

INTEGRATING EXPEDITIONARY AND GIS METHODS FOR TOURISM ROUTE PLANNING IN PERIPHERAL AREAS: A CASE STUDY OF THE KOLVA RIVER, RUSSIA

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ABSTRACT. Peripheral natural areas in Russia are being increasingly incorporated into tourism without scientifically grounded methods for assessing their potential, which creates risks and leads to missed economic opportunities for regional development. This study was conducted on the Kolva River in Perm Krai, Russia. We developed and tested a methodology for the integrated assessment of river-based tourism potential in peripheral areas using a combination of expeditionary field methods and GIS tools for tourist route planning. The methodology integrates field hydrological measurements, UAV surveys, campsite assessment based on six criteria, and GIS mapping. Using this approach, we designed a 144-km river expedition route. Thirty-two potential campsites were assessed, and eight were selected, with an average spacing of 25 km. Orthophoto maps were produced for key sections of the route. Twenty rock outcrops were recorded along the river, corresponding to a density of 0.14 units/km. Flood risk at the campsites was assessed using long-term hydrological records from local gauging stations. Hydrochemical analyses of water samples confirmed good water quality, and eight springs had sufficient discharge to supply drinking water along the route. The Kolva River is at the pioneer stage of tourism development, with no infrastructure or signs of recreational impact. The proposed approach to tourist route planning in peripheral areas may be considered broadly applicable to similar settings elsewhere, and the results can support spatial development planning and tourism route design in peripheral regions.

KEYWORDS: Kolva River, Perm Krai, tourist route design, hydrological regime, GIS, campsite assessment

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INTRODUCTION

Research background and existing problems

One of the current global trends in tourism development is the increased demand for tourism and outdoor recreation in natural environments (Buckley, 2012; Newsome et al., 2013). The Strategy for Tourism Development in the Russian Federation until 2035¹ places

particular emphasis on ecotourism among all nature-based types of tourism. Despite a deeper understanding of ecotourism in the scientific community, Russian legal documents consider it solely as tourism that is organized in protected areas (PAs). In recent years, numerous well-equipped trails and routes have appeared within Russia's PAs. According to the data presented in the state report for 2024, 1,443 routes have been developed and equipped within federal PAs alone, which were visited by more than

¹Decree of the Government of the Russian Federation No. 2129-r dated September 20, 2019 (2019). On Approval of the Tourism Development Strategy in the Russian Federation until 2035. [online] Available at: <http://www.pravo.gov.ru> [Accessed 7 May 2026].

17.91 million tourists². This is more than double the 2018 figure (6 million tourists)³. Today, favorable conditions exist for the design and development of routes within PAs: there is a state mandate, professional teams (PA staff), available funding (in the form of subsidies), and a well-defined managed territory for project implementation. A model has been created that allows for a reasonable degree of efficiency in managing nature protection processes and tourism development. Furthermore, PAs are becoming full-fledged participants in regional economies, generating economic output, creating jobs, and paying taxes.

However, these processes also create certain problems: increasing recreational pressure on the most visited PAs, the need to limit visits, and the risk of nature being “crowded out” by tourism infrastructure (Eagles et al., 2002).

At the same time, Russia has large expanses of natural territories that do not have protected status; these are also being incorporated into tourism processes to varying degrees.

Our research focuses on peripheral territories. By this term, we mean remote, sparsely populated areas with limited transport accessibility, minimal infrastructure, and weak economic integration but which often retain high natural value (Rodoman, 2016; Zyryanov et al., 2025). Periphery in tourism is far from homogeneous and is characterized by different stages of tourism development. According to the spatial model of R.W. Butler (Butler, 1980), which distinguishes six stages in the evolution of a tourist area, these may include territories at the pioneer stage, with insignificant tourist flows and a complete absence of tourism infrastructure and services, as well as territories actively involved in tourism processes (development, consolidation, and even stagnation stages).

The problem of the spontaneous involvement of natural territories lacking PA status in tourism processes is a pressing issue. The development of routes and tourism products in these territories is undertaken by representatives of the tourism business (tour operators, guides, outdoor guides), tourist clubs, and others. The management model that functions successfully for PAs does not work here. The territories through which routes pass become “donors” of natural resources; the efficiency of tourism development here is low, and the budgets of remote municipalities receive minimal revenue from tourism activities.

Existing Solutions and Defects

One solution is to expand the network of protected areas (PAs) at both the federal and regional levels. According to the State Report² for the period of implementation of the federal program “Conservation of Biological Diversity and Development of Ecotourism” in 2019–2024, 25 federal-level PAs and 137 regional-level PAs were established in the Russian Federation. An example is the creation of the “Permsky” natural park on the Vishera, Usva, and Chusovaya rivers. These rivers are among the most visited by tourists in Perm Krai. Tourist routes here emerged spontaneously and have existed since the early 20th century. The tourist flow consists of both organized and independent tourists. Precise data on the number of tourists using these routes are unavailable, but the total flow in the nature-based tourism segment in Perm Krai was estimated at 100,000 visits per year, with a growing trend

(Mirolyubova et al., 2023). The spontaneous development of nature-based tourism brings a range of problems to the territory where it occurs. The main services included in the tourism product (transport, equipment rental, guide services, etc.) are purchased in the regional capital, while the actual activities take place in the municipalities through which the routes pass. Under this model of tourism organization, municipalities receive minimal economic benefits but may incur costs associated with the presence of tourists in the area (e.g., the need for waste collection, remediation of damage from forest fires, organization of evacuation operations in case of accidents, etc.).

Increased tourist demand, growing recreational pressure, and the need to regulate activities became the main arguments justifying the creation of the first natural park in Perm Krai (Buzmakov et al., 2018; Zaytsev, 2015; Myshlyavtseva, 2012). The creation process took seven years, from the publication of the first paper (Buzmakov et al., 2011) to the adoption of the regulatory act in 2018. It should be emphasized that this is a long period given the rapidly changing current situation. The positive experience needs to be extended to other territories in the region. However, before making specific proposals for the design of new PAs, it is necessary to identify priority territories where such a need has arisen. These include, on the one hand, territories that are representative for the conservation of natural complexes and, on the other hand, those already experiencing recreational pressure or under threat of such pressure. Thus, there is a gap between the need for tourism development on natural territories without protected status and the lack of an adapted methodology for a comprehensive assessment of their tourism potential that takes into account both natural conditions and the socio-economic constraints of the periphery.

Since the study covers peripheral territories of the region, conducting comprehensive fieldwork involves significant organizational and financial difficulties.

The problem of integrating such territories into the economy is a focus of the Russian Geographical Society. The experience gained from the “Rivers of the Russian Geographical Society” project, which conducted comprehensive geographical expeditions to assess the potential of peripheral rivers, can be considered pioneering. The outcome of the project, in addition to accumulating knowledge about poorly studied geographical features, is the development of a research methodology that will yield applied products, namely scientifically based tourism routes, proposals for the creation of PAs, and recommendations for territorial development.

The Kolva River in Perm Krai has been selected as a pilot territory for testing the proposed methodology. It is a typical example of an underdeveloped peripheral territory with high natural potential and a pioneer level of tourism development (a detailed description of the study area is provided in the Study Area section).

Aim, Hypothesis, and Research Objectives

Aim – To develop and test a methodology for the comprehensive assessment of the potential of rivers in peripheral territories based on the integration of expeditionary and GIS methods for the design of tourist routes.

