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Climate change and challenges to sustainable development in the Russian Arctic

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Abstract
The Arctic region is one of the most exposed to the global climate change. Russia accounts for more than a half of the whole Arctic territory and population and allocates most of the economic activity of the region. From the Soviet time till now, the Arctic region also accounts for a substantial share of Russia's wealth. The article analyzes often ambiguous knowledge on climate change implications for the long-term economic development of the Russian Arctic. Based on the review of the key policy documents issued in Russia and ongoing and planned development programs, the study aspires to contribute more clarity on Russia's standing in the Arctic region. We aim to analyze the convergence of Russian climate and Arctic policies boosting the synergies between each other. The paper discovers, among other issues, the climate change adaptation priorities in policy areas aimed at minimizing net costs of climate change. While policies rhetorically aim at contributing to resilient and sustainable growth in the Russian North, they remain under-developed in accounting for multiple climate-related risks. Our analysis suggests that a comprehensive framework of Arctic policy measures should be centered around climate change as a core factor underlying the future of the region and should encompass two main policy dimensions: (a) strengthening the knowledge base on climate change, the adjunct risks, and emerging opportunities in the region and (b) developing the system for climate change risk management and resilience building ensuring that regional diversity and climatic and socioeconomic features of various locations are taken into serious account.

Keywords Russian Arctic · Arctic policy · Climate policy · Sustainable development · Climate change adaptation · Resilience building

JEL classification O1 · Q54 · R1

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1 Introduction

The Arctic has long been playing an essential role in economic development of Russia. Since the Soviet times, mineral resource base of the Arctic was developed by the population settlement in the polar regions on a permanent basis. In Soviet period, a large effort was put into exploration and infrastructural development of the Northern Sea Route (Armstrong 1955). Growing literature on historical legacies argue that Communist policy practices and governmental and public perceptions survived and often define the priorities of post-Communist and post-Soviet states as well as policy implementation (e.g., Lankina et al. 2016; Libman and Obydenkova 2015; Nazarov and Obydenkova 2020). The Soviet approach to economic development thus remains and prevails in the Russia's approach to the Arctic. The literature, however, highlights that an opposite, pure market economy approach to regional development in the Arctic is neither feasible nor efficient since it limits the potential for the realization of Arctic projects and the positive social, economic, and technological spillover effects for the regional economies; the government support and policies are, therefore, key for sustainable development of the Russian Arctic (Kryukov and Kryukov 2019; Likhacheva and Stepanov 2021).

As of today, the northern regions of Russia make up about 10% of national GDP and contribute around 20% to the Russia's total exports (Rosstat 2022). Numerous industrial companies specializing in the raw material extraction and processing operate in the Russian North. The Arctic accounts for the production of 18% of oil and 90% of natural and associated gas in Russia (Bogoyavlensky and Bogoyavlensky 2019). About 90% of nickel and cobalt, 60% of copper, and almost 100% of diamonds and rare earth metals are extracted there (TASS 2019). Around 2.5 million people in Russia live above the Arctic Circle (Rosstat 2021), which accounts for about a half of the total population of the Arctic in the world (The Arctic 2022).

The immense economic (not to mention military/security) importance of the Arctic region for Russia's national welfare (Leksin and Profiryev 2017) draws much attention to climate change implications for the region being one of the most exposed to an accelerated warming. Over the last two decades, the rise of the Arctic surface temperature has been twice as fast as the world average (IPCC 2019). The rapid warming leads to shrinking of the Arctic sea ice cover and permafrost thawing, which affects marine, freshwater, and terrestrial ecosystems. Climate change puts a large pressure on social-economic systems as well as opens new possibilities for economic development, calling for the constant reassessment of the prospects for the regional development and principles underlying Russian Arctic policy (Grémillet et al. 2015; Leksin and Profiryev 2017).

Despite the unambiguity of the general trend of climate change in the Arctic, the scale and direction of its impacts on the economy and population of the northern regions of Russia and the whole national economy are still largely uncertain (Olsen et al. 2012). Although there is abundant scientific evidence on global climate implications for the Arctic region (IPCC 2019; IPCC 2022), the literature on climate change impacts on the Russian Arctic development is rather scant and sometimes contradictory.

There have been some investigations into positive effects of the ice retreat for Russia, implying a decrease in the ice cover in the Northern Sea Route (Kattsov and Porfiriev 2012; Aksenov et al. 2017; Khon, Mokhov and Semenov 2017). Another strand of literature explores the greater accessibility of Arctic hydrocarbons and bioresources (Kjartan et al. 2017), reduction of the heating period in the Russian Arctic (Porfiriev et al. 2017; Moe, Lamazhapov and Anisimov 2022), and decline in temperature-related mortality in the northern regions (Shaposhnikov et al. 2019). Overall, a number of climate and economy integrated assessment models demonstrate that Russia being a northern country could actually benefit from climate change, e.g. increasing the productivity of agricultural crops (Stern et al. 2007; Nordhaus 2011; Roson and Sartori 2016).

