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Economic Assessment of Permafrost Degradation Effects on the Housing Sector in the Russian Arctic

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Abstract—This article is devoted to the methodology and analysis of the results of economic assessment and forecasting of the consequences of global climate change in the form of permafrost thawing and degradation for the housing sector in eight regions of the Russian Arctic. Changes in the state of permafrost soils during the implementation of the most negative (scenario RCP 8.5) of the IPCC forecast options as the most appropriate to the conditions of the Russian Arctic were taken as a physio-geographic basis for the assessment. It is shown that, under a conservative scenario of the housing sector development in this macroregion of Russia in 2020–2050, the annual average cost of maintenance and restoration of the lost housing stock will exceed ₽30 bln. With the implementation of the modernization scenario, the cost above will increase to ₽36 bln. The maximum expected loss is predicted in the Yamalo-Nenets Autonomous Okrug and Krasnoyarsk krai, and the minimum, in the Chukotka and Khanty–Mansi autonomous okrugs.

Keywords: Russian Arctic, permafrost, climate change, thawing, degradation, housing sector, construction, investments, risks, development scenarios.

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Global climatic change is most pronounced in Russia's northern territories. For the period 1980–2010, the average annual temperature in the Arctic region of the country increased by 0.5–2.5°C [1]. One of the important socioeconomic consequences of the temperature rise is permafrost thawing and degradation, which is common in the territory of 28 constituent subjects of the Russian Federation, covering almost two-thirds of the country's area. However, only in eight regions of the Russian North—the Komi Republic, Nenets, Yamalo-Nenets, Khanty–Mansi, and Chukotka autonomous okrugs; Krasnoyarsk and Magadan krais; and the Republic of Sakha (Yakutia)—does permafrost occupy a significant part of the economically developed space; in other regions it is fragmentary.[1]

Permafrost thawing and degradation decrease the bearing capacity of permafrost soils [2–5], thereby creating serious risks for the stability of the industrial and social infrastructure, buildings, and structures, the construction standards of which always take into account climatic and physiographic conditions of the environment [6–9]. An increase in temperature reduces the bearing capacity of permafrost, and an increase in the seasonally thawed layer in ice-rich soils

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[1] According to the methodology of the International Permafrost Association, the following permafrost types are distinguished by areal extent: continuous (90–100% of territory coverage), discontinuous (50–90%), massive-island (10–50%), and sporadic or island (less than 10% of area coverage); by the ice content in permafrost: high, medium, and low. Thus, in Murmansk oblast, the Middle Urals (Perm' krai, Sverdlovsk oblast), Southern Siberia (Irkutsk oblast, Altai krai, the Republic of Tyva, and Kemerovo oblast), and the Far East (Amur oblast and Sakhalin), permafrost, as a rule, is located either in hard-to-reach mountain regions or in spots with no substantial risk for economic activity.

Table 1. Population and housing stock of the Russian Federation and Russian Arctic regions in 2018

Region	Population, thou. people.	Share of urban population, %	Housing stock			
			Total, mln m^2	Per capita, m^2	Condemned and dilapidated, mln m^2	Cost of constructing 1 m^2 of housing, thou. rubles
Komi Republic	840.87	78.1	24	27.9	0.39	38785
Nenets AO	43.99	72.8	1	25.0	0.05	65695
Khanty–Mansi AO	1655.07	92.3	35	20.8	0.65	53016
Yamalo-Nenets AO	538.54	83.8	11	20.7	0.76	65859
Krasnoyarsk krai	2876	77.4	72	24.6	0.71	45603
Republic of Sakha (Yakutia)	964.33	65.6	22	22.1	1.58	61490
Magadan oblast	144.1	95.9	4	30.1	0.06	72061
Chukotka AO	49.34	70.5	1	24.1	0.01	113911
Total by region	7427.74	79.4	170	24.5	4.31	68009
Russian Federation	146880	74	3780	25.8	25.95	41358

Source: the authors' estimates and Rosstat data.

leads to uneven subsidence, provoking deformations and affecting the stability of engineering structures [10–12]. According to estimates, a 2°C increase in the average annual air temperature cuts in half the bearing capacity of foundation piles, entailing a threat to the reliability and stability of buildings and engineering facilities. Already at present, numerous—and significant—changes in the strength of buildings have been recorded in almost all northern regions of the country. In Norilsk alone, more than 300 houses had to be demolished in recent years due to the deformation of their building structures [13, pp. 154, 173].

