A multi-criteria decision analysis with special reference to loess and archaeological sites in Serbia (Could geosciences and archaeology cohabitate?)

Abstract: Geoarchaeology is a term used to describe the work of experts who deal with the archeological record and combine the expertise of their different disciplines, mainly archeology and geology. Because such scientists have different educational backgrounds and use different research methods it was expected that they might value archeological sites (or geoarchaeological geosites) somewhat differently. The principal aim of this study is to show the results of the application of a GAM’s (Geosite Assessment Model) main values, rank indicators and sub-indicators according to the experts’ preferences and attitudes, as it was presumed that they are not of the same importance. For this purpose, the authors used a AHP (Analytical Hierarchy Process), widely used in decision-making analysis, to define the criteria weights and rank the indicators. Two main groups of expert respondents, geoscientists and archeologists, were surveyed and gave their criteria weights. The results obtained by application of the AHP showed that there is a difference in indicator weights. While both groups gave their highest value to the scientific/educational indicator, the geoscientists gave their higher rank to the scenic/aesthetic rather than to the protection indicator, the archeologists ranked them opposite, and gave their higher rank to the protection indicator and lowest rank to the scenic/aesthetic indicator. This paper further provides information on group decision or consensus on weights and shows the final rankings for both groups, which are further examined and discussed.

Keywords: Geoarchaeology, Analytical Hierarchy Process, GAM, Attitudes, Loess

1 Introduction

Geodiversity, as the abiotic equivalent to biodiversity, was identified in the 2000s as a natural resource with a wide range of values, several of which are related to some aspects of the physical environment with high cultural and/or social significance [1]. These values began to be significant in the early development of human civilisation, when our early ancestors started to have a very close relationship with their physical surroundings. Indeed, the physical and natural environment, in terms of geology and landscape, were essential for supportive natural habitats, settlement selection and other components crucial for their survival [2].

Presently, some of these early human sites are undergoing comprehensive research by scientists from various disciplines, especially archaeology and geology. The
archaeologists and geoscientists often collaborate at the same locality, combining their expertise and understandings to make new discoveries and implement conservation actions [3]. This collaboration has been recognised de facto as ‘geoarchaeology’ [4], which has demonstrated that advances in areas of archaeological science with a strong geological, geomorphological, sedimentological or pedological component have significantly furthered the understanding of processes’ formation, improved interpretations and helped develop site preservation [5]. Indeed, Jones [4], in his United Kingdom (hereafter, the UK) introductory text, considered that “geoarchaeology is the application of earth science principles and techniques to the understanding of the archaeological record. It is essentially an approach to archaeology, carried out by practitioners with specialist knowledge about the physical environment in which archaeological stratigraphy is preserved, and excavations take place.” [4].

2 Geology and Archaeology overlapped - examples

The necessity for collaborative research work in these two disciplines, in order to provide a better understanding than previously possible of prehistoric and classical times, in particular with the consequent necessary conservation activities can best be appreciated through the consideration of some case studies; these can profitably examine, in terms of their significance to the development and implementation of geoarchaeology, both historically and recently excavated sites.

A particularly good is the study by Moroni et al. [3]; this study presented several different archaeological sites from Italy and Russia, with several geological features (stratigraphical, geomorphological, etc.) in which such geodiversity can be associated with archaeological sites and/or archaeological material. In these the recognition of the geological heritage value of archaeological sites facilitates their use for geotourism purposes [3].

In considering United Kingdom sites and scientists (archaeological and earth), in relation to their collaboration in the past and present, the best candidates are those of Palaeolithic and Neolithic interest in central southern and eastern England. It is worth noting that in the nineteenth century there were some British individuals who published both geological and archaeological studies. Significant amongst these, in relation to the sites mentioned below, are Sir John Evans (1823-1908) and Worthington G. Smith (1835-1917). Sir John Evans was a Hertfordshire-based geologist and archaeologist who pioneered the complex task of correlating Pleistocene geology and the activities of early humankind in Britain. His influence on the development of geoarchaeology was significant. He was awarded the Geological Society’s Lyell Medal in 1880 at which its President paid him the accolade that “We can now scarcely say where archaeology ends geology begins, nor whether to rank and value you most as an antiquary or a geologist.” [6]. Smith was an accomplished amateur naturalist who developed an interest in archaeology when he moved to Dunstable in 1885. His book, Man the Primeval Savage [7], was something of a classic text for many years. Particularly relevant to geoarchaeology, its Preface recorded “An effort has been made to present...a few results of research into the nature and surroundings of primeval man, as deduced from geological, anthropological and archaeological evidence.” [7].