On the other hand, there are a number of studies pointing out at climate change negatively affecting Russia's economic development, which mostly refer to numerous drawbacks of permafrost thawing. It may be fraught with infrastructural damage (Streletskiy et al. 2019; Hjort et al. 2022; Obydenkova 2022a) and spread of different infections. Other consequences of climate change in the Arctic covered in the literature include a significant transformation in natural disasters' pattern, which implies increase in frequency and intensity of catastrophic events (Porfiriev and Makarova 2014), extinction of multiple Arctic species, and drastic effect on the lifestyle of the indigenous population (Gassiy 2019; IPCC 2022). Moreover, numerous physical and ecological changes occurring in polar territories have irreversible impacts stretching far beyond the Arctic territories, albeit of undertaking strong adaptation and resilience building policy action (Lenton 2012; Semenov 2021; Obydenkova 2022b). Finally, the Arctic is also a fragile diplomatic zone shared among Russia and the USA, Canada, Finland, Norway, Iceland, Sweden, and Denmark, including Greenland. There are multiple actors involved into the Arctic governance, including Arctic Indigenous peoples and their organizations, with the Arctic Council playing the central role in the Arctic governance (e.g., Arpino and Obydenkova 2020; Saunavaara and Lomaeva 2021; Ambrosio et al. 2022; Hall et al. 2022). The Arctic Council traditionally takes a stand on sustainable development of the region and pays a constant attention to the climate change and environmental challenges of the region (Nicol and Heininen 2014).

However, despite the plenty of research and political attention, the lack of comprehensive understanding of the impacts of climate change on economic development in Russia persists, which may hinder the implementation of effective Arctic policy in the country. Although, in recent years, a lot of policy attention has been paid to the development of the Arctic declared as a new national priority, the great deal of climate-related uncertainty may limit the potential of implementing a regional policy aiming to minimize risks and maximize new opportunities of the climatic changes in the Russian North. Over the past few years, Russia's climate policy has also developed considerably as Russia joined the Paris Agreement and committed to achieve carbon neutrality by 2060 (Government of the Russian Federation 2021). At the same time, most of the policy focus so far has been concentrated on the adaptation to the risks of global energy transition including the growing pressure on Russian foreign exports, leaving less attention to the adaptation to physical climate risks (Makarov, Chen and Paltsev 2020; Makarov 2022, Stepanov 2023). But is there room for convergence of Russian climate and Arctic policies boosting the synergies between them for the sake of sustainable development in the region?

The present paper adds to the body of research on the Russian Arctic development policy, considering the existing links with emerging national climate change policy. Based on an analysis of domestic policy documents, available literature, analysis of implemented and scheduled infrastructure, and energy projects in the region, this study aims to systematize available estimates on climate change impact on economic development of the Russian North and identify key areas of state policy to minimize uncertainty, effectively manage climate risks, and exploit new opportunities, taking into account regional specifics of the Arctic territories of Russia.

The paper consists of five main sections. The following provides an overview of the available estimates of both positive and negative climate change implications in the Russian Arctic. The third section illustrates the role of permafrost melting in the long-term development of the Russia's northern regions, which is for now the biggest economic challenge to be addressed, depicting pace and scale of permafrost thawing and the adjunct implications. The fourth one delves into the question, whether Russian climate policy complements enough the Arctic policy and by what means greater complementarity could be achieved. The final section draws conclusion and brings the discussion on the key policy implications as well as the agenda for further research.

2 Overview of climate change implications in the Russian Arctic

Global warming is causing Arctic ice to melt at an exacerbated pace. The temperature increase in the Russian Arctic has been 0.8–1.2 °C per decade in 1976–2020, with the fastest growing average annual temperature in Taymyr and the coast of the East Siberian Sea (Roshydromet 2021). Since the 1980s, the September Arctic ice cover has been decreasing at a rate of 13% per decade and has almost halved by now (Roshydromet 2021; IPCC 2022). The Sixth IPCC assessment report indicates that the reduction of the yearly minimum (in September) Arctic Sea ice extent has been $-12.8 \pm 2.3\%$ per decade in 1979–2019, and the yearly maximum (in March) sea ice extent has decreased by $-2.7 \pm 0.5\%$ per decade in 1979–2019 (IPCC 2022).

Rapid ice melting opens up new transport and navigation opportunities in the Arctic region. Ice retreat allows for a longer navigation period in the Arctic Ocean, prolonging it from August and September of the 1980s to July and October (Mohov and Khon 2015). In this regard, the Northern Sea Route is considered a promising alternative to traditional sea routes in the future. Its anticipated advantage is a shorter navigation distance, e.g., the distance from Porsgrunn (Norway) to Qingdao (China) is about 40% shorter than through the Suez Canal and Malacca Strait, which may result in navigation time or fuel savings (Schøyen and Bråthen 2011). Some estimates demonstrate that in case of continuous Arctic warming, by the end of the twenty-first century, the mean transport distance from Northern Europe to Asia and North America can be shortened up to 50% compared to southern routes (Khon, Mokhov and Semenov 2017). However, economic studies show that the Northern Sea Route as a transit route can hardly be as commercially attractive as the Suez or Panama Canal routes due to high capital costs, need for ice breaking services, and lack of infrastructure required for stable and timely shipping (Makarov, Sokolova and Stepanov 2015; Aksenov et al. 2017). At the same time, the role of the Northern Sea Route in domestic and export shipping may increase significantly giving a strong impulse to the economic development of the Arctic region.

