of the Russian Arctic was sparsely populated and had little anthropogenic pressure due to its underdeveloped industrial environment and difficult accessibility. There was a relative balance between the development of local settlements, little social and industrial infrastructure, and Arctic ecosystems subject to little anthropogenic change. Increased interest in the resource potential of the Arctic has led to the development of industry, changes in the traditional

For citation: Samarina V.P., Skufina T.P. New Opportunities and New Risks for Sustainable Development of the Russian Arctic in the Context of Climate Change. *Arktika i Sever* [Arctic and North], 2024, no. 55, pp. 72–96. DOI: https://doi.org/10.37482/issn2221-2698.2024.55.72

life of Arctic inhabitants, and the growth of populated areas, including cities. These factors have tended to disrupt the fragile ecological balance of the Arctic territories and increase the risk of sustainable development of the Arctic.

We propose to understand the sustainable development of the Arctic as a set of purposeful actions aimed at balancing the relations between the economy, the natural environment, and society to meet the needs of nature users of the Arctic territories at present and in the long term.

The key concept of sustainable development is risk. Risk is a combination of the probability of a dangerous event and the severity of its consequences for the economy, population, and ecosystems of the Arctic. Certain external conditions of natural, technogenic, geopolitical and other origins enhance or weaken the risk of sustainable development of the Arctic. In our study, we will focus on an external natural condition, namely climate change.

The research problem is as follows. The Arctic climate has begun to change dramatically in recent years. This external condition, on the one hand, increases the risk of sustainable development of the Arctic, and on the other hand, in combination with the management factors of the Arctic zone of the Russian Federation, provides new development opportunities.

The aim of this paper is to assess new opportunities and identify new risks of sustainable development of the Russian Arctic under the condition of climate change by analyzing a set of significant factors.

In order to achieve this goal, it is necessary to solve a number of problems:

- assess the efficiency of sustainable development management in the Arctic on the basis of the author's methodology by comparing the costs of environmental protection and the amount of pollutants entering the Arctic ecosystems;
- analyze the dynamics of Arctic climate change indicators for the period from 1971 to the present;
- assess the impact of climate change on new opportunities and new risks for sustainable development of the Russian Arctic;
- consider environmental pollution as a risk for sustainable development of the Arctic, paying special attention to the content of greenhouse gases in the atmosphere;
- identify positive and negative effects of the implementation of new opportunities for the Arctic territories in the context of climate change.

Literature review

Analysis of numerous scientific works, as well as the authors' own research, made it possible to identify the following conditions that have developed in almost all Arctic territories and negatively affect their sustainable development:

- special natural and climatic conditions caused by the lack of oxygen and solar heat due to high latitudes; long, snowy and low-temperature winters; permafrost; ice sheet on

land and in the Arctic seas [1, Korchak E.A., Serova N.A., Emelyanova E.E., Yakovchuk A.A., pp. 2–5; 2, Skripnuk D.F., Samylovskaya E.A, pp. 2–4];

- slow biological and chemical-biological processes, which reduce the ability of ecosystems to self-clean and make them especially vulnerable to anthropogenic impact [3, Dauvalter V.A., Kashulin N.A., pp. 843–851; 4, Samarina V.P., pp. 22–28];
- short growing season of plants and insufficient ability of vegetation to absorb greenhouse gases [5, Skufina T.P., Samarina V.P., Samarin A.V., pp. 136–138];
- formation of local industrial clusters, significantly dependent on external supplies of material, technical, labor, information, social and other resources [6, Samarina V.P., Subbotina E.V., pp. 136–141; 7, Zaikov K.S., Kondratov N.A., Kudryashova E.V. et al., pp. 12–14; 8, Skufina T.P., Bazhutova E.A., Samarina V.P., p. 56];
- territorial economy, aimed primarily at the extraction of natural resources [9, Suopajärvi L., Poelzer G.A., Ejdemo T. et al., pp. 63–65; 10, Brigt D., Larsen I.B., Skorstad B., pp. 2–4; 11, Baranov S., Skufina T., Samarina V., p. 6337];
- low population of the territory, migration, which has increased in recent years [12, Hamilton L. C., Saito K., Loring P. A., Lammers R. B., Huntington H. P., pp. 113–118; 13, Andrew R., pp. 5–17];
- special significance and special protectionist nature of state management of the socio-economic development of territories [14, Kudryashova E.V., Lipina S.A., Zaikov K.S., Bocharova L.K., pp. 446–447; 15, Samarina V.P., pp. 22–27; 16, pp. 18–21].

Since almost all Arctic territories — both those belonging to Russia and those under the jurisdiction of other Arctic countries — have these characteristics, they can be considered as basic. Basic characteristics hinder the sustainable development of Arctic territories.

Methodology

The methodology of the presented research was developed on the basis of its purpose and scientific objectives. In order to fully identify and study new opportunities and new risks of sustainable development of the Russian Arctic in the context of solving management tasks, methodological tools should be based on the results of a comprehensive study of significant factors that determine the required processes and relationships. In this regard, the orientation of our research not only on theoretical and methodological principles, but also on applied management tasks is of particular importance. Consequently, approaches to research should be based on proven, unquestionable grounds. This determines the focus on the use of government statistics, official reports and forecasts of research organizations recognized in the scientific world. The analytical part of the study was based on the use of reliable methodological assessment tools.

The study was conducted on the basis of information on current (operating) costs for environmental protection and environmental management indicators — volumes of treated and/or recycled waste, wastewater, atmospheric emissions in the Arctic zone of the Russian Federation.

The study involved materials from the State Report "On the state and protection of the environment of the Russian Federation in 2021" for the period from 2017 to 2021 [1]. This time period was chosen because it includes the period of economic stagnation due to the coronavirus pandemic, which peaked in 2020, as well as the years before and after this stagnation. This approach to the research period allows us to indirectly assess the impact of external challenges on the effectiveness of managing the sustainable development of the Russian Arctic.

Quantitative determination of the effectiveness of management of sustainable development of the Arctic includes several stages:

- to identify the directions of environmental protection expenditures in the Russian Arctic zone, the structure of current (operating) costs in monetary and percentage terms were presented;
- to identify the balance of expenditures, correlation coefficients between the amount of current (operating) costs for environmental protection and the volume of treated and/or recycled waste, wastewater, and atmospheric emissions were calculated;
- to identify the dynamics of specific costs for managing sustainable development of the Arctic, the volume of investments per unit of environmental pollution was calculated; the list of proposed indicators is given in Fig. 1.

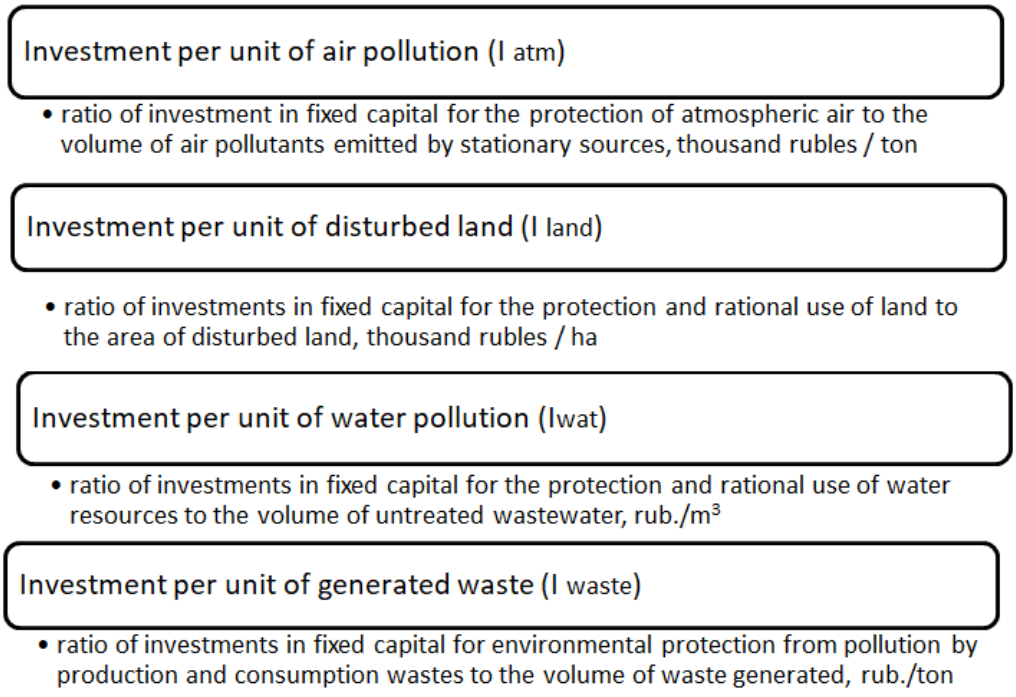

Fig. 1. Indicators of unit costs of sustainable development management in the Arctic [2].

