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Analysis of the Effectiveness of Urban Planning Solutions for the City of Nadym in a Half-Century Retrospective

Roman Yu. Fedorov [1]✉, Dr. Sci. (Hist.), Chief Researcher
Oleg S. Sizov [2], Cand. Sci. (Geogr.), Senior Researcher

[1] Earth Cryosphere Institute, Tyumen Scientific Centre SB RAS, ul. Malygina, 86, Tyumen, Russia
[2] Oil and Gas Research Institute RAS, ul. Gubkina, 3, Moscow, Russia
[1] r_fedorov@mail.ru ✉, ORCID: https://orcid.org/0000-0002-3658-746X
[2] kabanin@yandex.ru, ORCID: https://orcid.org/0000-0003-1509-8912

Abstract. The process of urbanization of the oil and gas production complex in the north of Western Siberia in the 1960s–1980s was marked by the active introduction of scientifically based approaches designed to minimize the negative effects of the Arctic and sub-Arctic climate on residents of new cities under construction. One of the serious problems in implementing project approaches to the formation of the urban environment in the Arctic was that they were only capable of predicting the specifics of the economic, social and environmental development of the new city in the relatively short term. The main aim of this article is to analyze the effectiveness of the urban planning theory developed by the LenZNIIEP team on the case of the city of Nadym, founded in the early 1970s. The study is based on the research work of LenZNIIEP. In order to obtain subjective assessments of the development and use of the urban environment of Nadym, a series of thematic interviews were conducted with experts and residents of the city. In addition, recent scientific literature on the topic of research has been analyzed. During the study, the features of design solutions and the evolution of the development of four urban planning subsystems of Nadym were considered. The task of urban planning physics was to minimize the discomfort caused to the city's population by the harsh landscape and climatic conditions. An important result of the development of urban ecology was the successful greening of open urban spaces in the Arctic climate. The main task of urban planning psychology was to create color schemes for buildings that are comfortable for Arctic conditions. The tasks of urban planning sociology included the adaptation of the urban environment to the demographic and socio-economic characteristics of the young Arctic city. The case of Nadym demonstrates that effective implementation of all urban planning subsystems can mitigate the effects of the harsh Arctic climate on the city residents and improve quality of their life. At the same time, due to the paradigm change in urban development of the Russian Arctic, the development of an "adaptive" approach is becoming increasingly relevant, as it was designed to identify and implement individual strategies for organizing a comfortable urban environment, taking into account the characteristics of local natural and climatic conditions.
Keywords: *socio-environmental problems, urban planning theory, design approaches, efficiency analysis, LenZNIIEP, Arctic cities, Nadym*

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Introduction

The process of urbanization of the oil and gas production complex in the north of Western Siberia in the 1960s–1980s was marked by the active introduction of scientifically based approaches designed to minimize the negative effects of the Arctic and sub-Arctic climate on residents of new cities under construction. Applied researches related to this issue were actively conducted in a number of specialized industry institutes. Among them, the Leningrad Zonal Research and Design Institute for Standard and Experimental Design of Residential and Public Buildings (LenZNIIEP), established in 1963 under the USSR State Construction Committee (Gosstroy), made a significant contribution to the development of individual and standard urban planning solutions for regions of the Far North. The comprehensive nature of the approaches developed by the institute was well characterized by the head of its scientific department, architect A.V. Yakovlev, who defined urban planning as "the organization of the environment and, thereby, the organization of human life (as a biological organism) and society (as a collective of people — from the family to the city)" [1, p. 5]. The urban planning theory developed by A.V. Yakovlev and his colleagues during those years included such subsystems as urban planning physics, urban planning ecology, urban planning psychology, and urban planning sociology (Fig. 1). Yakovlev justified the interdisciplinary nature of urban planning theory by the need to shift from a subject-oriented to a problem-oriented approach, in which the urban development of the North is a major theoretical and practical issue [1, Yakovlev A.V., p. 12].

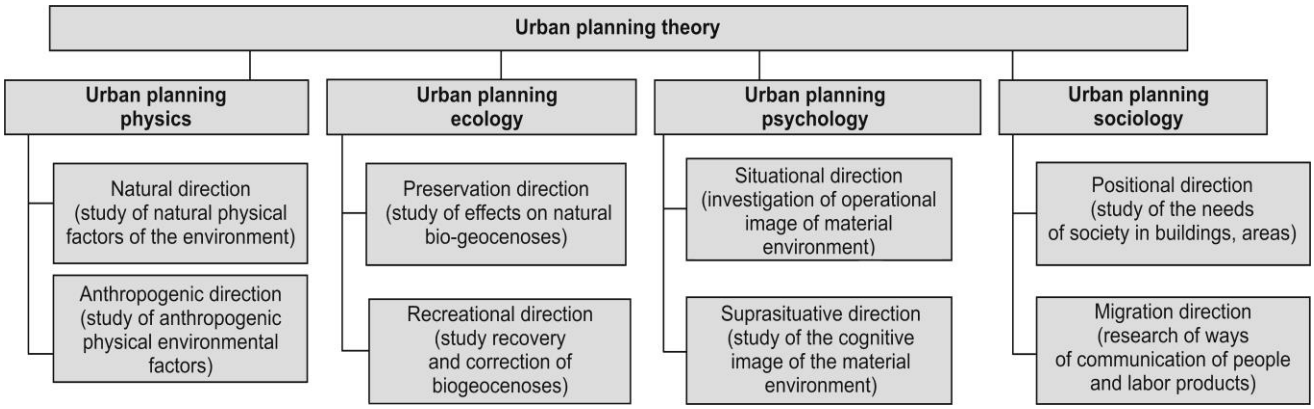


Fig. 1. Structure of urban planning theory (based on [1, Yakovlev A.V., p. 12]).

