

Sustainable development of the northern regions and differentiation of the level of transport accessibility of building materials

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Abstract. The research focuses on the theory and practice of assessing the transport accessibility of the territories of the Northern regions, where the absence of year-round ground communications makes it impossible to compare and analyses them. The consideration of seasonal lines of communication is justified by the lack of alternatives in the regions of the North. The conducted analysis of the spatial pattern of the transportation network in the Republic of Sakha (Yakutia) revealed the heterogeneity in the transport accessibility of the municipal districts of the Republic. The results of analysing the level of differentiation of transport accessibility of municipal entities performed by various techniques show a diverse differentiation, which is influenced by the vastness of territories, the small number and very dispersed allocation of inhabited localities in the Arctic regions and a number of other factors. The developed methodological framework has features of a novelty, since it takes into account the presence of seasonal types of transportation lines in the Northern regions of the country and their logistical component that makes it possible to consider the specific features of transportation systems in the regions of the North to the fullest extent.

1 Introduction

In Russia, the full territory of 16 constituent entities and part of the territory of 11 constituent entities of the Russian Federation are attributed to the regions of the Far North and equated localities. The specific features of the territories of the Northern regions as represented by the internal regional differences in the transport accessibility of municipal districts impose the significant additional charges on various aspects of the social and economic activity of the region in terms of increase in the cost of production, capital construction, transport and living standards. The Republic of Sakha (Yakutia) is one of the largest and specific regions of the Russian Federation. Seasonal prevalence of transport operation continues to adversely affect the social and economic development of the Republic of Sakha (Yakutia).

The level of transport accessibility of a territory is primarily characterised by its transport availability, which represents the quantitative parameters of the presence and length of transportation lines. Among researchers, the issues of transport accessibility are considered

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from the standpoint of crucial factors in logistics chains [1–3], the development of the public transport network [4–5], and as a social indicator that determines the living standards [6–8].

The concept of transport accessibility of the territory is interrelated with many social and economic processes occurring in the region and is defined as an economic category. In other words, transport accessibility is a complex and comprehensive concept that includes the factors of economical, geographical, political and social nature. The need for a comparative assessment of transport accessibility in the Northern regions is conditioned by the complexity of the analysis of these territories by existing techniques due to the seasonal prevalence of operation of transportation lines.

Thus, in most of the techniques applied the transport accessibility is determined by the following characteristics:

- total time expenditures on moving for any purpose;
- economic or price affordability of transport services;
- transport mobility of population.

In this regard, it is proposed to assess the transport accessibility to the territories of municipal districts based on calculation of the weighted average expenditures of time and money for transportation of goods (commodities and materials) from transport hubs of the Republic of Sakha (Yakutia), which are the basic material supply points for provision and sustainment of population, to the inhabited localities of municipal districts in the region.

2 Materials and Methods

The papers of domestic and foreign scientists on the study of the spatial development of the economy, regional transport systems of the North and Siberia were taken as the theoretical and methodological framework for the research: A. Granberg, P. Minakir, S. Suspitsyn, N. Voroshilov, O. Pchelintsev and others, where the main approaches to the assessment of transport systems are formulated [9–15].

The informational background of the research is based on analytical and statistical data of Rosstat and its territorial divisions, data from ministries and governmental agencies. The normative acts, forecast, analytical, statistical and conceptual data contained in the scientific literature are analysed. Scientific methods of synthesis, systemic analysis, classification, mathematical statistics and economic analysis were applied.

The study of transportation systems of the Northern regions of Russia shows that only three regions of these (Nenets Autonomous District, Chukotka Autonomous District, the Republic of Sakha (Yakutia) have less than 30 % of hard-surface capital roads in the structure of lines of communication, most of the transport lines there are seasonal (waterways, winter roads), which have no alternative and therefore are yearly renewable (Figure 1). After analysing the main approaches to the analysis and assessment of transportation systems, which are employed, for example, in interregional differentiation [16–18], it was revealed that recent studies of domestic and foreign scientists and practitioners in the field of regional economics and transportation systems management disregard the features of the transportation system available in the regions of the North – the widespread use of temporary vehicle roads (winter roads). They are usually not considered in the case studies of transport availability, transport accessibility and transport opportunities of territories [19–20].

