

Assessment of infrastructure provision of coastal territories of Lake Baikal for the development of tourism in the winter season



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Abstract The article examines the development of winter and ice-snow tourism as an important direction of ecological tourism in the coastal areas of Lake Baikal. It analyzes modern trends and challenges related to this type of tourism in Russia, including insufficient infrastructure and the environmental risks associated with unregulated use of natural resources. The authors propose a methodology for assessing the level of infrastructure provision of coastal areas of Lake Baikal for the development of tourism in the winter season to improve planning efficiency. This approach is based on a two-layer index system to comprehensively assess tourism infrastructure. The study evaluated the infrastructure supporting winter tourism in the coastal areas of Lake Baikal within the Republic of Buryatia, covering five municipalities: Barguzinsky, Kabansky, Pribaikalsky, Severo-Baikalsky districts, and the city of Severobaikalsk. The findings indicate that these municipalities have medium to low levels of infrastructure development. This deficiency restricts safe and comfortable recreation opportunities, which are critical for the sustainable growth of winter tourism. Given the increasing demand for winter and ice-snow tourism products in the Baikal region, there is a pressing need to develop strategies and programs aimed at improving infrastructure. These efforts must balance environmental preservation with meeting tourist expectations.

Keywords: lake baikal, winter and ice-snow tourism, infrastructure provision, Republic of Buryatia, Russia

1. Introduction

Modern trends in the development of the tourism market indicate the growing popularity and high demand for winter tourism (Wall, 2020). Particularly noteworthy is the growing importance of ice and snow tourism (ice and snow tourism) as a type of winter ecological tourism, which combines types of tourist activities on the basis of the use of natural resources of ice and snow (An et al., 2021, Liu et al., 2018). Significant experience in the development of winter and ice/snow tourism has accumulated in Northeast China, where it is considered a new tourism trend caused by global climate change and growing interest in a healthy lifestyle (Zhou, 2024).

The development of winter tourism solves the problem of seasonal asymmetry, which is one of the most acute in the tourism industry and reduces profitability, the efficiency of using fixed assets, and staff turnover. Winter tourism can also make a significant contribution by diversifying the local economy and creating jobs, which will help combat poverty and promote the sustainable development of territories (An et al., 2021, Martirosyan et al., 2024).

Successful examples of winter tourism and recreation development are common in countries with abundant snow cover and long winters: Scandinavian countries, Switzerland, Austria, Iceland, Canada, Finland, China, etc. (Jensen & Gyimóthy, 2020; Wang, 2010; Zhou, 2024; Karacabey et al., 2024; Bausch & Gartner, 2020). In Russia, in recent years, there has also been a significant expansion of types of tourist activities using natural ice and snow, including activities such as ice skating, snowmobiling, dog sledding, and cultural and sporting events. Winter tourism in Russia is traditionally associated with the construction of ice towns, ice fishing, skiing and hiking, and various entertainments using snow. This fact indicates the emergence of a new subspecies of winter recreation, "ice and snow tourism", which is considered a type of ecotourism that uses natural ice and snow (Budaeva et al., 2024).

An analysis of the scientific literature demonstrates the unevenness of research in the field of winter tourism and ice and snow tourism from researchers of winter recreation in Russia and the post-Soviet space. Considerable attention has been focused on ski tourism, highlighting the considerable potential of other types of winter tourism based on the use of ice and snow. The characteristics of ski resorts are presented (Otto & Tankova, 2014, Kochkorbaeva & Umarov, 2022), and project proposals for the development of ski resort infrastructure are highlighted (Mekhbaliev, 2010). Particular attention has been given to the study of sustainable tourism development in the Arctic zone of Russia. The concept of developing coastal Arctic settlements on the basis of the principles of the "blue" economy (the economy of marine nature management and coastal



zones (Potravny, 2021)) is considered, and the main concepts and resource potential, including infrastructure, opportunities and threats to the development of various types of tourism in the Arctic, are systematically analyzed (Lukin, 2016; Podshuveit et al., 2024). Existing studies by Russian scientists on the use of ice and snow for tourism purposes have focused mainly on the issues of creating ice sculptures and architectural structures (Mubarakshina & Salyakhova, 2018).

Modern trends in tourism development in Russia indicate a significant increase in tourist interest in winter Baikal, which is due to the diversity of landscapes, natural attractions, and a variety of activities, such as winter fishing or ice skating on the lake. Baikal ice is the basis of tourist activities (Beloborodova, 2007), and the initiative to create a zone on Baikal demonstrating "green" and low-carbon tourism in winter, including ice and snow activities, is especially relevant within the framework of the China–Mongolia–Russia economic corridor program (Yangutova et al., 2023).

