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Comparative Analysis of Gorges and Canyons in Southeastern Serbia as Potential Geoturistic Destinations by Using Gam Model

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ABSTRACT: Southeastern Serbia is rich with geomorphological creations that present true values for geotourism development. The most important features of these remarkable creations are their uniqueness and preservation. Geosites considered for the purpose of this paper are in an enviable state in terms of nature conservation. They are under protection of the Republic of Serbia, so their nature is well preserved. The mentioned geosites considered for the purpose of this paper are: Jelašnica gorge, Sićevo gorge, Jerma river canyon and Rosomača canyon. All the geosites present extraordinary natural potentials for geotourism development, because of their unique nature, geomorphological creations and anthropological heritage. The geosites are evaluated using GAM model (Geosite Assessment Model), suitable for identifying the most attractive geosites, planning and management of natural resources. This model is also suitable for the application of natural resources for geotourism. After the evaluation, the authors came to conclusions which of the evaluated geosites are the most suitable for geotourism development.

Key words: canyons, *gorges, GAM model, geosite assesment, geotourism*

INTRODUCTION

Geotourism is a segment of tourism that has been developing worldwide in recent years. It is considered a form of niche (Hose 2005) or ‘special interest tourism’, actively growing tourism market segment. Geotourism was first defined by Hose (1996), but its definition has recently been refined as a form of tourism that specifically focuses on landscape and geology (Newsome, and Dowling, 2010). This advances an earlier concept of geotourism as strictly ‘geological tourism’. Geotourism promotes tourism to ‘geo-sites’ and conservation of geodiversity and understanding of earth sciences through appreciation and learning. The aim of geotourism is to make visitors aware of, and to gain some understanding of geological features that surround them.

Dowling and Newsome (2006) argued that geotourism is sustainable tourism with a primary focus on geological features, which promotes environmental and cultural understanding, appreciation and conservation, and it is locally beneficial. Geotourism is intended to stimulate the knowledge of geodiversity, geoconservation and use them for sustainable development.

Geotourism has an increasingly strong focus on geological science of landscape and rock features as well as an inherent and fundamental desire for visitors to understand and learn about what they are observing.

Its rich geodiversity lies in the fact that there are approximately 650 distinctive geosites in Serbia. However, the majority of the Serbian protected areas are focused on biological objects rather than geological, resulting in a higher number of protected areas based on bio aspects. The Republic of Serbia has so far protected approximately 80 geoheritage sites, mostly those of speleological character (Djurović and Mijović, 2006).

Among these sites there are several remarkable canyons and gorges of great scientific importance and geotourism potential.

Since the late XVIII century, canyons and gorges have become popular tourist destinations. This trend continues to the modern days, when a large number of people visit these popular sites every year. Tourism potential of gorges has already been analyzed in numerous papers by several authors such as Cocean (1984, 1988), Ciangă (2001), Cocean (2011, 2013).

The region of Southeastern part of the Serbia is very rich with numerous canyons, caves and pits located in a relatively small area. These geosites are excellent representatives of this area’s geodiversity. Geoheritage sites usually include all geological, geomorphological, pedological and distinct archaeological values created during the formation of the Earth's crust (Djurović and Mijović, 2006). Although the geological and geomorphic resources in southeastern Serbia are abundant, minimal studies have investigated different dimensions of geotourism in this area. Some studies have been completed but they do not focus on the geotourism, but on geology of carst. The largest contribution to the knowledge of this area was given by: Cvijić J., Martinović Ž., Stanković S., Kostić M., Mitić D., Petrović J.

The aim of this paper is to present the area of southeastern Serbia as a potential geotourism destination, mainly focused on gorges and canyons. The main purpose is evaluation and a proposed inventory of the most attractive geosites in the area: Jelašnica gorge, Sićevo gorge, Jerma canyon and Rosomača canyon and to compare them.

