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APPLICATION OF GAM MODEL TO PROTECTED AREAS OF THE NORTHWESTERN PART OF CENTRAL SERBIA

Perić Marija[1], Stankov Slobodanka[2]

[1]*University of Belgrade, Faculty of Geography, Studentski trg 3/III, 11000 Belgrade, Serbia, E-mail: maki.peric84@gmail.com*
[2]*Western Serbia Academy of Applied Studies, Užice Department, College of Applied Sciences Užice, Trg Svetog Save 34, 31000 Užice, Serbia*

ABSTRACT:

The research in this paper refers to the definition and scientific explanation of relevant indicators (indicators and sub-indicators) that effect on the development of geoheritage (Petnička cave, gorge of the river Gradac and Trešnjica, and Taor springs) and their placement on the tourism market. By applying the GAM model, it has been proven that geoheritage in this part of Serbia represents a very significant tourism potential, which must not be neglected, and even more underestimated. The results of the research showed that the Petnička cave represents the greatest tourism potential Z_{32}, while the Taor springs have the lowest tourism value Z_{22}. In the future, geoheritage sites need bigger promotion, infrastructure construction and the creation of their own tourism brand.

Key words: *GAM model, protected areas, geoheritage, Serbia*

INTRODUCTION

The offer and arrangement of tourism activity in protected areas of nature in the northwestern part of the Central Serbia (Serbian Posavina with Mačva and Valjevska Podgorina), represents a great tourism potential that cannot be characterized and marked as sustainable. This is also one of the main hypotheses in the paper. It is obvious that geotourism has been developing spontaneously for many years. The concept of sustainable tourism development is partially used. The balance between environmental, economic and socio-cultural factors is not fully harmonized. In the certain phenomena and segments, its initial phases can be noticed, which should come to life and enable the comprehensive development of geotourism. It is necessary to valorize, affirm and present tourism potentials on the tourism market and as well as to respond to the demands of modern tourists.

In order to represent the quality of progressive growth of tourism in a certain area, it is necessary to have a larger number of geoheritage sites that are characterized by their authenticity [1]. The best contribution to the development of geotourism is based on the offer of tourism contents, based on rational and objective facts. In the future, more attention should be paid to the development and implementation of planning documents for a certain period of time.

The basic subject, goal and task in this paper is related to:

- Consideration of the current state, possibilities and perspectives of geotourism development on the national, regional and local tourism market for the needs of local communities and the interests of the visitors;

- Providing assumptions, possible solutions and determining guidelines for further development of geoheritage in order to tourism content influence to the quality of tourism products;
- Establishment of appropriate instruments and measures, legality and solutions for more rational, objective and planned development of tourism in the protected areas of nature.

Geotourism is most often seen as a form of sustainable and planned tourism based on preserved nature and spatial areas. The preserved environment is less represented, compared to degraded and devastated areas. This is a consequence of anthropogenic factors as well as giving the priority to certain spheres of interest and groups that are not in line with environmental protection. The problem is that once the "ecological balance" is disturbed, relationships in nature cannot be return to their primary state. The successful protection and preservation of the geolocation of the northwestern part of the Central Serbia cannot be imagined without the active work of all participants (from state institutions to the individuals) who must have a long-lasting and durable effect. The result of this cooperation is the preservation and protection of the natural environment and the satisfaction of tourists with the offered tourism products, i.e. geolocations.

In order to become dominant, sustainable development of geotourism must offer the authenticity, uniqueness and innovation of tourism contents, for which there is a growing demand. If the environment is preserved and unpolluted (air, water and land), then the opportunities for the development of geotourism are more favorable. The main goal is to preserve natural and anthropogenic values, in order to achieve the necessary "ecological balance" where satisfying the motives and desires of current tourists will not endanger future generations. It follows that the benefits of sustainable tourism extend to the long-term and that there is no way to speak of a short-term positive effect.