The specificity of the problem of the stability of fixed assets in various sectors and spheres of the Russian Arctic economy to the consequences of permafrost thawing and degradation requires special analysis and assessment. Some of them, proposed by the authors, made it possible to obtain an estimate of the expected loss from permafrost degradation for fixed assets and road infrastructure in the above-mentioned eight regions of the Russian North [14, 15]. This article attempts to make a similar assessment of the housing sector, given its increased vulnerability to permafrost thawing and degradation effects and its particular importance for the economy.

THE CURRENT STATE OF THE HOUSING STOCK IN THE RUSSIAN ARCTIC

The socioeconomic development of the Russian Arctic was historically based on the construction of large settlements, concentrating human resources and industrial facilities. During the Soviet period, large northern cities arose on the permafrost—Noril'sk, Vorkuta, Nar'yan-Mar, Magadan, Nadym, Noyabr'sk, and Novyi Urengoi. These cities fundamentally distinguish the Russian North from other Arctic regions of the world, in which large cities have never been built in the permafrost zone [16].

At present, in the regions of the Russian Arctic under consideration (with the exception of the Chukotka AO and Yakutia), about 80% of residents live in urban-type settlements, which is 5% higher than the average Russian level of urbanization. In total, there are 62 cities in these territories with a total population of about 7.5 mln people. The total area of the housing stock in 2018 here amounted to 170 mln square meters, or 4.7% of the total area of residential premises in Russia (Table 1).

The high level of urbanization determines the specifics of the functioning and development of the housing sector in the regions under consideration. It is associated with a significant share of apartment buildings, a centralized structure of organization and management of housing and communal services, and the social security system. In addition, the housing sector has a relatively high proportion of condemned and dilapidated housing, which, moreover, continues to increase. At the same time, the provision of the population with housing is lower than the average in Russia, which implies the need for an accelerated increase in the volume of construction work. The factors listed must be taken into account in a comprehensive analysis of the risks and consequences of permafrost degradation and in assessing the expected loss caused by them to the housing stock in the Russian Arctic regions.

METHODOLOGICAL APPROACHES TO ECONOMIC ASSESSMENT OF PERMAFROST DEGRADATION RISKS FOR THE HOUSING SECTOR

The economic assessment of permafrost thawing and degradation consequences from the point of view of the condition of the housing sector is based on two economic indicators: the total size of the housing stock in the regions under study and the actual cost of housing construction in each region. The use of the indicator of the actual or current cost of construction, and not the cadastral or market valuation of the corresponding objects, is necessitated owing to the fact that at present the database on cadastral valuation has not yet been fully formed and does not correspond to the actual number of residential premises in a particular region. In addition, the cadastral registration of the value of residential properties is carried out mainly for tax purposes, and their price can differ greatly (usually upward) from the real cost of housing. The validity of the market valuation of housing is also questionable since it includes not only the cost of construction work but also the profit of construction organizations and other expenses.

At the first stage of the assessment, it is necessary to determine the total size of the housing stock built in the permafrost zone. There is no state statistical information on the number of dwellings built on permafrost; therefore, the calculations used the previously developed assessment methodology based on data from the International Permafrost Association (IPA). According to this methodology, it is assumed that, in the zone of continuous permafrost, the share of the housing stock built on permafrost reaches 90%; the same indicator in the zones of discontinuous, massive-island, and sporadic (island) permafrost is 50%, 10%, and 0%, respectively. In general terms, the calculation formula for a specific region is as follows:

$$H_i = 0.9H_{ci} + 0.5H_{si} + 0.1H_{fi}, \quad (1)$$

where H_i is the total area of the housing stock built on permafrost in the ith region; H_{ci} is the area of the housing stock built in the continuous permafrost zone in the ith region; H_{si} is the area of the housing stock built in the discontinuous permafrost zone in the ith region; H_{fi} is the area of the housing stock built in the massive-island permafrost zone in the ith region; and i is the ordinal number of the region.

For the valuation of the housing stock built on permafrost in the eight regions of the Russian Arctic, we used Rosstat data on the current cost of construction of residential premises in the regional context (see Table 1). The housing stock was valued on the basis of the transformed formula (1)

$$E_i = \sum_{i=1}^{8} H_i * C_i, \quad (2)$$

where E_i is the total cost of the housing stock built on permafrost in the ith region; H_i is the area of the housing stock built on permafrost in the ith region; C_i is the cost of construction of 1 m^2 of housing in the ith region; and i is the ordinal number of the region.

