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Comparison of geotourism assessment models: and experiment in Bakony–Balaton UNSECO Global Geopark, Hungary

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ABSTRACT
Geological and scenic values of locations are the non-living curiosities that can be preserved and popularized a lot easier using the institutional background of geotourism, such as geoparks. UNESCO Global Geoparks Network is responsible for protecting and fostering natural, scenic and cultural values and especially geosites that are the exciting visible physical elements. Our goal was to quantify the geotourism potential around Csopak, a scenic village in the Balaton Uplands giving home for the headquarter of the Bakony-Balaton UNESCO Global Geopark. After designating 216 potential geosites using topographic and geological maps, we applied two assessment models: the Geosite Assessment Model (GAM) and the Modified Geosite Assessment Model (M-GAM). GAM has been applied with good results in Hungary on different areas, but M-GAM has not been used before. As M-GAM involves tourists into the process counting with their opinion, it may give a more realistic view of the geosites. The two methods produced different but comparable final values of geotourism potential counted from the Main Value and Additional Value scores. We discovered that the proportion of the difference of these values carries major information. The ratio of ΔAV/ΔMV used as linear functions and depicted on diagrams can derive which values are more important for the visitors. From this result we can draw conclusions about the future development trends: scientific or infrastructural values should be more effectively fostered. Using our results, geosites can be handled and developed as visitors expect it.

Key words: geotourism, geosite, assessment, geopark, Balaton Uplands

INTRODUCTION

To start geoconservation the first step is to recognise and evaluate sites that carry major geological information amongst the aspects of tourism. Generally, there are two ways of geosite assessment. The qualitative approach mainly uses the expertise of the assessors and procedures that focus on the quality of the examined site. It dates back to the 1960s (Watson & Slaymaker, 1966). The quantitative methodology is related to the ranking of geosites. It started to emerge in the 1990s (Grandgirard, 1997; Rivas et al., 1997) and has developed in order to do more appropriate and objective evaluations (Lai & Graefe, 2000; Melián-González & Garcia-Falcón, 2003). They use different numerical methods to rate a particular site. Since during qualitative assessment we do not have the exact process documented and there is a large factor of subjectivity depending on the assessors' expertise. It is mainly used to designate potential geosites. Proper gesoite assessments can be done by the combined use of these two methodologies (Pereira, P. & Pereira, D., 2010). We need experts from different fields of earth science to determine whether a site has enough scientific values, while quantitative assessment is essential to determine the importance of these scientific, aesthetic and infrastructural values.

Quantitative geosite assessing has been used in Hungary only a few times. For instance, in the famous volcanic region of Tokaj, Szepesi et al. (2016) made an assessment to revive Hungarian volcano tourism. It turned out during the assessing that the most appropriate model for the area was the Geosite Assessment Model (GAM) developed in Serbia by Miroslav D. Vujičić et al. (2011). Csorvási (2017) carried out geosite assessment in Fejér County in two study areas. 6 geosites with different attributes were chosen and assessed using 10 distinct assessment models. The most realistic result was given by the aforementioned GAM.

The GAM is a well-defined method, which can be used anywhere. However, it does not reflect the diversity of the aspects, which makes a certain geosite important for the visitors. To incorporate the opinions of the visitors in the assessment a modified version of the GAM emerged and it was called M-GAM (Tomić & Božić, 2014).

This study is aimed to make a dual geosite assessment at an area, where currently active geoturism is present: the Bakony-Balaton UNESCO Global Geopark. Although this was the first geopark of Hungary, there wasn't any quantitative assessment in the area. Our study aims to solve this issue on the Eastern area of the Geopark, where parallel with the study a new geological hiking map was compiled (Albert et al., 2018).

The results of the study highlight the advantages and disadvantages of the assessment methods. Is also demonstrates the implementation of the scientific assessment method into a practical communication between the geopark and the visitors via the geological hiking map.

METHODS: GAM AND M-GAM

The Geosite Assessment Model is a great milestone in the development process of quantitative methods. It is consisted of two main parts: Main Values (MV) and Additional Values (AV). There are subgroups within the MV and AV groups: scientific/educational values (VSE), scenic/aesthetic values (VSA), protection (VPr) and functional (VFn), touristic (VTr). These subgroups are also divided into smaller parameters called indicators: 12 of them is in the MV group and 15 is in the AV group. Each geosite is assessed by evaluating these indicators: they can get 0, 0.25, 0.5, 0.75 and 1 values. Then with the application of three simple equations we can produce the sum of a geosite's score:

$$MV = VSE + VSA + VPr,$$
$$AV = VFn + VTr,$$
$$GAM = AV + MV.$$

The evaluation system can be seen in Table 1. and Table 2.