One of the aims of this paper is to raise awareness about this destination by making an inventory of the most attractive geosites in the area and by presenting their values to a wider auditorium. The GAM model should also give detailed assessment of analyzed geosites indicating the major barriers which thwarted tourism development up to now, but also draw attention to the main values of the sites evaluated. In the final part of the paper we also briefly discuss barriers to developing geotourism based on canyons and gorges in southeastern Serbia.

STUDY AREA

On the territory of the Republic of Serbia there are numerous canyons and gorges, which are widespread throughout the country and representing a valuable fluvial geoheritage sites with great potential for future geotourism development.

For the purpose of this paper, authors selected four most representative canyons and gorges (Fig. 1) in southeastern part of Serbia, in order to discuss their geotouristic values which are described below.

Figure 1. Locations of the selected geosites

(source: https://serbiaatlas.com/Serbia_Map.png; modified)

Jelašnica gorge is a gorge created by the river Jelašnica which streches in NW-SE, between the villages of Čukljenik and Jelašnica. It is 1,5km long and covers an area of 116 ha. The highest point of the gorge is Radovanski kamen peak (580 m high), and the lowest point lies in the bed of Studena river at the exit of the gorge (293 m) (Kostić , 1954).

In its middle and upper stream, the Jelašnica river cut a deep gorge through limestone and made its bedrock through the Permian red sands over which limestones lie discordantly. There, the limestone parties stayed at the top of the hills, where they protrude above the red sandstone as panels. On the left side of the Jelašnica river these limestones make only a narrow belt, and on the right side they spread over red sandstones over the villages Jelašnica, Čukljenik and Gornja Studena. In those limestones, which are pretty dolomite, characteristic structures can be observed, created by disintegration and limestone creating. On the sides of the Jelašnica basin in Jelašnica gorge, one can find denudation poles, jags and rubble stones (Kostić, 1954).

The most striking element of Sićevo area relief is the Nišava river valley which is, due to its characteristic morphological assembly and Sićevo village, called **Sićevo gorge.** It spreads from the village Dolac at the exit from Belopalanačka valley, to the village Prosek at the entrance of Niš valley. It is 17km long, deeper than 350 m. Sićevo gorge is composite, grandiose and heterogeneous and by its morphological evolution – polygenetic, breakthrough and polyphase (Nature Conservation Institute, 1998).

Sićevo gorge can be divided into four divisions. First division, Kusača is 5,4km long and it spreads from the village Prosek to the village Sićevo. Second division starts from a dam on the Nišava river upstream to Banjica in the village Ostrovica. Third division, 2km long is known as Ostrovica valley and starts from Banjica to Ostrovica quarry. Fourth division of the gorge, 5,5km long, is a canyon-like part of the gorge and is called Gradištanski canyon (Mitić, 2006).

Pushing through Greben mountain (1337 m) and Vlaška mountain (1442m), **Jerma** builds a canyon 300-400 m high and 10-30 m wide. The canyon is a part of a special nature reserve "Jerma", which is located between massifs Greben and Vlaška mountain. This area has good access roads which go from Niš and Pirot and also from villages Vlasi and Zvonce. This area represents a phenomenon of fluvial and karst erosion and other geomorphological processes. The area is rich with underground karst relief (such as coves, sinkholes, cracks, oysters, sandbanks, caves and sinkholes) and has a distinct form expressed through a narrow rift, in places more than 700 m high.

Geomorphological features of this area are mostly kept in the original form. The largest direct changes occurred at breaking and construction of the tracks and the road through the Jerma river canyon. On that occasion there was a partial change in morphology of the terrain. However the main features of the relief of this area are kept and are not significantly altered from its original form. The Jerma river gorge consists of two parts: pit and canyon parts, so (like most of the gorges in Serbia) it builds a composite valley. A part of Vlaška mountain where the gorge is widest and deepest ("Klisura") is between the monastery and Trnski Odorovci village. S-SE side of the gorge is particularly high and steep (canyon part). Upper parts of the canyon spread from Trnski Odorovci village to west, and after they turn to south, so the northern part of Jerma walley is the most closed part.

