

The concept of "Smart City": specific nature of innovative development of Russian Arctic cities

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Abstract. Innovative development of Arctic regions has insignificant dynamics to withstand the emerging challenges and threats. The initial asymmetry of the economic development of Arctic regions stimulated scientific search and innovative orientation but later financial and economic crises and new development priorities reduced the innovation potential of this macro-region. The condition of the regional innovation system becomes critical for the development of the innovation activity in Arctic cities. The study reveals the current state of digital transformation of the Arctic cities of Yamalo-Nenets autonomous area. Digitalization of the economy, the implementation of the "Smart City" concept focused on socio-cultural interactions creates new opportunities for the innovative development of Arctic cities. The advantage of many arctic cities is the concentration of human potential, infrastructure, specific social and economic practices. It is assumed that Arctic cities may face non-systemic and ineffective digital transformation, so the process should be accompanied by the development of local innovation systems. The concept of "smart people - smart city - sustainable region" is proposed, which implies prior development of the socio-cultural and intellectual potential providing the ability of arctic people to meet the current challenges and ensure a decent future for themselves.

Keywords: the Arctic, Arctic regions and cities, "Smart City", local innovation system, human potential.

1. Introduction

Industrial development of Arctic territories, climate change, market-oriented changes in the economy, large-scale technological and cultural innovations that take place both in Russia and around the world sufficiently changed the cultural and economic path of Arctic development and dramatically influenced the sustainability of Arctic regions and cities. A whole set of interrelated problems of Arctic development, contradictions (gaps) between strategic objectives and actual living standards arise, which require studying and analyzing the situation in Arctic, and developing new scientifically sound social design of sustainable development strategies for Arctic cities.

According to the outcomes of the second decade of the XXI century, the Arctic regions remained mostly in the groups of "medium-weak" and "weak innovators" (except for Arkhangelsk region and the Arctic part of Krasnoyarsk region) in the rating of innovativeness of the Russian Federation's constituent entities (see Table 1) [1, 2].



Table 1. Results of innovative development of the Arctic regions of Russia

AZRF constituent entities	RU HSE*			AIRR**		
	2012*** (2010) [3]	2019 (2017) [4]	Growth	2014 (2013) [5]	2018 (2017) [6]	Growth
1	2	3	4	5	6	7
Murmansk region	26	36	-10	38	59	-21
Republic of Karelia	42	60	-18	64	60	4
Arkhangelsk region	37	45	-8	62	37	25
Nenets autonomous area	51	84	-33	81	83	-2
Republic of Komi	62	57	5	40	55	-15
Yamalo-Nenets autonomous area	33	59	-26	78	70	8
Krasnoyarsk region	12	12	0	18	20	-2
Republic of Sakha (Yakutia)	59	55	4	63	45	18
Chukotka autonomous area	67	85	-18	73	84	-11
Average rating by constituent entities of the AZRF	43.2	54.8	-11.6	57.4	57.0	0.4

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*** the year of the ranking release, the year of the database of the ranking in parentheses

Negative trends are marked in orange and positive trends are marked in green.

The specifics in methodology of each ranking explains serious deviations in the assessment of regional innovative development. Nevertheless, both indexes show a predominant decline in innovative development in the Arctic zone of the Russian Federation (AZRF). Thus, we can summarize that the situation has not significantly improved despite the efforts and investment in innovative development made in the Arctic regions.

The scientific community has accumulated considerable knowledge about the socio-economic situation in the Arctic regions. The researchers studied Arctic resource potential, the spatial organization of economic units and population, the specifics of socio-economic development, and the investment potential of the monotonous of the AZRF. But today the most urgent scientific problem is to search the paths and reserves of the sustainable development of Arctic cities in new social-economic conditions. However, the results of the analysis of Arctic regional innovation development trends show that the current state of innovation systems and human potential of the AZRF is insufficient to withstand the growing challenges and threats. New methods and in-depth research are required to understand the ability of Arctic regions and cities to generate the necessary knowledge and technologies.

