Research Article

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The evaluation of geosites in the territory of National Park „Kopaonik“(Serbia)

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Abstract: In the relatively small area of the National Park (NP) „Kopaonik“ a lot of exogenous and endogenous processes took part and continue to act until present day. In this paper are presented the geotouristic resources evaluation results for six geosites in the NP „Kopaonik“. The experts on this field gave their assessment in three versions. The first one is concerned with the evaluation of the educative contents, the second one is concerned with the evaluation of geotouristic values, while the third version, which is based on the Modified Geosite Assessment Model (M-GAM) offers the assessment regarding education, aesthetic significance, protection, functional and touristic values. The M-GAM method takes in consideration the opinion of visitors along with the estimation of subindicators given by experts, on whom relies the previous two versions. The include of visitors in the evaluation process leads to more objective estimations. Results obtained by this study can be useful for the improvement and planning of touristic activities on geosites because, bearing in mind their significance for the tourists, they indicate on the lower values that require more attention in the future.

Keywords: geosite assessment, educability, functionality, sustainable development

1 Introduction

Visiting and promoting geotouristic destinations contribute to the public awareness of the geodiversity values as well as their vulnerability. By respecting this natural segment, geoconservation, *i.e.* protection and reasonable use of geodiversities, is also supported. Geoconservation has a rich historical practice in Northwestern Europe, Australia and USA [1–4]. Group of authors has developed the new definition of modern geotourism: „The provision of interpretative and service facilities for geosites and geomorphosites and their encompassing topography together with their associated in situ and ex situ artifacts, to constituency-build for their conservation by generating appreciation, learning and research by and for current and future generations“ [60].

In recent years, several studies concerning the evaluation and management of geosites, as well as the studies in the area of defining the geoconservation strategy, have been conducted [5–17]. Numerous methods of geolocality evaluation on a given territory have been mainly focussed on the scientific value [18, 21, 24–26, 31] of a geosite, and then on other values, such as tourist values [6, 19, 20, 22, 23, 27–30]. Based on a few methods, [32] gave a model for the evaluation of touristic values of geosites and their use in the tourism industry. According to this method, the touristic value of a locality represents the average value of aesthetic, scientific, cultural and economic values. In order to choose the most representative geosites, [23] suggested three criteria: representativity, uniqueness and proximity.

In Serbia, geoheritage includes natural resources with prominent geological, geomorphological, pedological and archaelogical characteristics. First objects of geoheritage were protected in the middle of the XX century through individual inititives of well known experts in this field. By forming international associations dealing with identifying and presenting objects of geoheritage, such as European Association for the Conservation of the geological Heritage (ProGEO), the member of which is Serbia, as well as by forming the National Council for Geoheritage

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in 1995. The uniform policy of geoheritage protection was initiated in Serbia. The inventory of the geoheritage objects [33] comprises about 650 geological, paleontological, geomorphological, speleological and neotectonic objects. 80 objects are under protection. The geodiversity and geoheritage evaluation has been carried out mainly using the descriptive method, until the last decade of the XX century when eminent experts from all geodisciplines established and proposed scientific and educative criteria for geoheritage evaluation in planning the protection of natural landscapes [15, 17, 28, 29, 34, 35].

This paper deals with the evaluation of geosites on the territory of National Park (NP) „Kopaonik". The obtained results indicate educative and touristic purposes, advantages and disadvantages of the localities, and they give a suggestion for their protection, promotion and monitoring.

2 Materials and methods

2.1 Study area

The mountain of Kopaonik is situated between the central and southern part of Serbia. It is clearly bounded by the valleys of the following rivers: Jošanica and Pločanska in the north; upper flow of Rasina and Blatašnica in the northeast; Toplica, Kosanica, Dubnica and Lab in the east; Lab in the south and Sitnica and Ibar in the west [36]. The mountain extends from northwest towards southeast attaining 83 km, its largest width is equal to 63 km. On the central mountain plateau of Ravni Kopaonik (about 1.700 m above sea level), Suvo Rudište (1.976 m) ascends with Pančić's peak (2.017 m) which dominates in central Serbia. In 1981, this territory (its area includes 11.810 ha) became NP „Kopaonik"(Figure 1).

For the development of Kopaonik, the position (distance) of larger urban settlements is of crucial importance. The mountain centre at the very foot of Pančić's peak is located 368 km away from Novi Sad, 279 km from Belgrade, 151 km from Kragujevac, 178 km from Užice, 75 km from Kosovska Mitrovica, 109 km from Priština and 130 km from Niš.

The Kopaonik Mountain is the central part of the so-called Kopaonik Block and ridge [37], which is of small thickness and complex fabric. The unit extends from Belgrade to the Former Yugoslavian Republic of Macedonia in the NNW-SSE direction. Its continuation northern from Belgrade, beneath the Pannonian plane has been suggested by Pamić *et al.*, [38]. The Kopaonik unit on the east tectonically lies to the East Vardar zone [39], while its western boundary towards the Ophiolite belt of Dinarids marks the narrow belt of ophiolite mélange. According to some authors this anticline structure, placed between the Eastern and Western Vardar zone, was a microcontinent that split the Tethyan Ocean on two ocean basins [33, 37, 40, 41]. On contrary, some others are of opinion that it represents only a tectonic window in the Western Vardar zone [42–45]. The core of the anticline was intruded during Oligocene (31.5±0.3 Ma) by a large granitoid body that caused contact metamorphism [46, 47]. The most abundant are granodiorites associated with porphyroid quartzmonzonites and quartzdiorites [48].

In the base occur Triassic low-grade metamorphic rocks, known as the „shining schists od the central Kopaonik" [49]. The most abundant are phyllites and marbles. The finding of conodonts in the latter confirmed their Upper Triassic age [50]. Contact of metamorphic rocks with the ophiolite melange (with olistolithes and fragments of limestone, serpentinized peridotites, basalt, cherts, metamorphic rocks and gravelly claystones in matrix from arenite and claystone), as well as the contact with ophiolites is tectonic [41]. Ophiolites are a part of the large Ibar harzburgite-serpentinite massif. Harzburgite, generally strongly serpentinized, prevails. Lass abundant are dunites and rodingites, as well as relics of metamorphic sole in the base and parts of sheeted-dyke complex. Presence of boninites in the last reflected that ophiolites originate from an arc-related setting [51].

The Upper Cretaceous turbidites, up to 500 m thick, cover margins of the Kopaonik block. These rocks deposited in the trough (basin), which extended from Kragujevac over Kuršumlija to Podujevo exceeding 160 km in length [39]. The youngest rocks are volcanic and volcanoclastic rocks of the Oligocene and Lower Miocene age (ranging in composition from dacite to andesite) and sands, marls, claystones and conglomerates that deposites throughout Miocene until the Lower Pliocene.

