Human Capital in the Russian Arctic: Challenges and Responses

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The article deals with the issues of preservation and development of human capital in the Arctic. The results of studies on the influence of various natural and climatic factors characteristic of the northern regions on the functional systems of the body are presented. In the example of the city of Murmansk, the capital of the Russian Arctic, the method of statistical analysis of multidimensional images in the thermal infrared range of the city's territory is considered, which is used to zoning the natural and climatic factors of the Russian Arctic. According to the results of the study, three groups of Arctic regions of the Russian Federation were identified according to the prevailing diseases caused by natural and climatic factors.

Introduction

The strategic resources of the Arctic zone of the Russian Federation (AZRF) are not only natural resources, oil, gas, communications, sea and air routes, but also people: human capital (Lukin, 2014). In modern society, human capital is of great importance for the development of the economy and the state. Human capital is understood as a certain stock of health, knowledge, abilities, motivations, and habits formed as a result of investments and accumulated by people, which is used in the field of social production. In modern Russia, the situation with human capital is ambiguous. On the one hand, the majority of Russians in cities have or receive a good education, they have high consumer demands and requirements for the quality of life. On the other hand, the peculiarities of the national character, together with a high degree of bureaucracy and corruption in society, create serious obstacles to the development of human capital, which is the basis of a high-tech economy (Moskalenko, 2013; Govorova, 2018).

In the northern regions of the Russian Federation, a high migration activity of the population is currently preserved, and therefore, studies on the influence of geoecological (natural-climatic) features of the territory on the health of the population are very relevant. The purpose of this work was to study the influence of various natural and climatic factors characteristic of the northern regions on the functional systems of the body.

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Results and discussion

Climatic conditions have a huge impact on the quality of human life. The contribution of the weather and climate factor to the state of human health is about 20%, lifestyle is 50%, genetics about 20%, the level of health care about 10% (Eskov, 2004). However, under the conditions of the North and unfavorable technogenic impacts, this contribution can increase up to 30-40%.

Therefore, it is impossible to consider morbidity rates in the Arctic regions without analyzing the physical and geographical factors of the environment. Figure 1 shows the zoning of the territory according to the comfort of natural and climatic factors. This indicator is the result of a synthesis of the main climatic parameters, considered from the point of view of their comfort for human habitation.

