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Local Transport Systems of the Russian Arctic (On the Example of the Primorskiy District of the Arkhangelsk Oblast)

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Abstract. The article discusses the concept of transport system with a focus on the local transport system, as well as its role in the socio-economic development of the Russian Arctic. The empirical study is based on the materials of expeditions that took place on the Summer and Winter shores of the Onega Peninsula, as well as on the island territories of the Primorskiy district of the Arkhangelsk Oblast. The local transport system was analyzed in terms of its elements: infrastructure, regulatory system, vehicles used, information support, informal institutional system of transport support regulation, etc. The materials obtained during the expedition were supplemented with data on the organization of transport communication, timetables, logistics, and official information on the methods of organizing navigation on the Northern Dvina River and in the White Sea. On the basis of the theory of multiscale and the analysis of empirical data, it is concluded that the local transport system is the main factor determining the scenarios of socio-economic development of municipalities in the Russian Arctic. Transport connectivity of the Arctic zone should start with transformations "from below", from the local transport system, taking into account local knowledge and institutions. Proposals for the development of the local transport network of the Arctic region are presented.
Keywords: *local transport system, infrastructure, transport accessibility, institutional regulation, Russian Arctic*

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Introduction

The transport industry is one of the most important sectors of the economy, connecting all elements of its territorial structure into a single system through the transfer of people, goods, information and energy. Transport plays a key role in the formation of economic and social space [1, Mezhevich N.M., Khaliev A.A., p. 74]. For this reason, the transport factor is an obligatory element of the local and regional paradigm as a condition for the sustainable development of territories.

The importance of transport is recognized in numerous works of foreign researchers [2, Chew J., p. 83; 3, Var T., Gunn C.; 4, Hall C.M.; 5, Inskeep E.; 6, Martin C.A., Witt S.F., p. 255; 7, Page S.J.; 8, Picard M.; 9, Rose H.]. Analysis of the role of transport is more widely considered from

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a spatial or geographical perspective [10, Burton R.; 11, Smith R.A., p. 304], less often — from an economic perspective [12, Prideaux B., p. 53].

In domestic scientific works, despite the recognized importance of the role of transport in socio-economic development, there is still no single concept of transport system. L.I. Vasilevskiy defines the transport system as all modes of transport and all links of the transport process in their interaction [13]. Consistency in volume, time and location of routes is identified by E.B. Alaev as the main characteristic of the transport system [14, p. 237].

In transport geography, the object of study is the territorial transport system, which is characterized by the presence of transport-geographical relations in territories with a similar level of transport development [15, Tarkhov S.A., Shlikhter S.B.]. Foreign researchers emphasize that the functions of the territorial system (among which the quality of life is considered to be primary) depend not only on the movement of goods through transport networks, but also on the characteristics of other technical infrastructure networks to ensure the functioning of material, energy and information flows. Therefore, a unified approach to all these technical networks is necessary for the design and operation of the territorial system [16, Smith S., p. 911]. The creation of sustainable infrastructure is essential [17, Llorca C. et al., p. 95] due to climate change.

The principle of multilevelness is fully applicable to transport systems (TSs): they are divided into country (national), which include all transport routes; regional, representing TS of subjects; local TS of several municipalities [18, Gafarova K.E., Osadchiy E.I., p. 53]. A.N. Privalovskiy, in addition to the above-mentioned TSs, identifies local TS of one administrative district and macroregional ones, uniting TSs of several subjects or federal districts [19, p. 7].

The local approach to the development of transport systems was first considered in Russian science in the dissertation of A.N. Privalovskiy. According to his definition, local transport systems are an integral part of regional transport systems and the general transport system of Russia [19, p. 7]. The researcher proposed his own typology of local transport systems based on the density of the road network: from a very high level of transport development in the central regions of Russia to the lack of land transport in remote areas.

Numerous works by N.Yu. Zamyatina and A.N. Pilyasov are devoted to the local transport system, which is described as “a highly specific, time-evolving combination of various modes of transport and actors in a specific administrative-territorial unit (usually the size of a municipal district), aimed at ensuring the mobility of passengers and goods”. The specificity of the local transport system in their interpretation is determined by the particular combination of transport modes involved. Scientists emphasize the need for constant technological, organizational and institutional renewal, search for solutions to ensure transport connectivity of the territory in the face of such challenges as sparse population, seasonality, lack of roads, using various tools — social networks, lawmaking, contrivance, non-standard ways of using modes of transport, etc. [20, p. 94]. Scientists identify the following elements included in the structure of the local transport system: transport infrastructure; vehicles used in the given territory; business entities; local produc-

tion base for transport development; communication and navigation system; system of information support and innovative development of transport; transport regulatory system; informal institutional system of transport regulation, including local value norms and behavioral attitudes; groups of consumers of local transport system services.