²On the State and Protection of the Environment of the Russian Federation in 2024: State Report. (2025). Moscow: Ministry of Natural Resources and Environment of the Russian Federation, All-Russian Research Institute of Ecology. [online] p. 721. Available at: https://www.mnr.gov.ru/docs/gosudarstvennye_doklady [Accessed 7 May 2026].

³For comparison, according to the US National Park Service, the total visitation to 404 protected areas reached 331.9 million people (Flyr et al., 2024).

Hypothesis – It is assumed that the complementary use of traditional expeditionary methods and modern geoinformation technologies (GIS, remote sensing, UAVs) allows for the identification and assessment of the tourism potential of peripheral rivers with a level of detail and reliability exceeding that of desk-based studies alone and is more effective for integrating these territories into the regional economy.

Research objectives:

- Conduct hydrological and hydrochemical measurements on the surveyed section of the Kolva River;
- Perform a recreational geography assessment of the shoreline zone, identifying and mapping potential sites for tourist campsites and sources of drinking water;
- Develop a GIS called “Tourism in Peripheral Territories”;
- Design a tourist route and prepare its passport (route description);
- Prepare recommendations for replicating the developed methodology to other territories.

Structure and main contributions of this work

The paper is organized as follows. The Introduction substantiates the significance and relevance of the topic, identifies gaps in existing approaches, and justifies the choice of the expeditionary method as the main source of empirical data. The Study Area section provides a comprehensive geographical characterization of the Kolva River valley. The Methodology and Methods section presents the main methods and a detailed description of the research methodology. At the preparatory stage, methods of analyzing scientific and regional literature were used, as well as the analysis of cartographic materials and Earth remote sensing data (geoinformation methods). During the field stage, hydrological and hydrochemical measurements were carried out, a recreational geography assessment of the shoreline zone was performed, and the attractiveness of the territory was assessed using a scoring method. Aerial photography using UAVs was employed to create orthophotomaps of key sections of the route. The office stage concluded with the development of a scientifically based tourist route.

The Results section presents the hydrological and geomorphological characteristics of the Kolva River, the tourist route developed on its basis, as well as the GIS “Tourism in Peripheral Territories”. The Discussion addresses the potential of the authors’ proposed approach for tourism planning in peripheral territories, arguing that it is universal and can be recommended for similar studies elsewhere.

The main scientific contributions of this work are as follows. First, the complementary use of modern geoinformation methods and traditional expeditionary methods for identifying the tourism potential of peripheral territories is substantiated. Second, a GIS structure for assessing the tourism potential of rivers in peripheral territories is proposed and tested on the Kolva River. Third, specific applied products are presented: (a) a tourist-expeditionary route; (b) the GIS “Tourism in Peripheral Territories”.

The obtained results can be used in the practice of spatial development management and tourism planning in peripheral territories of regions. Furthermore, the specific scientific products resulting from the work have been transferred to the regional Ministry of Tourism, which

is responsible for tourism development in Perm Krai, and an implementation certificate has been obtained.

MATERIALS AND METHODS

Study area

The study was conducted on the Kolva River, located on the northeastern periphery of Perm Krai, Russia. A 183-km section of the river was surveyed, from the village of Talovo (61.34063°N, 58.15611°E) to the mouth of the Berezovaya River (61.01465°N, 57.14252°E), with the total length of the Kolva River of 460 km (Fig. 1). The field stage was carried out from June 27 to July 8, 2025.

The Kolva River basin lies in the eastern part of the moderately warm and moderately humid Atlantic-continent European region of the temperate climate zone. In terms of humidity, the Kolva basin belongs to the zone of sufficient moisture. The average annual precipitation is about 800 mm/year, with the highest amount of precipitation (more than 80 mm) occurring in July.

The flood period is characterized by increased water discharge, which leads to a significant rise in water levels. According to observations at the gauging station “Kolva River – Petretsova village” (drainage area 2,830 km²), during the flood period maximum water discharge exceeds 700 m³/s, while minimum average monthly discharge during the winter low-water period can drop to 3.1 m³/s. During the summer low-water period (June–August), the average water discharge is about 43 m³/s, and the average minimum summer discharge is 11 m³/s, although in some years the average monthly discharge during this period drops to 6.5 m³/s⁴.

The territory through which the Kolva River flows is currently poorly developed and almost uninhabited. Along the entire river from source to mouth, there are 31 settlements, including the center of the Cherdynsky Municipal District – the town of Cherdyn. Today, villages and settlements (14 in total) in the upper and middle reaches of the Kolva (above the village of Vizhaikha) are uninhabited. Permanent residents are present in the villages of Nyuzim, Gadya, Verkhnyaya Kolva, and Timenskaya (Lysenko, 2025). Territorial connectivity is maintained by roads and water transport. North of the village of Nyrob, all roads are unpaved and accessible only to off-road vehicles. Economic activity is carried out by a few enterprises engaged in timber extraction and primary processing.

According to the model of R.W. Butler (Butler, 1980), the Kolva River is at the exploration stage and does not play a significant role in the region’s tourism system. Individual fishing and hunting tourism are present here. However, the Tourism Development Strategy of Perm Krai considers these territories as promising for the development of nature-based and ecotourism (Mirolyubova et al., 2023).

The study area has relatively good scientific coverage. In 1847, the North Ural Expedition of the Imperial Russian Geographical Society under the leadership of E.K. Hoffman worked here. Large-scale geological research was conducted in the 1950s (Chagin, 2017). A number of modern studies are devoted to individual components of natural complexes – forest vegetation (Smirnova et al., 2014; Aleinikov, 2024; Aleinikov et al., 2024), the flora of rock outcrops (Efimik, 2014); hydrochemical surveys have been conducted here (Kazantseva, 2019); the morphology of floodplain-channel complexes has been studied (Chernov

⁴Scientific and Applied Reference Book: Main Hydrological Characteristics of Rivers in the Kama Basin (2015). Collective authors; edited by Georgievsky V. [online] Available at: <http://istina.msu.ru/> [Accessed 3 May 2026].

et al., 2023). The Kolva River basin is of great interest to archaeologists and historians (Chagin, 2012; Chagin, 2020; Denisov et al., 2012; Korchagin et al., 2012).

Comprehensive studies aimed at assessing the tourism and recreational potential have been conducted for the first time.

METHODS

Remote Sensing and Geodetic Methods

Remote sensing was used both at the stage of preparation for field research and in the field for terrain mapping. During the preparation stage, multi-temporal satellite images (Landsat-8/Sentinel-2) were studied to analyze the river's water level regime during the summer period, identify potential obstacles, and select suitable campsites along the shoreline.

In the field, a small unmanned aerial vehicle (UAV), namely the DJI Phantom 4, was launched at an altitude of 150 m to create high-resolution orthophotomosaics and digital elevation models (DEMs) of the river valley and potential campsites. For georeferencing the data obtained from the UAV, ground control points (GCPs) were established, whose planimetric and height coordinates were determined using a GNSS receiver (EFT M-4).

Field Hydrological and Hydrochemical Measurements

The expedition included 10 days of observations. The location of all major macro- and mesoforms of the river channel, tributaries, and potential hazards (e.g., fallen trees, rapids) was recorded using a portable Garmin GPS navigator.

Bathymetry: Water depth was measured using an echo sounder (Lowrance Elite FS 10).

Flow velocity: Flow velocity and direction were measured using a current meter (GR-21M).

