SOI: 1.1/TAS DOI: 10.15863/TAS
International Scientific Journal
Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2024 **Issue:** 02 **Volume:** 130

Published: 13.02.2024 http://T-Science.org

Issue Article

Olesya Anatolyevna Golubeva
Don State Technical University
Ph.D., Associate Professor

Grigory Aleksandrovich Zemsky
Don State Technical University
master's degree
Rostov-on-Don, Russia

Artur Aleksandrovich Blagorodov
Institute of Service Sector and Entrepreneurship (branch) DSTU
master's degree

Vladimir Timofeevich Prokhorov
Institute of Service Sector and Entrepreneurship (branch) DSTU
Doctor of Technical Sciences, Professor
Shakhty, Russia

Galina Yurievna Volkova
LLC TsPOSN «Ortomoda»
Doctor of Economics, Professor
Moscow, Russia

ABOUT THE FEATURES OF SUSTAINABILITY AND RESILIENCE OF CITIES OF THE RUSSIAN ARCTIC

***Abstract**: in the article, the authors consider it as the ability of urban systems to overcome natural or man-made crises as a concept that mutually complements the concept of sustainable development. In the Arctic, characterized by increased vulnerability of both natural and economic systems, the application of the concept of resilience is especially relevant. The article analyzes 19 quantitative indicators of 27 Arctic settlements of the Russian Federation according to the following subsystems: economic specialization, life support and utilities, socio-cultural, natural-ecological, administrative and managerial. The cluster analysis identified seven stable groups of cities that consistently demonstrate similarities with each other under various analysis options. Overcoming crises in city development requires the simultaneous fulfillment of the conditions of resilience in different subsystems of urban development: the weakness of any of these subsystems can lead to the collapse of the entire system as a whole, therefore assessing resilience requires an integrated approach.*

Russia declares ambitious plans for the development of its Arctic zone, but it is inevitably associated with environmental risks, for which the Russian Arctic is not always ready. These are climate change, pollution of sea waters with oil and chemical runoff, and degradation of ecosystems. The idea that plans for the development of the Arctic region and, first of all, the development of offshore deposits should be reconsidered taking into account environmental hazards, resonates not only among environmental organizations, but also among economists. The unfavorable economic and foreign policy environment is the right moment to do this.

***Key words**: sustainable development, Arctic cities, socio-ecological systems, the Arctic, climate change, oil spills, international environmental cooperation.*

***Language**: English*

Citation: Golubeva, O. A., Zemsky, G. A., Blagorodov, A. A., Prokhorov, V. T., & Volkova, G. Yu. (2024). About the features of sustainability and resilience of cities of the Russian arctic. *ISJ Theoretical & Applied Science, 02 (130),* 52-66.
Soi: http://s-o-i.org/1.1/TAS-02-130-8 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2024.02.130.8
***Scopus ASCC**: 2000.*

Introduction

UDC 332.23:338.17.

The Arctic is a single physical-geographical region of the Earth adjacent to the North Pole and including the outskirts of the continents of Eurasia and North America, almost the entire Arctic Ocean with islands (except for the coastal islands of Norway), as well as adjacent parts of the Atlantic and Pacific oceans. The Arctic is considered the most undeveloped region on Earth, with an area of about 27 million km². The bulk of the world's mineral resources are hidden here: 13% of oil, 30% of the world's natural gas reserves. Therefore, as economists suggest, the Arctic will become the center of the world.

Due to the promising growth of the Arctic, developed countries of the world are interested in getting some share for their own economic benefit. What is this benefit? This benefit can be considered as a lot of minerals (38%), large territory (6%), ensuring strategic security (5%) and biological resources (5%). Interested countries are Russia, Canada, Greenland, USA, Iceland, Norway and others, since oil and gas are the main factor in replenishing the national energy reserve. All these countries have a stable and strong economic system. This work will consider the following scientific works, which will identify the relevance of investments in the Arctic: “The Arctic: nanotechnology, military-industrial complex, investments, national idea” by Yuri Fedorovich Lukin, “The Arctic as an object of geopolitical interests of non-Arctic states” by Oleg Nikolaevich Podpelkin , “Problems of development of the Russian Arctic shelf” by Ivan Panichkin, “Problems of the “Arctic” topic in Russian and foreign media: management aspect” by T.A. Kovrigina.

Based on the research conducted, it can be noted that in recent years, in the geopolitical context, the value of the Arctic, which is one of the most important foundations of Russia’s defense and economic power, has increased significantly. The leadership of our country regularly emphasizes that the development of the Arctic territories is associated with the solution of long-term problems of fundamental geopolitical importance.

I. Panichkin notes that active work on the development of the Arctic shelf in the USSR began in the early 1980s. Development prospects were associated primarily with the Pechora and Kara seas, which are aquatorial extensions of the Timan-Pechora and West Siberian oil and gas provinces. The first investments were made in the creation of a drilling fleet in the period 1983–1992. In the Barents, Pechora and Kara seas, 10 large fields were discovered. And since then, step by step, Russia has been participating in the development and exploration of the Arctic regions of the country. In this regard, certain problems have now arisen regarding the modern development of the Arctic region, about the technologies of the sixth technological order, the military-industrial complex, and investments. According to Yu.F. Lukin, the problems posed were formulated extremely broadly and did not receive proper coverage. Many questions remain open. But, nevertheless, in order to implement its Arctic policy, Russia must create an Arctic organization of the state, including special objects, organizations and institutions, Arctic formations and bodies, which, in accordance with the Constitution of the Russian Federation, federal laws and other legal acts of the Russian Federation, are intended to carry out implementation tasks Arctic policy of the state using modern methods and means, as well as their management bodies. In addition to Russia, in recent years there has been an increasing interest of Arctic and non-Arctic states in the resources contained in the Arctic, as well as in the Northern Sea Route. The growth of geopolitical interests of Asian countries in the Arctic contains several fundamental aspects, namely:

Firstly, this is the logistics potential of the NSR, which opens up due to melting ice and can reduce the cost of economic growth in Asian countries.

Secondly, this is the presence of natural and biological resources, the volumes of which cannot yet be adequately assessed, as well as the virtually completed formation of scientific and technological capabilities for their cost-effective exploitation.

The third aspect is the actual geostrategic significance of the Arctic as a new platform for the interaction of international factors, which is associated with the persistent demands of Asian states for admission to participate in Arctic organizations and associations, for example, in the Arctic Council.

Fourthly, for Asian countries that are building up their respective economic and intellectual potential, the Arctic is a testing ground for developing the principles and technologies that will be needed for their future development of the resources and spaces of Antarctica and the highlands.

Fifthly, and in connection with the last, it is of fundamental importance (especially for the Russian Federation) that political and legal methods and information technologies are being developed in the Arctic to justify the statuses of “terra and aqua nullius”, internationalization and ensuring access to the resources available there without use of military means.

International relations in the Arctic are becoming a system-forming element of world geopolitics, defining the challenge that Russia faces. Our country played an important role in the development of the territory and subsoil.

Having studied the scientific works of experts, it can be noted that the Arctic topic has not yet been touched upon. But the main trends in the Arctic issue in Russia and foreign countries are becoming more and more relevant. The solution to long-term problems that are of fundamental geopolitical importance for the Arctic states is increasingly associated with the development of the Arctic territories. This trend stimulates special attention of countries to the development of the territory and nature of the Arctic. The question posed is currently becoming more relevant, so I want to work on this problem in the future.

Resilience is a relatively new approach to urban development compared to sustainability. They complement each other: the difference is that the concepts of sustainability work on stable, given trajectories, while resilience is responsible for the survival of the city in times of crisis, at bifurcation points, and at changing development trajectories. This aspect was examined in detail both in our previous works and in the works of colleagues (in particular, a slightly different view of the relationship between resilience and sustainability is given in the works, therefore a detailed analysis of the concept of resilience itself is not included in this article).

