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Issue Article

Yulia Igorevna Prokhorova
Institute of Service and Entrepreneurship (branch) of DSTU
Bachelor

Artur Aleksandrovich Blagorodov
Institute of Service and Entrepreneurship (branch) of DSTU
postgraduate student

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

Svetlana Yurievna Korablina
LLC TsPOSN «Ortomoda»
Ph.D., Associate Professor, Deputy directors

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

ANALYSIS OF THE FORMATION OF EFFECTIVE CONDITIONS FOR URBAN DEVELOPMENT IN THE NORTHERN TERRITORIES

Abstract: *In this article, the authors present some results of an analysis of northern urban development, taking into account natural and climatic factors. It is determined that the planning and development of residential areas in a northern city requires mandatory consideration of the terrain, wind conditions, snow drifts, vegetation patterns, and other factors. To identify the specific features of urban development in the modern conditions of the Far North and equivalent areas, the authors analyzed the natural and climatic factors determining the planning and development of the city of Nizhnevartovsk, which is necessary for the rational management of the city's development. Using geoinformation mapping based on remote sensing data (SAS Planet), the authors analyzed the development features of the residential area of Nizhnevartovsk, taking into account the main natural and climatic parameters. During a study of urban planning conditions in the residential area of Nizhnevartovsk, the authors found that development and engineering preparation of the area fully take into account the terrain, wind conditions, and snow drifts. An analysis of the planning and construction of buildings in the city's residential neighborhoods revealed that snow protection techniques are used in Nizhnevartovsk, which help achieve one of the key components of northern urban planning—wind regulation by aerodynamic groups of buildings, where optimal planning creates cross-ventilation and removes snow beyond the residential area. Furthermore, the authors identified the need for intensive landscaping in the city's new residential neighborhoods. Urban analysis of the northern city's territory is essential for spatial planning decisions and the management of residential development.*

Key words: *Urban development analysis, northern territories, improvement, natural and climatic factors, development of microdistricts, wind regulation, Nizhnevartovsk.*

Language: *English*

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Introduction

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An analysis of the historical status and current experience of urban development in northern conditions and the impact of natural and climatic factors on settlement patterns is essential for shaping the built environment of northern cities. Currently, for northern regions experiencing changing, complex, and unfavorable natural and climatic conditions, research into urban design and urban improvement is highly relevant. Among the key contemporary challenges facing northern cities is the need to identify key approaches to the spatial organization and classification of settlements, which is essential for the further development of northern urban development systems. Given the impact of natural and climatic factors on the livelihoods of the urban population, as well as the rational use and protection of land in northern latitudes, further, more detailed study of land management issues is required, particularly in light of the changing natural environment resulting from current climate change. A distinctive feature of northern urban development is the influence of natural and climatic factors on the spatial environment of northern cities, such as low winter temperatures, strong winds, snow drifts, and the presence of permafrost. These factors must be taken into account during building construction and landscaping. A key condition for implementing development and spatial planning projects is the study of wind flows, soil conditions, green spaces, terrain, and snow conditions within the urban space. Key features of planning and construction in the northern regions include ensuring their functioning in a manner most comfortable for the population. Analysis of these factors is necessary for more effective use of existing urban planning conditions and for long-term territorial development plans for populated areas. A pressing issue in land management in populated areas is identifying the key design challenges for urban areas located in northern latitudes, which is especially important for the development of the northern agglomerations of the Khanty-Mansi Autonomous Okrug-Yugra. In the current changing natural environment, it is necessary to refine and adjust urban planning decisions in Nizhnevartovsk. The main natural factors influencing the planning and development of Nizhnevartovsk include terrain, flooding and submergence, permafrost, wind conditions, snow drifts, and urban landscaping.