3 Methods

On the territory of NP „Kopaonik" there are numerous geoheritage objects that testify of the diversity of physico-geographical factors, which were decisive for the appearance of this mountain. After the identification of all geological objects, we have chosen those which are the most representative. The elements on which this classification is based can be defined as: indicial (geological objects as indices – require a detailed description of geological prop-

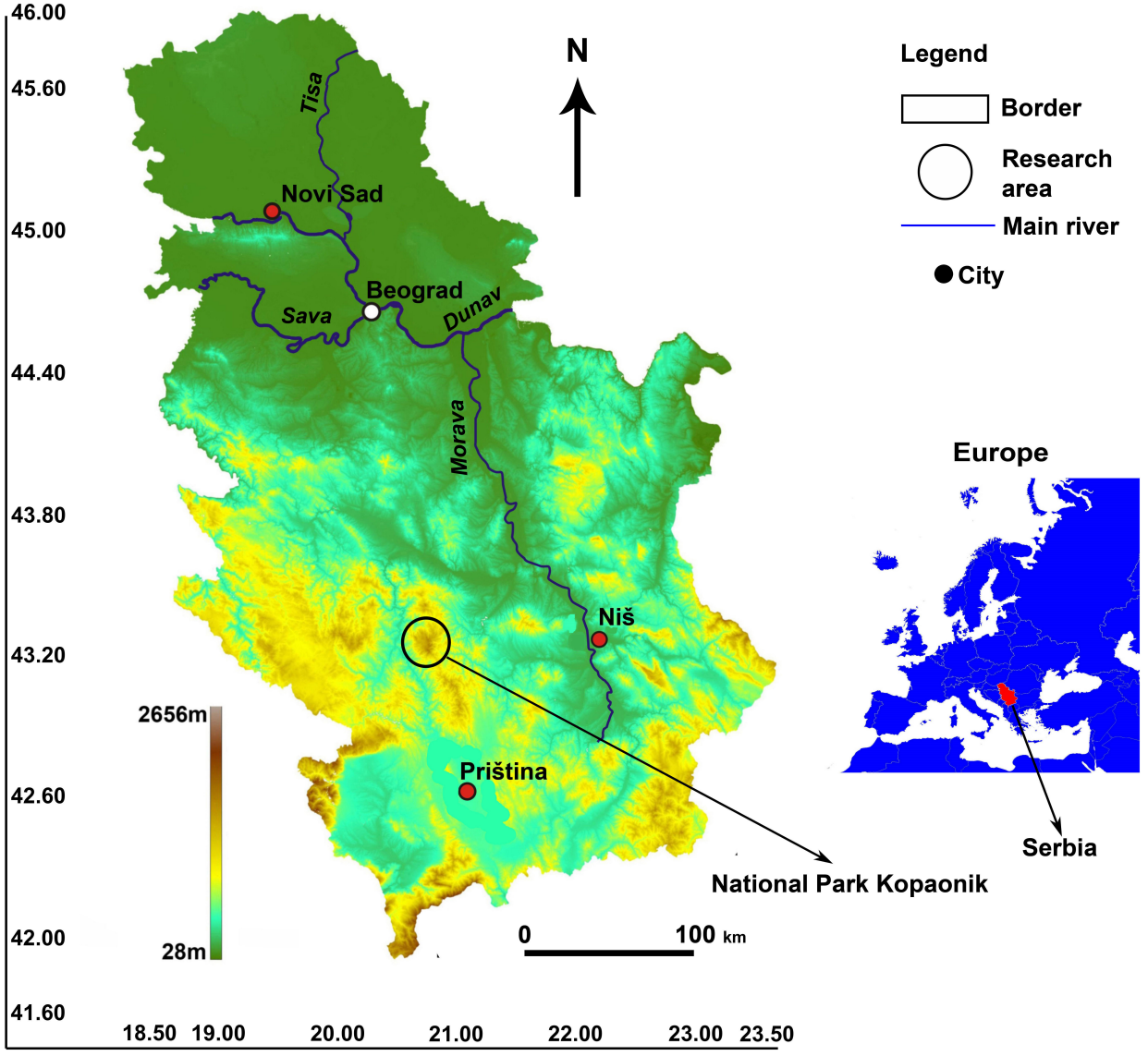

Figure 1: Geographic position of NP „Kopaonik“ in Serbia

erties); iconographic (*i.e.* view point Žljeb, Velika Šiljača, Velika Stena); symbolic (place for public use for reasons different from geological ones); documented (very important record, essential to understanding of geological properties on regional level, *i.e.* Žljeb (rock formation visible on the surface); scenic (highly recreative function of geological object/phenomenon on regional level – *i.e.* Jelica); conceptual (unique geological phenomena which can be used as excellent example of materials and theoretical references for geology – *i.e.* Jelica and Žljeb).

For the purpose of evaluating the educative potential of geolocality and geotourism development during May in 2017 were conducted studies by the authors of this paper and field experts. Fifteen experts gave their values on a scale from one to five points. According to obtained values the average ones were calculated and rounded to a whole numbers in aim of the easier calculation. The following characteristics are assessed: accessibility, connected resources, conditions for view points, educative content, fragility and representativity. The values for these criteria on a scale of one to five points, according to [54], are given in Table 1.

Table 1: Criteria for the evaluation of the educative potential

	Points
Accessibility criterium (Ac)	
Direct access from a trunk or regional road	5
Less than 1km from any road for passenger vehicles	4
More than 1km from any road for passenger vehicles	3
Less than 1km from any road for vehicles	2
Direct access to a macadam road	1
Criterion of connection to other resources (Ar)	
Connection to alternative forms distant not more than 500 m	5
Connection to alternative forms distant not more than 1000 m	3
No connected forms	1
Criterion of view points (Vie)	
Excellent conditions for view points (largest extent and easily visible)	5
Good conditions for view points (largest extent, but with some difficulties)	4
Medium conditions for view points (cannot be seen in real extent)	3
Eduucative content criterion (Edu)	
Clearness of educative-content examples on any level of teaching and wide public	5
Clearness of educative-content examples any teaching form	4
Clearness of educative-content examples to undergraduate and postgraduate students	3
Fragility criterion (Fra)	
Decimetre size of locality hardly affected by anthropogenic actions	5
Decimetre to metre size of locality under moderate influence of anthropogenic activities	3
Metre size of locality easily damaged under influence of anthropogenic activities	1
Representativity criterion (Rpr)	
Best example in Serbia of geological process or form	5
Best example in NP „Kopaonik" of geological process or form	4
Representativity of diverse geological contents	3

The calculation of educative potential (PEU) is based on relative weights proposed by [53, 54].

$$PEU = \frac{[(Ac \times 20) + (Ar \times 10) + (Vie \times 15)}{6} + \frac{(Edu \times 20) + (Fra \times 15) + (Rpr \times 20)]}{6} \quad (1)$$

The geotouristic potential of geosites is related to the presence of specific scenic aspects, when landscapes are on the top of the pyramid comprised of geotouristic significance forms [52]. If the scientific significance is also considered, a new form of geological tourism known as scientific geotourism is obtained [53].