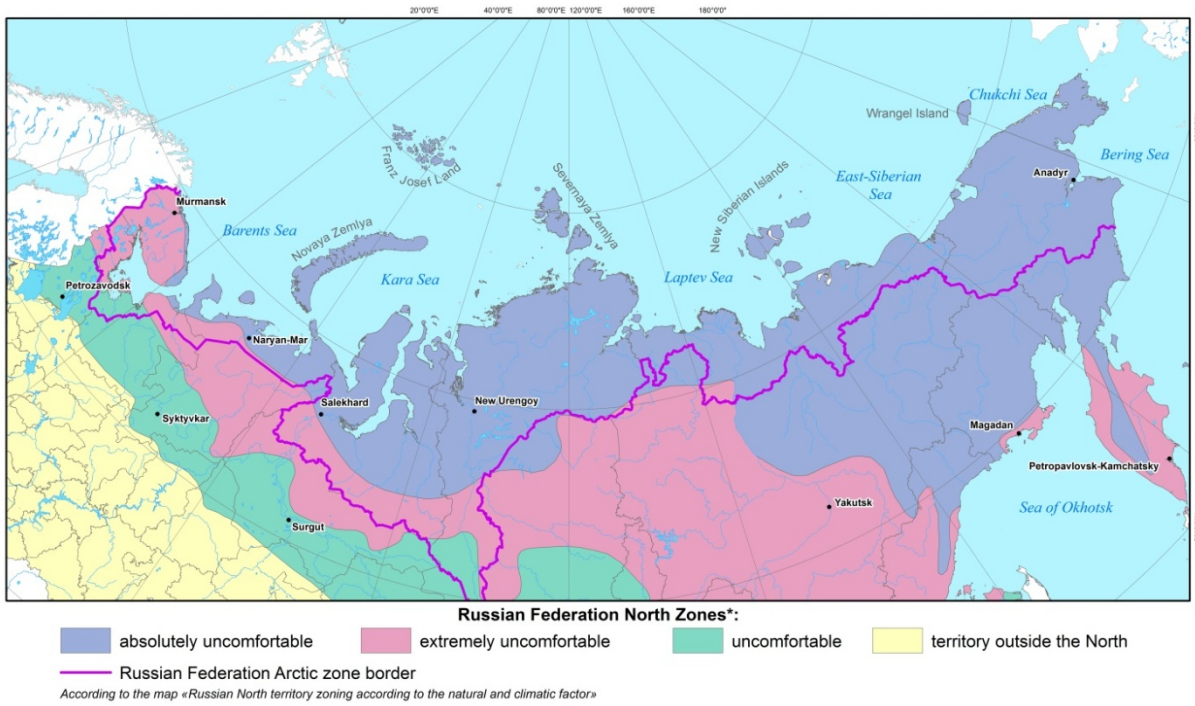


Figure 1. Zoning of the territory according to the comfort of natural and climatic factors

As can be seen on the map, 80% of the territory of the Arctic zone of the Russian Federation belongs to absolutely uncomfortable conditions. The Murmansk region and the Arkhangelsk region (its continental part) are characterized by extremely uncomfortable conditions for humans. And only two small areas in the south of the Arkhangelsk region and the north region of the Krasnoyarsk Territory (in the borders of the Arctic zone) are characterized by uncomfortable conditions.

A new and important stage of our work was the statistical analysis of long-term images in the thermal infrared range on the territory of the city of Murmansk, which can be used in the future zoning of natural and climatic factors in the Russian Arctic.

Murmansk, as we know, is a resource city in the Arctic zone of the Russian Federation, the world's largest ice-free Arctic port, the capital of the Arctic. The city is located in a territory characterized

by difficult natural conditions: sudden temperature changes, high humidity, complex wind conditions, short polar days and long polar nights. Every year, the technogenic load on the territory of the city increases, which ultimately provokes the development of various environmental problems on its territory.

The main sources of information for our study were images in the thermal infrared range obtained from the Landsat-8 imaging system. The spatial resolution of the images is 100 m.

Images in the thermal infrared range capture the intensity of thermal radiation of the underlying surface, which is measured in watts per square kilometer. Thus, thermal imaging data makes it possible to draw conclusions about which objects captured in the image radiate thermal energy more intensively, respectively, which objects are heated more.

32 images were selected for statistical analysis (from 2014 to 2020). They formed two sets of data. One characterizes the period of the year with positive temperatures, the second with negative ones.

After the formation of two data sets, all images were cropped along the border of the city of Murmansk, that is, all images have the same size and coverage. Each subsequent snapshot of the sample completely repeats the shape of the previous one. This is important because all static values are calculated using a regular network of equal-sized and geographically contiguous cells arranged in rows and columns.

Thus, when calculating the median within the boundaries of one cell of a regular network, all sample pixels are analyzed. As a result, the resulting raster is formed, in which each cell of the regular network (pixel) will correspond to the median calculated based on all sample values in a particular place in space.

The resulting rasters make it possible to draw conclusions about the main trends in the intensity of thermal radiation within the territory of the city of Murmansk. During the static analysis, the following value fields were calculated:

1. The minimum value of the intensity of thermal radiation;
2. The maximum value of the intensity of thermal radiation;
3. The median of the thermal radiation intensity, that is, the value that divides the ranked sample of the data set into two equal parts. Half of the sample values are less than the median, half are greater. Calculating the median reveals the central trends in a dataset.