Main part

The study utilized methods of information analysis, synthesis, multifactorial urban planning analysis, and geoinformation mapping. Urban planning analysis is a crucial component of urban development and forms the basis for the planned zoning of a city's territory, taking into account environmental, historical, cultural, socioeconomic, and other planning assessment factors. It is conducted in areas that address issues of planning and functional structure development, as well as engineering and transport infrastructure. Using geoinformation mapping and remote sensing data (SAS Planet), we analyzed the development features of residential areas in Nizhnevartovsk, taking into account key natural and climatic parameters. The study included an analysis of the primary natural and climatic factors that determine urban development and improvement in Nizhnevartovsk, including terrain, wind conditions, snow drifts, and green spaces. The results of the geoinformation analysis of the residential area of the city of Nizhnevartovsk allow us to determine measures to optimize the use of the urban territory, which should be implemented taking into account the problematic planning situations identified during the urban planning assessment. For the competent design of the urban environment and the development of the city territory, it is necessary to take into account the regulations of construction and climatic zoning and the meteorological characteristics of the area. A comprehensive analysis of the natural and climatic conditions of the territory is of great importance for urban planning. All work on the design and development of settlements in the northern regions, including in the city of Nizhnevartovsk, must be carried out taking into account natural and climatic features. In vulnerable northern regions, it is necessary to study unfavorable and dangerous hydrometeorological phenomena that pose a threat to the natural environment, the economy, the life and health of the population and lead to environmental and economic damage due to the restructuring of the climate system. The main natural and climatic factors of northern urban planning influencing the development and planning of populated areas are: the topography of the territory, which must be taken into account when organizing vertical planning and when arranging buildings; Wind conditions are taken into account during the development and planning of buildings to create a comfortable microclimate on the territory. Green spaces play a significant role, serving as windbreaks for the living environment, as do engineering works carried out to prevent flooding.

The peculiarities of the city's land formation and adverse processes disrupt favorable urban conditions, which determines the study of geodynamic processes and is a relevant and valuable contribution to urban planning. The city of Nizhnevartovsk is located in Western Siberia.in the eastern part of the Khanty-Mansi Autonomous Okrug - Yugra (Figure 1), in the conditions of northern latitudes, which are characterized by the action of extreme natural and climatic factors, which allows this territory to be classified as a region of the Far North or localities equivalent to them.

Figure 1. Physical and geographical position of the city of Nizhnevartovsk

Due to its complex geological structure and the specific development of physical and geological processes, the territory of the city of Nizhnevartovsk is classified as restricted for urban development, which requires additional and more detailed engineering surveys, as well as special measures for engineering and vertical preparation of the territory. The topography of the city is the determining factor in the functional zoning of the city. The features of the topography predetermine the engineering preparation of the territory and are necessarily taken into account when organizing vertical drainage and when locating buildings and structures. The geographical location of the territory determines its climatic features. The most important factors in shaping the climate are the westerly transfer of air masses and the influence of the continent. Atmospheric circulation in the territory is characterized by a rapid alternation of cyclones and anticyclones, which contributes to frequent changes in weather conditions and strong winds. According to construction and climatic zoning in accordance with SNiP 23-01-99* "Construction Climatology", the territory of the city of Nizhnevartovsk belongs to climatic region ID (climatic zone 2, designed for -43C). The climate characteristics are taken from the nearest meteorological station - Nizhnevartovsk. In the absence of data, information from the Surgut meteorological station is taken (according to SNiP 23-01-99* updated version). The territory of Nizhnevartovsk is characterized by a continental climate with severe, long winters, short cold summers, short transitional seasons, late spring and early autumn frosts. The coldest month of the year is January with an average maximum air temperature of -22 °C, the warmest month is July with an average maximum air temperature of +17 °C. The average long-term annual air temperature in Nizhnevartovsk is about -3.4 °C. The frost-free period lasts on average about 100 days. The sum of temperatures during the growing season of plants in the study area does not exceed 1,40 °C. The average amount of precipitation is 450-550 mm per year. Most precipitation occurs in summer (July, August) and autumn (September, October), often in the form of showers and

thunderstorms. The least precipitation occurs in late winter and early spring (February, March). Wind patterns in Nizhnevartovsk (Figure 2) vary year-round depending on circulation factors and local conditions. Wind direction in certain areas is significantly influenced by local conditions, including uneven terrain, river valley orientation, and various obstacles.