The assessment of the geotourism-development potential (PGU) proposed by Braga (2002) is based on five criteria (Table 2). Four of them are similar to those used in the PEU assessment. The spectacularity criterion has tried to solve the subjectivity problem. However, it is very important for assessing the touristic potential and it is based on the real use of geosites as brands in the touristic marketing strategy, as well as campaigns and documents [54].

The formula for calculating PGU is the following:

$$PGU = \frac{[(Ac \times 25) + (Ar \times 20) + (Edu \times 5)}{5} + \frac{(Spe \times 30) + (Fra \times 20)]}{5} \quad (2)$$

The spectacularity criterion has the highest relative weight due to the decisive role in promoting geotouristic activities, whereas the educative content has the lowest weight [53].

One of the main problem in this evaluation model, as well as in the previous one, is the objective approach. No one of the mentioned models include information about needs, attitudes, interests and opinions of tourist visiting geolocalities what is of particular importance in the evaluation of the tourism potential for given locality. The introduce of visitors in the evaluation process is a good way for obtaining a more objective approach. During this research, a model based on the geosites assessment model (GAM) is used. GAM was published in 2011 [29]. For its creation, a numerous scientific literature from the evaluation field

Table 2: Criterion and corresponding weight assessment used in geotourism

	Points
Accessibility criterion (Ac)	
Direct access from a trunk or regional road	5
Direct access from local or paved road	4
Direct access from path or macadam road	3
Less than 1km from any road	2
More than 1km from any road	1
Criterion of connection to other resources (Ar)	
Connection to alternative forms distant not more than 500 m	5
Connection to alternative forms distant not more than 1000 m	3
No connected forms	1
Eduucative content criterion (Edu)	
Clearness of educative-content examples on any level of teaching and wide public	5
Clearness of educative-content examples any teaching form	4
Clearness of educative-content examples to undergraduate and postgraduate students	3
Spectacularity criterion (Spe)	
Used as brand in national tourism	5
Used as brand in local tourism	3
Not used as brand in tourism	1
Fragility criterion (Fra)	
Decimetre size of locality hardly affected by anthropogenic actions	5
Decimetre to metre size of locality under moderate influence of anthropogenic activities	3
Metre size of locality easily damaged under influence of anthropogenic activities	1

was used [5, 6, 19, 21, 26, 32, 55–58]. Modification of GAM model, *i.e.* the development of M-GAM model led to more objective evaluation [14].

One of the aims of this paper is to establish the current state and geotouristic potential of localities in Kopaonik through application of M-GAM model for touristic evaluation of geosites. The GAM model consists of two indicator groups: Main Value (*MV*) and Additional Value (*AV*).

The main values (*MV*) follow from the natural characteristics of a geosite and there are three indicator groups: scientific/educative value (*VSE*), landscape/aesthetic value (*VSA*) and protection (*VPr*). The additional values (*AV*) occurred due to the human influence and the adaptation for the visitors' needs. They are comprised of two indicator groups: functional (*VFn*) and touristic value (*VTr*) [29]. The total of 12 *MV* subindicators and 15 *AV* subindicators are evaluated using values from 0.00 to 1.00, defining GAM as the following equation [59]:

$$GAM = MV + AV \tag{3}$$

The number of subindicators in *MV* and *AV* is represented by the two following equations:

$$MV = VSE + VSA + VPr \tag{4}$$

$$AV = VFn + VTr \tag{5}$$

i.e.:

$$MV = VSE + VSA + VPr \equiv \sum_{i=1}^{12} SIMV_i, \tag{6}$$

where $0 \le SIMV_i \le 1$,

$$AV = VFn + VTr \equiv \sum_{j=1}^{15} SIAV_j, \tag{7}$$

where $0 \le SIAV_j \le 1$

Here, $SIMV_i$ and $SIAV_j$ represent 12 subindicators of Main Values (i = 1,...,12) and 15 subindicators (j = 1,...,15) of Additional Values.

On the basis of the evaluation results, a matrix of *MV* and *AV* is created, where they are presented along the X (*MV*) and Y (*AV*) axis. The matrix is divided into nine fields (zones), using main grid lines denoted as Z (i, j), (i, j=1, 2, 3). The main grid lines on the X axis have a value of 4 and on the Y axis their value is 5. The evaluated geolocality, depending on its assessment, occupies the corresponding field. Thus, its value is clearly determined and, depending

Table 3: The structure of Geosite Assessment Model (GAM)

Indicators /Subindicators	**Description**
Main values (*MV*)	
Scientific/Educative value (*VSE*)	
Rarity($SIMV_1$)	Number of identical localities in immediate surroundings.
Representativity ($SIMV_2$)	Didactic and "school" characteristics of locality on the basis of its own quality and general configuration.
How much locality has been studied ($SIMV_3$)	Number of publications in recognized journals, master works, MSc and PhD theses, as well as other publications.
Interpretation level ($SIMV_4$)	Possibility of interpreting geological and geomorphological processes, phenomena and forms.
Landscape/Aesthetic value (*VSA*)	
View points ($SIMV_5$)	Number of view points accessible to walking paths. Each of them must provide view from distinct angle and be situated at less than 1 km from locality.
Area ($SIMV_6$)	Total area of locality. Each locality is considered in quantitative relationship with other localities.
Landscape and nature in surroundings ($SIMV_7$)	Quality of view point, presence of water and vegetation, absence of damage caused by human activity, proximity of urbane area, etc.
Locality adaptation into surroundings ($SIMV_8$)	Degree of contrast with nature, contrast of colors, forms, etc.
Protection (*VPr*)	
Present state ($SIMV_9$)	Present state of geosite.
Protection level ($SIMV_{10}$)	Locality is under protection of local or regional associations, national or international institutions.
Sensitivity ($SIMV_{11}$)	Sensitivity level of geosite /subject to natural or anthropogenic damage.
Bearing capacity ($SIMV_{12}$)	Proper number of visitors on locality at the same time, but not menacing its present state.
Additional values (*AV*)	
Functional values (*VFn*)	
Accessibility ($SIAV_1$)	Possibilities of accessing the locality
Additional natural values ($SIAV_2$)	Number of additional natural values within 5 km circle (also including other geolocalities)
Additional anthropogenic values ($SIAV_3$)	Number of additional anthropogenic values within 5 km circle
Proximity of emitive centres ($SIAV_4$)	Proximity of emitive centres
Proximity of important roads ($SIAV_5$)	Proximity of important roads within 20 km circle
Additional functional values ($SIAV_6$)	Parking place, petrol stations, car service etc.
Touristic values (*VTr*)	
Promotion ($SIAV_7$)	Level of promotion activities.
Organised visits ($SIAV_8$)	Number of organised visits to locality per year.
Proximity of visitor centres ($SIAV_9$)	Proximity of visitor centres to locality.
Interpretative tables ($SIAV_{10}$)	Interpretative characteristics of text and graphical material, quality, size and adaptation to environment.
Number of visitors ($SIAV_{11}$)	Number of visitors per year
Touristic infrastructure ($SIAV_{12}$)	Level of additional infrastructure for visitors (walking paths, places of rest, waste baskets, toilets etc.)
Guiding service ($SIAV_{13}$)	If yes, competence level, knowledge of foreign languages, interpretative skills etc.
Accommodation facilities ($SIAV_{14}$)	Accomodation facilities in the vicinity of locality
Restaurant facilities ($SIAV_{15}$)	Restaurant facilities in the vicinity of locality

