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ORIGINAL ARTICLE

Speleological objects becoming show caves: evidence from the Valjevo karst area in Western Serbia

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Abstract

The interaction between speleology and tourism has been active in science and society for a very long time. In many countries, tourist caves shape the economic situation at the local and regional level. This shows their value for the development of local communities and for scientific research and promotion of science. Caves represent the indicators of cave tourism development, and they are one of the main geosites for geotourism travel. Transforming speleological objects into show caves has brought numerous positive results for many regions in the world, including Serbia. In this paper, we try to reveal the ability of speleological objects becoming show caves. The case study of our research is four caves in the Valjevo karst area (West Serbia). We examined their current state and the possibilities for cave tourism development. Using the M-GAM (modified geosite assessment model), we evaluated these four caves and thus determined their values and show cave potential. The obtained results point out the significant values of the explored speleological geoheritage, which possess imposing cave tourism potential. Moreover, the regional conception and creation of a geopark in this area is an evident potential, and more concrete indicators are presented in this paper. Cave tourism in the Zlatibor region is considered an important aspect of a potential geopark in Western Serbia and Valjevo karst area as a crucial complementary potential. The importance of including these caves in the tourist market has been determined by the research results. Active cave tourism of researched geosites can significantly influence both local and regional economic growth, as well as the concept of sustainability of the cave environment and its ecosystem, education, and responsibility.

Keywords Cave tourism · Show caves · Valjevo karst area · Western Serbia

Introduction

The International Show Cave Association (ISCA) defines a show cave (sometimes called a tourist cave) as a "natural occurring void beneath the surface of the earth that has been made accessible to the public for tours" (International Show Caves Association 2019). While some show caves offer adventure caving, the vast majority of visitors walk in groups along well-lit concrete, gravel, steel-mesh, or even fiberglass pathways, pausing at intervals to listen to a guide's commentary about the cave's exploration or tourism history, its geological formation or significance, or the beauty and wonder of its features (Crane & Fletcher 2016). Caves pose a series of challenges to tourism operators with regard to presentation and visitor numbers because of the fragility and irreplaceability of the very formations that attract the tourists. There is an inevitable conflict between the functions of entertainment (mass tourism) on the one hand, and protection (cave tourism and geotourism) on the other (Crane and Fletcher 2016).

Caves started to be available for tourists over 400 years ago. Today, a great number of show caves host over 50.000 visitors per year (Cigna 2016). They have

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been attractive since ancient times, and today, they are recognized as one of the most interesting attractions (Petrović 2006). It is because they already exist as ready semi-made "products" with their very characteristic cultural setting, own extremely distinctive local atmosphere, and unusual features. They also have an impact on human health, so it makes cave tourism of interest to visitors of all kinds (Mulaomerović et al. 2012). It is therefore evident that show caves are presently one of the most important geotouristic targets all over the world, and they represent an important economic resource for many of the still developing countries. Moreover, it is possible to maintain the aesthetic and scientific values of a cave when transforming it into a show cave; but to reach this goal, it is important to follow strict rules before, during, and after the cave tourism development (Cigna 2016).

Considering the use of caves, the focus of cave tourism has to be conservation of cave environment (Tičar et al. 2018) because they are easily alterable from the environmental point of view (Guirado et al. 2019). Therefore, arranging caves that are not yet prepared for tourist visits must be done with scientific commitment and stable financial support, which is going to make sure that the cave environment is properly preserved.

In recent years, a significant number of papers on cave tourism in Serbia have been published (Antić and Tomić 2017; Antić et al. 2019; Tomić et al. 2019; Vuković and Antić 2019). The application of M-GAM (modified geosite assessment model) has crucially contributed to the knowledge about tourist caves in Serbia. This created new topics in the field of cave tourism and opened some questions concerning other caves in Serbia.

Our study focuses on speleological objects in the Valjevo karst area, which has great potential for show cave arrangement and cave tourism development. While observing the speleological geoheritage of this area, we have singled out four caves that stand out as adequate indicators for tourist affirmation and initiation of cave tourism development. Selected caves are the following: Petnička Cave, Degurićka Cave, Ribnička Cave, and Šalitrena Cave. The main goal of this paper is to show the results of M-GAM, which confirm the existence of important values of the explored caves and their ability for becoming show caves. As such, they could have a major impact on cave tourism development in Serbia.

Study area

The Valjevo karst area covers the surface between the Valjevo mountains and the Valjevo basin (Fig. 1). It is mostly built of limestone and dolomitic rocks. This region covers an area of 304 km^2. Of the total area of Valjevo karst, carbonate rocks account for 286.3 km^2 and non-carbonate rocks for 17.7 km^2. The terrain and river valleys (canyons and gorges) play a dominant role in the relief of the Valjevo karst, followed by surface and underground karst forms as microrelief forms (Lazarević 1996).

All these facts point to the existence of a variety of geosites within an area, which can be very attractive to tourists. Furthermore, the explored karst area holds a crucial potential for the future of cave tourism development in Western Serbia. Creating a cave tourism product by merging show caves in Western Serbia could have a major impact on regional tourism development, whether they are positioned as either primary or complementary tourism offers.