Introducing the concept of resilience for Arctic cities is especially important. Earlier works allow us to confidently assert that Arctic cities are characterized by increased vulnerability both in terms of the natural environment and in the sphere of socio-economic development, therefore, here the analysis of the possibilities of overcoming crises is more important than anywhere else. The topic of resilience is especially relevant for the Russian Arctic, which has experienced absolutely unprecedented transformations in its settlement system over the past quarter century.

Let us note that the very topic of the resilience of various social, socio-ecological systems has been relatively developed, including for the Arctic, but there is almost no work regarding the cities of the Arctic, which have a number of specific features. The novelty of this work lies, firstly, in the very treatment of the topic of the resilience of Arctic cities, and secondly, in the development of a comprehensive methodology for its analysis, including the characteristics of permafrost and climate, migration indicators, transport and geographical location, economic structure and features of small-scale development. business, organization of heat supply systems, residential development, innovation activities, administrative management, etc.

Main part

The problem of choosing parameters for assessing resilience is rooted in the ambiguity of the term itself: at the moment there is no consensus even on a term suitable for use in Russian. In turn, the ambiguity of the term "resilience" is largely due to its dual origin: the term arose in ecology and almost simultaneously in psychology (and in these industries the concept of "resilience" was established in Russian), and then was transferred to economics and economic geography (where discussions arose regarding not only the translation of the term, but also regarding the variability of its content). We would like to preserve the original meaning of the term as much as possible - as much as possible when transferring it to geography - and follow the tradition of translating the term resilience as "resilience" so as not to interrupt the continuity with ecology and psychology. In the practice of analyzing urban resilience, in turn, two main approaches have emerged, each of which has both advantages and disadvantages, namely:

The first approach takes into account the complexity of the urban system, including environmental, managerial, behavioral, and economic aspects. However, adherents of this approach do not generalize, working at the micro level with individual cities.

The second approach is to quantify resilience using large data sets, however, resilience is essentially reduced to purely economic aspects. In general, the criterion for demonstrating resilience is the dynamics of population and/or gross product. Various parameters are tested for the explanatory power of these changes, although there are variations in analysis techniques. For example, R. Martin used a set of two indicators to calculate resilience: resilience (the ability to maintain initial economic indicators during a crisis) and recovery capacity. Some authors additionally used methods of proportion shift, or statistical analysis of mutual influence based on the obtained indicators. The strength of such an "economy-centric" approach is the unconditional proof of the role of one or another factor in shaping the trajectory of a city's passage through the crisis, and the weakness is the narrowness of the scope of analysis.

The similarity of both approaches is that resilience in both cases is assessed empirically - as a reaction to a crisis. In the first case, we are talking about a multicomponent set of resilience parameters that describes the structure of the city as a complex system. In the second case, the influence of certain factors on a narrow aspect of a city's resilience – its economic vitality – is assessed, but for a large sample of cities that are comparable in terms of experience in overcoming a specific crisis.

However, taking into account the undoubted advantage of the second approach (the ability to compare cities with each other), we conducted a preliminary study using Martin's method, expanding the range of parameters used by including a number of natural, transport-geographical and other indicators. An assessment was made of the resilience of Russian Arctic cities in the long-term (1989–2017) and relatively short-term (2009–2023) periods. However, this "universal" approach turned out to be inapplicable to the Russian Arctic: the population of many cities has been declining for almost the entire period since 1989, making it impossible to measure the "crisis" itself. For the group of "oil and gas" cities, considered separately, the factors that positively influenced resilience were: the initial stage of the resource cycle, the status of a regional center, the high proportion of the indigenous population in the city's "hinterland," the large size of the city itself; a negative influencing factor is the location in the suburban area of a larger city. For other cities, positive factors include: the status of a regional administrative center, the pronounced role of certain branches of the public sector (defense industry, nuclear energy, etc.), the share of people employed in education, the role of a central location (by position in the settlement network). Interestingly, location on the seashore or a navigable river turned out to be negatively associated with resilience in the long term (obviously, the crisis of transportation along the Northern Sea Route in the 1990s had an impact). The obtained calculations were used for further analysis, however, the obvious limitations of the second approach to assessing resilience - through a universal criterion - forced it to be abandoned.

As a result, an attempt was made to use a mixed approach: from the first of the above-mentioned approaches, ideas about resilience as a function of the structure of a multi-component city system were taken, from the second, the focus was on comparing a large number of cities according to common criteria. At the same time, it was necessary to move away from the actual assessment of resilience as a response to the crisis, moving on to an assessment of potential resilience based on an analysis of the characteristics of the urban system. In other words, from testing resilience indicators for their role in overcoming a crisis, we moved on to the parameters of the urban system, which should presumably ensure the resilience of the system in the event of a potential crisis.

The legitimacy of this transition is determined by the given conditions for the selection of indicators for each of the individual subsystems: as a criterion for the selection of indicators, their connection with resilience was determined, shown in earlier studies on the characteristics of the response to the crisis of the corresponding subsystems (natural-ecological, economic specialization, life support subsystem) or discovered during our own field research (to describe the sociocultural subsystem).

The research methodology includes four blocks:

selection of cities for analysis;

compiling a multi-component set of indicators of potential resilience;

clustering of cities of the Russian Arctic according to a multicomponent complex;

according to a set of parameters of potential resilience.

Selecting cities for analysis. To form the sample, the authors used a previously tested technique: in addition to the 21st Arctic urban district, some of the largest settlements of municipal districts were added, subject to a number of conditions. Thus, a total of 27 settlements were included in the analysis.

Compilation of a multicomponent comprehensive set of resilience parameters for individual city subsystems was based on an analysis of literature on specific subsystems of the city, expert analysis of materials (including field socio-geographical studies) on the passage of a number of crises in Arctic cities.

The indicators were selected, first of all, according to the criterion of compliance with the theoretical model of resilience, which implies the ability of the urban system to withstand a crisis. This ability is determined by three main parameters, namely:

the first is readiness for change in a broad sense, accepting the risk of something new: in the event of a crisis, the development of the city can rely on new types and forms of activity;

the second is involvement in world processes (the term "involvement" itself is borrowed from the psychological interpretation of resilience and can be interpreted as involvement in external interactions, allowing both to receive additional resources from the outside and to monitor and objectively assess the development of the situation).

Let's illustrate this with an example. A global city, concentrating economic, political, information flows, has a higher chance of surviving any disasters than an isolated village - although it (in the absence of disasters) could maintain stability for centuries. Here again, the parallel between an ecosystem with changing population numbers of individual species, but surviving extreme changes in external conditions, and an ecosystem stable in population numbers, which, however, is vulnerable to extreme external changes, is relevant. Note that the parameters of involvement and readiness for change are necessary, but not sufficient: a single-profile city with high involvement in global economic relations is vulnerable, and for its viability a third parameter is needed - fate control - a widely used category in works both on viability, and in terms of sustainability of development, which implies the availability of resources and opportunities to influence the situation.

