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GIS-BASED GEOTOURISM PLANNING AND DEVELOPMENT:
CASE STUDY OF VOGHJABERD–GEGHARD AREA,
ARMENIA

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This article assesses the geotourism potential of the Voghjaberd–Geghard area (Armenia) using GIS technologies and Multi-Criteria Decision Analysis (MCDA). The assessment is based on an analysis of the relief, transport accessibility, hydrography, and spatial distribution of natural and cultural sites. The results revealed high potential for geotourism development in the Voghjaberd–Geghard area and allowed the identification of three geotourism clusters. The study demonstrated the effectiveness of using GIS and MCAD for assessing territories, planning sustainable geotourism development, and identifying sensitive areas.

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Introduction. Geotourism has emerged as an approach to sustainable tourism development emphasizing the conservation and interpretation of geological, geomorphological, and cultural heritage resources of territories. It promotes responsible travel to natural and cultural sites focusing on visitors' understanding of local landscapes and geological processes.

It goes without saying that Geographic Information Systems (GIS) have become essential instruments in tourism planning and development. GIS enables the collection, analysis, visualization, and management of spatial data, identifying tourism resources, assessing their accessibility, evaluating environmental sensitivity, developing tourism infrastructure, etc. Through spatial analysis, GIS facilitates the identification of areas with high tourism potential while minimizing negative impacts on natural and cultural resources.

The rich geological and cultural heritage of Armenia offers broad opportunities for geotourism development. Among its most notable destinations is Voghjaberd–Geghard area: it is well-known for unique geological formations, including the Azat River gorge and basalt column structures, as well as cultural

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monuments such as Garni Temple and Geghard Monastery. Combination of geological, historical and cultural attractions makes the area a suitable destination for integrated geotourism development. Despite the significant popularity of the study area among domestic and international visitors, comprehensive spatial planning for geotourism still remains insufficiently developed and limited. Obviously, GIS-based approaches can provide with an effective framework for evaluating geotourism resources by integrating multiple spatial criteria: geological significance, landscape attractiveness, accessibility, infrastructure availability, and environmental constraints.

The aim of the paper is to study geotourism development potential and suitability of Voghjaberd–Geghard area through GIS-based analysis. Accordingly, the following objectives were identified:

- 1) to analyze the physical-geographical characteristics of the study area including terrain conditions and accessibility factors influencing geotourism development;
- 2) to study the spatial distribution of tourism attractions (geological, geomorphological and cultural) of Voghjaberd–Geghard area;
- 3) to identify the areas with different levels of geotourism development potential and suitability within the study area based on GIS-analysis;
- 4) to provide with recommendations for decision-makers.

Results and Discussion.

Summarizing the Research Problem. As mentioned, the GIS have become an important tool in tourism planning and spatial decision-making. In geotourism studies, GIS-based approaches can be applied for development suitability assessment, route planning and optimization, etc. Continuous integration of GIS methods can contribute to more effective territorial organization and planning of tourism, thus, supporting sustainable development of tourism destinations. Despite the aforementioned advantages, there is still a lack of GIS-based geotourism planning studies on the example of Armenia. Basically, the existing research mainly focused on descriptive analyses of natural and cultural heritage sites, while spatial modeling and GIS-supported suitability assessment approaches have received limited attention.

As a result, the spatial relationships between natural conditions, spatial accessibility, and tourism infrastructure remain poorly evaluated in the context of geotourism planning. This limitation reduces the effectiveness of territorial planning and sustainable tourism management, particularly in mountainous areas characterized by complex geomorphological conditions. Therefore, the application of GIS-based spatial analysis and MCDA (Multi-Criteria Decision Analysis) methods represents an important approach for identifying areas with different levels of geotourism development potential.

Theoretical Provisions of Geotourism. The earliest published definition of geotourism was suggested by Hose (1995) describing it as the provision of interpretive and service facilities enabling tourists to get relevant knowledge and understanding of the geology and geomorphology of a certain site [1]. According to Dowling (2013), geotourism is a new form of tourism based on the geological environment [2].

Nowadays, geotourism is one of the newest concepts within the broad field of tourism, focusing on promoting geological and geomorphological features in landscapes as tourist attractions [3]. As a form of tourism, geotourism specifically focuses on geology and landscape. It is promoting tourism to *geological sites (geosites)*, as well as conservation of *geological heritage and diversity (geoheritage, geodiversity)*, and understanding of earth sciences through appreciation and learning. The aforementioned results are achieved via visits to geological features, use of *geological trails (geotrails)* and viewpoints, guided tours, etc [4].