RESEARCH METHODOLOGY

The GAM *(Geosite Assesment Model)* presents a model for the evaluation of geolocations that will be applied to four protected natural assets: Petnička cave, Taor springs, the gorge of the river Gradac and the gorge of the river Trešnjica. The numerous of foreign authors [2-20] have made a great contribution to the study, valorization and evaluation of geoheritage objects on the example of individual countries (Bosnia and Herzegovina, Spain, Portugal, Malta, Great Britain and Brazil). Also, domestic authors [21-28] have contributed to the study of geoheritage objects (Bela Crkva, Fruška gora, Donje i Srednje Podunavlje, the Lazar river canyon). There are a large number of methods for the evaluation of geolocations where the biggest importance should be given to the conceptualization of questions and objectivity in giving the answers. The biggest attention in this paper will be paid to the geology (scientific/educational, landscape/aesthetic and protection), tourism and functional values.

The geoecology evaluation of geolocality is divided into two sets of indicators, the main values *(MV)* and the additional values *(AV)* [23,28,29]. These indicators are divided into 12 and 15 sub-indicators, with range between 0.00 and 1.00. The *main values* are natural features (relief, climate, hydrography and pedology) of geolocality. The *additional values* are caused by anthropogenic influence, i.e. the actions of the human's (for the needs of enthusiast's/nature lovers, i.e. tourists).

In the matrix (Figure 1), *the main values* (MV) are divided into three groups of indicators, scientific/educational value (VSE), landscape/aesthetic value (VSA) and protection (VPr) [28].

On the shown matrix (Figure 1), *the additional values* (AV) are divided into two groups of indicators, functional value (VFn) and tourism value (VTr). The basic equation for calculating the GAM model according to the authors [23,27,28,29]:

$$GAM = MV + AV \tag{1}$$

where *MV* represent the main values, and *AV* state the additional values which, based on the systematization and classification, are divided into three or two sets of sub-indicators. Based on the above, the conclusion of the following equations is derived:

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

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

where *VSE* means scientific/educational value, *VSA* represents landscape/aesthetic value, *VPr* states protection, *VFn* and *VTr* establish functional value and tourism potential. According to the stated characteristics, features and properties, it can be concluded that each set or group of indicators consists of a number of sub-indicators. Based on the above, equations can be reported according to the authors [23,27,28,29]:

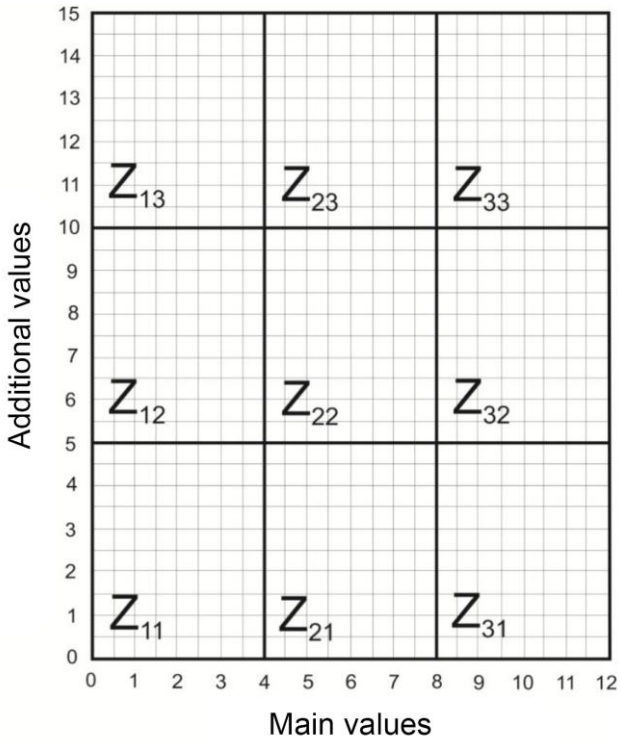

Figure 1. The main and the additional values

$$MV = VSE + VSA + VPr \equiv \sum_{i-1}^{12} SIMV_i \tag{4}$$

$$0 \le SIMV_i \le 1$$

$$AV = VFn + VTr \equiv \sum_{j-1}^{15} SIMV_j \tag{5}$$

$$0 \le SIMV_j \le 1$$

where $SIMV_i$ and $SIMV_j$ represent 12 sub-indicators of the main values shown in the matrix (Figure 2) and their range is in the interval (i = 1, …, 12), and includes 15 sub-indicators in the interval (j = 1, ..., 15). In the statement with the original concept, meaning and definition of the GAM model, each of the sub-indicators can get one of the following values 0.00, 0.25, 0.50, 0.75 and 1.00 [23,27,28,29].