Petnička Cave is located in the western part of Serbia near the village Klinci, about 5 km southwest from the Valjevo city (Jovanović 1951; Kličković 2015). First research about this cave was conducted in 1892 by Josif Pančić and Jovan Cvijić (Božić 2008).

The Petnička cave consists of three parts: big cave (Concert Hall and High Hall), small cave (Bears Hall and Pharynx) and Banja channel. A large part of the Big Cave is a Concert Hall, with length around 22 m. The small cave consists of a branched channel system and halls with a total length of around 530 m. These two parts of the cave are connected by a narrow 50 m long channel (Jovanović 1951).

The length of its main passageway is 484,5 m, and the total length of all passageways is 580 m. The total surface of the cavity system is 3.393,5 m^2. The total length of the tourist trail is 414 m (Božić 2008) (Figs. 2 and 3).

Degurićka Cave is a very important karst spring for this region. The cave is located about 5 km south of Valjevo, 200 m upstream of the hydropower plant in the village of Degurić. The entrance to the cave is located at 236 m above sea level and faces west. It is located below the 20-m high vertical limestone section, which is cut by the Gradac River. The entrance is 7 m wide and 3.5 m high (Figs. 4 and 5). The main channel of the Degurić cave has a south-southeast direction. Water flows through it continuously. The measured length of the main channel to the second siphon is 807 m, while 500 m of channel was recorded behind the second siphon (Savez Speleoloskih Organizacija Srbije, SSOS 2019).

Ribnička Cave is located in the valley of the river Ribnica, south of Mionica, in the western part of Serbia (Figs. 6 and 7). The cave entrance is 25 m wide and 12 m high and only 1 m above the riverbed, and the total length of the cave is 127 m. From the main chamber, several short galleries diverge. The microclimate of the cave is strongly influenced by daily and seasonal fluctuations of outside climatic factors, especially temperature, and it is a consequence of the cave entrance dimensions (Đurović 1998).

Šalitrena Cave is located near the Brežđe village. It is one of the richest multi-layered Palaeolithic sites in Serbia. Two

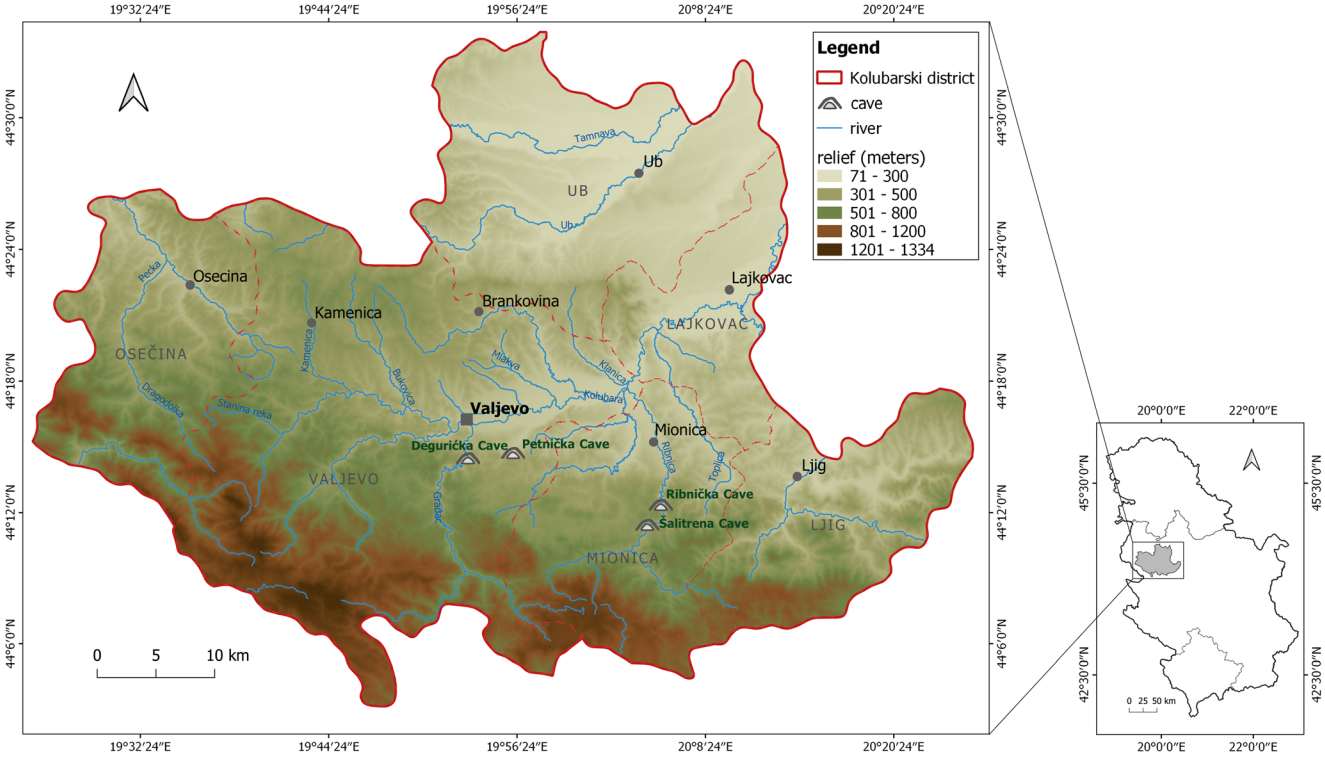

Fig. 1 Location of the explored karst area

Gravettian, one Aurignacian, and many Mousterian layers have been identified at this site, which has been investigated by the Archeological Institute of Serbia, since 1983 (Mihailović 2014) (Fig. 8).