Hydrophysical and hydrochemical parameters were measured in situ using a portable WTW Multi 3630 IDS multimeter. The following parameters were recorded: water temperature (°C), pH, dissolved oxygen (mg/L and % saturation), and electrical conductivity (µS/cm).

Water samples for subsequent laboratory analysis were collected in pre-cleaned polyethylene and glass bottles. A

portion of each sample was preserved (samples for metals were preserved by acidification with nitric acid to pH < 2), and all samples were stored in a refrigerator at 4 °C until transportation to the laboratory.

Campsite Assessment

Based on satellite imagery, the river was divided into sections of 25±5 km. The identification of potential campsites was carried out within a 10-km zone (1.5 hours at an estimated travel speed of 5–7 km/h). A total of 32 potentially suitable campsites were identified.

The on-site assessment of campsites was conducted according to six criteria reflecting the main requirements for campsite organization on a water route. The selection of criteria was based on an analysis of literature sources and the authors' field experience. Each criterion was evaluated on a three-point scale (1 – worst value, 3 – best value). The scores were summed; no weighting coefficients were assigned. The scoring scale of criteria is presented in Table 1.

The area of flat ground was determined based on a group of up to 25 people, taking into account functional zoning (tent area, food preparation area, sanitary zone, equipment storage area). An area of more than 200 m² was considered sufficient for comfortable accommodation.

Water access was assessed in terms of the ease of landing, embarking, loading, unloading, and mooring watercraft. Within this methodology, a steep, sheer bank without shallows received the lowest score.

Vegetation cover is considered from the perspective of the need to prepare the site for setting up camp as well as a habitat for hematophagous insects; open areas (pebble bars, sandy beaches) are preferred.

Location relative to the drinking water source assesses the convenience of replenishing supplies, taking into account the river flow. The best option (3 points) is the presence of a source directly at the campsite. A source located upstream (2 points) is convenient: water is collected en route before the group arrives at the campsite. A source located downstream (1 point) is inconvenient: after setting up camp, it is necessary to move against the current to collect water.

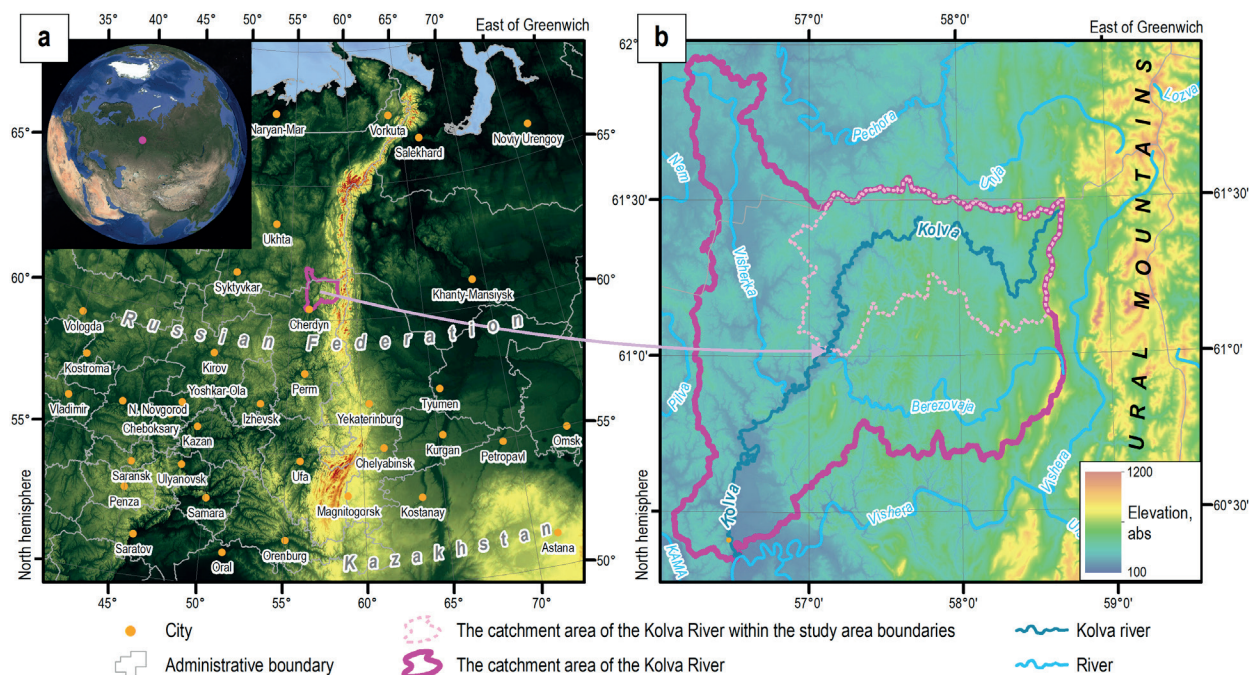


Fig. 1. Maps showing the location of the study site (a) and the boundaries of the Kolva River catchment area (b)

The **safety** criterion was considered from the perspective of the likelihood of the site being flooded by high waters. High probability corresponds to the minimum value (1 point).

Aesthetics in this study were assessed according to a single criterion – the presence and extent of the view of the river valley. No view corresponds to 1 point, a limited view – 2 points, and a wide panoramic view – 3 points. Further development of the methodology may include additional parameters (insolation, spatial isolation, visibility of anthropogenic features).

Laboratory Chemical Analysis

Water samples (11 in total) were analyzed for major ion content. The concentrations of the following parameters were determined:

Cations: potassium (K^+), sodium (Na^+), and calcium (Ca^{2+}) were measured using capillary electrophoresis.

Anions: chlorides (Cl^-) and sulfates (SO_4^{2-}) were determined by capillary electrophoresis, while bicarbonates (HCO_3^-) were determined according to GOST 31957-2012.

Nutrients and metals: nitrates (NO_3^-) were measured by capillary electrophoresis; total iron (Fe) and manganese (Mn) were analyzed using a photometric method.

Integral parameters: total hardness was calculated.

Data processing and statistical analysis

Statistical analysis was applied to determine the relationships between hydrological parameters. Longterm hydrological characteristics (mean discharge, coefficients of variation, skewness, and autocorrelation) were calculated using the specialized software package "Gidroraschety". The calculations were based on observational data spanning 85 and 149 years from the gauging stations (76105/Petretsova; 76112/Cherdyn).

RESULTS AND DISCUSSION

Hydrological characteristics of the Kolva River

Table 2 presents the main hydrological characteristics obtained during the field work (summer low-water period).

The **upper section (from the village of Talovo to the village of Cherepanovo)** is characterized by the highest sinuosity of the channel and the presence of a large number of riffles.

The **middle section (from the village of Cherepanovo to the village of Petretsova)** is characterized by a decrease in channel sinuosity, the presence of more pronounced pool sections, and an increase in the number of islands and mid-channel bars (braided channel). The maximum depth was recorded at the apex of the left meander at 122.2 km of the route (61.26687°N, 57.24030°E). The maximum flow velocity was measured at 69 km of the route (61.38139°N, 57.63110°E). This value was the highest recorded during

the entire study period.

Remains of a bridge structure (Fig. 2d) were noted in the channel, as well as a characteristic obstacle – trees leaning over the channel (sweepers) (Fig. 2c).