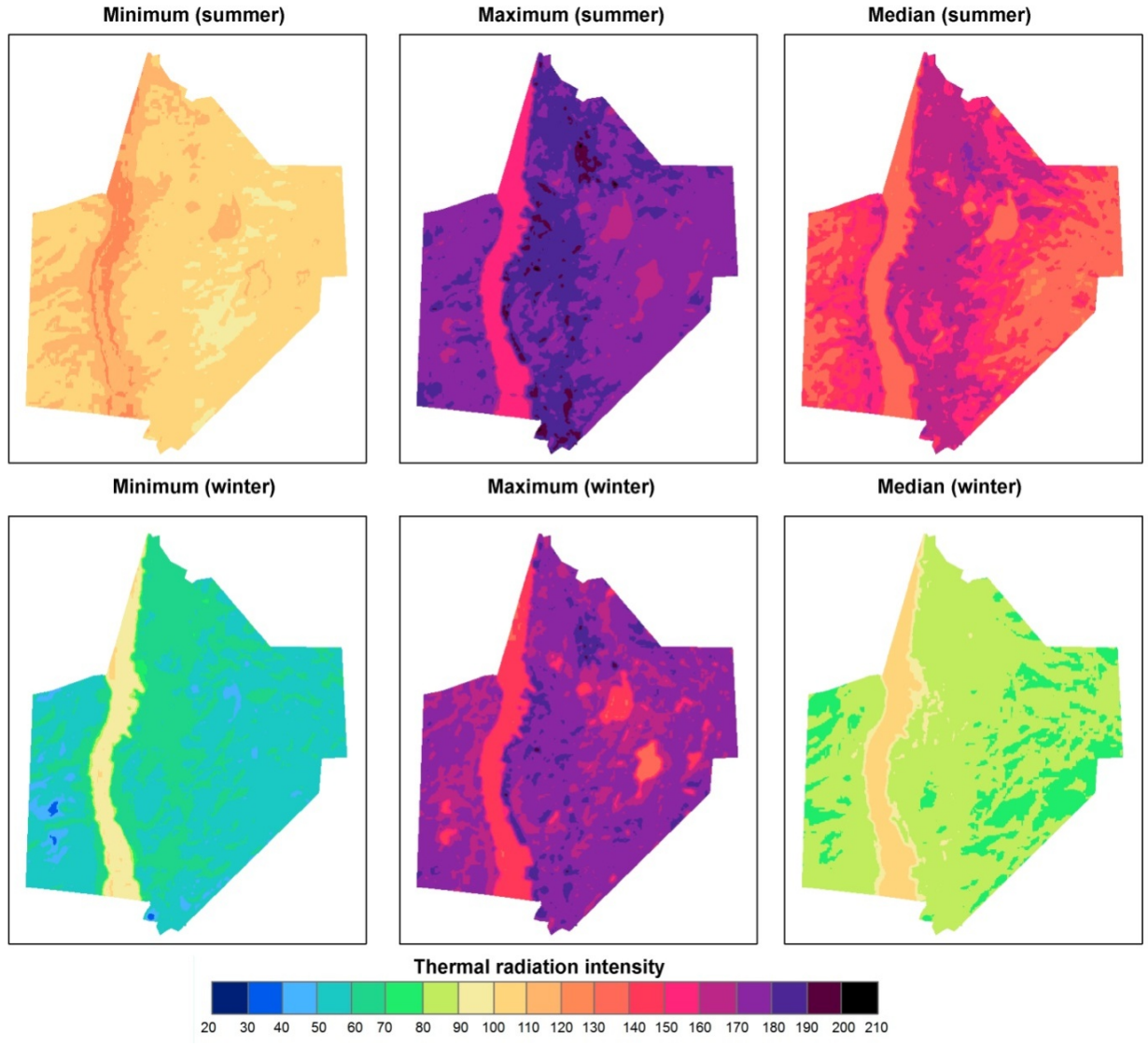
Table 1 shows the main results of the statistical analysis. Visualization of the calculation results of three value fields is shown in Figure 2.

