Concept of Sustainability in the Arctic

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Abstract. The current stage of the development of the Arctic region of Russia coincided with the development and implementation of the ideas of sustainability: the identification of mechanisms and risk management, the ability to withstand future climate change through reorganization and upgrading. Under the new development conditions, we propose a model of the architectural and spatial organization of an environmental object of any level (building, settlement, city) that takes into account the specific region constraints. The authors suggest using a parcel with a set of patterns as the basic unit of the planning level. The patterns within this level are connected. Outside, the levels of the parcels are linked to each other and the natural surroundings. At the building level, engineering systems and their resilience are identified. At the level of external relations, environmental systems are identified - manifestations of the environment with possible aggressive impacts. Their resilience lies in their reaction to change. Engineering systems shall interact with social ones: when designing, the social responsibility of investors should be considered to provide the autonomy of each parcel, and after construction, it is necessary to define the responsibilities of all users. The system of parcel patterns is flexible, stable, and ready for probabilistic aggressive impacts of the outside world.

1. Introduction
Large territories of the Russian Federation in the Arctic (hereinafter referred to as the AZ RF) are only home to 2.5 million people. The development prospects of the AZ RF are connected with increasing mineral production, the Northern Sea Route, and the protection of the country's borders. The current development stage of the Arctic is different from the previous “expansion waves”: there are new conditions that require a complete overhaul of the habitat organization paradigm, as well as the creation of a comfortable and attractive living space. The traditional methods of habitat organization do not comply with the current sustainable development goals [1]. In 1996, Russia approved the Concept for the transition to sustainable development that declared the gradual recovery of ecosystems to sustainability. The sustainability definition by Brundlandt given in the Our Future report (1987) specifies the goals of sustainability, human welfare, and ecosystem balance activities. This definition stipulates that systems shall organize themselves and adapt to changes. However, the resilience theory (Holling, Gunderson, 2002) reviews the systems via adaptation cycles [3]. They can be used to forecast and direct sustainability activities. Experts forming the habitat shall be held responsible for the overcoming of the mentality that neglects activities that are safe for the biosphere.

The subject matter of this research is habitat, and it focuses on its architectural and spatial organization in Arctic Russia.
2. Materials and methods

The settlement centers formed during the intensive development of the Far North demonstrate a number of specific parameters that are typical of the Arctic habitat. Risk and vulnerabilities in building and structure design and construction are inevitable components of the development of the Russian Arctic [4]. The current development stage corresponds to the development and spread of sustainability ideas: determining mechanisms, risk management, and the ability to mitigate future climate change through reorganization and upgrading [5].

The factors that form the habitat in the Arctic region can be classified as targets and restrictions. The targets include economic and geopolitical factors. Throughout the entire history of the Arctic, the government and large businesses have been showing great interest in the valuable resources that are the main goal of the development. Geopolitics requires the country to guard its borders in order to prevent foreign agents from controlling deposit developments.

The habitat formation restrictions in the Arctic include geo-climatic, social and demographic, environmental, transport, and uncertainty factors. Permafrost soils, year-round negative air temperatures, and snow cover lasting 9-10 months determined the narrow range of available architectural and design solutions. It seemed that the permafrost will always be there, and elevated pile buildings will provide the durability of settlements and cities [6]. Over the last 30 years, temperatures in the Arctic increased by 6 degrees, and this fact poses a safety threat to buildings and settlements. Various development scenarios for global warming result in dismal forecasts of permafrost melting in areas where it is thin, and the flooding of the estuaries of the northern rivers. Permafrost melting poses the highest threat to the area around Norilsk. The destruction of oil reservoirs in that region in 2020 was not the first of such accidents but it was the largest one. Thus, the extreme climate and natural conditions are aggravated by the uncertainty factor: the probability of rapid changes in habitat parameters.

The development of the region cannot be implemented by simply drawing there some colossal human resources “at the wish of the ruling party’s hand”, the way it was done in the Soviet Union. The region is sparsely populated, with a population density of 0.63 people per 1 km². Patchy colonization is both a reason and a consequence of the poor development of transport and engineering networks. Today, these are also complemented by information networks. The problems of limited availability of energy carriers, food, and consumer goods are complemented by the problems of supporting and preserving the environment and the fragile Arctic ecosystem. The specific requirement to protect the country's borders is also being reviewed: today, only the 200-mile wide strip along the coast be properly protected, while the countries claiming the mineral resources of the Arctic possess brand-new technologies for their extraction and capture.

Thus, habitat formation in the Arctic depends on the adaptability of the habitat. According to Holling, a sustainable system can accept changes while retaining its basic structure or transitioning to an alternative sustainable state via transitions, mode shifts, adaptation cycles, and transformability [7]. The aggregate impact of a group of factors on the architectural and spatial organization of the habitat in the Arctic requires searching for adaptation options. The architectural and spatial system is a set of nested subsystems of different scales. Adaptation cycles can be used for any system. They are characterized by their potentials and interconnectedness, and they include exploitation, accumulation, upgrading, and reorganization [8]. When the system reaches the critical zone (emergence) with high potential and interconnectedness (accumulation cycle), it makes an adaptation breakthrough, while low potential and interconnectedness (exploitation cycle) results in the system crisis. Such levels within the architectural and spatial organization include buildings (residential, office, and production units), settlements (quarter, district), and cities. It is necessary to identify, which of these levels is suitable for the adaptation breakthrough and what means are required for that.