2. Goal and methods

Arctic regions lag behind the pace of innovative development of the most other Russian regions, what necessitate a comprehensive study of the current situation, risks, and reserves for the development of the Arctic regions and cities. It is necessary to continue searching for strategic solutions and scenarios for the sustainable self-development innovative systems, implying appropriate socio-cultural, socio-technical, and institutional transformations based on the concept of "Smart City". Resonating co-

development of local innovation systems and implementing "Smart City" concept would contribute to the better realization and development of human potential, thereby increasing the ability of urban communities to meet the challenges of time and ensure themselves a decent future in the long term perspective.

In this research we used descriptive statistic analysis based on national statistics and existing empirical research. We based on general scientific systemic and dialectical approaches, and also on institutional and evolutionary economic theories. We focus on the active role of individuals in the development of their habitat (activity approach). In compliance with the humanistic approach and the concept of sustainable innovative development of society, we assume that human innovative activities should be designed for sustainable community development and improvement of the quality of life (). Individuals as subjects of their activities, have different ideas about the quality of life, produce senses and make goals, guiding them(subject-oriented approach).

3. Results and discussion

3.1. The national level of the innovation system

The results of the innovative development of the Arctic regions, as well as other regions of the Russian Federation were largely due to the Strategy for the Innovative Development of the Russian Federation for the period up to 2020 (the Strategy).

Table 2. Some results of the implementation of the Strategy *

No.	Indicator name	Unit of measure	2010 [8]	2019 [8]	2020 (as planned)
1	Coefficient of inventive activity (number of domestic patent applications for inventions filed in Russia, per 10 thousand people)	units	2.01	1.59	2.8
2	Share of organizations engaged in technological innovation in the total number of organizations - total	percentage	7.9	21.6	25.0
3	Share of innovative goods, works, services in the total volume of exports of goods, works, services of industrial manufacturing organizations	percentage	4.5	5.2	15.0
4	Share of innovative goods, works, services in the total volume of shipped goods, works, services of industrial manufacturing organizations	percentage	4.9	6.1	25.0
5	The aggregate level of innovation activity of industrial manufacturing organizations (share of industrial manufacturing organizations implementing technological, organizational, and (or) marketing innovations in the total number of such organizations)	percentage	10.8	15.1	60.0
6	Domestic spending on research and development, the <i>share of GDP</i>	percentage	1.13	1.03	3.0

Negative trends are shown in orange and positive trends are shown in green.

* Source: [8] and the Decree of the Government of the Russian Federation of December 8, 2011, No. 2227-r On the Strategy for the Innovative Development of the Russian Federation for the period up to 2020.

The Strategy was designed to meet the challenges and threats faced by Russia in the field of innovative development that arise due to the outstripping growth of the global economy and increased

competition for intellectual and investment potential. Failure to achieve the key targets of the Strategy was caused both by the turbulence of the global economic system (financial crisis of 2009-2010, structural crisis of 2014) together with growing tensions in interstate relations and by possible inaccuracies in determining resource risks and target values. However, the main infrastructural goals of the Strategy were achieved. National reports on innovations in Russia (2011-2017) and relevant annual forums held by the Russian Venture Company, reflected the fact of the institutional development of the national innovation system and regional innovation systems in the Russian Federation. This situation allowed the transition from strategic planning "by areas" to state planning "by goals". In the Strategy for Scientific and Technological Development of the Russian Federation (Presidential Decree No. 642 of December 1, 2016), these goals and priorities were formulated in terms of "big challenges", one of which is: "... the need for effective development and use of territories, including by overcoming imbalances in their socio-economic development, as well as by strengthening Russia's position in the economic, scientific, and military development of ... the Arctic and the Antarctic".

The national innovation system and its regional parts need further scientific analysis and practical improvement. The provisions of the Strategy for Scientific and Technological Development and their implementation are specified by the tasks contained in the documents of the subsequent level of the strategic planning: programs [9]. The concept of "smart city" is widely introduced in the programs of digitalization of the urban economy in Russia [10]. On the agenda, there is a scientific and technological breakthrough and concentration of resources in certain promising areas, digitalization of the economy and the public sphere, artificial intelligence, big data, etc. The Russian government has announced a major reorganization in the system of Russian development institutions, in particular, their management will be concentrated on the platform "VEB.RF" [11].

