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Application of GIS technology in cross-border tourism cooperation planning. Taking the analysis of the spatial pattern of cross-border eco-tourism cooperation in the Altai Mountains region as an example

Since the 1960s, the application of GIS technology in the field of geography has led geography to the development path of informatization and digitization. GIS technology, which focuses on spatial information analysis and spatial data management, has become an important spatial system for geographic exploration. GIS technology has extremely important advantages in collecting, processing, simulating, analyzing and expressing geospatial data. *Object:* This paper takes the spatial pattern of cross-border tourism cooperation in the Altai Mountains region as the research object. *Methods:* The research methods are: the terrain analysis, three-dimensional scene simulation, data statistics, suitability analysis, visual domain analysis, transportation network analysis, and project site selection of GIS technology in tourism planning. *Results:* The presented research is analytical in nature. The specific application of GIS technology in tourism planning is discussed. Also, 7 types of GIS applications were considered in the paper. In summary, GIS is mainly composed of data input system, data management system, spatial analysis system and data output system. It has very important application value in tourism management and development.

Keywords: GIS, tourism planning and development, spatial pattern, application value, ecotourism, 3D scene simulation, terrain analysis.

Introduction

The Altai Mountains cover 600,000 sq km of Russia, Mongolia, Kazakhstan, and China reaching an altitude of 4.500 m above mean sea level and including many peaks over 4000 m. They are home to over 75 species of mammals, and 2000 species of wild plants inhabiting a wide range of habitat types extending from the alpine zone down through scattered high mountain forest and mountain steppe to lowland desert steppe and sparse riparian forests in the valleys. The wild and domesticated species of the Altai Mountains, together with the distinct ecosystems in which they live, comprise the area's biodiversity — a unique assemblage with intrinsic values as an irreplaceable product of natural selection, biogeography, and local history, and utilitarian values for human livelihoods today and in the future [1] (Fig. 1).

Relying on the comprehensive natural landscape of the mountains around the Altai Mountains to create an international tourist hotspot, and learning from the Alpine cross-border tourism cooperation model of Switzerland, Italy, Slovenia, and Croatia, cross-border tourism in the Altai Mountains region is fully qualified to become a world-class. It is a tourism brand that can achieve a tourism scale of more than 10 million people and an income of more than 1 billion U.S. dollars.

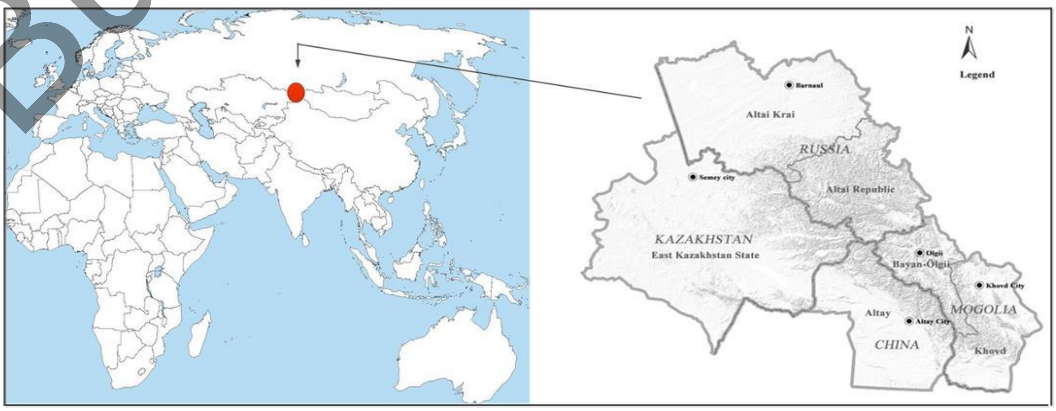

Figure 1. Area map around the Altai Mountains

Literature review

Tourism planning is a highly comprehensive and highly complex systematic project, involving the acquisition of tourism spatial information data, tourism environment analysis and resource evaluation investigation, market research, spatial layout, project development, resource environmental protection, and sustainable development. As well as topography, land use, transportation, humanities, economy, and other levels, the amount of information and data is huge [2].

GIS technology, with its powerful functions such as graphical data collection, data analysis and processing, spatial data visualization, and spatial analysis, can effectively plan regional tourism and provide new development methods and new tools for the micro and macro management of the tourism industry. It provides strong support for improving the efficiency of tourism planning and strengthening the scientific nature of planning [3].