Ice shrinking increases accessibility of the Arctic resources as well. The region contains large deposits of non-ferrous and rare earth metals, hydrocarbons, gold, etc. According to the US Geological Survey of 2008, 13% (90 bn barrels) of unexplored oil resources and 30% (47.3 bn cubic meters) of undiscovered natural gas are stored in the Arctic territories (Bird et al. 2008). Overall, 43 of 61 large hydrocarbon fields in the Arctic are in Russia, most of which are located on the continental shelf (Budzik 2009). The Barents Sea is acknowledged to be the most promising area for resource extraction, being rich in hydrocarbons and bioresources, especially fish (Nilsson and Filimonova 2013), and already holding a developed port infrastructure, which is also of importance for the Northern Sea Route exploitation. The Kara Sea is considered less perspective for resource extraction, though having abundant marine resources (Kjartan et al. 2017). However, in order to extract Arctic oil and gas at Russian continental shelf, special exploration and extraction technologies must be applied, which requires strong governmental support and cooperation with foreign partners, which is, however, tend to be more and more complicated in a current geopolitical situation (Stepanov 2022).

Extensive economic development of the Arctic may come into collision with the aims of conservation of the Arctic environment. Greater accessibility of the Arctic region increases local environmental risks such as pollution of soils, groundwater, rivers, and seas with heavy metals, hydrocarbons, and other toxic substances (Heininen and Exner-Pirot 2020). Along with the development of the shelf and growing shipping in the Arctic waters, risks of liquid hydrocarbon spills and other accidents increase (Bobylev et al. 2010). Those can be accompanied by emissions of toxic pollutants from fossil fuel combustion, which also threatens Arctic ecosystems and indigenous population (Makarov and Stepanov 2016). Global efforts to phase down the consumption of fossil fuels due to climate concerns may significantly affect the prospects of Arctic oil and gas extraction, especially on the shelf where it is the most expensive. This may have a positive impact on the Arctic environment, with simultaneous undermining the opportunities for extension of economic activity opened up due to warming in the region.

Some other related environmental risks in the Russian Arctic are exacerbated by climate change itself. Many Arctic animals and plants are on the brink of the extinction, e.g., polar bears, seals, and walruses, as they run out of time to adapt to rapid climatic changes and, partly, to increasing anthropogenic impact on the environment (Porfiriev and Terentiev 2016; Pagano et al. 2018). By the end of the twenty-first century, several seabird species that nest and breed in the Arctic may die out forever (Porfiriev and Terentiev 2016).

Warmer winters and springs, climate change-driven droughts and more intensive dry airflows, and more frequent lightning strikes jointly amplify risk of fire by times (Kharuk et al. 2022; Witze 2020). For example, the frequency of wildfires in the Siberian Arctic has increased threefold and the exposed area has doubled during the last 20 years (Kharuk et al. 2022). Moreover, many fire points do not cease to exist during the cold period but shift underground and still smolder up to a new spring or summer. Such disasters called “zombie fire” or “overwintering fire” (Chung 2021) are also dangerous due to their reciprocal impact: climate change increases the frequency of fires, while the fires lead to additional CO_2 released into the atmosphere.

Floods become a great challenge for some territories in the Arctic as well. As a result of changes in the snow depth and the volume of meltwater and precipitation regime, spring flooding, river, and coastal floods intensify. Floods provoke the direct damage to people, destruction of assets, switching of resource flows from production to recovery, different types of income loss, indirect effects throughout supply chains, and public health losses, including increasing risk of infectious disease (Revich 2009).

Extreme temperatures and weather anomalies that are a direct consequence of climate change are even a more important hazard for public health. Such disasters are associated with direct injuries and health risks for people with respiratory diseases (IPCC 2007). Moreover, it is often hard for injured people to get medical care in the regions being cut off due to extreme weather (Revich 2009). Changing weather regime can induce mental health risks, especially within the communities of indigenous peoples (IPCC 2022). Given the expected rise in temperature fluctuations, heat waves are likely to be one of the key challenges to the public health in the region (IPCC 2021). Numerous regions globally become exposed to the global sea level rise, which is caused by melting of the Arctic glaciers. This may lead to flooding of the coastal infrastructure and deaths of thousands of people around the globe. Moreover, with the melting of the Arctic ice, the volumes of released greenhouse gases, especially carbon dioxide and methane, can surge (Schaefer et al. 2011;

Makarov and Stepanov 2016; IPCC 2021). This is mostly due to huge reserves of carbon and methane in the seas, soils, and permafrost of the Arctic (IPCC 2019; IPCC 2021). Although deep permafrost is protected from melting by an icy transition layer, models show that a further increase in depth of seasonal thawing resulting from an increase in air temperature can disrupt this equilibrium, although large uncertainties of the scale of the natural emissions as well as climate sensitivity still remain (Miner et al. 2022).

In spite of the fact that both positive and negative implications of climate change in the Russian Arctic can be observed, there are still numerous uncertainties regarding regional and sectoral context, scale, and pace of climate processes. Negative consequences of the Arctic warming will come on their own almost with no regard to policy action which can only soften these impacts effectively managing the uncertainties. At the same time, the opportunities to take advantage of climatic change, for example by exploiting new resource fields and navigation routes, will largely depend on the policy action, new investment and technology solutions required for the sustainable and resilient growth in the Russian Arctic.