In order to understand the place of geotourism in the overall structure of contemporary tourism, the following main directions or blocks of types of tourism should be discussed:

- *culture-based tourism*: focusing on the variety of historical and cultural heritage and attractions of a certain area;
- *nature-based tourism*: tourist use of both biotic and abiotic components of natural environment.

Geotourism belongs to the group of nature-based tourism. However, the combination and complex use of both cultural and natural attractions is a crucial principle towards ensuring sustainable and overall development of geotourism. In Fig. 1, the relationship of geotourism with other types of tourism (particularly, cultural tourism, ecotourism and adventure tourism) is shown.

In terms of geotourism planning and development, geoparks have a great role and significance as unique spatial units. Geopark is a unified area characterized by a geological heritage of international significance and where that heritage is being used to promote the sustainable development of communities living there. Nowadays, there are around 100 global geoparks in 29 countries. A geopark achieves its goals through conservation, education and tourism [2].

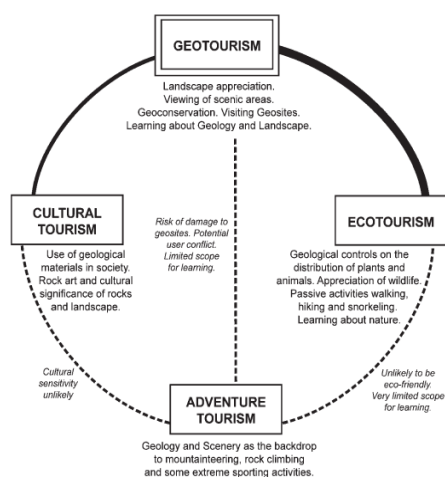


Fig. 1. Relationship of geotourism with other types of tourism [2].

Accordingly, in case of relevant planning and management, geoparks can be considered as suitable destinations for sustainable tourism development (particularly, geotourism) including environmental, cognitive, educational, scientific and research, social, cultural and economic priorities.

A Brief Geographical and Geomorphological Description of the Study Area.

The study area (Fig. 2) is located in the Southern edge of Kotayk, East of Yerevan, stretching from Voghjaberd in the West to Geghard in the East. It is mainly situated along with the border of Ararat Marz, basically including the basins of Azat River mid- and up-flows and its right-side tributaries (such as Goght River). The central part of the area (Garni sector) is the Northernmost part or section of Khosrov Forest State Reserve.

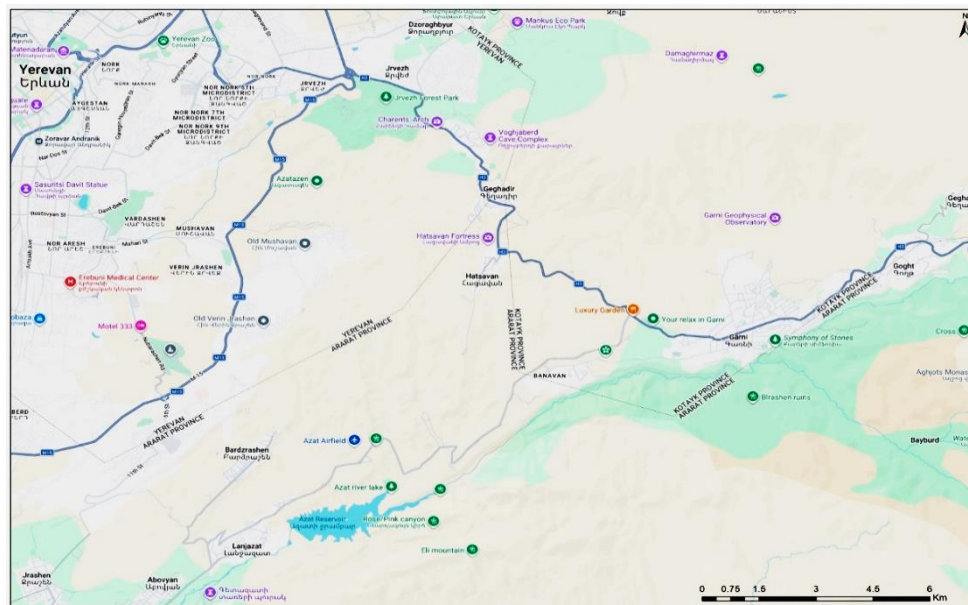


Fig. 2. Topographic and physiographic characteristics of Voghjaberd–Geghard area.