The **lower section (from the village of Petretsova to the mouth of the Berezovaya River)** is characterized by a further increase in average depths and average channel width and a decrease in the size of the detrital rocks composing the channel. The length of riffles and pools increases, and their alternation becomes more pronounced. An increase in the number of sandy bars, beaches, and mid-channel bars is noted (Figs. 2a, b).

Thus, the hydrological characteristics of the Kolva River during the low-water period indicate that in summer the river is suitable for organizing recreational rafting (non-category, Category I difficulty) and is typical for the Northern Urals (Komlev, 2011). No special experience is required to navigate natural (riffles, sweepers) and technogenic (bridge abutments) obstacles. Low flow velocities and the long length of the route determine the choice of faster watercraft (kayaks, boats, motorized catamarans). The hydrological regime of the river imposes certain limitations on the use of water routes during the summer season. The most favorable period for navigation is the first half of summer (June–July). In the second half of the summer season, in the upper reaches, the river becomes significantly shallower and is suitable for navigation only with specialized watercraft (airboat, hovercraft, water-jet craft).

Campsite assessment and spatial distribution

According to the developed methodology (section "Campsite Assessment"), 32 potential sites located within the accessibility zones of a day's travel were assessed. These sites are located both on river terraces and on beaches. The river terraces of the Kolva River are wide horizontal platforms elevated above the water level by 1.0–1.5 to 2.5–3.0 meters (Fig. 3a–c), and sometimes higher. The terrace scarps drop rather steeply to the water, making landing and access to the shore difficult (Fig. 3a). In summer, the terraces are overgrown with herbaceous vegetation (Fig. 3b, c).

In the middle reaches of the river, gravel beaches appear, and further downstream there are sandy-gravel and sandy beaches of varying lengths, from a few meters to several hundred meters (Fig. 3d–f). Campsites on beaches are characterized by gentle access to the water, good ventilation, flat areas, and the absence of vegetation.

For route organization, 8 campsites were selected. The average distance between campsites was 25 km (Table 3).

During the expedition, approximately 50 more potential campsites were visually assessed, but these were located outside the designated ten-kilometer zones.

In the upper and middle reaches of the route, campsites are predominantly located on river terraces that drop steeply to the water (Fig. 3a). In most cases, additional

Table 1. Criteria and assessment scale for water tourism campsites

Score	Area of flat ground, m ²	Water access	Vegetation cover	Location relative to drinking water source	Safety (flooding risk)	Aesthetics (valley view)
1	≤100	Steep, high, sheer, clayey bank; no shallows	Dense woody vegetation	Downstream of the campsite	High	Absent
2	101–200	Shallows; low steep bank	Tall grass vegetation	Upstream of the campsite	Moderate	Limited
3	>200	Gentle access to campsite; pebbles, sand	No vegetation	At the campsite	None	Wide panoramic view

Table 2. Hydrological characteristics of the Kolva River

Parameter	Upper section	Middle section	Lower section
Length (km)	60	84	39
Channel width, average (m)	25–30	40–45	50–60
Channel width, max (m)	80–90	>100	>100
Average depth: pool (m)	0.8–1.1	1.0–1.5	1.3–1.5
Average depth: riffle (m)	0.3–0.5	0.3–0.7	0.4–0.8
Max depth (m)	4.3	7.2	6.0
Flow velocity, average (m/s)	0.7–1.0	0.6–0.8	0.4–0.5
Flow velocity, max (m/s)	1.8	2.8	1.5
Water discharge (m ³ /s)	25	50	60

measures are required to facilitate access to the terraces (steps, handrails, local shrub removal). During summer, the terraces are densely overgrown with herbaceous vegetation, which makes camping less convenient and necessitates mowing (Fig. 3b, c). Another disturbing factor is the high abundance of bloodsucking insects (gnats, midges, and other biting flies) inhabiting the tall grass. When the grass is disturbed, large numbers of these insects rise up from the vegetation.

The most convenient terraces for camping are found at the localities of the former villages of Susay, Parshakova, Timenskaya, and Tulpan. These localities are spaced approximately 25 km apart, which corresponds to a one-day paddle for most watercraft (e.g., motorized catamaran, kayak). For the motorized watercraft traditionally used on this route, the daily travel distance may be greater.

Beach campsites offer more convenient water access and

good ventilation but are more vulnerable to water level rise during rainfall-induced floods (see the Flood Risk section).

It should be noted that the level of tourism development on the river is extremely low. Recreational pressure is practically absent, and no traces of human presence were observed at the selected campsites. The proposed density of campsites (one campsite per 25 km) is sufficient at the current level of tourism development. However, should tourist flows change, the density of campsites can be increased.

Attractive objects and recreational potential

The most attractive objects along the route are the shoreline rock exposures (Fig. 4a). Throughout the entire route, 20 shoreline rock outcrops were recorded. The most significant in terms of height, extent, and shape are the Dyrovaty Kamen rock, Zapadnye Kamni rock, Besov Kamen

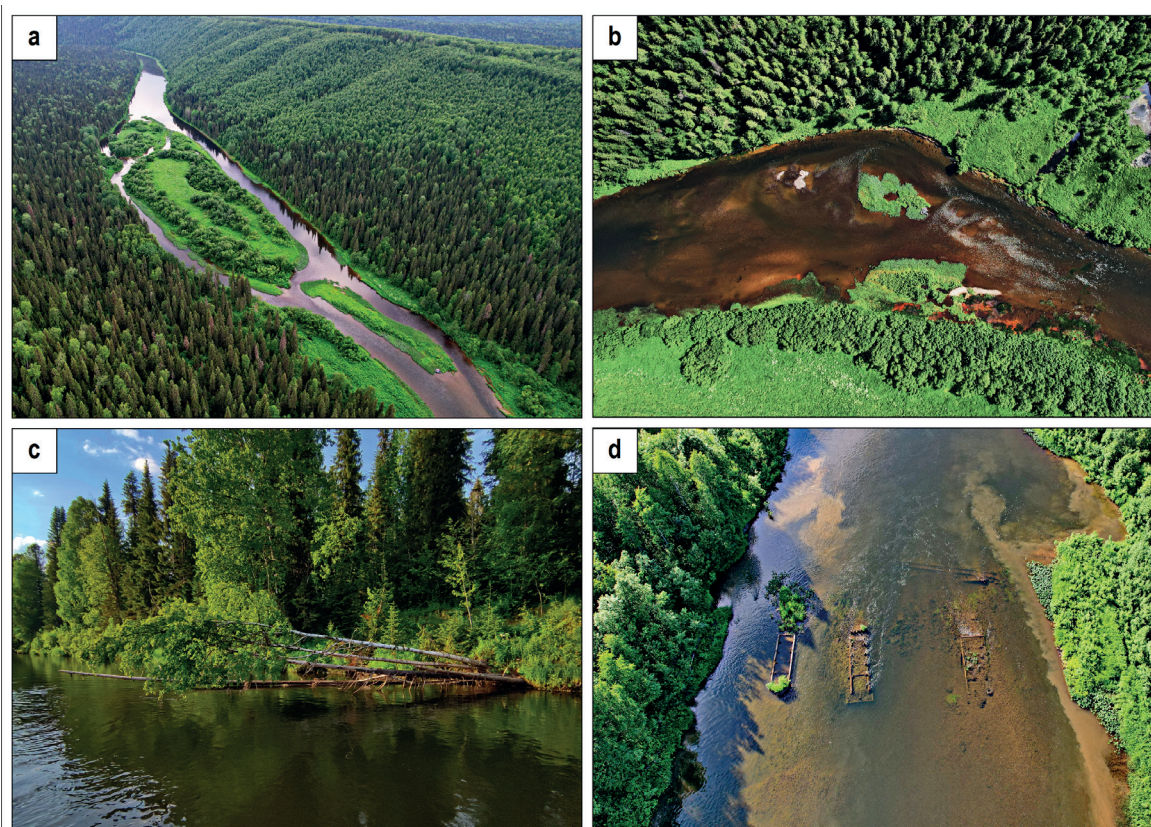


Fig. 2. Channel conditions of the Kolva River and various in-channel features (during the survey period): a – islands and side channels; b – riffle and shallow bars; c – overhanging trees above the channel; d – in-channel obstacles (remnants of bridge piers, submerged timber)