2. Problem formulation

An analysis of the dynamics of the number of persons accommodated in collective accommodation facilities (CAF) in the Republic of Buryatia in the winter season (from January to March) from 2019 to 2023 revealed steady growth, with the number increasing from 44.8 thousand people in 2019 to 92.5 thousand people in 2023 (Figure 1). The share of those accommodated in CAF in the winter season increased from 11% in 2019 to 16.4% in 2023.

As the ice surface of Lake Baikal is drawn into tourism, the problem of chaotic and unregulated recreational use of the water body is becoming more acute, which can cause negative consequences for both the ecological state of Lake Baikal and the local population. Thus, the widespread tradition of "Kiss of Baikal", which involves drilling a hole in the ice of the lake and drinking strong alcohol from it, has caused indignation and serious concern among the public of Buryatia about the unregulated recreational use of Lake Baikal. According to E.V. Aigina, the accelerated development of tourism on Baikal in recent years has led to negative manifestations of overtourism, especially in the difficult winter season (Aigina, 2022).

The development of winter tourism in Baikal faces the problem of a shortage of year-round recreational infrastructure, which, in most cases, is due to the insufficient development of engineering and public utility infrastructure. Thus, tour operators note that "the number of people who want to come exceeds the number of rooms that are currently available on winter Baikal" (Zhilkina, 2024). For safe travel to an icy surface, specialized transport is necessary. Despite the dynamic development of winter transport services, tour operators note the insufficient supply and, as a result, the high cost of this type of service. Under these conditions, assessments of the infrastructure provision of winter and ice and snow tourism are especially relevant.

The development of ice and snow tourism places significant importance on the level of infrastructure support for tourist destinations. According to Peter Murphy, Mark P. Pritchard, and Brock Smith, the destination environment and its service infrastructure become integral to the traveler's overall perception of trip quality (Murphy et al., 2000).

In the process of conducting tourist activities, both general regional and specific tourist infrastructures are utilized. The general infrastructure includes airports, roads, electricity and gas supplies, etc. The specific tourist infrastructure encompasses collective accommodations, tourist attractions, tourist information centers, etc. (Morozov & Morozova, 2021).

The level, use, or lack of infrastructure and technology at a destination are visible features of developed and underdeveloped tourism products that can influence visitors' trip experience (Choy, 1992; Johnson & Edwards, 1994).

Basic tourism infrastructure is the basis for the creation and operation of tourist facilities and is necessary for the provision of publicly accessible services (Maksanova & Dagdanova, 2016). Researchers highlight the multifaceted nature of the problem of developing tourism infrastructure, as well as regional disproportions in its development in the territory of Russia (Morozov & Morozova, 2021). For Lake Baikal, studies indicate that the weak development of tourism, including winter tourism, is a consequence of the insufficient amount of year-round functioning recreational infrastructure and underdeveloped engineering and public utility infrastructure (Belov et al., 1993; Evstropeva et al., 2022; Zabortseva, 2018).

In general, the analysis of literary sources shows that despite the relevance of studying tourism infrastructure, the methodological aspects of assessing the infrastructure provision of territories for tourism development in the winter season remain insufficiently studied.

3. Research area

As the object of our study, we chose the coastal areas of Lake Baikal within the borders of the Republic of Buryatia, which is a subject of the Russian Federation within the most remote federal district of the country, the Far East (Figure 2).

Lake Baikal is a unique phenomenon on Earth with ancient origins, unique flora and fauna, and exceptional water properties. In terms of area, the lake is among the largest lakes in the world (eighth place), and in terms of depth, it is no greater than - 1,637 m. Its bowl contains 20% of the world's fresh surface water. Lake Baikal and its coastal territory are UNESCO World Heritage Sites. In accordance with Article 2 of the Federal Law "On the Protection of Lake Baikal", the boundaries of the Baikal Natural Territory (BNT) are established, and three zones are distinguished: central (CEZ), buffer and ecological zones of atmospheric influence.

Tourism development on Lake Baikal in winter directly depends on favorable climatic conditions and stable ice cover. The climatic features of Lake Baikal allow us to distinguish it "as a region distinguished by oceanic features - milder winters and

cooler summers compared with the surrounding areas” (Galaziy, 1979). Lake Baikal, unlike other large lakes in Russia (Ladoga, Onega, Teletskoye), freezes completely every year, gradually becoming covered with ice from north to south. The ice cover is usually very transparent (Shimaraev et al., 1994), which makes the area significantly attractive for tourism in the winter season. Freezing usually begins in early January (Galaziy, 1993), with the ice thickness reaching its maximum by the end of March (70–115 cm on average over the water area) (Berkin, 2009). The strength and thickness of the ice cover allow us to organize annual ice roads used to deliver goods to coastal settlements. This, in turn, supports the local economy and promotes the development of infrastructure for tourism in the winter season.