In 2014, Tomić & Božić basically used the methodology of GAM to assess 3 Serbian geosites. However, they added a small change to the model: the Modified Geosite Assessment Model supplements the experts' aspects with the opinion of visitors and tourists. In this way they involve the audience into the evaluation process increasing objectivity. It has been necessary as geotourists are mainly not geologists or earth scientists: they may be also open for cultural, historical, scenic and entertaining sights, possibilities. Usually an average visitor searches for a particular place for the sum of the mentioned attributes. The researchers interviewed 96 visitors about their personal importance of each indicator of the GAM. Then the values were summed and every single indicator got its Importance (Im) factor. If we multiply the GAM score with his, we produce the M-GAM score of a geosite:

$$MGAM = Im(GAM) = Im(MV + AV).$$

In the article describing M-GAM Tomić & Božić introduces the scatterplot matrices of both models. Considering the matrix field of every geosite, we can easily determine the geotourism development of each geosite

(Figure 1). Amongst using these diagrams for visualizing the differences between the two models, it is also an opportunity to analyse the differences between the GAM–M-GAM MV and AV values of a geosite. This method provides an opportunity to designate if scientific or infrastructural values need development.

Table 1. GAM and M-GAM MV indicators with their Im factor

Indicators:	Im	0	0.25	0.5	0.75	1
Scientific/Educational values - VSE:						
Rarity, nearby occurrence (SIMV1)	**0.95**	Common	Regional	National	International	The only occurrence
Representativeness of a formation (SIMV2)	**0.7**	None	Low	Moderate	High	Utmost
Knowledge on geoscientific issues (SIMV3)	**0.66**	None	Local publications	Regional publications	National publications	International publications
Level of interpretation (SIMV4)	**0.84**	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 but easy to explain to common visitor
Scenic/Aesthetic values - VSA:						
Viewpoints to the geosite (SIMV5)	**0.83**	None	1	2 to 3	4 to 6	More than 6
Surface, area of the geosite (SIMV6)	**0.58**	Small	x	Medium	x	Large
Surrounding landscape and nature (SIMV7)	**0.91**	x	Low	Medium	High	Utmost
Environmental fitting of sites (SIMV8)	**0.87**	Unfitting	x	Neutral	x	Fitting
Protection values - VPr:						
Current condition (SIMV9)	**0.92**	Totally damaged (as a result of human activities)	Highly damaged (as a result of natural processes)	Medium damaged (with essential geomorph. features preserved)	Slightly damaged	No damage
Protection level (SIMV10)	**0.78**	None	Local	Regional	National	International
Vulnerability (SIMV11)	**0.87**	Irreversible (with possibility of total loss)	High (could be easily damaged)	Medium (could be damaged by natural proc. or human activities)	Low (could be damaged only by human activities)	None
Suitable number of visitors (SIMV12)	**0.58**	0	0 to 10	10 to 20	20 to 50	More than 50

Table 2. GAM and M-GAM AV indicators with their Im factor

Indicators:	Im	0	0.25	0.5	0.75	1
			Functional values - VFn:			
Accessibility (SIAV1)	**0.75**	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 or public transport)
Additional natural values (SIAV2)	**0.66**	None	1	2 to 3	4 to 6	More than 6
Additional anthropogenic values (SIAV3)	**0.67**	None	1	2 to 3	4 to 6	More than 6
Vicinity of emissive centres (SIAV4*)	**0.71**	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 (SIAV5)**	**0.74**	None	Local	Regional	National	International
Additional functional values (SIAV6*)**	**0.69**	None	Low (1)	Medium (2-3)	High (4-6)	Utmost (6<)
			Touristic values - VTr:			
Promotion (SIAV7)	**0.71**	None	Local	Regional	National	International
Organized visits (SIAV8)	**0.56**	None	Less than 12 per year	12 to 24 per year	24 to 48 per year	More than 48 per year
Vicinity of visitors' centre (SIAV9)	**0.74**	More than 50 km	50 to 20 km	20 to 5 km	5 to 1 km	Less than 1 km
Interpretative panels (SIAV10)	**0.87**	None	Low quality	Medium quality	High quality	Utmost quality
Number of visitors (SIAV11)	**0.58**	None	Low (less than 5000)	Medium (5001 to 10000)	High (10001 to 100000)	Utmost (more than 100000)
Tourism infrastructure (SIAV12*)**	**0.7**	None	Low (1)	Medium (2-3)	High (4-6)	Utmost (6<)
Tour guide service (SIAV13)	**0.74**	None	Low	Medium	High	Utmost
Hostelry service (SIAV14)	**0.73**	More than 50 km	25 to 50 km	10 to 25 km	5 to 10 km	Less than 5 km
Restaurant service (SIAV15)	**0.76**	More than 25 km	10 to 25 km	10 to 5 km	1 to 5 km	Less than 1 km

(*) We have counted with the distance of Budapest. Another option could have been Veszprém or Székesfehérvár, but every geosite gets the same value in all 3 cases.
(**) We have worked with the distance of Route 8.
(***) We have set up a circle area with a radius of 2 km.