Geographic information system (GIS) is a computer-based technology that is used to manage and manipulate geographic data [4]. The main worth of GIS is in geographical analysis where vector and raster data models are used to perform six prime analysis functions: proximity analysis, network analysis, overlay analysis, temporal change analysis, statistical analysis, and three-dimensional visualization [5, 6].

GIS offers valuable manifold benefits for the development of modern tourism. The use and application of GIS technologies in the tourism sector can be divided into three major application areas: tourism development and research, tourism planning, and tourism marketing [7].

In tourism development and research, the use of GIS provides valuable information on areas facing environmental degradation and requiring rehabilitation and restoration. Burrough [8] presents a use case of GIS-based image analysis and data visualization functionalities for the mapping of object data. In tourism planning, Minagawa Tanaka [9] has successfully used GIS technologies to describe and identify tourism infrastructure elements, such as visitor centers, hotels, trails, and field situations. Using queries to geo-relational data, proximity and overlay functions were used to provide tourists with updated information about both places to visit and to explore [10], as well as to obtain information about specific tourist services [11]. Furthermore, GIS successfully applies to promote, plan, implement, manage, and market tourism resources. According to Rahman [12], modern tourism marketing strategy depends on making an analysis on geodemographic characteristics, experiences, cultural heritage, time-space factors, all of which can be performed using GIS and, thus, makes it possible to locate and analyze the geodemographic characteristics of actual and potential travelers.

Selected spatial pattern of ecotourism landscape

Kazakhstan Katon-Karagay Nature Reserve (National Park) and Markakol Nature Reserve (National Park). Russian Federation, Teletskoye Lake, Altai Nature Reserve, Belukha Mountain, Katunsky Cumin Reserve and Ukok Plateau, Kosh-Agach, Sumul'tinskiy Khrebet, etc.; Kanas Nature Reserve, China, Liangheyuan Nature Reserve District, Burgen Beaver National Nature Reserve. Mongolia Siilkhemiin Nuruu National Park; Khukh Serkhiin Nuruu National Park; Altan Khukhii Uul Nature Reserve; Bulgan Gol-Ikh Ongog National Park. Tsambagarav Uul National Park; Chigertein Golin Ai Sav National Park; Harusnur Ramsar Wetland, etc. (Fig. 2).

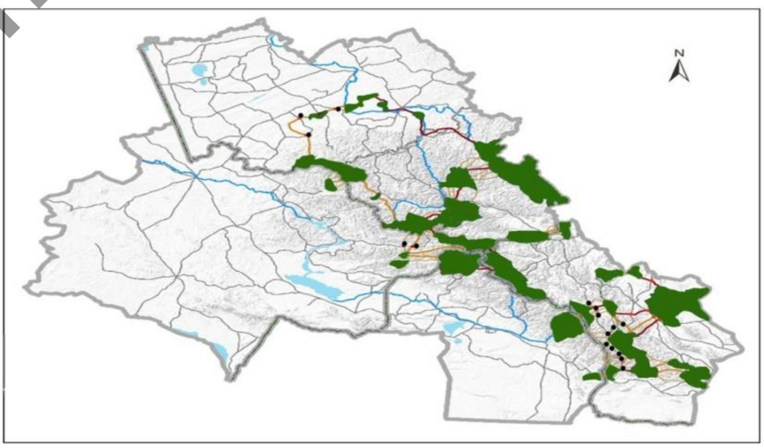

Figure 2. Selected spatial pattern of ecotourism landscape

Experimental

Statistics

Since the conditions of ecotourism resources in the Altai Mountains are basically similar, the selected ecological blocks are used as data statistics objects in the planning operation process (Utilization area, building height, building density, green area ratio, floor area ratio, etc.).

Refine and analyze the relevant data of surveying and mapping topographic maps of various scenic spots through the GIS system, and display the data in the form of data, charts, and maps in a complete and intuitive way, to estimate and save costs for the land use of tourism planning and the filling and excavation in the implementation of the plan provide effective reference.

Filling and digging statistics

Due to the uneven terrain, the construction of the area around the Altai Mountains is difficult, and the spatial pattern of the scenic spots is unbalanced. In order to save construction costs, vertical planning is mainly used.