The efficiency of Arctic sustainable development management was assessed by comparing the costs of environmental protection and the amount of pollutants entering Arctic ecosystems. Management of sustainable development of the Arctic can be considered effective if the costs of

[1] State report "On the state and protection of the environment of the Russian Federation in 2021". Moscow, Ministry of Natural Resources and Environment of Russia; Moscow State University named after M.V. Lomonosova, 2022. 684 p.
[2] Compiled by the authors.

environmental protection measures contribute to increasing the environmental compatibility of production and reducing the negative impact on the natural environment.

Changes in the Arctic climate were assessed by comparing indicators characterizing air temperature, precipitation, snow cover, sea and river ice, permafrost, etc. for the period from 1971 to the present day. The study was carried out using materials from AMAP, a Norwegian research organization dealing with climate change in the Arctic [3]. The impact of climate change on new opportunities and new risks for sustainable development of the Russian Arctic was determined on the basis of the author's research and was correlated with the opinion of authoritative Arctic researchers.

Pollution of the Arctic environment was assessed on the basis of data presented in the state report "On the state and protection of the environment of the Russian Federation in 2021" [4]. The concentration of greenhouse gases in the atmosphere (carbon dioxide and methane) was monitored at the Arctic stations of Teriberka and Tiksi, as they are located in conditions close to natural; data is presented for the period from 2012 to 2021.

Results and discussion

1. Efficiency assessment of sustainable development management of the Arctic territories

The problem of ensuring sustainable development of the Arctic territories has been repeatedly discussed by the scientific community. Differing in details, all studies are aimed at developing mechanisms for long-term harmonization of relations between the economic, environmental and social aspects of the functioning of Arctic socio-economic systems.

The problem of ensuring sustainable development is multifaceted. And the results of sustainable development management can be assessed in different ways. In our study we will focus only on some points. The result of managing the sustainable development of the Arctic is proposed to be a reduction in the negative anthropogenic impact on the natural environment. In this study, the negative anthropogenic impact is assessed on the basis of emissions from stationary sources into the atmosphere, wastewater discharges, and waste generated.

An assessment of the dynamics of current (operating) costs for environmental protection in the Arctic zone of Russia showed that they increased from 32,133 million rubles in 2017 to 38,146 million in 2019, but decreased to 36,577 million in 2021. The structure of current (operational) costs for environmental protection in the Arctic zone of Russia in 2019 and in 2021 is shown in Fig. 2.

[3] Climate change in the Arctic. Key Trends and Impacts: Arctic Monitoring and Assessment Program 2021. URL: https://www.amap.no/documents/download/6887/inline#:~:text (accessed 23 July 2023).
[4] On the state and protection of the environment of the Russian Federation in 2021. State report. Moscow, Ministry of Natural Resources and Environment of Russia; Lomonosov Moscow State University, 2022, 684 p.

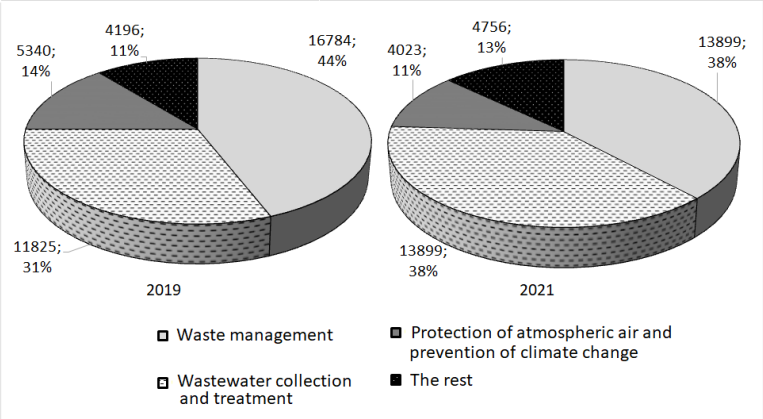

Fig. 2. Structure of current costs for environmental protection in the Arctic zone of Russia, million rubles; % [5].

The largest share of costs was allocated to waste management (44% in 2019; 38% in 2021), collection and treatment of wastewater (31% in 2019; 38% in 2021) and atmospheric air protection and climate change prevention (14% in 2019; 11% in 2021). In 2021, the costs of waste management decreased by 2,885 million rubles, and by 584 million rubles for the protection of atmospheric air and prevention of climate change [17, Samarina V.P., Skufina T.P., Savon D.Y., Shinkevich A.I., p. 3]. At the same time, the costs for wastewater collection and treatment increased by 2,074 million rubles. The total expenditures on environmental protection in the Arctic zone of Russia decreased by 1,569 million rubles or by 4.1% in 2021 compared to 2019.

The assessment of the efficiency of sustainable development management in the Arctic was made on the basis of a comparison of environmental protection costs and the volume of pollutants. Management of sustainable development of the Arctic can be considered effective if the costs of environmental protection measures are balanced and contribute to increasing the environmental compatibility of production and reducing the negative impact on the natural environment [17, Samarina V.P.; Skufina T.P.; Savon D.Y.; Shinkevich A.I., p. 5–7]. To identify the balance of costs, correlation coefficients were calculated between the amount of current (operating) costs for environmental protection and the volume of treated and/or recycled waste, wastewater, and atmospheric emissions. Calculation of correlation coefficients showed a direct correlation between the size of current (operating) costs for environmental protection in the Arctic zone and the volume of treated wastewater (k = 0.68), as well as the volume of reused and recycled waste (k = 0.77). Thus, the effectiveness of managing the sustainable development of the Russian Arctic territory can be seen here. At the same time, a significant negative correlation coefficient between the financial indicators of costs and the indicator characterizing air purification (k = –0.92) indicates ineffective spending of funds.

We further determined the indicators of unit costs of sustainable development management in the Arctic. For this purpose, according to the author's methodology presented above, the volume of investments per unit of environmental pollution was calculated (Fig. 3).

[5] The authors' calculations based on the materials of the State report "On the state and protection of the environment of the Russian Federation in 2021". Moscow, Ministry of Natural Resources and Environment of Russia; Lomonosov Moscow State University, 2022, 684 p.