At the final stage, the expected permafrost thawing and degradation loss for the housing stock of the regions studied was determined for the period up to 2050. The following assumptions were taken into account. Since the planning (program) documents for the development of the housing stock and housing construction are of a medium-term nature, the scenario calculations take into account the total area of the housing stock in view of the current plans for its mid-term (2019–2025) development. To estimate the expected loss in the interval 2025–2050, it is assumed that the total area of the housing stock remains unchanged.

The lack of official long-term forecasts for the size of the population permanently residing in the regions under study makes it extremely difficult to assess the long-term needs for housing. Moreover, there is significant uncertainty in the prospective estimates of Russia's population as a whole: for example, according to one of the Rosstat forecast scenarios until 2035, it may decrease by 680000 people; according to another scenario, it may increase by 500000 [17], 90% being due to migration, the extent of which varies greatly depending on economic factors and political decisions. Given this uncertainty, it is assumed that the population of the regions will be conditionally constant on the horizon until 2050.

The loss calculations also disregard the factors of housing demand/supply, living standards of the population, wages dynamics, and the level of bank rates and mortgage lending, which have a significant impact on the formation of effective demand of the population and the volume of housing construction, but which are absent in long-term (for 10–20 years) forecasts and are largely determined by the economic development of the country as a whole and not by climatic circumstances.

Another important assumption is related to the impossibility of assessing the actual rate and extent of

Table 2. Forecast of housing stock growth dynamics in Russian Arctic regions for the period up to 2050, % of the baseline 2018

Region	Forecast scenario	
	conservative	modernization
Komi Republic	100.00	107.03
Nenets AO	159.28	210.82
Khanty–Mansi AO	119.96	133.31
Yamalo-Nenets AO	138.96	174.86
Krasnoyarsk krai	106.96	116.55
Republic of Sakha (Yakutia)	151.95	177.58
Magadan oblast	110.77	125.49
Chukotka AO	100.00	150.00

Source: the authors' estimates.

the disposal of the housing stock, which are highly variable. Thus, in 2005, the housing stock decreased by 35.6 mln square meters, and in 2017, by 15.7 mln square meters. The retirement rate depends on many factors, which include not only the condition of dwellings recognized as condemned or dilapidated but also the legal procedures for such recognition and formalization of the retirement process, due to which dwellings recognized as dilapidated and subject to demolition can remain in this status for many years.

Taking into account the above assumptions, the value of the aggregate available housing stock built on permafrost in the eight Russian Arctic regions under consideration in the long term (2020–2050) can be calculated using the following formula:

$$H = \sum_{i=1}^{8} H_i = \left[\sum_{i=1}^{8} (H_{bi} + H_{ki} - H_{di})\right] \times 30, \qquad (3)$$

where H is the area of the aggregate available housing stock; H_{bi} is the area of the housing stock in the ith region for the base year of estimates (2020); H_{ki} is the area of annual new housing construction in the ith region in the forecast period; H_{di} is the area of annual (condemned and dilapidated housing) retirement in the ith region in the forecast period; and i is the ordinal number of the region.

In addition, the total area of residential premises in the base year 2020 (H_b) was determined on the basis of Rosstat data for 2018; the area of retired residential premises (H_d) in 2020–2050 in annual terms was based on retrospective data on the average annual rate of disposal for 2008–2018; the area of annual construction of new housing in the forecast period (H_k) was based on a specific scenario from the two adopted scenarios of housing stock development in 2020–2050—conservative (inertial) and modernization ones.

The conservative scenario assumes the preservation during the entire forecast period of the values of the average annual rates of construction and retirement of housing typical of the period 2008–2018. At the same time, the rates of annual construction in seven of the eight regions are assumed to be equal and corresponding to the average regional value for the specified retrospective period. In the Komi Republic and Chukotka AO, given that, according to official statistics, the rate of housing stock disposal is significantly ahead of the rate of construction,[2] it is assumed that the annual volume of housing commissioned is equal to the volume of its disposal.