In the vertical planning, the elevation value is used to study the topography after planning. This is prone to large deviations in the terrain design of mountain tourist areas (for example, the retaining wall is too high, the leveling of the site is too difficult, the earth and stone are difficult to balance, etc.).

Using GIS can simulate the planned topography of the site, analysis and adjustment are carried out at the same time, through the superimposition of the planned topography and the original topography, it can clearly display the topography of the project land and the fill and excavation data of the project site development.

Case: It is estimated that 1.8 million square meters of filling, 860,000 square meters of excavation, unbalanced filling and excavation, need to borrow soil in other areas, or modify the vertical plan (Fig. 3)

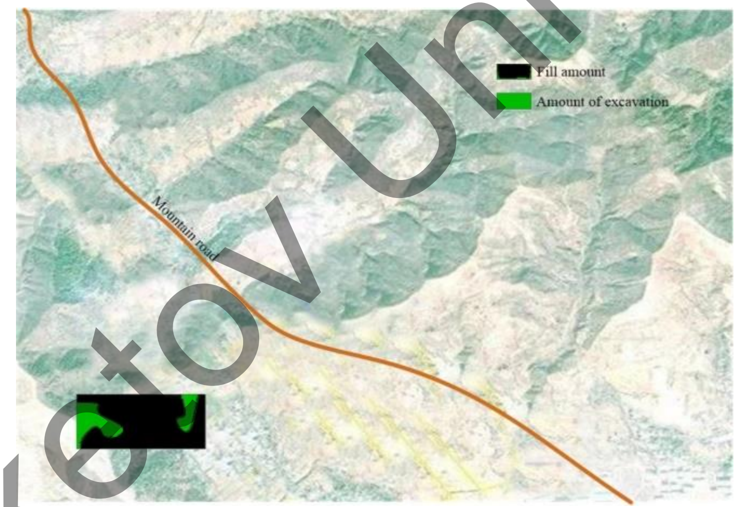

Figure 3. Analysis diagram of filling and excavation of a landscape in Altai Mountain

Land use index

Land use indicators include the spatial distribution of various types of land in the project site, used area, building density, green area ratio, floor area ratio, etc. Through the analysis of surveying and mapping topographic maps, statistics of various land data indicators are used to predict and analyze the available land for future projects.

Terrain Analysis

Terrain analysis is a necessary prerequisite for the construction of eco-tourism projects, especially in the development of mountainous tourist attractions.

The terrain of the Altai Mountains is very complex, and more accurate measurement techniques are needed to support the project, that is, using GIS to analyze features such as elevation, slope, aspect, and hydrology (topography-based catchment line).

At the operational level of tourism planning, this technology has strong guidance for terrain control, water system planning, drainage conditions analysis of mountainous areas, and suitability analysis of construction conditions (Fig. 4, 5).

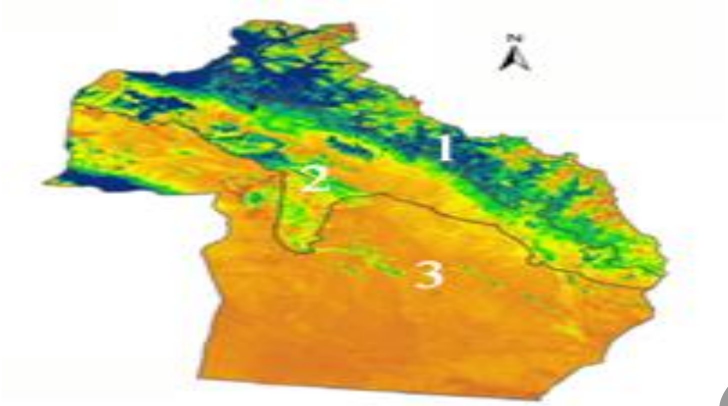

Figure 4. Schematic diagram of land division in the Altai Mountains of China
(1. Mountain zone; 2. Oasis zone; 3. Desert zone)