The coastal areas of Lake Baikal within the borders of the Republic of Buryatia include the territories of five municipalities: Barguzinsky, Kabansky, Pribaikalsky, Severo-Baikalsky districts and the city of Severobaikalsk (Figure 2). Notably, the territories located in the CEZ BNT are experiencing significant restrictions on economic activity and are characterized by a steady decline in population (Mikheeva et al., 2016). Thus, the population of coastal settlements of Lake Baikal located in the CEZ BNT in the territory of the Republic of Buryatia decreased from 77.2 thousand people in 2014 to 72.1 thousand in 2022. In some settlements, the population decreased by 40–30% during this season (Zorino and Khatun village of Barguzinsky district, Zolotoy Klyuch settlement of Pribaikalsky district of the Republic of Buryatia). Experts largely associate the migration outflow with the ban on industrial omul fishing and the tightening of living conditions in the Central Economic Zone of the Baikal Natural Territory. Under these conditions, the development of ice and snow tourism as a type of ecotourism is particularly relevant. Unique natural features, picturesqueness and diversity of coastal landscapes, species diversity and endemism of flora and fauna provide high tourist value for Lake Baikal and its coasts.

4. Methodology

This research builds an infrastructure provision for the development of tourism in the winter season index system with two layers: a target layer and an indication layer, as shown in Table 1. The index system consists of two layers, a target layer and an indicator layer, as shown in Table 1. It includes three targets (collective accommodation facilities (CAF), communal infrastructure, and the environment) and six indicators to provide a comprehensive quantitative assessment of infrastructure provision for winter tourism development. The CAF indicators include five specific metrics characterizing the general network placement (e.g., the share of CAF as a percentage of the total number of CAF in the coastal areas of the Republic of Buryatia) and an indicator reflecting CAF suitability for winter tourism (e.g., the share of year-round CAF as a percentage of the total number of CAF). The communal infrastructure indicators assess the state of housing stock improvement in terms of sewerage and heating, enabling an evaluation of the territory's readiness for winter tourism development. The environmental indicators are particularly significant for the study area because of the strict ecological restrictions on economic activities imposed by Lake Baikal's special environmental status.

The selected indicators align with established frameworks for tourism infrastructure assessment (e.g., Maksanova & Dagdanova, 2016; Morozov & Morozova, 2021) and address critical dimensions of winter tourism:

- CAF indicators: Reflect capacity and year-round readiness (essential for seasonal demand).
- Communal infrastructure indicators: These indicators directly impact tourist safety and comfort (e.g., heating in winter).
- Environment indicators: Ensures compliance with Baikal's ecological regulations (Zabortseva, 2018).

We used the aggregation function to assign aggregate values to the contributions of the corresponding decision variables to determine the overall area score.

We start by making a data matrix:

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix}, \quad (1)$$

where:

- x_{ij} - the value of sample (i) of the j th assessment indicator in matrix X ;
- m – number of territories;
- n – number of indicators.

4.1. Step 1: Standardization

To eliminate scale differences, each indicator was normalized via min–max scaling:

$$x'_{ij} = \frac{x_{ij} - x_{j \max}}{x_{j \max} - x_{j \min}}, \quad (2)$$

where:

- $x_{j \max}$ and $x_{j \min}$ are the maximum and minimum values of indicator j , respectively;
- x'_{ij} is the standardized value, ranging from 0 to 1.

4.2. Step 2: Target-level scores

The aggregate scores for each target (I_{1i}, I_{2i}, I_{3i}) were calculated as follows:

$$\begin{cases} I_{1i} = x'_{1i} + x'_{2i}, \\ I_{2i} = x'_{3i} + x'_{4i}, \\ I_{3i} = x'_{5i} + x'_{6i}, \end{cases} \quad (3)$$

where:

I_{1i} – scores of the i -th territory for the target CAF;

I_{2i} – scores of the i -th territory for the target communal infrastructure;

I_{3i} – scores of the i -th territory for the target environment.

4.3. Step 3: Comprehensive score

The comprehensive assessment of the infrastructure provision for winter tourism development (I_i) for each territory is the sum of the target-level scores:

$$I_i = I_{1i} + I_{2i} + I_{3i}. \quad (4)$$

4.4. Step 4: Classification

The resulting estimates allow us to evaluate the infrastructure provision for the development of tourism in the winter season on the basis of the developed scale of the infrastructure development level: high, medium and low (Table 2).

The data sources used for the assessment included materials from the Federal State Statistics Service of Russia and the Federal Service for Supervision of Natural Resources in the Republic of Buryatia.