One of the serious challenges in implementing project-based approaches to urban development in the Arctic was their ability to predict the specifics of the economic, social and environmental development of a new city in the relatively short term, often only a few decades. Such factors as the depletion of natural resources, which are linked to the extractive industries served by the city, changes in the principles and priorities of the state's economic development, climate change and transport accessibility, as well as migration processes, in most cases require significant adjustments to the development of the urban environment, which was originally designed with other historical realities in mind. Taking this problem into account, it is highly relevant to review

the design approaches that have been implemented in the context of assessing their effectiveness in terms of individual criteria for sustainable development and the viability of a particular city.

Over the past decades, new approaches to understanding the urbanization of Arctic regions have been developed in Russia. Conceptual frameworks for the study of frontier urbanization and the anthropology of zonality in the Russian Arctic were developed and successfully tested by N.Y. Zamyatina, A.N. Pilyasov, and R.V. Goncharov [2; 3; 4]. A.A. Medvedkov studied the geo-ecological factors of the viability of Arctic cities in the cryolithozone [5]. In foreign science, the study of the socio-ecological problems of Arctic cities is reflected in a number of research areas, among which the works devoted to the concept of the "winter city" (Winter City Urban Design) and climate-sensitive Arctic design (Climate-Sensitive Urban Design) should be highlighted. These studies were widely presented in the publications of N. Pressman, D. Chapman, E. Sanborn and others [7; 8; 9, Costamagna F., Lind R., Stjernström O.]. Based on examples of cities in the Russian Arctic, over the past decade, foreign research teams have studied the impact of climate change, as well as individual social and economic factors, on the transformation of the urban environment [10, Esau I., Miles V.; 11, Laruelle M., Esau I., Miles M. et al.; 12, Orttung R.W., Anisimov O., Badina S. et al.], etc. However, despite the steady growth of publications devoted to the problems of urbanization in the Russian Arctic, the analysis of the socio-ecological aspects of the implementation of project-based urban planning approaches in its territory has not yet become an independent area of research.

The main aim of this article is to analyze the effectiveness of the urban planning theory developed by the LenZNIIEP team on the case of the city of Nadym, founded in the early 1970s, in the context of its evolution amid the socio-economic transformations of the late 20th and early 21st centuries (Fig. 2). Nadym was chosen as the object of this study because it was built in the Russian Arctic "from scratch", in accordance with a pre-developed and scientifically based urban planning concept. This circumstance, as well as the "young" age of the city, which celebrated its 50th anniversary in 2022, made it possible to trace the socio-ecological history of Nadym in detail and provide a reliable assessment of the effectiveness of the urban planning solutions implemented there.

Fig. 2. General view of residential development in Nadym (photo by O.S. Sizov, August 23, 2020).

Materials and methods

The source material for this study is based on an analysis of research papers and reports by LenZNIIEP, stored in the Central State Archive of Scientific and Technical Documentation of St. Petersburg and the Municipal Archive of the Nadym District Administration of the Yamalo-Nenets Autonomous Okrug. To study subjective assessments of the characteristics of the urban environment in Nadym, a series of thematic interviews was conducted with experts and residents of the city. During the study, we also interpreted and reviewed previous research conducted by us and other authors on the environmental, geotechnical, and social aspects of the development of the urban environment in Nadym. Most of them were devoted to assessments of the state of the urban environment [13, Kirilyuk L.I.; 14, Krasnenko A.S., Pechkin A.S., Kobelev V.O. et al.; 15, Pechkin A.S., Pechkina Yu.A., Krasnenko A.S. et al.]. Geotechnical problems of stability of civil engineering structures in the context of geocryological conditions of the area where Nadym is built are considered in the work [16, Osokin A.B., Bomkin S.V.]. I. Esau, V. Miles, A.V. Soromotin, M.I. Varentsov and P.I. Konstantinov studied the microclimatic features of the development of the city of Nadym [10; 11; 17]. Sociocultural aspects of the development of the urban environment of Nadym were touched upon by V.A. Kibenko [18]. In the period from 2020 to 2022, as part of the RFBR grant “Open urban spaces as a factor in ensuring sustainable development in the Arctic in the context of climate change”, the socio-ecological aspects of the development of green, blue and white spaces of Nadym were studied [19, Fedorov R, Kuklina V, Sizov O. et al.; 20, Fedorov R.Yu., Sizov O.S., Kuklina V.V. et al.; 21, Sizov O.S., Fedorov R.Yu., Pechkina Yu.A. et al.; 22, Kuklina V., Sizov O., Fedorov R., Butakov D.]. However, despite the existence of these works, no attempts have been made to systematically study the effectiveness of design approaches in the formation of the urban environment of Nadym. The only exception to this is our recent publication devoted to the analysis of the effectiveness of wind protection measures in the city of Nadym [23, Sizov O.S., Fedorov R.Yu., Soromotin A.V.].

Research results

Urban planning physics. According to the definition given by A.V. Yakovlev, "urban planning physics studies the physical factors of the urban environment, the laws of its emergence and change under the influence of the city, and develops ways to optimize them in relation to human requirements using urban planning tools" [1, Yakovlev A.V., p. 8]. Specific tasks of urban planning physics in the Russian Arctic include correcting background climatic conditions to reduce their discomforting effects on humans, as well as ensuring the stability of buildings and elements of urban infrastructure built on permafrost.