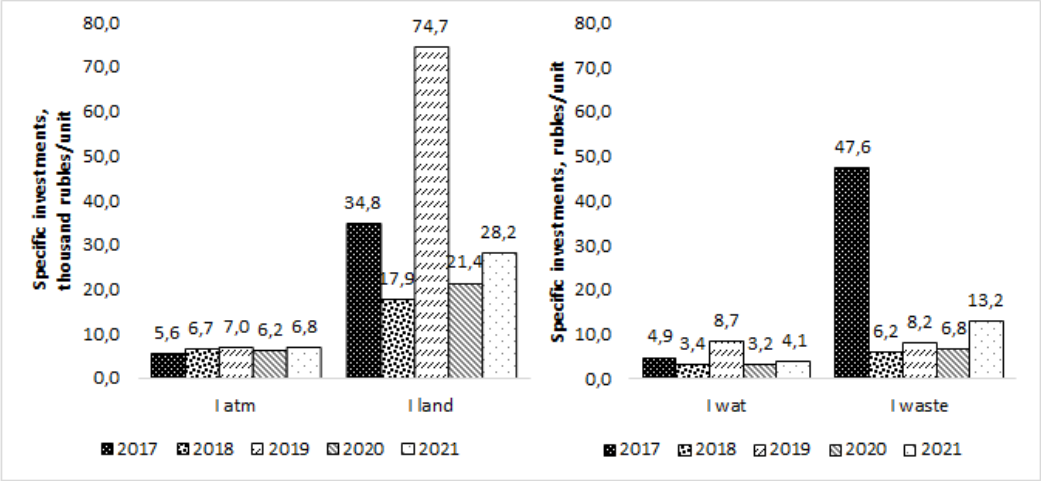

Fig. 3. The volume of investments per unit of environmental pollution in the Russian Arctic [6].

The analysis of specific investments per unit of environmental pollution allows us to state an increase in the funds attracted to ensure sustainable development of the Arctic. In 2019, compared to the previous year, specific investments per unit of water pollution increased by 76.15%, reaching the value I_{wat} = 8.7 rubles per m^3; the increase in specific investments in the protection, rational use and recultivation of land amounted to 114.73%, reaching the value I_{land} = 74.7 thousand rubles per hectare; in measures to protect atmospheric air — 24.76%, reaching the value I_{atm} = 7.0 thousand rubles per t; the increase in specific investments in fixed assets intended for the disposal and recycling of production and consumption waste amounted to 30.9%, reaching the value I_{waste} = 8.2 rubles per t. In 2020, the size of all specific investments per unit of environmental pollution decreased: specific investments per unit of water pollution decreased by 63.22%, reaching the value I_{wat} = 3.2 rubles per m^3; specific investments in protection, rational use and recultivation of land decreased by 71.35%, reaching the value I_{land} = 21.4 thousand rubles per hectare; measures to protect atmospheric air decreased by 11.43%, reaching the value I_{atm} = 6.2 thousand rubles per t; the decrease in specific investments in fixed assets intended for the disposal and recycling of production and consumption waste amounted to 17.07%, reaching the value I_{waste} = 6.2 rubles per t. In 2021, on the contrary, there is an increase in indicators: I_{wat} = 4.1 rub/m^3 (an increase of 28.12%); I_{land} = 28.2 thousand rubles/ha (increase 31.78%); I_{atm} = 6.8 thousand rubles/t (increase 9.68%); I_{waste} = 13.2 rubles/t (increase 112.90%).

Thus, despite the increase in current costs for managing the sustainable development of the Arctic, their use cannot be considered fully effective and efficient: financial investments do not always lead to a reduction in pollution. Investment in sustainable development is uneven and depends on the current situation.

2. *Indicators of Arctic climate change*

In recent years, the Arctic climate has begun to change noticeably. The reason for this is, on the one hand, warming caused by greenhouse gases in the atmosphere, which is largely pro-

[6] Authors' calculations.

duced by anthropogenic activities; on the other hand — natural cyclical processes of temperature fluctuations. While the causes may be different, the result is the same. As long as the Arctic remained one of the most inaccessible places on the planet, scientific theories about its geopolitical and economic importance were perceived as pure abstraction. However, the situation has changed in recent years. Over the past half-century, the Arctic has warmed three times faster than the Earth's surface as a whole. The speed of these changes is increasing. AMAP, a research organization in Norway that studies climate change in the Arctic, has predicted that the average annual surface temperature in the Arctic will increase by 3.3–10°C by 2100 compared to annual averages for 1985–2014 [7]. The melting of permafrost and glaciers is already evident, as well as a larger and earlier clearing of the water surface from ice and land surface from snow cover. According to the AMAP report "Climate change in the Arctic. Main trends and impacts", the Arctic has undergone significant, in many ways critical, climatic changes from 1971 to the present (Fig. 4).

[7] Climate change in the Arctic. Key Trends and Impacts: Arctic Monitoring and Assessment Program 2021. URL: https://www.amap.no/documents/download/6887/inline#:~:text (accessed 23 July 2023).

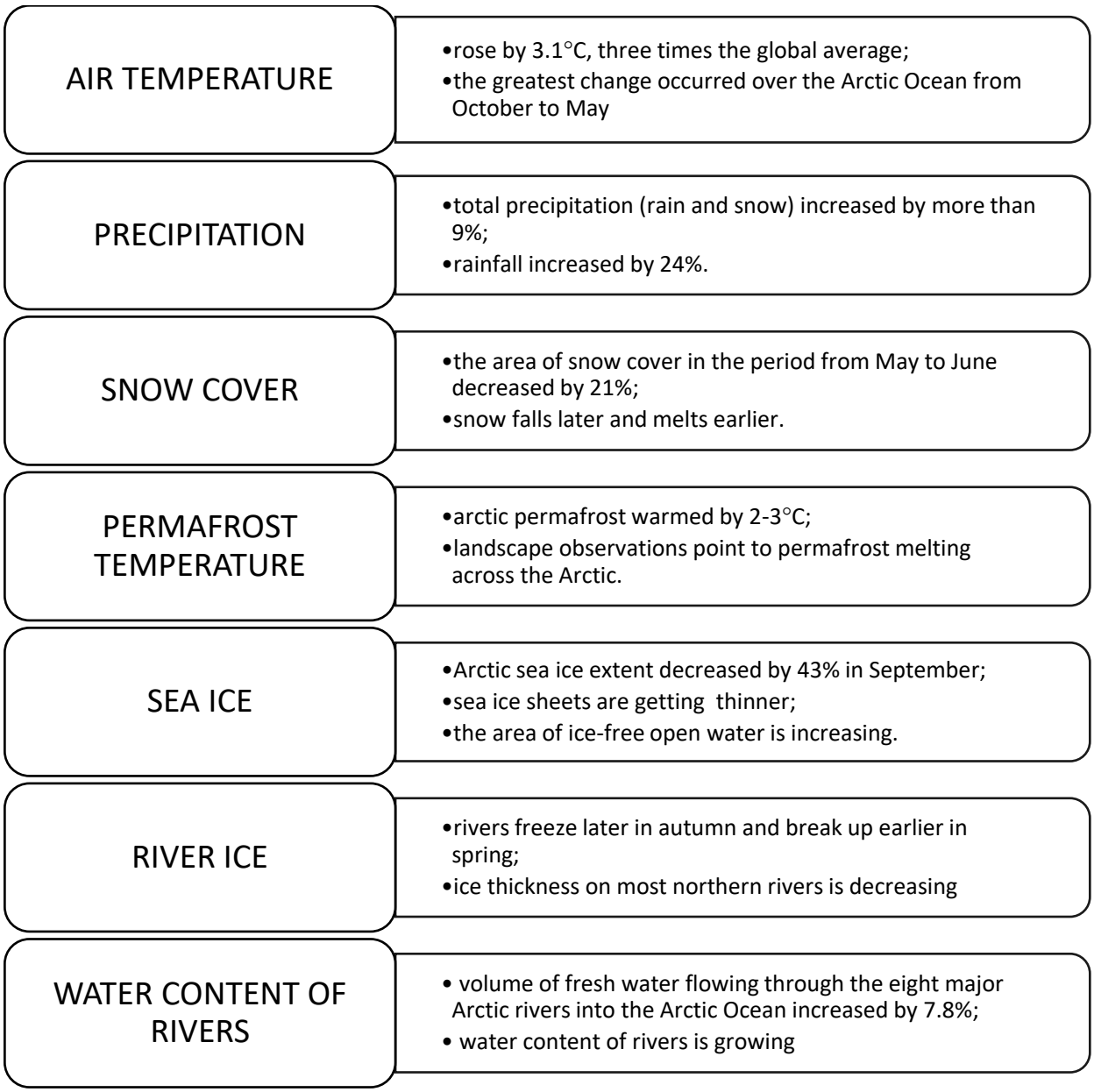

Fig. 4. Climate changes in the Arctic [8].