The methodology we propose has some differences from those suggested in other studies on this topic. Our methodology employs multicriteria aggregation, similar to the Tourism Infrastructure Index (TII) (Morozov & Morozova, 2021). However, unlike TII, it incorporates environmental indicators and utilizes standardization through min–max scaling (TII uses z scores), which reduces sensitivity to outliers. The winter tourism readiness index (WTRI) (An et al., 2021) is more focused on assessing infrastructure related to ice and snow (e.g., snowmobile trails). In contrast, our evaluation covers a broader range of communal services (e.g., sewage, heating), which allows it to be scaled for nonskiing winter tourism (e.g., ice festivals). Like our methodology, the ecotourism infrastructure assessment (EIS) (Zaborceva, 2018) takes environmental indicators into account. However, unlike EIS, which relies on qualitative evaluations, our approach uses quantitative aggregation, enabling direct comparisons. Additionally, the two-layer structure (target + indicator) simplifies the prioritization of policy measures.

5. Results and Discussion

According to official statistics, the largest number of accommodation facilities in 2023 on the coast of Lake Baikal in the Republic of Buryatia is located in the Kabansky District (92 accommodation facilities or 40.9% of the total number of accommodation facilities in the coastal areas of the Republic of Buryatia), and the smallest number is located in Severobaikalsk (17 accommodation facilities or 7.6%, respectively) (Figure 3).

Moreover, in the Severobaikalsk and Severobaikalsky district, almost all facilities (99.9% and 90.9%, respectively) operate year-round. In other districts, the share of year-round accommodation facilities is significantly lower: in the Barguzinsky and Kabansky districts, it is 42.9% and 38%, respectively; in the Pribaikalsky district, it is 33.9% (Figure 4).

The grade-level security communal infrastructure was carried out on the basis of two indicators: “proportion of the area of the housing stock equipped with water disposal (sewage)” and “proportion of the area of the housing stock equipped with heating.” The highest level of sewerage provision in 2023 was determined in Severobaikalsk (approximately 100%), followed by the Kabansky and Severo-Baikalsky districts (47.7% and 45.1%, respectively), the Pribaikalsky district (26.3%) and the lowest level in Barguzinsky district (Figure 5).

In terms of heating provisions, Severobaikalsk is in first place at 100%, followed by the Kabansky and Pribaikalsky districts at 62.3% and 55.4%, Severobaikalsky district at 49.2%, and the lowest level is in Barguzinsky district at 18.2% (Figure 6).

The assessment of the coastal areas of Lake Baikal for the third objective “Environment” included an assessment of two indicators. The first, the share of recycled and neutralized production and consumption waste, allows us to assess the development of the waste management system in the area. The data indicate a low level of utilization and disposal of production and consumption waste in the coastal areas of Lake Baikal. The maximum value in the Severo-Baikalsky District was 2.2% of the total volume of waste generated (Figure 7).

The second indicator allows an assessment of the degree of development of the system for capturing and neutralizing air pollutants. The assessment revealed that the level of emission purification is significantly different and varies from 0 to 90.1% of the total amount of air pollutants emitted. The best indicator in the Kabansky district was 90.1% (Figure 8).

We calculated the assessment scores of municipalities for each indicator and assessments of infrastructure provision for the three goals in accordance with Formulas 2 and 3 (Figure 9). On the basis of the obtained assessments, we calculated the comprehensive scores of infrastructure provision for tourism development in winter for each municipality of the Republic of Buryatia in the coastal territory of Lake Baikal. The results are shown in Figure 10. In accordance with the obtained total scores, the municipalities were classified into three levels: high, medium and low levels of infrastructure provision.

The results of our assessment reveal significant disparities in infrastructure provision across the coastal municipalities of Lake Baikal in the Republic of Buryatia. Notably, none of the studied areas achieved a "high" level of infrastructure readiness for winter tourism, with the Severobaikalsk, Kabansky, and Severo-Baikalsky districts classified as "medium," whereas the Barguzinsky and Pribaikalsky districts scored "low." These findings align with broader trends observed in remote and ecologically sensitive regions, where infrastructure development often lags behind tourism demand due to environmental restrictions and economic constraints (Zabortseva, 2018; Morozov & Morozova, 2021).

The challenges identified in Baikal’s coastal territories mirror those faced by other global destinations reliant on seasonal tourism. China’s top-down policy framework, combined with public–private partnerships, could offer a model for Baikal (Zhou, 2024; An et al., 2021).