The cave is very inaccessible. It is necessary to cross the river, which is quite shallow, to access the cave. The tourism infrastructure is completely absent, and the rural roads are in very poor condition. Cave itself is closed for visitors because archeological research is ongoing.

Methodology

The methods used for this research are based on the "Modified Geosite Assessment Model" (M-GAM), developed by Tomić & Božić (2014). This model represents a modified version of the GAM model created by Vujičić et al. (2011) combined with the Importance factor (*Im*) first introduced by Tomić (2011) in his research. The M-GAM model is based on former geosite assessment methods created by different authors

Fig. 2 Entrance to the Petnička Cave

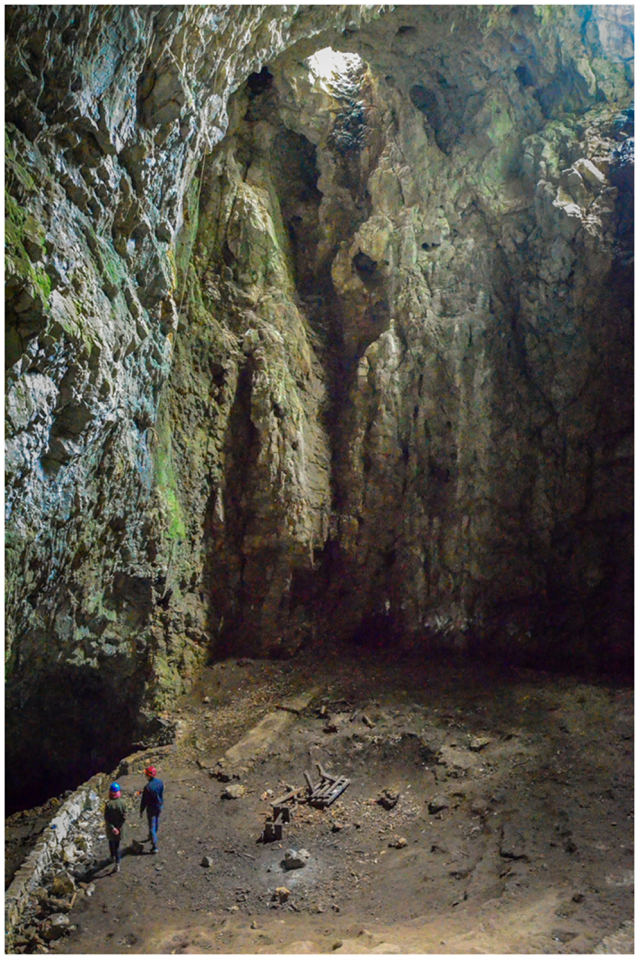

Fig. 3 Petnička Cave

(Bruschi and Cendrero 2005; Coratza and Giusti 2005; Erhartič 2010; Hose 1997; Pereira et al. 2007; Pralong 2005; Reynard 2008; Reynard et al. 2007; Serrano and González-Trueba 2005; Tomić 2011; Zouros 2007). Its advantage is that it integrates the opinion of both tourists and experts so that none of them is favored throughout the assessment process. This method has been successfully applied several times for the evaluation of different geosites in Serbia (Antić and Tomić 2017; Boškov et al. 2015; Božić et al. 2014; Božić and Tomić 2015; Tomić et al. 2019; Tomić et al. 2020; Vukoičić et al. 2018; Antić et al. 2019; Antić and Tomić 2019; Vuković and Antić 2019), USA (Tomić et al. 2015; Jonić 2018), Slovenia (Tičar et al. 2018), Iran, and Hungary (Pál and Albert 2018).

The M-GAM model consists of the following two key indicators: main values and additional values, which are further divided into 12 and 15 indicators respectively, each individually marked from 0 to 1. This division is made due to two general kinds of values: main—that are mostly generated by geosite's natural characteristics; and additional—that are mostly human-induced and generated by modifications for its use by visitors. The *main values* comprise the three following groups of indicators: scientific/educational (VSE), scenic/aesthetical values (VSA), and protection (VPr), while the *additional values* are divided into two groups of indicators, functional (VFn), and touristic values (VTr). The main and additional values are more detailed and presented in Table 1. In total, there are 12 subindicators of main values, and 15 subindicators of additional values which are graded from 0 to 1 that define M-GAM as a simple equation:

$$M{-}GAM = MV + AV \quad (1)$$

where MV and AV represent symbols for main and additional values. Since main and additional values consist of three or