The research and the evaluation of geolocality is shown by numerical values. The procedure of work and the site evaluation is presented in detail and elaborated in the procedures shown above. The first step is to form a matrix that includes the X and Y axes. There are four fields or zones of principal values on the X axis. Five fields are located on the Y axis where the additional values are shown.

Based on the obtained results, shown by numerical values, the locality will belong to a certain field in the matrix (the main and the additional values) [23].

If, based on the evaluation of a geolocation and during the calculation, the main values are six and the additional values are three, they occupy a field in the matrix $Z_{18.}$ This also indicates and states the low level of the main and the additional values. The obtained results objectively show whether the geolocation represents a significant tourism potential, what value it has and what must be undertaken in order to affirm itself in the tourism market [30].

RESULTS AND DISCUSSION

In the period of the survey research (2017-2019), a total of six respondents were surveyed. The four of them were from the Local Self-Government of the City of Valjevo and two from the Tourist Organization of Ljubovija. The experts employed in these institutions are engaged in the development of strategies, studies and projects related to protected natural assets in the northwestern part of the Central Serbia. The respondents, with explanation, based on rational data and facts, gave the identical or similar answers during the evaluation procedure of geolocations, which is stated in the below presented tables.

From the Table 1, it can be stated that the Monument of Nature "Petnička cave", by the evaluating of the geolocation, has high ratings of indicators and sub-indicators, i.e. there is no significant difference between the main and the additional values. Thanks to the rich biodiversity, the intermittent source of the Banja spring and the stalactites and stalagmites, the tourism visits are regularly organized every year. The number of tourists increases thanks to the Petnica Research Station, which is located in the immediate vicinity.

Table 1. The estimation of indicators and sub-indicators of MN "Petnička cave" geolocality

Indicators/Sub-indicators		Marks	Indicators/Sub-indicators		Marks
MV	***Maine values***		***AV***	***Additional values***	
VSE	*Scientific/Educational value*	**2,75**	*VFn*	*Functional values*	**3,00**
$SIMV_1$	Rarity	0,75	$SIAV_1$	Accessibility	0,75
$SIMV_2$	Representativeness	0,75	$SIAV_2$	Additional content of natural features	0,50
$SIMV_3$	Site research	0,75	$SIAV_3$	Content of anthropogenic values	0,50
$SIMV_4$	Level of interpretation	0,50	$SIAV_4$	Distance of emitting centers	0,50
VSA	*Landscape/Aesthetic value*	**2,25**	$SIAV_5$	Close to important roads	0,50
$SIMV_5$	Lookouts	0,25	$SIAV_6$	Additional functional values	0,25
$SIMV_6$	Surface area	0,50	*VTr*	*Tourist values*	**5,50**
$SIMV_7$	Landscape / Natural surroundings	0,75	$SIAV_7$	Promotion	1,00
$SIMV_8$	Geolocation integration	0,75	$SIAV_8$	Organized visits	0,50
VPr	*Protection*	**3,00**	$SIAV_9$	Close to visitor centers	0,25
$SIMV_9$	Current situation	0,75	$SIAV_{10}$	Interpretive boards	0,50
$SIMV_{10}$	Level of protection	0,75	$SIAV_{11}$	Number of visitors	0,75
$SIMV_{11}$	Sensitivity	0,75	$SIAV_{12}$	Tourist infrastructure	0,50
$SIMV_{12}$	Carrying capacity	0,75	$SIAV_{13}$	Guide service	0,50
VSE + VSA + VPr		**8,00**	$SIAV_{14}$	Accommodation services	0,75
			$SIAV_{15}$	Restoration services	0,75
			VFn + VTr		**8,50**

The only minor shortcoming that can be noticed is the insufficient construction of the tourism infrastructure/superstructure and the existence of only one lookout point which is located near the Uspenje Presvete Bogorodice church (near the cave). Every year, the promotion of the protected natural asset is held at various fairs, gatherings and congresses by the Tourist Organization Valjevo, tourist guides/escorts, managers and all interested citizens.