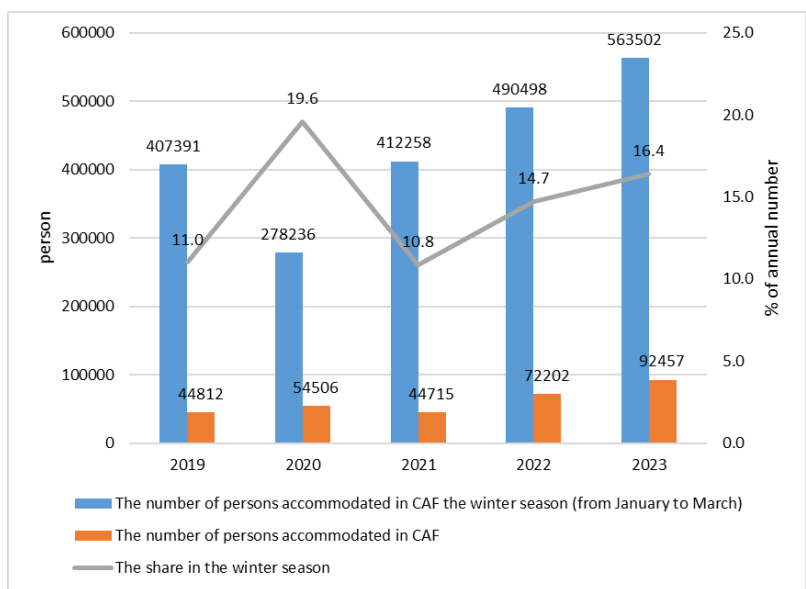


Figure 1 Dynamics of the number of persons accommodated in the CAF of the Republic of Buryatia from 2019–2023.



Figure 2 Research area.

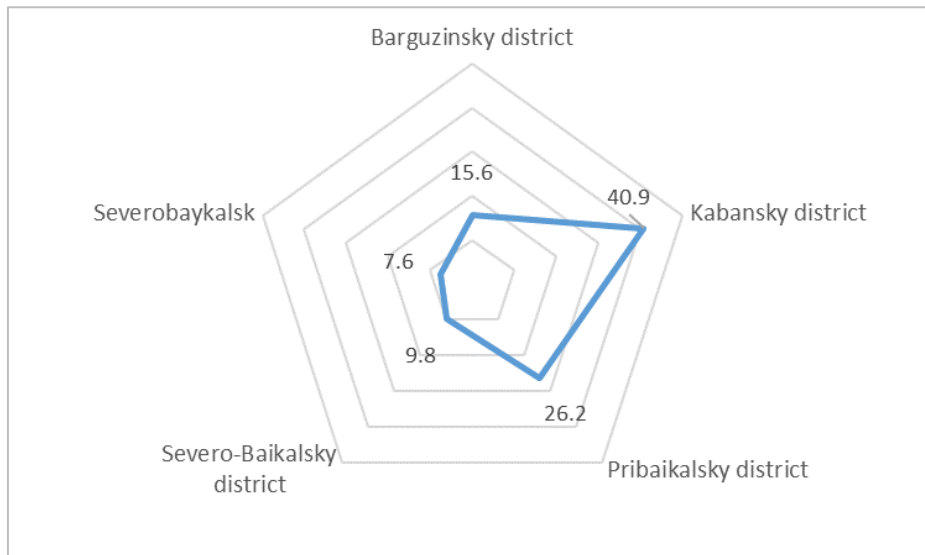


Figure 3 Distribution of CAF in the coastal areas of the Republic of Buryatia (2023).

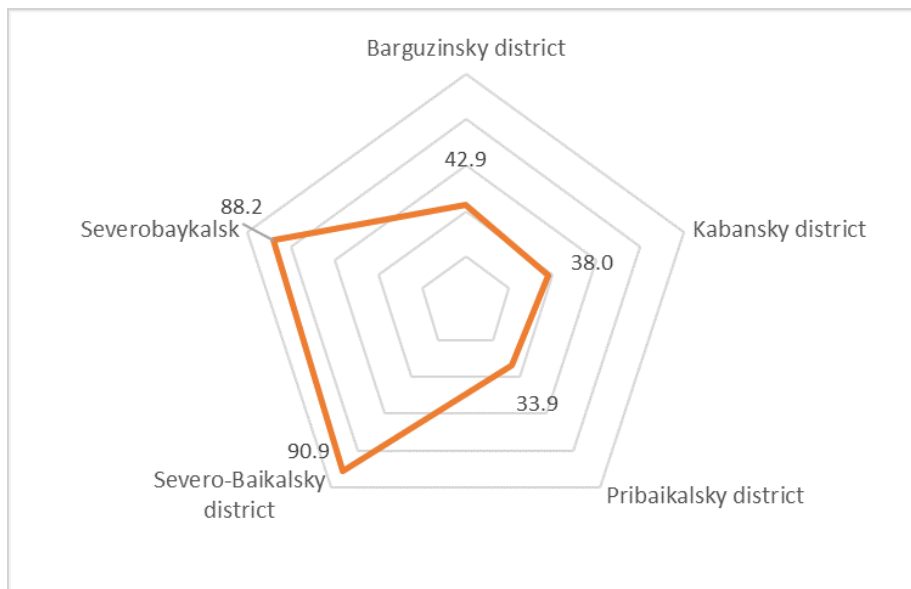


Figure 4 The share of year-round CAF in the coastal rural areas of the Republic of Buryatia (2023).