Each of the urban subsystems has its own characteristics of the formation of resilience, which are measured by separate parameters. Thus, in the economic subsystem, readiness for change is manifested in the ability to generate and/or perceive innovations (what is called “absorptive capacity” of the local production system in foreign literature on economic geography); in society, readiness for change is creativity, “openness of thinking,” which is traditionally (according to Florida) assessed through indicators of tolerance, diversity (as a necessary resource for creativity), development of creative activities, etc. Control of fate in the case of a city is sufficient and diverse resources for the development of economic activities (system of economic specialization), trust (in the sense as it is used in sociology - trust) in the place among the local population (one can also recall Yi-Fu Tuan’s concept of topophilia): in case of crisis and trust in the place, the community is ready to fight for the city rather than migrate to other places. At the same time, control of fate includes institutional opportunities to influence the development of the city (sociocultural subsystem). Administratively, a resilient city must have an effective system of self-government, and high administrative status is also desirable. Of the five urban subsystems identified in the model (economic specialization, administrative and managerial, life support, sociocultural and natural-ecological), the named parameters are not applicable only to the natural-ecological subsystem. The assessment of its resilience parameters was based on the idea of the natural-ecological subsystem of the city as a source of ecosystem services for other subsystems (including services for the provision of food, water, fuel resources, etc.), and resilience as an opportunity, first of all, a sharp increase (in crisis conditions) in the volume of ecosystem services (in addition, minimization of the risk of irreversible changes in the subsystem under conditions of external influences is taken into account).

The three parameters mentioned are based on a theoretical study and comparison of different approaches to assessing resilience - theoretical calculations were tested based on studying the behavior of individual subsystems of Arctic cities both in the specialized literature and during field studies; It is not possible to consider in more detail the rationale for the theoretical scheme for choosing parameters due to limitations in the volume of the article.

The selection of indicators was carried out in two stages: at the first stage, 35 indicators were selected that corresponded to the theoretical model of resilience, then, after a detailed analysis (including correlation analysis, paired scatterplots and the application of the principal component method), 19 indicators were selected (three -four for each subsystem).

Subsystem of economic specialization. An obvious and well-studied factor in a city’s resilience (a factor in overcoming the economic structural crisis) is the level of diversification of its economy. Sectoral diversity stimulates economic interactions, promotes the innovation process and reduces the risk of fatal consequences for the city in the event of degradation of one of the sectors (in the conditions of the Russian Arctic, where a significant part of the cities were formed in connection with the development of nearby mineral deposits, the threat of depletion of the raw material base becomes of great importance) . A well-known factor in increasing the resilience of a city in the event of a crisis in the city-forming industry is the ability to search for innovation.

Based on these features, to assess the level of resilience, the well-known Herfindahl-Hirschman index, calculated using employment indicators by sectors of the urban economy (Rosstat), as well as the widely used indicator of patent activity, were chosen. In addition, for the first time, an indicator of the presence of innovative enterprises in the city was used, expertly selected from the database of SPARK organizations (in the context of quantitative assessment of the vitality of the city’s economy, special attention is paid to innovative firms offering technological, organizational or marketing innovations.

Unfortunately, some statistical data appear to be distorted, in particular, the level of employment in the mining industry of some cities of the Yamal-Nenets Autonomous Okrug is clearly underestimated (their residents working in fields remote from the city, including those working on a rotational basis, are registered at their place of work). In some cases, this circumstance distorts the values of the Herfindahl-Hirschman index (an obvious example is the city of Muravlenko), although in general the index apparently gives an adequate picture. Partly to level out these distortions, a comprehensive indicator of the level of development of the mining industry was used - a score based on the following indicators:

a) the share of the territory within a radius of 150 km located within the boundaries of licensed areas (LU) for hydrocarbon resources and solid minerals;

b) the share of the territory within a radius of 150 km located within the boundaries of promising licensed areas of hydrocarbon resources and solid minerals (with a license to conduct prospecting work);

c) the number of license areas of different types within a radius of 150 km.

The apparent duplication of indicators (taking into account both relative and absolute metrics) is due to the peculiarities of the mining industry: licensed areas of hydrocarbon resources can differ in significant sizes (therefore, in places of hydrocarbon production, relative metrics are important), while areas for the extraction of solid minerals are usually small in size (places of their concentration are detected through absolute metrics).

Life support subsystem. The heat supply system is critical to the resilience of human settlements in the Arctic climate. To assess the state of heat supply systems in Arctic cities, the authors collected data from heat supply diagrams. The ratio of the reserve/shortage of thermal power to the thermal load reflects the ability of heat supply organizations serving populated areas to promptly replace capacity that is out of service in the event of an emergency, and, to a first approximation, the ability to "control fate." Indicators of the ratio of losses in the heating network to the heat load, the share of local fuel, the structure of the fuel used (share of coal, oil, etc.) were also considered - however, it was not possible to collect a complete set of indicators for the totality of the cities studied.

In addition, data were used on the share of wooden housing stock in the total volume of multi-apartment housing according to the federal database "Housing and Communal Services Reform" (in the conditions of the Far North, multi-apartment wooden housing is, as a rule, low-quality housing stock of standard houses from the 1960s–1970s, non-prestigious "pieces of wood"). In essence, the selected parameter characterizes the share of obsolete housing stock. In addition, a scoring assessment of transport provision, described in detail in earlier works, was used. Other sectors related to life support (food industry, water supply, etc.), according to preliminary estimates, do not provide a strong differentiation of cities and were excluded from consideration.

Sociocultural subsystem. When assessing the resilience of a sociocultural subsystem, the authors started from the understanding of resilience in psychology as a combination of involvement in external relations, the ability to control fate and innovative changes. The first indicator, "fate control," is also widely used in sustainability research. Of the approximately two dozen indicators initially considered, four were selected. Involvement in external relations is assessed through the ratio of the average value of outgoing migration for 2017–2021. to migration turnover (the sum of those leaving and entering). It is not advisable to use the migration balance, since almost all Arctic cities have a large migration turnover. It was very difficult to choose the "control of fate" indicator. Foreign works, as a rule, rely on indicators of the development of democratic institutions - especially when it comes to the involvement of certain categories of local residents (women, indigenous peoples, etc.) - however, taking into account Russian political realities (in particular, the situation of control of elected bodies authorities of city-forming enterprises) it was decided to abandon such assessments. As a result, the number of small and medium-sized businesses per 1000 residents was chosen as the base indicator - not only as an indicator of the level of development of entrepreneurship and flexibility of economic behavior, but also as an indicator of the level of trust in the territory ("if we don't believe in the future of the city, we don't invest", which is clearly evident in field studies).

The Arctic cities of Russia are traditionally distinguished by great ethnocultural diversity, and this aspect, in the authors' opinion, certainly requires consideration. Therefore, it was decided to introduce an unusual indicator - the registered number of national-cultural autonomies per 1000 inhabitants. The experience of the members of the team of authors with the migration service and migrant adaptation services (A. V. Burtseva), ethnological monitoring and early warning of conflicts (V. P. Klyueva) allows us to expertly evaluate this indicator as a good indicator of the ability of ethnocultural groups to legally defend their interests in dialogue with authorities. Thus, this indicator largely reflects the presence of institutional mechanisms to control the fate of a multi-ethnic urban community, and in this capacity "works" better than indicators of ethnic diversity as such, as well as the territorial structure of migration flows (which were also considered at the first stage). The traditional indicator of the number of publications in the RSCI over the last five years per 1000 inhabitants was chosen as an indicator of the ability for innovative development; indicators of the number of registered users of the RSCI, as well as foreign databases of scientific publications, were also considered; the presence of a university and/or the number of students are all generally highly correlated.

Natural-ecological subsystem. Among the natural factors characterizing the resilience of cities (with one sign or another), the following components of the geosystem cover were included: the universal index of thermal discomfort, used to assess the severity of weather, the gully index - one of the most expressive quantitative indicators, revealing the potential for the development of mechanical denudation, due to the dissected relief and lithological conditions of the territory, the annual production of phytomass as an integral parameter is often used in assessments of the sustainability of the natural environment, since bioproduction characteristics determine the environmental protection potential of permafrost landscapes and the rate of their recovery after mechanical and aerotechnogenic transformation. Finally, the most important indicator was the permafrost distribution index, assessed through a combination of the distribution pattern (continuous, discontinuous and massive island) and the ice content of permafrost. With an increase in ice content and permafrost continuity (which also reflects the severity of the climate), the viability of the infrastructure decreases: the costs of its construction and maintenance are higher.