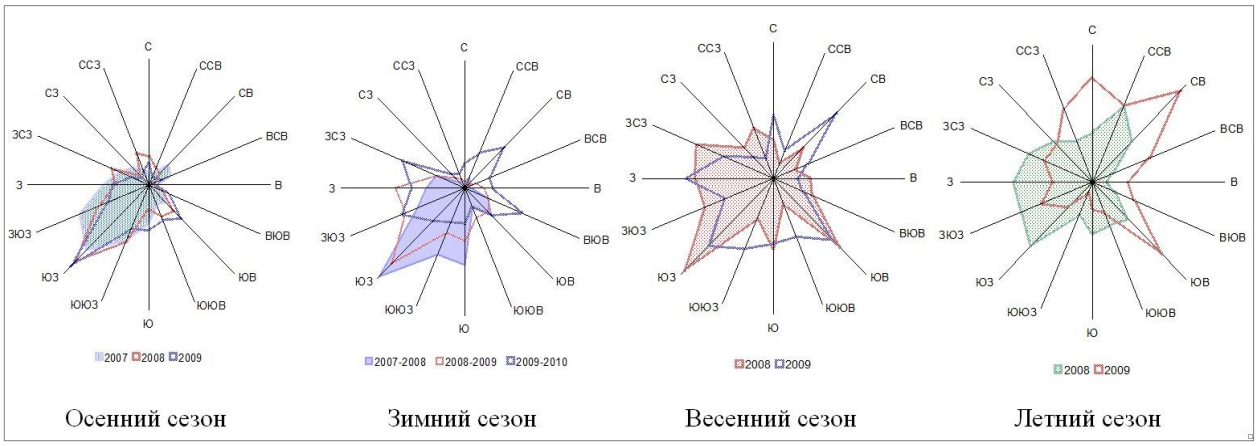

Figure 2. Prevailing wind direction by season in the city of Nizhnevartovsk

The average long-term annual wind speed in Nizhnevartovsk is 5.2 m/s. In autumn, southwesterly winds predominate, with occasional northerly, northeasterly, and southeasterly winds. In winter, Nizhnevartovsk is influenced by prevailing southwesterly winds. In some years, these are joined by northeasterly and southeasterly winds. Frequent and strong winds are observed in the study area, especially in spring, with maximum speeds in April and May. During spring, winds from various directions prevail, with westerly, southwesterly, and southeasterly winds predominating. Northeasterly winds also occur to a small extent. During this time, horizontal air movement is characterized by fairly high speeds, which can reach up to 27 m/s. Summer seasons are characterized by the dominance of northerly, northeasterly, northwesterly, and westerly winds in Nizhnevartovsk. The first snowfall occurs, on average, in the first ten days of October, and by the end of October, a stable snow cover has formed. Snow cover reaches its greatest depth in the second ten days of March. Stable snow cover lasts approximately 200 days per year. Snow cover begins to melt, on average, in the first ten days of May, and its final melting occurs in late May. Unfavorable meteorological conditions in Nizhnevartovsk include fog, thunderstorms, snowstorms, and icy conditions. Snow drifts up to 2 meters deep are possible. Snowstorms occur from October to May. Wind direction during snowstorms coincides with the prevailing southwesterly and southerly flow in winter. Snowstorms with southwesterly winds produce the heaviest snow drift. Fog can occur year-round, even during calm weather and low wind speeds. Fog formation contributes to the accumulation of hazardous atmospheric pollutants and reduces visibility. Thunderstorms occur primarily from April to September and are accompanied by squalls, heavy rainfall, and often hail. Frequent thunderstorms are a distinctive feature of the summer. Ice and hoarfrost are observed from October to May, with icy conditions occurring between two and five days per year, and the average annual number of days with hoarfrost fluctuates between 40 and 60 days. Another important factor in northern urban development is wind conditions. Wind speed and direction directly influence the living environment, and the favorable conditions depend on the type of development.

A significant portion of Nizhnevartovsk's southwestern and southeastern areas is susceptible to flooding. To address these issues, it is necessary to implement engineering preparation and protection measures, as well as manage surface runoff. Construction in the Far North and equivalent areas must be completed as quickly as possible without compromising the quality, reliability, strength, and durability of the structures being erected. Modern building and structure construction technologies are best suited to these conditions. The most advanced approaches to rapid construction include modular construction and the construction of transformable buildings and structures. Using geoinformation mapping and remote sensing data (SAS Planet), we analyzed the development of residential areas in Nizhnevartovsk, taking into account prevailing wind directions in the area. The residential area (Figure 3) extends along the Ob River in a southeastern direction and is divided into three parts: the central, eastern, and old parts of the city. The central part of the city, within the boundaries of Kuzovatkina, Severnaya, Khanty-Mansiyskaya, and Pikmana Streets, is formed by microdistricts of high-rise and mid-rise residential buildings, with a regular network of wide, perpendicular streets. This area includes two linear