3 Permafrost melting and the adjunct economic challenges

Permafrost melting is one of the most significant impacts of climate change in Russia. Without taking it into account, no estimates of climate change-induced damage for Russian economy are robust. Ignorance of permafrost melting is one of the major reasons why many integrated assessment models show that Russia may benefit from moderate warming. For instance, the RICE model by William Nordhaus indicates that Russia has the lowest social cost of carbon among all the regions (Nordhaus 2011). Stern review states that “in higher latitude regions, such as Canada, Russia and Scandinavia, climate change may lead to net benefits for temperature increases of 2 or 3°C, through higher agricultural yields, lower winter mortality, lower heating requirements, and a possible boost to tourism” (Stern et al. 2007). Roson and Sartori (2016) who provided the estimates of climate change damage functions for 140 countries came to conclusion that Russia is one of the countries which “are expected to get moderate gains from a +3°C increase in temperature, and these gains are typically due to an increase in tourists’ arrivals (and diminished outgoing domestic tourists).” In general, large uncertainties underlying the integrated assessment models-based calculations exist due to limited data, understanding relationships between physical and economic processes as well as an inherent inability of these models to account for very specific local Arctic climate change implications (Ackerman, DeCanio, Howarth and Sheeran 2009; Pindyck 2013; Lenton and Ciscar 2013; Weyant 2017). The benefits that Russia may derive from various climate change impacts are likely to be more than compensated by losses due to permafrost melting which is frequently simply not considered by these models.

Permafrost covers up to 2/3 of Russia’s territory embracing 28 regions of Russia; many big industrial enterprises and cities sit on it. In 9 regions (Komi Republic, Republic of Sakha (Yakutia), Nenets, Yamalo-Nenets, Khanty-Mansiysk, Chukotka Autonomous Districts, Krasnoyarsk Area, Magadan Region, Kamchatka Area), permafrost covers a significant part of the economically used territory (Fig. 1) (Porfiriev, Eliseev and Streletskiy 2019).

At several sites near the southern boundary of continuous permafrost, the active layer increases with the trend up to 15 cm per decade. By the middle of the twenty-first century,

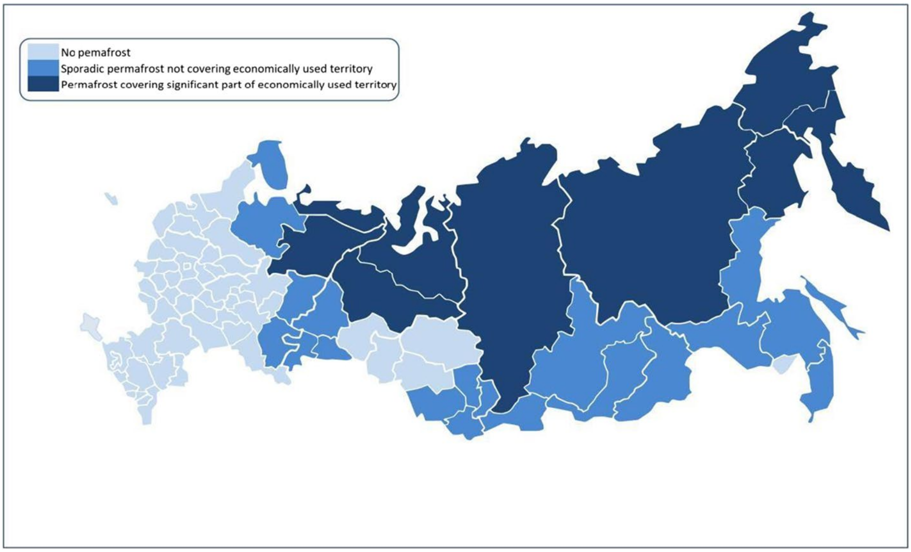

Fig. 1 Russian regions with territories covered by permafrost (adopted based on Streletskiy et al. 2019). Note: the borders of the Russian Federation and its regions are shown in accordance with the Constitution of the country for September 2022

the territory covered by permafrost may reduce by 22 ± 7% in SSP2-4.5 scenario and by 28 ± 10% in SSP5-8.5 scenario. By the end of the century, the reduction will account for 40 ± 15% and 72 ± 20% correspondingly (Roshydromet 2021).

Permafrost thawing is potentially a systemic macroeconomic risk to the large parts of the Russian economy. Permafrost forms the hard bedrock for homes of 2.5 million people (1.7% of total population), crucial facilities, including pipelines, and several industrial centers. Expected changes in ground bearing capacity pose a risk to residential, industrial, and infrastructure facilities built on permafrost. According to Roshydromet (2014a), in such Arctic cities as Igarka, Dikson, and Khatanga, 60% of infrastructure facilities is deformed, in Dudinka 55%, in Pevek 50%, and in Taymyr Peninsula 100% (Roshydromet 2014a). Pipelines and facilities located on the permafrost are usually built on pile foundations. According to Roshydromet (2021), their bearing capacity has already reduced by 20–40% across the whole permafrost area. Russian Building Codes and Regulations require at least 40% reserve of bearing capacity. In the coming decade, this requirement would be violated on most of the permafrost area and by the middle of the century, on all the area covered by permafrost (Roshydromet 2021).

By the middle of the twenty-first century, the zone of high risk of thawing will cover many critical assets, including 1590 km of pipeline East Siberia–Pacific Ocean, 1260 km of pipelines in Yamal Nenets Autonomous Districts, and 280 km of the railroad Obskaya-Bovanenkovo. Such large cities as Vorkuta and Novy Urengoy will also be included into zone of the highest risk. Another important asset potentially under risk of permafrost melting is Bilibino nuclear power station as well as power lines around it providing neighboring mining enterprises with electricity (Roshydromet 2021).