Most aptly then, the best examples of the historic and modern interplay of archaeologists and geoscientists, and the development of geoarchaeology, are the excavations of Palaeolithic and Neolithic archaeological sites related to Quaternary river sands and gravels and/or loess deposits in eastern England. Some of these sites are statutorily protected, as at Gaddesden Row in Hertfordshire [8] and Biddenham (Deep Spinney) Pit near Bedford in Bedfordshire [9–11] as geological Sites of Special Scientific Interest (hereafter SSSI). Lill and Smalley [12] and Jones [4] have aptly summarised for the purposes of this paper the distribution and nature of wind-blown deposits, including loess, in England. Significant loess sites with archaeological interest were unearthed in the Whipsnade area near Luton, Bedfordshire in the nineteenth century [13, 14] and re-examined in the twentieth century [15–19]. Two sites in particular were excavated, at Caddington and Whipsnade itself (both near Dunstable in Bedfordshire), and reported in the literature. At the time of their excavation the loess was called, by the eponymous term, ‘brick earth’. The site of one of these nineteenth century brick manufacturing sites at Caddington is preserved in the modern name, ‘Brick Kiln Barns’, of a housing development completed in 2009 and the adjacent ‘Brickkiln Farm’. The Palaeolithic and Neolithic finds were generally found beneath gravels overlying material derived from loess that had accumulated in solution hollows, or dolines, in the Chalk bedrock. The general nature of the area’s loess was initially scientifically described and analysed by Loveday [20] and then by Avery et al. [21].

A 2008 English Heritage report [22] prepared by a working group of Palaeolithic specialists recognised “the importance of existing media, such as Time Team, and new media for promoting public awareness of the Pleistocene.”
Could geosciences and archaeology cohabitate?

3 Study area - loess and archaeology overlaid

The typical geographical zones for the thickest loess deposition are river plains, plateaux and along river basins [28]. Hence, the banks of the Danube and its tributaries, together with the fertile plains of central Europe mostly covered by loess deposits, were ideal places for prehistoric human settlements, principally because of their fertile soils. This overlap of loess deposits and potential archaeological interest is evident throughout Europe, although not necessarily across all prehistoric periods [29]. Dodonov et al. [30] reports high rates of loess deposition during the Middle Pleistocene which caused most of the sites to be deeply ‘hidden’ under thick (up to 50 m) loess sediments in most of central and eastern Europe. Unlike this period, being called “the terra nova for Lower Palaeolithic archaeology” [31], in the same part of Europe, the Upper Palaeolithic has many archaeological sites within the Gravettian culture. The best examples of this period are the loess sections near Krems-Wachtberg (with significant infant burials) and numerous others in central Europe with so-called “Venus figurines” (Willendorf II, Moravany, Nusloch, Pestkovce) [32]. Many other representative Middle and Upper Palaeolithic sites are found, for example, in the East Carpathian Foreland [33], Předmostí, Dolní Věstonice and Pavlov in the Czech Republic [34], Russia (Kostienki) [35], the Ukraine (Molodova) [35] and Poland (Kraków-Spadzista) [36, 37].

As a major Quaternary palaeoclimatic and palaeoenvironmental European archive, the loess-palaeosol sequences in Serbia (particularly in the Vojvodina region) are significant geodiversity elements [28, 29, 38–41]. Such loess areas are considered key regions for the origins of civilization, with valuable historical, archaeological, anthropological and palaeontological sites, much in evidence in Serbia, for example [28, 29, 41]. This is especially the case for River Danube, the environs of which were significant locations for both Palaeolithic and Neolithic cultures due to their capacity to provide adequate food, water, productive soils, shelters and strategic points which gives them their high rank of cultural and social values [29].