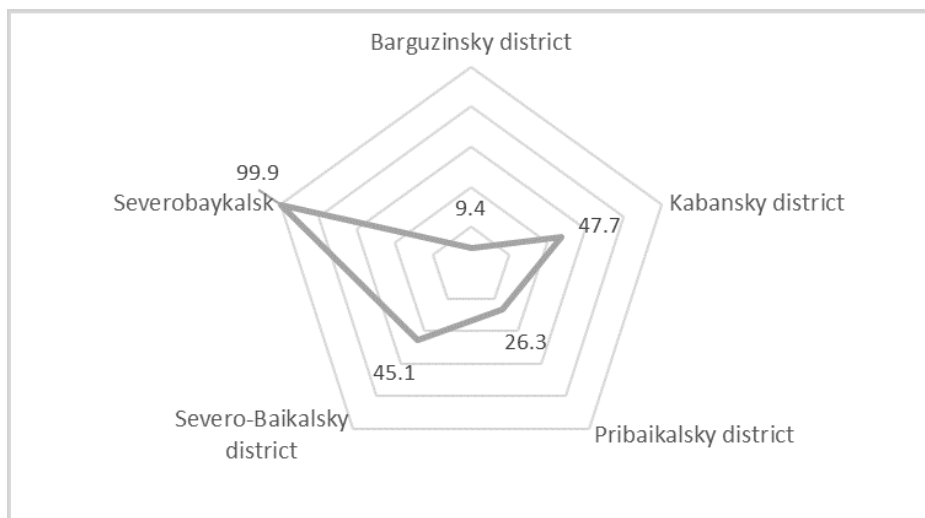


Figure 5 Proportion of the area of the housing stock equipped with water disposal (sewage) coastal territories of Lake Baikal (Republic of Buryatia) as a percentage of the area of the housing stock (2023).

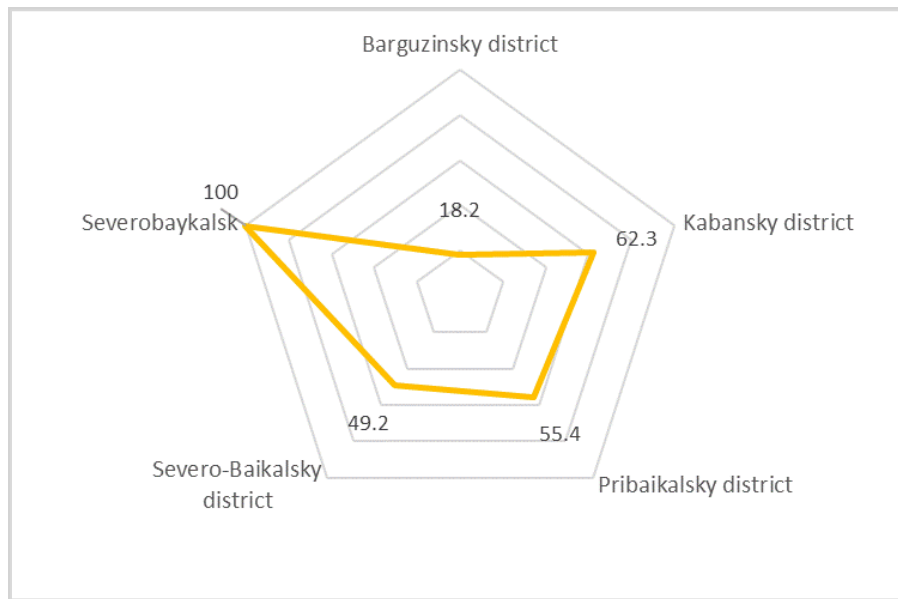


Figure 6 Proportion of the area of the housing stock equipped with heating coastal territories of Lake Baikal (Republic of Buryatia), % of the area of the housing stock (2023).