Rosomača gorge is a gorge created by the Rosomača river which belongs to the basin of the Visočica river. This gorge is characterized by small pots – eddies. These are depressions that formed the characteristic sections of vertical fluvial erosion. They are located in places where the river abruptly falls from a cascade into the trough, however, due to the high kinetic energy of water, it delves riverbed immediately behind the cascades. The width of the pots can be 4 m in diameter.

All the gorges and canyons mentioned above possess extraordinary natural values, presented in different geological-geomorphological formations that attract attention of the visitors. This is the reason why the authors think that those geomorphological features have a certain level of tourist value. In this regard, an evaluation is made on the selected gorges and canyons as geosites, in order to obtain a clear insight in the degree of the attractiveness of the localities for a future geotourism development in SE Serbia and to compare them.

METHODOLOGY

During the last two decades, several attempts have been made to evaluate the quality of geomorphological heritage in various contexts. In order to reduce subjectivity, numerous quantitative assessment methods have been developed (Coratza and Giusti 2005; Pereira et al. 2007; Reynard et al. 2007; Rybar 2010). Various methods are based on several assessment criteria: rarity, representativeness and integrity, but others, such as ecological value, palaeogeographic importance, educative value, are dependent on the context of the assessment and on the aims of the research (Reynard et al, 2007).

In the context of the promotion of the geomorphological heritage Geosite Assessment Model (GAM) was created. This model, proposed by Vujičić et al. 2011, can identify the most attractive geosites, which should assist in planning and in the sustainable management of natural resources, as well as in the application of natural resources for geotourism. The assessment includes an inventory of sites as well as proposals for their protection, promotion and monitoring (Pereira et al. 2007).

The methodology is based on several existing models and is represented by two main groups of values (Main Values) and additional criteria (Additional Values).

The first group, main values, comprises three indicators: scientific/educational (VSE), scenic/aesthetical (VSA) and protection values (VPr). The second indicator group of the geosite assessment model, additional values, is further divided in to two indicators, functional (VFn) and touristic values (VTr). The complete structure of GAM is presented in Table 1.

Main Values					
Grade	*0*	*0.25*	*0.5*	*0.75*	*1*
Scientific/Educational values (VSE)					
Rarity	Common	Regional	National	International	The only occurence
Representativeness	None	Low	Moderate	High	Utmost
Knowledge on geoscientific issues	None	Local publications	Regional publications	National publications	International publications
Level of interpretation	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
Scenic/Aesthetic values (VSA)					
Viewpoints	None	1	2 to 3	4 to 6	More than 6
Surface	Small	-	Medium	-	Large
Surrounding landscape and nature	-	Low	Medium	High	Utmost
Environmental fitting of sites	Unfitting	-	Neutral	-	Fitting
Protection (VPr)					
Current condition	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
Protection level	None	Local	Regional	National	International
Vulnerability	Irreversible (with possibility of total loss)	High (could be easly damaged)	Medium (could be damaged by natural processes or human activities)	Low (could be damaged only by human activities)	None
Suitable number of visitors	0	0 to 10	10 to 20	20 to 50	More than 50
Additional Values					
Grade	*0*	*0.25*	*0.5*	*0.75*	*1*
Functional values (VFn)					
Accessibility	Inaccessible	Low (on foot with special equipment)	Medium (by bicycle)	High (by car)	Utmost (by bus)
Additional natural values	None	1	2 to 3	4 to 6	More than 6
Additional anthropogenic values	None	1	2 to 3	4 to 6	More than 6
Vicinity of emissive centres	More than 100 km	100 to 50 km	50 to 25 km	25 to 5 km	Less than 5 km
Vicinity of important road network	None	Local	Regional	National	International
Additional functional values	None	Low	Medium	High	Utmost
Touristic values (VTr)					
Promotion	None	Local	Regional	National	International
Annual number of	None	Less than 12 per	12 to 24 per year	24 to 48 per year	More than 48 per