Table 2. The overall assessment of the analyzed geolocation - "Petnička" cave using GAM model

Values				
Main values		Additional values		
VSE + VSA + VPr	Σ	***VFn + VTr****	Σ*	Total
2,75+2,25+3,00	8,00	3,00+5,50	8,50	Z_{32}

From the attached Table 1 and Table 2, it can be concluded that the geolocation Petnička cave has the high values due to its natural and created characteristics, which shows Z_{32} and the high valuation in the matrix. Thanks to its authenticity and invaluable values, it represents a significant tourism destination for many visitors and the "seal" of the City of Valjevo.

Table 3. The estimation of indicators and sub-indicators of LEF "Gorge of the river Gradac" geolocality

Indicators/Sub-indicators		Marks	Indicators/Sub-indicators		Marks
MV	***Maine values***		***AV***	***Additional values***	
VSE	*Scientific/Educational value*	**2,25**	*VFn*	*Functional values*	**3,50**
$SIMV_1$	Rarity	0,50	$SIAV_1$	Accessibility	0,50
$SIMV_2$	Representativeness	0,50	$SIAV_2$	Additional content of natural features	0,50
$SIMV_3$	Site research	0,75	$SIAV_3$	Content of anthropogenic values	0,50
$SIMV_4$	Level of interpretation	0,50	$SIAV_4$	Distance of emitting centers	0,50
VSA	*Landscape/Aesthetic value*	**2,25**	$SIAV_5$	Close to important roads	0,75
$SIMV_5$	Lookouts	0,25	$SIAV_6$	Additional functional values	0,50
$SIMV_6$	Surface area	0,50	*VTr*	*Tourist values*	**4,50**
$SIMV_7$	Landscape / Natural surroundings	0,75	$SIAV_7$	Promotion	0,75
$SIMV_8$	Geolocation integration	0,75	$SIAV_8$	Organized visits	0,50
VPr	*Protection*	**3,00**	$SIAV_9$	Close to visitor centers	0,25
$SIMV_9$	Current situation	0,75	$SIAV_{10}$	Interpretive boards	0,50
$SIMV_{10}$	Level of protection	0,75	$SIAV_{11}$	Number of visitors	0,50
$SIMV_{11}$	Sensitivity	0,50	$SIAV_{12}$	Tourist infrastructure	0,50
$SIMV_{12}$	Carrying capacity	1,00	$SIAV_{13}$	Guide service	0,50
VSE + VSA + VPr		**7,50**	$SIAV_{14}$	Accommodation services	0,50
			$SIAV_{15}$	Restoration services	0,50
			VFn + VTr		**8,00**

The Landscape of Exceptional Features of the gorge of the river Gradac has a certain rarity and authenticity thanks to the large number of speleological objects (60) arranged for tourist visits (Degurićka cave, Kaljava, Tmuša, Vratoca, Visoka and Gradska).

The research of the site is very good thanks to different profiles of scientists (geomorphologists, hydrologists, climatologists and regional geographers), which is manifested through the presentation and publication in various journals, seminars, symposiums, congresses, diplomas, master's and doctoral theses. The most important hydrological phenomena are the Bukovska river, Zabava, Gradac springs, Paklje, Lučica, Vidan, Novakovićeva česma, Studenac and Bogatićka vodenica.

The cave is located in the immediate vicinity of the City of Valjevo and the most important infrastructure facility is the Valjevo-Užice railway. Among the natural tourism values, the most important are the archeological site of Valva and Jerinin grad, the speleological objects and mills (Lelićka, Savatijevića and Filipovića).

Among the anthropogenic tourism values, the central place is occupied by the monastery of Ćelije and the hydroelectric power plant in Degurić, both under the state protection. The visits to the protected natural asset are mostly organized with the accompaniment of a local tourist guides, escort or manager of the protected natural asset.

The most important accommodation and catering capacities are "Vidra", "Splav Gradac", "Rašević", "Tadića mlin", "Narcis", "Grand" and "Bubica" [30].