Administrative and management subsystem. The set of indicators that can characterize the viability of the management subsystem differs from standard and fairly well-known indicators of the effectiveness of municipal management due to the specifics of the task. About a dozen indicators underwent preliminary calibration, and three were retained in the final list. The administrative status of the city and the level of its own budget revenues (average for 2017–2021) show the ability to control fate, respectively, in political-administrative and financial relations. Additionally, the indicator of the average number of employees in the sector “Public administration and ensuring military security” was also used; social security” in relation to the total number of employees, in% (average for 2017–2023). The indicator of budget expenditures per capita (average for 2017–2023) indirectly reflects the amount of financial resources that could potentially be used by the city itself to quickly respond to crisis situations.

The choice of indicators is reflected in more detail on the resource created within the project.

The primary selection of variables was carried out using the principal component method and analysis of paired scatterplots. Preference was given to indicators that have a high impact in the first five components, allowing cities to be differentiated and further divided into groups according to resilience using cluster analysis. A data set with selected indicators was prepared for clustering, namely:

– Variables with significant values differing by orders of magnitude were logarithmized;

– all variables were centered and scaled.

At the first stage, clustering was carried out using hierarchical clustering methods and the K-means method. The selection of the best number of clusters was made using the “shoulder” method with optimization of the cluster compactness characteristics, as well as the “silhouette” width optimization method.

At the second stage (due to unsatisfactory results obtained using classical methods), the t-SNE and UMAP methods were used to reduce the dimensionality of the data set (used when the principal component method is not able to identify the first two or three components with a high proportion of explained variance, including number due to the large number of variables). Using dimensionality reduction algorithms, the data was projected into two variables (analogous to principal components). Due to the element of randomness in the operation of the algorithms, each dimension reduction operation was performed in 1000 iterations. The GMN method was applied to the results of each iteration of dimensionality reduction for clustering with automatic selection of the optimal shape of clusters and the optimal number of clusters according to the BIC maximization criterion. The source data, code that reproduces the cluster analysis, and graphs are published as supplementary materials to the article on GitHub.

At the last stage, the resulting groups were expertly assessed for interpretability

Despite the multi-stage selection of variables at the first stage, the results of clustering using classical methods (hierarchical clustering and the K-means method) do not allow us to identify stable groups of cities that would be characterized by special values of the selected indicators and their combinations. As you can see, the silhouette width analysis method (right) falsely indicates 3 or 5 groups. They can indeed be identified, but, as can be seen in the same figure on the left, the compactness of clusters, regardless of the clustering method, decreases extremely smoothly, which indicates the instability of clusters - the slightest variations in the values of variables, replacement or exclusion of one variable from the analysis immediately lead to displacement a significant number of cities into completely different groups.

The conclusion about the impossibility of dividing the cities under consideration into stable interpretable groups using classical methods is also confirmed by the principal component method. Only half of the variance is explained by the first three components, and in order to explain at least 75% of the differences between cities (and, consequently, groups of cities) using variables, at least six components are required, each of which includes the influence of all variables. This leads to the impossibility of forming stable clusters.

Only when applying the methodology described above using the UMAP + GMM method was it possible to identify seven stable groups of cities and analyze the differences between these groups in terms of the studied variables. Comparison of the results allows us to identify groups of cities with relatively similar configurations of the resilience system. So, for example, the second cluster (Vorkuta, Norilsk, Dudinka) greatly “loses” due to the severity of natural conditions and transport conditions - although it has a fairly high level of small business development and diversity of society; there is almost no wooden housing here (the dilapidated wooden barracks that existed in these cities have been demolished). In general, the Yamal cities, Kola and Naryan-Mar (sixth and seventh groups) have a high level of budgetary security (in terms of budget expenditures per inhabitant), as well as a good level of small business development (due to well-organized state support). The “trouble” of the sixth group (Labytnangi, Tarko-Sale, Noyabrsk, Muravlenko, Salekhard) is a large proportion of multi-apartment wooden housing (these are low-quality two-story buildings of standard series, and not individual buildings); in this they differ sharply from most other “oil and gas” and other cities with high budgetary security (Gubkinsky, Novy Urengoy, etc. - the seventh group). The fourth group (Onega and others) are cities with a relatively homogeneous population, worn-out infrastructure and high migration outflow. The fifth group consisted of obvious leaders in many respects - Murmansk and Arkhangelsk.

Because the Arctic Ocean receives much less solar energy compared to other oceans on Earth, it is all covered in ice (with the exception of the coastal areas of Norway and the Murmansk region, which are fed by warm currents). This is also facilitated by the strong desalination of surface waters due to the large volumes of runoff from northern rivers. In summer, the coastal waters of Canada, Alaska and Russia become ice-free. The central part of the Arctic Ocean is covered with ice all year round.

The processes of climate change in the Arctic, economic growth in the world and the development of technology determine the beginning of a new stage in the development of the region, the foundation of which is the growing interest in the mineral resource base of the Arctic, as well as the possibilities of using its transit potential. In Russia, the development of the Arctic zone is often viewed as a mega project that can become an economic driver.

The article uses the results of a project carried out within the framework of the program to support individual research at the Faculty of World Economy and International Affairs of the National Research University Higher School of Economics in 2021 on the country's growth. But as economic activity in the Arctic intensifies, the environmental aspects of its development become more and more relevant. According to the Intergovernmental Panel on Climate Change (IPCC), the Arctic is one of the four regions of the world most vulnerable to global climate change and one of the most fragile ecological systems on the planet. The consequences of the processes occurring here are likely to affect the global climate system.

Arctic ecosystems are extremely vulnerable to economic development. The flora and fauna of high latitudes are characterized by relative species poverty with relatively high genetic diversity, which determines the exceptional biological value of this region. Only about 1% of all species of living organisms live in the Arctic, but many animal taxa are most fully represented here. In particular, the Artik is home to all species of birds of the order Loons, 25% of species of salmon-like fish, 10% of lichen species and 6% of moss species.

Arctic ecosystems are ideally adapted to extreme temperatures, low light levels, short summers, permafrost and snowy winters, but they are especially sensitive to any changes in natural conditions, primarily caused by anthropogenic impact. At low temperatures, the processes of assimilation of any waste and pollution proceed slowly, and therefore ecosystems are not able to fully cope with the consequences of pollution even over hundreds of years.

The Russian part of the Arctic is the most developed and, as a result, the most polluted. The first stage of this pollution is associated with nuclear tests, active industrialization of the region and the development of the Northern Sea Route (NSR). Key sources of pollution were nuclear test sites on Novaya Zemlya, Siberian chemical plants, and the operations of the northern naval and icebreaker fleets.

The process of development of the Russian part of the Arctic, in contrast to the Canadian one, where the mineral resource base is developed on a rotational basis, was carried out by settling the polar regions on a permanent basis. This led to the formation of scorched spots around the city-forming factories. The northern territories also suffered from pollution from debris left over from geological and scientific work, as well as activities at military facilities.

The collapse of the USSR led to partial deindustrialization and emigration of the population from the Arctic zone, but environmental problems have not disappeared. On the territory of the Russian Arctic, there are 27 areas most susceptible to anthropogenic influence (11 on land and 16 in the seas and coastal zones), which are called “impact” areas. The main centers of environmental disaster were the Norilsk region (more than 30% of the total emissions of pollutants), areas of development of oil and gas fields in Western Siberia (more than 30%), the Murmansk region (10%), and the Arkhangelsk region (pollution with specific substances). Their ecosystems are subject to changes in chemical composition, pollution and degradation of soils, ground and vegetation, and the appearance of harmful chemicals in food chains; In addition, the incidence of disease in the local population increases.