The area is home to several important Mesolithic and Neolithic archaeological sites (Padina [42], Lepenski Vir [42], Vlasac [42], Vinča - Belo Brdo [25], Starčevo [27], and Haidučka Vodenica [42]), some of them located in the area upstream of the Iron Gates, or actually inside of this amazing Danube Gorge that confines some 150 km of the River Danube [43].

The Eneolithic period is recorded in some of its most recognizable prehistoric layers in the Danube valley - Baden, Kostolac and Vučedol [44]. Other loess landscapes of the Pannonian Plain were also the cradle of many Neolithic and Eneolithic cultures; one of them dating from around the fifth millennium BC, is the Tisza Culture [45] particularly interesting for the long history of the study of its sites [46] and from an archaeological perspective for their practice of the shallow burial of their dead on their sides in a flexed position. A systematic study of the local Tisza Culture sites, in a renowned loess area, was undertaken in the mid-2000s by the Museum of Vojvodina [47] in Novi Sad. Vasiljević et al. [29] also report that besides archaeological material, the loess has also preserved much representative palaeontological material at sites in the Danubian area.
of Serbia; these include the Middle Pleistocene Bear (*Ursus Deningeri*, Ruma loess section), the Middle Pleistocene ‘steppe’ mammoth (*Mammuthus trogontherii*, Drmino open lignite mine near Kostolac) and many other representatives of the Quaternary mammal fauna [26, 40, 48, 49].

4 Methodology

The evaluation of geosites has been developing since the 1990s in terms of their interpretative potential and actual provision [51, 52], especially as a means to help fund and underpin geoconservation [53, 54]. The aim of this study is to clarify the differentiation of attitudes between archaeologists and geoscientists regarding fundamental values that could be attached to particular localities with archaeological and/or geological significance. These two types of researchers or academics derive their approaches and mindsets from the social (archaeology, history) and natural (earth sciences) sciences, with their different knowledge bases. It is to be expected that they will then also have different views on the same values. Therefore, the study has been designed to inspect their attitudes on the same indicators developed for the preliminary Geosite Assessment Model (hereafter, GAM) developed by Vujičić *et al.* [23], but appropriately customised for archaeological sites.

The GAM was created from literature regarding the scientific, aesthetic and other values of geosites [50, 55–58]. It was further developed and used in other study areas, see [59–65]. The model consists of two groups of indicators, from which the first group of indicators, named “main values”, is defined by Vujičić *et al.* [23] as those that bring fundamental values to a specific site, mostly indicating the scientific and conservation significance. The main values are divided into three indicator groups: scientific/educational, scenic/aesthetic and protection values, which further consist of more sub-indicators that are then finally graded by relevant marks, see [23]. The complete scheme of the main values is given in Table 1. The second group of indicators (defined as Additional values) within GAM is mostly related to tourism values, and thus is excluded from this study and evaluation.

As previously noted, these indicators are modified to suit both archaeological sites and geosites, that is, the description of sub-indicators are for this purpose more general and not specifically connected to geosites. Additionally, in the questionnaire for archaeologists, the sub-indicator “knowledge on geoscientific issues” (scientific and educational values) is replaced by “exploration and excavation of the site” because the archaeologist’s field of research can be closely connected with this indicator.

4.1 Analytic Hierarchy Process

In order to compare these indicators and sub-indicators, the Analytic Hierarchy Process (hereafter, AHP) was used. This method is very popular in contemporary research because its usefulness outweighs other rating methods [66]. The AHP approach is used to construct an evaluation model and it has criterion weights. It integrates different measures into a single overall score for ranking decision alternatives. Its application usually results in simplifying a multiple criterion problem by deconstructing it into a multilevel hierarchical structure [67]. The goal is at the top of the hierarchy, while the criteria, sub-criteria and alternatives are on the levels and sub-levels of the hierarchy (Figure 1). AHP gradually compares alternatives and measures their impact on the goal, which helps people to make the correct decision [68].