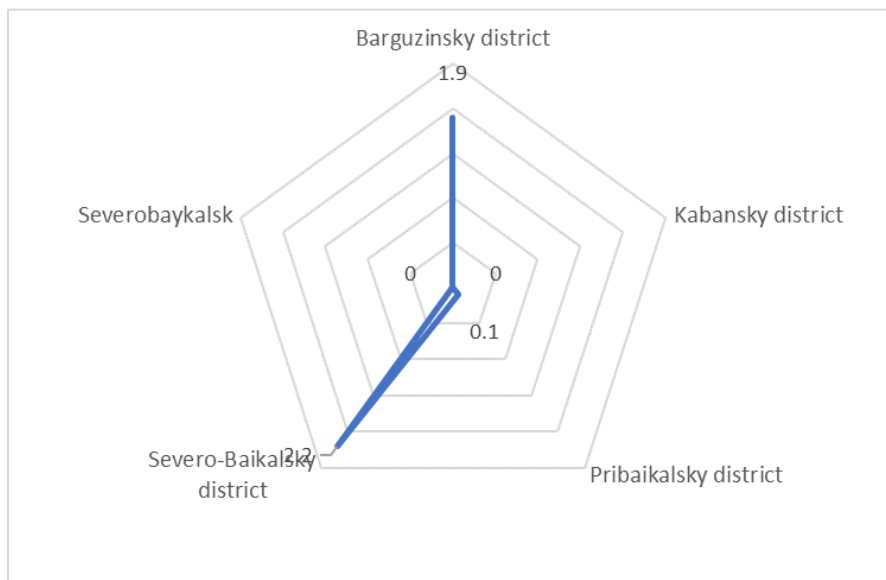


Figure 7 Share of recycled and neutralized production and consumption waste of coastal territories of Lake Baikal (Republic of Buryatia), % of the total volume generated (2023).

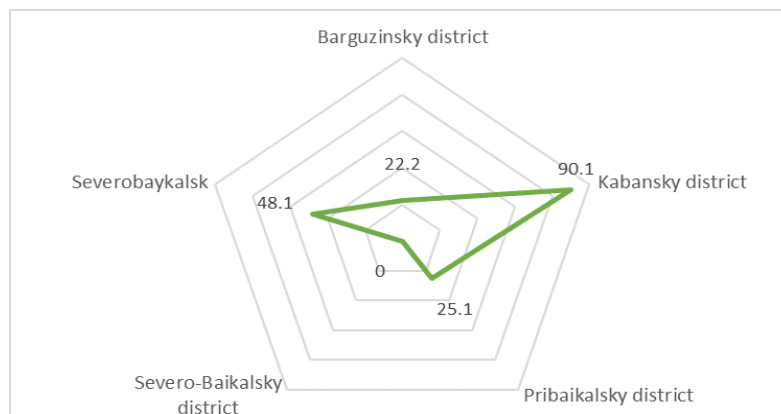


Figure 8 Share of capture and neutralization of air pollutants of coastal territories of Lake Baikal (Republic of Buryatia), % of the total amount of waste (2023).

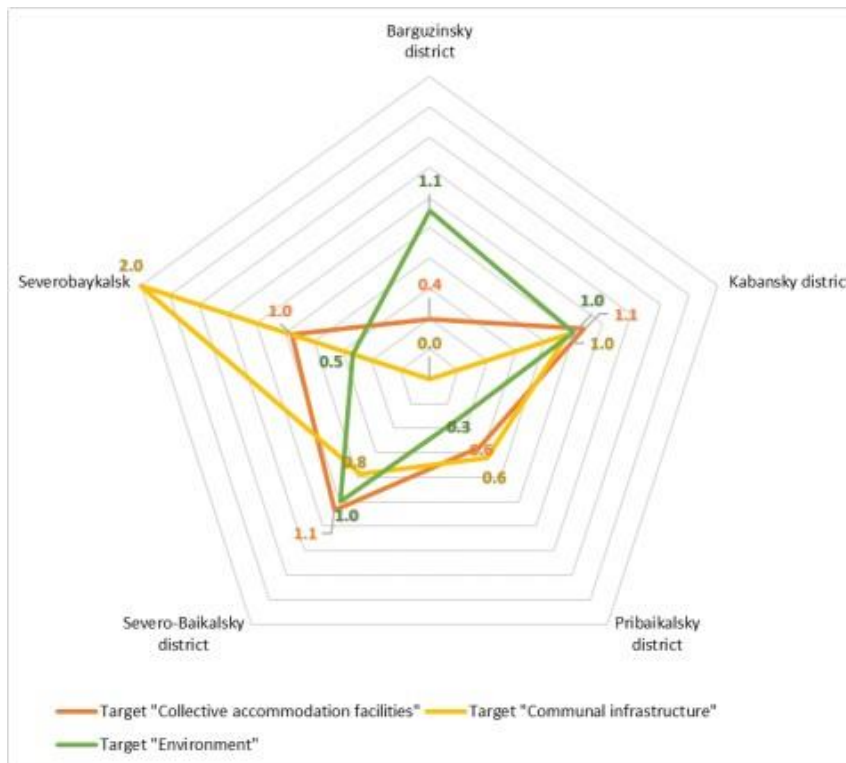


Figure 9 Results of the assessment of infrastructure provision for three targets of thecoastal areas of Lake Baikal (Republic of Buryatia) (2023).