There is an urgent need for large-scale work to dispose of industrial waste that accumulates in large quantities around enterprises. The development of the Arctic shelf poses enormous risks. The development of the NSR can change the habitat of marine animals, carries additional risks of oil and petroleum product spills, and will also be accompanied by emissions of sulfur and nitrogen oxides from the combustion of bunker fuel.

The processes of economic development of the region, the factor of climate change, as well as the special sensitivity of Arctic ecosystems to external influences determine the growing concern of the international community about the environmental problems of the Arctic. The United Nations Environment Program (UNEP) identifies three main ones: climate change and the melting of Arctic ice; pollution of the waters of the northern seas by oil and chemical runoff, as well as by maritime transport; reduction in the population of Arctic animals and changes in their habitat. Any economic activity in the region faces the need to take these problems into account. Companies operating in the Arctic are forced to follow separately more stringent standards, take additional measures to ensure the safety of production processes for the environment, face additional pressure from environmental organizations, take into account changing environmental conditions, and interact with indigenous peoples whose activities are closely related to it.

Currently, the Arctic is experiencing climate changes that are unprecedented in speed and nature. Over the past few decades, the average surface temperature in the Arctic has increased twice as fast as the global average, although it is extremely heterogeneous across regions. In some polar regions of the Western Hemisphere it was 3–4 °C compared to the mid-20th century. In the 21st century Temperature records are recorded almost every year. The result was the melting of the ice of the Arctic Ocean. Satellite data from 1979 to 2012 show Arctic ice extent declining at a rate of 3.9% to 4.5% per decade. The area of September ice (i.e., during the period of minimum ice cover) has been decreasing over the past 30 years at a rate of 13% per decade. A sharp decrease in sea ice cover was recorded in September 2007 and 2012, when it amounted to 37 and 49% of the average ice area in the period 1979–2000. The absolute minimum ice was recorded in September 2012. Despite the fact that in 2013 the ice extent actually returned to normal and increased in 2014, the long-term downward trend is beyond doubt. Seafloor thickness in Arctic seas has decreased by an average of more than 40% since the 1980s, primarily due to the melting of perennial ice.

According to estimates by the Intergovernmental Panel on Climate Change (IPCC), on which Roshydromet also relies, under any warming scenario, the temperature increase in the Arctic will be approximately twice the global average. As a result, the processes of reduction will continue and thinning ice cover. According to Roshydromet estimates, further strengthening of the mutually influencing trends of increasing air temperature and reducing the area of ice cover will lead to the fact that in the 2035s. in September the ice may disappear altogether.

Climate change in the Arctic is exacerbated by the presence of intense positive feedback, namely:

Firstly, the gradual melting of ice leads to a decrease in the reflectivity of the earth's surface, which increases its temperature. Snow and ice reflect approximately 80% of incoming solar radiation, while the open ocean surface reflects only 20%.

Second, thawing permafrost releases large amounts of methane, a potent greenhouse gas. Participants in the climate conference of the parties to the UN Framework Convention on Climate Change (Lima, December 2014) were shown photographs of unusual holes on the Yamal Peninsula - with a diameter of 20 - - 30 m and a depth of about 10 m. The most realistic explanation for their formation is the melting of subsurface ice as a result increase in air temperature. Natural gas or methane from the permafrost could penetrate into the resulting container, and the resulting pressure would explode the thin soil layer.

Scientists predict that more and more such holes will form, and from them carbon dioxide and methane will flow into the atmosphere. According to UNEP, the permafrost of the Arctic zone contains 1,700 billion tons of these gases - this is twice what is currently contained in the atmosphere. Thus, as the Arctic region warms, positive feedback mechanisms will accelerate climate change processes both at the regional and global levels.

Thus, the melting of continental Arctic ice (primarily in Greenland, but also on the islands of the Russian Arctic) threatens to increase the level of the world sea. According to IPCC estimates, by the end of the 21st century. it could reach 80 cm from the current one, which would have catastrophic consequences for small island states, areas of large river deltas, as well as cities located in low-lying coastal areas.

Another group of possible catastrophic consequences—warming of polar waters, as well as desalination of the North Atlantic due to melting glaciers—could lead to a weakening of the Gulf Stream, which is extremely dangerous for the climate of Europe.

The consequences of climate change for the ecosystems of the Arctic itself are very serious. Over the past 34 years, the vertebrate population here has decreased by 10%, and the number of reindeer, which is extremely valuable to humans, has decreased by one third in the first decade of the 21st century.

Perhaps the most negative consequence of climate change in the region is the degradation of permafrost. It negatively affects the reliability and stability of building structures and engineering structures located on it, primarily economic infrastructure and main pipelines. In Igarka, Dikson, Khatanga, about 60% of infrastructure facilities are deformed, in Dudinka - 55%, in Pevek - 50%, in the villages of Taimyr - 100%. Up to 55 billion rubles are spent annually on maintaining their performance and repairs in Russia.

In Western Siberia, several thousand accidents occur annually on oil and gas pipelines, a fifth of them are caused by mechanical impacts and deformations due to uneven settlement of the soil during thawing of permafrost, leading to weakening of foundation structures.

Along with numerous risks, climate change also brings a number of positive consequences. The harsh weather conditions of the Arctic are becoming milder, which makes its wider economic development possible. Thus, climate change has become one of the key factors that made possible a new stage in the development of the NSR.

The most dangerous pollutants for the Arctic seas are heavy metals, petroleum hydrocarbons, organochlorine compounds, detergents, radionuclides, and polyaromatic hydrocarbons. Most of this pollution is anthropogenic in nature. The reasons for the entry of heavy metals are the development of ore and hydrocarbon deposits, industrial, especially metallurgical plants, as well as maritime transport. Fuel spills also make a significant contribution to pollution of the Arctic Ocean.

Oil and gas projects on the Arctic shelf face a number of difficulties caused by severe weather conditions, short daylight hours, ice cover, icing of infrastructure, as well as the need to transport equipment over fairly long distances by sea. In many Arctic regions, existing infrastructure and facilities are insufficient to effectively and promptly respond to oil spill emergencies. Due to low temperatures in the Arctic, the resistance of hydrocarbons to decomposition and assimilation increases, and, as a result, the restoration processes of Arctic ecosystems slow down.

The greatest danger comes from oil spills. Thus, as a result of the crash of the Exxon Valdez oil tanker off the coast of Alaska in 1989, about 260 thousand barrels spilled into the sea. oil, an oil slick of 28 thousand km2 formed. This caused a sharp decline in fish populations, in particular pink salmon, and local ecosystems have not yet fully recovered. In addition, the disaster caused enormous public concern, and a class-action lawsuit by thousands of fishermen, landowners and businessmen resulted in a record fine of $2.5 billion (which was reduced to $500 million a decade later) against ExxonMobil.

However, it would be a mistake to assume that the alternative to tanker transportation – transporting oil and petroleum products from the Arctic by pipelines – will always be more environmentally friendly. According to Greenpeace, since 2003, Russia has seen a constant increase in the number of oil pipeline breaks leading to oil spills. Unfortunately, there is very little information about them; companies are not trying to make them public. According to an estimate summarizing data from publications of specialized companies and expert opinions, the volume of oil spills in Russia can reach 20 million tons per year. They will only increase in the future as pipeline infrastructure becomes obsolete and permafrost thaws.

