Alloy modeling in ecological tourism development concept in Russia

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Abstract. Russia has developed and adopted a government-level strategy for the development of the tourism industry. This strategy includes a set of measures for developing ecological tourism. Russia has an enormous amount of natural resources, including numerous reserves, wildlife sanctuaries, parks, lakes, mountain ranges, and other attractions that will draw not only domestic tourists but also tourists from all over the world. The creation of digital models that simulate key aspects of natural sites where tourist projects are planned to be implemented allows us to forecast changes in the state of the natural ecosystem, tourist flows, and supporting infrastructure with precision. This paper presents the main results of modeling river rafting routes in the Republic of Tyva (Russia). This object of research was chosen because it represents the initial level of tourism development in the republic (according to the national tourism rating among Russian regions). To achieve this, first, it is necessary to determine the factor that could affect the condition of our key rafting sites.

1 Introduction

According to the report of the UN World Tourism Organization, by the end of 2023, the income from international tourism reached the level of 2019 (before the introduction of restrictions related to the COVID-19 pandemic). Specific tourist destinations showed significant growth by the beginning of 2024: Serbia (+127%), Turkey (+82%), Pakistan (+72%), Tanzania (+62%), Portugal (+61%), Romania (+57%), Japan (+53%), Mongolia (+50%), Mauritius (+56%), Morocco (+44%). The subsequent development of international tourism and the level of confidence in it among citizens is feared by experts due to the presence of economic and geopolitical problems [1, 2]. It is expected that this will be the reason for tourists to choose routes in regions closer to their homes.

To ensure and develop the Russian tourism industry, the Government has developed a national project until 2030, which envisages public and private funding for the construction and modernization of infrastructure for tourism clusters in various regions of the country. It is planned to increase the share of tourism in the country's GDP up to 5% due to the completion of construction of year-round resorts, development of existing transport and other related infrastructure, development of educational programs for schoolchildren, college and university students related to tourist trips (Kommersant Publishing House). Thus, not only

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the economic component of the industry will be ensured, but also the active promotion of the values of a healthy lifestyle of citizens will be ensured.

One of the directions of tourism, contributing to the formation of a healthy lifestyle, is ecological tourism. According to the Russian legislation, it refers to the activity of organizing nature trips related to the observation and introduction of tourists to nature for its preservation [3]. At the same time, it should comply with at least one of the principles that realize acquaintance with wildlife, local customs and culture; minimize negative consequences of environmental and socio-cultural nature, as well as comply with environmental protection requirements; involve the local population in the tourism process; economically develop the region and carry out activities in the field of environmental education [4, 5].

Ecotourism in Russia demonstrates every year growth rates (+40%), starting from 2022. In total, there are 231 federal specially protected natural areas in Russia, including 104 state nature reserves, 65 national parks, 62 federal wildlife sanctuaries [5]. It is noted that the potential of using such territories has not been realized [4]. At the same time, it is required to use models of territories' development that allow to assess the anthropogenic load on it (for instance, the impact of the development of transport accessibility, the number of visitors).

To solve the problems of assessing changes in the states of objects and processes within a certain time interval under the influence of random factors, simulation modeling methodologies are used [6]. They are used to create digital doubles of real objects, reflecting their investigated aspects, to conduct experiments in the field of predicting pedestrian flows [7, 8], the speed and nature of motor vehicle traffic when changing the street road network [9, 10], assessing the state of natural systems from changes in specific characteristics [11, 12], etc.

Based on this, the purpose of the work is to develop a simulation model of a natural territory suitable for assessing the possibility of realizing the concept of ecological tourism. This requires to establish the object of research, the model of which should be developed; to create a project of modernization of the territory within the framework of the implementation of the concept of ecological tourism; to identify the key characteristics of the object of research, which will be affected by the developed project; to formalize the obtained results.