When the hierarchical model of the problem is established, the decision-maker (in this case archaeologists and geoscientists) can compare the elements in pairs at each level of the hierarchy with the element in the higher level of the hierarchy. For decision makers, the criterion weights represent a measure of the relative importance of the elements.

The AHP is used to determine the preferences among the set of elements at a given level of a hierarchy by employing pair-wise comparisons of these elements with respect to the elements at the higher level using Saaty’s scale (1, 3, 5, 7, 9, where is 1 equally importance and 9 of absolute importance, see Figure 2). If element $i$ is more important than element $y$ relevant index value is assigned in the matrix $A$, but if the judgment is that $y$ is more important than $i$, the reciprocal of the relevant index value is assigned to the matrix $A$. The results of all the comparisons are placed in positive reciprocal quadratic matrices. Next stage is calcu-
Table 1: Main value indicators of the GAM according to Vujičić et al. [23]

<table>
<thead>
<tr>
<th>Indicators/Sub-indicators</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific/Educational value</td>
<td>-</td>
</tr>
<tr>
<td>Rarity</td>
<td>Number of closest identical sites</td>
</tr>
<tr>
<td>Representativeness</td>
<td>Didactic and exemplary characteristics of the site due to its own quality and general configuration [50]</td>
</tr>
<tr>
<td>Exploration and excavation of the site</td>
<td>Level of excavation and exploration of the site. Number of written papers in acknowledged journals, thesis, presentations and other publications.</td>
</tr>
<tr>
<td>Level of interpretation</td>
<td>Level of interpretive possibilities on geosite (geological and geomorphologic processes, phenomena and shapes and level of scientific knowledge) and archaeological site (knowledge on contexts representing some human activity (prehistoric or historic) and archaeological record)</td>
</tr>
<tr>
<td>Scenic/Aesthetic</td>
<td>-</td>
</tr>
<tr>
<td>Viewpoints</td>
<td>Number of viewpoints accessible by a pedestrian pathway. Each must present a particular angle of view and be situated less than 1 km from the site.</td>
</tr>
<tr>
<td>Surface</td>
<td>Whole surface of the site. Each site is considered in quantitative relation to other sites.</td>
</tr>
<tr>
<td>Surrounding landscape and nature</td>
<td>Panoramic view quality, presence of water and vegetation, absence of human-induced deterioration, vicinity of urban area, etc.</td>
</tr>
<tr>
<td>Environmental fitting of sites</td>
<td>Level of contrast to the nature, contrast of colours, appearance of shapes, etc.</td>
</tr>
<tr>
<td>Protection</td>
<td>-</td>
</tr>
<tr>
<td>Current condition</td>
<td>Current state of site</td>
</tr>
<tr>
<td>Protection level</td>
<td>Protection by local or regional groups, national government, international organizations, etc.</td>
</tr>
<tr>
<td>Vulnerability</td>
<td>Vulnerability level of site</td>
</tr>
<tr>
<td>Suitable number of visitors</td>
<td>Proposed number of visitors on the site at the same time, according to surface area, vulnerability and current state of site.</td>
</tr>
</tbody>
</table>

Figure 2: Screenshot of the “Expert Choice 2000” software’s interface during questionnaires
lation of the eigenvector, standard AHP method, for each matrix, the so-called local priority vector is calculated using the principal eigenvector of a comparison matrix, as suggested by Saaty [68]. In group decision-making an aggregation of each individual’s resulting priorities is computed using the geometric mean which is more consistent with the meaning of priorities in AHP.

The final stage is calculation of the Consistency ratio (CR), which serves to determine the consistency of the judgements. The closer $\lambda_{\text{max}}$ is to $n$, the more consistent the judgments. The difference $\lambda_{\text{max}} - n$ can be used to measure the inconsistency, but instead of using this difference directly, Saaty defined a Consistency Index (CI) which is calculated according to the formula $(\lambda_{\text{max}} - n) / (n - 1)$. As final step the ratio of consistency (CR) can be calculated from the ratio of the consistency index (CI) and the random index (RI) according to formula $CR = CI/RI$ defined in [68]. RI represents the random index derived from numerous randomly generated $nxn$ matrices. If the consistency ratio (CR) is less than 0.10, the result is sufficiently accurate and there is no need for adjustments in comparison, or for repeating the calculation. If the CR is above the 0.10 the judgements are considered untrustworthy and the results should be then re-analyzed with aim to determine the reasons for inconsistencies.