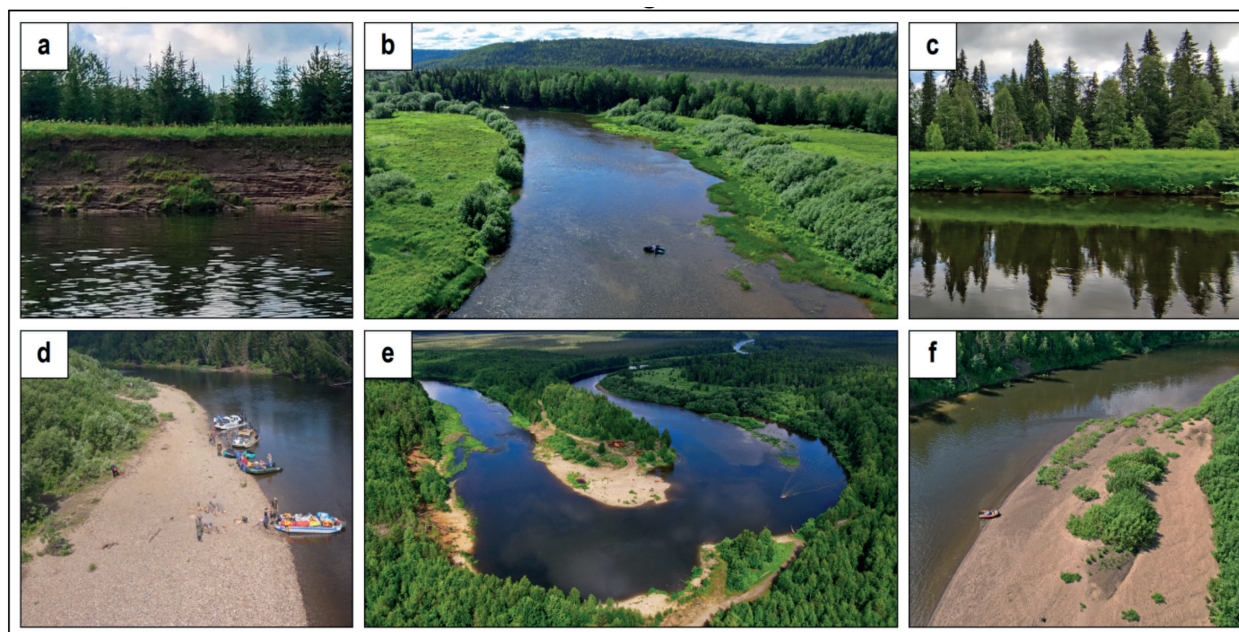


Fig. 3. Examples of possible camping locations and their characteristics: a – steep bank; b – floodplain of the Kolva River in its upper reaches; c – overgrown with grass vegetation; d – pebble beach; e – floodplain of the Kolva River in its middle reaches; f – sandy beach

Table 3. Sites for tourist campsite organization

Segment (km)	Search zone (km)	Potential sites (units)	Distance from route start (km)	Latitude (°N)	Longitude (°E)	Area (m ²)	Campsite location description
0	0	2	0	61.33755	58.08104	230	Talovsky Most locality. Beach
25	20–30	3	24.5	61.42446	58.00452	1714	Susay locality. Terrace
50	45–55	7	48	61.41945	57.80116	4000	Parshakova locality. Terrace
75	70–80	8	74.5	61.38746	57.55385	7950	Opposite the village of Timenskaya. Terrace
100	95–105	3	93.5	61.35776	57.42286	2100	Tulpan locality. Terrace
125	120–130	6	118	61.29130	57.25355	4565	Beach
150	145–155	2	149	61.14902	57.26323	3903	Village of Gadya. Terrace
175	170–180	1	174	61.04124	57.14456	7033	Beach

rock, Kumayskiye Skaly rock, and Yezhovy Kamen rock. Kumayskiye Skaly and Yezhovy Kamen also contain grottoes measuring 7×4 m and 6.5×9 m, respectively. Smaller shoreline rock exposures were observed along the entire route.

Panoramic views of the river valley and the extensive parma (elevated forested uplands) open from the high bedrock slopes of the river (Fig. 4b). For example, from the village of Talovo, the outlines of Tulymsky Kamen (1469 m a.s.l.), the highest mountain of Perm Krai located 48 km to the southeast (straight-line distance), are visible. Extensive panoramas are also visible from the high slopes near the villages of Cherepanovo, Verkhny Nyuzim, Tulpan, Petretsovo, and Korepino. From the high slopes of Korepino village, the outlines of Buzhuysky Kamen (550 m a.s.l.), located 31 km to the east, as well as Korkasskaya Mountain (516 m a.s.l.) and Nizva Mountain (533 m a.s.l.), located 19 km and 26 km to the south, respectively, are clearly visible.

Objects of scientific and educational interest include

oxbow lakes and mires located in the Kolva River valley – the Neryinskoye mire, the Anylskaya oxbow lake, and others (Fig. 4c, d).

The Kolva River occupies an intermediate position among the rivers of the Northern Urals in terms of the density of attractive features such as shoreline rock outcrops. The density of shoreline rock outcrops on the Kolva River is 0.14 units/km. For comparison, we provide data for the neighboring rivers Vishera, Berezovaya, and Yazva. According to pilot guides (Toropov, 2008), on the Vishera River (200-km section from the locality “71st block” to the town of Krasnovishersk) there are 50 rock outcrops (0.25 units/km); on the Berezovaya River (100-km section from the locality “Tatarsky Most” to the settlement of Valay) there are 31 rock outcrops (0.31 units/km); on the Yazva River, 11 rock outcrops occur over 145 km (0.08 units/km).

Attractive objects on the Kolva River are distributed extremely unevenly along the route. The highest concentration of shoreline rock exposures is observed

in the upper 50-km section (from the locality Talovsky Most to the locality Parshakova). These objects are of particular interest to geomorphologists, geologists, and geobotanists. Other landscape features also contribute to the attractiveness of the area – extensive mire complexes, oxbow lakes, and high riverbanks with panoramic views – which suggests that the river has a relatively high attractive potential.

Furthermore, beyond the expedition route, there remains a section of the Kolva River containing natural features unique on the Ural scale: Divya Cave (10.1 km in length) and the shoreline rock outcrops of Vetlan, Bobysky, and Diviy. The proposed routes could be extended to include these features in the itinerary.