The study area is characterized by highly dissected volcanic and canyon-type terrain. Meanwhile, it combines significant geomorphological diversity with cultural heritage landscapes. Topographically, the area is distinguished by deep river valleys, steep canyon slopes, and elevated volcanic plateaus, which strongly influence accessibility, organization and spatial distribution of tourism activities.

The absolute height of the area varies from around 1400 to 1700 *m* above the sea level (a.s.l.). In the East, the study area reaches the Western slopes of Geghama volcanic range. The area is characterized by a dry continental climate, with a moderately warm, long summer and a cold winter. The maximum temperature reaches +38°C in July–August, while the minimum temperature drops to –29°C in January. The average annual precipitation is 534 *mm*. [5].

Administratively, Voghjaberd–Geghard area is basically included in the territory of Garni community of Kotayk Marz, with an area of around 231 *km*² and a population of around 13500 people residing in 6 villages: Garni (the community seat, 30 *km* from Yerevan), Geghard, Goght, Hatsavan, Geghardir and Voghjaberd [5].

The main transportation artery of the area is the H3 Yerevan–Garni–Geghard road. It keeps being the primary and priority way of communication between Yerevan and tourist destinations of Garni, Geghard and Goght. However, the road is

being affected by Voghjaberd landslide significantly: it is one of the largest and most active landslide zones of Armenia, causing a real danger for the local population, houses, infrastructure, etc.

The main natural and cultural tourist attractions of Voghjaberd–Geghard area. According to the official database of the Ministry of Environment of RA, 9 of 33 natural monuments of Kotayk Marz (more than 25%) are located within the study area (Tab. 1).

Table 1

Natural monuments of Voghjaberd–Geghard area [6]

№	Name	Location	Type
1	Basalt symphony, column-shape basalts	Azat River gorge, 1.0 km South-East of Garni village	geological
2	“Unnamed” basalt cave	Azat River gorge, 1.0 km South-East of Garni village	
3	“Unnamed” slope erosion	Right bank, Azat River	
4	“Unnamed” folded lava formations,	Azat River gorge, 1.0 km South-East of Garni village	
5	“Unnamed” niches	3.0 km North-East of Goght village	
6	Sageri lich (Սագերի լիճ, Goose Lake, in Armenian)	4 km North of Geghard village	hydrological
7	Vishapalich (Վիշապալիճ, Dragon Lake, in Armenian)	4 km East of Geghard village	
8	Dzori aghbyur (Զորի աղբյուր, Gorge source, in Armenian)	Goght River right bank, 0.3 km North-East of Goght village	hydro-geological
9	Voghjaberd cave complex	North-East of Voghjaberd village	natural-historical

It should be noted, that along with Geghard Monastery, the Upper Azat River valley is included in the list of UNESCO World Heritage Site.

Table 2

The main historical and cultural monuments of Voghjaberd-Geghard area [5, 7]

Historical and cultural monuments	Period of foundation	Location
Garni pagan temple	I century, reconstructed in XX century	Garni
Mashtots Hayrapet church (St. Astvatsatsin)	XII century	Garni
St. Sargis chapel	XIII century	2 km East of Garni
Garni bridge	XI century	across the Azat River, Garni
Complex of open air stations	ston age	1.5 km South-West of Voghjaberd
Complex of cave settlements	X–XV centuries	Voghjaberd
Charents Arch	1970	Voghjaberd
Remains of fortress	classical age (antiquity)	Hatsavan
Geghard Monastery complex	X–XVII centuries	Goght
Havuts Tar Monastery complex	XI century	Khosrov Forest, East of Garni village

Obviously, the aforementioned monuments can be served as geotourism destinations for visitors particularly interested in the patterns of geological and

geomorphological processes and their dynamics, hydrology and hydro-geology of mountainous areas, as well as real and potential natural hazards (particularly, landslides and stone-falls).

In Garni, one of the two visitor centers of Khosrov Forest State Reserve is located, providing entrance to the Northern part of the reserve (Garni sector). In case of relevant management, conservation and monitoring activities, there is a great potential of combining geotourism and ecotourism through integrated nature based tours.