From 1971 to 2019, the average annual surface air temperature in the Arctic has increased by 3.1°C, which is three times faster than the global average. This conclusion is based on AMAP instrumental data with interpolation applied over the Arctic Ocean, where observations are sparse. The largest change in air temperature over this 49-year period occurred over the Arctic Ocean between October and May, averaging 4.6°C, with a peak warming of 10.6°C in the northeastern Barents Sea.

In the Arctic zone of the Russian Federation the situation was similar. In all sectors of the Russian Arctic, the trend for an increase in average temperature has been evident since the late

[8] Compiled by the authors based on materials from AMAP "Climate Change in the Arctic. Key Trends and Impacts: Arctic Monitoring and Assessment Program 2021". URL: https://www.amap.no/documents/download/6887/inline#:~:text (accessed 23 July 2023).

1970s and has sharply intensified in the 21st century. In 2021, the temperature increased by 1.9°C. The warming for 45 years from 1976 to 2021 for the Russian Arctic as a whole is 0.69°C/10 years [9].

Based on observational and modeling data, total Arctic annual precipitation (rain and snow combined) increased by more than 9% from 1971 to 2019. Rainfall increased by 24% over this period, with no overall trend in Arctic snowfall. The greatest increase in precipitation occurs during the cold season, from October to May. Together with the disruption of glaciological processes in the Arctic, the increasing volume of precipitation leads to an increase in the water content of rivers: the volume of fresh water flowing through the eight main Arctic rivers into the Arctic Ocean increased by 7.8%.

A distinctive feature of the Arctic zone of the Russian Federation is a significant area of permafrost, which is characterized by low temperatures and a small layer of seasonal thawing. The depth of permafrost in some places reaches 1.5 km [18, Skuf'in P., Chuvardinskiy V., p. 191–195]. Since the 1970s, Arctic permafrost has warmed by 2-3°C. In many colder permafrost areas, rates of warming over the past 20 years have been greater than at any time since 1979. The seasonally thawed layer has become deeper in many areas since the 1990s, and landscape observations indicate permafrost melting across the Arctic.

Climate change has had a huge impact on the ice cover of the Arctic seas. Late-summer Arctic sea ice has shrunk by 43% in half a century, becoming thinner. Strong, sustained winds over ice-free sea surfaces generate strong storms and gales.

The combined effects of long-term warming (higher water temperatures, longer ice-free seasons, thawing permafrost) and extreme events (storm waves and ripples) cause increased erosion. Coastal erosion is accelerating in many parts of the Arctic, which have some of the highest erosion rates on Earth.

Climate change is thus a pressing issue in the Arctic, where temperatures are rising much faster than the global average, and widespread changes in precipitation, snow cover, permafrost, sea and continental ice, and extreme events are transforming the Arctic environment, having long-lasting impacts on sustainable development. These changes have long-term consequences for the Arctic.

3. Impact of climate change on new opportunities and new risks for sustainable development of the Russian Arctic

Warming in the Arctic provides new opportunities, but also leads to new risks for sustainable development. New development opportunities were appreciated by experts, politicians, and industrialists around the world. This has intensified the struggle for the Arctic, which is taking place in several directions.

[9] State report “On the state and protection of the environment of the Russian Federation in 2021”. Moscow, Ministry of Natural Resources and Environment of Russia; Lomonosov Moscow State University, 2022, 684 p.

Firstly, and most importantly, these are new opportunities for the exploitation of mineral resources. The Russian Arctic is extremely rich in mineral resources (Fig. 5). However, most of the deposits are located in remote places with harsh climatic conditions, beyond the Arctic Circle.

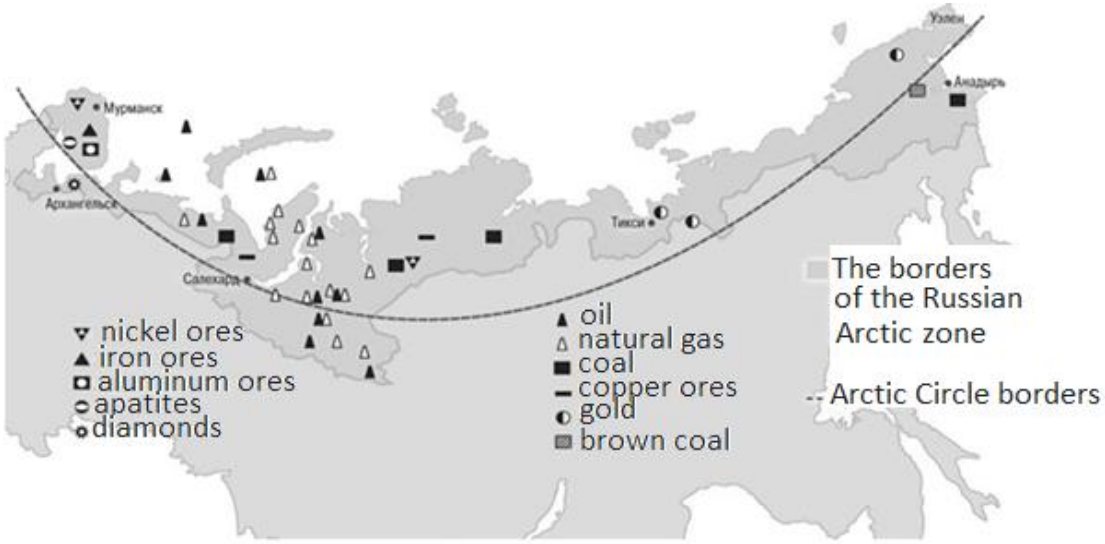

Fig. 5. Mineral deposits in the Russian Arctic [10].

Due to the melting of glaciers, multi-year ice and snow, and a general warming of the climate, extracting and exporting natural resources in the Arctic will become much easier and cheaper. Deposits that were previously impractical to exploit are becoming accessible, moving from the category of off-balance sheet to on-balance one. Warming also opens up new opportunities for geological exploration and the search for new deposits. According to experts, the Arctic contains 13% of the world's undiscovered oil reserves and 30% of gas, rich deposits of uranium and rare earth minerals, as well as gold and diamonds [11]. However, the majority (84%) of particularly significant energy minerals are located in the shelf strata [19, Höök M., Bardi U., Feng L., et al., p. 1999–2001]. Industry representatives from many countries are interested in the Arctic as an area for industrial development of mineral deposits. This is due to the value of the natural resources that are located there.