The area chosen for the construction of Nadym was located in the Yamalo-Nenets Autonomous Okrug, approximately 100 km south of the Arctic Circle, and was characterized by unfavorable natural and climatic conditions. In order to minimize the impact of harsh climatic conditions on future city residents, during the process of developing the planning concept for Nadym, the LenZNIIEP team focused on creating a compact urban environment, the layout of which was intended to minimize outdoor movement and improve thermal comfort through the active use of the wind protection functions of multi-storey buildings (Fig. 3). According to the proposed project, the radius of service for schools was not to exceed 400 m, for kindergartens — 250 m, and for public transport stops — 320 m [1].

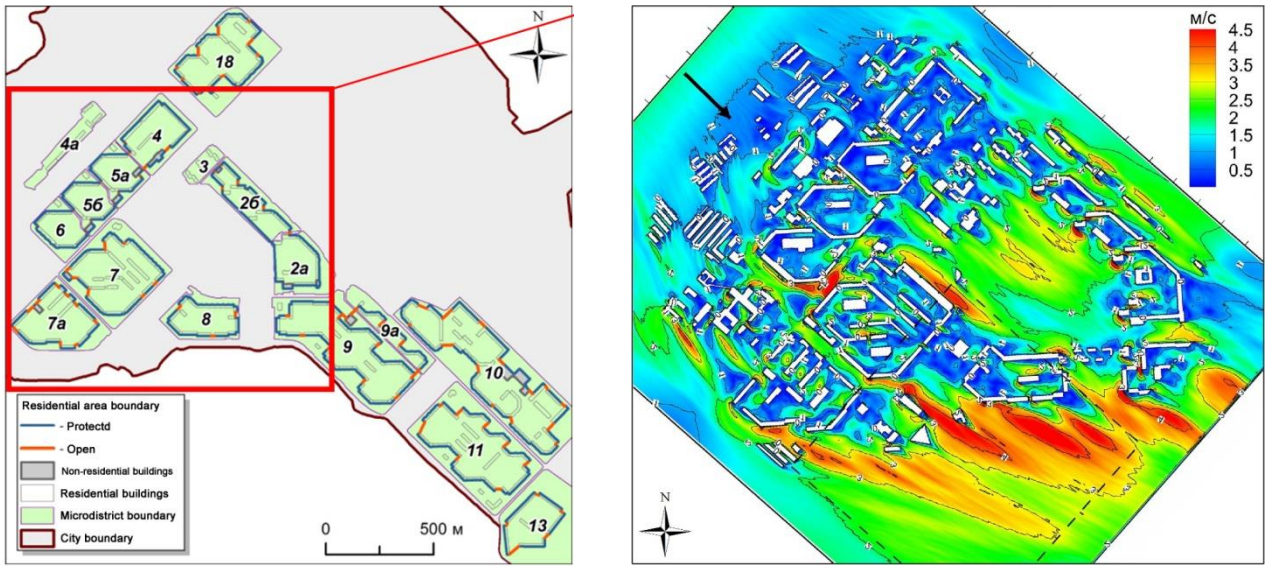
a) b)

Fig. 3. Master plan projects for the city of Nadym: a) approved (developed by LenZNIIEP) [2]; b) final city development (OpenStreetMap).

It should be noted that compactness was directly linked to the tasks of optimization of microclimatic conditions, including wind and snow protection. Aerodynamic complexes combining public and residential buildings, as well as open urban spaces permanently accommodating 4 to 8 thousand people, were considered as an optimal solution capable of adjusting the microclimatic characteristics of a separate small settlement or microdistrict of the city [1, Yakovlev A.V., p. 144].

[1] Ibid. F. 19. Invt. 3. Arch. 11. Sh. 19.
[2] Ibid. F. 19. Invt. 3. Arch. 11. Sh. 22

In accordance with this approach, residential development in Nadym was implemented in the form of semi-closed planning units acting as aerodynamic groups (Fig. 4). In 2023, we conducted a study on the effectiveness of the wind protection measures developed by LenZNIIEP for Nadym 50 years after the start of construction [23, Sizov O.S., Fedorov R.Yu., Soromotin A.V.]. As a result of the study, which was based on an interdisciplinary approach that included analysis of scientific and technical documentation, interviews with local residents, meteorological measurements and remote sensing data, it was established that about 90% of the perimeter of the microdistricts built in 1970–1980 is protected from the wind by the outer walls of buildings. Furthermore, meteorological data showed a significant decrease in average wind speeds within the city limits compared to background conditions. In residential areas, wind speeds decrease by 1–1.3 m/s. Overall, it can be concluded that the wind protection measures proposed during the design of the city's master plan were successfully implemented and achieved the intended effect [23, Sizov O.S., Fedorov R.Yu., Soromotin A.V.]. Unlike residential areas, not all public spaces popular for walking and recreation have been equally protected from wind exposure. This situation is most noticeable on the embankment of Lake Yantarnoe.