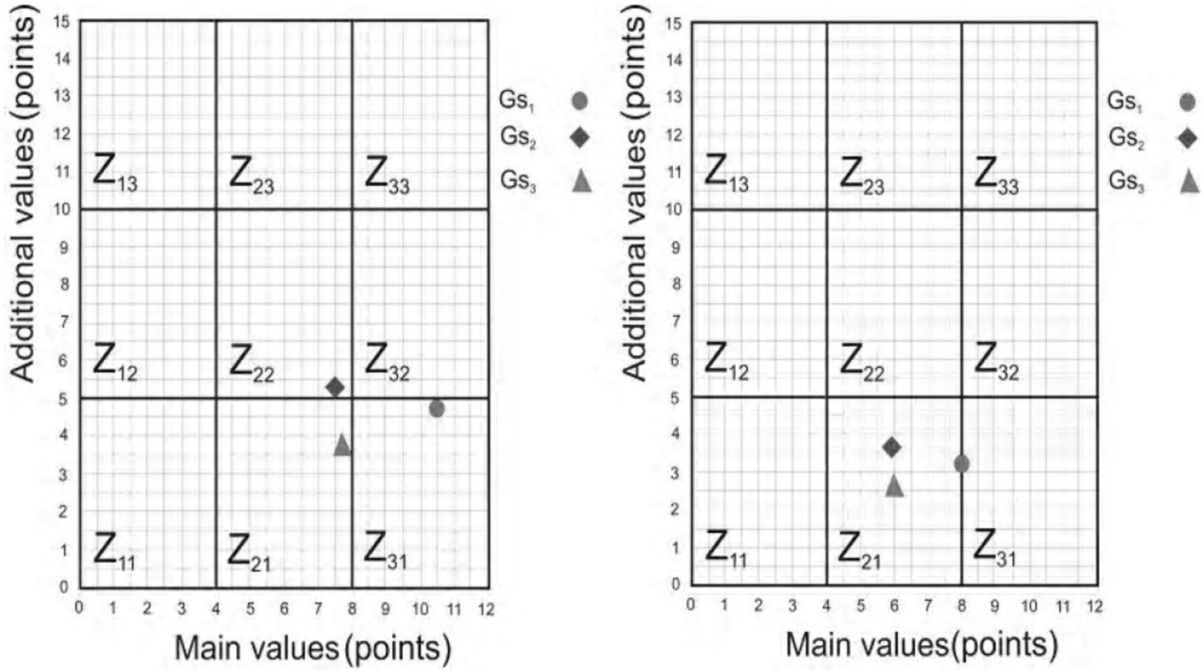

Fig. 1 Scatterplot matrices in Tomić & Božić (2004). GAM values can be seen on the left and M-GAM values on the right.

By analysing the scatterplot matrices one can determine the relative scientific and infrastructural values of the sites and the decision-makers could easily plan which sites can be utilized for geotourism. For example, geosites that can be found in fields Z_{23} and Z_{33} own enough scientific values and have active tourist use. Here, future planning demands the wise consideration of tourism's effect on the nature, communities and the possibilities of sustainable development. In the case of field Z_{23} the increasing of tourism infrastructure would be recommended to satisfy the visitors. Fields Z_{31} and Z_{32} contain geosites with high scientific but low additional values. These sites can be the candidates for future infrastructural projects: information panels, nature trails would attract geotourists.

Study area

The surrounding of Lake Balaton is one of the most visited tourist destinations in Central Europe. Every kind of visitor can find something to do here: the beaches on the shore, famous wine cellars and cultural heritage mean high tourism potential. But the great variety of natural values make this area even more distinctive. The northern coast of the lake is a part of the Transdanubian Mountains and is also well-known for its unique geological formations. The climate of the Balaton Uplands has Mediterranean features on the lower areas, but on higher altitudes is mainly temperately cool and wet. Due to its mountains and hills it does not have great rivers. But there are lots of small streams in the deep valleys called "séd". The valleys of the "séd" streams have cool microclimate during hot summer days (Dövényi, 2012; Futó, 2013). There are two institutions responsible for the natural values of the area: Balaton Uplands National Park and Bakony–Balaton UNESCO Global Geopark (Figure 2).