In Tab. 2, the main monuments of historical and cultural heritage of the study area are shown: along with the aforementioned elements of geoheritage, these attractions provide with broad opportunities of integrated geo-eco-cultural tours and field trips.

GIS-based Spatial Analysis. Framework and Results. A GIS-based spatial suitability assessment approach was applied to evaluate geotourism suitability within the Voghjaberd–Geghard area. The methodological framework integrates terrain, accessibility, and tourism-related spatial parameters in order to identify areas with different levels of geotourism development potential.

The spatial database was developed using topographic, geomorphological, and infrastructural datasets. Several thematic layers were generated and analyzed within the GIS environment, including elevation, slope, transportation network, hydrography, settlements, and tourism-related locations.

Terrain Analysis. Terrain characteristics were considered among the key factors influencing geotourism accessibility and recreational suitability. A Digital Elevation Model (DEM) was used to derive slope and elevation layers for the study area.

Accessibility and Tourism Infrastructure. Accessibility plays a major role in geotourism development. The study area is strongly connected to Yerevan through the main transportation corridor passing from Yerevan via Garni toward Geghard and adjacent canyon landscapes. The spatial distribution of roads, settlements, and tourism attractions demonstrates the existence of a linear geotourism corridor associated with the Azat River valley.

Suitability Assessment Framework. The geotourism suitability assessment was based on the integration of several spatial criteria, including: slope conditions, elevation characteristics, accessibility to roads and settlements, distribution of tourism attractions and cultural heritage sites.

Each thematic layer was reclassified into suitability categories and integrated within a weighted overlay model. Lower slope angles and accessible middle-altitude terrain were considered more favorable for tourism development, while steep and physically constrained areas received lower suitability values.

Table 3

Criteria used for GIS-based geotourism suitability assessment

№	Criterion	Role in suitability assessment
1.	Slope	evaluation of terrain accessibility and hiking conditions
2.	Elevation	assessment of topographic suitability and landscape attractiveness
3.	Accessibility	proximity to roads and settlements
4.	Tourism attractions	spatial distribution of natural and cultural heritage sites
5.	Hydrography	presence of rivers and canyon landscapes increasing scenic value

In Tab. 3, the criteria used for assessment of geotourism development suitability are shown. The suitability assessment was based on expert interpretation of several spatial criteria, including slope conditions, accessibility, hydrography, and the elevation. Particular attention was given to canyon sections and river valleys where geotourism resources are concentrated. Areas characterized by slopes exceeding 20° were identified as terrain-constrained zones requiring special management and safety considerations.

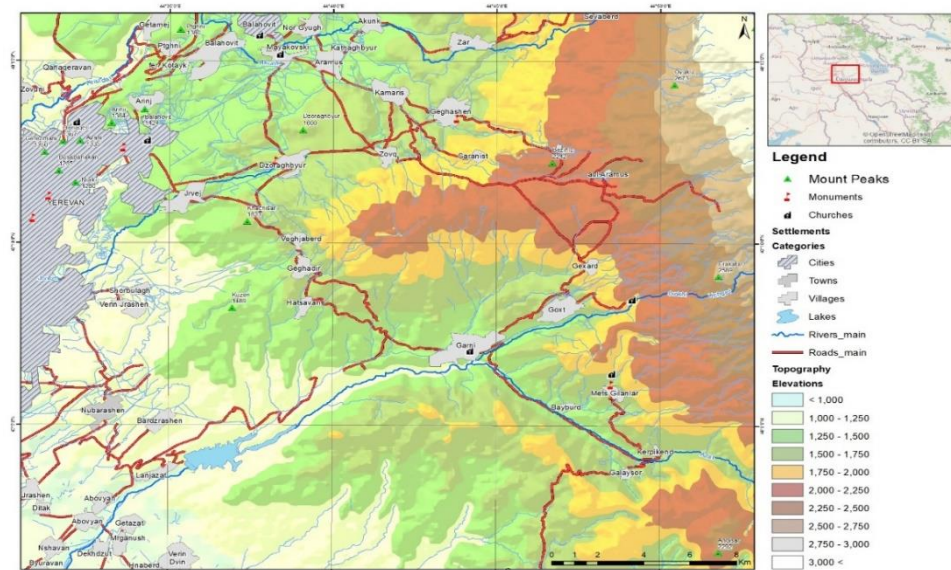


Fig. 3. Elevation map of the Garni–Geghard Area.