For the purpose of this study the hierarchy model was constructed using “Expert Choice 2000” software; created by Thomas Saaty and Ernest Forman in 1983, it is supplied by Expert Choice Inc. [details at http://expertchoice.com/]. Expert Choice is decision-making software based on multi-criteria decision making; it implements the AHP.

5 Research

5.1 Structuring the hierarchy and research phase

The first stage of the research was the selection of the most appropriate indicators which describe the main values of a (geo)site. As previously mentioned, the indicators were developed from the GAM and were further modified to better describe both archaeological sites and geosites. The complex hierarchy of the main values, which are further decomposed into a multi-level hierarchical structure with sub-indicators on lower levels, are shown in Figure 3. The second stage involved the selection of the archaeologists and geoscientist, followed by a qualitative interview with them. The data from the interviews was then entered into “Expert Choice 2000” (Figure 2), which lead to calculation of the global weights of the criteria. These were further synthesized using the geometric mean approach suggested by Saaty [69]. To ensure that individual archaeologists and geoscientists without fail could identify his/her personal preference, the CR was calculated to evaluate the consistencies of their judgments.

5.2 Sampling Framework

The survey was conducted in 2014 during a field trip to the Belo Brdo Neolithic archaeological site. This is situated on the right bank of the Danube River, in the village of Vinča, 14 km downstream from Belgrade. All interviewees had visited the site Vinča site – Belo brdo. This small convenience sample of seven experts in the fields of either archaeology (and who were working at the Vinča site) geosciences and geoscientists in the field of psychical geography (based at the Faculty for Sciences, Department for Geography, Tourism and Hotel management, University of Novi Sad). Therefore, they were considered competent to answer the survey because they could be expected to have the knowledge and understanding of the Vinča site – Belo brdo; they are experts in their particular fields of research. The survey included seven experts (archaeologists and geoscientists) who did the pair-wise comparison of the criteria. An interview was conducted utilizing a questionnaire, and answers were expressed in the form of a pairwise comparison matrix. None CR values of interviewers were higher than 0.1 so there were no need for re-evaluation.
Table 2: Comparative analysis – Ranking of criteria weights for main values (Geoscientists vs Archaeologists) extracted from Expert Choice 2000 software analysis

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Sub-indicators</th>
<th>Indicators</th>
<th>Sub-indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific/Educational</td>
<td>Rarity (0.424)</td>
<td>Scientific/Educational</td>
<td>Level of interpretation (0.370)</td>
</tr>
<tr>
<td>value (0.725)</td>
<td>Representativeness (0.236)</td>
<td>value (0.514)</td>
<td>Exploration and excavation of the site (0.274)</td>
</tr>
<tr>
<td></td>
<td>Exploration and excavation of the site (0.189)</td>
<td></td>
<td>Representativeness (0.263)</td>
</tr>
<tr>
<td></td>
<td>Level of interpretation (0.151)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scenic/Aesthetic</td>
<td>Viewpoints (0.426)</td>
<td>Protection (0.399)</td>
<td>Current condition (0.321)</td>
</tr>
<tr>
<td>(0.209)</td>
<td>Surrounding landscape and nature (0.374)</td>
<td>Environmental fitting of sites (0.416)</td>
<td>Protection level (0.180)</td>
</tr>
<tr>
<td></td>
<td>Environmental fitting of sites (0.102)</td>
<td></td>
<td>Suitable number of visitors (0.152)</td>
</tr>
<tr>
<td></td>
<td>Surface (0.097)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protection (0.066)</td>
<td>Current condition (0.428)</td>
<td>Scenic/Aesthetic</td>
<td>Environmental fitting of sites (0.416)</td>
</tr>
<tr>
<td></td>
<td>Vulnerability (0.260)</td>
<td>(0.087)</td>
<td>Surface (0.245)</td>
</tr>
<tr>
<td></td>
<td>Protection level (0.253)</td>
<td></td>
<td>Surrounding landscape and nature (0.214)</td>
</tr>
<tr>
<td></td>
<td>Suitable number of visitors (0.059)</td>
<td></td>
<td>Viewpoints (0.124)</td>
</tr>
</tbody>
</table>