The modernization scenario is based on the national project "Housing and Urban Environment" for 2018–2024, the indicators of housing construction of which provide for the commissioning of up to 120 mln square meters throughout Russia by 2025, which is 1.5 times higher than the current level [18]. Based on this, the average annual growth rates and volumes of housing construction in the regions of the Russian Arctic considered were calculated for the period up to 2050 (Table 2).

Six global models of climate change, which were used by the Intergovernmental Panel on Climate Change (IPCC) in the preparation of the V Assessment Report on Climate Change for the period up to the mid-21st century, were used to assess the impact of permafrost thawing and degradation effects on the sustainability of residential buildings built on permafrost in the period up to 2050.[3] These global models make it possible to predict with high reliability the surface air temperature in the northern regions of Russia [19].

The most severe scenario of global climatic changes, RCP8.5, was taken as the basis for calculations based on these models. According to the authors and a number of other experts, it best reflects the dynamics of large-scale climate changes in the northern regions of Russia, making it possible to assess the maximum risks (expected loss). In this case, the forecast is based on the assumption of a gradual increase in the surface air temperature, under the influence of which the degradation of permafrost soils will also proceed gradually. In addition, it is taken as a fact that the decline in the sustainability of residential buildings caused by these processes and the expected economic loss associated with it will be distributed evenly over the next 30 years.

[2] The authors suggest that this circumstance is most likely due to the imperfection of the statistical accounting of the housing stock at the municipal level.

[3] These include CanESM2, CSIRO-Mk3-6-0, GFDL-CM3, HadGEM2-ES, IPSLCM5A-LR, and NorESM1-M.

Table 3. Housing stock of the regions studied, 2018

Region	Total housing area in the regions (thou. m^2)	Housing stock value (billion rubles)	Total housing area in permafrost (thou. m^2)	The cost of the permafrost housing stock (billion rubles)
Komi Republic	24452.00	989.06	8036.60	331.20
Nenets AO	1128.50	77.97	1128.50	77.97
Khanty–Mansi AO	35187.00	1724.45	15183.60	748.10
Yamalo-Nenets AO	10089.50	651.20	10089.50	651.20
Krasnoyarsk krai	72210.00	3279.82	12492.30	569.06
Republic of Sakha (Yakutia)	21568.90	1345.49	21568.90	1345.49
Magadan oblast	4178.80	301.12	4187.80	301.12
Chukotka AO	1154.80	51.08	1154.80	51.08
Total	169969.50	8420.19	73842.00	4075.22

Source: The authors' estimates and Rosstat data.

To assess the decrease in the bearing capacity of soils, data on permafrost temperature and thaw depth were used, which were obtained as a result of a study previously conducted by the authors using geotechnical models of permafrost changes [15, 20] and which were further taken into account in assessing the risks of decreasing the stability of the housing stock and expected economic loss in the regions studied in three scenarios: minimum, average, and maximum loss of bearing capacity [15, Fig. 3].

ASSESSMENT OF EXPECTED LOSS TO THE RESIDENTIAL STOCK OF THE RUSSIAN REGIONS FROM PERMAFROST DEGRADATION

In accordance with the methodology proposed, we have estimated the total size of the housing stock built on permafrost and its cost. According to Rosstat, in 2018 the total area of housing in the regions under consideration was 169.96 mln square meters. The official state statistics has no actual data on the book value of housing: so the cost estimate was based on the cost of construction of 1 m^2 of living space in the region. The total current value of residential premises in 2018 was ₽8.5 trillion. According to our calculations, 20.6 mln square meters of housing stock in the regions with a total cost of ₽4.1 trillion were built on permafrost (Table 3).

The regional housing stock is almost completely built on permafrost in the Nenets, Yamalo-Nenets, and Chukotka autonomous okrugs; the Republic of Sakha (Yakutia); and Magadan oblast. In the Komi Republic, Krasnoyarsk krai, and the Khanty–Mansi Autonomous Okrug, only part of the housing was built on permafrost in several municipalities.[4] Kamchatka krai is excluded from the calculations, although located in the permafrost zone; however, geotechnical data show minimal possible loss for residential buildings in this territory.

In accordance with the methodology adopted, we have considered the previously listed scenarios of the influence of permafrost thawing and degradation on the stability of housing and provided forecast estimates of the costs of reducing the risk (expected loss) for the period up to 2050. The results are summarized in Table 4.