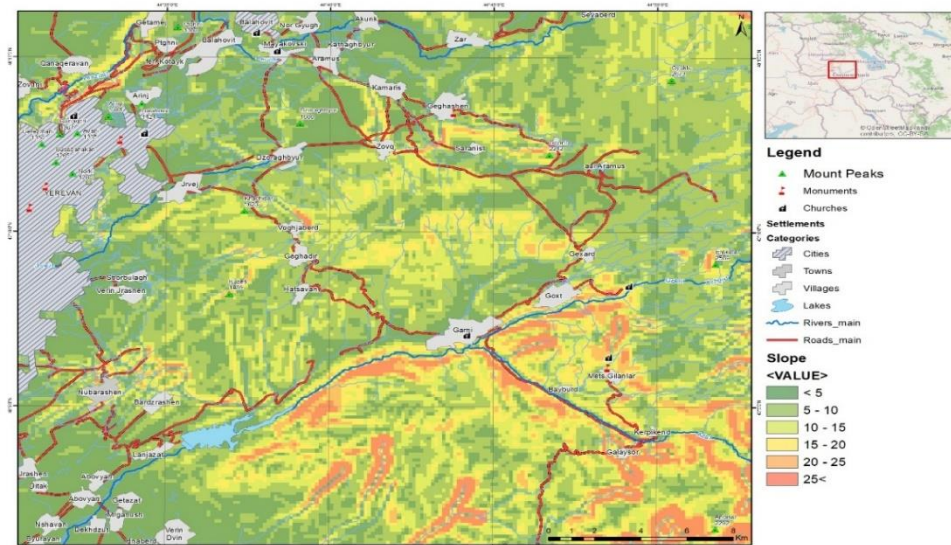


Fig. 4. Slope Angle map of the Garni–Geghard Area.

The elevation map (Fig. 3) demonstrates considerable topographic variation within the study area, ranging from low-altitude valley systems to elevated volcanic highlands exceeding 2 500 m a.s.l. The Voghjaberd–Geghard belt is primarily situated within middle-altitude terrain, which provides relatively favorable conditions for accessibility and recreational activities. Higher elevation zones are concentrated in the Eastern and Southeastern parts of the study area and are associated with increased terrain ruggedness and reduced accessibility.

The slope map (Fig. 4) derived from DEM indicates that the central and northern parts of the study area are characterized by relatively gentle terrain (0–15°), which is generally suitable for hiking and recreational activities.

In contrast, the Southern canyon sections and dissected mountainous areas exhibit steeper slopes exceeding 25°, limiting accessibility and increasing terrain constraints for geotourism development.

Accessibility, Distribution and Spatial Zoning of Tourist Attractions. It goes without saying that Voghjaberd–Geghard tourist belt keeps being one of the most accessible geotourism areas in Central part of Armenia due to the factor of close vicinity of Yerevan, direct communication opportunities and dense concentration of both natural and cultural attractions. Major geotourism attractions, including canyon landscapes, volcanic formations, cultural heritage sites, and recreational areas, are spatially interconnected, forming a continuous tourism corridor with significant development potential.

For better planning and development of geotourism, as well as for a systemized, rational and sustainable use of geoheritage, it is suggested to carry out a territorial zoning of the study area. Particularly, 3 tourist (and geotourist) clusters or sectors can be identified within the Voghjaberd–Geghard tourist belt: Western (Voghjaberd–Geghardir–Hatsavan), Central (Garni) and Eastern (Geghard–Goght) (Fig. 5). Each of the sectors has a specific combination of geoheritage and cultural heritage elements: thus, a targeted policy and activities towards tourism development should be accomplished.

The Western sector is located in the immediate vicinity of Yerevan, including the settlements of Voghjaberd, Geghardir and Hatsavan. Its main tourist attractions include complexes of ancient open air stations and medieval cave settlements, remains of antiquity period fortifications, etc. And of course, Voghjaberd landslide can be considered as a special geotourist attraction as well. Therefore, the Western sector can be seen as a suitable destination for integrated geotourist tours focusing on geological, archaeological and ethnographic observations and trips, study of rural settlements' development and distribution, etc.