Flood risk assessment for campsites

To assess the potential adverse impacts of high waters during the summer period, hydrological calculations were performed for rain-induced flood conditions. In terms of runoff volume and peak discharge, rain floods are inferior to the spring freshet. The runoff generated by individual rain floods does not exceed 10–15% of the spring snowmelt flood runoff. The hydrographs of rain-induced floods are generally sharply peaked and are characterized by rapid rises and falls in water levels. Peak water levels during rain floods are on average significantly lower than those observed during the spring freshet. As a reference gauging station located within the study reach, the Kolva River gauging station at the village of Petretsova was selected for the calculations (Table 4). The observation series from 1927 to 2012 covers various phases of the river's hydrological regime, which confirms the representativeness of the station's data. To extend the data series up to the current year of 2025, data from the gauging station analogue

on the Kolva River at Cherdyn were used. The original observation period spans 1936–2011, with the extended period covering 2012–2025. The Kolva-Cherdyn station fully meets the criteria for analogue stations, with a data series correlation coefficient of 0.76, which is a satisfactory value.

The series of maximum water levels during rain-induced floods was tested for homogeneity and stationarity. According to all applied criteria, the series is homogeneous and stationary; therefore, design water levels with specified exceedance probabilities may be estimated using analytical Kritsky–Menkel frequency curves (theoretical distribution curve) (Fig. 5b). To determine the pattern of day-to-day changes in discharge and water level, a hydrograph was constructed for rain-induced floods with 1% and 10% exceedance probabilities⁵. It should be noted that the instantaneous discharge at the peak of the flood on 10 June 1996 was 475 m³/s, whereas the corresponding mean daily discharge was 459 m³/s. The flood rise lasted 5 days, and the difference between the pre-flood discharge and the peak discharge was 386 m³/s (89.2 versus 475 m³/s) for the model year. Over the same period, the water level increased by 229 cm, from 163 cm to 392 cm above the gauge zero.

In order to obtain water level values, a Q(H) rating curve was constructed. Using this relationship, a water level hydrograph for the period of a rain-induced flood was derived (Fig. 5a).

Therefore, if extremely rare rain-induced flood conditions are not considered, the expected rise in water level ranges from 1.1 to 2.1 m. In this case, the time to reach the peak water level is about 3–4 days, while the rate of water level increase may reach 0.5–0.9 m per day. These factors must be taken into account when choosing a place to set up a tent camp, especially when organizing it on beaches for overnight stays.

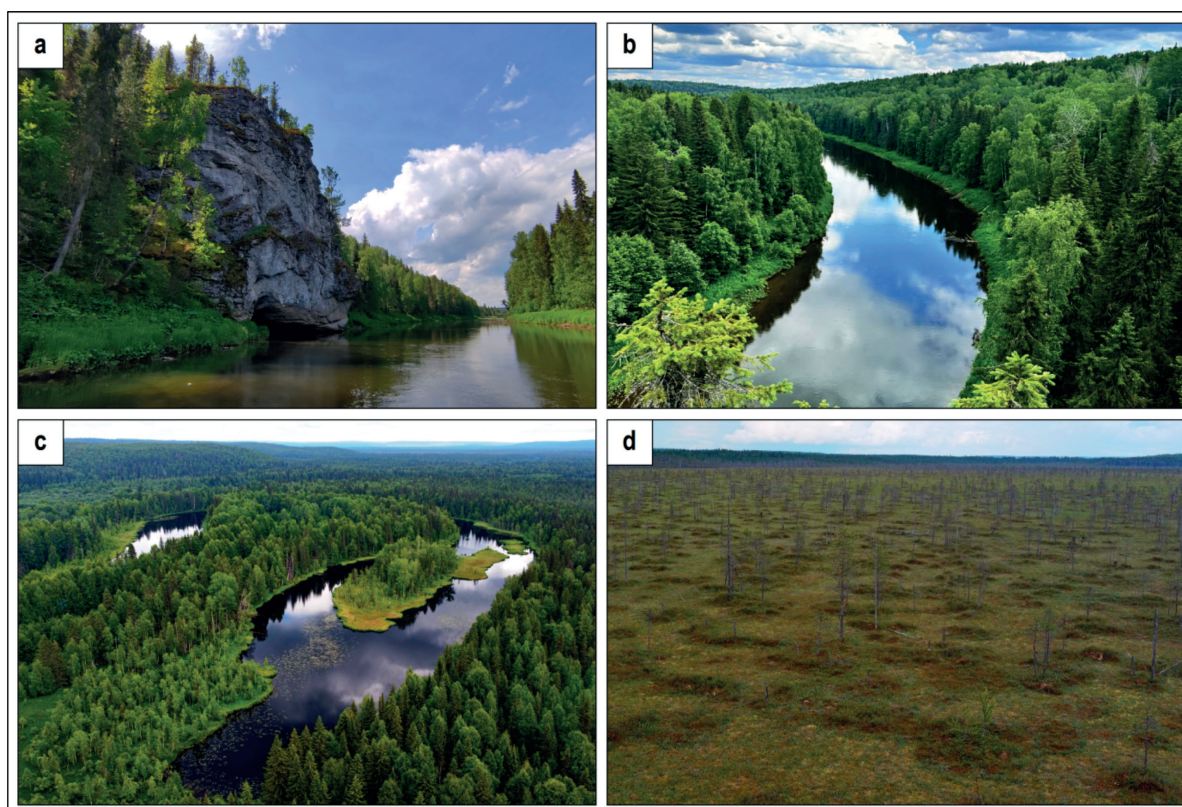


Fig. 4. Attractive sites along the expedition route:
a – Kumaishie Kamni rock formation; b – panoramic view of the Kolva River from Kumaishie Kamni;
c – Domashnee oxbow lake; d – Vizesinskoe marsh

⁵CODE OF RULES 529.1325800.2023 (2023). Determination of the main design hydrological characteristics. [online] Available at: https://norm-load.ru/norm/svod-pravil/4/sp_529_1325800_2023_svod_pravil_opredelenie.html [Accessed 8 May 2026].

This applies primarily to campsites located on beaches (0 km – Talovsky Most locality; 118 km – gravel beach in front of the village of Petretsova). In the event of elevated water levels, camping can be relocated to the terraces (61.33705° N, 58.08175° E; 61.29041° N, 57.23867° E).

Drinking water sources and water quality

The waters of the Kolva River are characterized by low mineralization (TDS 107–155 mg/dm³) and a predominantly slightly alkaline pH. According to the classification of O.A. Alekin (1953), they belong to the hydrocarbonate class with calcium as the dominant cation. The river waters are soft (total hardness does not exceed 3 meq/dm³). The oxygen regime is good (oxygen content exceeds 9 mg/dm³).

Water sampling was carried out at 86 observation points, including 3 points on the Kolva River itself and 83 points on its tributaries (including springs). Analysis of water samples from the Kolva River, its tributaries, streams, and springs showed the absence of significant sources of pollutant input in this territory. The springs identified along the route have a predominantly hydrocarbonate-calcium composition, which is typical for regions underlain by carbonate rocks. All spring samples are classified as fresh waters of low to moderate mineralization (TDS 104–255 mg/dm³). Compared to surface waters, the springs have higher hardness and bicarbonate content, which is associated with their filtration through bedrock.

An assessment of the suitability of the surveyed rivers and springs for drinking purposes, based on comparison with sanitary-hygienic standards for “drinking water from decentralized water supply systems”, showed the following: total iron – 0.05–0.236 mg/dm³ (below the standard of 0.3 mg/dm³); manganese – less than 0.005 mg/dm³ (below the standard of 0.1 mg/dm³); total hardness – 1.7–3.63 meq/dm³ (below the drinking water standard of 7–10 meq/dm³). Total dissolved solids, sulfates, chlorides, and sodium are significantly below the

sanitary-hygienic standards. The river and spring waters have organoleptic characteristics that comply with the standards.