The performed work has a theoretical significance consisting in the realization of interdisciplinary approach. For the accomplishment of the work requires systematization and consolidation of knowledge from the fields related to ecology, economics, sociology, geography, information technology, simulation modeling. This promotes research both within each specific field and interdisciplinary developments.

In addition, the work has practical relevance. It consists in the creation of a general concept of modeling the states of natural areas in order to analyze the sustainability of the ecosystems concerned (thus identifying vulnerable sites for which strategies can be developed quickly to ensure their security) and the creation of tools (both documentary and technical) capable of monitoring or supporting, at different levels (tourist company owner or authorities), the adoption of informed decisions aimed at the development of infrastructure and the support of stable and sustainable tourism.

2 Methods

The list of studied research related to the creation of simulation models of complex systems has shown that the use of author's methods is not required to formalize objects and processes of the subject area. To solve such objectives, it is enough to use general scientific methods that make it possible to obtain a textual description of the research object and apply to the obtained results methodologies capable of transforming them using unified graphical languages and technical means of modeling [6, 10, 11].

To create the concept of transformation of the natural territory and to develop activities related to eco-tourism, the methods of statistical analysis and comparison were used. The analysis of the characteristics of natural objects, on the territory of which the relevant projects are realized or created, made it possible to establish the characteristics most attractive for tourists, the density of distribution of tourist places by regions and their demand. As a result of applying the method of comparison, positive practices in the implementation of similar projects and a place for the creation of a tourist cluster were established.

The methods of structuring, analysis, synthesis and observation were used comprehensively to determine the key characteristics of the selected place for the implementation of the concept of ecological tourism. As noted in research, with the help of these methods the multi-level structure of the research object is determined, which is a hierarchy of objects, processes and relations between them [6, 13, 14].

The simulation model was developed using the methodology of agent-based modeling. This approach makes it possible to establish classes of objects of the subject area with similar behavior and characteristics that can affect the change of state of both the whole system and specific parts of it [7, 8, 14]. A graphical method was used to visualize the obtained results.

3 Results

Analysis of statistical data has shown that the most popular month in which tourists visited Russia's specially protected areas was July. June, August and September were also popular months for visiting. Such data can be explained by the pronounced seasonality in Russia and coincidence with the vacation season for the majority of the country's population. The research analyzed the number of tourists by regions of the country where protected areas are located. Fig. 1 shows the results of the most popular regions visited during the calendar year.

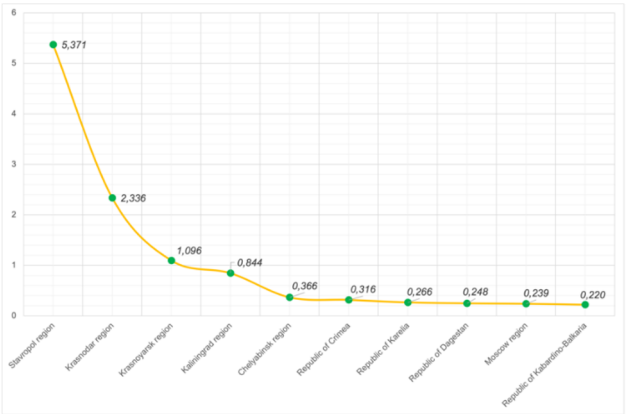

Fig. 1. Total attendance of Russian regions by tourists (in mln), where specially protected natural areas are located [compiled according to the Association of Tour Operators: https://www.atorus.ru/node/50962]

The leader in terms of the number of ecotourists is Stavropol Krai, which has 108 specially protected nature reserves and natural monuments with unique biological objects of cultural and historical heritage and landscape diversity. In such places there are ecotrails on foot (for instance, to Mount Beshtau), in addition to them there are routes involving excursions on horseback or bicycles.

If we analyze the attendance of natural sites, the rating looks as shown in Fig. 2.