Main Values					
Grade	*0*	*0.25*	*0.5*	*0.75*	*1*
organized visits		yeae			year
Vicinity of visitors centres	More than 50 km	50 to 20 km	20 to 5 km	5 to 1 km	Less than 1 km
Interpretative panels	None	Low quality	Medium quality	High quality	Utmost quality
Annual number of visitors	None	Low (less than 5000)	Medium (5001 to 10 000)	High (10 001 to 100 000)	Utmost (more than 100 000)
Tourism infrastructure	None	Low	Medium	High	Utmost
Tour guide service	None	Low	Medium	High	Utmost
Accomodation	More than 50 km	50 to 25 km	25 to 10 km	10 to 5 km	Less than 5 km
Restaurants	More than 25 km	25 to 10 km	10 to 5 km	5 to 1 km	Less than 1 km

Table 1 - *Indicators and subindicators in the GAM model according to Vujičić et al. (2011)*

In total sum, there are 12 secondary indicators of Main Values, and 15 secondary indicators of Additional Values which are graded from 0 to 1 as it is shown in Table 1. This defines GAM in a form of equation:

$$GAM = MV + AV$$

where MV and AV are signs for main values and the additional values, respectively. As each of the two values MV and AV are composed of the three and two groups of indicators, two equations can be written:

$$MV = VSE + VSA + VPr;$$
$$AV = VFn + VTr$$

Based on the results of the assessment, a matrix of main and additional values could be created (Figure 2), where these values are presented via X and Y axes respectively. The matrix is divided into nine fields (zones) that are indicated by Z(i,j) (i,j=1,2,3) based on the grade they received in the previous evaluation process. Major gridlines that create fields, for X axe have value of 4 and for Y axe of 5 units (Vujičić et al., 2011).

RESULTS AND DISCUSSION

In order to assess the current use and geotourism potential of our study area and to see which values should be the focus of future improvements we used the previously explained model.

Geosite	Name of geosite	Protected since	Geodiversity
GS_1	Jelašnička gorge	1995. – Nature park (I category)	Limestone structures, caves, cavelets, denudation poles, jags, rubble stones, small waterfall and thermo-mineral springs
GS_2	Sićevo gorge	2000. – Nature park (II category)	Limestone structures, caves, caverns, rock shelters, cliffs, cavelets, thermo-mineral springs
GS_3	Jerma river gorge	2014. – Special Nature Reserve (I category)	Limestone structures, caves, cavelets, giant pots, cliffs more then 200m high
GS_4	Rosomačka gorge	1997. – Nature park	Small gorge consists of brescian and conglomeration sandstones with giant pots at the bottom

Table 2. *Basic information about geosites*

Table 2. shows the basic information about the geosites evaluated using the GAM method. The sites' main geodiversity and the protection level is also indicated Table 2.

Geosite	Main Values (VSE+VSA +VPr)	Additional Values (VFn +VTr)	Field
GS_1	3.25+2.25+2.25=7.75	4+5.25=9.25	Z_{22}
GS_2	3.25+4+3.25=10.5	6+5.75=11.75	Z_{33}
GS_3	3.25+2+2=7.25	4+4=8	Z_{22}
GS_4	3.5+2+3.25=8.75	4+2.75=6.75	Z_{23}

Table 3. *Results of the evaluation process by GAM model*

Table 3 and Figure 3 show the results of a comparative analysis of four canyons and gorges: Jelašnica gorge (GS_1), Sićevo gorge (GS_2), Jerma canyon (GS_3) and Rosomača canyon (GS_4). The highest main values obtained Sićevo gorge (GS_2), 10.5, comparing to the significantly lower values for Jerma canyon (GS_3), 7.25. On the other hand, the lowest additional values were obtained by Rosomača gorge (GS_4), 6.75, in comparison with Sićevo gorge (GS_2) and its values, 11.75.

When analyzing the scores of different subindicators representing scientific values (VSE), we can see that all the geosites have the same values, 3.25, except for Rosomača canyon, 3.5. Rosomača canyon is a unique geomorphological creation in Serbia and in the region, and this subindicator was evaluated with the highest score (1).