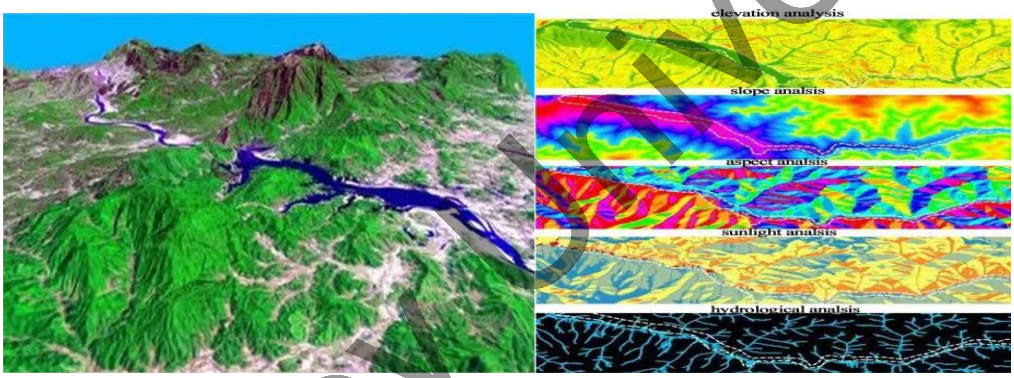

Figure 5. Topographic analysis diagram

3D scene simulation

Three-dimensional scene simulation can simulate the current situation of mountain landscape spatial pattern and the planned terrain, traffic, water system, vegetation, architecture and other scenes in 3D mode. Through the simulation function of the three-dimensional scene of various scenic spots in the Altai Mountains area, you can feel the terrain and the atmosphere of the site in an intuitive digital environment, and provide an excellent research foundation for road traffic planning, project layout and other program design content (Fig. 6).

Figure 6. Three-dimensional simulation diagram

Suitability analysis

The area around the Altai Mountains belongs to a special ecosystem. In cross-border tourism planning, tourism projects are often developed and constructed in areas with beautiful ecological environments. This involves ecological sensitivity and construction suitability analysis. Use GIS technology to analyze and evaluate individual factors such as terrain, water system, land, vegetation, and buildings, and use map overlay methods to generate comprehensive analysis results, and divide the development area according to the levels of suitable construction, more suitable construction and unsuitable construction, or Ecological protection areas are divided according to the high, medium, and low levels of ecological [13].

Analysis of Landscape Horizon

The analysis of the landscape horizon is an important content in mountainous ecotourism planning. The horizon analysis of the cross-border ecological landscape GIS in the Altai Mountains area includes whether the points are mutually visible, the visual domain of the points, and the visual domain of the route. The visual field of the surface (Fig. 7). Through the analysis of landscape horizons, it is possible to analyze the scope of sights and viewing routes, as well as the visual conditions of each scenic spot, which has a strong guiding role in planning the spatial pattern of important scenic spots, viewing facilities and viewing routes [14].

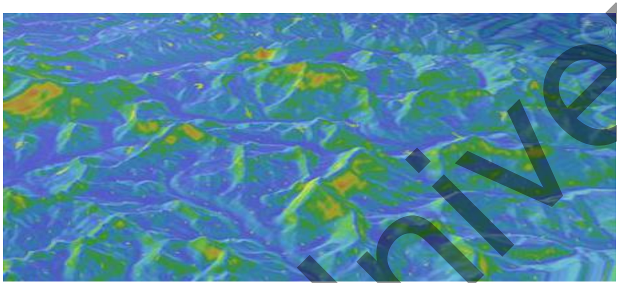

Figure 7. Analysis of Landscape Horizon

Traffic network analysis

In the Altai Mountains, GIS can construct a network data set to import linear elements (roads, etc.) and point elements (entries, stops, junctions) into the network data set, and set traffic attributes such as connectivity, traffic cost, turning radius, etc. Accurately construct the transportation network, and can also simulate the road conditions such as one-way lanes, no-turns at intersections, time-sharing road conditions, and above-ground and underground traffic changes. On this basis, the shortest driving path is calculated, which provides clear road traffic planning and service facility planning for tourist attractions guidelines [15] (Fig. 8-10).