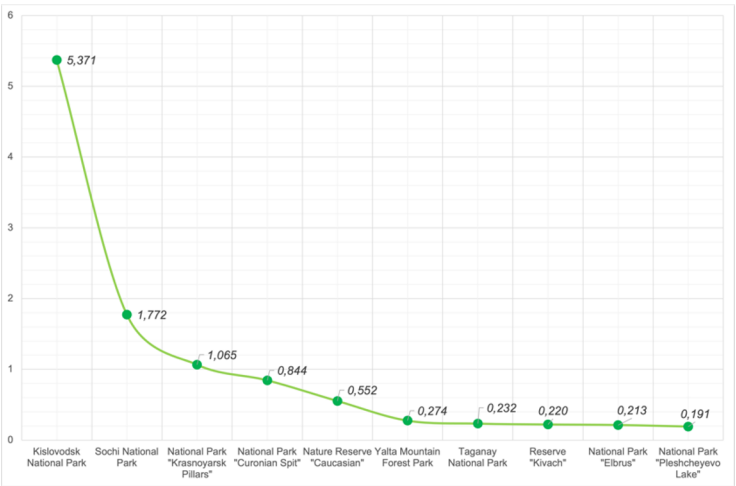

Fig. 2. Total attendance (in mln) of specially protected natural sites in Russia [compiled according to the Association of Tour Operators: https://www.atorus.ru/node/50962]

The high popularity of Kislovodsk National Park is due to its convenient location: its part is located in the city limits of Kislovodsk in Stavropol Krai. The town is a popular resort place with a wide therapeutic profile.

The national project related to the development of tourism stipulates that tourist clusters should be created in each region. The Republic of Tyva was chosen to test the methodology of using simulation modeling to make it possible to predict changes in the processes. Tyva has significant tourist resources, including natural-recreational and historical-cultural characteristics. The location of the region, the relief of the territory, the relatively small population and the development of transportation infrastructure create certain difficulties for the development of tourism. According to the National tourist rating of regions, Tyva ranks 84th, which corresponds to the initial level of development of the tourism industry.

Tyva is located in the center of the Asian continent. On its territory there are practically all natural zones of the Earth: deserts, mountains, steppes, taiga, tundra and alpine meadows. At the same time in the region there are two reserves, the natural park “Taiga”, 15 state nature reserves and 15 natural monuments. Reserves and natural park are mostly located closer to the borders of the republic, and nature reserves and natural monuments - in the center.

The center of the republic is a group of hollows surrounded on all sides by high mountain ranges. Within Tyva there are 45 peaks with the height of more than 3 thousand meters. One of the largest rivers of Russia and the world - Yenisei - originates in Tyva, so most of the republic belongs to the basin of this river. Some of the tourist routes are rafting on the rivers.

In addition to hiking and rafting, there are event tourism (for instance, up to 200 cultural events are held in the summer), ethno-cultural and health tourism in the republic.

As an example, let us consider one of the routes, which involves rafting on the river. To create a digital twin and model scenarios of environmental impact, the key characteristics of the object are established.

The rafting is carried out along the river Bash Khem (52.307421, 96.880060), the beginning of the route is located at the cordon of the Azas reserve (https://maps.app.goo.gl/MkG2W1PaEaduP8je7), located at an altitude of 1250 meters. The river overcomes a 250 m drop in 45 km of the route. The narrowness of the river alternates with open green terraces. In the Bash Khema hill the category of difficulty of rafting is 5, in the canyon there are about 10 rapids of difficulty 4 (they are rocky shivers). Overcoming of the route is carried out during several days with stops. In specific cases it can be shortened and simplified.

Here is a fragment of a digital model of one of the river sections, along which the rafting is carried out (Fig. 3). The areas marked in green color denote height differences on land, in blue - water rapids.