The importance of the Arctic as a source of resources for Russia is obvious. The Arctic zone of Russia contains (from all-Russian reserves): 40% of gold, 80% of oil, 50-90% of gas, nickel, copper, antimony, cobalt, tin, tungsten, mercury, apatite, phlogopite, 90% of chromium and manganese, 99% of platinum metals, 100% of local diamonds and vermiculite; from the world's reserves: 30% of diamonds and natural gas, 20% of nickel, 50% of apatite, 35% of niobium, 15% of copper, platinum metals and tin, 10% of oil (excluding shelf) and cobalt, 6-8% of tungsten and mercury [20, Petrov V.A., Volkov A.V., p. 191–192]. The Arctic zone of the Russian Federation accounts for about 30 billion barrels of oil and 33 trillion m^3 of gas out of the expected 90 billion barrels of oil and 50 trillion m^3 of gas, respectively. American experts counted 11 billion barrels of oil in the Bar-

[10] Parlamentskaya gazeta [Parliamentary newspaper], dated 02.12.2016. URL: https://www.pnp.ru/politics/arktika-nastoyashhee-i-budushhee.html (accessed 23 July 2023).
[11] World Energy Outlook 2022. URL: https://www.iea.org/reports/world-energy-outlook-2022/ (accessed 23 July 2023).

ents Sea alone, which at current prices is equivalent to 1.25 trillion dollars [12]. As for gas, according to the Annual Energy Outlook (AEO) for 2023, 11 trillion m^3 have been discovered in the Arctic zone of the Russian Federation [13]. The region is also rich in biological resources, including fur-bearing animals (arctic fox, sable, mink, etc.). The number of reindeer amounts to millions. The Arctic and subarctic seas are home to the largest populations of commercial fish. Based on this, we can conclude that the Arctic is an important component of the Russian economy. This territory is of strategic importance for our country, it provides a geo-economic position in the world and influences the internal development of industry related to the use of natural resources extracted in the Arctic.

The total value of Arctic resources could be trillions of dollars. Attention to the Arctic is increasing precisely because of such significant potential income; every country wants to improve its economic condition as a result of sustainable development, including through rational environmental management in the process of mining and processing minerals and the exploitation of other natural resources, and climate change opens up new opportunities for this.

Secondly, new logistics opportunities predetermined the struggle for trade routes. What is the Arctic in this case? The Arctic means billions of dollars, the opening of new zones of influence and, of course, new trade routes. Melting glaciers are opening up previously inaccessible trans-Arctic shipping routes, and this has a huge impact on economic competition in the Northern Hemisphere. The main actors in this rivalry are 3 countries: Russia, China and the USA. Clearing the water surface of ice makes the Northern Sea Route accessible along its entire length and increases navigation time. Climate change will transform the world's logistical routes: transporting sea cargo between the western and eastern hemispheres through the Arctic will be easier, safer, faster, and therefore commercially reasonable. However, the use of the Northern Sea Route leads to new risks. First of all, there are risks of natural genesis: the Arctic waters, free of ice, are exposed to strong winds: as a result, storm waves and ripples arise, significantly complicating navigation. There is also risk associated with the creation and development of infrastructure. The Northern Sea Route requires high-tech ports and cargo hubs capable of receiving, sorting and dispatching cargo. Most of these facilities are under construction. However, under the sanctions imposed on Russia by unfriendly countries, these projects are becoming increasingly difficult to implement. It was planned to use foreign technologies, equipment and machinery in the construction and operation of port and warehouse facilities, but the supply of many of them was suspended or completely cancelled. Warming also leads to the thawing of permafrost, which forces changes in construction technologies in the Arctic and leads to a multiple increase in the cost of infrastructure projects. The expansion of the icebreaker fleet occupies a separate place. Currently, the Russian Federation has relied on the construction of powerful icebreakers — they are necessary for the

[12] World Energy Outlook 2022. URL: https://www.iea.org/reports/world-energy-outlook-2022/ (accessed 23 July 2023).
[13] Annual Energy Outlook 2023. URL: https://www.eia.gov/outlooks/aeo (accessed 23 July 2023).

operation of the Northern Sea Route. Plans for their construction may be disrupted under sanctions. In addition, icebreakers built with great difficulty and significant financial costs may not be in demand both due to political restrictions and due to further warming and accelerated melting of ice.

Thirdly, Arctic development plays a huge role in the development of the mining and processing industries. The Arctic provides about 11% of Russia's national income and 22% of all Russian exports. Russia mines almost all of its diamonds, apatite nepheline and copper ores, phlogopite, vermiculite, 97% of platinum, 90% of nickel, 95% of gas, 60–80% of oil, antimony, rare and rare earth metals in these regions. Warming will increase access to mineral resources. Advances in technology and better accessibility mean that the costs of extracting and processing Arctic natural resources will only fall in the future. At the same time, it is necessary to take into account the requirements of decarbonization of production aimed at reducing greenhouse gas emissions. The Russian Federation has made commitments to sequester CO_2 emissions up to full carbon neutrality. This constrains the potential for expansion of mining and processing industries in the Arctic. It should also be taken into account that due to the high vulnerability and low self-cleaning ability of Arctic eco-systems, the consequences of major man-made disasters and accidents will be especially significant. As a result, Arctic industrial facilities and technologies for the extraction, transportation and processing of minerals should have an increased "safety margin" in the environmental aspect. Besides, materials and technologies used in the construction of industrial buildings and structures should have special characteristics that can withstand extreme natural and climatic conditions [21, Kalinin M.O., Korkishko A.N., p. 98], which leads to an increase in the cost of economic activity of enterprises in the Arctic. The thawing of permafrost negatively affects the development of industrial enterprises in the Arctic, resulting in land subsidence and swamping of territories. This leads to damages of buildings and structures, disruption of production and social infrastructure. Over the past fifty years, the sustainability of buildings and infrastructure built in the permafrost zone has decreased significantly. Particularly negative consequences of climate change are noted on the Taimyr Peninsula, where almost all industrial buildings and structures, transport lines, including pipelines, were damaged [22, Tazayan Yu., p. 67–69]. In addition, as in the case of the construction and operation of port infrastructure, geopolitical factors related to sanctions against Russia increase the risk.

Fourthly, climate change opens up new opportunities in fishing and fish farming. More than a third of Russian commercial fish and seafood is harvested in the Arctic, and about 20% of canned fish is produced. An increase in water temperature and a decrease in the thickness and duration of the sea ice cover lead to the fact that more and more species of subarctic fish and marine mammals are migrating to the Arctic seas, which were previously not suitable for their livelihoods. This increases the possibilities of industrial fishing in the Arctic parts of the Barents, Bering, and Okhotsk seas. Our research shows that the economic benefits of fishing have a significant positive impact on the social development of coastal Arctic settlements [23, Samarina V.P., Skufina

T.P., p. 48–56]. Salmon farming and other forms of aquaculture are also spreading northwards in some parts of the North Atlantic Arctic, creating additional economic opportunities. The social risk of artificial fish farming is possible competition with local fisheries. The ecological risk is the spread of parasites such as salmon lice to local wild fish populations.

Fifthly, there are expanding tourism business opportunities in the Arctic, which creates competition for tourists. Tourism has entered the daily life of almost a third of the population of our planet. Over 9 months in 2022, 10.2 million foreigners visited our country, which cannot but have an impact on the economy of our country. Arctic routes are attracting more and more tourists. Due to the decrease in ice area in the Arctic, new routes are appearing; tourists are ready to pay a lot of money to look at the northern lights and communicate with the local population. Arctic cruise tourism has grown. Here are just a few examples: the number of cruise ship passengers in Iceland increased from 265,935 in 2015 to 402,834 in 2017, an increase of more than 66%; cruise passenger trips in northern Norwegian ports increased by 33% between 2014 and 2019; the number of cruise ship passengers on Svalbard increased from 39,000 in 2008 to 63,000 in 2017; in Greenland, the number of passengers increased from 20,000 to 30,000 over the same period. Overall, the number of visitors to the high Arctic grew from 67,752 in 2008 to 98,238 in 2017, an increase of more than 57% [24, Ren C., James L., Pashkevich A. et al., pp. 5–7; 25, Zhilenko V.Yu., pp. 149–152].

Among Russian residents and foreign visitors, there is a noticeable trend towards increasing interest in Arctic continental, predominantly ecological, natural tourism [26, Abakumova Yu.M., pp. 36–38]. For example, the “Russian Arctic” tourist park: in summer 2019, it was visited by 1306 people from 44 countries [14]. The routes “Chasing the Northern Lights”, “Visiting the Polar Bear” and other programs developed by Russian tour operators are in stable demand among tourists. However, it should be taken into account that natural and climatic features, unique landscapes, inaccessibility, which, among other things, form the attractiveness of the Arctic for tourists, ultimately affect the logistics, infrastructure and economic aspects of organizing tourism activities. Experts also note problems with permitting visits to some Arctic territories and specially protected areas [27, Vasilieva A.V., Volkov A.D., Karginova-Gubinova V.V. et al., pp. 5–8].