Our work studies the eastern part of the Balaton Uplands. The geological history of rocks here dates back to ancient times to times when life was only present in oceans. The great variety of rocks is caused by the intensive work of the nature: volcanoes, deep and shallow seas, deserts and lagoons has transformed the area. Plates were folded into mountains by the force of fierce earthquakes and tectonic movements (Albert et al., 2018). The oldest formations here are from the Silurian Period, so they are more than 410-420 million years old. Between the sediments of Lovas Slate we can find the layers of a basic volcanic rock: Alsóörs Metarhyolite. The outcrops of these formations are rare and highly protected. The most specific rock of the area was formed during the Permian. It is called red Balatonfelvidék Sandstone due to its colour. This formation is commonly used especially in the surroundings of Balatonalmádi-Vörösberény as a building stone (Budai & Konrád, 2011). Besides these famous features Neogene sediments have less importance than marls and limestones from the Mesozoic. Such rocks as in the Alps can be found here from this era (Budai et al., 1999).

Fig. 2 The extent of the Bakony–Balaton Geopark (red border) and the examined area (green border)

GEOSITE ASSESSMENT

Convinced by the promising outcomes of the GAM applications in Hungary, we have decided to use this method. Moreover, having a geodatabase of geosites assessed with the same methodology as the previous works may facilitate a countrywide initiative in the future to create a National Geosite Cadastre.

In line with the assessing work the design of the first Hungarian large-scale geological hiking map has started that depicts the examined area (Albert et al., 2018). For both works prior hiking and geological maps were suitable as data sources. The preliminary assessing was carried out with the help of a database that served as a basis of our map. In addition, we have used our field drafts. Data gathering and qualitative geosite designation were followed by consultation with experts of the area and the application of the two quantitative models.

Datamining and filtering

The extent of the area was inherited from the hiking map of Felsőörs and its surroundings (Schwarcz, 2013) as it was the technical base for the geological hiking map. This map was also a source for the datamining by selecting different map symbols that may have denote geosites (cliffs, breaks, gullies) with coordinates. We also used georeferenced military (Gauss-Krueger) and civilian (Uniform National Mapping System – EOTR, MÉM OFTH 1977) topographic maps with the scale of 10k and 25k. Their map key contains much larger amount of information. So that we searched for all the elements with the possibility of geosite features in the key books. Then these point-feature elements were inserted into the preliminary GIS database.

For processing geological data sources, we looked for the corresponding sheets of the engineering geological maps of the area (1:20 000, 1986) in the library of the Mining and Geological Survey of Hungary (MBFSZ). It contains clastic and intact outcrops, boreholes, quarries, mines and explorational pits. We set up 3 map size groups according to importance (<50 m; 50–100 m, 100 m<) and only geosites with these sizes were recorded. The 50k-scale Geological map of the Balaton Highland (Budai et al., 1999) does not contain outcrops: this was used to check the correct geological formation of the formerly designated sites.

We put the elements of the key section list of MBFSZ into our database as they carry fundamental geological features although their infrastructure is often poor (MBFSZ, 2018). We also looked through the available Google photos in the area as hikers who used Google services and made photos of their walk often uploaded these to Google/Picasa. After designating, we had nearly 450 potential geosites in our database.

This huge amount of sites from this small area includes many unimportant, inaccessible and non-existent geosites. To reduce the number of sites that has to be checked on the field a preliminary filtering was applied. We chose the OpenStreetMap database to filter our points by the current extent of settlements and industrial areas. Google photos and key sections were good to correct this phase, because some outcrops have been preserved despite construction works. In Hungary, mining areas with valid permission are cannot be visited by civilians so we deleted them from the database. During fieldwork we also made a filtering according to the geological importance, distance and size. After this phase, only 75 geosites remained to be quantitatively assessed.

Quantitative assessment

The onsite documentation of the remaining geosites had large importance in the subsequent work phases. We used GPS and mobile applications on the field to record tracklogs and mark evaluable geosites. We wrote a detailed report on each site with geological index and characteristics. Photos of every visited place were taken. The remaining work sessions were carried out in office. Using GAM/M-GAM requires multiple methods to get results: indicators can be evaluated by executing spatial queries in the geodatabase (GIS methods), analysing and classifying the sites using photos and notes and consulting with experts.