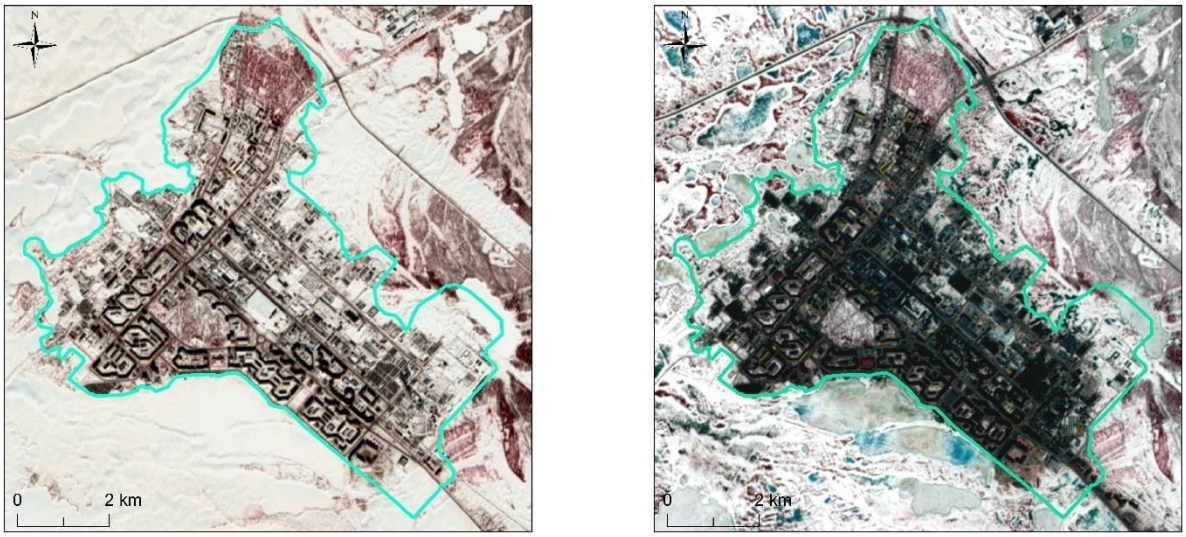


a) b)

Fig. 4. Implementation of the concept of aerodynamic groups: a) assessment of the closeness of residential areas within the microdistricts of Nadym; b) results of numerical vortex-resolving modelling in the western part of the residential area of Nadym [17, Varentsov M.I., Repina I.A., Glazunov A.V., et al.].

The relatively dense multi-storey development of Nadym has given rise to another well-defined microclimatic phenomenon associated with surface temperature inversions, which in modern scientific literature is commonly referred to as the urban heat island. From 2016 to 2022, under the leadership of I. Esau, the long-term dynamics of the urban heat island intensity in Nadym was studied. For comparison, observation data from other cities — Salekhard, Novy Urengoy, and Apatity, where long-term observations were also conducted — were used. For all cities, the average monthly values of heat island intensity (the difference in temperature between the stationary city weather station and the suburban weather station of Roshydromet) were calculat-

ed. According to the results of the study, in winter, the atmospheric air temperature in Nadym, compared to background areas, can be 3–4 degrees higher. In Salekhard and Novy Urengoy, where the compactness and density of development is lower, these indicators are lower [10; Esau I., Miles V.]. As an observable indicator of the heat island, city residents note that snow begins to melt earlier in Nadym than in the surrounding area (Fig. 5). Some city residents suggest that the urban heat island and wind protection measures have a beneficial effect on the condition and height of trees growing within the city limits. This assumption has been confirmed by recent geobotanical studies [21, Sizov O.S., Fedorov R.Yu., Pechkina Yu.A., et al.].



a) b)

Fig. 5. Impact of the heat island in Nadym on snowmelt: a) image from April 17, 2019; b) image from May 9, 2019.

In Nadym, a plot of land consisting of sandy upswell formed from thawed alluvial soils with thin permafrost lenses (Fig. 6) was allocated for the urban development that took shape in the 1970s and 1980s. This factor made it possible to avoid the use of expensive thermal stabilization methods for the building foundations and the airfield runway, unlike a number of other cities and towns in the Yamalo-Nenets Autonomous Okrug, which were built in areas of continuous permafrost. In the late 1980s and 1990s, new development sites shifted to the edge zones of the first floodplain terrace and to the high floodplain of the Nadym River, which were characterized by the spread of permafrost lenses of significant thickness, with the inclusion of clayey soils of the Salekhard suite in the frozen zone, in some cases having a high ice content due to ice inclusions. This period coincided with a decline in the quality of survey work, one of the reasons for which was the closure of LenZNIIEP. The situation that developed led to critical deformations of a number of buildings constructed during this period [16, Osokin A.B., Bomkin S.V., p. 332]. In general, the example of Nadym clearly demonstrated that the sandy upswell, on which the main part of the city was built, surrounded by a zone of permafrost, can be considered as a kind of “arctic oasis”. At the same time, unlike desert zones, where sand is often a limiting factor for the development of many life-support practices implemented in other natural and climatic zones, in Arctic conditions it can

be considered a factor that can significantly improve the quality of life of the urban population [22, Kuklina V., Sizov O., Fedorov R., Butakov D.].