Four samples from tributaries of the Kolva River located downstream of the village of Raksher do not meet the sanitary-hygienic standards with respect to pH, which was below 6. These sources are not recommended for consideration as potential drinking water replenishment points along the route. The majority of springs and the waters of the Kolva River are suitable for drinking and recreational purposes. Given that groundwater is generally more protected from surface contamination than surface water, it is recommended that springs (approximately 15 features) be used for drinking purposes on the tourist route. Eight springs have the greatest discharge and suitable water quality.

The distribution of identified springs along the route is uneven. The criterion for a campsite's access to spring water was the distance to the nearest source. Critical thresholds adopted in this study were more than 6 km upstream and more than 2 km downstream. If a spring is located within these distances, the campsite was classified as “supplied with drinking water”; if the distance to the nearest source exceeds these thresholds, the campsite was classified as “not supplied” (Table 5).

GIS development and tourist route design

Based on the results obtained during the field work, a GIS project was developed. A digital elevation model (Neal et al., 2023) was used as a cartographic base. The following layers were created: potential sites for tourist campsites; attractive tourist features, divided into two classes (significant attractive features and background attractions); spring locations; route start and end points and possible emergency exit points; and the route itinerary (Fig. 6).

Within the surveyed 183-km section, two variants of tourist routes can be proposed (Table 6).

Table 4. Characteristics of the Kolva River gauging stations at Petretsova and Cherdyn

Post code/ name	Station opened / closed	Catchment area, km ²	Distance from the mouth, km	Distance from the source, km	Gauge (station) zero, m B.S.	Mean catchment elevation, m	Mean channel slope, ‰
76105/ Petretsova	19.04.1927 / 03.2012	2830	237	223	142.73	270	0.9
76112/ Cherdyn	10.09.1877 – current time	13400	7,6	452	112.85	233	0.7

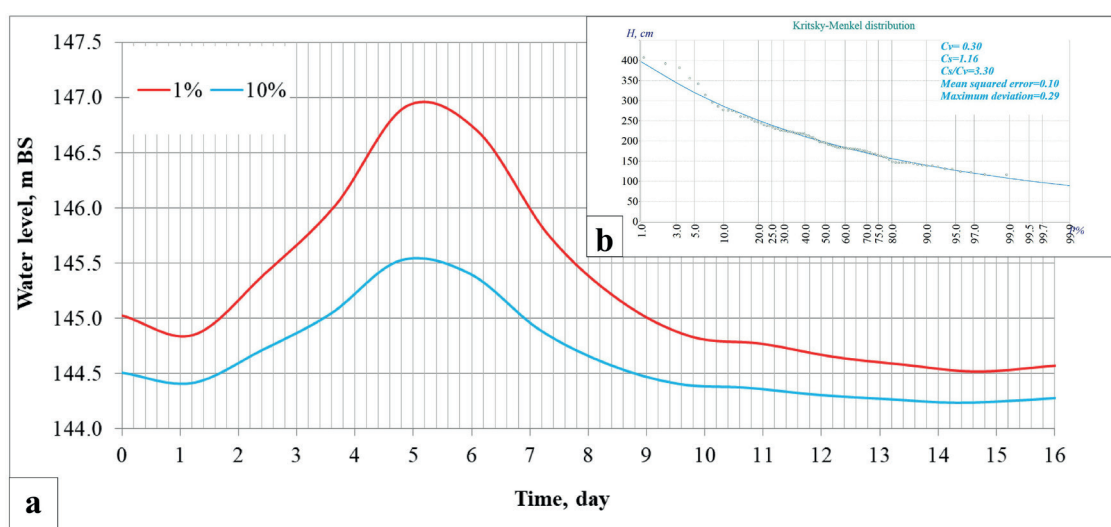


Fig. 5. Results of hydrological calculations for the Kolva River cross-section at Petretsova: a – water level hydrographs of rain-induced floods with 1% and 10% exceedance probabilities; b – Kritsky–Menkel distribution curve of maximum water levels for the summer–autumn flood period

As an example, Variant 2 is described below (Table 7).

The active part of the route begins at the base camp near the destroyed bridge over the Kolva River (Talovsky Most locality). The route is navigable during the summer low-water period (June–July). No challenging natural or manmade obstacles were identified on the surveyed section. The main obstacles on the route are:

Shallow sections (riffles) – requiring selection of the navigable channel depending on water level;

Overhanging trees above the channel (sweepers) – occurring in sections with eroding banks;

Submerged timber and remnants of bridge piers – localized to specific sections (including bridge pier remnants at 68.1 km).

Attractive features along the route are grouped by section in Table 8.

Panoramic viewpoints were recorded on the high bedrock slopes near the villages of Cherepanovo, Verkhny Nyuzim, Tulpan, Petretsova, and Korepino. From the high slope near Korepino village, the outlines of Buzhuysky Kamen (550 m a.s.l.), Korkasskaya Mountain (516 m a.s.l.), and Nizva Mountain (533 m a.s.l.) are visible.

Emergency exit points from the route are located near the road at 121.1 km (61.26716° N, 57.24113° E) and in the village of Verkhnyaya Kolva.

Thus, the obtained data confirm that the Kolva River is at the pioneer stage of tourism development (the exploration

stage according to Butler, 1980). This stage is characterized by the absence of service infrastructure (no equipped campsites, navigation signs, information boards, etc.). At the same time, the identified attractive potential and the developed route create prerequisites for the territory to transition to the next stage – involvement – which will require management decisions from the municipality and the region.

Limitations of the study

The main limitation of the study is that field work was conducted only during the summer low-water period (June–July 2025) and lasted 10 days. This does not allow us to assess the suitability of the route during other hydrological seasons (spring flood, autumn floods) and does not reflect the long-term dynamics of channel processes.

A scoring method was used to assess campsites and attractiveness. Such methods are widely used in evaluation studies on tourism topics. They are relatively simple to apply and universal (Ruiz-Pedrosa et al., 2024; Brilha, 2016; Macerinskiene, 2010; Pralong, 2005). At the same time, they have certain disadvantages: the problem of assigning weighting coefficients and selecting an optimal scale. In our study, a 3-point scale was chosen. For some criteria, such as access to drinking water, it proved excessive (a binary classification of “supplied – not supplied” would

Table 5. Source water supply for parking areas

Number	Name	Source water supply	Distance to nearest source, km
1	Talovsky bridge	not provided	> 17
2	Susay	provided	< 2
3	Parshakova	provided	< 1
4	Timenskaya	not provided	> 7
5	Tulpan	not provided	> 9
11	Petretsovo Beach	provided	< 6
12	Gadya	not provided	> 18
13	Korepino Beach	provided	< 2