Scenic/Aestetic values (VSA) are presented through viewpoints, surface, surrounding landscape and nature and environmental fitting of sites (Table 1). All the sites evaluated are protected on national level and all of them are near international roads, in fact international road M-5 goes through Sićevo gorge. Sićevo gorge (GS_2) obtained maximum score, because it covers the biggest area and has many viewpoints. The lowest scores were obtained by Jerma river gorge and Rosomača gorge (both 2) because both of them have no viewpoints and cover small area.

An important subindicator within Main values is protection (VPr). As already noted in this paper, all of the sites are protected by national legislative (Table 2), they are all in solid condition (the scores for all the sites are 0.75) and medium vulnerability. The main difference and the reason why Sićevo gorge obtained the highest score (3.25) is the biggest area which can be suitable for more than 50 visitors. Jelašnica gorge can be noted as the most vulnerable one, as for it is one of the most popular free-climbing destination and the most loaded geosite from this list. Drilling holes for free-climbers endangered one of the most attractive site of Jelašnica gorge, a beautiful cavelet. The Institute for Nature Conservation of Serbia stopped all the climbing activities in Jelašnica gorge until further notice, which was a result of uncontrolled drilling of the top of this cavelet. The future of these activities is still unknown, but we can expect certain restrictions.

After evaluating the Additional values (AV), the scores showed that Sićevo gorge (GS_2) has the highest value (11.75) comparing to the lowest value (6.75) for Rosomača canyon. When talking about functional values (VFn), all the sites have high evaluation (4), especially Sićevo gorge (GS_2) which has maximum value (6). All the sites are accessible by car and by bus, except from Jerma canyon, which is accessible only by car and small buses because of the low tunnels. Rosmača canyon is not accessible during spring months because of the high waters of the Rosomača river, besides this, all the other gorges and canyons are accessible all year round. All the geosites are near emissive centers (cities such as Niš, Pirot) and have rich athropogenic values: monasteries St. Petka and The Holy Mother of God in Sićevo gorge, Poganovo monastery in Jerma canyon, old villages in Jelašnica gorge and Rosomača canyon; and natural values: exceptional examples of karst relief, preserved nature values, rare flora and fauna species. They mostly differ in additional functional values, where Sićevo gorge has the highest score.

In the end, there are Touristic values (VTr) where the geosites got the lowest scores: the highest score has Sićevo gorge (GS_1), 11.75 out of 9 and the lowest score has Rosomača canyon (GS_4), 6.75 out of 9.

Figure 2. Sićevo gorge (upper left); Jelašnica gorge (upper right); Jerma gorge (bottom left), Rosomača river gorge (bottom right) (Photos: Began M.)

The main reason for the general lowest results in Touristic values is the insufficient development of tourism in this area. Actually, insufficient development of outdoor, active or geotourism. There are only few guides that could handle groups interested for these geosites, and on the other hand – there aren't much of tourists interested in these natural areas. The reason for this is a lack of adequate tourist promotions of these areas and the activities that could be interesting for potential tourists and geotourists. On the other hand, high scores are obtained concerning the accommodation and restaurants because the sites are near settlements where the visitors can find mentioned facilities.