GIS methods are suitable to evaluate those indicators which depend on measuring distances and quantities from other geographic features. These spatial queries were carried out with QGIS open software. “Rarity, nearby occurrence”, “viewpoints to the geosite”, “accessibility”, “additional natural values”, “additional anthropogenic values”, “vicinity of visitors’ centre”, “hostelry service” and “restaurant service” were scored by setting up buffer zones around geosites and counting the corresponding elements within the circle with a certain radius. In the description of the GAM some of the spatial-dependent indicators are vaguely defined. Indicators such as the “vicinity of emissive centres”, “vicinity of important road network”, “additional functional values”, “tourism infrastructure” do not have determined parameters to define the exact values for evaluation. The values in Table 1 and 2 of these indicators are determined for the study area.

For most of the indicators, our field notes, photos and the corresponding scientific publications were good materials to perform the assessment. The available tour guides and information panels of the National Park and the Geopark also helped us to reach higher objectivity by providing exact data in some cases. Also, we consulted with experts in the case of some indicators such as the "knowledge on geoscientific issues", "promotion", "number of visitors" and "tour guide service".

RESULTS OF THE ASSESSMENT

The next step was the calculation of the GAM/M-GAM results based on the assessed indicator values of each geosite. For this we exported the database into an Excel table, where the calculation and visualization of the data was more appropriate than in QGIS. The results are visualized on Figure 3a-b.

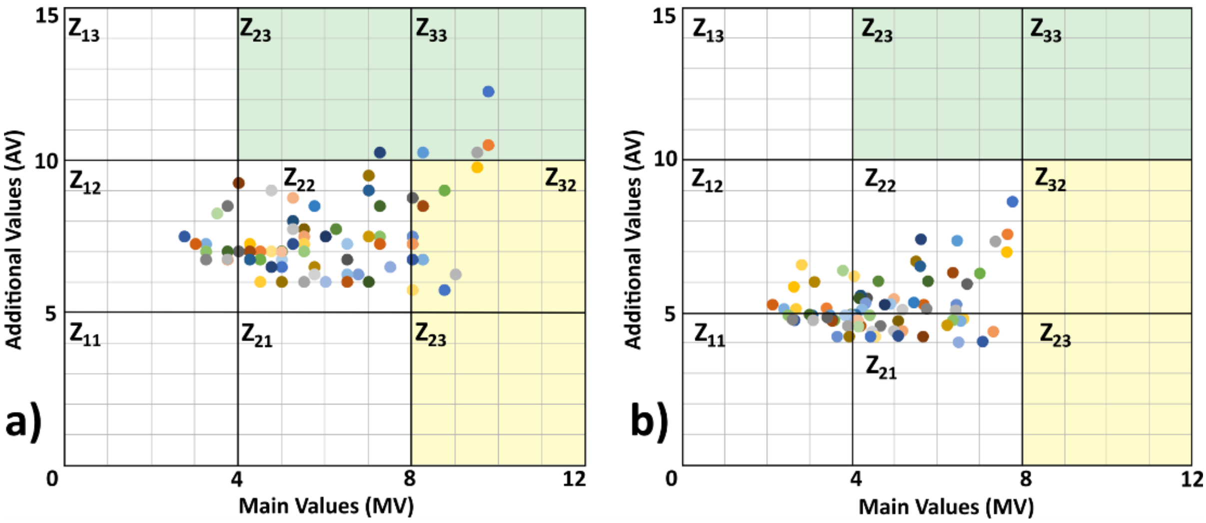

Fig. 3 Scatterplot diagrams of the results. a: GAM values in a 15 by 12 matrix determined by the possible GAM maximum scores; b: M-GAM values in a matrix determined by GAM maximum scores modified by the Im factor. Green matrix fields mean already popular geosites with good scientific and infrastructural balance while yellow fields mean geosites with high scientific values but poor infrastructural potential.

The Main Values can be found on the horizontal axis, while Additional Values are on the vertical axis. If we divide both axes into three equal parts, the whole diagram can be seen as a 3x3 matrix. These fields carry major information that relate to the nature and development of geotourism.

Tomić & Božić (2014) did not use a diagram defined by the maximum values of M-GAM, they inserted their Im factor modified results into the GAM diagram. The analysis of the result using only the GAM matrix may produce false conclusions because amongst the assessed geosites there were frequently visited (i.e., Lóczy Cave: 160k visitors/y) sites as well which fell into the Z_{22} matrix cell after applying the Im factor (Figure 4b). So it seemed that the GAM matrix is not expressive for the presentation of M-GAM values. To better differentiate the geosites, we decided to use an M-GAM matrix adjusted to the maximum values.