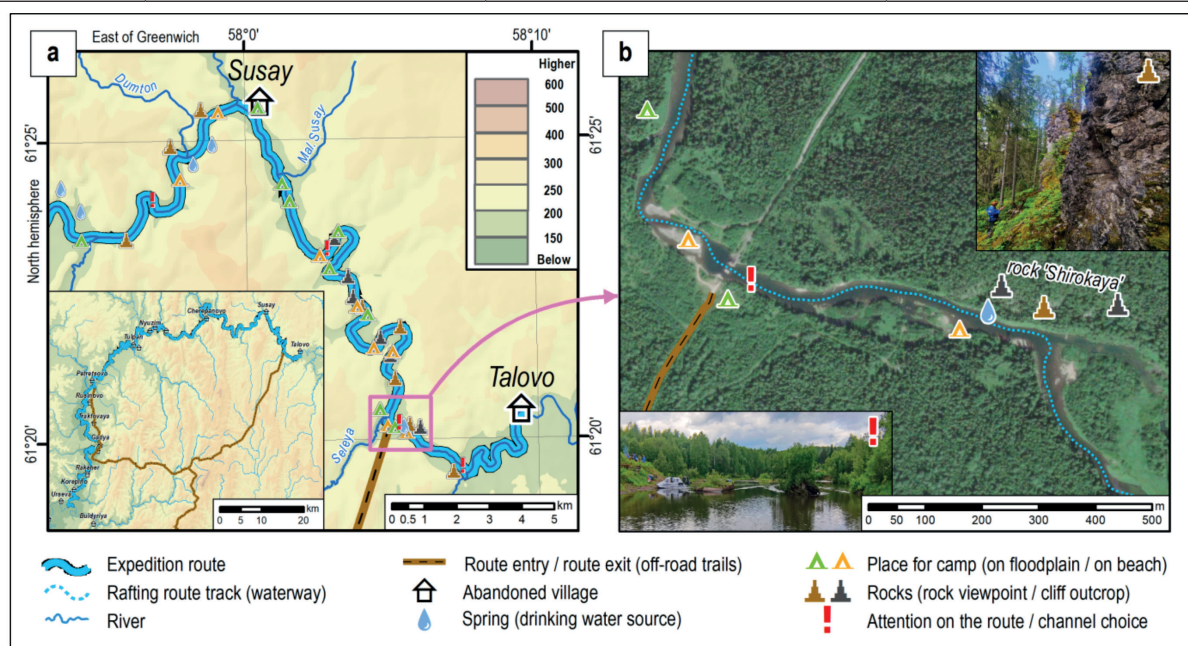


Fig. 6. Example of the GIS project “Tourism” presented at different scales: a – with relief display; b – superimposed on a satellite image

Table 6. Tourist route variants on the Kolva River

Variant	Section	Length (km)	Duration (days)
1	Talovsky Most locality – Petretsova village	115	from 7
2	Talovsky Most locality – Verkhnyaya Kolva village	144	from 8

Table 7. Itinerary of the tourist route⁶

Day	Route section	Distance (km)	Mode of travel
1	Perm – Nyrob settlement – Talovsky Most locality	482	motor vehicle, offroad vehicle
2	Talovsky Most locality – Talovo village – Talovsky Most locality (radial excursion, 8 km upstream)	16	airboat
3	Talovsky Most locality – Susay locality	24.5	motorized catamaran, motorboat, airboat
4	Susay locality – Parshakova locality	24	same as above
5	Parshakova locality – Cherepanovo village – Timenskaya village	26	same as above
6	Timenskaya village – Nyuzim village – Tulpan locality	19	same as above
7	Tulpan locality – beach located 2 km upstream of Petretsovo village	30.5	same as above
8	Beach – Petretsovo village – Gadya village	25.5	same as above
9	Gadya village – Verkhnyaya Kolva village	2	same as above
	Verkhnyaya Kolva village – Nyrob settlement – Perm city	471	motor vehicle, offroad vehicle

Table 8. Attractive features along the route

Route section	Attractive features
Talovsky Most locality – Susay locality	Zapadnye Kamni rock, Yezhov Kamen rock (grotto)
Susay locality – Parshakova locality	Dumton vauclose spring, Besov Kamen rock, Kumayskiye Skaly rock (2 caves), 6 springs
Parshakova locality – Timenskaya village	Neryinskoye mire, abandoned village of Cherepanovo (valley panorama), 2 springs
Timenskaya village – Tulpan locality	talus slope of Orlovskaya Mountain, Anylskaya oxbow lake, Tulpan village (Pokrovskaya Church, 1895), 1 spring
Tulpan locality – Petretsova village	1 spring
Petretsova village – Verkhnyaya Kolva village	Vizesyinskoye mire, Domashneye Lake, abandoned village of Petretsova (panorama), cave (Gadya village), 1 spring

suffice). For other criteria, such as landscape aesthetics, a 3-point scale appears insufficient.

A detailed campsite assessment was conducted within 10-km zones, which corresponds to routes using motorized watercraft. If conditions change (e.g., using only rowboats or kayaks), daily travel distances will decrease, the route duration will increase, and the number of assessed campsites will be insufficient. The study was carried out on a single river (the Kolva) within a single region (Perm Krai). One may also note the insufficient consideration of socioeconomic factors due to the specific nature of the study object. For rivers with permanent settlements and economic activity, such factors should be taken into account. This limits the possibility of generalizing the findings to other peripheral territories. To confirm the universality of the proposed methodology, its application to other rivers of the Northern Urals and other regions is required. This limitation will be addressed in the 2026 field season – the refined methodology will be tested on the Vishera River.

The lower section of the river from the mouth of the Berezovaya River to the town of Cherdyn, which is more accessible and likely more developed in terms of tourism, was not included in the study.

Future research

The Kolva River is a convenient object for studying the processes of involving peripheral territories in tourism activities. Since the studied territory is at the initial stage of tourism development, monitoring should be continued at intervals of 3–5 years. To provide arguments in favor of expanding the network of regional protected areas (in our case, extending the “Permsky” natural park to include the Kolva River), an assessment of the economic effects of different tourism development models is required: “spontaneous development” vs. “managed development”.

For future research, a hypothesis can be formulated: with adequate promotion, wide audience reach, and a well-developed tourism product, a pioneer territory may

⁶The route plan is part of the tourist route passport and is drawn up in accordance with GOST R 50681-2010 (2011). Tourist services. Design of tourist services. [online] Available at: <https://tour-vestnik.ru>. [Accessed 10 May 2026].

transition to the next stage – the involvement stage – within a period of 5–7 years. This stage is characterized by an increase in tourist flows, the inclusion of local communities in the provision of tourism services, and the establishment of tourism as a factor of economic growth.

Within the framework of further research, it will be necessary to address questions concerning the choice of development model for peripheral territories, and the determination of recreational capacity and permissible loads, as well as the assessment of economic, social, and environmental effects.

CONCLUSIONS

To solve the problem of integrating peripheral territories into regional economies, a scientific basis for their potential is required, particularly for tourism development. The complementary use of modern geoinformation technologies (GIS, remote sensing, UAVs) and traditional

expeditionary methods allows us to identify and assess the tourism potential of peripheral rivers with a level of detail and reliability that exceeds the capabilities of desk-based studies alone.

When studying the potential of a water body, it is necessary to assess its hydrological characteristics, hydrochemical parameters, recreational geographical potential of the shoreline zone, and attractiveness.

The study conducted on the Kolva River provided a scientific basis for and enabled the design of a tourist-expeditionary route for a territory at the pioneer stage of tourism development. The thematic GIS "Tourism in Peripheral Territories" created in this study is an open and accessible tool for making management decisions regarding territorial development.

The practical significance of the work lies in the transfer of readymade products – the tourist route passport and the thematic GIS – to the Ministry of Tourism of Perm Krai. Further research is planned on the Vishera River. ■

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