public centers of city significance. The public center is located along Lenin Street, at the intersection with Pobedy Avenue, and is connected by a system of boulevards and alleys to the city's recreational spaces: the Ob River embankment, the 40th Anniversary of Victory Park of Culture and Recreation, and Lake Komsomolskoye. A public center is located at the intersection of Chapaeva and Mira Streets. The eastern part of the city, within the boundaries of Internatsionalnaya, Khanty-Mansiyskaya, and Lenina Streets, is formed by blocks of high-density, high-rise residential buildings. The old part of Nizhnevartovsk is located southeast of Khanty-Mansiyskaya Street, between the Ob River and Lake Emtor. The old part of the city is predominantly made up of individual residential blocks, with scattered industrial, utility, and warehouse areas. Low-rise and mid-rise residential neighborhoods are located southeast of the Maly Yegan River. During the analysis of the residential zone of Nizhnevartovsk, residential neighborhoods in the central and eastern parts of the city, as well as the old part of the city, were studied. In the old part of Nizhnevartovsk, the territory of microdistrict 16P was analyzed (Figure 4). The territory of the microdistrict is located in the southeastern part of the city. Residential buildings in the microdistrict are located to the west of the prevailing winds in the area. The development zone of microdistrict 16P is formed by mid-rise residential buildings. The buildings are located on the windward side of the prevailing winds in the area. They have a rectangular shape, without any difference in height, which helps protect the residential area from the adverse effects of northern winds.

Figure 3. Residential area of the city of Nizhnevartovsk

Figure 4. Development in the old part of Nizhnevartovsk

The study analyzed residential microdistricts No. 12, No. 14, No. 15, No. 15a, No. 16, and No. 16a in the central part of Nizhnevartovsk (Figure 5). The territory of the microdistricts under consideration is located in the southern part of the city. Residential buildings in the microdistricts are exposed to the southwesterly direction of the prevailing winds in the area. The development zone of the studied central part of the city is formed: within the boundaries of microdistricts No. 12, No. 14, and No. 15 by mid-rise and multi-story residential buildings; within the boundaries of microdistricts No. 15A, No. 16, and No. 16A — by multi-story residential buildings. The buildings in microdistricts No. 12 and No. 14 feature a partially closed layout, which facilitates the creation of enclosed spaces within the microdistrict and protects the area from the negative effects of winds. The buildings in microdistricts No. 15 and No. 15a feature a rectangular layout, taking into account wind protection through the use of mid-rise buildings, which also contributes to the creation of enclosed spaces within the microdistrict and protects it from the negative effects of winds. The buildings in microdistrict No. 16 feature a rectangular layout, taking into account wind protection through the use of high-rise and mid-rise buildings, which contributes to the creation of enclosed spaces within the microdistrict and also protects it from the negative effects of winds. The buildings in microdistrict No. 16a feature an open layout, and the area is protected from the negative effects of winds by high-rise buildings. In the eastern part of the city, the territory of residential areas No. 23, No. 24 was analyzed,

No. 25, No. 26, No. 31a (Figure 6). Residential buildings in these neighborhoods are located taking into account the prevailing southwesterly wind direction in the area. Residential blocks No. 23, No. 24, No. 25, No. 26, and No. 31a predominantly feature a rectangular layout, which creates an enclosed space within the neighborhood and contributes to wind protection through the use of mid-rise buildings. An analysis of the residential neighborhoods in Nizhnevartovsk suggests that residential development is characterized by a closed layout, in which

rectangular buildings create a windbreak front from the prevailing wind direction, as well as partial development, which ultimately helps reduce the negative impact of winds.