B.V. Nikitin, considering the local transport system (LTS) of the Kamchatka Krai, proposes his own typology, dividing LTS into two main types: with the predominant role of road transport and those located in the off-road zone, which is characterized by combinations of several types of transport: air, all-terrain, sea, river [21, p. 60].

In scientific works [22, Zamyatina N.Yu., Pilyasov A.N.], local transport systems of remote territories are often described as underdeveloped in comparison with the transport systems of central Russia. In this article, we follow the approach "from below", in which the process of transport development takes into account the important features of local transport systems "in their deviation from the average statistical ranking" [23, Pilyasov A.N., Zamyatina N.Yu., p. 58]. The approach "from above" is based on national-scale projects, which are often poorly consistent with the needs of the local population.

The "from below" approach, taking into account the principle of a multi-level transport system, is consistent with the principle of glocality, which means the end-to-end balancing of the approach "from above" and the approach from communities "from below" in the most important issues of territory development. The principle of glocality connects external expert and local knowledge [24, Pilyasov A.N., Zamyatina N.Yu., p. 10].

Scientists emphasize in their works on the local transport system that the territories of the North and the Arctic need a special model of transport arrangement due to their specificity, in which lack of roads is an essential part, and not a negatively perceived phenomenon, as happens in the central regions of Russia, characterized by a fairly high degree of transport development.

To determine the features and significance of the local transport system of Primorskiy district — one of the territories included in the Arctic zone of the Russian Federation — the materials of field research conducted in 2022 were used.

Geography and research methods

The LTS study was carried out using the example of the Primorskiy district of the Arkhangelsk Oblast. The Primorskiy district is located in the northwestern part of the Arkhangelsk Oblast, occupies the lower reaches of the Northern Dvina, its delta, as well as the coast of the White Sea — the Summer and the Winter coasts on an area of 46.1 thousand km^2, on which 215 settlements are located. The permanent population of the district as of January 1, 2023 was 28.7 thousand people, the entire population is rural. The population density is 0.6 people per 1 km^2, which is more than three times lower than the average rural population density in the Russian Federation. The district is part of the Arctic zone of the Russian Federation.

Economic activities in this area are typical for rural areas: fish farming and fishing, agriculture, logging and construction activities, housing and communal services, tourism and trade [1].

The study on the territory of the Primorskiy district of the Arkhangelsk Oblast was carried out in July–August 2022. During trips to the islands of the Northern Dvina River delta and the White Sea coast, data on how the LTS is organized "on the ground" was collected.

The Primorskiy district is characterized by researchers as quite favorable in terms of assessing transport and communication problems and transport discrimination of the population, which is described as the inaccessibility of a socially guaranteed minimum due to the insufficient development of the transport system. The level of transport discrimination is measured by the standard time it takes to reach any point via a single transport network from a given settlement. However, in the Primorskiy district, transport conditions are radically different in regional centers and on the periphery, where both freight and passenger traffic show a significant deterioration in accessibility and quality [25, Tutygin A.G., Chizhova L.A., Lovdin E.N., p. 170].

Some settlements of the Primorskiy district are classified as hard-to-reach. The regulatory acts of the Arkhangelsk Oblast define hard-to-reach areas as areas from which there is no pedestrian accessibility to the administrative center during the working day for all residents of the area [2]. One of the characteristics of a hard-to-reach territory is the underdevelopment of transport infrastructure.

Data collection was carried out taking into account the theory of multiscale, the main feature of which is the consideration of the interaction of scales of different levels. While the overview scale requires the analysis of statistics and literature sources, the medium scale is based on statistical data and surveys of regions, the large scale relies on interviews that take into account local characteristics [26, Goncharov R.V., Pilyasov A.N., Zamyatina N.Yu.]. In accordance with this theory, sociological and anthropological research methods such as expert and in-depth interviews are considered the most relevant, making it possible to identify the full range of standard and unique practices in the use of transport by the population [26]. During field research, over 40 polystructured interviews were conducted with residents of the listed villages in the Primorskiy district. In our research we also rely on the "way from below", which corresponds to the principle of glocality, i.e. we study characteristic areas with all local features as typological samples.