Table 1. Characteristics of the results obtained

Index	Warm period	Cold period
Minimum	The minimum values correspond to forest vegetation, according to thermal images it is possible to divide the dense forest vegetation of slopes and interfluves, which is characterized by minimum values and more sparse vegetation of elevated areas.	The maximum values of thermal radiation are characteristic of the non-freezing Kola Bay. The thermal structure of the Kola Bay is homogeneous. Land lakes are no longer released, as they are covered

Index	Warm period	Cold period
	The maximum values of the sample correspond to water bodies, and the water of the Kola Bay has a higher intensity of thermal radiation than lakes within the city. Moreover, the resulting image shows the thermal structure of the Kola Bay (there is a decrease in the intensity of thermal radiation from north to south, a decrease in the intensity of thermal radiation from the coastal zone to the center of the bay is also clearly visible, which may be an indirect sign of the warming influence of port zones). Near the lakes, shallow waters of southern exposure are clearly distinguished, which are better warmed up by the sun. The lakes clearly distinguish shallow waters of the southern exposure, which are better warmed by the sun On the territory of the city, the warmest were Lake Quarrynoye and Srednye Lake. Urban development is characterized by average values of thermal radiation.	with ice and have a lower intensity of thermal radiation. Anthropogenic buildings are characterized by average values of the intensity of thermal radiation. On the resulting raster, geological structures (cracks) are clearly readable. The minimum values within the city correspond to the "Yellow Mountain" quarry in the deposit of boulder gravel sand material (this indirectly indicates that during the cold period of the year, work on the quarry is not carried out).
Maximum	The minimum values are the Kola Bay (without separation of the thermal structure of the water), slightly higher intensity of thermal radiation of the lakes. Anthropogenic buildings stand out brightly: residential and industrial buildings, a port zone. The most "hot spots" are the shopping center "Murmansk Mall", one of the workshops of the Murmansk fishing port, the Hipermarket "Tvoy", the 186th microdistrict (is an industrial zone).	The main trends of the warm season are repeated. The differences lie in the fact that the lakes and the Kola Bay are characterized by the same level of intensity of thermal radiation. The intensity of thermal radiation of anthropogenic buildings is lower than in the warm period. The hottest spots of the city in the cold period of the year correspond to the hot spots of the warm period.
Median	Not only anthropogenic buildings are clearly distinguished, but also the zone of influence of anthropogenic buildings. For example, in the north-eastern part of the city, "Languages" of increased intensity of thermal radiation are visible, and these "languages" stretch much to the east of the technogenic buildings. According to the authors, in this place there is a removal of air masses heated in the field of industrial production by cuttings under power lines and thalwegs outside the city.	The zone of influence of man-made buildings is not as clearly distinguished as on the raster obtained over the summer period, this is due to the fact that anthropogenic buildings are strongly emasculated in the cold period of the year and thermal contrasts between different buildings are no longer so visible, which indicates good thermal insulation of buildings and structures. The brightest technogenic object at this time of the year is the combined heat and power plant, located in the north-east of the city. The waters of the Kola Bay do not freeze due to the warm current. They have the maximum intensity of thermal radiation, against

Index	Warm period	Cold period
		the background of cooled anthropogenic buildings.



At the next stage, an assessment was made of the influence of natural climatic factors on the health of the population. Currently, there is a high migration activity of the population in the northern regions of the Russian Federation, and therefore studies on the impact of geoecological (natural and climatic) features of the territory on public health do not lose their relevance.

The natural and climatic factors characteristic of the northern territories include: low temperatures, frequent disturbances of the magnetic field, an increased content of toxic substances in environmental components, the polar day and the polar night.

As a result of the analysis of existing data, the influence of various natural and climatic factors characteristic of the northern regions on the functional systems of the body was shown (Table 2).

Table 2. The influence of geoecological (natural and climatic) factors of the territory, characteristic of the northern latitudes, on the human body