Despite this, Arctic tourism is beginning to have a noticeable impact on the Russian economy: the northern territories are developing, new jobs are emerging, new educational and cultural programs that help keep young people in the northern territories are appearing, the economy of the Arctic regions is diversifying, more income is coming to the budgets of various levels. The COVID-19 pandemic disrupted these trends in 2020, with most Arctic tourism trips canceled or postponed. Political reasons led to the fact that Russia and the countries that joined the sanctions, including all circumpolar countries, practically stopped exchanging tourists. Deterioration of relations between the countries and reduction of incomes of the population are the most important risks to the development of Arctic tourism. In addition to political risks, there are socio-cultural

[14] Russian Arctic: official website of the national park. URL: http://www.rus-arc.ru/ (accessed 23 July 2023).

ones associated with the impact of tourism on local communities, as well as the aggravation of environmental and economic risks accompanying the development of tourism infrastructure.

Sixthly, climate change opens up new opportunities for strengthening the military presence in the Arctic and intensifies the struggle for geopolitical influence. The significant military potential of the Arctic cannot be ignored. The state borders of a number of circumpolar countries run along the Arctic Ocean. Defense industry enterprises, land, air and sea military bases, airfields and other military infrastructure facilities of circumpolar states are located in the Arctic. The Cold War ended many years ago and it would seem that relations between Russia and the "collective West", including European countries and the United States, should have normalized. However, the military operation in Ukraine, which began in February 2022, led to a sharp increase in tension between Russia and, primarily, the United States. Thus, the significance of Russia's military presence in such an important region of the Earth as the Arctic has increased. Russia has long been building new military (land and sea) bases on the northern continental territories and on the islands of the Arctic seas, including Kotelnyy Island. Military exercises of the Russian army are actively taking place in Arctic latitudes. At the same time, the armies of other circumpolar countries also regularly conduct their exercises in the Arctic territories. In addition, circumpolar countries are actively working to create military equipment capable of operating in high Arctic latitudes, since material and technical support is extremely important for increasing their military presence in the Arctic. Climate change allows increasing the range of weapons capable of operating in Arctic temperatures, expanding military bases, and making the military personnel's stay there more comfortable.

4. Arctic environmental pollution as a risk for sustainable development

Arctic ecosystems, like no other, are susceptible to environmental pollution. The reason for this is the reduced rate of self-cleaning processes due to low temperatures, chemical and physical characteristics of soils, and degraded vegetation.

The peculiarity of environmental management in the Arctic, which forms the external effects of the industrial development of Arctic territories, is that industrial, logistics and other activities here are carried out, as a rule, by large corporations operating on the basis of the corporate standards and rules they have developed. As our research has shown, the largest Russian corporations with production assets in the Arctic are actively modernizing equipment and developing technologies that reduce the flow of pollutants into natural areas, including the emission of greenhouse gases into the atmosphere [4, Samarina V.P., pp. 45–49; 5, Skufina T.P., Samarina V.P., Samarin A.V., pp. 57–58]. As a result, for the period 2017–2019, there is a reduction in emissions of air pollutants — from 3,356.5 thousand tons to 3,284.6 thousand tons, wastewater discharge — from 638 million m3 to 619 million m3, waste recycling is expanding — from 18.7 million tons to 35.5 million tons. Previously, we noted the effect of decoupling in the economic development of the Murmansk Oblast, when an increase in production volumes was accompanied by a decrease in the load on the natural environment [28, Samarina V.P., pp. 26–29]. The processes of greening

production largely contribute to maintaining this trend. A special place is occupied by the social effects and social significance of decarbonization projects. Greenhouse gas sequestration is part of the project of ensuring sustainable development for the benefit of future generations, which has become the humanitarian basis of modern globalized society.

The dynamics of greenhouse gases are monitored in the Russian Arctic at three stations located in the settlements of Teriberka, Tiksi and Novyy Port. The results of observations at Teriberka and Tiksi stations are of particular interest because they are located in conditions close to natural (Table 1).

Table 1

Concentrations of carbon dioxide and methane in the Russian Arctic [15]

Year	Teriberka				Tiksi			
	CH_4, ppb		CO_2, ppm		CH_4, ppb		CO_2, ppm	
	Value	Annual growth	Value	Annual growth	Value	Annual growth	Value	Annual growth
2012	1910.2	---	396.6	---	1910.2	---	396.1	---
2013	1907.8	-2.4	398.8	2.2	1915.1	4.9	399.1	3.0
2014	1913.5	5.7	400.7	1.9	1930.8	15.7	400.7	1.6
2015	1924.4	10.9	402.2	1.5	1940.1	9.3	403.2	2.5
2016	1946.7	22.3	405.7	3.4	1946.4	6.3	406.1	2.9
2017	1947.1	0.4	409.1	3.5	1956.7	10.3	408.7	2.6
2018	1950.4	3.3	411.4	2.2	1960.4	3.7	411.3	2.6
2019	1961.8	11.4	414.1	2.7	1983.7	23.3	414.3	3.0
2020	1980.4	18.6	415.8	1.8	1993.6	9.9	416.5	2.2
2021	1999.1	18.7	418.5	2.6	2014.1	20.5	419.1	2.6
Growth for 2012–2021								
2012–2021	88.9 ppb 4.65%		21.9 ppm 5.52%		103.9 ppb 5.44%		23.0 ppm 5.81%	

The study for the ten-year period from 2012 to 2021 showed an almost constant increase in the concentrations of carbon dioxide and methane. Over ten years, CO_2 concentration increased by almost 6%, reaching a maximum (418.5 ppm in Teriberka and 419.1 ppm in Tiksi) in 2021; CH_4 concentration increased by 5%, also reaching a maximum (1999.1 ppb in Teriberka and 2014.1 ppb in Tiksi) in 2021. These values are similar to those reported by the Barrow Arctic Research Centre in Alaska [16].

In 2020, the growth rate of CO_2 concentration decreased to 1.8–2.2 ppm per year. The probable reason for this was the reduction in production caused by the COVID-19 pandemic. In 2021, greenhouse gas emissions increased again (an increase of 2.6 ppm per year). In the same year, there was a significant increase in the concentration of CH_4 in the atmosphere (18.7 ppb in Teriberka and 20.5 ppb in Tiksi).

The energy crisis in the circumpolar countries, caused by the rising cost of energy resources against the backdrop of a reduction in their supplies from Russia due to political and economic reasons, leads to an increase in the share of coal, fuel oil, and wood among energy sources.

[15] Compiled by the authors based on materials from the State report "On the state and protection of the environment of the Russian Federation in 2021". Moscow, Ministry of Natural Resources and Environment of Russia; Moscow State University named after M.V. Lomonosova, 2022, 684 p.
[16] Barrow Arctic Research Centre. URL: https://polarpedia.eu/ru/arkticzeskij-issledowatielskij-centr-barrou/ (accessed 23.07.2023).

The use of such energy resources leads to an increase in greenhouse gases and a weakening of the policy of decarbonization of production [29, Shutko L.G., Samorodova L.L., p. 65]. The risks of sustainable development of the Arctic are increasing manifold.