Long-term economic damage due to permafrost thawing is difficult to estimate but is likely to be very high. Roshydromet (2014b) estimates that maintaining and repairing infrastructure as well as its protection from the melting permafrost costs 55 billion rubles annually. According to Russian Academy of Science estimates, the decrease of permafrost area by 25% by 2080 would result in losses of $250 billion for Russia because of damage to infrastructure facilities (IFRI 2021). The head of the Ministry of Natural Resources and Ecology of Russia, Alexander Kozlov, states that, in 23% of cases, the degradation of permafrost causes the failure of technical systems, and, in 29%, it is the reason for the reduction of hydrocarbon production. In addition, it leads to problems with railways and highway construction as well as to the deformation of more than 40% of the infrastructure in permafrost areas. As a result, according to the estimates of Russian Academy of Science, by 2050, the damage from the degradation of permafrost may amount to about 5 trillion rubles (RBC 2021). According to the former Deputy Minister for the Development of the Far East and the Arctic, Alexander Krutikov, by 2050, only the damage caused to buildings and infrastructure due to the melting permafrost may cost Russia up to 9 trillion rubles (RG 2020). It is worth noting that all these estimates should be considered with a certain degree of caution due to the lack of information about the methodology for developing them.

The potential losses from melting permafrost vary across regions and are significantly higher in the aggressive warming scenarios. Streletskiy et al. (2019) estimated the total cost of infrastructure exposed to the negative effects of permafrost melting. According to these estimates, costs may reach $105 billion by the middle of the twenty-first century under the SSP5-8.5 scenario while overall exposure of the assets may reach $301.1 billion. The cost of infrastructure includes the total value of immovable assets, including residential buildings, social institutions (hospitals, schools, universities, airports, etc.), and critical infrastructure (roads, bridges, pipelines, etc.). Estimates of the cost of infrastructure subject to permafrost melting suggest the need to replace 53.8% of residential buildings, 19.7% of social institutions, and 18.8% of infrastructure facilities located in permafrost. The largest cost of the affected infrastructure is seen in the Yamalo-Nenets Autonomous District and the Republic of Sakha—it is $52.3 billion and $21.3 billion, respectively. The cost will be also high in the Komi Republic, Nenets Autonomous District, and Krasnoyarsk Krai—from $8.5 to $10 billion (Streletskiy et al. 2019).

The resistance of the transport infrastructure is exposed to significant risks: Porfiriev, Eliseev, and Streletskiy (2019) calculate that the costs of the road infrastructure network improvements in the period 2020–2050 may range from 422.68 billion rubles to 864.81 billion rubles per year. The greatest costs will be typical for the Chukotka Autonomous District, the Republic of Sakha, and the Magadan Region. Other assessments show that the total costs for maintenance of road infrastructure owing to permafrost degradation in Russia's northern regions are estimated to range from $7.0 billion to 14.4 billion by 2050, and costs for replacement of residential infrastructure are expected to reach US $0.5–0.6 billion per year over 2020–2050 (Hjort et al. 2022).

The way the permafrost thawing may turn into the short-term catastrophic risk if no action is taken to maintain infrastructure was demonstrated in 2020: due to an accident at Thermal Power Station-3 in Norilsk, caused partly by thawing of the soil and the partial destruction of the bearing supports, more than 21 thousand tons of fuel spilled into the rivers Ambarnaya, Daldykan, and their tributaries (RBC 2020). According to Rospotrebnadzor estimations, the damage reached 148 billion rubles (Rospotrebnadzor 2020). Similarly, thawing of permafrost creates the risk of deformation of pipelines with corresponding risks of oil leaks with catastrophic damage to the environment. Therefore, additional financial resources are needed to guarantee uninterrupted consistent functioning of infrastructure units. Such financial burden could count a 1% of GRP for Western Siberia (Suter, Streletskiy and Shiklomanov 2019).

Permafrost degradation and shortening of the cold season affects continental transport opportunities in the Arctic not only due to impacts on paved roads. Most of transportation in the region is operated through winter roads ("zimniki") or ice roads (over the frozen rivers or lakes). According to State Hydrological Institute of Roshydromet (2016), the duration of the ice period on rivers in the circumpolar North has been decreasing with average speed by 12 days/100 years since the 1970s. In the high Arctic, the speed is 4 times more. Operation period of winter roads decreased by 7–10 days in the past 30 years. The largest decreases in potential period of winter road operation took place in the north of Chukotka Autonomous District, south of Yamalo-Nenets Autonomous District, and east of Nenets Autonomous District. Some settlements on these territories (with total population 264,000 people) faced the decrease of winter road operability by 4% or 1015 days since 1970 to 2000. By the middle of the century, both overland travel days and ice road operation days will decrease by 10–15% (Gädeke et al. 2021). To the end of the century, a decrease can be more substantial under the aggressive RCP8.5 scenario (up to 40% compared to nowadays).

Permafrost melting may affect not only transportation but also extracting facilities. For instance, it leads to the deformation of oil wells and the reduction of their productivity that may provoke losses of 10–20% of oil extraction (Roshydromet 2021).