In Figure 4a-b, most of the geosites are out of fields that have the best values. It is important to select geosites with large scores, because they are the most developed ones, or worth near-future development. We applied Jenks' natural breaks (1967) method for clustering. The clustering resulted 24 geosites with higher potential than the others; these are the ones

Table 3. The clustered geosites with their score

ID	Name:	Score:
62	Lóczy Cave	16.43
31	Felsőörs, Forrás-hegy nature trail	15.26
19	Lake Köcsi nature trail	14.74
59	Koloska Cliffs	14.65
22	Alsóörs, Vöröskő nature trail	13.85
63	Lóczy Clave, limestone cliffs	13.30
67	Csopak, Pele Circuit	13.05
55	Nádaskút, werfen key section	12.71
21	Miske Cliff	12.67
23	Alsóörs Metarhyolite key section	12.22
58	Main Dolomite in Koloska Valley	12.14
42	Triassic (T3s and T3f) key section	11.84

ID	Name:	Score:
26	Cliffs next to Miske Cliff	11.74
47	Kopasz Hill, quarry	11.74
6	Kő Hill, Ember Cliff	11.55
60	Koloska Linden	11.43
16	Nagy-kő orra	11.31
50	Cliffs next to Csákány Hill Cave	11.15
68	Sárkány (Dragon) Hole	11.14
29	Király-kút Valley, limestone cliffs	10.97
66	Tamás Hill, sediments with dolomite	10.89
71	Csákány Hill Cave	10.83
73	Balatonalmádi, Triassic key section	10.81
3	Balatonalmádi, P/T key section	10.66

that are worth more detailed examination. In Table 3 the elements of the set with high scores or high chance of future development can be seen.

COMPARISON OF THE VALUES

The M-GAM differs from GAM because of the Im factor that represents the visitors' opinion about each GAM indicator's importance. Because of the estimating process, the Im is always smaller than or equal one:

$$Im \leq 1.$$

That's why the M-GAM scores are mainly smaller than GAM scores. If we draw a GAM diagram and put GAM and M-GAM values inside of it, the difference can be well seen (Figure 4). In the next step, we plotted linear functions between points from the different models. The variable was the Main Value, the function value was the Additional Value in each case. By counting the steepness of a function, we can determine whether the AVs or MVs were modified by Im more significantly. In our case every function has a steepness larger than 1 (Figure 4), so AVs ("infrastructure") were much more corrected by visitors than MVs ("science") without any exception. We created 3 groups according to the value of steepness by equidistantly trisecting the difference of the maximum and minimum steepness:

$$\textit{Green: } 1{,}006 \leq s(g) \leq 1{,}39167;$$
$$\textit{Yellow: } 1{,}39167 \leq s(y) \leq 1{,}77733;$$
$$\textit{Red: } 1{,}77733 \leq s(r) \leq 2{,}163.$$

The modificatory effect can also be expressed by the comparison of the Δx ($=\Delta MV$) and Δy ($=\Delta AV$) values of each geosite (Figure 5). This kind of representation even more highlights that in the full score of a geosite AV values are more modified by the Im factor (ΔAV is always larger than the ΔMV). From left to right the functions of ΔMV and ΔAV differences spectacularly shrink. This also means that the full value of a geosite decreases, so the importance slightly depends on the Additional Values. There is also a difference between the deviation of ΔMV and ΔAV values meaning that average people can more easily differentiate infrastructural indicators than scientific ones.

ΔAV-ΔMV value also worth mentioning (Figure 6). This index-number indicates how important are the infrastructural Additional Values to a tourist and how strongly AVs have decision influencing effect when searching for destinations. This number is greater than 0 in the case of every 24 examined geosite.

Taking into consideration the results of this comparison, we can state that an average geotourist is eager to visit a geosite with better infrastructure even if it has less scientific-educational values.