Table 1. Structure of lines of communication in the Northern regions of the Russian Federation, 2019.

	Inland waterways	Winter roads	Roads with a firm covering	Railways

Magadan region	21.8	3.4	74.8	0.0
The Republic of Komi	29.4	8.2	49.7	12.8
Sakhalin region	0.0	43.4	42.2	14.4
Khanty-Mansiysk Autonomous Okrug	43.1	8.1	41.4	7.4
Yamalo-Nenets Autonomous district	55.7	2.8	34.9	6.6
Nenets Autonomous district	50.1	13.2	36.7	0.0
Chukotka Autonomous region	0.0	60.3	39.7	0.0
The Republic of Sakha (Yakutia)	34.5	38.0	25.5	2.0

Despite the seasonal prevalence of operation (usable time is more than 8 months), winter roads can be attributed to regular (renewable) vehicle roads, some of which are categorised as regional roads. Ground road transport in the Arctic areas of the Republic is an important component of the provision and sustainment of population and development of the economy.

Severe natural and climatic, unfavorable economic and geographic, as well as difficult socio-economic conditions of the regions of the North-East are the factors, which form the high cost of population's life. All these per capita expenses vary widely region-wise and are objectively higher in the North.

Therefore, it is indisputable that the regional appreciation of the cost of living of the population in the North-East is much higher than it is indicated at an average across the entire North [21]. Multiple regional appreciation of the life activities of the population of the macroregion occurs as a result of high prices of food products, industrial consumption goods, higher cost of housing and communal services, medical, educational, cultural, construction and transport services (Figure 1).

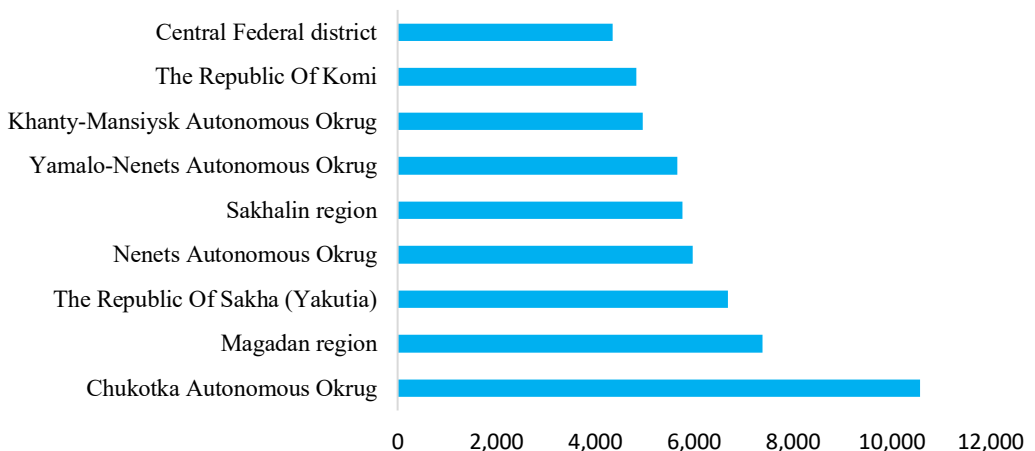


Fig. 1. Comparison of the cost of the minimum set of food products in the regions of the North of the Russian Federation, 2019.

In the conditions of the North, social and economic special features are mainly conditional upon the initial social and economic factors and unbiased difficulties of economic development of the territories.

3 Analysis of the level of differentiation of transport accessibility of municipal districts of the Republic of Sakha (Yakutia)

The integral index method is used to build a system of integrated coefficients of transport accessibility that affect the real increase in the cost of works (services) in the territories of municipal districts of the Republic of Sakha (Yakutia). This method allows one to identify and substantiate the specifics of differentiating the conditions for such works, depending on variations in the level of transport accessibility of the municipal district.