[1] Strategiya sotsial'no-ekonomicheskogo razvitiya munitsipal'nogo obrazovaniya «Primorskiy munitsipal'nyy rayon» do 2030 goda [Strategy for the socio-economic development of the municipal formation "Primorsky Municipal District" until 2030]. URL: https://www.primadm.ru/upload/economy/Strategia_2030.pdf (accessed 17 May 2023).

[2] Zakon Arkhangel'skoy oblasti ot 9.09.2004 g. № 825 «O perechnyakh trudnodostupnykh mestnostey na territorii Arkhangel'skoy Oblasti» [Law of the Arkhangelsk Oblast of September 9, 2004 No. 825 "On the lists of hard-to-reach areas on the territory of the Arkhangelsk Oblast"]. URL: http://docs.cntd.ru/docu (accessed 17 November 2022).

The materials obtained during the expedition were supplemented with data on the organization of transport communications, schedules, logistics, and official information on the methods of organizing navigation on the Northern Dvina River and in the White Sea.

Local transport system of the Primorskiy district

The analysis of the local transport system was carried out on the basis of the theory of importance of the LTS role put forward by N.Yu. Zamyatina and A.N. Pilyasov, taking into account the elements included in the structure of the local transport system [20, p. 94].

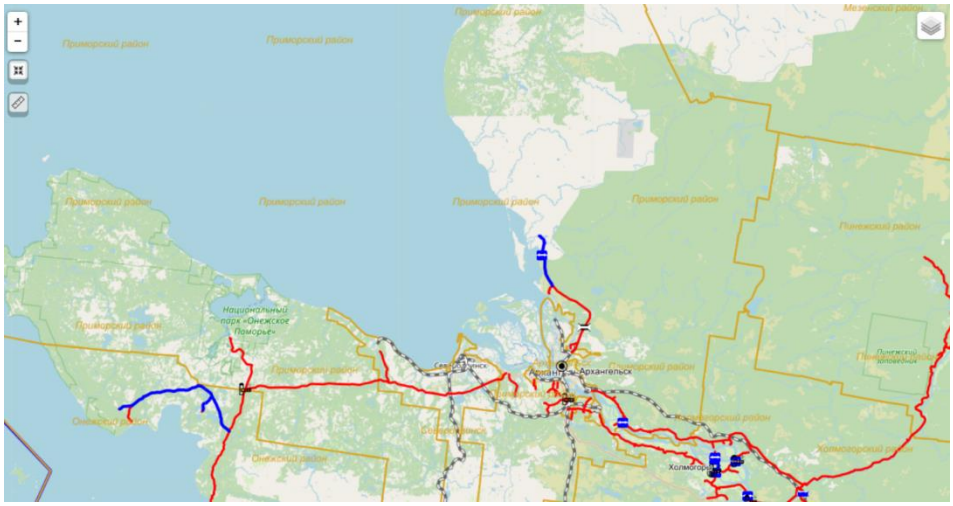

Fig. 1. Map of roads and railways in the Primorskiy district [3]. Red color on the map indicates motor roads, blue color — winter roads.

The transport infrastructure of the Primorskiy district is represented by air, road and sea/river transport. Most of the railway tracks passing through the territory of the Primorskiy district belong to the Arkhangelsk branch of the Northern Railway, but there are also narrow-gauge tracks and timber tracks. The island and coastal territories of the district, which are included in the off-road zone (see Fig. 1), are remote from railway stations of the Arkhangelsk Oblast.

One of the main positive factors influencing the development of the road transport system is the geographical location of the district. The Primorskiy district is directly adjacent to the regional center — Arkhangelsk, and two large cities of the region: Severodvinsk, Novodvinsk, which is characterized by the presence of regional roads and the federal highway M-8 “Arkhangelsk – Kholmogory – Moscow”. Table 1 presents the types of LTS in the Primorskiy district: LTS with a predominant role of road transport and LTS in off-road zones.