Table 4. The overall assessment of the analyzed geolocation - "Gorge of the river Gradac" using GAM model

Values				
Main values		Additional values		
VSE + VSA + VPr	Σ	***VFn + VTr***	Σ	Укупно
2,25+2,25+3,00	7,50	3,50+4,50	8,00	Z_{22}

Based on the evaluation of the geolocality the gorge of the river Gradac, presented it the Table 3 and Table 4, it can be stated that there are significant differences between the main and the additional values, although the overall score of Z_{22} indicates the high evaluation in the presented matrix. The landscape of exceptional features of the gorge of the river Gradac is characterized by curiosities and representativeness, where on the basis of natural and created values it favors the development of specific types of tourism.

Table 5. The estimation of indicators and sub-indicators of SNR "Gorge of the river Trešnjica" geolocality

Indicators/Sub-indicators		Marks	Indicators/Sub-indicators		Marks
MV	***Maine values***		***AV***	***Additional values***	
VSE	*Scientific/Educational value*	**3,00**	*VFn*	*Functional values*	**2,50**
$SIMV_1$	Rarity	1,00	$SIAV_1$	Accessibility	0,25
$SIMV_2$	Representativeness	0,75	$SIAV_2$	Additional content of natural features	0,50
$SIMV_3$	Site research	0,75	$SIAV_3$	Content of anthropogenic values	0,50
$SIMV_4$	Level of interpretation	0,50	$SIAV_4$	Distance of emitting centers	0,50
VSA	*Landscape/Aesthetic value*	**1,75**	$SIAV_5$	Close to important roads	0,50
$SIMV_5$	Lookouts	0,25	$SIAV_6$	Additional functional values	0,25
$SIMV_6$	Surface area	0,50	*VTr*	*Tourist values*	**5,50**
$SIMV_7$	Landscape / Natural surroundings	0,50	$SIAV_7$	Promotion	0,75
$SIMV_8$	Geolocation integration	0,50	$SIAV_8$	Organized visits	0,50
VPr	*Protection*	**2,50**	$SIAV_9$	Close to visitor centers	0,25
$SIMV_9$	Current situation	0,75	$SIAV_{10}$	Interpretive boards	0,50
$SIMV_{10}$	Level of protection	0,75	$SIAV_{11}$	Number of visitors	0,50
$SIMV_{11}$	Sensitivity	0,50	$SIAV_{12}$	Tourist infrastructure	0,50
$SIMV_{12}$	Carrying capacity	0,50	$SIAV_{13}$	Guide service	0,50
VSE + VSA + VPr		**7,25**	$SIAV_{14}$	Accommodation services	1,00
			$SIAV_{15}$	Restoration services	1,00
			VFn + VTr		**8,00**

The Special Nature Reserve the gorge of the river Trešnjica is one of the most important tourism site of the study area. Thanks to the rich biodiversity, the colony of griffon vultures, hydrographic objects (Tribuća, Sušica, Crni potok and Dubrašnica), the California trout pond and cultural and historical values (Veliki i Mali Grad), it represents the authenticity of this part of Serbia. The most part of the village of Gornja Trešnjica has been placed under the state protection. Thanks to its natural and created characteristics, it favors the development of alternative tourism formes (excursion, sports, events, ecological and cultural).

Table 6. The overall assessment of the analyzed geolocation – "Gorge of the river Trešnjica" using GAM model

Values				
Main values		Additional values		
VSE + VSA + VPr	Σ	***VFn + VTr***	Σ	Укупно
3,00+1,75+2,50	7,25	2,50+5,50	8,00	Z_{22}

From the attached Tables 5 and Table 6, it can be stated that the main and the additional values have approximately high grades, which is manifested by the value and affiliation to the field Z_{22}. One of the limiting factors is the existence of only one lookout point near the California trout pond and the inaccessibility of the terrain (arranged 7 km trail for tourists and visitors, and adequate equipment is necessary for further visits).