	Grades (0.00-1.00)				
	0.00	0.25	0.50	0.75	1.00
$SIMV_1$	Usual phenomenon	Regional	National	International	Unique
$SIMV_2$	No	Low	Moderate	High	Highest

$SIMV_3$	No	Local publications	Regional publications	National publications	International publications
$SIMV_4$	No	Average level of process but difficult for explaining to people not in geological specialty	Good example of process but difficult for explaining to people not in geological specialty	Average process level but easy for explaining to average visitor	Good process example and easy for explaining to average visitor
$SIMV_5$	No	1	2 to 3	4 to 6	More than 6
$SIMV_6$	Low	-	Moderate	-	High
$SIMV_7$	-	Weak value	Moderate	High	Highest
$SIMV_8$	Does not fit	-	Neutral	-	Fits
$SIMV_9$	Completely destroyed (as result of human activity)	Highly damaged (as result of natural processes)	Moderately damaged (with preserved essential geomorphological properties)	Slightly damaged	Undamaged
$SIMV_{10}$	Unprotected	Protected on local level	Protected on regional level	Protected on national level	Protected on international level
$SIMV_{11}$	With no possibility of "recovery" (with possibility of total loss)	High (can be damaged easily)	Moderate (can be damaged due to natural or human actions)	Low (can be damaged due to human activities only)	Can suffer no serious damage
$SIMV_{12}$	0	0 to 10	10 to 20	20 to 50	More than 50
$SIAV_1$	Inaccessible	Low (only by foot with special equipment and competent guides)	Moderate (by bicycle and other similar vehicles)	High (by car)	Highest (by bus)
$SIAV_2$	No	1	2 to 3	4 to 6	More than 6
$SIAV_3$	No	1	2 to 3	4 to 6	More than 6
$SIAV_4$	More than 100 km	100 to 50 km	50 to 25 km	25 to 5 km	Less than 5 km
$SIAV_5$	No road in the vicinity	Local road	Regional road	National road	International road
$SIAV_6$	No	Low	Moderate	High	Highest
$SIAV_7$	No	Local	Regional	National	International
$SIAV_8$	No	Less than 12 yearly	From 12 to 24 yearly	From 24 to 48 yearly	More than 48 yearly
$SIAV_9$	More than 50 km	From 50 to 20 km	From 20 to 5 km	From 5 to 1 km	Less than 1 km
$SIAV_{10}$	No	Low quality	Moderate quality	High quality	Highest quality
$SIAV_{11}$	No	Low (less than 5000)	Moderate (from 5001 to 10,000)	High (from 10,001 to 100,000)	Highest (more than 100,000)
$SIAV_{12}$	No	Low level	Moderate level	High level	Highest level
$SIAV_{13}$	No	Low quality	Moderate quality	High quality	Highest quality
$SIAV_{14}$	More than 50 km	25–50 km	10–25 km	5–10 km	Less than 5 km
$SIAV_{15}$	More than 25 km	10–25 km	10–5 km	1–5 km	Less than 1 km

on the main value, the existence of the so-called "touristic value" is determined as well.

While in GAM all grades for each subindicator are given by experts 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. A questionnaire survey consisted of 150 valid template lists and was carried out in the first week of July in 2018. The answers were given by accidental tourists in Kopaonik and a group of 50 Russian tourists that had a field work on Kopaonik organized by the Russian-Serbian geographic society.

The importance factor (*Im*) gives visitors the opportunity to express their opinion about each subindicator in the model. After each respondent rates the importance of every subindicator, the average value of each subindicator is calculated as the final value of that subindicator. 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.

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:

$$Im = \frac{\sum_{k=1}^{k} Iv_k}{K} \tag{8}$$

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 modified GAM equation is defined and presented in the following form:

$$M - GAM = MV + AV \tag{9}$$

$$MV = \sum_{i=1}^{n} Im_i * MV_i \tag{10}$$

$$AV = \sum_{i=1}^{n} Im_j * AV_j \tag{11}$$

The obtained value of the importance factor (*Im*), determined by visitors for each subindicator separately, has to be multiplied with value that was given by experts, also for each of the subindicators alone. Final values of M-GAM subindicators are always equal or less than GAM values [14].

4 Results

According to mentioned criterion (5) six geosites have been selected: Velika Stena (GS_1), Velika Šiljača (GS_2), Oštri Krš (GS_3), Jelica (GS_4), Bela Stena-Žljeb (GS_5) and Gvozdac (GS_6) (Figure 2).

Velika Stena (1.591 m), also known as Veliko Stenje offers an extraordinary insight into metamorphic rocks from the basement (epidote-actinoliteschists and marbles).

Velika Šiljača (1.625 m) is also in the zone of metamorphic rocks: phyllite, marbles and green schists. Green schists, derived from diabase rocks and their tuffs, are only here exposed in larger masses.

The occurrence of garnet skarns in a form of steep cliff above the Valley of Gobeljska River at 1.5 km north from Velika Gobelja is known as Oštri krš, and is located within the Nature Reserve "Gobelja". This asymmetric peak (1.741 m) is located along the upper forest boundary; hence it offers an amazing view on boundless and preserved forests in the locality of "Gobelja", which belongs to the first level of protection. This is the only place in Kopaonik where Edelweiss (*Leontopodiumalpinum*) can be found.

At Jelica, *i.e.* from Jaram (1.788 m) to Srebrnac, the all varieties of skarns can be traced from their contact with granodiorite to weakly metamorphosed limestones. This cites characterizes: rarity, accessibility and practical educative value, making it a geoheritage object worth of protecting. In the Inventory list of geoheritage objects in Serbia, it is included in the group called "Igneous and metamorphic rocks" as "Outcrops of skarns-Jaram, Kopaonik".