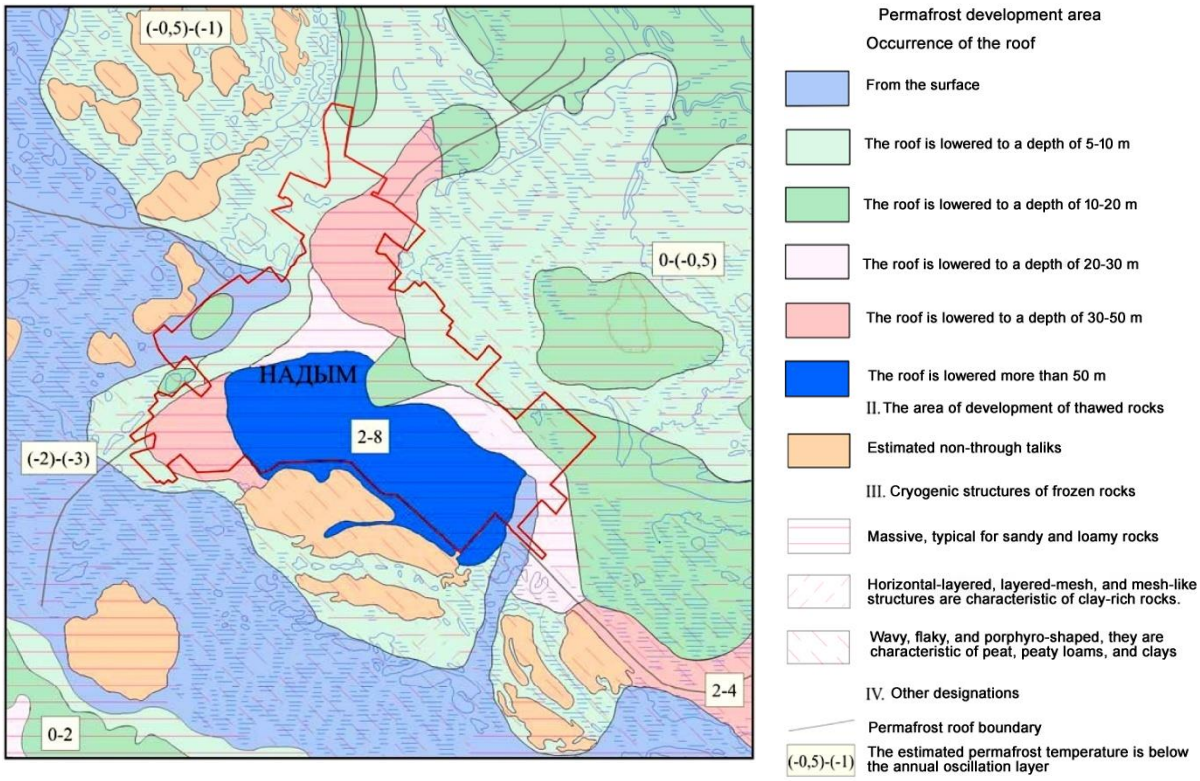


Fig. 6. Geocryological map of Nadym and its surroundings [24, Gryaznov O.N., Abaturova I.V., Petrova I.G.].

Urban planning ecology. In the Arctic, urban planning ecology has a number of specific areas of focus. The first of these is related to the fact that the harsh and sometimes extreme natural and climatic conditions require the transformation of the local natural environment to make it as comfortable as possible for city residents. As a rule, this task includes urban greening, improving water bodies located on their territory, and creating ecological buffer zones and recreational facilities. The second area is related to the development of measures to minimize environmental pollution from industrial enterprises, transport, and various types of anthropogenic activities.

Apparently, even within a single research team, there were different opinions regarding the optimal approaches to urban greening in the Far North. The most comprehensive and consistent study of the problem of greening Arctic cities was conducted by E.N. Pomazkova. The author concluded that “there are no insurmountable obstacles to the greening of populated areas in all northern vegetation zones” [3]. At the same time, in a 1971 research report on “Recommendations for the Design of Greening and Winter Gardens in Residential and Public Buildings for the Northern Zone of the Country”, authored by N.N. Khomutetskaya, a largely opposite conclusion was made, according to which, in Arctic cities, “greening in open ground cannot play a major role due to the short growing season of plants, as well as a number of technical difficulties associated with planting and caring for green spaces” [4].

[3] Central state archive of scientific and technical documentation of St. Petersburg. F. 17. Invt. 2-9. Arch. 452. Sh. 26.
[4] Ibid. F. 17. Invt. 2-7. Arch. 1298. Sh. 6.

Initially, the general plan for Nadym, developed by LenZNIIEP, did not include a park. However, due to the proactive approach of the First Secretary of the Nadym City Committee of the CPSU, E.F. Kozlov, during the development of Nadym, an area of natural vegetation located in the city center was preserved and transformed into a park, which was subsequently named after him [20, Fedorov R.Yu., Sizov O.S., Kuklina V.V., et al.]. In addition to the Park named after E.F. Kozlov, a cedar grove was also preserved on the outskirts of Nadym. Over time, these two green spaces have become important ecological and recreational areas for the city's residents (Fig. 7). From the first years of Nadym's existence, targeted work was carried out to green its streets. Despite the low survival rate of a number of woody plant species, the experience of greening Nadym can be considered successful [21, Sizov O.S., Fedorov R.Yu., Pechkina Yu.A. et al.]. Overall, the 50-year history of the development of green spaces in Nadym has clearly demonstrated the following pattern: if the natural and climatic conditions of an Arctic city allow for the use of at least a limited number of tree and shrub species in greening, the value of publicly used open green spaces will always be higher than that of growing plants indoors. In particular, a study of the practices of using green spaces in Nadym has fully confirmed their specific socio-ecological functions, which were identified as early as the 1960s by E.N. Pomazkova. These included improving the microclimate by mitigating temperature fluctuations, reducing wind speed, protecting against snow and dust, and increasing the humidity of excessively dry air in the North [5]. In addition, the author considers vegetation cover to be a kind of protective layer that prevents permafrost soils from thawing in summer and protects against the spread of quicksand, ravines and the blowing away of the dried soil layer [6].