Functional system of the body	Natural and climatic factors	Effects on the body
Cardiovascular system	Cold period	Increased tonic tension of peripheral vessels, increased blood pressure, increased overall peripheral resistance, arterial hypertension, coronary heart disease may develop (Bashkatova, 2014)
Skin, respiratory system	Temperature differences at the exit from the room (+28...+30 °C) to frost (-35...–40 °C)	Such drops lead to spasm of the vessels of the skin and (reflexively) coronary vessels (neurovasculitis - damage to nerve endings and small blood vessels). With physical exertion in the cold, ischemic effects can occur, when it is necessary to strengthen the work of the heart, and the coronary vessels narrow from the cold. These drops are also very negative for the skin, which ages rapidly (wrinkles) due to capillary spasms and loss of elasticity. When a person leaves a warm and dry room, the dry frosty air of the street causes a spasm of the capillaries of the mucous membrane of the respiratory system (Bashkatova, 2014, Scafetta, 2007, Voets, 2004, Xie, 2001)
Respiratory system	Low indoor humidity	Erosion of the mucous tissue of the respiratory system, premature aging of the skin of the hands and face (Bashkatova, 2014)
Skin, vision	Reduction of total ozone in the atmosphere	Increase in the incidence of malignant neoplasms, especially with damage to the skin and retina of the eye (Dorshakova, 2004)
Respiratory system	Low temperatures	"Polar dyspnea" is associated with a change in alveolar ventilation and perfusion, impaired diffusion of gases through the alveolar membrane, morphological changes in the acinus (Aghajanyan, 1987, Anchugin 1988, Vlasov, 1992, Gerasimov, 2003, Popova, 2009)
The body as a whole	Frequent non-periodic perturbations of the geomagnetic field, which last from a few minutes to many hours	They act at the molecular and submolecular levels and lead to a special state of the body - polar stress syndrome (Bashkatova, 2014)
	Increased content of toxic substances in the Arctic and subarctic, where they are brought from other regions by sea currents	Chronic intoxication of the body (Degteva, 2004)
Metabolism	Extreme natural conditions	"Polar" ("Northern") metabolic type, in which the body moves to a qualitatively new level of homeostasis, characterized by greater use of fats and proteins for energy

Functional system of the body	Natural and climatic factors	Effects on the body
		needs and less use of carbohydrates (Avtsyn, 1985, Bashkatova, 2014, Kaznacheev, 1980, Panin, 2010, Sevostyanova, 2013, Khasnulin, 2013)
		Poor absorption of vitamins (Bashkatova, 2014)
Nervous system	Polar Day	Working capacity decreases, apathy appears, inadequate reactions, a feeling of anxiety and tension, depression occur. A person feels constant drowsiness. The fact that vision at this time transmits little information negatively affects the work of the brain. (Bashkatova, 2014)
	Polar Night	Increased mental activity, irritability, short temper, sound and light hypoesthesia, lability of mood and emotions (Khasnulin, 2013)

Analysis of national reports on the state of sanitary and epidemiological well-being of the population in the regions of the Arctic zone of the Russian Federation (State report 2017, 2018, 2019, 2020, Report, 2018) allows us to consider such indicators as the total incidence per 1000 inhabitants and the structure of the incidence of the population by risk groups.

From the histogram (Fig. 3) it can be seen that the highest indicator of the total incidence was recorded in the Republic of Komi, the Republic of Karelia and the Arkhangelsk Region.