Steep limestone escarpments (Bele stene) on the left side of the road Brzeće-Kopaonik, in a part known as Zavoj (Curvature), were named Žljeb due to their well-expressed curves (1.772 m). Bele stene (White rocks) were formed along a fault that separate two distinct lithologies: metamorphic rocks below and carbonate rocks above. Transition from one to another lithology is obvious.

Gvozdac is a name for steep, almost vertical cliffs from porphyroid quartzmonzonite above the canyon of Gvozdačka river. There is a small cave in its footwall, which served as a sanctuary for centuries.

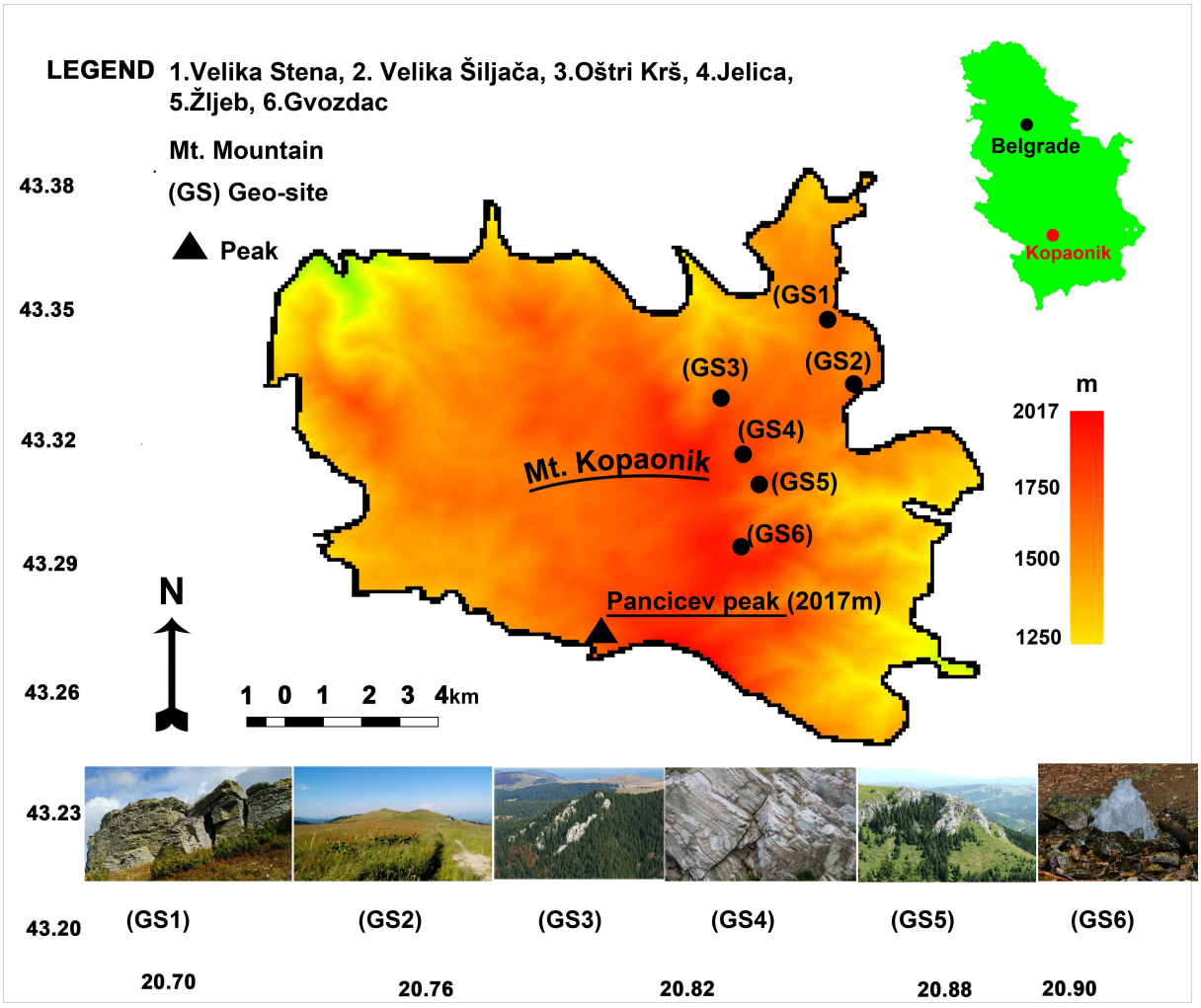

Figure 2: Position of geosites in NP „Kopaonik“

Table 4: Results of educative potential for mentioned geosites (PEU)

Geosite name and number	Potential educative use (PEU)	Geosite PEU average weight
Velika Stena (GS_1)	Moderate	56.7
Velika Šiljača (GS_2)	Moderate	60
Oštri krš (GS_3)	Moderate	58.3
Jelica (GS_4)	High	83.3
Žljeb (GS_5)	High	83.3
Gvozdac (GS_6)	Moderate	51.7

The educative-potential assessments for six geosites according to the methodology proposed by Braga (2002) and Rocha (2010) are given in Table 4. The results are classified in order to obtain a high-quality insight concerning PEU for the six geosites (Table 4): low (<30), moderate (30-60) and high (> 60).

Geosites Jelica (GS_4) and Žljeb (GS_5) are situated by the highway Brzeće-Kopaonik, at a distance of less than 500 m. All visitors and broad public can acess them easily, view points are in an excellent condition and they offer clear examples of educative contents on any teaching level. These localities are the best examples of geological processes and their educative potential (PEU) can be