Despite some problems, the Strategy gave a significant impetus to boost innovation activities in the Russian regions.

3.2. The regional level of the innovation system

Our previous study revealed, that together with the common problems of sustainable socio-economic development in Russia and abroad, Arctic has its specific challenges of sustainable development: geographical and climatic risks, vulnerable and difficult-to-renew ecosystems, a special social and ethnic way of life of northern peoples, the resource wealth of the Arctic [12]. The analysis of key social-economic indicators revealed positive achievements of Yamalo-Nenets and Chukotka autonomous areas (Russia), Yukon (Canada), Norway's Troms and Finnmark, and Sweden's Norrbotten County in regional sustainable development. The most balanced socio-economic development has been achieved in Iceland, and in the northern provinces of Norway and Sweden.

Arctic regions in different historical periods were developing extremely unevenly, both in terms of industrial, infrastructural development, and in the socio-economic development [13]. The asymmetry in the economic development of Russian regions began in the Soviet period of industrial development of the Arctic and increased further [14]. There are several reasons for the increasing asymmetry in the Arctic economy: differences in the distribution of production factors and the efficiency of their use [15]; strengthening of regional economic specialization [16]. Theoretically, this situation can induce innovative activities, but in practice it leads more often to the reduction in the economic efficiency and socio-economic degrading of territories [17, 18]. Differentiation by the level of economic development, specificity of the economic and social activities in the Arctic allows different typologization of the Arctic regions and cities.

In one of the typologizations of the Arctic regions, we divided them into industrial, raw material, and agricultural [19]. However, we revealed a high asymmetry of the socio-economic development within the regions, which makes the study of regions at the local level (cities and municipalities) more relevant. For example, despite the fact that Yamalo-Nenets autonomous area according to the suggested typology is a "raw material" region with high level of economic independence, its municipal districts Shuryshkarskiy, Priuralskiy, Krasnoselkupskiy, and their settlements remain

peripheral, agricultural, and economically underdeveloped (depressed) municipalities. The only industrially developed AZRF regions are Murmansk and Arkhangelsk. The majority of the Arctic territories are economically underdeveloped and agricultural.

The asymmetric development of the Arctic regions is a basic economic and socio-cultural factor, which should be considered in the theoretical assumption about the possibility of developing effective regional innovation systems in the AZRF.

The authors have analyzed the periods of developing and stagnation of innovation systems on the example of Yamalo-Nenets autonomous area (Yamalo-Nenets Autonomous Okrug, YNAO). The historical analysis of the developing regional innovation system (RIS), began in early 1990s, showed that this process was not homogeneous with several rises in 1998, 2005, and 2012. Each ascending trend was initiated by the political impulse, going from the federal center in a form of a specific regulatory document. In the 1990s, it was the decision to save the scientific and technological potential (Presidential Decree No. 426 of April 27, 1992). In the 2000s, the "Fundamentals of the Policy of the Russian Federation in the Development of Science and Technology for the period up to 2010" (approved by the President of the Russian Federation on March 30, 2002, No. Pr-576). In the 2010s, it was the Strategy for the Innovative Development of the Russian Federation for the period up to 2020. The impulses were implemented by the authorities and adopted by the regional community in socio-economical changes and brought certain results. In particular, in 1998, a regional law on innovation activity was passed in the YNAO [20].

In our previous research, we obtained the results, which remain relevant to this day and which substantiated the theoretical prerequisites for the development of the innovation systems in the Arctic region. We pointed out the most significant prerequisites: human potential, the presence of large companies in the territory, the initiated structural transformations [21, 22].

The studies conducted in 2004 - 2005 showed that YNAO has favorable conditions for creating and developing a regional innovation system, planned in the normative documents [23, 24].

The regional government responded positively to the results of the study: the law "On Innovation Activities" was significantly improved, a program for the development of innovative activities was adopted, financing was allocated, and the responsible executive body was designated.

The innovative development does not happen linearly: it has both rises and falls. The downturns in innovation development in Russia were determined by events significant for the country: the economic crisis of 1998, and in the 2000s, the global financial crisis of 2008. During the crises, financing of innovation programs was reduced, management bodies and organizations were optimized, and, as a result, the pace of the innovation development decreased.