Finally, permafrost thawing deliberates dangerous substances conserved in permafrost. In the Soviet Union, Arctic served as a place where vast array of radioactive materials was sequestered (Miner et al. 2022). Release of these elements may trigger radioactive proliferation. Permafrost thawing may have some other health impacts provoking the spread of diseases, whose pathogens are currently frozen, including anthrax, smallpox, and previously unknown bacterial and viral diseases. In particular, the substantial threat comes from a rapid increase in surface air and permafrost temperature in the cattle burial grounds. In addition, some toxic wastes previously buried in the permafrost may leak to the environment including those containing mercury, which migrates into the rivers and affects human via fish. These and other health-related risks of permafrost melting may lead to the costs in the healthcare sector equal 3% of the total annual healthcare budget (Revich, Eliseev and Shaposhnikov 2022).

Despite the gradual progress in accumulating knowledge, the current understanding of Arctic climate change dynamics and its implications for the permafrost continues to be fragmented due to the scarcity of high spatiotemporal resolution data, low density of permafrost measurement networks, and the network of hydrometeorological data collection stations. Lack of monitoring facilities underlies high uncertainties on the speed and scale of future climate change in the northern regions of Russia. Even less certain are the assessments of the possible economic risks which require further development of integrated assessment models better tailored to account for climate and economic features of diverse and spacious regions of Russia. The ambiguity of climate change impacts for the Arctic limited the understanding of the interactions between climate and economic systems in the region as well as intrinsic drawbacks of integrated assessment models that do not take into account some specific characteristics of the Arctic making it more complicated to develop and implement science-based governmental policy.

4 Russian Arctic and climate policies: are there enough synergy?

For the last decade, fostered economic development of the Arctic region has become one of the key policy priorities in Russia. A number of large projects were initiated including the first offshore Prirazlomnaya oil platform which was put into operation in 2014 to extract oil from the field in the Pechora Sea and the Gates of the Arctic terminal launched in 2016 in the Kara Sea to transship oil from continental Novoportovskoye oil field. In 2017, Yamal LNG's flagship project on extraction, liquefaction, and supply of natural gas was launched, which is now the biggest Arctic LNG project in the world operated by Russian private gas company NOVATEK, though strongly supported by the government (Neftegaz 2020). In 2019, the floating nuclear power station Akademik Lomonosov started operation. The cargo traffic along the NSR has been rapidly growing, and, in 2021, it amounted to 34.8 mn t (Portnews 2022), which is 6 times more than in 2014.

> Overall, Russia has ambitious plans for further development and exploration of the Arctic, which is supported by new strategic documents adopted over the past years and several changes in the governmental structure. In 2019, the Federal Ministry for the Development of the Far East was transformed into the Ministry for the Development of the Far East and the Arctic. This was followed by the extension of authority of the Russian Far East and Arctic Development Corporation launching business support programs aimed at attracting investors to the Far East and the Arctic, e.g., advanced special economic zones and the special status of the Arctic zone of the Russian Federation suggesting mild taxation and simplified administrative schemes. In October 2020, the Strategy for the Development and National Security of the Arctic Zone of the Russian Federation up to 2035 was adopted (President of the Russian Federation 2020b), outlining the importance of economic growth at polar territories and improving living standards of their population. In August 2022, the Strategy for the Development of the Northern Sea Route up to 2035 (Government of the Russian Federation 2022b) was issued, which underlines the importance of this transit route and the anticipated demand for its use. According to this strategy, by 2023, the cargo traffic through the Route should increase by 47 million t and by 2035 it should be more than 238 million t. Moreover, this plan envisages the construction of container ships, Arctic-class cargo ships, and the building of icebreaker fleet, e.g., projects of Arctic-class atom icebreakers 22220 and 10510. The development of port infrastructure will continue within the framework of construction and reconstruction in the seaports of Murmansk, Sabetta, Pevek, etc. Further development of the hydrocarbon resource base stays at a core of the Russia's Arctic policy as well as energy companies' corporate strategies, for example NOVATEK's plans for the Arctic LNG-2 project which is to be launched in the near future (Neftegaz 2022). Although great progress has been made, the plans for intensive economic growth of the Arctic region face unsettled challenges, including those related to the lack of technologies in infrastructure and shipbuilding which is drastically enhanced by the Western economic sanctions. Not surprisingly, the launch of Arctic LNG-2 has been postponed from 2022 to 2024.

Given the ambitious plans of the Arctic development, the climatic factor is historically perceived not at as threat but rather an opportunity for economic development in the variety of policy documents and public discussions (Stepanov 2023). Overall, the state policy documents touch upon the role of climate change in the long-term development of the Arctic very slightly and indirectly. Most of the strategic documents highlight the overall greater accessibility of the northern territories and cover the climatic risks rather generally, mentioning at least environmental protection as a track of action. For example, according to the Fundamentals of the State Policy of the Russian Federation in the Arctic until 2035 (President of the Russian Federation 2020a), the policy implies "the development of the Arctic zone of the Russian Federation as a resource base and its rational use in pursuit of rapid economic growth of the Russian Federation," only slightly touching upon environmental protection and "continuation of work on elimination of accumulated environmental damage" with no referring to climate change as a fundamental risk at all. In spite of the fact that climate change is mentioned among the list of the inherent features of the Arctic zone of Russia, in the Strategy for the Development and National Security of the Arctic Zone of the Russian Federation up to 2035, detailed risks forced with the Arctic warming are not included. The key tracks of action in the region are resource extraction, including at the offshore fields, further development of the Northern Sea Route, icebreaker building, etc. Environmental protection and climate action are also not on list of the performance indicators of the state policy in the Arctic, though it includes the share of crude oil and natural gas produced in the Arctic in the total volume of production in the country.