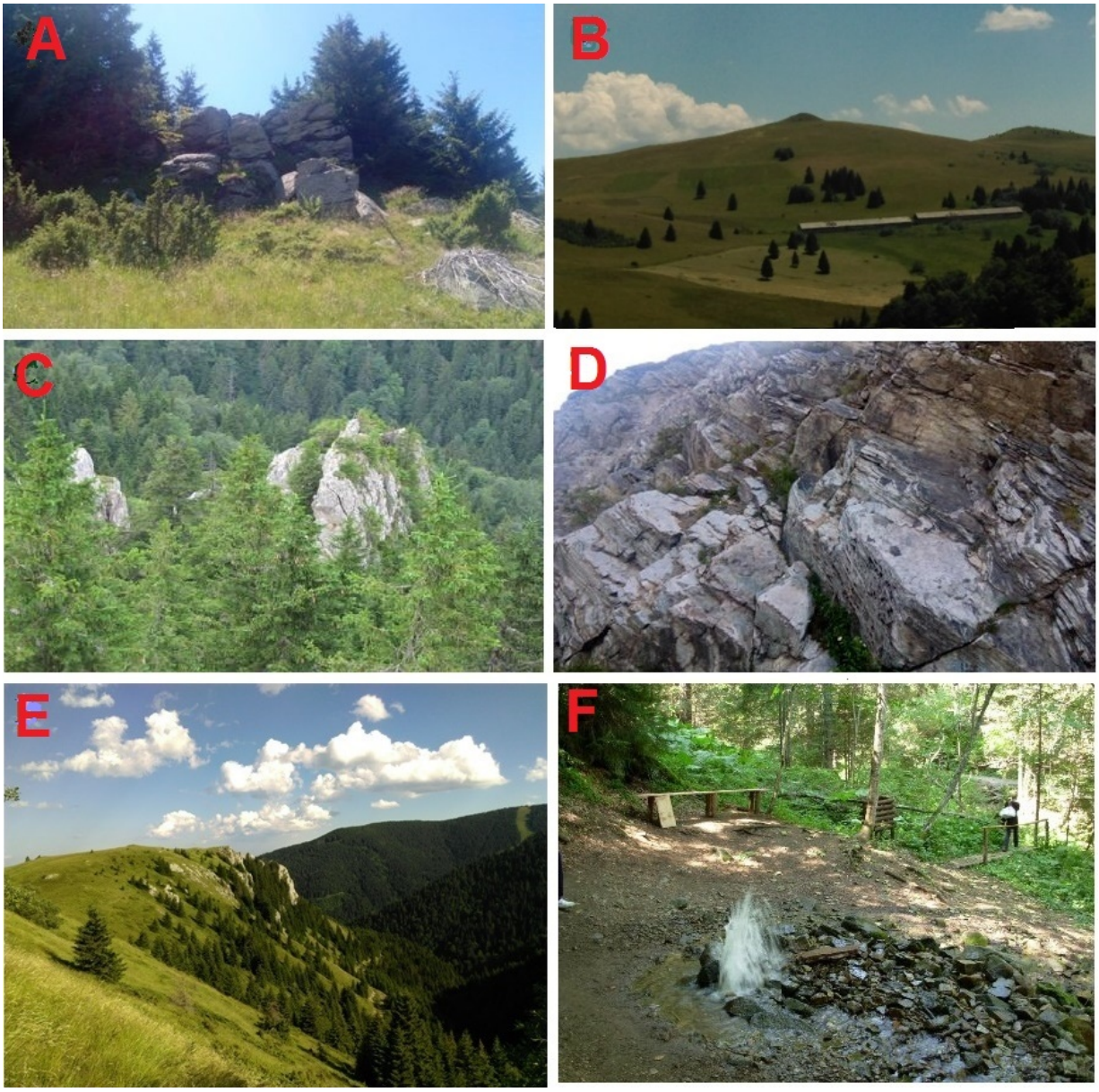

Figure 3: A-Velika Stena (GS_1), B-Velika Šiljača (GS_2), C-Oštri Krš (GS_3), D-Jelica (GS_4), E-Bela Stena-Žljeb (GS_5), F-Gvozdac (GS_6)

highly assessed (83.3). The other analysed geosites (GS_1, GS_2, GS_3 and GS_6) have a moderate value in PEU assessment. The highest number of points gets a locality which is connected to other resources and which view points are in excellent condition (especially GS_1 and GS_2). Localities GS_3 and GS_6 belong to the first level of protection, thus when considering the accessibility and representativity criterion they are assigned the minimal number of points.

The spectacularity level and the scientific significance classify the considered localities as important geotouristic localities of Serbia. The obtained values are for the purpose of obtainiing grades on the PGU scale (Table 5) classified as low (<30), moderate (30-60) and high (> 60) ones.

According to the methodology (3), four out of six localities have a high geotouristic significance (PGU). Localities GS_4 and GS_5 have the maximum number of points; their special importance is in the recognisability on the national level (educative importance and spectacularity level). Localities GS_1 and GS_2 have a moderate PGU. Though they are not used as a tourism brand, they can be used as clear examples in the education of undergraduate and postgraduate students. For localities GS_3 and GS_6, a special significance level is obtained using the proximity and connection to other touristic resources. In the immediate sur-

Table 5: Geotouristic-potential results for mentioned geosites (PGU)

Geosite name and number	Potential geotourism use (PGU)	Geosite PGU average weight
Velika Stena (GS_1)	Moderate	43
Velika Šiljača (GS_2)	Moderate	43
Oštri krš (GS_3)	High	64
Jelica (GS_4)	High	100
Žljeb (GS_5)	High	100
Gvozdac (GS_6)	High	65

Table 6: Overall ranking of the analysed geosites obtained by using M-GAM model

Name of geosite	Main values		Additional values		Field
	VSE+VSA+VPr	$\sum$	VFn+VTr	$\sum$	
Velika Stena (GS_1)	1.07+2.47+1.81	5.35	1.12+3.15	4.27	Z_{21}
Velika Šiljača (GS_2)	0.61+2.88+2.14	5.63	3.12+4.84	7.96	Z_{22}
Oštri krš (GS_3)	0.95+3.12+1.82	5.89	2.41+3.92	6.33	Z_{22}
Jelica (GS_4)	2.09+2.14+1.91	6.14	4.50+6.72	11.22	Z_{23}
Žljeb (GS_5)	2.11+3.16+2.29	7.56	4.04+6.82	10.86	Z_{23}
Gvozdac (GS_6)	1.90+2.36+2.31	6.57	3.23+6.14	9.37	Z_{22}
Mean value	-	6.19	-	8.34	-

roundigs of GS_3 there are noticeable glaciation traces. This is the only edelweiss locality on Kopaonik especially distinguished for its richness of plant communities. Geolocality GS_6 belongs to the natural reservates Metođe and Jelak, the first level of protection, in the immediate vicinity of geyser "Gvozdac" and sanctuary "Metođe".

In order to achieve more precise geolocality evaluation results, the previous results are compared with the M-GAM results. The final results are given in Table 6 and the corresponding plot is given in Figure 4.

Within the group for the main values GS_5 displays the highest scientific and landscape/aesthetic value, while the geosite GS_6 is emphasizing in protection. The least obtained values of all analyzed localities displays GS_2 for educative value and GS_4 for landscape value, whereas the geosite GS_1 is in the lowest rank regarding protection.

The additional values comprise two indicator groups which represent functional and touristic values. The geosites GS_4 and GS_5 have the best access. They are near a highway and a great number of other natural and anthropogenic values occur in their surroundings. Additionally, they are the nearest objects to the "Kopaonik" tourist centre. The other geosites are assigned lower values due to their isolation and bad access, but the touristic value is high because all of them are 5 km away from the main tourist centre "Kopaonik", in the immediate vicinity of "Srebrenac" tourist complex (GS_4 and GS_5) or not far from tourist settlement "Brzeće" (GS_6).