Spills are possible not only during transportation, but also during drilling. The history of the development of the continental shelf knows a number of similar accidents with catastrophic consequences. The largest accident in the Gulf of Mexico in 2010 was an explosion and fire on the Deepwater Horizon platform, operated by BP. Its results were a disaster for marine and coastal ecosystems, and the total damage, according to some estimates, amounted to about $40 billion. So far there has not been a single major accident on the shelves in the Arctic latitudes, but scientists say that if something similar to what happened in the Arctic in the Gulf of Mexico, the catastrophe would be truly planetary in scale.

Taking into account the exceptional danger of oil spills in the Arctic, issues of their prevention and liquidation of consequences are reaching the international level. The 2013 Arctic Council Ministerial Meeting in Kiruna adopted an agreement on cooperation on Arctic marine oil spill preparedness and response, and at the 2015 conference in Iqaluit a framework plan for cooperation on preventing oil pollution from activities was signed. on the extraction of hydrocarbon resources and the intensification of shipping in the maritime Arctic.

The danger of oil spills in the Arctic also exists in Russia. Domestic drilling platforms are technologically imperfect, and this problem may worsen in the future due to the introduction of sectoral sanctions and the cessation of supplies of offshore drilling equipment from Europe. In particular, the Prirazlomnaya platform on the shelf of the Pechora Sea (the only one currently producing oil on the Russian Arctic shelf) is actually assembled in pieces - its lower part was built at Sevmash, and the upper part, where the main premises and the residential block are located , dismantled from a decommissioned Hutton tension leg platform, not intended for operation in Arctic ice.

In response to a request from environmental activists, Gazprom Neft states that the platform meets the most stringent safety requirements. In addition, the company has developed a plan for the prevention and response to possible oil spills, agreed upon with the Federal Agency for Sea and River Transport of the Ministry of Transport, the Ministry of Energy and approved by the Russian Ministry of Emergency Situations. The plan analyzes various risk scenarios and contains calculations of the costs of creating emergency units. In addition, the company purchased special equipment capable of collecting oil in ice conditions and eliminating the spill in a short time. In 2014, under the auspices of the Russian Security Council with the participation of the Ministry of Transport, the Ministry of Defense, the Ministry of Emergency Situations, the Nenets Autonomous Okrug, the Sovcomflot company and other organizations, large-scale exercises “Arctic-2014” were held, within the framework of which, among other things, actions were worked out in the event of a possible oil spill.

Despite all these measures, many environmental organizations insist that oil production on the Arctic shelf is inadmissible, at least until technologies for collecting oil spills in the Arctic latitudes are developed. In 2015, the Russian branch of the World Wildlife Fund proposed a 10-year moratorium on the development of oil reserves on the Arctic shelf.

The initiative was supported by a number of well-known politicians, officials, and economists. Their position is based not only on environmental, but also on economic arguments, which are especially relevant in the context of low oil prices and sanctions from Western countries. Thus, according to E.M. Primakov, "on the Arctic shelf, production profitability is ensured only at a price of 100–120 dollars per barrel. In such conditions, should we speed up oil production on the Ice Ocean shelf? Some of our competitors have already taken such a pause. The United States drilled its last well on the Arctic shelf in 2003, Canada in 2005." V. A. Kryukov believes that "oil production in the Arctic is not only high environmental risks, but also an extensive development path and a high-cost activity, which in the current economic situation must definitely be abandoned. The country needs a modernization maneuver, support for truly innovative solutions, and not an attempt to continue to solve the problems of economic development using an extensive model."

In the Energy Strategy of the Russian Federation until 2030, "active development of the mineral resource base of the oil and gas complex" of the Arctic, including its shelf, is included in a number of priority tasks. It is often argued that maintaining the proper level of oil production against the backdrop of depleting fields in Western Siberia is, in principle, impossible without developing the shelf. However, the overwhelming majority of all proven oil reserves, according to Rosnedra, are not located on the Arctic shelf, but on the mainland of the country. The industry's problem lies not in the lack of new deposits, but in the efficiency of development of already discovered ones.

The main potential for successful development of the country's energy sector lies in increasing the efficiency of field development and transportation of hydrocarbon raw materials. Thus, an increase in the oil recovery factor from today's 38% by only 4 percentage points will allow the production of an additional 30 million tons (219 million barrels) of oil per year. For comparison: in 2014, only 300 thousand tons (2.19 million barrels) were produced at Prirazlomnaya.

Due to the fact that the development of the shelf corresponds to the interests of a number of large companies and has already been designated as one of the priorities of Russian energy policy, it is unlikely that the proposal for a moratorium will receive unconditional support, but it may at least push the state, companies and "green" groups to search for compromise. Norway and the United States have such experience, having imposed a moratorium on hydrocarbon production in especially fish-rich waters off the Lofoten Islands and in Bristol Bay in Alaska.

With regard to gas production in the Arctic, both environmental and reputational risks are incomparably lower. Firstly, the process of eliminating gas leaks is much easier than oil, and the environmental consequences are not as serious, since the gas dissipates quickly. Secondly, natural gas as the least dirty type of fossil fuel (it is non-toxic and is not accompanied by side emissions during combustion, except for CO_2, which, however, are still less than oil and coal) has a positive reputation in the eyes of the environmental community. Companies understand this well. Thus, the late president of Total, C. de Margerie, noted in one of his last interviews that in the event of an accident in the Arctic, the damage to the company's image would be too high. Therefore, Total is ready to participate, first of all, in gas projects, where the process of eliminating gas leaks is much easier compared to oil.

5 IVF. – 2015. – No. 11

It is important to understand that, regardless of the actual safety measures that companies take, the development of oil and gas reserves in the Arctic (both continental and especially offshore) is associated with huge reputational risks, as demonstrated by the situation with the disembarkation of Greenpeace activists from the Arctic Sunrise vessel on the platform " Prirazlomnaya" followed by widespread criticism of Gazprom around the world. Taking into account the fact that at present the public opinion factor has a serious influence on the decisions of investors, and the political situation contributes to the aggravation of the situation around any problems related to Russia, these risks should not be underestimated.

To date, a number of international agreements have been concluded aimed at protecting Arctic ecosystems. In particular, in 1992, 15 countries on the northeastern coast of the Atlantic Ocean signed the Convention for the Protection of the Marine Environment of the Northeast Atlantic. One of the objectives of the Convention is to prevent and eliminate pollution from marine sources and the adverse effects of offshore activities in order to protect public health and preserve marine ecosystems. In addition, the Convention declared the water area from Iceland to the Azores a protected area.

Russia is not one of the countries party to the Convention. She is involved in international cooperation on environmental protection in the Arctic as a member of the Arctic Council. Environmental issues occupy a central place in his activities. Thus, all six working groups (on eliminating pollution of the Arctic, on implementing the Arctic monitoring and assessment program, on preserving Arctic flora and fauna, on prevention, preparedness and response to emergency situations, on protecting the Arctic marine environment, on sustainable development in the Arctic) are functioning within the Council are related to environmental issues. At recent ministerial conferences of the Arctic Council, the topic of preventing oil spills and eliminating their consequences, as well as reducing soot and methane emissions in the Arctic, received special attention. A special task force has been created to address this last issue.

At the bilateral level, the Agreement on Assistance in the Event of an Oil Spill in the Barents Sea was concluded between Russia and Norway back in 1994. It includes a joint emergency action plan, and also involves holding joint exercises of national services on an ongoing basis.

Currently, there is increasing talk about the need to unite the efforts of different states, companies and non-governmental organizations in eliminating the consequences of natural and man-made disasters, for example, in the form of creating a global emergency rescue company (GARC), coordinating the actions of interested participants in the event of a disaster anywhere in the world. This approach is especially important for potential disasters in the Arctic, as speed of response is critical to preventing damage. Russia could be one of the main initiators and beneficiaries of the creation of GASK: it is vulnerable to disasters of various types, while it has extensive experience in effectively preventing and eliminating the consequences of disasters (the Russian Ministry of Emergency Situations is one of the best in the world), as well as a fleet of aircraft and rescue equipment, which it could provide to GASK.