Underestimation of climate risks in the Arctic policy of the Russian Federation can be explained by the general neglect of the climate factor in long-term planning of Russia's development for several decades (Kokorin and Korppoo 2013; Obydenkova 2022c; Makarov 2022), though in recent years Russia's climate policy, especially its mitigation-related dimension, has boosted. As a participant of the Paris Agreement, Russia pledged to tackle the climate problem and approved its Nationally Determined Contribution (NDC) in 2020, which implies that, by 2030, Russia will cut its greenhouse gas emissions by at least 30% from 1990 level. However, the Russia's climate policy tend to be mostly determined not only by the climate change itself, but by the external risks brought with the international low-carbon transition, including risks of decreased demand for fossil fuel exports or the introducing carbon trade barriers, e.g., EU carbon border adjustment mechanism which may bring additional costs to Russian exporters (Makarov, Chen and Paltsev 2020; Stepanov and Makarov 2021; Makarov et al. 2021).

In this regard, national climate policy highlights the need for a mitigation of the low-carbon transition risks for Russia as a key exporter of the fossil fuels and carbon-intensive goods (like metals, fertilizers, chemicals), which is broadly mentioned in many climate change-related governmental documents. For instance, Russia's Energy Security Doctrine (President of the Russian Federation 2019) highlights the necessity to take into consideration interests and vulnerability of energy abundant countries regarding international climate policies and perceives renewable energy resources as a challenge to the national energy security. According to Russia's NDC (UNFCCC 2020) and the Strategy of Socio-economic Development of Russia with a Low Level of Greenhouse Gas Emissions until 2050 (Government of the Russian Federation 2021), decarbonization of the national economy should not disrupt socioeconomic processes and hinder sustainable economic growth; therefore, the absorption capacity of forests plays a central role in decarbonization. Overall, Russia's climate and energy policy is aimed at "adaptation to the global energy transition" but not to climate change itself, thus to a large extent systematically neglecting growing physical climate-related risks (Moe, Lamazhapov and Anisimov 2022; Stepanov 2023).

In December 2019, the National Climate Change Adaptation Plan 2020–2022 (Government of the Russian Federation 2019) was issued, which emphasizes that "the wide socio-economic consequences of temperature and pressure contrasts, extreme precipitation and floods noted in recent years prove the growing vulnerability of the population and the economy to extreme weather and climate impacts." Along with negative consequences, numerous positive effects of climate change are listed, e.g., facilitating access to the continental shelf of the Russian Federation in the Arctic Ocean and reduction of energy consumption during the heating period. Moreover, according to the National plan, by May 2022, regional adaptation plans should have been developed, but as of June 2022, only seven (out of eighty-five) regions have adopted them (Republic of Crimea, Belgorod, Volgograd, Vologda, Kemerovo, Kursk, and Penza regions) (TASS 2022). As constraining factors, insufficient information and methodological base are mentioned by the representatives of the regions (Federation Council 2021).

Some important policy and technological measures to accumulate climate change-related information that have been recently taken in Russia are crucial to bridge the knowledge gap necessary for further comprehensive assessments of economic risks of the Arctic warming. An important step was made in the beginning of 2022 when federal scientific and technical program in the field of Russia's environmental development and climate change for the period up to 2030 was adopted (Government of the Russian Federation 2022a). The program involves the creation and application of low-carbon technologies in various sectors of the economy, as well as the development of new environmental and climate monitoring systems. Other measures include National Program for Carbon Measurements Facilities (2021), launch of the first-in-the-world satellite "Arktika-M" on high-elliptical orbit (2021), and development and deploying of national network for permafrost monitoring.

Taken together, despite a few progressive steps in 2021–2022, climate change policy in Russia has been conducted at a slower pace; thus, a great deal of work is to be done in coming years. Moreover, existing plans do not take into consideration the Arctic in any meaningful way. National climate policy and Arctic policy are in fact developing almost separately, while regional development programs mostly focus on potential positive impacts brought by Arctic warming rather than preventing and adapting to negative impacts. This notion implies current inability of the country to fully marry environmental protection and economic development, which, however, is becoming a noticeable general trend in the Arctic states turning into the so called "Arctic paradox" (Heininen et al. 2020). For the coming years, the search for a new balance between resource utilization and preservation of ecosystems will be a major challenge for the Arctic states and Russia in particular, though opportunities to strengthen Arctic and adaptation policies may lie precisely in their integration and in the creation of opportunities for their mutual gain.

5 Discussion and conclusion

For the last years, the Russian climate policy has to a large extent been focused on hedging the risks of global energy transition putting an increasing pressure on the economy heavily reliant on fossil fuel production and exports. Various measures implemented by state agencies and companies have vastly been subordinated to the goal of managing the risks for the demand for Russian hydrocarbons and carbon-intensive goods due to climate policies abroad (Makarov et al. 2021). Climate change adaptation policy remained at the backyard of decision-making process bringing no tangible results.