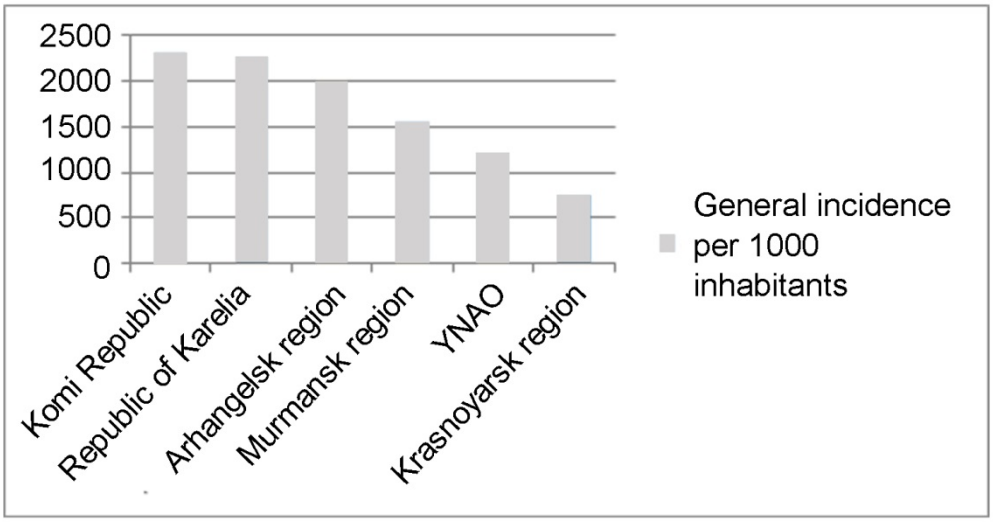


Figure 3. General morbidity of the population by region

The incidence of the population by risk groups was ranked in descending order of the number of cases per 1000 inhabitants. For the analysis, the first three groups of diseases were considered (Table 3). Table 3 shows a ranked list of three risk groups with the maximum number of cases per 1000 inhabitants by region. In general, from a list consisting of 16 groups of diseases (for which statistics are collected in the framework of reports on the state of health of the population), 4 groups of diseases and injuries are given. From this we can conclude that diseases of the respiratory system, diseases of the circulatory system, musculoskeletal system and connective tissue, diseases of the genitourinary system are characteristic for the regions under consideration.

Table 3. Groups of diseases with the highest number of cases per 1000 inhabitants

Region	Risk group by quantity cases per 1000 residents		
	1st place	2nd place	3rd place
Murmansk Oblast	Diseases of the circulatory system	Diseases of the musculoskeletal system and connective tissue	Respiratory diseases (including SARS and influenza)
Republic of Karelia	Respiratory diseases (including SARS and influenza)	Diseases of the circulatory system	Diseases of the musculoskeletal system and connective tissue
Archanel region	Respiratory diseases (including SARS and influenza)	Diseases of the circulatory system	Diseases of the musculoskeletal system and connective tissue
Komi Republic	Respiratory diseases (including SARS and influenza)	Diseases of the circulatory system	Diseases of the musculoskeletal system and connective system ткани
Yamalo-Nenets Autonomous Okrug	Respiratory diseases (including SARS and influenza)	Injury	Diseases of the genitourinary system
Krasnoyarsk Krai	Respiratory diseases (including SARS and influenza)	Injury	Diseases of the genitourinary system

The subjects of the Russian Federation under consideration can be clearly divided into three groups according to the prevailing diseases.

1. In the Murmansk region, the region with the most favorable climate (4th place in terms of total morbidity in the list), in the first place - diseases of the circulatory system, then diseases of the musculoskeletal system and connective tissue, and in third place - respiratory diseases (including ARVI and influenza).
2. When moving to the north (the Republic of Karelia) and to the east (Arkhangelsk region, the Komi Republic), with an increase in the continentality of the climate, respiratory diseases, including ARVI and influenza, come first, diseases of the circulatory system come in second place, and diseases of musculoskeletal tissue take the third place.
3. Even further east (Yamalo-Nenets Autonomous Okrug, Krasnoyarsk Territory) - respiratory diseases remain in the first place, injuries come in second place, and diseases of the genitourinary system come in third place.

Conclusion

The article deals with the issues of preservation and development of human capital in the Arctic. On the example of the city of Murmansk, a method of statistical analysis of multidimensional images in the thermal infrared range on the territory of the city is proposed, which can be used for zoning the natural and climatic factors of the regions of the Russian Arctic. As a result of research

on the influence of various natural and climatic factors on the functional systems of the body, the Russian Arctic regions were ranked according to the prevailing diseases. It was shown that the regions of the Russian Arctic can be clearly divided into three groups according to the types of prevailing diseases. The Arctic zone is a strategic territory of the Russian Federation in many respects, primarily as the main resource base. Therefore, it is imperative to provide the local population with everything necessary to maintain and improve health: a high level of medical care, prevention and social programs to help the population to ensure a decent standard of living.

The Arctic zone is a strategic territory of the Russian Federation in many respects, primarily as the main resource base. Do not forget that for any production and maintenance of infrastructure, people are needed. As The Doctor of Economics Prof. Viletta Gassiy (2022) notes in her interview to the correspondent of IA REGNUM, "The Arctic is alive as long as people live in it".

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