While the parameters of the internal habitat are quite clear, the parameters of the external environment need to be reviewed. Adaptability to the surrounding natural (or technogenic) environment has 2 aspects: changes in building designs and changes in the settlement as a whole [9].
Building design solutions determine their location on the land (or water) surface [10]. To prepare for possible future climate change, it is not enough to raise the building 1-1.2 m above the ground. We need to account for the probability of the sea-level increase and use high piles for new buildings and raise the existing ones where necessary.

Settlement changes may happen according to 3 scenarios. The first one is based on the building design: high-elevated structures in a flooded area can become the core of a settlement on the water where transport and engineering communications are also raised above the ground and boats are used to cover large distances. The second scenario stipulates the relocation of the settlement to higher grounds. Previously, mining towns were relocated in the USA and China, but the first transpolar city to be relocated was Kiruna (Sweden) in 2017. About 20 historical buildings are going to be moved, and the rest are going to be built from scratch. The third scenario is a protective one, and it stipulates the construction of a dam around the settlement.

The development of new settlements and relocating the old ones is difficult not only because of significant costs and time inputs. Thawed permafrost releases carbon. Therefore, breaking the ground should be avoided if possible. Thus, the existing settlements shall be upgraded.

The resilience ideas stipulate a flexible treatment of buildings taking into account their operation conditions and transformation for the new conditions, yet they are indivisible from the social and environmental sustainability [11].

When upgrading settlements, it is possible to improve habitat planning and organization errors and drawbacks. The analysis of the external parameters of the habitat shows that the parameters that are normal for someone living in the moderate climate, such as comfortable paved streets, squares, and public spaces are absent from the cities and settlements of the AZ RF. This does not mean they do not exist, but most of the year they are covered by snow. Natural green spaces that can be made into squares, parks, and rest areas, do not grow there. Buildings and structures are the only elements shaping the environment in the polar regions.

The laws of coordination between the object and space or the space retention by the object do not apply here. Here, all of the architectural and spatial advantages and disadvantages are laid bare [12]. Windbreak and snow control are manifested in the location of buildings but they are absent from public spaces. In terms of sustainability as the readiness to different events and emergencies, the organization of public spaces is not a prioritized goal [13]. The dominant occupations of the local residents take place indoors.

The fragility of existence in the Arctic applies not only to settlement but also to nature. Finding the best mode of interaction between the man-made and natural environments is one of the key problems for planning and development activities.

3. Results

Under new development conditions, we propose a model for the architectural and spatial organization of an environmental object of any level (building, settlement, city) that takes into account the constraints mentioned above.

The traditional criteria for a comfortable environment (the habitat is not usually considered) include the following: safety, comfort, availability, sustainability, etc with a specific degree of detail. The quantitative restrictions of the internal environment are expressed by the range of temperatures and humidity values, element dimensions (room height, corridor width, stair and staircase parameters, etc). For the external environment, these include the location of buildings to provide light, windbreak, water supply and discharge, as well as road parameters, distance from adverse technogenic and natural impacts, etc. The habitat itself features elements, to which these parameters can be applied. The parameters may expand and reduce (contract) depending on the size of the architectural space [14]. Thus, we suggest using the dynamic approach to the organization of the habitat. It stipulates the creation of possible existence scenarios for each of the levels, including the adaptation to changes [15].
Human activities take place in cities, towns, and buildings or, more specifically, in workshops, offices, studios, etc. Smaller architectural spaces are nested within larger ones, and the number of living spaces is increasing at every next iteration. At some stage, the external environment of some deeper level is not aggressive and has few differences from the internal environment. This contradiction does not allow for the construction of a model based on the comparison of external and internal environment parameters [16]. The fractal structure of clear distributions based on the responsibilities for various components complies with this goal [17].

We suggest using a parcel with a set of patterns as the basic unit of the planning level. The parcel of the region is agglomeration, the parcel of agglomeration is a city (settlement, the parcel of a city/settlement is a building (structure), the parcel of a building is an apartment (room, office) [18]. The patterns within the level are connected. Outside, this level, parcels are linked to each other and the natural surroundings. I.e. external connections are the most fragile ones, and they have to be prepared for the possible changes in the environment. At the building level, engineering systems are identified. Their resilience is a means of compensating for changes and returning to the initial balance. At the level of external relations, environmental systems are identified. These include the environmental phenomena with potentially aggressive impacts. Their resilience lies within their response to changes: the ability to withstand those without any damages to the system itself. These conditions require balance: the engineering system shall pick up some of the load on the environmental system. The self-sufficient set of patterns for each of the parcels (functions, metabolism, communications, and transport) facilitates its autonomous existence and minimizes risks for itself and the external outline of the habitat. The adaptation cycle of the accumulation stage facilitates the highest adaptability so that the most evolving systems can ensure the breakthrough (Figure 1).

The extremely dispersed transport system is a key risk for all of the human activity spots. To counter this risk, autonomous settlements with their own metabolic systems are created. Engineering systems shall interact with social ones: when designing, the social responsibility of initiators and clients should be considered to ensure the autonomy of each parcel, and after construction, it is necessary to define the responsibilities of all users [19]. Thus, the system of pattern parcels is flexible and sustainable, and it is ready for the potential aggressive impacts from the outside world.

4. Conclusions
The concept of sustainability in the architecture of the Arctic is based on the combination of technical and social solutions. The adaptability of architecture manifested by autonomous parcels mitigates the risks of aggressive impacts from the Arctic environment. The natural strategies for the adaptation to negative environmental impacts (mutation) take place over a relatively long period [20]. Technical and social strategies can increase their potential quickly through experiments. They can be adapted to the aggressive Arctic climate in terms of the sustainability concept.
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