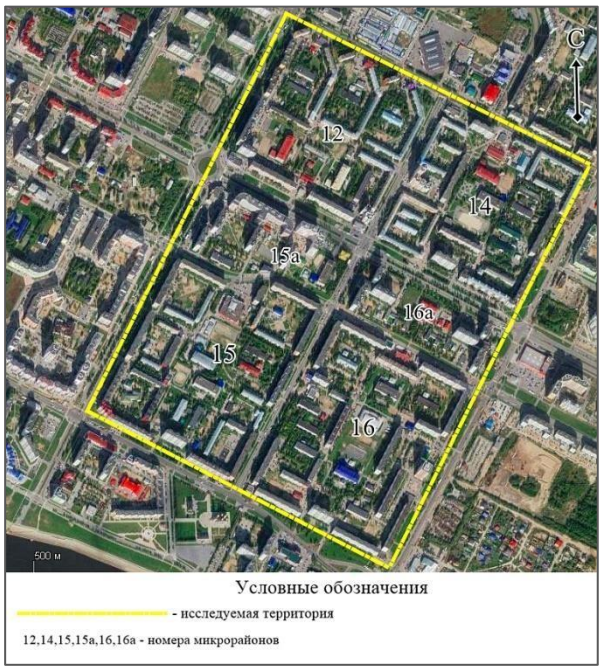

Figure 5. Development in the main parts of the city of Nizhnevartovsk

Figure 6. Development in the east parts of the city of Nizhnevartovsk

The study area takes into account urban planning principles such as residential layout, high compactness, and windbreak buildings, which provide protection from harsh climatic conditions at sub-zero outside temperatures. This type of development is optimal for northern regions, as strong winds further complicate living conditions in the Far North and equivalent areas. It can be concluded that the residential area of Nizhnevartovsk is developed with wind conditions in mind, which contributes to the creation of a favorable living environment. Particular attention in northern urban planning is paid to snowdrifts, which are accompanied by strong winds. Snowdrifts in the study area are observed from October to May. An analysis of the layout and development of buildings within residential neighborhoods in Nizhnevartovsk revealed that snow protection techniques are used within the area, which help achieve one of the key components of northern urban planning—wind regulation through aerodynamic building clusters. Optimal planning ensures cross-ventilation and snow removal beyond the boundaries of the area. An example of aerodynamic building cluster planning is residential neighborhoods in the central part of the city—the analysis was conducted using several residential neighborhoods. Neighborhood No. 7 is located in the northern part of the city (Figure 7). Residential buildings in the neighborhood are located with the prevailing southwesterly wind direction in the area in mind. Microdistrict No. 7 in Nizhnevartovsk includes residential buildings, preschools and schools, a shopping mall, stores, an administrative building, a sports and fitness center, heating stations and transformer substations, a medical facility, the city drama theater, the Nizhnevartovsk Pension Fund of the Russian Federation, and garages. The residential area of Microdistrict No. 7 in the central part of the city under study is composed of mid-rise buildings. The site layout provides for cross-ventilation with snow removal (Figure 8).

Figure 7. The study area of microdistrict No. 7 of the city of Nizhnevartovsk

Figure 8. Layout of buildings in the microdistrict No. 7 of the city of Nizhnevartovsk, reducing snow drifts

Figure 8 shows the direction of snow drift beyond the residential area, formed by the special arrangement of buildings parallel to each other. This facilitates the unimpeded transport of snow masses and has a positive impact on the occupancy of this microdistrict. Thus, it can be concluded that the development of Microdistrict No. 7 takes into account snow drift protection, which meets the requirements of northern urban planning and contributes to a comfortable living environment. In addition, the territory of Residential Microdistrict No. 8A was analyzed. This microdistrict is also located in the northern part of the city. Residential buildings in this microdistrict are located to the west of the prevailing winds in the area. The residential area of Microdistrict No. 8A in the central part of the city under study is formed by multi-story buildings (Figure 9). Figure 9 shows the direction of through snow transport beyond the residential area, formed by the special arrangement of buildings parallel to each other. This facilitates the unimpeded transport of snow masses and has a positive impact on the occupancy of this microdistrict. Thus, it can be concluded that the development of Microdistrict No. 8A takes into account protection from snow drifts, which also meets the basic planning and development requirements of northern cities. An analysis of the territory of Residential Microdistrict No. 10 in Nizhnevartovsk was conducted (Figure 10). Figure 10 shows the direction of through snow transport beyond the residential area of Microdistrict No. 10 in Nizhnevartovsk. This territory is formed by the special arrangement of buildings, which facilitates the unimpeded transport of snow masses, which has a positive impact on the occupancy of this microdistrict. The territory of Microdistrict No. 10 is located in the northeastern part of the city. The residential buildings of the microdistrict are located towards the west of the prevailing winds in the area.

Figure 9. Layout of buildings in the 8A microdistrict of Nizhnevartovsk

Figure 10. Layout of buildings in microdistrict No. 10 of Nizhnevartovsk to reduce snow accumulation

Microdistrict No. 10 includes residential buildings, preschool and school facilities, retail buildings, a store, an administrative building, heating plants, medical facilities, and a hotel. The residential development zone of Microdistrict No. 10 in the central part of the city under study is comprised of mid-rise and multi-story buildings. An analysis of the development of residential Microdistrict No. 10B in Nizhnevartovsk was conducted (Fig. 11).