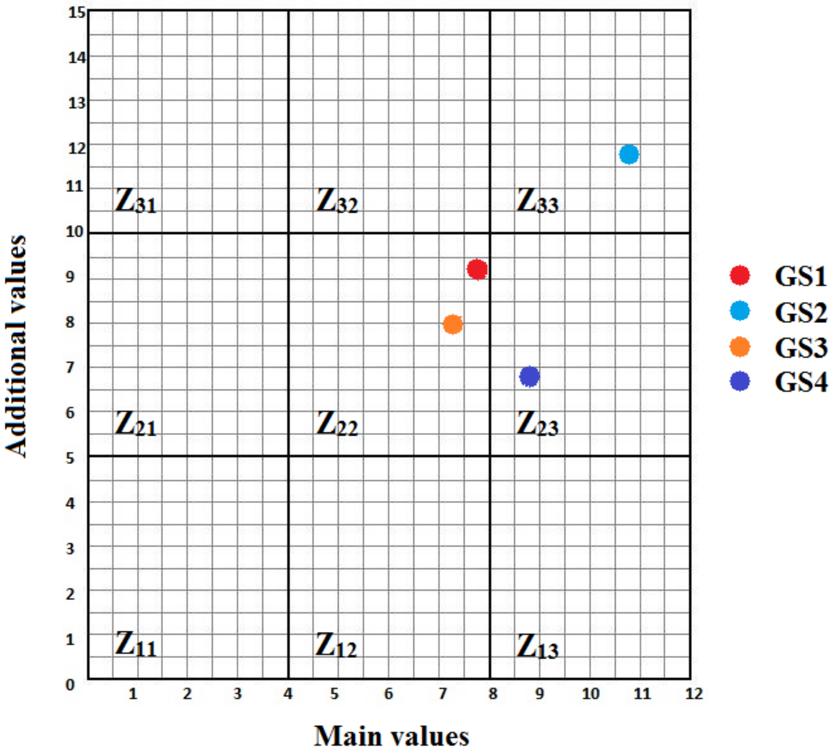

Figure 3. Position of the assessed geosites in GAM matrix

All the four evaluated geosites on general obtained solid scores. These geomorphological sites are nationally protected and represent extraordinary examples of geomorphological creations. They are rich with karst relief features (coves, cracks, oysters, sandbanks, caves, sinkholes), thermo-mineral water springs and beautiful landscapes. Apart from these features, the geosites evaluated are home to different flora and fauna species, in fact some of them are home to relict species, such as Ramonda Serbica and Ramonda Nathaliae (Jelašnica gorge) and lilac trees (Jelašnica gorge and Sićevo gorge). Also, there are numerous anthropogenic values within the sites evaluated, such as old mills and houses, old coal mine in Jelašnica gorge, two monasteries, a quarry, two small hydro power plans (one of them, St. Petka hydro power plan, was build in 1908), few archaeological sites, Sićevo art collony in Sićevo gorge, monastery Poganovo and Zvonačka spa in Jerma gorge (near the canyon), old traditional villages and monasteries near Rosomača canyon. Very important factor for further development are access roads that are in good conditions. All the geosites evaluated have good access roads suitable for individual and group visits. Also, they are all 5-15km away from the international road M-5 (connecting Niš, Serbia and Sofia, Bulgaria), which actually goes through Sićevo gorge.

Conclusion

Figure 3 shows the results of this evaluation. It is evident that Jelašnica gorge (GS_1) and Jerma canyon (GS_3) are in the field Z_{22}, Rosomača canyon (GS_4) in the field Z_{23}. The highest value definitely obtained Sićevo gorge (GS_2) as the largest one and the one with the greatest potential.

The geosites presented didn't get high scores when it came to touristic values because tourism is insufficiently developed in these areas and needs to be introduced the right way so it can promote the unique nature of the geosites and preserve it from degradation. High scores that Sićevo gorge obtained within Main values and Additional values' subindicators except from Touristic values put it in field Z_{33}. This field assumes that tourism is already developed in an area evaluated by GAM model. The fact is that there is a certain amount of tourist activities in Sićevo gorge (pilgrimage to the monasteries, visits to hydro power plans, outdoor activities, excursions, cultural visits) but definitely not sufficiant to claim that Sićevo gorge is a genuine geotourism destination.

Surely, it is necessary to underline the urgent need for proper and specific protection of the geosites, because tourism sometimes leads to rapid degradation of the sites. Sometimes faster then it leads to any kind of economic prosperity.

The comparative analysis of the gorges in SE Serbia helped testing their importance, both from the point of the development and the science but also from the aspect of development and of geotourism. The highest values were obtained by Sićevo gorge, which was expected, because it covers the largest area and is the most famous one. Also, this gorge has the greatest potentials for developing of various types of tourism in this area. This is why Sićevo gorge should be in focus for further research and geotourism development, because it has the greatest potentials which could, with the minimum investments, make Sićevo gorge a significant geotourism destination.

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