If the *conservative scenario* is implemented, the total area of the housing stock in the regions under consideration will increase by 21.8 mln square meters over 30 years and will amount to 103.66 mln square meters, the total value of this fund in 2018 prices being about ₽4.8 trillion. The expected loss to the housing sector from permafrost degradation for the period 2020–2050 is estimated in the range from ₽420 bln to ₽2.5 trillion, depending on permafrost temperature and thaw depth. Based on the average scenario, the loss is expected to reach ₽907 bln (18.8% of the total cost of housing built on permafrost). To mitigate the

[4] In this paper, estimates are based on calculations of the actual cost of construction of new residential buildings in contrast to similar estimates in the previously published article by the authors [14], calculated on the basis of the cost of fixed assets.

Table 4. Estimation of housing stock restoration and maintenance costs due to permafrost thawing and degradation

Region	Housing stock under the risk of permafrost degradation, %*	GRP, bln rubles (in 2018 prices)	Development scenarios					
			conservative			modernization		
			Total housing area, thou. m^2	Economic loss, billion rubles (in 2018 prices)		Total housing area, thou. m^2	Economic loss, billion rubles (in 2018 prices)	
				for the period 2020–2050	annual average		for the period 2020–2050	annual average
Komi Republic	100 (100/100)	665.74	8036.60	88.8 (88.8/88.8)	2.96 (2.96/2.96)	8601.19	89.7 (89.7/89.7)	2.99 (2.99/2.99)
Nenets AO	99 (0.3/99.1)	305.21	1797.47	92.6 (0.3/92.7)	3.09 (0.01/3.09)	2379.06	122.8 (0.4/122.8)	4.09 (0.01/4.1)
Khanty–Mansi AO	4.1 (0.0/60.9)	4447.5	18213.54	2.3 (0.0/33.7)	0.08 (0.0/1.12)	20240.93	2.6 (0.0/38.1)	0.09 (0.0/1.27)
Yamalo-Nenets AO	99.8 (79.1/99.8)	3083.5	14020.58	416.5 (330.1/416.5)	13.88 (11.0/13.88)	17642.86	536.4 (425.1/536.4)	17.88 (14.17/17.88)
Krasnoyarsk krai	74.0 (0.1/99.4)	2280	13361.33	188.2 (0.3/251.5)	6.27 (0.01/8.38)	14559.61	197.1 (0.3/263.3)	6.57 (0.01/8.78)
Republic of Sakha (Yakutia)	6.5 (0.0/97.7)	1084.6	32772.92	114.7 (0.0/1723.7)	3.82 (0.0/57.46)	38302.83	134.1 (0.0/2016.2)	4.47 (0.0/67.21)
Magadan oblast	2.6 (0.0/97.2)	170.72	4638.95	3.8 (0.0/142.5)	0.13 (0.0/4.75)	5255.38	4.0 (0.0/149.0)	0.13 (0.0/4.97)
Chukotka AO	0.6 (0.6/81.1)	78.143	1154.80	0.8 (0.8/101.8)	0.03 (0.03/3.39)	1732.20	1.1 (1.1/152.7)	0.04 (0.04/5.09)
Total	53.8 (29.9/95.2)	12115.41	103666.7	907.7 (420.2/2851.2)	30.26 (14.01/95.0)	119611.58	1087.7 (516.6/3368.2)	36.26 (17.22/112.27)

*The calculations are from the authors' article [14]. The minimum/maximum values of loss caused by permafrost warming and thawing and the corresponding degree of weakening of the soil bearing capacity are indicated in brackets.

consequences of permafrost degradation, it is necessary to spend more than ₽30 bln annually, which is equivalent to 0.25% of the GRP in 2018 prices. Under scenario of the maximum increase of thaw depth and permafrost temperature, the cost of maintaining the housing stock will more than triple—up to ₽95 bln annually (almost 1% of the GRP in 2018 prices).

The greatest loss for the entire forecast period will be sustained by the Yamalo-Nenets AO, ₽416.5 bln, which is primarily due to the permafrost degradation dynamics in this region. The smallest loss, ₽753.1 mln, is predicted in the Chukotka AO, which is associated with the relative (in comparison with other territories) limited area of the housing stock affected by permafrost degradation. Under scenario of maximum decrease in bearing capacity, the greatest loss (₽1.7 trillion) is predicted in the Republic of Sakha (Yakutia), which is almost entirely located in the permafrost zone, and the area of the housing stock here by 2050 will reach 32.7 mln square meters, or about 30% of the total housing area in the regions of the Russian Arctic considered.