The Central sector has a favorable geographical location within the study area and in terms of accessibility from Yerevan. There are rich and densely distributed elements of geoheritage (basalt columns, caves, lava folds, slope erosions, niches, etc.) in the sector: particularly, in the Azat River valley, a UNESCO World Heritage Site. In combination with the use of cultural and historical attractions (Garni temple, Havuts Tar complex, churches, chapels, bridges, local rural traditions and lifestyle), the Garni area can be suitable for geological and geomorphological field trips and observations. Meanwhile, including the northernmost parts of Khosrov Forest, Garni

area can become an unique focal point of geotourism, ecotourism, rural tourism, adventure tourism and cultural tourism.

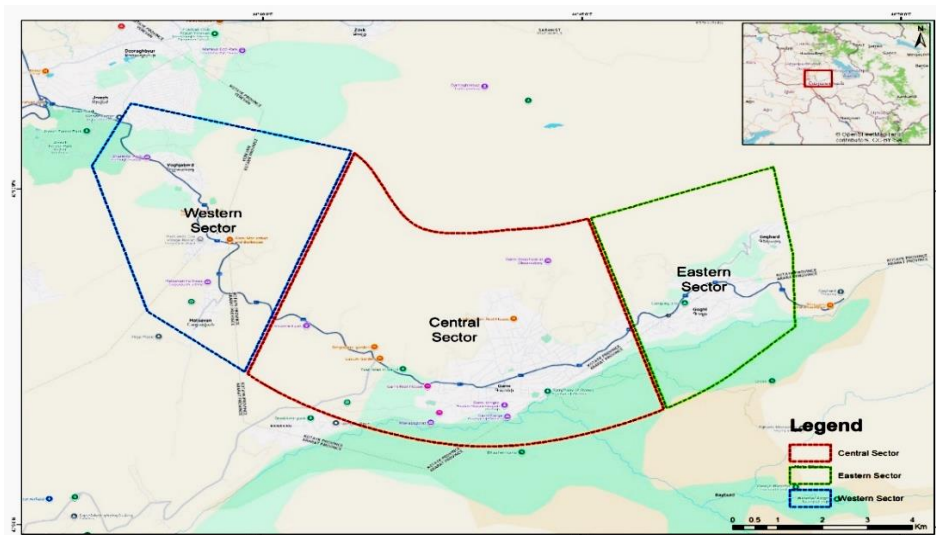


Fig. 5. Suggestion for territorial zoning of Voghjaberd–Geghard belt.

The Eastern sector includes Geghard and Goght areas, the westernmost slopes of Geghama volcanic range. It is mainly famous for deep valleys of upper-flow basin of the Azat River and its tributaries, as well as small mountainous lakes. The primary cultural attraction here is Geghard Monastery complex, UNESCO World Heritage Site. Accordingly, Geghard–Goght area is suitable for geotourism focusing on hydrological and hydro-geological interests, as well as hiking, extreme and adventure tours combined with cultural tourism.

Conclusion. The study area (Voghjaberd–Geghard) is characterized by a variety of resources and possibilities for development of geotourism. Based on geographical, geomorphological and geological features of the area, several sub-directions or specialized types of geotourism can be practiced here: co-called “pure-geological”, speleological, hydro-geological and hydrological. Also, the diversity of the forms of relief and physical-geographical features of the area provide with opportunities of combining geotourism with ecotourism and adventures tourism. Historical and cultural heritage of Voghjaberd–Geghard area (rural lifestyle, customs and traditions, architectural monuments, remains of settlements and fortifications) are contributing to organizing more diverse and complex geo-tours.

For the better use of tourism development potential, it is suggested to distinguish 3 spatial zones within the study area. Each of them has a specific combination of geotourism resources and can be used as territorial units or destinations for tourism planning and development.

The geotourism suitability assessment was conducted through a GIS-based spatial analysis integrating several key criteria, including terrain conditions, accessibility, hydrography, and the distribution of natural and cultural attractions. Particular attention was paid to slope characteristics, as terrain steepness directly

influences accessibility, safety, and recreational use. Areas characterized by slopes exceeding 20° were identified as terrain-constrained zones requiring special management considerations for tourism development.