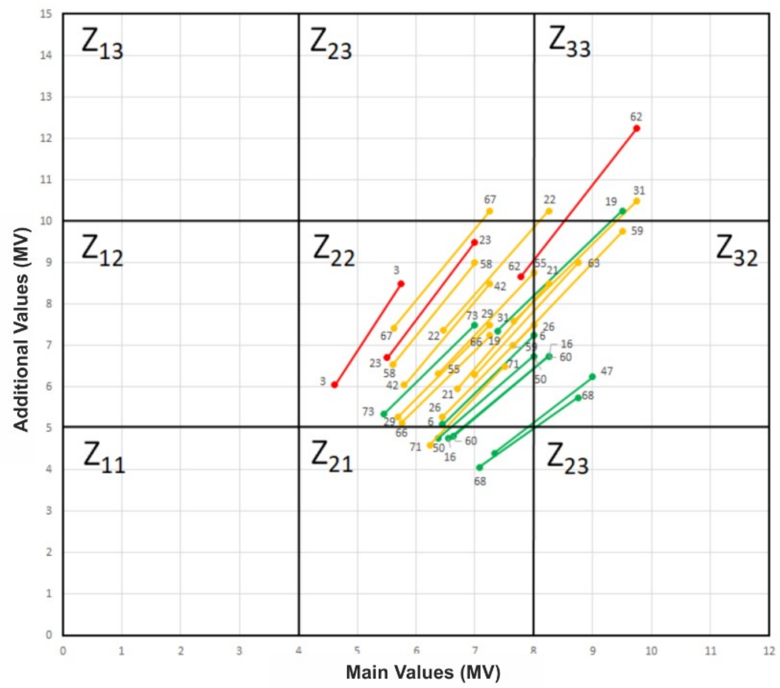

Figure 4. The 3 steepness groups of the linear functions depicted in a GAM matrix