In addition to the listed agreements at the regional or bilateral level, the Climate and Clean Air Framework Coalition, developed at the initiative of UNEP and including 46 participants, including Russia, can play a special role in protecting the Arctic environment. The goal of this organization is to reduce emissions of short-lived pollutants: “black carbon” (soot) (solid particles formed during incomplete combustion of biomass, wood, diesel fuel, mainly consisting of pure carbon, which adsorb solar radiation at all wavelengths), methane and chlorofluorocarbons. According to some estimates, “black carbon” is the second most important catalyst for global climate change after carbon dioxide.

The Russian Ministry of Foreign Affairs sent an application to join the Coalition back in August 2012, but for formal reasons the country was able to become its full member only in 2014. The Coalition is distinguished by flexibility and the absence of a rigid framework (voluntary choice by countries of directions and priorities of work, as well as voluntary contributions to the general fund). Its work scheme already allows for the implementation of projects to reduce emissions in Russia with foreign funding. At the moment, such projects are not among the priorities of the Coalition.

However, there is every reason to make the fight against emissions in the Arctic one of its priorities. The impact of black carbon is particularly strong in this region. Due to industrial production, forest fires, and fuel combustion, soot falling on snow or ice surfaces reduces its reflectivity, which in turn contributes to an increase in temperature.

In addition to the environmental value, as well as the potential financial benefits that Russia could receive, active participation in the Coalition also benefits it because the fight against soot emissions directly corresponds to strategic plans for modernizing the energy and transport sectors in the Arctic. Of course, to benefit from international cooperation on these issues, Russia must start with measures taken at the national level.

The development of scientific cooperation in the Arctic region will also be beneficial for Russia. The Arctic is the best place in the world for climate research. Its Russian part could lay claim to the role of a natural laboratory on a global scale, in which scientists from different countries could conduct joint research. This will make it possible to attract funding for the modernization of meteorological stations and other scientific infrastructure, including that necessary for the development of the Northern Sea Route.

The importance of the Arctic for Russia is difficult to overestimate. According to the “Fundamentals of the state policy of the Russian Federation in the Arctic for the period up to 2020 and beyond,” the region is considered as a strategic resource base, and its development is among the main national interests of the country.

The socio-economic development of the region should not only not be accompanied by deterioration of the environmental situation, but also be carried out in parallel with the elimination of accumulated environmental damage and the rehabilitation of degraded ecosystems. “Ensuring environmental safety”, “preserving and ensuring the protection of the natural environment of the Arctic, eliminating the environmental consequences of economic activity in the context of increasing economic activity and global climate change” are officially included in the priorities of the state policy for the development of the Arctic zone. And “maximum environmental conservation” was declared as one of the main principles, which means “the application of the most stringent environmental and environmental standards, the use of the most effective environmental technologies.”

Today, the national environmental regulatory framework includes about 40 federal laws, approximately 1,200 government regulations and orders, as well as orders of ministries and departments. However, these documents apply, as a rule, to the entire territory of Russia, which makes it impossible to fully take into account the specifics of the natural and climatic conditions of the Arctic region. As a result, environmental requirements for Arctic territories are almost equivalent to those for regions less sensitive to anthropogenic impact.

The practical implementation of the directives and requirements laid down in the regulatory framework for the development of the Arctic region also leaves much to be desired. Thus, in Russia, approaches to determining the permissible anthropogenic impact on Arctic ecosystems have not yet been developed, which prevents the establishment of objective requirements for the activities of economic entities in the region. In addition, business representatives note that the procedures for approving technical documentation are too bureaucratic and can last more than a year. As a result, it becomes possible to selectively apply legal norms and use them as a means of government pressure on business.

Another weakness of Russian environmental regulation is its excessive centralization. Environmental problems should be addressed where they arise – in municipalities and regions. This allows you to take into account the specifics of the problems of specific territories and find more accurate solutions. This principle is observed in most developed countries, including the Arctic ones - the USA, Canada, Iceland.

A serious impetus for the development of Russian environmental legislation could be accession to the OECD. It was the requirements put forward by this organization that became the basis for the formation of Russia's "road map" towards improving the regulatory framework in terms of environmental protection in such areas as waste management, preventing environmental damage and increasing environmental responsibility, ensuring environmental and industrial safety, access to environmental information, environmental monitoring. Despite the fact that currently negotiations on Russia's accession to the OECD are frozen, a number of changes to environmental legislation have already been launched.

An important specific feature of Russian environmental policy in the Arctic is its close connection with the military presence in the region. Since Soviet times, many environmental functions have been assigned to military units stationed in the Arctic. This is still relevant today: for example, units of the Eastern Military District in October 2014 removed 10 tons of waste (household garbage) from Wrangel Island and the area of Cape Otto Schmidt. Minister of Defense S.K. Shoigu also made a proposal for the participation of military units that work on Franz Josef Land, Cape Otto Schmidt, Wrangel Islands, Kotelny, Novaya Zemlya, Novosibirsk, in the Arctic cleanup program, carried out jointly with the Ministry of Natural Resources and Russian Geographical Society. A "regional environmental center of the Northern Fleet will soon be formed, which will carry out environmental monitoring and control compliance with Russian and international environmental legislation both in the places where the fleet is deployed and in the Arctic zone where our military personnel are stationed."

Russian energy companies are gradually taking more and more measures to reduce their negative impact on the environment. Thus, in 2013, Novatek's expenses on environmental protection measures amounted to 363 million rubles, with the bulk of the funds coming from the disposal of waste from its activities (about 109 million rubles). Gazprom Neft company in 2014–2016 implements a program for the reclamation of oil-contaminated lands, sludge pits and the processing of oil-containing waste. According to the latest report on sustainable development of the Rosneft company, even taking into account the commissioning of new assets, gross emissions of harmful substances are being reduced, primarily due to the Targeted Gas Program aimed at reducing the volume of flaring of associated petroleum gas.

Only part of the environmental activity of Russian energy companies is a consequence of legislative regulation. To a certain extent, we are talking about the social responsibility of business, and partly about reflecting the growing interest of the public (and, as a result, investors) in environmental issues.

In the Arctic, however, companies' environmental efforts are increasingly aligned with the concept of "shared values": they pay close attention to environmental issues, based on the understanding that these issues will be critical to them in the long term. In particular, it was the Arkhangelsk Pulp and Paper Mill, Novatek and Gazprom operating in the Arctic zone of Russia that became laureates of the Carbon Disclosure Project in 2014, which assessed the completeness of companies' disclosure of information on greenhouse gas emissions. Particular attention is paid to environmental safety when implementing the Yamal LNG project of the Novatek company. Gazprom is spending record amounts on climate research related to permafrost degradation, as it has a serious impact on the company's work in the Arctic. Both Novatek, Gazprom, and Rosneft actively interact with representatives of small indigenous peoples, understanding the need to find compromises with them as the main stakeholders of these companies in the region.

Of course, the initiatives being implemented are not yet enough to alleviate the problems associated with the environmental safety of the Arctic region. In Russia, we just have to build a comprehensive system of safety, prevention and elimination of the consequences of man-made accidents, combining the efforts of federal, regional authorities and business. The pipeline infrastructure needs to be updated. The problem of pollution of the Arctic by industrial waste remains acute.

Conclusion

Today, the topic of the Arctic is relevant, as there is a surge of interest in the Arctic in the world. Let's consider what this may be connected with.