Figure 11. Layout of buildings in microdistrict No. 10B of the city of Nizhnevartovsk, reducing snow accumulation

The yellow arrows in Figure 11 indicate the direction of snow drift beyond the residential area, formed by the special arrangement of buildings—parallel to one another. This facilitates the unimpeded transport of snow masses and has a positive impact on the occupants of this microdistrict. Microdistrict No. 10B is located in the northwestern part of the city. Residential buildings in the microdistrict face the westerly direction of the prevailing winds in the area. The microdistrict includes residential buildings, preschools and schools, stores, transformer substations, and heating stations. The residential zone of Microdistrict No. 10B, in the central part of the city under study, is formed by mid-rise and multi-story buildings. The development of Microdistrict No. 10B takes into account snowdrift protection, which complies with northern urban planning and contributes to a comfortable living environment. Thus, it can be concluded that the planning and development of Nizhnevartovsk's residential area complies with northern urban planning requirements regarding protection from snow drifts. Using the development of residential microdistricts in Nizhnevartovsk as an example, the organization of cross-ventilation and snow removal beyond the residential area is demonstrated. Buildings in the study areas are spaced at a certain distance, parallel to each other, which facilitates the unimpeded transport of snow. The buildings have a streamlined shape, and the outer building lines are free of indentations, depressions, and protrusions, which also helps reduce snow drifts. Green spaces play a significant role in protecting residential areas from winds. The most effective approach to greening Nizhnevartovsk's urban areas is the creation of a unified, integrated landscaping system utilizing the full range of green space functions, namely wind regulation (wind protection). In Nizhnevartovsk, wind protection is the most commonly used function of green spaces to ensure a comfortable urban environment. Green spaces located within the city's residential areas prevent cold wind gusts from penetrating residential areas, which has a positive effect on the living environment. The area of greenery within the city of Nizhnevartovsk is approximately 6,000 hectares. Limited-use plantings (green areas within residential areas) amount to approximately 49 hectares. In accordance with SP 42.13330.2011 Urban Development. Planning and Development of Urban and Rural Settlements. The updated version of SNiP 2.07.01-89 - greenery in residential areas must comply with the standard of 10 m² per person. The study analyzed the area of greenery in residential areas in accordance with the regulatory document. It has been determined that the area in the new microdistricts of the city under construction needs to be landscaped. To ensure the continued rational use of the territory and a favorable living environment for the population, it is

necessary to provide windbreaks—green spaces—to create a comfortable living environment and protect residential areas from winds and snow drifts.

Having analyzed the priority and level of greenery in Nizhnevartovsk, it can be concluded that current green spaces do not fully meet the specific needs of northern urban development, which adversely impacts the living environment. Thus, as a result of the urban planning analysis of Nizhnevartovsk, taking into account natural and climatic factors, it can be concluded that the development of the studied area fully takes into account factors such as terrain, engineering preparation of the areas, wind conditions, and snow drifts. The development and layout of buildings and structures in Nizhnevartovsk are based on the prevailing southwesterly wind directions in the area. It is characterized by a closed and partial layout, in which rectangular buildings create a windbreak front of screen-like buildings on the side of the dominant wind direction, which helps reduce the negative impact of winds. Green spaces, a factor in northern urban development that serves as a windbreak for populated areas, do not fully address all the negative impacts on the living environment, which negatively impacts urban development as a whole. Green space creation and renovation should be primarily focused on the multi-apartment residential developments in Blocks No. 23, 24, 25, 26, and 31a. To create a comfortable microclimate, windbreaks must be provided. Dense tree plantings can serve as a natural barrier. In open spaces, conifers should be preferred, planted on the side of the prevailing wind. When creating a windbreak, it is recommended to plant greenery in several rows (up to four rows), with increasing height and density as the row progresses. Multi-row plantings utilize several types of landscaping: shrubs, deciduous trees, mixed tall-stemmed trees, and conifers. Plants are planted in sequential rows from low to high, with the highest row located on the windward side. Recommendations for landscaping in Nizhnevartovsk, identified during the urban planning analysis of the study area, can be taken into account by local governments to develop measures for the efficient and rational use of the city's territory and a favorable living environment. A comprehensive climate analysis, based on the initial climatic characteristics of the construction area, is crucial for northern urban development. All design and development work in settlements in the northern regions, including Nizhnevartovsk, must be carried out taking into account the natural and climatic characteristics. The results of the urban development analysis of Nizhnevartovsk's territory, taking into account the impact of the northern region's natural and climatic conditions, can be taken into account by local governments when implementing management decisions to develop measures for the efficient use of the city's territory. The characteristics of such natural and climatic factors as terrain, wind patterns, snow drifts, as well as recommendations for landscaping Nizhnevartovsk's territories, must be taken into account when making further urban development decisions.

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