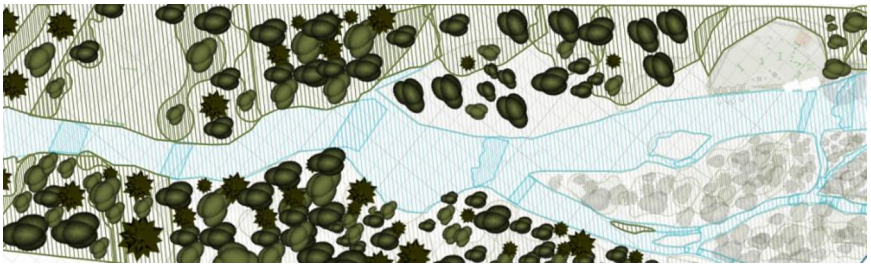

Fig. 3. Fragment of the digital twin of river rafting

The agents in this model are: watercraft, instructors and tourists. During rafting, the agent is a watercraft with a limited number of tourists and a corresponding number of instructors. In this case, the change in the states of tourists and instructors, as an object of research, corresponds to the behavior of the watercraft. At the parking place the behavior of tourists and instructors is different, so they are allocated in specific categories of objects. Based on this, we present a fragment of the diagram of transitions of the states of the main agents during overcoming the shown part of the route (Fig. 4).

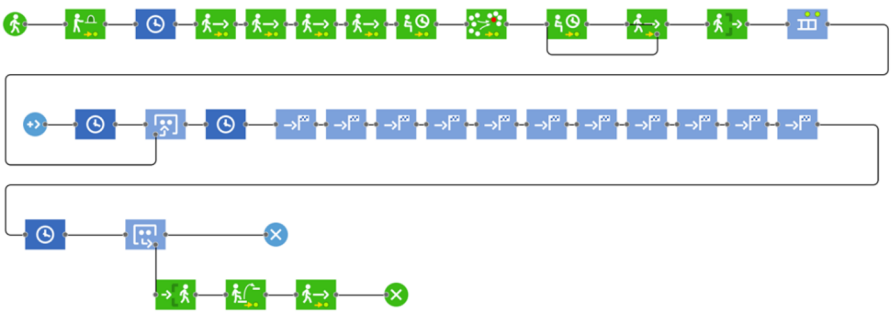

Fig. 4. Fragment of the diagram of state transitions for the main categories of objects when traversing the alloy section

In the diagram, the icon shows the states of objects when crossing the threshold. Behavior of tourists during intermediate stops includes the states of waiting for the group to assemble ( ), grouping into groups housed in boats ( ), moving around during a stopover ( ) and splitting up the group during a traffic stop ( ).

The created digital twin of the territory belonging to the tourist rafting zone makes it possible to assess the complexity of the routes, its congestion, as well as the need to create supporting infrastructure and a set of measures to ensure nature conservation.

4 Discussion

The stated research methods were used to obtain accurate, correct, and valid results. The results are based on rigorous scientific methodology. They align with the characteristics of related research in the field of creating digital doubles of real objects [5, 7, 10, 15]. In such research, the authors definitively established the aspects of the subject area, which were

subsequently systematized to identify the key ones—those that significantly affect the change in the states of its processes.

The digitalization of processes related to forecasting tourist flows allows for the assessment of eco-tourism development in a given territory. As other research on economic development and digital solutions for process management has shown, our model meets the requirements for sustainable regional development [2, 3, 16].

5 Conclusions

The Russian Government forecasts a significant increase in the number of tourist trips across the country. To meet this demand, we must modernize existing tourism infrastructure, develop transportation, adapt tourist routes, and implement measures to reduce environmental impact. It is of the utmost importance that the state of the environment is addressed by public authorities, business representatives, and the population alike. This must be done in a timely manner and with the prevention of further environmental problems as a priority.

This is primarily due to the fact that identifying problems at a real object is a lengthy process. The solution to these problems is the creation of digital models capable of analyzing a large amount of data in a fairly short time interval and forecasting changes in the states of ecosystem objects. Constant monitoring of the state of key ecosystem parameters is essential to ensure the accuracy of forecasts. Furthermore, the use of research results will ensure the environmental safety of the natural object and the development of the regional economy. It will also stimulate the processes of preserving cultural heritage and strengthening the cultural identity of the region.

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