Table 1

Types of LTS in the Primorsky district [4]

Type of LTS	Settlements
A. LTS with a predominant role of road transport	
A1. “Entrance Gate”	Arkhangelsk agglomeration (railway, M-8 highway), Talagi/Vaskovo airport
A2. Highway settlements	Izhma, Una, Luda, Rikasikha, Laiskiy Dok, Maloe

[3] Road map of the Road Agency “Arkhangelskavtodor”. URL: https://www.ador.ru/roads.shtml (accessed 17 May 2023).
[4] Source: compiled by the author based on the typology of B.V. Nikitin.

	Toinokurye, etc.
A4. Settlements along departmental roads	Settlements near Severalmaz deposits
A5. Isolated highway settlements (located in close proximity to roads, but separated from them by a river)	Verkhovye, Kushkushara, Gorka, Dom Invalidov, etc.
B. LTS of the off-road zone	
B1. Settlements with seasonal land communication (winter road)	Patrakeevka, etc.
B2-2. Remote settlements on the sea coast	Villages: Pushlakhta, Letnyaya Zolotitsa, Letniy Navolok, Lopshenga, Yarenga, Pertominsk, etc.
B2-3. Remote settlements on rivers	Verkhnyaya Zolotitsa, Nizhnyaya Zolotitsa, Kuya, etc.
B3. Island territories	Villages: Pustosh, Vyselki, Odinochka, Voznesenie, Andrianovo, etc.

The “Strategy for the socio-economic development of the municipal formation “Primorskiy Municipal District” until 2030” [5] notes that the transport system, due to the lack of road communication between some municipalities of the region and the administrative center, cannot fully provide for the population, production and economic development. Figure 2 shows the length of highways in the Primorskiy district with 5-year intervals for 2007, 2012, 2017 and 2022. As the statistical data demonstrate, the length of roads has not increased over 15 years, but roads with hard and improved surfaces (cement concrete, asphalt concrete and asphalt concrete types, crushed stone and gravel, treated with binders) have decreased.

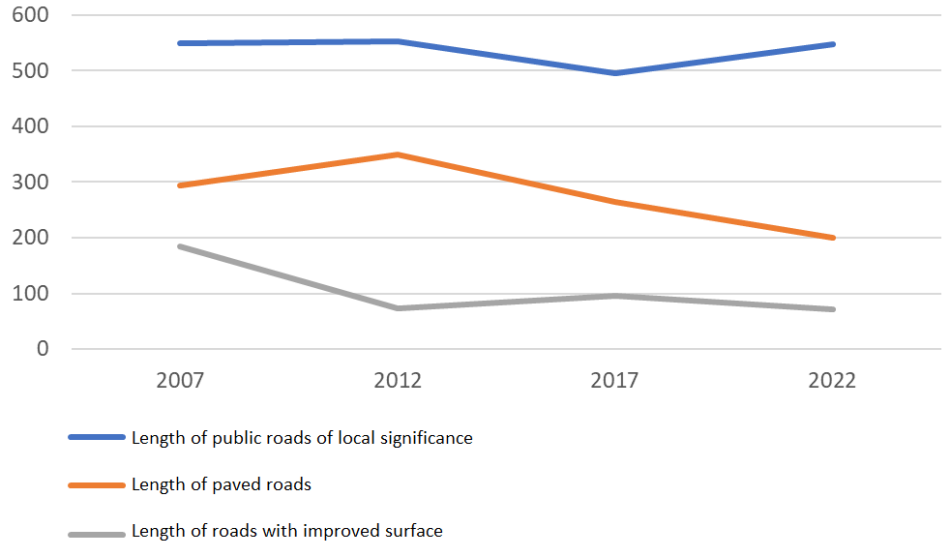

Fig. 2. Length of motor roads in the Primorskiy district, 2007–2022 [6]

There are many island territories in the Primorskiy district, which are connected by water transport during the navigation period [7]. In winter, transport and pedestrian ice crossings are cre-

[5] Reshenie Sobraniya deputatov munitsipal'nogo obrazovaniya «Primorskiy munitsipal'nyy rayon» ot 25 iyunya 2015 g. N 156 «2015 strategiya sotsial'no-ekonomicheskogo razvitiya munitsipal'nogo obrazovaniya "Primorskiy munitsipal'nyy rayon" do 2030 goda» [Decision of the Meeting of Deputies of the municipal formation "Primorsky Municipal District" dated June 25, 2015 N 156 “2015 strategy for the socio-economic development of the municipal formation "Primorsky Municipal District" until 2030”]. URL: http://municipal.garant.ru/#/document/168765844 (accessed 17 May 2023).