Fig. 4 Entrance to the Degurićka Cave

Fig. 5 Degurićka Cave

two groups of subindicators, we can derive these two equations:

$$MV = VSE + VSA + VPr, \tag{2}$$

$$AV = VFn + VTr, \tag{3}$$

Now that we know that each group of indicators consists of several subindicators, Eqs. (2) and (3) can be written as follows:

$$\mathrm{MV} = \mathrm{VSE} + \mathrm{VSA} + \mathrm{VPr} \equiv \sum_{i=1}^{12} \mathrm{SIMV}_i \ , \ \text{where} \ 0 \leq \mathrm{SIMV}_i \leq 1 \ , \tag{4}$$

$$\mathrm{AV} = \mathrm{VF}n + \mathrm{VT}r \equiv \sum_{j=1}^{15} \mathrm{SIAV}_i \ , \ \text{where} \ 0 \leq \mathrm{SIAV}_j \leq 1 \ . \tag{5}$$

here, SIMV_i and SIAV_j represent 12 subindicators of main values (i = 1,...,12) and 15 subindicators (j = 1,...,15) of additional values.

As it was mentioned before, M-GAM focuses not only on the expert's opinion but also on the opinion of visitors and tourists regarding the importance of each indicator in the assessment process. Visitor inclusion in the assessment process is done through a survey where each respondent is asked to rate the importance (Im) of all 27 subindicators (from 0.00 to 1.00) in the M-GAM model (Table 2). The importance factor (Im) gives visitors the opportunity to express their opinion about each subindicator in the model and how important it is

Fig. 6 Entrance to the Ribnička Cave

Fig. 7 Ribnička Cave

for them when choosing and deciding between several geosites that they wish to visit. After each respondent rates the importance of every subindicator, the average value of each subindicator is calculated and the final value of that subindicator is the importance factor. Afterwards, the value of the importance factor (Im) is multiplied with the value that was given by experts (also from 0.00 to 1.00) who evaluate the current state and value of subindicators (Table 2).

This is done for each subindicator in the model after which the values are added up according to M-GAM equation but this time with more objective and accurate final results due to the addition of the importance factor (Im). This parameter is determined by visitors who rate it in the same way as experts rate the subindicators for main and additional values by giving them one of the following numerical values: 0.00, 0.25, 0.50, 0.75, and 1.00, marked as points. The importance factor (Im) is defined as follows:

$$\mathrm{Im} = \frac{\sum_{k=1}^{K} \mathrm{Iv}_k}{K} \tag{6}$$

where Iv_k is the assessment/score of one visitor for each subindicator, and K is the total number of visitors. Note that the Im parameter can have any value in the range from 0.00 to 1.00. Finally, the M-GAM equation is defined and presented in the following form:

$$M{-}GAM = MV + AV \tag{7}$$

$$\mathrm{MV} = \sum_{i=1}^{n} \mathrm{Im}_{i^*\mathrm{MV}i} \tag{8}$$

Fig. 8 Šalitrena Cave

Table 1 The structure of modified geosite assessment model (M-GAM)

Indicators/Subindicators	Description
Main values (*MV*)	
Scientific/Educational value (*VSE*)	
Rarity ($SIMV_1$)	Number of closest identical sites
Representativeness ($SIMV_2$)	Didactic and exemplary characteristics of the site due to its own quality and general configuration
Knowledge on geoscientific issues ($SIMV_3$)	Number of written papers in acknowledged journals, thesis, presentations and other publications
Level of interpretation ($SIMV_4$)	Level of interpretive possibilities on geological and geomorphologic processes, phenomena and shapes and level of scientific knowledge
Scenic/Aesthetic (*VSA*)	
Viewpoints ($SIMV_5$)	Number of viewpoints accessible by a pedestrian pathway. Each must present a particular angle of view and be situated less than 1 km from the site.
Surface ($SIMV_6$)	Whole surface of the site. Each site is considered in quantitative relation to other sites
Surrounding landscape and nature ($SIMV_7$)	Panoramic view quality, presence of water and vegetation, absence of human-induced deterioration, vicinity of urban area, etc.
Environmental fitting of sites ($SIMV_8$)	Level of contrast to the nature, contrast of colors, appearance of shapes, etc.
Protection (*VPr*)	
Current condition ($SIMV_9$)	Current state of geosite
Protection level ($SIMV_{10}$)	Protection by local or regional groups, national government, international organizations, etc.
Vulnerability ($SIMV_{11}$)	Vulnerability level of geosite
Suitable number of visitors ($SIMV_{12}$)	Proposed number of visitors on the site at the same time, according to surface area, vulnerability and current state of geosite
Additional values (*AV*)	
Functional values (*VFn*)	
Accessibility ($SIAV_1$)	Possibilities of approaching to the site
Additional natural values ($SIAV_2$)	Number of additional natural values in the radius of 5 km (geosites also included)
Additional anthropogenic values ($SIAV_3$)	Number of additional anthropogenic values in the radius of 5 km
Vicinity of emissive centers ($SIAV_4$)	Closeness of emissive centers
Vicinity of important road network ($SIAV_5$)	Closeness of important road networks in the in radius of 20 km
Additional functional values ($SIAV_6$)	Parking lots, gas stations, mechanics, etc.
Touristic values (*VTr*)	
Promotion ($SIAV_7$)	Level and number of promotional resources
Organized visits ($SIAV_8$)	Annual number of organized visits to the geosite
Vicinity of visitors centers ($SIAV_9$)	Closeness of visitor center to the geosite
Interpretative panels ($SIAV_{10}$)	Interpretative characteristics of text and graphics, material quality, size, fitting to surroundings, etc.
Number of visitors ($SIAV_{11}$)	Annual number of visitors
Tourism infrastructure ($SIAV_{12}$)	Level of additional infrastructure for tourist (pedestrian pathways, resting places, garbage cans, toilets etc.)
Tour guide service ($SIAV_{13}$)	If exists, expertise level, knowledge of foreign language(s), interpretative skills, etc.
Hostelry service ($SIAV_{14}$)	Hostelry service close to geosite
Restaurant service ($SIAV_{15}$)	Restaurant service close to geosite