Due to the peculiar features of functioning of the transport system of Yakutia, the delivery of construction equipment, building and erection structures and materials, fuel, relocation of physical resources of organizations can take several calendar periods. In this regard, we calculated the weighted average composite logistics costs in the context of municipal districts. This calculation represents the differentiation of expenditures for the delivery of goods, and the largest values are achieved in the remote Northern and Arctic municipal districts of the Republic.

It is proposed to form a multi-criteria pattern that establishes a corrective coefficient for transport accessibility of the territories of municipal districts in the Republic of Sakha (Yakutia) and the real increase in the cost of repair and construction works of vehicle roads in the region, using the integral index method, which allows one to distinguish the conditions for such works depending on variation of the transport accessibility level:

$$K_{TA_i} = 1 + \frac{I_{kt.exp} + I_{ktlc}}{2}$$

where K_{TA_i} – corrective coefficient for differentiation of the transport accessibility level of the territory for each i -th base district.

$I_{kt.exp}$ – index of the standardized coefficient for differentiation of time expenditures for transportation within each i -th base district and the centre of the region, for the delivery of goods from the basic transport hubs of the Republic

I_{ktlc} – index of the standardized coefficient for differentiation of the level of transport and logistics expenditures for the delivery of goods for each i -th base district;

$$I_{kt.exp} = \frac{K_{t.exp_i} - \min(K_{t.exp_{i...n}})}{\max(K_{t.exp_{i...n}}) - \min(K_{t.exp_{i...n}})}$$

where $K_{t.exp_i}$ – coefficient for differentiation of time expenditures for transportation within the district and to the centre of the region, for the delivery of goods from the basic transport hubs of the Republic to each i -th base district:

$$K_{t.exp_i} = \frac{\sum_i^n (t_a \times l_a + t_b \times l_b)}{\sum_i^n (l_a + l_b)}$$

where n – number of inhabited localities in the municipal district under consideration;

l_a – distance of vehicle roads, taking into account the seasonal ground lines of communication from the district centre to the n -th inhabited locality of the i -th municipal district;

t_a – time expenditures associated with the delivery of goods by motor vehicle from the district centre to the n -th inhabited locality of the i -th municipal district;

l_b – distance of vehicle roads, taking into account the seasonal ground lines of communication from the basic transport hub of the region to the n-th inhabited locality of the i-th municipal district;

t_b is the time expenditures associated with the delivery of goods by motor vehicle from the n-th inhabited locality of the i-th municipal district to the basic transport hub of the region.

When calculating the time expenditures for movement within the municipal districts and to the basic transport hubs of the region, the average driving speed of heavy vehicle was used: on federal roads – 80 km/h; on regional roads – 40 km/h, on winter roads – 20 km/h.

The index of the standardized coefficient for differentiation of the level of transport and logistics expenditures for the delivery of goods for each i-th base district:

$$I_{k_{tlc}} = \frac{K_{tlc_i} - \min(K_{tlc_{i...n}})}{\max(K_{tlc_{i...n}}) - \min(K_{tlc_{i...n}})}$$

where K_{tlc_i} is the weighted average composite transport and logistics costs for the delivery of goods for each i-th base district;

$$K_{tlc_i} = (C_{tr\ i} + C_{st\ i} + C_{add\ i})$$

where $C_{tr\ i}$ is the cost of transportation of goods for the i-th mode of transport, rub/t;

$C_{st\ i}$ is the cost of storage of goods for the i-th mode of transport;

$C_{add\ i}$ are the additional costs for the delivery of goods for the i-th mode of transport (transshipment/pumping transfer, sorting, taring, etc.), rub/t.

Traditional traffic flow charts for the delivery of goods to the Republic have changed with the launch of railway to Nizhny Bestyakh town settlement in Megino-Kangalassky district in 2019. Thus, the municipal districts of the Republic of Sakha (Yakutia) can be divided into 3 groups in terms of adjoining to the basic entry transport hubs of the region: Berkakit railway station, Nizhniy Bestyakh railway station, Osetrovo river port. After all the constituent elements of the indices were determined, the scale of correction coefficients was calculated for the territory of the municipal districts of the Republic of Sakha (Yakutia), which represent the real increase in the cost of various works (services) within the region (Figure 2).