[6] Federal State Statistics Service: passport of the municipal district. URL: https://rosstat.gov.ru/scripts/db_inet2/passport/pass.aspx?base=munst11&r=11652000 (accessed 17 September 2023).

ated annually for residents of the island territories. According to information from the Main Directorate of the Ministry of Emergency Situations for the Arkhangelsk Oblast, there were 5 pedestrian and 7 transport ice crossings in the Primorskiy district in 2023.

It is noted that there is practically no infrastructure for water transport in the Arkhangelsk Oblast: 47% of berths do not meet safety requirements [8]. As a result, passengers are often transported in violation of the rules. Thus, in summer, the populated areas of the Summer Coast of the White Sea can be reached through Cape Zayatskiy. There is no berth for small vessels on the cape; a rusty barge pulled ashore is used as a landmark. The local population uses high rubber boots called "brodni" to land on a shore, to which a small-sized vessel cannot approach closely due to insufficient depth. Crews of small vessels carry passengers unprepared for such disembarkation on their backs to the shore.

Transport regulatory system. Regulatory documents emphasize the need for state support for the transport sector: maintaining state regulation of tariffs for passenger and luggage transportation by all types of transport; maintaining the practice of budget financing of lost revenues resulting from state regulation of tariffs for passenger and luggage transportation by all types of transport [9]. From the perspective of LTS development, one can highlight such aspects as repair of roads and bridges, renewal of the vehicle fleet (passenger buses and river boats); development of air and inland water transport in order to provide transport services to remote and hard-to-reach areas of the Arkhangelsk Oblast.

The state program of the Arkhangelsk Oblast "Development of the transport system of the Arkhangelsk Oblast" justifies the provision of subsidies to the budgets of municipal districts of the Arkhangelsk Oblast to co-finance activities for the construction and acquisition of river vessels. In addition, compensation for lost income arising from the transportation of passengers and baggage by air, including to settlements located on the White Sea coast, is subsidized. It should be noted that, in our opinion, these measures are aimed at maintaining the functioning of the LTS, but not at its development.

Vehicles used in the area. The local transport system of the Primorskiy district is characterized by multimodality. The model of transport multimodality in the study areas reflects the uniqueness of remote areas with low population density: it is a combination of locally specific, often seasonal, "small" modes of transport (all-terrain vehicles, snowmobiles, cars) with "long-distance" modes of transport that are neutral in relation to the characteristics of the local space (railroads, airplanes, etc.) [22, Zamyatina N.Yu., Pilyasov A.N.]. In addition, the most important feature of the development of the transport system is the widespread use of seasonal ice crossings; river and sea transport is becoming essential, and the role of air transport is increasing. Sea-

[7] Ibid.
[8] Gosudarstvennaya programma Arkhangel'skoy oblasti «Razvitie transportnoy sistemy Arkhangel'skoy oblasti» [State program of the Arkhangelsk Oblast "Development of the transport system of the Arkhangelsk Oblast"]. URL: https://dvinaland.ru/budget/programs/18 (accessed 17 May 2023).
[9] Ibid.

sonal routes are of critical importance. At the same time, LTS with a predominant role of road transport differs significantly from LTS of off-road zones, which tends to increase: the share of the population living in settlements that do not have regular bus and (or) railway communication with the administrative municipal center or urban district in the total population of the Primorskiy district increased from 17 to 20% in the period of 2012–2022 [10].

Thus, in order to get to the settlements of the Summer Coast of the White Sea in summer, local residents have to change several types of transport: a car to Cape Zayatskiy, a private boat across the Unskaya Bay, a taxi or a private car to Arkhangelsk in Luda village. This method is the most expensive, but at the same time it does not limit the transportation of luggage so much. In winter, when crossing the Unskaya Bay on the ice of the White Sea, residents use their cars, swamp vehicles, karakats, and snowmobiles. Therefore, the delivery of large cargo to coastal villages is mostly done in winter using their own transport. Almost every family has motor boats, snowmobiles, swamp vehicles and other transport equipment. This is confirmed by data from the Main Directorate of the Ministry of emergency situations for the Arkhangelsk Oblast: the number of small vessels in the Primorskiy district increased from 3437 in 2018 to 3528 vessels in 2022.