The Arctic is an area of the globe that includes areas from the North Pole to the Arctic Circle or the northern border of the tundra. The Arctic zones were not initially divided, so they are claimed by five states - Russia, Norway, Denmark, Canada and the USA.

The Arctic is known to us all for its extreme conditions: permafrost, long and cold winters, short and cool summers, the absence of conventional roads, the need to deliver almost everything necessary from the “mainland”.

The peculiarity of the Arctic is that it is home to a number of unique animals: musk ox, wild reindeer, bighorn sheep, polar bear, lemming, wolverine, ermine, long-tailed ground squirrel, etc. Many of them are listed in the Red Book, so they should be treated with special attention and thrift.

Another interesting fact: there are no trees in the Arctic, but in its warm part dwarf shrubs, grasses, grasses, lichens and mosses are often found. Low summer temperatures result in low species diversity and small plant sizes. And in the Arctic desert there is practically no vegetation, since it is the northernmost of the natural zones.

Today there is great interest in the Arctic - many countries are ready to invest in the development of the rich natural resources of the macroregion. The Arctic contains a very large amount of undeveloped energy resources - oil, uranium, gas.

The extraction of natural resources in the Arctic is extremely complex and dangerous from an environmental point of view. In the harsh climate of the Arctic, the likelihood of emergency situations increases many times. The ability to eliminate the consequences of an oil spill, as well as its effectiveness, are complicated by numerous storms with high waves, thick fog and many meters of ice. If an accident occurs during the polar night, which lasts here for several months, then work to eliminate the consequences will have to be carried out in the dark. Another danger is icebergs, a collision with which can be fatal for an oil production platform. These conditions make it difficult to do business in the Arctic. Therefore, to attract investors, preferences (advantages, benefits) are needed so that it is profitable for them to develop the riches of the Arctic zones.

Currently, the problem of global warming is acute. Temperatures in the Arctic are rising twice as fast as in the rest of the world. This could lead to the extinction of many plant and animal species in the region.

Warming threatens the existence of Arctic indigenous peoples.

SIPN are the indigenous peoples of the North who live in the vast expanses of the North. Previously, they were called “small nations of the North.” These include: Evens, Evenks, Chukchi, Dolgans, Yukaghirs, etc.

Their food and way of life directly depend on the flora and fauna. Without conducting traditional economic activities, it is impossible to imagine the full existence of indigenous peoples. Warming also leads to rising water levels, which makes life more difficult for some animals. For example, when searching and catching fish. All this leads to the fact that animals have to literally “survive” and look for food in areas where people live.

We believe that if the environmental problem is not solved, then the Arctic has no future. Therefore, to preserve the existence of indigenous peoples, as well as many species of plants and animals, it is necessary to take certain measures now.

The results of applying a whole series of methods for assessing the resilience and resilience potential of Arctic cities in Russia convince us of the absolute specificity of the Arctic city phenomenon: a significant part of them has a unique set of potential parameters of resilience, due to various combinations of the organization of subsystems of economic specialization, life support, socio-cultural, natural-ecological and administrative - managerial.

The conclusions of the work can be divided into conceptual and applied components. The conceptual conclusion is that the resilience of Arctic cities is formed each time by a unique combination of sociocultural, institutional, industrial, technological and natural-ecological parameters. It is interesting that resilience does not depend on the total population of the city, specialization, etc., which destroys many stereotypes regarding the patterns of urban development in general: in the Arctic, the largest cities are neither the most innovative nor the most comfortable in terms of the quality of the housing stock, etc.

The main applied conclusion is the fundamental inadequacy of standard solutions for the development of Arctic cities: with a relatively small total number, their totality is highly diverse. Increasing the resilience of each city should be planned based on the strongest subsystem of a particular city, around which a system of interconnection (and interchangeability in crisis situations) of urban subsystems should be built in such a way that the features of a strong subsystem create positive effects in weaker ones - through the flow of personnel and innovations, the use of common infrastructure, through the development of new types of economic activities based on the advantages of a “strong” natural-ecological subsystem, diversification of the economy based on the diversity of experience and external relations of a multi-ethnic urban community, etc. - depending on the specific city.

To find a balance between the economic development of the region and the development of its resource base, on the one hand, and minimizing damage to the environment, on the other, it is important to establish a dialogue between the state, business, representatives of small indigenous peoples of the North and environmental organizations. Shelf development should begin only when Russia is ready for it both economically and technologically. It is worth continuing to involve the military, but also foreign partners, in solving environmental problems, especially since now there are more and more opportunities in the world to finance projects to prevent and eliminate environmental damage.

In order for the Arctic to be used as a driver for the country's economic development and to ensure Russia's full sovereignty over the Arctic territories, it is necessary to preserve the unique polar ecosystems and return the Arctic to the role it deserves - the role of the world's largest natural scientific laboratory, where nature and human activity are in a state of flux. stable equilibrium.

References:

1. Baburin, V.L., Badina, S.V., Goryachko, M.D., Zemtsov, S.P., & Koltermann, K.P. (2016) Assessing the vulnerability of the socio-economic development of the Arctic territory of Russia. *Vestn. Moscow un-ta.* Ser. 5. Geogr. 2016. No. 6, pp. 71–77.
2. Baburin, V.L., & Zemtsov, S.P. (2015). Evolution of the system of urban settlements and the dynamics of natural and socio-economic processes in the Russian Arctic. *Regional studies.* 2015. T. 50. No. 4, pp. 76–83.
3. Vinogradova, V.V. (2020). Thermal impact on the territory of Russia in the middle of the 21st century according to model data. *Izvestia RAS. Geographical series*. 2020. T. 84. No. 3, pp. 404–413. DOI: 10.31857/ S2587556620030115.
4. Goncharov, R.V., Dankin, M.A., Zamyatina, N.Yu., & Molodtsova, V.A. (2021). Cathedrals in the desert or strongholds? Diversity of cities and towns in the Russian Arctic by the nature of relationships with the surrounding territory. *Urban Research and Practice*. 2021. T. 5. No. 1. pp. 33–56. DOI: https://doi.org/10.17323/usp51202033-56.
5. Zhikharevich, B.S., Klimanov, V.V., & Maracha, V.G. (2020). Shock resistance of territorial systems: concept, measurement, management. *Regional studies.* 2020. No. 3. pp. 4–15. DOI: 10.5922/1994-5280-2020-3-1.
6. Zamyatina, N.Yu., & Goncharov, R.V. (2020). Arctic urbanization: phenomenon and comparative analysis. *Vestn. Moscow un-ta. Ser. 5. Geogr.* 2020. No. 4, pp. 69–82.
7. Shamalo, I.A. (2020). Vitality of Arctic cities: analysis of approaches. *Bulletin of St. Petersburg University. Geosciences.* 2020. T. 65. No. 3. pp. 481–505. DOI: 10.21638/spbu07.2020.305.
8. Smirnov, A.V. (2020). Human development and prospects for the formation of a knowledge economy in the Russian Arctic. *Arctic: ecology and economics.* 2020. No. 2(38), pp. 18–30. DOI: 10.25283/2223-4594-2020-2-18-30.
9. Lukin, Yu.F. (2015). Arctic: nanotechnology, military-industrial complex, investments, national idea. *Arctic and North*, 2015. No. 20, pp. 164-168.
10. Panichkin, I. (n.d.). *Problems of development of the Russian Arctic shelf.*
11. Leonov, S.N. & Shevareva, Y.S. (2017). Problems and prospects for the development of traditional types of economic activity of indigenous peoples of the North of the Far East. *Regionalistics* No. 2. – 2017, pp.26-45
12. Yudin, V.I. (2010). State policy of the Russian Federation regarding the indigenous peoples of the North at the present stage. *Power* No. 2. – 2010. – pp. 37-40