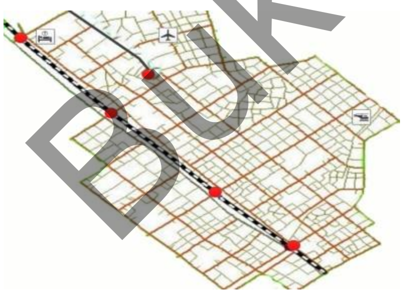

Figure 8. Traffic network analysis

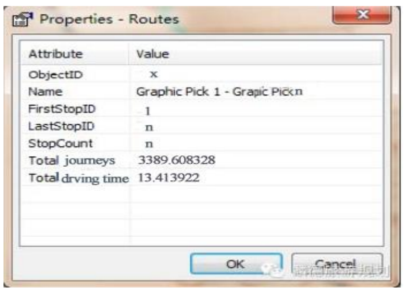

Figure 9. Schematic diagram of traffic simulation data statistics

Figure 10. Schematic diagram of service area

Optimal site selection of the project

The optimal site selection of the project is to combine topographic and geomorphological analysis, suitability analysis, horizon analysis, refer to traffic network analysis, and determine the appropriate location of the project by using the “location allocation” technology or the use of buffer overlay technology according to the project's limited conditions, and determine the site selection of the project based on planning needs. This function has scientific guiding significance for the spatial pattern of the project layout of tourist attractions in tourism planning.

Concluding remarks

In summary, GIS is mainly composed of data input system, data management system, spatial analysis system and data output system. It has very important application value in tourism management and development. In addition to the above seven types of applications, GIS technology also includes the display of three-dimensional scenes in tourist attractions, tourism decision support, tourism planning and mapping, tourism resource value evaluation, environmental monitoring and protection, and tourism The application of information query and other aspects also has a huge effect [16, 17].

The full application of GIS technology in tourism planning can greatly improve the scientificity, operability and landing of the planning. It is one of the important directions for the future development of tourism planning. It is also the tourism management unit to provide a complete and reliable data basis for its development. Scientific and reasonable tourism management and development plans promote the development of the tourism industry.

Acknowledgments

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References

1 The Altai Mountains Biodiversity Strategy Preparation Team (2009). The Altai Mountains Biodiversity Conservation Strategy, Safeguarding the biological diversity and natural ecological processes of the Altai Mountains landscape alongside local livelihoods and economic development. Retrieved from https: //panorama.solutions/sites/default/files/Altai_Mountains_Biodiversity _Conservation_Strategy_English_-_Small.pdf

2 Lew, A.A. (2007). Invited Commentary: Tourism Planning and Traditional Urban Planning Theory: Planners as Agents of Social Change. Leisure. *Loisir: Journal of the Canadian Association of Leisure Studies, 31*(2), 383-392. https://doi.org/10.1080/14927713.2007.9651387

3 Boers, B. & Cottrell, S. (2007) Sustainable Tourism Infrastructure Planning: A GIS-Supported Approach. *Tourism Geographies, 9*(1), 1-21. http://doi.org/10.1080/14616680601092824

4 Bennett, D. & Armstrong, M. (2001). Fundamentals of geographic information systems (GIS). *Manual Geospatial Sci Technol.,* 411-430. http://doi.org/10.1201/9780203305928.ch25

5 Fotheringham, S. & Rogerson, P. (1994). Spatial Analysis and GIS. CRC Press.

6 Kurian, G. (2011). Spatial Analysis. The encyclopedia of political science. CQ Press. https://dx.doi.org/10.4135/9781608712434

7 Sureshkumar, M., Uttej, B.S.DB. & Mahadevan, K. (2017). Applications of GIS in Tourism. *Int J Latest Eng Manag Res., 2*(4), 12-16.

8 Burrough, P.A. (2001). GIS and geostatistics: Essential partners for spatial analysis. *Environmental and ecological statistics., 8*(4), 361-377. http://doi.org/10.1023/A:1012734519752

9 Minagawa, T. (1998). Application of geographic information systems to tourism development planning: a case study of Lombok. Indonesia.

10 Christ, C., Hillel, O., Matus, S. & Sweeting, J. (2003). Tourism and Biodiversity: Mapping Tourism’s Global Footprint. Conservation International.

11 Kim, N. & Graefe, A.R. (2000). GIS application of outdoor recreation management: social and physical variables of carrying capacity. *International Journal of Tourism Sciences, 1*(1), 1-18. https://doi.org/10.1080/15980634.2000.11434515

12 Rahman, M.A. (2010). Application of GIS in ecotourism development: A case study in Sundarbans, Bangladesh. Retrieved from http://www.diva-portal.org/smash/get/diva2:326461/FULLTEXT01.pdf

13 Zhang, Yu. & Chen, X. (2016). A Study on the Choices of Construction Land Suitability Evaluation of Ecological Index. *Procedia Computer Science, 91,* 180–183.http://doi.org/10.1016/j.procs.2016.07.054

14 Mazrekaj, R. (2020). Impact of Road Infrastructure on Tourism Development in Kosovo. *International Journal of Management, 11*(4), 466-474.