Grades (0.00–1.00)	0.00	0.25	0.50	0.75	1.00
1.	Common	Regional	National	International	The only occurence
2.	None	Low	Moderate	High	Utmost
3.	None	Local publications	Regional publications	National publications	International publications
4.	None	Moderate level of processes but hard to explain to non experts	Good example of processes but hard to explain to non experts	Moderate level of processes but easy to explain to common visitor	Good example of processes and easy to explain to common visitor
5.	None	1	2 to 3	4 to 6	More than 6
6.	Small	-	Medium	-	Large
7.	-	Low	Medium	High	Utmost
8.	Unfitting	-	Neutral	-	Fitting
9.	Totally damaged (as a result of human activities)	Highly damaged (as a result of natural processes)	Medium damaged (with essential geomorphologic features preserved)	Slightly damaged	No damage
10.	None	Local	Regional	National	International
11.	Irreversible (with possibility of total loss)	High (could be easily damaged)	Medium (could be damaged by natural processes or human activities)	Low (could be damaged only by human activities)	None
12.	0	0 to 10	10 to 20	20 to 50	More than 50
13.	Inaccessible	Low (on foot with special equipment and expert guide tours)	Medium (by bicycle and other means of man-powered transport)	High (by car)	Utmost (by bus)
14.	None	1	2 to 3	4 to 6	More than 6
15.	None	1	2 to 3	4 to 6	More than 6
16.	More than 100 km	100 to 50 km	50 to 25 km	25 to 5 km	Less than 5 km
17.	None	Local	Regional	National	International
18.	None	Low	Medium	High	Utmost
19.	None	Local	Regional	National	International
20.	None	Less than 12 per year	12 to 24 per year	24 to 48 per year	More than 48 per year
21.	More than 50 km	50 to 20 km	20 to 5 km	5 to 1 km	Less than 1 km
22.	None	Low quality	Medium quality	High quality	Utmost quality
23.	None	Low (less than 5000)	Medium (5001 to 10 000)	High (10 001 to 100 000)	Utmost (more than 100 000)
24.	None	Low	Medium	High	Utmost
25.	None	Low	Medium	High	Utmost
26.	More than 50 km	25–50 km	10–25 km	5–10 km	Less than 5km
27.	More than 25 km	10–25 km	10–5 km	1–5 km	Less than 1 km

Source: (Vujičić et al., 2011)

Table 2 Subindicator values given by experts for Petnička Cave (C_1), Degurićka Cave (C_2), Ribnička Cave (C_3), and Šalitrena Cave (C_4)