The next impetus was given by the Strategy for the Innovative Development of the Russian Federation for the period up to 2020., The very fact of its development was of great importance and caused positive expectations in the regional community. With the mitigation of the consequences of the 2008 crisis and the economic recovery, the region revived the programs of the innovation activities, industrial and technological infrastructure development. Thus, in YANAO was gained quite a unique experience of creating an innovation system in the Arctic conditions [25].

Nevertheless, the nonlinear character of innovation development manifested itself again in 2014: revision of regional development priorities resulted in the reducing of financing of innovative development programs and elements of the regional innovation system.

The specific of the current period is in the absence of rising innovation development despite the strengthening of the federal agenda for the development of the scientific and technological potential of the country and digitalization of the economy. In this connection, as of 2020, the compliance of the Yamalo-Nenets Autonomous Okrug with the basic conditions necessary for the creation of a regional innovation system was updated.

The study of the scientific and educational system of the region in 2019 [26] noted the presence of only one university (regional branch) in YANAO with 700 students. The presence of large fuel and energy companies in the territory did not lead to the development of their research capabilities in the interests of the region, they eliminated technological departments in the territory and created closed

industry-specific innovation systems, using primarily external scientific and technological potential [27]. The existing information system do not provide the necessary inflow of knowledge to the region it remains to be investigated why the capabilities of the information sphere were not fully used. Although, one of the important research issues is to understand what the reduced demand for new knowledge and technology in society and management means [27]. According to statistical data, the level of mobility and education of the population remains high in Arctic regions in comparison with the southern regions. Nevertheless, small businesses occupy primarily service and low-tech niches (trade, transport, construction). Besides, entrepreneurs have a lack of competencies and opportunities to improve their businesses in these niches [28]. The YNAO economy is characterized by the dominance of corporations, state and municipal enterprises in settlements, and, therefore, a low level of competition in the regional economy. This situation explains the failure of the institutional activities and development programs launched in the 2000s which have not led to more effective economic structure. Organizations in the public sector of the economy do not introduce satisfactory innovative development, which may indicate a conservative institutional environment in the authorities.

Today regional innovation system of the YNAO has partially lost its characteristics of own creativity and intellectuality, demonstrate the increasing dependence on the import of technology and equipment from other regions, which, weakens the regional potential for sustainable development.

3.3. *The local level of the innovation system*

Regional innovative development are crucially influenced by the scientific, educational, and technological potential of cities. We distinct three models of local innovation systems: generating; developing; implementing [19]. Thus, according to our research, Murmansk, Apatity, and Arkhangelsk have "generating" model. 26 Arctic cities have conditions for implementing the "developing" model of regional innovation system. For the remaining settlements (734 settlements), "implementing" model of local innovation systems are relevant.

The Arctic city is a special category of settlements in Russia and should not be mixed with the concept of a northern city [29]. The Arctic city "is characterized by harsher climatic conditions, remoteness, life on the edge, on the frontier" [p.3 in 30]. The Arctic city is a set of social, economic, and cultural spaces and processes with pronounced specific characteristics (climate, remoteness, infrastructure), the elements of which are active social agents, communities, and institutions capable of ensuring their sustainable functioning and environmental safety. Within the framework of this study, the list of Arctic cities is determined by the fact of their location on the territory of the AZRF [31].

It is possible to improve the level and the quality of life in the Arctic cities through the development of technological entrepreneurship by stimulating activities of the residents of these cities themselves in business start-ups. There are at least 14 main directions to ensure a comprehensive approach to develop and improve the quality of life in the Arctic, which poses a huge set of tasks involving the search for new technologies: their generation, testing, and implementation [26].

Digitalization of the economy, implementation of the concept of "Smart City" provide new opportunities for the innovative development of the Arctic cities and their institutional and socio-cultural transformation [32].

The "smart city" standard stipulated the trend of innovative development of cities for the coming years [33-35]. According to the approach formed by the Ministry of Construction of Russia, "a smart city introduces and uses a set of advanced digital and engineering solutions and organizational measures aimed at achieving the highest possible efficiency of resource management and service provision, in order to create on its territory sustainable favorable conditions for living and staying, and the business activity of the present and future generations" [10]. This concept of "smart city" is congruent with the approach of Russian researchers [36], and corresponds to the European and international experience of creating smart cities [37].