Despite the growing policy attention to the Arctic and the climate change taking place in the region, Russia seemed to have been inefficient to develop a viable strategy coping with this challenge in the region (Obydenkova 2022c). It may be partly explained by priorities of economic and security benefits, i.e. resource extraction and navigation along the Northern Sea Route, over the goals of sustainable development (e.g., Demchuk et al. 2021; Libman and Obydenkova 2013 2014; Heininen et al. 2020; Nazarov and Obydenkova 2020). Even though the general ambivalence of the Arctic development by the Arctic states is an emerging trend of Arctic governance in last years, given growing access to the Arctic territories due to climate change (Heininen et al. 2020), the solutions needed to strike the right balance between environmental/climate and economic development objectives have to have a pronounced country-specific character.

Intensive climate change in the Arctic and accumulated climate-related risks for Russian economic development make adaptation to climate change not less important than mitigation. Although both adaptation and mitigation could provide opportunities for resilience building and green growth, emission reduction policy in the Russian Arctic can barely help smooth immediate impacts of the already much heated Arctic.

A comprehensive framework of Russian Arctic policy measures centered around climate change is yet to be developed. This framework could encompass two main policy dimensions: (a) strengthening the knowledge on climate change, the adjunct risks, and emerging opportunities in the region and (b) developing the system for climate change risk management and resilience building ensuring that regional diversity and climatic and socioeconomic features of various locations are taken into serious account.

The accumulation of knowledge on the permafrost melting, reduction of ice cover in the Arctic Ocean, coastal erosion, temperature, and precipitation changes are key to the buildup of comprehensive climate change adaptation policy for the Arctic region. Therefore, a combination of efforts starting from the expansion of the data collection networks to strengthening the satellite group and enhancing geospatial data-based techniques is required to collect primary data on climatic processes consistent across administrative regions. The important steps towards information gathering and climate change monitoring made during the last years should be followed by a comprehensive modelling assessment of the economic impacts of climate change in Russia which is so far almost absent.

Considering rapid climatic changes in the Artic region, the knowledge base and the climate-adjunct risk assessments need to be updated on the regular basis that requires additional funding. To reduce great uncertainties on the speed, scale, and regional distribution of climate-related impacts, additional financial resources are needed both from the government and large businesses operating in the Artic (in the oil and gas, mining, shipping, and other industries).

The greater role in accumulating knowledge on climate change in the Arctic region could be also attributed to international cooperation. Climatic changes happening in the Russian Arctic are of global importance. Today, Arctic serves as a natural laboratory for studying climate change for increasing number of stakeholders both from Arctic and non-Arctic states. The intensification of the climate change-related data exchange through interactions of scientific groups, organization of joint field studies, realization of the pan-Arctic research projects could foster knowledge accumulation as well as cooperation with Arctic indigenous peoples. Therefore, the current suspension of the collaboration between Russia and other Arctic states within key Arctic institutions, e.g. Arctic Council working groups, serves as a severe barrier for further bridging the knowledge gap necessary to support climate change adaptation.

The development of the system of climate change risk management and resilience building based on the most acute data could embrace planning both active and passive risk management/adaptation measures complementing each other. Passive measures could include the adaption of infrastructure building requirements to changing climate conditions, building maps of territories exposed to climate-related natural hazards, informing the public and businesses about potential threats, etc. Active measures could include (but not be limited to) special efforts to increase infrastructure resilience, various forest management practices, intensive maintenance of buildings and infrastructure exposed to climate risks, etc. Active adaptation measures like industrial infrastructure buildup and enforcement or intensive maintenance of buildings and social infrastructure exposed to climate risks could create immediate positive economic effects ranging from creating new jobs to increasing the quality of housing and medical, sport, cultural, and other social and public services.

As territories of the Russian Arctic vary significantly in terms of climate and socio-economic features, the climate change adaptation policy should also embody options designed for the specific regions. It is critically important to rely on local and often indigenous knowledge when adopting risk management practices. One of the solutions could be the establishment of the network of regional centers of climate change competence and nature-based technologies uniting local scientists, local businessmen, public officers, NGO representatives, and indigenous peoples which may help form “bottom-up” solutions contributing to nationwide Arctic climate change adaptation policies. This effort could be supplemented with an organization of a special training (short intense educational program) for regional administrators responsible for risk management and resilience building at the level of Russian northern regions.

A possibility to achieve greater synergies between Russian Arctic and climate policies depends not only on climate risk management and increasing regional adaptation capacity but also on exploiting various opportunities for the “green growth” detailed analysis of which, however, falls outside the scope of the present research and could be a part of further investigation. To illustrate, renewable energy solutions may be implemented to cover the needs of small-scale decentralized energy consumers in the northern regions. Climate policies in the Arctic could also potentially bring substantial environmental and public health benefits. In the Russian Arctic, there are more than two dozen areas most prone to local environmental pollution called “impact” zones (predominantly located in Norilsk region, Western Siberia, and Arkhangelsk region). Industrial modernization and emission reduction policies represent a win-win option to combat climate change and local pollution. Finally, there are a number of options for economic diversification and strengthening resilience to transitional risks and taking advantage of global low-carbon transition. The Arctic’s richness in new metals and minerals (copper, nickel, platinum, rare earth metals, etc.) opens up a window of opportunities for the smart development of resource-intensive industries integrated into the global value chains for producing goods and parts of equipment needed for global energy transition.

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