The *modernization scenario* assumes an acceleration of housing construction by 50% in relation to the current level, which will lead to an increase in the total area of housing to 119.6 mln square meters by 2050. The total cost of the housing stock will be ₽7.2 trillion in 2018 prices. The expected loss from permafrost thawing and degradation is estimated in the range from ₽500 bln to ₽3.36 trillion, depending on the changes in permafrost temperature and thaw depth. With the average change, the magnitude of the expected loss is estimated at ₽1.08 trillion for the period 2020–2050 or ₽36.26 bln in average annual terms, which is equivalent to 0.29% of the GRP in 2018 prices. With the maximum change of permafrost temperature and thaw depth, the expected loss increases threefold, to ₽3.37 trillion for the entire period, or by more than ₽112 bln on average per year. The Yamalo-Nenets AO and the Republic of Sakha (Yakutia) will suffer the greatest loss under the average and maximum scenarios of permafrost degradation.

* * *

The thawing and degradation of permafrost due to global climate change significantly increase the uncertainty and risks of economic activity in the regions of the Russian Arctic. This also applies to the construction of housing and the functioning of the housing sector, which is critically important for the life and work of the population, first of all, permanently residing in these regions, as well as shift workers. The loss of stability and destruction of residential buildings, which are increasingly occurring in the territories of the Russian North with permafrost, not only substantially decrease the comfort of living but also increase the risks to human health and societal well-being.

The associated additional costs expected in the period 2020–2050 to mitigate socioeconomic losses in the eight regions of the Russian Arctic under consideration may amount to more than ₽30 bln on average per year, or about 0.3% of their total GRP, under the average estimated changes in permafrost temperature and thaw depth and three times more—about ₽112 bln per year (about 1% of the total GRP)—if the maximum changes in permafrost temperature and thaw depth. At the same time, the indicated values of loss do not take into account indirect costs associated with the construction of additional (reserve) housing for resettlement from condemned and dilapidated housing stock, as well as the costs of temporary evacuation (resettlement) of people who find themselves homeless and without part of their property.

Such a significant scale of the expected loss requires adequate preventive measures to reduce the risk and adapt to the new socioeconomic reality on the part of the federal government and the authorities of the Russian Arctic regions, primarily the construction industry. Indeed, even under a conservative development scenario and a minimal scale of loss from destabilization and destruction of residential buildings as a result of permafrost warming and thawing in the eight regions under consideration, it will be necessary to build an additional 243000 m^2 of housing annually. With the maximum deformation and destruction of the housing stock, the need for additional construction will increase by six times, to 1.5 mln square meters. This means the need to double at least the construction capacity, given that the current scale of regional construction is only about 2.8 mln square meters, and taking into account the aforementioned imperatives of reserving space for temporary and permanent resettlement of people from condemned and dilapidated housing, to replace the planned retirement of housing, and to improve housing provision for the local population.

Solving the problems of the development of the housing sector in the regions of the Russian Arctic, caused by permafrost thawing and degradation and the risks of reducing the bearing capacity of permafrost soils, in addition to increasing the capacity of the construction industry, requires its technical modernization. We mean the development of structural and technological solutions for the construction of residential buildings and social (utilities, energy, etc.) infrastructure facilities, ensuring adaptation to regional climate changes and their consequences for the stability of structures in the context of permafrost degradation, as well as for the effective functioning of the housing sector. Such solutions, in particular, can be proposed within the implementation of the national project "Ecology" (2020–2030), an organic part of which is the federal project "Implementation of the Best Available Technologies," including new structural materials with increased strength characteristics, as well as energy-efficient and “green” technologies.

When developing such technological solutions and, most importantly, organizing the management of their implementation in the housing sector of the northern regions of the country, it seems useful to use the above methodology and the results of assessing the costs of reducing the risk due to loss of bearing capacity of permafrost soils. More broadly, these assessments should be used in the development and implementation of strategic planning documents directly related to the country’s Arctic region, primarily the National Adaptation Plan, the activities of the first stage of which until 2022 were approved by the order of the Government of Russia at the end of 2019 [21], and also the Strategy for the Development of the Russian Arctic until 2035, the draft of which, developed by the Ministry of the Russian Federation for the Development of the Far East and the Arctic, is currently (early September 2020) undergoing approval by the government [22].

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