The index of digitalization of urban economy "IQ of cities" was developed by the Ministry of Construction of Russia together with the The Lomonosov Moscow State University in the framework of the "Smart City" Standard. The IQ index of the efficiency of digital transformation of the urban

economy [38] is integral, based on several sub-indices of the directions of digital transformation. The directions of digital transformation are understood as the sections of the Standard, to which the directions are added to take into consideration the level of intelligent social services, the economic level and the level of investment activity. The IQ of the city means the level and effectiveness of digital transformation of the city participating in the implementation of the "Smart City" project, expressed in the efficiency of urban infrastructure. Cities are divided into four groups: the largest cities with a population of over 1 million people, large cities with a population from 0.4 to 1 million people, large cities with a population 0.1 - 0.4 million people, and administrative centers and pilot municipalities with the population of fewer than 0.1 million people.

In the YNAO, cities, involved in the "Smart City" project, include the administrative center Salekhard, the large cities of Novy Urengoy and Noyabrsk. The IQ level of the cities is presented in Table 3.

Table 3. IQ of the cities in the YNAO

Cities	2019, score	2018, score	Dynamics, score	Dynamics, %
Novy Urengoy	33.25	26.00	7.25	6%
Noyabrsk	32.34	28.85	3.49	3%
Salekhard	31.51	33.26	-1.75	-1%

In relation to other cities, the position of Yamal cities can be expressed through their place in the overall list. The YNAO smart cities are in the first third of the IQ list of all Russian smart cities. Thus, the leader among administrative centers is Dubna with 72.88 points. In the end of the IQ list is Snezhinsk with 20.88 points. The leader in the category of large cities is Shchelkovo with 74.00 points, in the end of the list is Salavat with 18.75 points. Therefore, the digital transformation in the Arctic cities has begun and further ranking will show the presence and effectiveness of local innovation systems necessary for producing and adaptation of digital technology.

To study the cities of the YNAO for the effectiveness of actual implementation of basic and additional requirements of the Standard by sections, directions, and activities, we conducted a survey of local governments of 7 cities of the YNAO: Salekhard, Labytnangi, Nadym, Novy Urengoy, Gubkinsky, Muravlenko, and Noyabrsk [19]. We analyzed "smart city" technologies according to four attributes: implemented, being implemented, planned, and unimplemented. A planned technology is not implemented but implies that the city is making efforts to implement it. An activity that is being implemented implies that the implementation of the technology has already begun, but its full completion may happen in the next year or in the medium or even long-term perspective, given the significant scale of some technological innovations. The Standard contains 8 sections, 28 directions, and 57 activities.

The results of the implementation of the Standard in the cities of the YNAO as of December, 2020 by sections are presented in Table 4.

Table 4. Results of the implementation of the Standard in the cities of the YNAO

Section	Implementation of activities (implemented and being implemented) in the cities of the YNAO, by sections (%)						
	Salekhard	Labytnangi	Nadym	Novy Urengoy	Gubkinsky	Muravlenko	Noyabrsk
City management	40	30	30	30	30	30	40
Smart utilities	27	0	18	36	27	9	36
Innovations for the urban environment	71	14	0	57	14	14	57

Smart city transport	53	24	24	41	24	12	36
Public safety systems	50	100	25	0	25	25	75
Environmental safety systems	0	0	0	0	25	0	0
Level of communication networks	0	0	0	100	0	0	0
Tourism and service	33	0	33	0	66	33	100

It was revealed that the Standard is implemented in all cities of the YNAO, including proactively in small ones, not included in the monitoring of the Ministry of Construction of Russia but the rate of the implementation in them is lower. Generalized results of the Standard implementation by the cities of the YNAO, calculated as the ratio of implemented and being implemented activities to the total number are presented in Table 5.