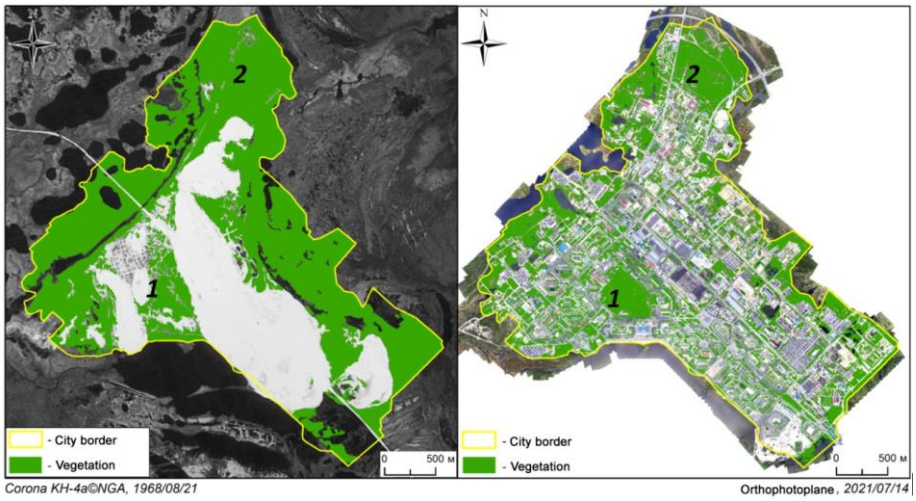


Fig. 7. Changes in vegetation cover in the city of Nadym from 1968 to 2021: 1) Park named after E.F. Kozlov; 2) cedar grove.

Unlike green spaces, water bodies play a less important role in the ecological needs of Nadym residents. The city is surrounded by a system of oxbow and thermokarst lakes, the largest of which is Lake Yantarnoe, which is about 2 km long and covers an area of 0.8 km^2 (Fig. 8). Despite the limited recreational opportunities of Lake Yantarnoe, it is currently actively used for cat-

[5] Ibid. F. 17. Invt. 2-9. Arch. 452. Sh. 3
[6] Ibid. F. 17. Invt. 2-9. Arch. 452. Sh. 4.

amaran rides in the summer, and Reindeer Herders' Day is held on the frozen surface of the lake in early spring. After renovation, the embankment of Lake Yantarnoe has become one of the centers of attraction for walks and recreation for the residents of Nadym.

Fig. 8. Main water bodies near Nadym: 1) Lake Yantarnoe; 2) Lake Yantarnoe-2; 3) Lake Prodolgovatoe.

Currently, the main source of pollution in the urban environment is motor vehicles. Maximum concentrations of surface lead distribution (3.3±0.11 mg/kg) were recorded near major highways, intersections, car parking areas, as well as near enterprises that have their own vehicles or operate vehicles [13, Kirilyuk L.I., p. 88]. Returning to the analysis of the effectiveness of design solutions in the urban planning physics in the context of its environmental impact, it is worth noting one of the problems that arose during the development of the city, which the LenZNIIEP team could not foresee. When designing the urban environment of Nadym, it was assumed that most of the city's residents would travel on foot or by public transport. This assumption was correct until the second half of the 1990s. Later, the number of cars owned by Nadym residents began to grow steadily. At the same time, cars were often parked in the courtyards of residential buildings, which, due to wind protection measures, were prone to air stagnation. Residents of multi-storey buildings began to complain about exhaust fumes penetrating their apartments. This situation was exacerbated by the fact that in winter, cars parked in the courtyards of apartment buildings could be left running for long periods of time to warm up.

Urban planning psychology. Interviews with Nadym residents who moved from other regions indicate that one of the most significant psychological challenges during the first years of living in the city was adapting to the short winter daylight hours and white nights. In Nadym, the annual duration of sunshine is 1,500 hours, while, according to an estimate, the average winter sunshine duration is no more than 25 hours per month. At the end of December, daylight duration is approximately 3 hours, while at the end of June, it reaches 23 hours [7]. In this situation, during winter, the visual dominants of the urban environment should be adapted to the prevailing twi-

[7] Municipal archives of the Nadym District administration. F. 19. Invt. 3. Arch. 11. Sh. 5.

light for most of the day, the abundance of snow, and the occasional snowstorms and blizzards. At the same time, in summer, city residents often lack night twilight.

In the process of designing new settlements adapted to the conditions of the Far North, the LenZNIIEP team tried to pay attention to the specific aspects of urban planning psychology. This primarily involved searching for the optimal visual imagery of an Arctic city, in particular, the color of buildings. The authors of a 1962 research project entitled “The Use of Color in Urban Development in the Northern Regions of the Country as a Means of Enhancement of the Architectural, Artistic, and Functional Value of Buildings” tended to believe that light tones, close to white, are most appropriate for cladding buildings in northern cities. According to the authors, white is justified for northern cities by artificially creating the impression of greater illumination and enriching the overall environment with light tones. This phenomenon was called “light enrichment” or “light compensation”. Over time, this approach has undergone significant revision. Thus, in a monograph published in 1987, A.V. Yakovlev noted that the recommended color scheme should be maintained within the yellow-red tones. Moreover, according to the author, blue, light blue, and green tones are “cool” and difficult to distinguish during fog or snowstorms, while yellow, orange, and red tones are psychologically “warm” and act as good landmarks and visual dominants in winter [1, Yakovlev A.V., p. 161].