5. Effects arising in the process and as a result of the implementation of new opportunities in the Arctic territories in a warming climate

The effects that arise in the process and as a result of the implementation of new opportunities for the Arctic territories under warming conditions strengthen or weaken the risk of long-term sustainable development of the Arctic. In our understanding, this is a complex of factors caused by climate change, which have a significant impact on the development of the production sector of the Russian Arctic, the livelihoods of the population of these territories, and on the environment. A distinction is made between positive and negative effects. The positive effects of new opportunities in the Arctic territories in a warming climate are weakening, and the negative effects, accordingly, are increasing the risk of sustainable development. Based on scientific research, the effects of new opportunities in the Arctic territories in the context of climate change were systematized [4, Samarina V.P., pp. 56–68; 12, Hamilton L.C., Saito K., Loring P.A., et al., pp. 116–119; 16, Socio-economic development..., pp. 56–80; 30, Volkov A.D., Tishkov S.V., Karginova-Gubinova V.V. et al., pp. 211–219; 31, Lipina S.A., Smirnova O.O., Kudryashova E.V. et al., pp. 128–131; 32, Larchenko L.V., Gladkiy Yu.N., Sukhorukov V.D., pp. 2–7; 33, Skufina T.P., Mitroshina M.N., pp. 88–93; 34, Kryukov V.A., Kryukov Ya.V., pp. 35–42] (Table 2).

Table 2

Effects of implementation of new opportunities of the Arctic territories in the conditions of climate change, determining the risk of sustainable development

Positive effects that reduce risk	Negative effects that increase risk
Ecological	
Collection of pollutants, recycling of production and consumption waste, treatment of discharged wastewater, etc.	Pollution of the atmosphere, water bodies, land destruction, degradation of flora and fauna; increase in population morbidity, etc.
Innovative	
Introduction of research developments and high-tech technologies that meet the interests of numerous stakeholders; inflow of investment.	Increased unemployment of the Arctic population as a consequence of the introduction of innovative and digital technologies that reduce employment.
Investment	
Investing in production — growth in productivity, quality of products; investing in environmental protection measures — reducing the anthropogenic load on the natural environment; investing in the population — growth of human capital.	Corruption, ineffective spending of funds; freezing socio-economic development projects due to outflow of investments caused by the unstable economic situation.
Infrastructure	
Development of transport infrastructure in the interests of business and the population; development of social infrastructure (health care, education, etc.) together with production; development of logistics routes ensures accessibility of goods and services	Destruction of natural ecosystems; significant, often irreversible changes of landscapes, acquisition of land for industrial and residential areas.
Social	
Increasing the attractiveness of the Arctic territories for living due to an increase in the quality of life, wages, and developed social infrastructure.	Unemployment, industrial morbidity among those employed in hazardous enterprises; migration outflow of the working population.

In addition to the positive effects noted above, the possibility of ensuring sustainable development of the Russian Arctic is increasing due to the strengthening of national security at the global level, progressive development of industrial and logistics corporations operating in the Arctic. The risk of accidents of natural and anthropogenic genesis is increasing. The weakening of international cooperation of circumpolar countries, including in the field of environmental protection and environmental management, increases the risk of sustainable development both for the Russian Arctic territories and for the territories under the jurisdiction of other states. Undoubtedly, new risks and new opportunities for sustainable development of the Russian Arctic are related to climate change.

Conclusion

Thus, climate change is a global external factor in the development of the Arctic, which has a long-term impact on people's livelihoods, the Arctic, national and global economies, and environmental management, opening up new opportunities on the one hand, and increasing the risks of sustainable development on the other.

Risk is a key concept of sustainable development and is a combination of the probability of a hazardous event and the severity of its consequences for the balanced development of the Arctic economy, population, and ecosystems. The termination of Russia's international cooperation with other circumpolar countries in the field of environmental protection, rational use of natural resources, and counteraction to global warming contributes to increasing the risk of sustainable development in the Arctic. Currently, all official meetings of the Arctic Council, which Russia chairs until 2023, are suspended until further notice. All other cooperation between circumpolar countries and the Russian Federation on environmental protection, ecosystem conservation, detailed and thorough study of natural, anthropogenic, socio-economic processes in the Arctic, expanded monitoring and documentation of changes, including climate change, development and implementation of mechanisms to limit further warming have been suspended. Cooperation between the Arctic regions of the circumpolar countries and the adjacent Russian Arctic regions has also been terminated. In previous years, such cooperation was the basis of regional strategies.

Under these conditions, it seems advisable to act in three main directions in order to reduce the risk of sustainable development:

- study in detail natural, anthropogenic, socio-economic processes in the Arctic in order to better understand the consequences of climate change;
- expand monitoring and documentation of changes in the Arctic;
- based on new data obtained, develop and implement mechanisms to limit and minimize the negative effects of further warming, including at the international level;
- develop and implement projects that contribute to the discovery of new opportunities for sustainable development of the Arctic and the process of positive changes aimed at

harmonizing relations between the economic, environmental and social spheres to meet the needs of environmental users of the Arctic territories now and in the long term.

References

1. Korchak E.A., Serova N.A., Emelyanova E.E., Yakovchuk A.A. Human Capital of the Arctic: Problems and Development Prospects. *IOP Conference Series: Earth and Environmental Science*, 2019, vol. 302, art. 012078. DOI: https://doi.org/10.1088/1755-1315/302/1/012078
2. Skripnuk D.F., Samylovskaya E.A. Human Activity and the Global Temperature of the Planet. *IOP Conference Series: Earth and Environmental Science*, 2018, vol. 180, art. 012021. DOI: https://doi.org/10.1088/1755-1315/180/1/012021
3. Dauvalter V.A., Kashulin N.A. Assessment of the Ecological State of the Arctic Freshwater System Based on Concentrations of Heavy Metals in the Bottom Sediments. *Geochemistry International*, 2018, vol. 56, no. 8, pp. 842–856. DOI: https://doi.org/10.1134/S0016702918080037
4. Samarina V.P. *Regional'naya ekonomika: Severo-Arkticheskie territorii Rossii* [Regional Economy: The North-Arctic Territories of Russia]. Apatity, Universitetskaya kniga Publ., 2022, 141 p. DOI: https://doi.org/10.47581/2021/03.Samarina.002 (In Russ.)
5. Skufina T.P., Samarina V.P., Samarin A.V. Concerning Processes of Decarbonization of Production and Prospects for the Arctic as a Carbon-Neutral Territory. *Ugol'*, 2022, no. 6 (1155), pp. 54–58. DOI: https://doi.org/10.18796/0041-5790-2022-6-54-58
6. Samarina V.P., Subbotina E.V. Economic Systems Management on the Assumption of Environment Changing. *Mining Informational and Analytical Bulletin (Scientific and Technical Journal)*, 2016, no. 11, pp. 135–142
7. Zaikov K.S., Kondratov N.A., Kudryashova E.V., Lipina S.A., Chistobaev A.I. Scenarios for the Development of the Arctic Region (2020–2035). *Arktika i Sever* [Arctic and North], 2019, no. 35, pp. 4–19. DOI: 10.17238/issn2221-2698.2019.35.5
8. Skufina T.P., Bazhutova E.A., Samarina V.P. Entrepreneurial Activity in the Russian Arctic Territories Compared to the All-Russian Situation. *Arktika i Sever* [Arctic and North], 2019, no. 37, pp. 51–68. DOI: 10.17238/issn2221-2698.2019.37.51
9. Suopajärvi L., Poelzer G.A., Ejdemo T., Klyuchnikova E., Korchak E. Social Sustainability in Northern Mining Communities: A Study of the European North and Northwest Russia. *Resources Policy*, 2016, no. 47, pp. 61–68. DOI: https://doi.org/10.1016/j.resourpol.2015.11.004
10. Brigt D., Bay-Larsen I., Skorstad B. *The Will to Drill — Mining in Arctic Communities*. Springer, Springer Polar Sciences, 2017, 228 p. DOI: https://doi.org/10.1007/978-3-319-62610-9
11. Baranov S., Skufina T., Samarina V. Regional Environment for Gross Domestic Product Formation (The Case of Russia Northern Regions). *Advanced Science Letters*, 2018, vol. 24, no. 9, pp. 6335–6338. DOI: https://doi.org/10.1166/asl.2018.13047
12. Hamilton L.C., Saito K., Loring P.A., Lammers R.B., Huntington H. P. Climigration? Population and Climate Change in Arctic Alaska. *Population and Environment*, 2016, no. 38 (2), pp. 115–133. DOI: https://doi.org/10.1007/s11111-016-0259-6
13. Andrew R. Socio-Economic Drivers of Change in the Arctic: AMAP Technical Report. In: *AMAP Technical Report No. 9. Arctic Monitoring and Assessment Programme (AMAP)*. Oslo, Norway, 2014, 33 p.
14. Kudryashova E.V., Lipina S.A., Zaikov K.S., Bocharova L.K. Arctic Zone of the Russian Federation: Development Problems and New Management Philosophy. *The Polar Journal*, 2019, vol. 9, iss. 2, pp. 445–458. DOI: https://doi.org/10.1080/2154896X.2019.1685173
15. Samarina V.P. *Antikrizisnoe upravlenie regionami Rossii* [Anti-Crisis Management of Russian Regions]. Saint-Petersburg, 2021, 129 p. DOI: https://doi.org/10.47581/2021/03.Samarina.001 (In Russ.)
16. Bazhutova E.A., Biev A.A., Emel'yanova E.E., Samarina V.P., Serova V.A., Serova N.A., Skufina T.P. *Sotsial'no-ekonomicheskoe razvitie severo-arkticheskikh territoriy Rossii: monografiya* [Socio-Economic Development of the North-Arctic Territories of Russia]. Apatity, 2019, 119 p. DOI: https://doi.org/10.25702/KSC.978.5.91137.408.2 (In Russ.)