Sea transportation of passengers on the territory of coastal settlements is carried out on vessels of outdated projects, which have exhausted their service life [11]. For example, the motor ship “Belomorye” carries passengers to the White Sea coast once a fortnight in summer. The ship makes only three stops in settlements located on the White Sea coast, and residents of other villages do not consider the ship as a means of transport to get home from the administrative center of the Arkhangelsk Oblast. One of the reasons is the limited transportation of large cargo (building materials, furniture, etc.). According to local residents, until the early 2000s, a barge of a fishing collective farm was used to transport passengers and cargo from Luda village to Zayatskiy Cape. After the vessel exhausted its resource, a new one did not appear. The population of the island territories located at the mouth of the Northern Dvina River has to hire a private barge for an additional fee. *“Previously, it was convenient with (the motor ships) “Balkhash” or “Kommunar”, because they were quite capacious ships. Besides, its fore body is completely open and one could easily transport a sofa, for example... But now, if it is a sofa or a bed, we realize that it won’t fit through the openings unless it’s in boxes. That’s why you have to order this barge for a certain time. It floats for a very long time.”*

The only year-round mode of transport to the White Sea coast is small aviation. Passenger transportation by air is carried out by OJSC “The Second Arkhangelsk United Aviation Division”. Airports that take small-engine planes and helicopters are located in the villages of Verkhnyaya

[10] Passport of the municipal formation “Primorskiy Municipal District”. URL: https://rosstat.gov.ru/scripts/db_inet2/passport/ (accessed 17 August 2023).
[11] Gosudarstvennaya programma Arkhangel'skoy oblasti «Razvitie transportnoy sistemy Arkhangel'skoy oblasti» [State program of the Arkhangelsk Oblast “Development of the transport system of the Arkhangelsk Oblast”]. URL: https://dvinaland.ru/budget/programs/18 (accessed 17 May 2023).

Zolotitsa, Lopshenga and Pertominsk. Low prices and availability of air travel are due to subsidies from regional authorities. However, the downside of air travel is the strict baggage restrictions.

Settlements on the White Sea coast can be classified as settlements with no alternative land transport, especially during winter and thaw, which lasts from the day when navigation along the river officially stops until the formation of ice crossings, and in the spring it can last from two weeks to two months. Due to snow drifts and the snow removal tractors breaking down, traffic on the only road to the airport on the Summer Coast may be stopped, and traffic through the Unskaya Bay may be cut off in the season of slush spring thaws. At the same time, replacing one type of transport with another may be complicated by difficult weather conditions.

It should be noted that the transport sector is one of the industries most exposed to climate change risks, which are observed both in the Arkhangelsk Oblast and globally. In particular, ice formation occurs at later dates, ice is less durable [27, Grishchenko I.V.]. Extreme climatic phenomena such as fog, heavy rainfall, hazardous snowfall and blizzards, which have become more intense in recent years, can have a wide range of impacts on transport infrastructure and services. In particular, they may cause the cancellation of flights and vessels.

Interview respondents noted the impact of hydrometeorological conditions on their mobility. In conversations with residents, it was often possible to hear similar stories about how regular flights of motor vessels were cancelled due to wind, storm or fog, but people found out about it when they were already at the berth.

Economic entities. Sea transportation of passengers to coastal settlements in the Primorskiy district is carried out by LLC “Shipping Company ‘Arcticraid’”, as well as individual entrepreneurs. The main river transport carrier is JSC Arkhangelsk River Port [12]. Air transportation is carried out by OJSC “The Second Arkhangelsk United Aviation Division”. Thus, LTS unites mainly private companies, as well as divisions of government organizations.

The number of small business entities has a positive trend in the Primorskiy district and a clear upward trend in the municipal region, with 30% accounting for retail trade [13]. However, there is a tendency towards a decrease in the number of retail trade facilities (Fig. 3), the reason for which may be both a general decrease in population and unprofitability.