Table 7. The estimation of indicators and sub-indicators NM "Taor springs" geolocality

Indicators/Sub-indicators		Marks	Indicators/Sub-indicators		Marks
MV	***Maine values***		***AV***	***Additional values***	
VSE	*Scientific/Educational value*	**,00**	*VFn*	*Functional values*	**2,25**
$SIMV_1$	Rarity	0,50	$SIAV_1$	Accessibility	0,25
$SIMV_2$	Representativeness	0,50	$SIAV_2$	Additional content of natural features	0,50
$SIMV_3$	Site research	0,75	$SIAV_3$	Content of anthropogenic values	0,50
$SIMV_4$	Level of interpretation	0,25	$SIAV_4$	Distance of emitting centers	0,50
VSA	*Landscape/Aesthetic value*	**2,25**	$SIAV_5$	Close to important roads	0,25
$SIMV_5$	Lookouts	0,25	$SIAV_6$	Additional functional values	0,25
$SIMV_6$	Surface area	0,50	*VTr*	*Tourist values*	**4,00**
$SIMV_7$	Landscape / Natural surroundings	0,75	$SIAV_7$	Promotion	0,50
$SIMV_8$	Geolocation integration	0,75	$SIAV_8$	Organized visits	0,50
VPr	*Protection*	**2,75**	$SIAV_9$	Close to visitor centers	0,25
$SIMV_9$	Current situation	0,50	$SIAV_{10}$	Interpretive boards	0,25
$SIMV_{10}$	Level of protection	0,75	$SIAV_{11}$	Number of visitors	0,50
$SIMV_{11}$	Sensitivity	0,50	$SIAV_{12}$	Tourist infrastructure	0,50
$SIMV_{12}$	Carrying capacity	1,00	$SIAV_{13}$	Guide service	0,50
VSE + VSA + VPr		**7,00**	$SIAV_{14}$	Accommodation services	0,50
			$SIAV_{15}$	Restoration services	0,50
			VFn + VTr		**6,25**

The Natural Monument Taor springs is a rare geomorphological and hydrological phenomenon thanks to its natural, created and imposing characteristics (the bigren accumulations). Out of a total of nine former mills, only two remain that are partially in function (Drojićka and Delićka).

Protected natural asset is characterized by the originality, representativeness, rarity and diversity. They contributing to the various of specific forms of movements in tourism (ecotourism, sports events, excursions, transit and weekend tourism).

Table 8. The overall assessment of the analyzed geolocation – "Taor springs" using GAM model

Values				
Main values		Additional values		
VSE + VSA + VPr	Σ	***VFn + VTr***	Σ	Укупно
2,00+2,25+2,75	7,00	2,25+4,00	6,20	Z_{22}

Out of a total of four geolocations on the territory of the study area, the protected natural asset Taor springs has the lowest values of Z_{22}, which can be concluded from the Table 7 and Table 8. The main shortcoming is insufficient investment in infrastructure and superstructure, inaccessibility of the terrain and capturing water to supply the population of Municipality of Kosjerić. In addition to the mentioned weaknesses, the irrational use of the bigren accumulations, as well as inadequate tourist signals (information boards) are ledding to the unsatisfactory situation and to the lower values of the indicators and sub-indicators.

The attached evaluations of the geoheritage sites (Petnička cave, the river Gradac and the river Trešnjica gorge and Taor springs) pointed out that the potentials for tourism movements and trips of visitors to the northwestern part of the Central Serbia are solid. It is necessary to place tourism contents on the tourism market and respond to the demands of modern tourists.

The biggest shortcoming is the insufficient investment in infrastructure, accommodation and catering facilities and better accessibility to the studied geoheritage sites. In the future, promotion at fairs, conferences, congresses and workshops will be an unavoidable part, in order to make ecotourism more important.