17. Samarina V.P., Skufina T.P., Savon D.Y., Shinkevich A.I. Management of Externalities in the Context of Sustainable Development of the Russian Arctic Zone. *Sustainability*, 2021, vol. 13 (14), art. 7749. DOI: https://doi.org/10.3390/su13147749
18. Skuf'in P., Chuvardinskiy V. Continental Glaciation and Conditions for the Formation of Exaration Relief on the Territory of the Baltic Shield. *Science and Innovations 2021: Development Directions and Priorities*, 2021, vol. 1, pp. 191–195. DOI: https://doi.org/10.34660/INF.2021.38.79.027
19. Höök M., Bardi U., Feng L., Pang X. Development of Oil Formation Theories and Their iImportance for Peak Oil. *Marine and Petroleum Geology*, 2010, vol. 27, iss. 9, pp. 1995–2004. DOI: https://doi.org/10.1016/j.marpetgeo.2010.06.005
20. Petrov V.A., Volkov A.V. Resource Potential of the Arctic Zone of Russia. *Scientific Works of the Free Economic Society of Russia*, 2021, no. 228 (2), pp. 181–195. DOI: https://doi.org/10.38197/2072-2060-2021-228-2-181-195
21. Kalinin M.O., Korkishko A.N. Analiz primeneniya innovatsionnykh materialov dlya resheniya problem bezopasnogo stroitel'stva v usloviyakh Arktiki [Analysis of the Use of Innovative Materials to Solve the Problems of Safe Construction in the Arctic]. In: *Arktika: sovremennye podkhody k proizvodstvennoy i ekologicheskoy bezopasnosti v neftegazovom sektore* [Arctic: Modern Approaches to Industrial and Environmental Safety in the Oil and Gas Sector]. Tyumen, 2022, pp. 96–99. (In Russ.)
22. Tazayan Yu. Stroitel'stvo zdaniy i sooruzheniy na vechnoy merzlote [Construction of Buildings and Structures on Permafrost]. *Molodoy uchenyy* [Young Scientist], 2020, no. 48 (338), pp. 67–72.
23. Samarina V.P., Skufina T.P. The Estimation of Remuneration Efficiency in Monopsony: Concerning the Arctic Fishing Industrial Cluster. *Arktika i Sever* [Arctic and North], 2022, no. 47, pp. 43–56. DOI: 10.37482/issn2221-2698.2022.47.43
24. Ren C., James L., Pashkevich A., Hoarau-Heemstra H. Cruise Trouble. A Practice-Based Approach to Studying Arctic Cruise Tourism. *Tourism Management Perspectives,* 2021, vol. 40, art. 100901. DOI: https://doi.org/10.1016/j.tmp.2021.100901
25. Zhilenko V.Yu. Sea Cruise Tourism in Specially Protected Natural Areas of Arctic. *Service and Tourism: Current Challenges*, 2021, vol. 15 (3), pp. 149–156. DOI: https://doi.org/10.24412/1995-0411-2021-3-149-156
26. Abakumova Yu.M. Concept and Some Features of Tourism in the Arctic. *Forum molodykh uchenykh* [Young Scientists Forum], 2021, no. 4 (56), pp. 34–40.
27. Vasilieva A.V., Volkov A.D., Karginova-Gubinova V.V., Tishkov S.V. Opportunities of Development of Eco-Tourism in the Karelian Arctic in the Conditions of the Existing Environmental and Social Challenges. *Journal Risk Financial Management*, 2022, no. 15 (10), art. 484. DOI: https://doi.org/10.3390/jrfm15100484
28. Samarina V.P. Decoupling Effect in Economic Development of the Murmansk Region. *The North and the Market: Forming the Economic Order*, 2014, vol. 2, no. 39, pp. 24–30.
29. Shut'ko L.G., Samorodova L.L. Carbon Footprint and Decoupling Effect in Kuzbass Coal Mining. *Ugol'*, 2022, no. 2 (1151), pp. 61–66. DOI: https://doi.org/10.18796/0041-5790-2022-2-61-66
30. Volkov A.D., Tishkov S.V., Karginova-Gubinova V.V., Shcherbak A.P. Environmental Problems of the Arctic Region: Its State and Dynamics as Perceived by the Population (Results of a Sociological Survey in Arctic Karelia). *Region: Economics and Sociology*, 2021, no. 3 (111), pp. 203–239. DOI: https://doi.org/10.15372/REG20210309
31. Lipina S.A., Smirnova O.O., Kudryashova E.V., Belyaevskaya-Plotnik L.A., Bogdanova Yu.N., Bocharova L.K., Zaikov K.S., Kreydenko T.F., Lipina A.V., Sivobrova I.A., Sokolov M.S., Sorokina N.Yu., Stepanova V.V., Cherepovitsyn A.E. *Arktika: strategiya razvitiya: monografiya* [Arctic: Development Strategy]. Arkhangelsk, 2019, 338 p. (In Russ.)
32. Larchenko L.V., Gladkiy Yu.N., Sukhorukov V.D. Resources for Sustainable Development of Russian Arctic Territories of Raw Orientation. *IOP Conference Series: Earth and Environmental Science. 4th Intern. Sci. Conf. "Arctic: History and Modernity"*, 2019, vol. 302 (1), art. 012121. DOI: https://doi.org/10.1088/1755-1315/302/1/012121
33. Skufina T.P., Mitroshina M.N. Transformation of the Socio-Economic Space of the Russian Arctic in the Context of Geopolitics, Macroeconomics, and Internal Factors of Development. *Arktika i Sever* [Arctic and North], 2020, no. 41, pp. 87–112. DOI: 10.37482/issn2221-2698.2020.41.87

34. Kryukov V.A., Kryukov Ya.V. The Economy of the Arctic in the Modern Coordinate System. *Outlines of Global Transformations: Politics, Economics, Law*, 2019, no. 12 (5), pp. 25–52. DOI: https://doi.org/10.23932/2542-0240-2019-12-5-25-52

The article was submitted 21.07.2023; approved after reviewing 28.07.2023; accepted for publication 29.07.2023

Contribution of the authors: the authors contributed equally to this article

The authors declare no conflicts of interests