Main indicators/subindicators	C_1	C_2	C_3	C_4	Im	Total value C_1	Total value C_2	Total value C_3	Total value C_4
I Scientific/educational values (VSE)									
Rarity ($SIMV_1$)	0.25	0.25	0.25	0.25	0.89	0.22	0.22	0.22	0.22
Representativeness ($SIMV_2$)	0.50	0.25	0.25	0.25	0.79	0.39	0.19	0.19	0.19
Knowledge on geo-scientific issues ($SIMV_3$)	0.75	0.25	0.25	0.25	0.45	0.33	0.11	0.11	0.11
Level of interpretation ($SIMV_4$)	0.75	0.75	0.75	0.75	0.85	0.63	0.63	0.63	0.63
II Scenic/aesthetic values (VSA)									
Viewpoints (each must present a particular angle of view) ($SIMV_5$)	0.50	0.25	0.25	0.25	0.79	0.39	0.19	0.19	0.19
Surface (each considered in quantitative relation to other) ($SIMV_6$)	1.00	0.50	0.00	0.00	0.54	0.54	0.27	0.00	0.00
Surrounding landscape and nature ($SIMV_7$)	0.75	1.00	0.50	0.50	0.95	0.71	0.95	0.47	0.47
Environmental fitting of sites ($SIMV_8$)	1.00	1.00	1.00	1.00	0.68	0.68	0.68	0.68	0.68
III Protection (VPr)									
Current condition ($SIMV_9$)	0.75	1.00	1.00	1.00	0.83	0.62	0.83	0.83	0.83
Protection level ($SIMV_{10}$)	0.75	0.75	0.75	0.75	0.76	0.57	0.57	0.57	0.57
Vulnerability ($SIMV_{11}$)	0.50	0.50	0.50	0.50	0.58	0.29	0.29	0.29	0.29
Suitable number of visitors ($SIMV_{12}$)	0.75	0.50	0.75	0.50	0.42	0.31	0.21	0.31	0.21
Additional indicators/subindicators									
I Functional values (VFn)									
Accessibility ($SIAV_1$)	1.00	0.75	1.00	0.25	0.75	0.75	0.56	0.75	0.18
Additional natural values ($SIAV_2$)	0.75	0.75	0.50	0.50	0.71	0.53	0.53	0.35	0.35
Additional anthropogenic values ($SIAV_3$)	1.00	1.00	0.25	0.25	0.70	0.70	0.70	0.17	0.17
Vicinity of emissive centers ($SIAV_4$)	1.00	1.00	0.75	0.75	0.48	0.48	0.48	0.36	0.36
Vicinity of important road network ($SIAV_5$)	0.50	0.50	0.50	0.50	0.62	0.31	0.31	0.31	0.31
Additional functional values ($SIAV_6$)	1.00	0.50	1.00	0.00	0.59	0.59	0.29	0.59	0.00
II Tourist values (VTr)									
Promotion ($SIAV_7$)	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.00
Annual number of organized visits ($SIAV_8$)	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00
Vicinity of visitors centers ($SIAV_9$)	1.00	0.50	0.25	0.25	0.87	0.87	0.43	0.22	0.22
Interpretive panels ($SIAV_{10}$)	0.50	0.25	0.00	0.00	0.81	0.40	0.20	0.00	0.00
Annual number of visitors ($SIAV_{11}$)	0.25	0.25	0.25	0.00	0.43	0.11	0.11	0.11	0.00
Tourism infrastructure ($SIAV_{12}$)	0.25	0.00	0.25	0.00	0.73	0.18	0.00	0.18	0.00
Tour guide service ($SIAV_{13}$)	0.00	0.00	0.00	0.00	0.87	0.00	0.00	0.00	0.00
Hostelry service ($SIAV_{14}$)	1.00	0.75	1.00	0.50	0.73	0.73	0.55	0.73	0.36
Restaurant service ($SIAV_{15}$)	1.00	0.75	1.00	0.50	0.78	0.78	0.58	0.78	0.39

$$AV = \sum_{i=1}^{n} Im_{j^*AVj} \tag{9}$$

As it is seen from the previous equations, the value of the importance factor (Im) for each subindicator in the model is rated by visitors and afterwards multiplied with the values given by experts for each subindicator respectively.

In the research by Božić and Tomić (2015) about different geotouristic market segments, the importance factor (for each subindicator) for Serbian tourists was calculated through a survey. The resulting values of the importance factor have been adopted from the mentioned research and used for the purpose of this paper.

According to the final assessment results, a matrix of main (X axes) and additional values (Y axes) can be made (Fig. 9). The matrix is divided into nine sections marked with $Z(i,j)$, (i,j = 1,2,3). Depending upon the final score, each analyzed geosite will fall within a certain section of the matrix. For example, if the main values of a geosite are 7 and the additional values are 4, the geosite will belong to the Z_{21} field of the M-GAM matrix.