Residents of Nadym note that, in their subjective opinion, grey tones, close to the natural color of concrete slabs, predominated in residential buildings of the 1970s and 1980s, which primarily consisted of multi-storey panel buildings constructed according to standard designs. Since the early 2000s, due to the increased availability of modern facinf materials, the use of original color schemes has become widespread in the construction and renovation of buildings in Russian Arctic cities. Bright colors are most often preferred. During a survey we conducted in 2020–2022 among residents of Nadym, it was found that most of them consider warm tones, including shades of yellow, orange, green and red, to be the most comfortable. At the same time, many local residents noted that the blue shade used in the cladding of residential buildings in the Yubileiny microdistrict reminded them of winter. The use of dark colors in building cladding was also perceived negatively by most respondents. Thus, public opinion generally coincided with the recommendations formulated in the late 1980s by A.V. Yakovlev. However, it should be noted that not all city residents were unanimous in their opinions. Some of them noted that in certain cases they experienced psychological fatigue from overly bright building cladding, while the use of light colors, in their opinion, sometimes made the perception of architectural volumes more aesthetic.

Urban planning sociology. In the 1960s and 1970s, the LenZNIIEP team focused on studying specific aspects of urban sociology in the North. An important distinguishing feature of a significant number of cities in the Russian Arctic, including Nadym, was their insular location surrounded by hundreds of kilometres of uninhabited space. Nadym was designated as a base city for the development of the Medvezhye gas field and a number of other elements of industrial infrastructure created for the extraction and transportation of natural gas. According to the classification

adopted in the USSR, base cities were created to service industrial facilities within a radius of 150–200 km on a rotational basis. The estimated daily commute distance for their residents was 20–50 km, and in some cases could reach 150 km [8]. The distance from Nadym to the regional capital, Tyumen, located on the "mainland", was about 1,000 km by air. In addition to air transport, during the navigation period, the city was connected to the outside world via the Nadym River, a tributary of the Ob River. However, with the exception of winter roads and causeways designed for off-road trucks, Nadym had no developed land transport links with other cities.

In order to begin designing a new Arctic city, it was important to have a "social profile" of its average future resident in order to select the optimal types of residential buildings and social and service facilities. One of the common features of the social profile of the inhabitants of the new Arctic cities built at that time was that the overwhelming majority of their population was of working age. In the centers of new development, the proportion of the urban population of retirement age could be no more than 1–3%. The gender structure of the population of the new cities was characterized by a predominance of men (up to 52–55%), and in some cases, up to 70% [9].

Let us consider the evolution of the demographic characteristics of the population of Nadym.

Table 1

Data from the All-Union Population Censuses in Nadym [10]

Year	Men	Women	Total
1979	13504	12554	26058
1989	26589	25997	52586
2002	22389	23554	45943
2010	22534	24077	46611
2020	22173	23800	45973

By 1980, the population of Nadym had reached 30,400 people. Only 500 people were above working age, while the rest were either of working age (21,100) or children: 500 under one year old, 3,800 aged 1–6, and 4,500 aged 7–15 [18, Kibenko V.A., Ryabkova O.V.]. As of 2023, the population of Nadym was 44,845 people, including children under 7 years old — 4,485 people, adolescents from 8 to 18 years old — 5,292 people, young people aged 19 to 30 — 5,381 people, adults aged 31 to 60 — 19,283 people, elderly people aged 60 and over — 9,776 people, and Nadym's centenarians aged over 80 — 628 people [11]. Since the 1990s, the number of women living in Nadym has exceeded the number of men. While in 1979 men accounted for 51.8% of the total population of Nadym, in 2020 they accounted for 48.2% (Table 1). This situation can be explained by the stabilization of the city's population in the 1990s, a decline in the influx of young professionals, and the general process of "settling" in the city by a significant portion of people who arrived in the 1970s and 1980s. It should be noted that, from the very beginning of Nadym's existence, there was a heated debate about the optimal length of stay for specialists working there. In the 1970s, most researchers be-

[8] Ibid. F. 29. Invt. 2-1. Arch. 8. Sh. 59.
[9] Ibid. F. 29. Invt. 2-1. Arch. 8. Sh. 36.
[10] Demoscope Weekly. URL: http://www.demoscope.ru (accessed 23 January 2025).
[11] Population of Nadym. URL: https://awdb.ru/yamalo-neneckiy-avtonomnyy-okr/nadym/ (accessed 23 January 2025).

lieved that the rapid and effective adaptation of most newcomers to Arctic cities was greatly hampered. Furthermore, the optimal length of stay for people in uncomfortable areas was considered to be 5–7 years [12]. However, in practice, a significant number of people began to consider Nadym as a permanent place of residence. This situation was most often associated with more attractive career opportunities compared to other regions, as well as the desire to maintain the family and social ties formed during their residence in the city. The increasing average age of Nadym residents and the growing number of families with children are placing new demands on the urban environment. In our interviews, city residents most frequently noted a need for the development of individual housing construction, as well as the creation of new public spaces for family recreation.

The development of Nadym's transport links with the outside world has become an important factor in improving the social well-being of its residents. In this regard, the most significant event was the opening of the bridge across the Nadym River in 2015, which provided the city with road transport links with the outside world (Fig. 9). This contributed to increased spatial mobility of the city's residents and reduced the cost of supplying them with food and essential goods. In particular, the arrival of chain supermarkets and online shopping pick-up points in the city, according to residents, has significantly improved the quality of life of Nadym residents.