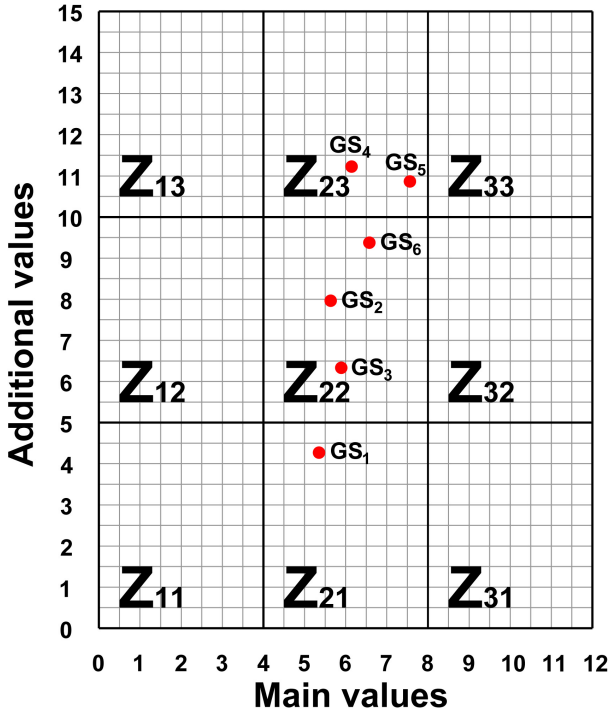

Figure 4: Position of evaluated geosites in GAM matrix

After comparing the final results for all six geosites, the differences in the main and additional values, as well as their positions in the GAM matrix (Figure 4), can be seen clearly. Geosites GS_4 and GS_5 plot in the field Z_{23} that

Table 7: The assessment results for educative and geotouristic values including those gained by using M-GAM method

Name of geosite	Potential educative use (PEU)	Potential geotourism use (PGU)	Modified Geosite Assessment Model (M-GAM)
Velika Stena (GS_1)	Moderate	Moderate	Z_{21} (moderate /low)
Velika Šiljača (GS_2)	Moderate	Moderate	Z_{22}(moderate / moderate)
Oštri krš (GS_3)	Moderate	High	Z_{22} (moderate / moderate)
Jelica (GS_4)	High	High	Z_{23} (moderate / high)
Žljeb (GS_5)	High	High	Z_{23} (moderate / high)
Gvozdac (GS_6)	Moderate	High	Z_{22} (moderate / moderate)

clearly points to moderate level of the main values and high level of the additional values. Geosites GS_2, GS_3 and GS_4 are in the field Z_{22}, suggesting on moderate level of the both, main and additional values. The geosite GS_1 having moderate level of the main values and low level of additional values plots in the field Z_{21}.

One of the main drawbacks is the quality of guiding service. Competent guides are necessary, if possible those with geological or similar education, in other words specialists in the field of geoscience. The elements like interpretative tables and touristic infrastructure are also occasionally absent. These geosites are on the list of NP „Kopaonik" tourist attractions and as such they deserve to be presented to both domestic and foreign tourists to the maximum. However, it is necessary to remove the drawbacks in order to make the promotion effect as significant as possible.

5 Discussion

According to comparative analyze of three methodologies applied in the evaluation of educative (accessibility, connection to other resources, view points, educative content, fragility and representativity) and geotouristic (accessibility, connection to other resources, educative content, spectacularity and fragility) values with those obtained by M-GAM method (educative, landscape, protection, functional and touristic), which also includes the opinion of tourists beside the expert ones, the objective evaluation of geosites for geotourism development in the territory of NP „Kopaonik" was established. Results for six geosites: Velika Stena (GS_1), Velika Šiljača (GS_2), Oštri Krš (GS_3), Jelica (GS_4), Bela Stena-Žljeb (GS_5) and Gvozdac (GS_6) are given in Table 7.

According to presented results the geosite Velika Stena (GS_1) displays moderate value for geotourism development. Majority of negative points this locality owes to functional values (hardly accessible, deficiency of natural and anthropogenic resources in the nearby vicinity, as well as the lack of additional functional values) and to touristic values that are caused by insufficient promotion, organized visits, interpretative panels and the lack of guide service. All of it is the consequence of low number of visitors. This locality is regarding educative and aesthetic value of particular importance.

The geosite, Velika Šiljača (GS_2) is of moderate value for geotourism development due to all of the used methods. It's aesthetic and functional values are outstanding, whereas a promotion activity and organized visits, which directly impact a number of visitors are disadvantages. The lack of guide service and interpretative panels additionally contribute to lower quality of this locality.

The geosite, Oštri krš (GS_3) is in respect of results of the comparative analyze of noteworthy educative and spectacularity value, including the protection level as belongs to the first level of protection. However, due to low marks for functionality and insufficient promotion activity it is moderately valuable for geotourism development.

Jelica (GS_4) and Žljeb (GS_5) belong to geosites of high values. The advantage of these localities in respect to other analyzed is their position next to the main road, accessibility and proximity of another natural and anthropogenic sites along with the established infrastructure. Protection level paid attention of tourists and was marked somehow lower by them due to present state and vulnerability of the geosite Jelica (GS_4). The geosite Žljeb (GS_5) or Bele stene is in the first level of protection and the conventional symbol in the promotion of NP „Kopaonik" due to memorable and high spectacularity.

Gvozdac (GS_6) represents the geosite of moderate value for most of the parameters due to difficulty accessing, inadequately studies and low scenic quality that is diminish by the presence of water and vegetation (during rainy and foggy weather). Nevertheless, the touristic and protection value of this locality is valuable.

According to overall obtained results through this study the analyzed localities in the NP „Kopaonik“ are of high educative and aesthetic value as well as of high spectacularity and protection level. Easier access and additional functional values, such as touristic promotion of localities, better organized visits and guide service as well as more comfortable infrastructure for visitors (walking tracks, resting places, garbage cans, and better arrangement of tourist places themselves) is required and obligatory. Higher level of analyzed values for given localities could be achieved by better organization and arrangement as well as through improvement of the promotion of geotouristic localities in NP „Kopaonik“ and making them mutually connected to each other.

6 Conclusions

This study is a modest contribution to insufficiently studied geosites in the area of central and south Serbia. By the application of three different methods a six geosites in the NP “Kopaonik” (Velika Stena, Velika Šiljača, Oštri Krš, Jelica, Žljeb and Gvozdac) were ranked. Educative (accessibility, connection to other resources, view points, educative content, fragility and representativity) and geotouristic (accessibility, connection to other resources, educative content, spectacularity and fragility) values and those of the GAM method (educative, landscape, protection, functional and touristic) were determined by experts. Results obtained in all three cases are very similar. The inclusion of tourists in the third method (M-GAM) led to results, which in all cases were of lower values than GAM values are, contributing to more objective and accurate results. The applied comparative analyze led to conclusion that geosites Velika Stena, Velika Šiljača, Oštri Krš and Gvozdac are of moderate level, while Jelica and Žljeb display high values. The similarity of results obtained during this study reflects on high confidential level in answers given by experts and by visitors. Better results and higher evaluating potentials of the analyzed geosites could be achieved by better organization and arrangement, as well as throughout underlining and mutual connecting of the localities for visitors in the NP „Kopaonik“. Since all geosites are located within the first protection zone of the NP „Kopaonik“, their future development must be based on a sustainable development.