In order to deliver goods to island villages, shop owners have to use several logistics chains using different types of land transport [28, Kuznetsova S.Yu., Nenasheva M.V.]. The complexity of logistics chains and possible supply interruptions cause a sharp rise in transportation costs. Thus, the cost of transportation on ice crossings requires expenses for their arrangement and maintenance, and in some cases, for the use of adapted transport. Transportation by river is cheaper, but requires transshipment bases, which leads to additional costs and slows down the movement of

[12] Strategiya sotsial'no-ekonomicheskogo razvitiya munitsipal'nogo obrazovaniya «Primorskiy munitsipal'nyy rayon» do 2030 goda [Strategy for the socio-economic development of the municipal formation “Primorsky Municipal District” until 2030]. URL: https://www.primadm.ru/upload/economy/Strategia_2030.pdf (accessed 17 May 2023).
[13] Economy. URL: www.primadm.ru/economy/ (accessed 17 August 2023).

goods [29, Goncharov R.V., Zamyatina N.Yu., Pilyasov A.N.]. Thus, the remoteness and inaccessibility of territories increases the cost of products and goods.

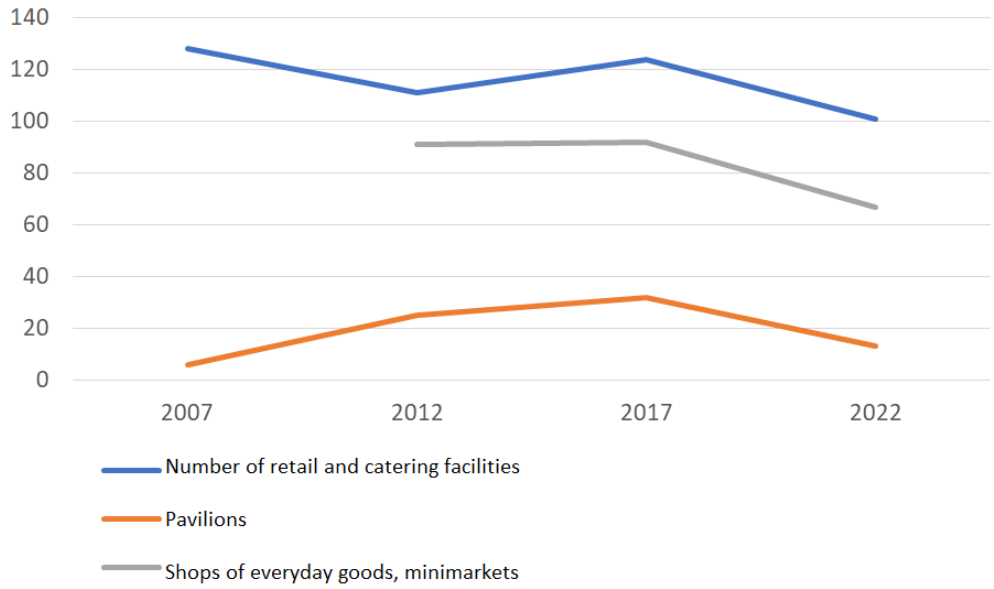

Fig. 3. Number of retail trade facilities in the Primorskiy district, 2007–2022 [14]

Communication and navigation systems are rather limited. In particular, only one mobile operator is available on the White Sea coast. However, if power grids are not functioning due to repair work or cables are broken due to storm winds, the population may be left without mobile communications.

Navigation conditions are provided by the port of Arkhangelsk at the mouth of the Northern Dvina River. However, navigation along the White Sea, for example, in Unskaya Bay, is often ensured by the local population: the channel is marked with high branches with reflective elements to ensure movement in the dark. Movement on sea ice during the freeze-up period, despite the increasing role of government agencies (Ministry of emergency situations and the National Park) in ensuring safety, is started by the local population independently by laying ice roads, taking into account the knowledge and experience of previous generations.

The information support system is based on traditional means of communication. From the respondents' stories, we learned that when planning mobility, local residents receive basic information about hydrometeorological conditions from official sources such as radio, television and the Internet. However, informal leaders and local activists of territorial public self-government can play an important role in it. They often take on the function of informing about flight cancellations and repair work, using social networks and the so-called "word of mouth".

Innovative transport development can also be initiated from below. For example, in Arkhangelsk, small-sized all-terrain vehicles, popularly called "motor dogs", were invented and

[14] Federal State Statistics Service: passport of the municipal district. URL: https://rosstat.gov.ru/scripts/db_inet2/passport/pass.aspx?base=munst11&r=11652000 (accessed 17 September 2023).

are now being produced. A craftsman in the village of Bereznik, Arkhangelsk Oblast, collects "karakats", which are buoyant and are in demand among the population.