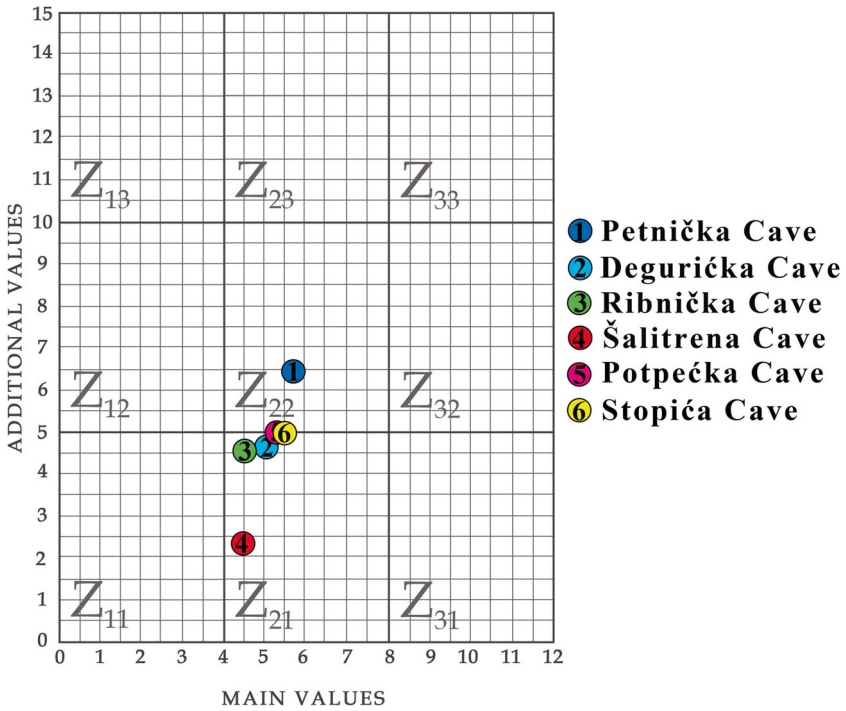

Fig. 9 Position of geosites in the M-GAM matrix

Results and discussion

Show caves are one of the most important attractions from the nature-based tourism point of view. Thus, they deserve much attention in their development. The fundamental criteria presently adopted are the protection of the cave environment, the safety of the visitors and a correct profit from the cave management. All such criteria must be taken into account, otherwise, the development would have very negative effects (Cigna 2016). Gurnee (1994) concluded that it will be the global objective of cave owners and operators to continue to improve methods for giving the maximum enjoyment to the visitor without jeopardizing the quality of the underground environments of caves. Bella et al. (2001) acknowledge that a show cave should be an educational site where a part of underground spaces is technically adjusted for cultural and educational purposes or other community-based utilization at the same time with keeping the stability of cave geosystems and supporting their protection. On the other hand, De Freitas (2010) argues that the approach to managing show caves depends on the type of cave, whether the cave or section of a cave is a low energy, stable environment. Caves or sections of caves that are active, high-energy environments, such as those with a large throughput of water, are much less sensitive to internal human-induced change. It is indisputable among authors and researchers that it is necessary to consider all aspects of the cave natural environment and the anthropogenic impact on the caves before the management structures decide to turn the speleological object into a show cave.

Revealing the ability of speleological objects becoming show caves, using M-GAM is crucial for cave tourism development. The Valjevo karst area in Western Serbia is a very particular case study since it holds numerous caves with extraordinary tourism potential, which are not prepared for tourist visits. Determining the potential for cave tourism development is implied before any primary investments are made. The results of this paper show the position of the explored caves in the M-GAM matrix. This data can be the ground point for creating a cave tourism product of Western Serbia, which could economically empower this region. Furthermore, if the results from the M-GAM are high, management can be assured that any form of investment for cave tourism development will be successful.

Table 2 shows the results of the tourist evaluation according to the M-GAM method. The subindicators of scientific and educational values possess relatively similar scores, which have a moderate level. Firstly, the rarity of the caves is not high because there are similar geosites in this region. Some of them are highly developed tourist destinations, such as Stopića Cave and Podpećka Cave in the Zlatibor region. Secondly, with the help of field explorations, we concluded that most of the caves have low values of representativity because there is a small number of speleothems. Although there is a deficit of speleothems, these caves have a certain level of aesthetic and ambient value. The first speleological unit in Petnička Cave is a unique large hall, nearby the cave lake. These elements are the essential reason why this cave stands out for its representativeness. While all other caves

were rated with low scores, Petnička Cave was given a score of 0.50 for its representative qualities.

Some parts of the caves might be more aesthetically appealing to tourists when arranged for visits. Particularly noteworthy is the lack of lighting, pedestrian tracks, signalization, and organized tours. All the caves have these deficiencies, and this is a major problem. The absence of these changes cannot be an attraction for current generations, who increasingly seek more pristine areas. Only when these impediments are overcome, other factors of tourism improvement can be implemented. Furthermore, the scientific knowledge of these caves is not sufficiently developed. Petnička Cave has been the topic of several national publications, but additional research could have positive results on scientific clarification of this cave. As for the other caves, they have not been a topic in scientific publications in the fields of speleology, geology, geography, and tourism. If there were more scientific and non-scientific publications about these caves, their popularity might be on a much higher level. One of the significant advantages of these caves is that they have a moderate level of geomorphological processes that can be easily explained to a common visitor. This means that it is not necessary to invest much in tourist presentations and education of tour guides, which reduces the amount of funds needed for cave arrangement and cave tourism development (Table 3).

The subindicators of scenic/aesthetic values have not been so similarly evaluated as previous subindicators. Viewpoints in caves are important because they give an attractive view of a particular speleological unit. During our field research, we determined the existence of two viewpoints in Petnička Cave (one in the "High Hall" and one in the "Bears' Hall"). Petnička and Degurićka Caves are much larger than the other two, and they have richer and more diverse landscapes. Nearby the Degurićka Cave there is the Gradac River with natural conditions for swimming. This area is a favorite getaway for citizens of Valjevo City and it is a true destination for nature-based tourism. It should be mentioned that the Degurićka Cave is completely flooded. The river flows from the cave and it cannot be entered without proper equipment.