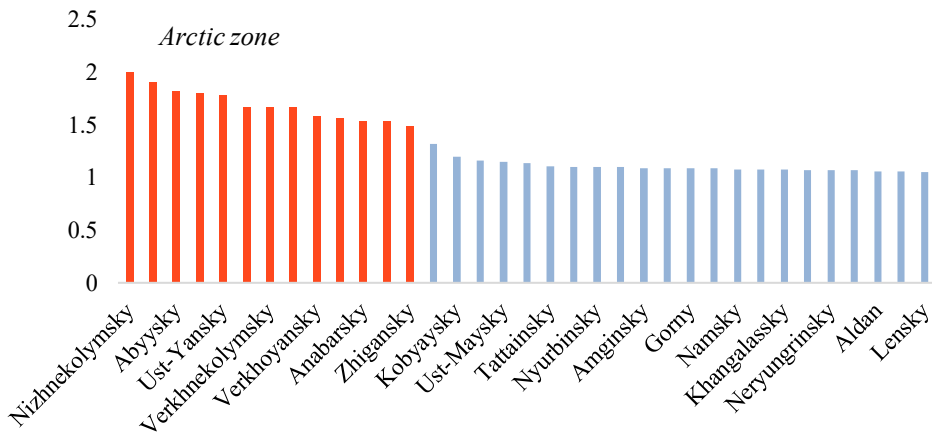


Fig. 2. The results of calculating the multi-criteria pattern of the correction coefficient for transport accessibility of the territories of the municipal districts of the Republic of Sakha (Yakutia).

Based on the valuation of transport and logistics costs, this technique allows one to consider the changes in the transport system affecting all stages of the transportation process. First of all, this is related to the progressive switching the volumes of deliveries of goods to

railway since 2019, which leads to essential changes in the workflow management of the entire transport system in the Republic of Sakha (Yakutia). As noted in studies [22–23], the construction of a bridge over the river Lena near Yakutsk, as well as the introduction of bridge crossings on regional vehicle roads will increase the importance of both the railway junction in Nizhny Bestyakh town settlement and the transport and logistics hub emerging here as the basic logistics centre, which ensures the year-round processing of the main freight traffic to the Central district of the Republic of Sakha (Yakutia). This will affect the storage terms of internavigational cargo stocks, and in some areas the year-round transport accessibility will be ensured.

4 Conclusion

The development of transport infrastructure of the regions of the North is of a complex nature. It depends on many factors and has a number of directions and peculiarities. Their identification and assessment require improvement of the existing methods and development of the new ones to ensure the objectiveness in evaluation of the effectiveness of its use, taking into account the current economic conditions.

Summarizing the results of the conducted spatial analysis of the transport system operation in the Republic of Sakha (Yakutia), it may be concluded that:

1. Analysis of the main approaches to the assessment of transport systems has revealed that the features of the transport system in the regions of the North – the use of temporary vehicle roads (winter roads) – are not considered in the case studies of transport availability, transport accessibility and transport opportunities of territories. The study of transport systems of the northern regions of Russia shows that among 27 subjects attributed to the regions of the Far North, in three regions (Nenets Autonomous District, Chukotka Autonomous District, Republic of Sakha (Yakutia)) more than 70% roads are seasonal ones (waterways, winter roads).

2. The conducted analysis of the spatial pattern of the transportation network in the Republic of Sakha (Yakutia) has revealed the heterogeneity in the transport accessibility of the municipal districts of the Republic. The results of analysing the level of differentiation of transport accessibility of municipal entities performed by various techniques show a diverse differentiation, which is influenced by the vastness of territories, the small number and strongly dispersed allocation of inhabited localities in the Arctic regions and a number of other factors.

3. Based on the conducted analysis of intraregional differentiation of transport accessibility of municipal districts of the region under consideration, the regional territorial zoning can be approved at the legislative level, taking into account the existing spatial differentiation.

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