The informal institutional system of transport regulation includes local values and behavior, which, according to the results of field research, are characterized by a high level of mutual assistance and willingness to help in the process of ensuring traffic [22, Zamyatina N.Yu., Pilyasov A.N.]: *"You won't be left in trouble, even if they drive by, they'll still pick you up somewhere, drop you off."* The need to survive and overcome disruptions in transport provision determines the possibility of the existence of informal economic relations and the readiness of local communities to quickly become involved in them: *"Our bay was almost frozen. You know, we still have men from Pertominsk going here (to Yarenga) on boats to collect cargo. They were already caught by the ice, but they had to be taken out so that our store wouldn't be left empty."*

Consumer groups of local transport system services include business entities, tourists, as well as local residents who were born and raised in these settlements. Local residents have deep knowledge of local features, natural phenomena and weather. However, their long-term residence has formed their habits of reduced comfort during transportation and an unclear sense of danger. Thus, local residents begin to cross the channel between the islands as soon as some ice cover is formed, risking their lives: *"Those who are not afraid are the first to cross the bay in winter, without a care in the world, well, and then no one cares anymore, that's it, let's go."*

Interpretation of results

During the study, we came to the conclusion that LTS is one of the factors determining the socio-economic development of local communities. In particular, the features of the LTS of the off-road zone listed above may determine the fact that the overall coefficient of natural increase (decrease) of the population in the Primorskiy district decreased from positive indicators of 0.3 ppm in 2017 to negative indicators of -6.4 ppm in 2022. The number of residents of working age and under working age is decreasing, while the percentage of pensioners is increasing[15].

The local transport system should become the basis for the development of strategic documents for the development of regions and federal infrastructure. We have formulated recommendations that can help to consider the components of LTS, taking into account the "bottlenecks" identified during the study, while, from our point of view, the approaches to LTS with a predominant role of road transport and LTS of off-road areas should be different.

Recommendations for LTS with a predominant role of road transport:

- ensuring stable functioning of highways: analysis of Russian and foreign experience for the effective selection of types of road surfaces most suitable for local conditions, construction of bridges;
- maintaining public transport routes, considering opportunities to increase subsidies;

[15] Passport of the municipal formation "Primorskiy Municipal District". URL: https://rosstat.gov.ru/scripts/db_inet2/passport/ (accessed 17 August 2023).

- creation of mini-hubs at points of multimodal change of LTS transport modes, as, for example, occurs at Cape Zayatskiy in Unskaya Bay, where road transport is replaced by small vessels;
- development of infrastructure on the highways (gas stations, mini-hotels/guest houses), including for the expansion of first aid facilities.

Recommendations for LTS of off-road areas:

- launching barges or large vessels on regular routes to ensure the delivery of large cargo to remote settlements on the sea coast, which can also serve as passenger ships;
- development of snowmobile trails: infrastructure, traffic safety, and regulations;
- ensuring affordable air travel: subsidizing routes, improving airport infrastructure;
- development of river transport: use of various models of vessels, taking into account local specifics, including off-season ones: snowmobiles, hovercraft, etc.;
- supporting the use of different modes of transport in different seasons: use of not only all-season land modes of transport, but also a combination of several modes of transport (including off-road ones, invented taking into account local specifics);
- attracting youth and students to invent and use new technologies, simplifying the legalization of off-road vehicles as a result of invention. The introduction of such vehicles will also support small businesses in the territories.

Further mechanisms for LTS development could also include informing the transport community about the importance of innovative approaches and the methods that can be used, reducing management and communication barriers that hinder cooperation between stakeholders, increasing funding for planning and implementation of necessary measures, engaging regional level management to provide clarity on policy direction, developing partnerships at the local level with a focus on the importance of “from below” development. The transport system should be studied locally, including observations about the uniqueness of transport infrastructure in each location.

Climate change should also be taken into account. Key indicators demonstrate that the climate continues to change, and incoming data on socioeconomic impacts emphasize the vulnerability of the population to weather and climate events due to potential damage. The potential impacts of climate change need to be considered when planning the development of local transport systems, modes of transport used and their all-season nature, road surface types and other aspects.

Thus, the transport connectivity of the Arctic zone should begin with transformations “from below”, with a local transport system taking into account local knowledge and institutions.

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