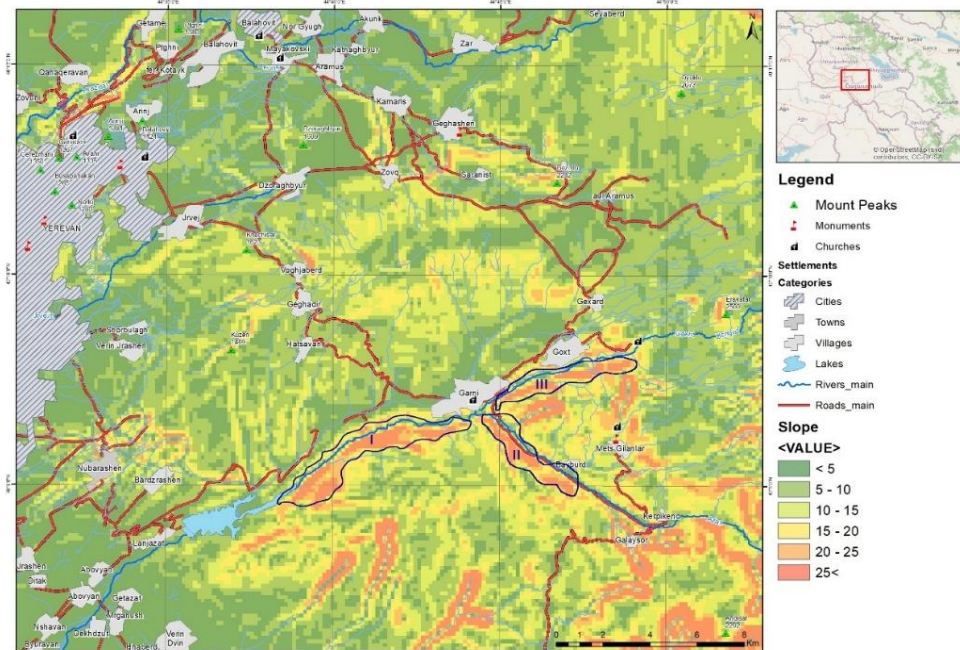


Fig. 6. Spatial zoning for geotourism-sensitive areas (I–III).

Fig. 6 summarizes the results of the GIS-based spatial assessment. Highlights three areas (I–III) characterized by the combined presence of steep slopes, river valleys, transportation accessibility, and a concentration of natural and cultural attractions. These areas represent key zones for geotourism planning and management within the study area.

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Հետազոտության շրջանակներում ԱՏՀ և բազմաչափ որոշումների ընդունման վերլուծության (MCDA) մեթոդների կիրառմամբ գնահատվել է Ողջաքերդ–Գեղարդ տարածքի գետտուրիստական ներուժը: Վերլուծության հիմքում դրվել են ռելիեֆային պայմանները, տարածքի հասանելիությունը, ջրագրական ցանցի առանձնահատկությունները, ինչպես նաև բնական և պատմամշակութային ժառանգության օբյեկտների տարածական բաշխվածությունը: Արդյունքները ցույց են տվել Ողջաքերդ–Գեղարդ գոտու բարձր գետտուրիստական ներուժը և հնարավորությունը տվել առանձնացնել երեք գետտուրիստական գոտի: Հետազոտությունը հիմնավորում է ԱՏՀ և MCDA մեթոդների կիրառելիությունը գետտուրիզմի տարածքային պլանավորման, գեոժառանգության կառավարման և զգայուն տարածքների բացահայտման գործընթացներում:

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ПЛАНИРОВАНИЕ И РАЗВИТИЕ ГЕОТУРИЗМА С ИСПОЛЬЗОВАНИЕМ
ГЕОИНФОРМАЦИОННЫХ СИСТЕМ (ГИС)
НА ПРИМЕРЕ РЕГИОНА ВОГДЖАБЕРД–ГЕГАРД, АРМЕНИЯ

Р е з ю м е

В статье оценивается геотуристический потенциал территории Вогджаберд–Гегард (Армения) с использованием ГИС-технологий и многокритериального анализа принятия решений (МАПР). Оценка основана на анализе рельефа, транспортной доступности, гидрографии и пространственного распределения природных и культурных объектов. Результаты выявили высокий потенциал развития геотуризма в зоне Вогджаберд–Гегард и позволили выделить три геотуристических кластера. Исследование показало эффективность применения ГИС и МАПР для оценки территорий, планирования устойчивого развития геотуризма и выявления чувствительных зон.