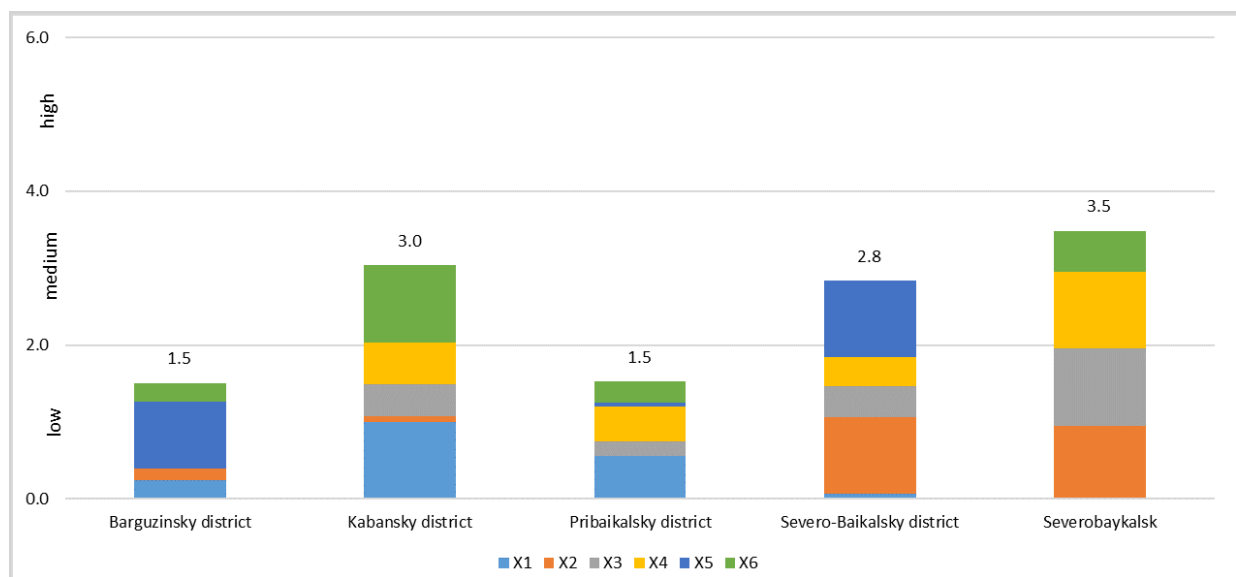


Figure 10 Comprehensive assessment of the provision of infrastructure for the development of tourism in the winter season for each municipality of the Republic of Buryatia of the coastal territory of Lake Baikal.

Table 1 Assessing the index system of infrastructure provision for the development of tourism in the winter season.

Target	Indicator	Name
Collective accommodation facilities	Share of CAF, in % of the total number of CAF in the coastal areas of the Republic of Buryatia	X ₁
	Share of year-round CAF, % of the total number of CAF	X ₂
Communal infrastructure	Proportion of the area of the housing stock equipped with water disposal (sewage), in % of the area of the housing stock	X ₃
	Proportion of the area of the housing stock equipped with heating, % of the area of the housing stock	X ₄
Environment	Share of recycled and neutralized production and consumption waste, % of the total volume of generated	X ₅
	Share of capture and neutralization of air pollutants, % of the total amount of waste	X ₆

Table 2 Level scale of the infrastructure provision for the development of tourism in the winter season.

Scores, I_i	Level of the infrastructure provision
4-6	high
2-3.9	medium
0-1.9	low

6. Conclusions

As a result of the conducted research, we determined that the infrastructure provision for tourism in the winter season in the municipalities of the Republic Buryatia of the coastal territories of Lake Baikal is average and low. Given the growing interest in winter and ice–snow tourism on Lake Baikal and, as a consequence, the growth in the volume of tourist products using the ice surface of the lake for effective development.

For ice–snow tourism in the coastal rural areas of Baikal, it is necessary to develop comprehensive measures aimed at regulating the tourist flow and improving the infrastructure, which will preserve the unique natural environment and meet the growing demand of tourists.

The development of winter and ice/snow tourism on Lake Baikal opens up broad opportunities for the economic development of rural areas; however, it is important to consider the impact on the environment and ensure that tourism development does not threaten the ecological safety of the area. Problems associated with insufficient provision of utilities and transport infrastructure and accommodation facilities also require attention, since they limit opportunities for safe and comfortable recreation.

In conclusion, balancing these aspects is crucial for the long-term sustainability of winter and ice–snow tourism in the coastal areas of Lake Baikal and contributes to their economic development.

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Ethical considerations

Not applicable.

Conflict of interest

The authors declare that they have no conflicts of interest.

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