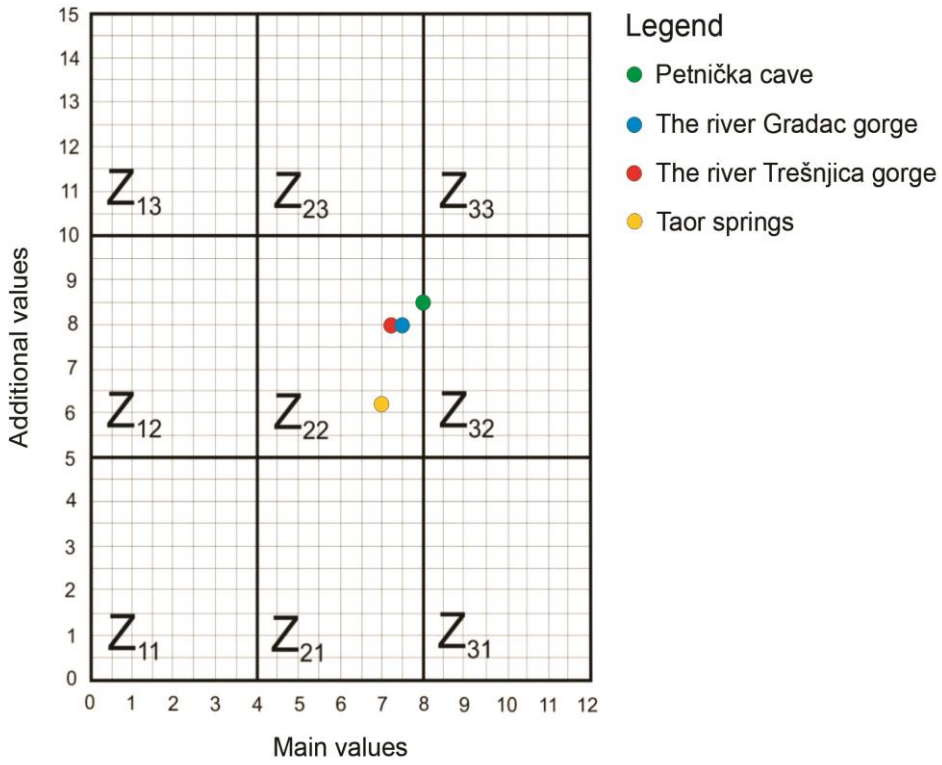

Figure 2. Research results, 2019.

CONCLUSION

The geotourism in protected areas of nature is a very important tourism offer of the northwestern part of the Central Serbia. In the future, in order to geoheritage sites occupy a satisfactory position in the tourism industry and visitors be satisfied with them, it is necessary to develop and implement strategies, studies and projects. The diversity of tourism values of geoheritage sites determines and creates opportunities for complementary, independent or complex development of tourism, which as such is presented on the domestic and foreign tourism market. However, this can have advantages only if attractive programs and contents are represented in the tourism offer. Other tourism motives (events, fairs, exhibitions) are the additional contents that affect the enrichment and extension of each visitor stay.

With good organization, geotourism can have multiple and positive effects on the current and future condition of geoheritage sites and it can contribute to the preservation of nature protection [1,31]. By scientific understandings of the natural attractions and curiosities of a specific area, an image about a place that differs from other parts of Serbia can be created.

Results of the GAM model research shows that the geodiversity and geoheritage of the study area have the potential and opportunity for tourism development. In the Figure 2, the Petnička cave presented the biggest tourism potential Z_{32}, while the Taor springs have the lowest additional and main values Z_{22}. In order to place the geopotential on the tourism market, it is necessary to invest a lot in tourism motives, desires and contents, i.e. to valorize the geoheritage sites. The construction of road infrastructure, the arrangement of accommodation and catering facilities, and promotion through fairs, conferences and congresses are need to be imply.

At the same time, more attention should be paid to the importance of educating tourists and all other participants, i.e. developing rules of conduct and ethics. The movements of tourists must be based on a limited number of participants, especially in the areas with a sensitive geolocation which are under a strict degree of protection. The local population that lives near protected natural assets in order of better promotion and more successfully development of geotourism should actively participate in the

creation of tourism content. In the future, it should be provided accommodation, food, services of a local tourist guide/escort, transport, and thus contribute to a more organized development of geotourism.

In the last few years, in many European countries, the great attention has been paid to the sustainable development of geotourism. It is assumed, that based on their examples, experience and practice, the better "adjustment" of protected natural assets and their influence in the tourism offer of the northwestern part of the Central Serbia will be provided. The unpolluted environment and "untouched" nature is representing the more favorable potentials for the successful implementation of geotourism in a particular area, region or district. In order to get positive results, the most important thing is that visitors who participate in tourism movements, advocate for the preservation of the natural environment from degradation, devastation and pollution, all for the purpose of a healthier life of the domicile population. In this way, the protection of cultural identity is also contributed.

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