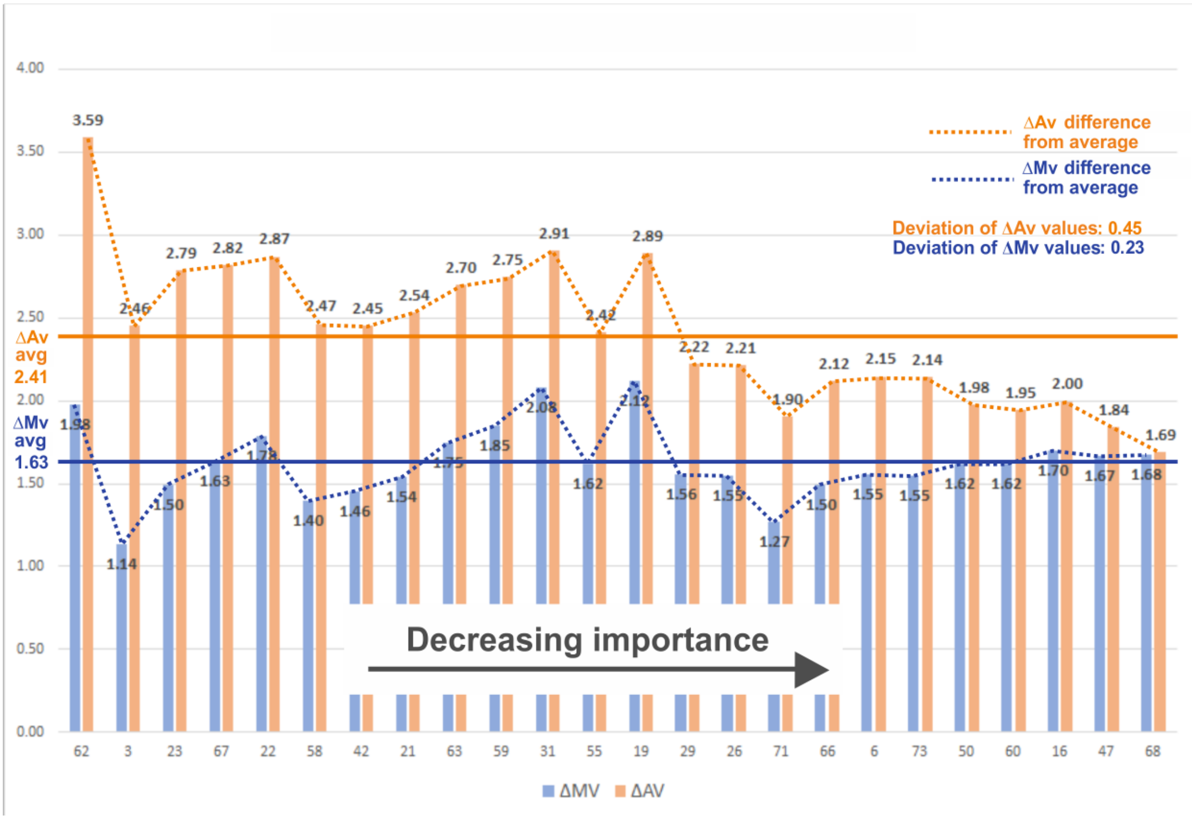

Figure 5. The diagram of ΔMV and ΔAV

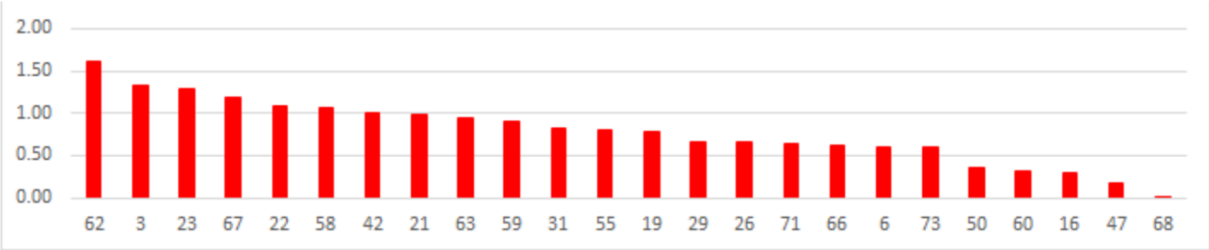

Fig. 6 ΔAV-ΔMV values of the 24 geosite

The major task for the caring institutions' (Balaton Uplands National Park Directorate and Bakony–Balaton UNESCO Global Geopark in this case) is to develop sites with high Main Values in order to present the geological uniqueness of it to the visitors. Naturally it is impossible to upgrade every geosite to the same infrastructural level, but this is not something to achieve! Planning the infrastructural investments with taking consideration of the results of an assessment is what a caring institution should do!

CONCLUSIONS

Our study is unique, because a comparison of GAM and M-GAM has never been done before in such details. We found that if M-GAM results are put in the GAM matrix, the local importance of the geosites are too much diminished, and thus, the method did not seem to reflect the reality. However, when a M-GAM matrix was used, the M-GAM method correctly reflected the current state of the geosites.

Using the M-GAM method parallel with the GAM could be the base of detailed examination too. It is because the Im factor modifies the various sites differently. After the use of Im factor, a general skew along the AV axis was detected. This means that AVs have more effect on tourists than MVs and the opinions of average visitors are differentiated better by infrastructural values (ΔAV has greater deviation). The magnitude of the skew can reflect the sensibility of certain geosites to infrastructural parameters. With analysing these results we can give advices and show further opportunities to the corresponding authorities for developing certain geosites.

The M-GAM has the deficit that it was evaluated on a certain area. We suppose that the Im value is unique for all geosites, and the values published by Tomić & Božić (2014) are not universal. Thus, we plan to designate some geoistes in the current study area where we ask tourists to fill a questionnaire similar to the one in Serbia for each geosite. By the results we will be able to tell a better prognosis for future plans for each geosite.

A rare but spectacular way to present geologically important information is the aforementioned geological hiking map. The 24 examined geosites are marked with a special pictogram, and the 9 most visited are described in details on the back of the map. This kind of map is a good opportunity to bring the geological and anthropogenic heritage nearer to the people as it presents topographic, touristic and geological information too (Figure 7). The popularization of geological treasures serves different purposes: the development of geosites attract more and more tourists who impinge the area's economic situation and give over heritage to younger generations.

Acknowledgement

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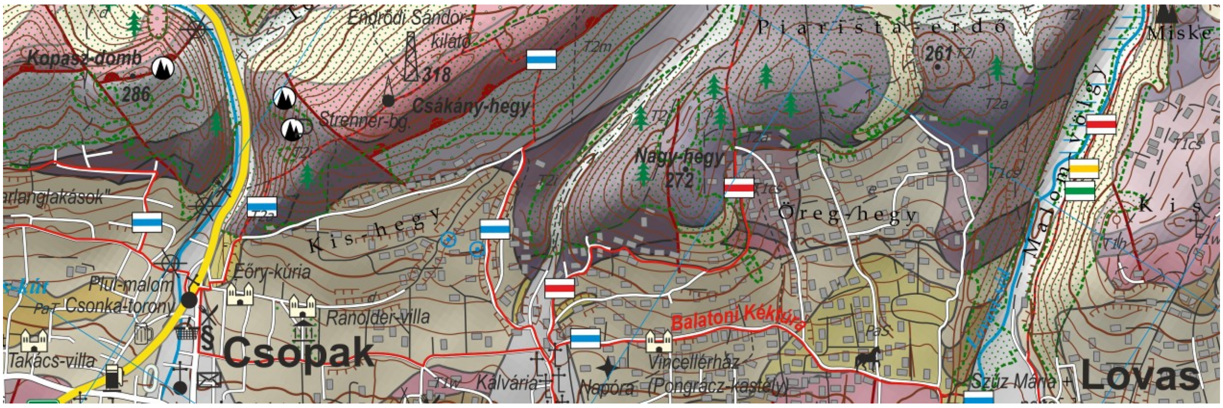

Fig. 7 An excerpt of the geological hiking map (Albert et al., 2018)

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