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Table S1: Supplementary materials

Main Indicators / Subindicators	Values given by experts (0-1)						Im (0-1)						Total value					
	GS1	GS2	GS3	GS4	GS5	GS6	GS1	GS2	GS3	GS4	GS5	GS6	GS1	GS2	GS3	GS4	GS5	GS6
I Scientific/Educational values (VSE)	2	1,5	2	2,75	2,75	2,5	1,48	1,23	1,7	2,43	2,65	2,36	1,07	0,61	0,95	2,09	2,11	1,9
1. Rarity	0,25	0,25	0,25	0,25	0,25	0,25	0,22	0,19	0,24	0,18	0,24	0,22	0,06	0,05	0,06	0,05	0,06	0,06
2. Representativeness	0,5	0,25	0,5	0,75	0,75	0,5	0,32	0,28	0,42	0,58	0,7	0,5	0,16	0,07	0,21	0,55	0,53	0,36
3. Knowledge on geoscientific issues	0,25	0,25	0,5	0,75	0,75	0,75	0,12	0,16	0,42	0,73	0,75	0,64	0,03	0,04	0,21	0,55	0,56	0,48
4. Level of interpretation	1	0,75	0,75	1	1	1	0,82	0,6	0,62	0,94	0,96	1	0,82	0,45	0,47	0,94	0,96	1
II Scenic/Aesthetic (VSA)	3	3,25	3,5	2,75	3,5	3	2,8	3,06	3,32	2,69	3,4	2,74	2,47	2,88	3,12	2,14	3,16	2,36
5. Viewpoints	0,75	1	1	1	1	0,5	0,6	0,86	0,92	1	1	0,3	0,45	0,86	0,92	1	1	0,15
6. Surface	0,25	0,25	0,5	0,25	0,5	0,5	0,24	0,24	0,4	0,25	0,48	0,46	0,06	0,06	0,2	0,06	0,24	0,23
7. Surrounding landscape and nature	1	1	1	0,75	1	1	0,96	0,96	1	0,72	0,92	0,98	0,96	0,96	1	0,54	0,92	0,98
8. Environmental fitting of sites	1	1	1	0,75	1	1	1	1	1	0,72	1	1	1	1	1	0,54	1	1
III Protection (VPr)	2,75	3	2,5	2,75	3	3	2,46	2,72	2,5	2,71	2,92	2,94	1,81	2,14	1,82	1,91	2,29	2,31
9. Current condition	1	1	1	0,75	1	1	0,8	0,86	0,91	0,72	0,92	0,94	0,8	0,86	0,92	0,54	0,92	0,94
10. Protection level	0,5	0,75	0,5	0,75	0,75	0,75	0,48	0,68	0,4	0,74	0,75	0,75	0,24	0,51	0,25	0,56	0,56	0,56
11. Vulnerability	0,75	0,75	0,75	0,75	0,75	0,75	0,7	0,72	0,7	0,75	0,75	0,75	0,53	0,54	0,53	0,56	0,56	0,56
12. Suitable number of visitors	0,5	0,5	0,25	0,5	0,5	0,5	0,48	0,46	0,48	0,5	0,5	0,5	0,24	0,23	0,12	0,25	0,25	0,25
IV Functional values (VFn)	2,5	4,25	3,5	5	4,75	4	2,22	3,98	3,34	5	4,72	3,82	1,12	3,12	2,41	4,5	4,04	3,23
13. Accessibility	0,25	0,5	0,25	1	0,75	0,25	0,2	0,48	0,24	1	0,72	0,25	0,05	0,24	0,06	1	0,54	0,06
14. Additional natural values	0,5	1	1	1	1	1	0,48	0,92	0,96	1	1	0,98	0,24	0,92	0,96	1	1	0,98
15. Additional anthropogenic values	0,25	0,75	0,75	1	1	1	0,2	0,72	0,74	1	1	0,96	0,05	0,54	0,56	1	1	0,96
16. Vicinity of emissive centers	0,75	1	0,75	1	1	1	0,68	0,98	0,72	1	1	0,96	0,51	0,98	0,54	1	1	0,96
17. Vicinity of important road network	0,25	0,5	0,25	0,5	0,5	0,25	0,24	0,46	0,2	0,5	0,5	0,25	0,06	0,23	0,05	0,25	0,25	0,06
18. Additional functional values	0,5	0,5	0,5	0,5	0,5	0,5	0,42	0,42	0,48	0,5	0,5	0,42	0,21	0,21	0,24	0,25	0,25	0,21
V Touristic values (VTr)	5,5	6,5	6,25	7,75	7,75	7,5	4,81	5,95	5,51	7,46	7,58	7,02	3,15	4,84	3,92	6,72	6,82	6,14
19. Promotion	0,25	0,25	0,5	0,5	0,5	0,5	0,25	0,25	0,48	0,5	0,5	0,42	0,06	0,06	0,24	0,25	0,25	0,21
20. Organized visits	0,75	1	0,75	1	1	1	0,68	1	0,75	1	1	1	0,51	1	0,56	1	1	1
21. Vicinity of visitors centers	0,75	0,75	0,75	1	1	0,75	0,6	0,6	0,6	0,98	1	0,7	0,45	0,45	0,45	0,98	1	0,53
22. Interpretative panels	0,75	0,75	0,75	0,75	0,75	0,75	0,5	0,6	0,62	0,7	0,7	0,72	0,38	0,45	0,47	0,53	0,53	0,54
23. Number of visitors	0,5	0,75	0,75	1	1	1	0,48	0,72	0,72	0,98	0,98	1	0,24	0,54	0,54	0,98	0,98	1
24. Tourism infrastructure	0,5	0,5	0,5	0,75	0,75	0,75	0,48	0,4	0,42	0,62	0,7	0,6	0,24	0,2	0,21	0,47	0,53	0,45
25. Tour guide service	0,5	0,5	0,75	0,75	0,75	0,75	0,42	0,48	0,5	0,68	0,7	0,7	0,21	0,24	0,38	0,51	0,53	0,53
26. Hostelry service	0,75	1	0,75	1	1	1	0,7	1	0,72	1	1	0,9	0,53	1	0,54	1	1	0,9
27. Restaurant service	0,75	1	0,75	1	1	1	0,7	0,9	0,7	1	1	0,98	0,53	0,9	0,53	1	1	0,98