Table 3 Overall ranking of caves in Western Serbia by M-GAM

Geosite name	Main values		Additional values		Field
	VSE + VSA + VPr	Σ	VFn + VTr	Σ	
Petnička Cave	1.57 + 2.32 + 1.79	5.68	3.36 + 3.07	6.43	Z22
Degurićka Cave	1.15 + 2.09 + 1.90	5.14	2.87 + 1.87	4.74	Z21
Ribnička Cave	1.15 + 1.34 + 2.00	4.49	2.53 + 2.02	4.55	Z21
Šalitrena Cave	1.15 + 1.34 + 1.90	4.39	1.37 + 0.97	2.34	Z21
Potpećka Cave	1.68 + 1.85 + 1.79	5.32	1.90 + 3.05	4.95	Z21
Stopića Cave	2.21 + 1.85 + 1.43	5.49	1.90 + 3.05	4.95	Z22

Possible options for enabling tourist visitations would be to arrange boat tours or to build a pedestrian track that runs along the walls of the cave. The other two caves are less accessible. The Ribnička Cave is located right next to the monastery and is completely overgrown with grass, while the Šalitrena Cave is extremely inaccessible; it is necessary to cross the river and pass through unregulated pathways. Nevertheless, all caves fit in the environment and they are the true representatives of rich geodiversity.

The current natural condition of the explored caves is very good. All caves, except Petnička Cave, have no serious damage. Considering that the Petnička Cave was once a popular tourist destination, it has some infrastructure in its immediate vicinity, which is ruined by human factors. Also, inside the cave, a few graffiti and garbage can be seen. If the cave were still open for visitors, problems of this type would not exist.

The suitable number of tourists that can visit the caves in one tour is different. For Degurićka Cave, the visit is almost impossible without the suitable equipment and Šalitrena Cave is too small for more than 30 tourists. However, Petnička and Ribnička caves can take up to 50 tourists for each tour. After evaluating the functional values, it can be concluded that all caves possess adequate complementarities that are important for tourism development.

The promotion and the annual number of organized visits are rated with the lowest scores, because the caves are not equipped for tourism development and do not have any kind of promotion or organized visits. This is a very important defficiency, which needs to be corrected so that cave tourism development could have an impact on local and regional tourism and economic development.

The proximity of the visitor centers was observed in relation to the Petnica Research Center, which is located in the vicinity of the Petnička Cave. Therefore, this cave received the highest rating, while other caves further from the research center received a lower rating.

The Degurićka Cave is relatively close to the Petnica Research Center, so it is not necessary to build an additional visitor center. However, when it comes to Ribnička Cave and Šalitrena Cave, they need additional visitation centers.

Interpretive panels exist at Petnička and Degurićka caves and are completely absent at Ribnička and Šalitrena caves. Tourst visits are completely unorganized. When it comes to visiting these caves, tourists are self-initiative. According to the local tourist organization of the city of Valjevo, there are less than 5000 tourists annually, which is very low. The entrance to the Šalitrena Cave is forbidden due to archeological excavations. A very positive aspect of this area is the large number of rural villages, with rural catering establishments that provide solid quality accommodation and food services.

These caves have the possibility of a scientifically educational interpretation that can be presented to visitors in a quality way. Therefore, they are a priority of cave tourism

development. However, it is necessary to intensively work on investment plans and development strategies, through marketing and management structures.

Looking at regional tourism development in Western Serbia, it is evident that these speleological objects should be transformed into show caves as soon as possible. First, construction work should be done in Petnička Cave, then in Degurićka Cave and then further strategic directions for the other two caves should be considered.

Conclusion

Compared to the caves of the Zlatibor region, the explored caves have a much more modest geomorphological diversity. The interior of the caves has less speleothems and the environment around the caves has less karst landscapes. In addition, the caves of the Zlatibor region are arranged for tourists, they have lighting, pedestrian tracks, tour guide services, and organized management. Therefore, Stopića and Podpećka caves are much more touristically developed than all of the caves from the Valjevo karst area. Nevertheless, the results of the research indicate the presence of exceptional tourism potentials, which can be valuable indicators for the development of cave tourism in Western Serbia. The center of a potential Karst geopark would initially be the Zlatibor region, while the caves of the Valjevo region would, with the exception of the Petnička Cave, represent the complementary cave tourism values. The popularity of the caves from the Zlatibor region should be used to promote the caves of the Valjevo region. Furthermore, the establishment of the Western Serbia Karst Geopark Visitor Center near the Petnička Cave would further contribute to the promotion of cave tourism in Western Serbia. Strategic plans need to be implemented in order to maximize the use of all existing tourism potential. This would certainly contribute to regional economic development and would improve the position of the city of Valjevo in the tourist market.

It is evident that all the natural conditions for establishing a karst geopark in Western Serbia exist. However, the management of speleological objects needs to be modernized. In order for these caves to have a positive economic effect, the infrastructure investment in technical equipment, such as lights, pedestrian tracks, and safety equipment must be a priority. Also, the management and rescue team responsible for caves is important for controlling and improving the quality of cave tourism service. These ventures can have a huge impact on regional economic and tourism development. They can start local businesses, create jobs, and generally improve socio-economic development and environmental conservation.

The conducted research confirms the importance and necessity for the inclusion of the explored caves in the tourist market. In addition to the speleological values themselves, these geosites possess remarkable complementary social values, such as the Petnica Research Center, which is a scientific institution on a national level. Combining all the aforementioned tourism potentials, it is evident that a very high-quality tourist product can be created in this area. The management of caves and other local and regional management structures should pay full attention to these speleological objects, as well as to maximize their improvement and protective measures. This creates a sustainable way of tourism and economic development, quality promotion of speleology, and protection of caves.

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