15 Jovanović, V. & Njeguš, A. (2008). The application of gis and its components in tourism. *Journal of Operations Research, 18*(2), 261-272.

16 King, G.Q. (1991). Geography and GIS Technology. *Journal of Geography, 90*(2), 66-72. https://doi.org/10.1080/00221349108979238

17 Pareta, Dr.K. (2013). Remote sensing and GIS based site suitability analysis for tourism development. *International Journal of Advanced Research in Engineering and Applied Sciences, 2*(5), 43-58.

Ф. Хан, А. Адай, Б.Д. Жанділла

Туризм саласындағы трансшекаралық ынтымақтастықты жоспарлау кезінде ГАЖ-технологияларды қолдану. Алтай тауларындағы экотуризм саласындағы трансшекаралық ынтымақтастықтың кеңістіктік құрылымын талдау мысалында

1960 жылдан бері география саласында ГАЖ (ГИС) технологияларын қолдану географияны ақпараттандырумен цифрландырудың даму жолына түсірді. Кеңістіктік ақпаратты талдау және деректерді басқаруға бағытталған ГАЖ технологиясы географиялық зерттеулер үшін маңызды кеңістіктік жүйеге айналды. ГАЖ технологиясы геокеңістіктік деректерді жинауда, өңдеуде, модельдеуде, талдауда және таратуда өте маңызды артықшылықтарға ие. *Мақсаты:* Мақалада зерттеу нысаны ретінде Алтай тауы аймағындағы трансшекаралық туристік ынтымақтастықтың кеңістіктік құрылымы қарастырылған. *Әдісі:* Зерттеу әдістері ретінде жер бедерін талдау, жергілікті талдау, орналасу орнын үш өлшемді модельдеу, деректер статистикасы, жарамдылықты талдау, визуалды аймақты талдау, көлік желісін талдау және туризмді жоспарлауда ГАЖ технологияларын қолдана отырып жоба орнын таңдау талданған. *Қорытынды:* Ұсынылған зерттеу аналитикалық болып табылады, мақалада туризмді жоспарлауда ГАЖ технологиясының нақты қолданылуы талқыланған. Сонымен қатар, ГАЖ Қосымшаларының 7 түрі қарастырылған. Осылайша, ГАЖ негізінен деректерді енгізу жүйесінен, деректерді басқару жүйесінен, кеңістіктік талдау жүйесінен және деректерді шығару жүйесінен тұрады. Бұл туризмді басқару мен дамытуда өте маңызды қолданбалы мәнге ие.

Кілт сөздер: ГАЖ, туризмді жоспарлау және дамыту, кеңістіктік құрылым, қолданбалы құндылық, экотуризм, 3Д көріністі модельдеу, жергілікті жерді талдау.

Ф. Хан, А. Адай, Б.Д. Жанділла

Применение ГИС-технологий при планировании трансграничного сотрудничества в области туризма. На примере анализа пространственной структуры трансграничного сотрудничества в области экотуризма в Горном Алтае

ГИС-технологии, с их мощными функциями, такими как сбор графических данных, анализ и обработка данных, визуализация пространственных данных и пространственный анализ, могут эффективно планировать региональный туризм и предоставлять новые методы развития и инструменты для микро- и макроуправления туристической отраслью. В настоящей статье в качестве объекта исследования рассмотрена пространственная структура трансграничного туристического сотрудничества в Горном Алтае. Авторами проанализированы местность, трехмерное моделирование сцены, статистика данных, пригодность, визуальная область, транспортная сеть и выбор места проекта с использованием ГИС-технологий в планировании туризма. Представленное исследование носит аналитический характер. Обсуждено конкретное применение ГИС-технологий в планировании туризма. Кроме того, были рассмотрены 7 типов ГИС-приложений. Таким образом, ГИС, в основном, состоит из системы ввода данных, управления данными, пространственного анализа и системы вывода данных. Это, в свою очередь, имеет важное прикладное значение в управлении и развитии туризма.

Ключевые слова: ГИС, планирование и развитие туризма, пространственная структура, прикладная ценность, экотуризм, 3Д-моделирование сцен, анализ местности.