Table 5. Generalized results of the implementation of the Standard in the cities of the YNAO

Indicators	Salekhard	Labytnangi	Nadym	Novy Urengoy	Gubkinsky	Muravlenko	Noyabrsk
Implemented and being implemented, units	23	11	11	18	15	8	23
Share in the total number of activities	40.4%	19.3%	19.3%	31.6%	26.3%	14.0%	40.4%
Implemented, units	19	10	7	9	6	6	23
Share in the total number of activities	33.3%	17.5%	12.3%	15.8%	10.5%	10.5%	40.4%
Being implemented, units	4	1	4	9	9	2	0

The leader in the implementation of the Standard in the YNAO is Noyabrsk - it has the largest number of the implemented solutions. In addition, the city has outlined plans for the implementation of all other "smart city" technologies included in the Standard. Given the implemented technologies for the urban environment and urban transport, Noyabrsk is compared with Salekhard, and it become the second in the ranking of the implementation of "smart city" technologies. The third line is placed by Novy Urengoy. Taking into consideration those being implemented, 18 systems are operating in the city, but only 9 have been implemented, so Labytnangi is ahead of Novy Urengoy in this indicator. Gubkinsky, Nadym, and Muravlenko are next in the rating. The implementation of the "smart city" technologies varies from 40.4% to 14% of the planned quantity in Standard. Given the fact that the deadline for introducing most of the technologies is set for 2024, it can be assumed that Noyabrsk, Salekhard, and Novy Urengoy in the next four years will achieve high levels of implementation of the Standard.

The socio-cultural and intellectual potential becomes determinant for the development of innovation in the Arctic cities and implementation of the "smart city" standards, their advantage is the concentration of human potential, infrastructure, social and economic practices.

However, the lack of human potential can lead to non-systemic and ineffective digital transformation. The process must be accompanied by the development of effective local innovation systems. The low level of the scientific and educational potential or its absence in a particular settlement can be compensated by the functional and instrumental indicators of information interfaces of Industry 4.0. Modern communication capabilities of digital systems make it possible to build spatial collaborations that will provide a mobile and targeted sum of competencies necessary to develop local innovation systems. Functional completeness is achieved by communicating in a networked information space of synchronized data exchange in real-time with remote competency centers and centers of excellence. In this context, a fundamentally different approach to the design of spatial development is formed. Those who are located in the territory (the localized part of the team) should identify the problem, be able to describe it, formulate technical requirements and then the terms of reference to find agents who are able to offer the globally competitive technology. These may be competency centers and centers of excellence located in other territories. Then both parts of the team globalize the solution found.

4. Conclusion

The digital transformation of Arctic cities, based on the concept of "Smart City" should be accompanied by the developing effective local innovation systems capable of generating and implementing new knowledge and technology, performing smart digitalization of social and economic industries, sectors, and management areas, including through multi-agent territorially-distributed interaction.

The design and implementation of the innovative development in the Arctic regions and cities of Russia in the concept of "Smart City" seem advisable simultaneously with the involvement of the endemic population in the implementation of projects by creating communities in which competencies will be improved, experience and knowledge will be adopted, and subsequently, further technological development will be carried out. Thus, cities will create intelligent (technological) communities in the main areas of the smart city: housing and utilities, safety, transport, ecology, communications, management, etc. At that, the city's dependence on developers and contractors will be reduced, and it will have its own "smart" communities capable of solving modern technological problems. Improving the competencies of the population will contribute to the development of technological entrepreneurship, increasing employment, and the quality of life.

"Smart City" will continue to spread (adopt) technology in the nearest settlements of the region, thereby implementing the concept of "smart people - smart city - sustainable region", which is regarded not as total digitalization but as a focus on the priority development of the socio-cultural and intellectual potential of the population to form their ability to meet the current challenges and provide a decent future, forming the "Communities of the Future". The concept of "smart people - smart city - sustainable region" implies using a socio-cultural approach to the study and development of models of the Arctic cities in the AZRF, the search for reflexive and subject-oriented management systems in the Arctic cities and regions.

The obtained results can be considered in the developing the methodology of the socio-cultural and digital transformation of the Arctic cities; searching and developing technologies to create an environment favorable for living and to form a labor, cultural, leisure, innovative, and educational environment; and also developing adaptive management systems of migration, employment, and self-employment processes that increase the sustainability of the Arctic urban communities.

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