Fig. 9. Pontoon crossing and the start of construction of the road bridge across the Nadym River (photo by O.S. Sizov, 2012).

Discussion

The example of Nadym demonstrates that, in Arctic conditions, the effective and coordinated development of all four urban planning subsystems outlined above enables the city's population to gradually approach certain quality-of-life standards and indicators characteristic of more southern and developed regions. In the case of Nadym, from an urban planning physics perspective, this situation was reflected in the creation of compact buildings with wind protection functions, which made the urban microclimate more comfortable for residents. The preservation of natural vegetation and successful greening played a positive role in Nadym's urban planning ecol-

[12] Central state archive of scientific and technical documentation of St. Petersburg. F. 29. Invt. 2-1. Arch. 8. Sh. 22.

ogy. From the point of view of urban planning sociology, the development of ground communications and the arrival of federal retail and consumer services networks in the city were of great importance in improving the quality of life of Nadym's residents. Attention to urban planning psychology has only begun to grow in recent decades. Despite attempts to create a more psychologically comfortable visual image of the city for its residents, much work remains to be done to give it a unified, well-thought-out style.

All the urban planning subsystems analyzed above are closely interconnected, but they are characterized by different transformation dynamics. In this regard, urban planning physics, which is related to the specifics of development, as well as the functional and microclimatic parameters it has formed, has the least dynamic changes. In Nadym, this situation has been particularly evident, as the city has maintained a trend toward a low volume of new residential and public buildings since the 1990s. Moreover, due to the fact that most of the city's buildings are located within the distribution of thawed sandy soils, the deformation of buildings as a result of the degradation of permafrost rocks was insignificant, unlike in most other cities built in the Russian Arctic.

The urban planning ecology has experienced more rapid transformations. These changes were driven by significant anthropogenic transformations of the city's landscapes and environment, characterized by an increase in the share of green spaces due to artificial landscaping, as well as the emergence of new sources of environmental pollution.

Unlike the two previous subsystems, not all of the LenZNIIEP team's design concepts in urban planning psychology and sociology were implemented in the urban environment of Nadym during the Soviet era. As in many other young Arctic cities, the social and cultural spheres in Nadym lagged behind the production sector in the first decades of the city's existence, failing to fully meet the needs of its residents. Furthermore, these subsystems proved to be significantly more dependent on external influences associated with changes in the formational and socio-economic principles of society's development that occurred as a result of the collapse of the USSR and the subsequent formation of a market-type economy. At the same time, social factors such as the growth of consumer and recreational demands of the population, the diversification of the structure of social and domestic services, the increase in the number of cars, etc., had a noticeable impact on urban ecology: on the one hand, contributing to the growth of anthropogenic pressures on the environment, and on the other hand, increasing the urban population's demand for ecosystem services.

Conclusion

Summing up the study, it is important to note that over the half-century history of Nadym, the paradigms of urbanization in the newly industrialized areas located in northern Western Siberia have changed significantly several times. At the time of the design and construction of Nadym, the prevailing approach of the USSR was to create base cities intended to become multifunctional centers for the development of major oil and gas fields. However, at the turn of the 1970s and 1980s, the creation of base cities began to be abandoned in favor of more compact organizational

and economic centers. Starting in the 1990s, the construction of new cities in the Tyumen North was ceased. The question of the prospects for previously built cities was repeatedly raised due to the fact that their original role as frontier settlements — springboards for industrial development — was gradually being lost. At the same time, the socio-ecological aspects of Arctic urbanization have changed dramatically over the past fifty years. While in the late 1960s and early 1970s, production functions dominated in newly constructed cities, with social development and environmental protection measures lagging behind, in the first decades of the 21st century, a peculiar inversion of the basic functions of northern Western Siberian cities can be observed. Their direct involvement in oil and gas production has declined, while the population's demand for high-quality social infrastructure and recreational facilities in urban areas has grown significantly. Moreover, as our previous research has shown, the "colonial" approach, aimed at reproducing the standards and principles of urban organization characteristic of the "mainland" in Arctic conditions, is increasingly replaced by the "adaptive" approach, aimed at identifying and implementing individual strategies for organizing a comfortable urban environment, taking into account the specific features of local natural and climatic conditions [20, Fedorov R.Yu., Sizov O.S., Kuklina V.V., et al.].

Since the early 1990s, after the closure of LenZNIIEP, which monitored and adjusted the municipal infrastructure it had designed, the factor of spontaneity has become more prominent in the development of the urban environment in Nadym. However, by that time, the city's population had stabilized and subsequently stopped growing. In this regard, as noted above, the volume of subsequent housing construction was small, and the originally designed basis for urban development continued to dominate. This situation necessitated the integration of new functional elements of urban infrastructure into its rigid foundation, designed to meet the changing utilitarian and recreational needs of the population. Therefore, an analysis of the initial urban planning approaches implemented in Nadym, along with a retrospective study of the evolution of their implementation in the context of the shifting paradigm of Arctic urbanization, is of great practical importance for the subsequent scientifically based adjustments to urban development concepts. This approach is equally relevant for other cities in the Russian Arctic built in accordance with design methods established in the USSR. Therefore, such a revision of urban planning solutions is essential for developing optimal strategies for adapting urban infrastructure elements to dynamically changing social, economic, and environmental realities.

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