Consistency ratio (CR): 0.08                      Consistency ratio (CR): 0.04

5.3 Questionnaire design

The survey was undertaken as a series of formal individual interviews. The respondents were asked to express their preferences (using Saaty’s scale) between criteria comparing each one with another (Figures 2 and 3). The criteria used for the comparison derived from the GAM (main values) specially modified for this survey. A pilot survey project was completed, to ensure the clarity of the questions, before the actual survey was undertaken. Because the feedback from all of the pilot survey respondents was satisfactory, the survey design was considered to be clear and adequate for the final research interviewees.

6 Results and discussion

The weight among the indicators of the main values is shown in Table 2. There are differences among geoscientists and archaeologists point of view, when rankings are taken into consideration. The ranking shows that geoscientists gave the highest weight to the scientific/educational value (0.725), scenic/aesthetic value (0.209) followed, while lowest weight went to the protection value (0.066). Similarly, archaeologists also ranked the scientific/educational value (0.514) as most important, protection (0.399) was ranked as second important and scenic/aesthetic (0.087) values were ranked as least important.

As herein presented, both groups perceive scientific and educational values as most important, but geoscientists gave larger criteria weight to this group value. As for geologists the main purpose of geosites is to conduct research and make scientific discovery, it is to be expected that the scientific/educational value had the highest weighting. Hence, it can be argued that geoscientists have more interest in research, and archaeologists better show the balance between research and conservation. In accordance with the previously stated, it was expected that archaeologist would give greater importance to the protection value and geologist ranked it with the lowest value. This may be interpreted as archaeological sites together with artefacts need, or are perceived as such, to have more protection and that they have a higher level of vulnerability. For geoscientists, sites are seen as being robust and durable and, hence, not in need of so much attention for conservation. This protection-related misbalance might exist because geologists generally investigate sites purely for the purpose of science, whilst archaeologists conserve artefacts and sites, both in situ and ex situ, and are naturally more inclined towards conservation and further presentation to a wider audience – typically on-site visitors.

The ranking of individual sub-indicators within indicator groups is presented, compared and discussed in the following.

Scientific/educational values sub-indicators. On the more specific scale, this indicator group shows also certain differentiation among its sub-indicators. Within geoscientists preferences rarity (0.424) is distinguished as most important, while representativeness (0.236), Exploration and excavation of the site (0.189) and Level of interpretation (0.151) are more or less equally important. On
the other hand, archaeologists demonstrated the highest level of interest for the level of interpretation (0.370), exploration and excavation of the site (0.274) and representativeness (0.263). It is quite surprising that rarity (0.093) is perceived as least important for archaeologists, which is expected to be a high value for both groups (as noted for geoscientists). Also, the preferences for level of interpretation (0.151).

Protection sub-indicators. Within this group of sub-indicators both groups of experts gave quite similar rankings with current condition and vulnerability as most important, protection level with medium values, while suitable number of visitors is at the bottom of the list. This could be expected as devastated and degraded sites are not of much use for science, would be very difficult research and could even provide misleading results. Suitable number of visitors which correlates with carrying capacity of the site is of least importance for geoscientists and for archaeologist. Although it got the lowest rank by both groups, this sub-indicator got a much higher grade from archaeologists (0.152), as in practice too many visitors can damage archaeological sites, as they prove to be more vulnerable than most geosites. The mentioned sub-indicator can correlate and connect to the sub-indicator vulnerability which was highly ranked by archaeologist and again prove that they pay more attention to the degradation of the site.

Scenic/aesthetic subindicators. Here again there is a misbalance in ranking criteria which is related to the viewpoints sub-indicator. As geoscientists observe the surroundings during their research it was expected to be ranked with higher values. Conversely, archaeologists gave the lowest grades as they amend the space according to excavation conditions and less use their observation skills. Nevertheless, observation is also used by archaeologists and it is surprising that this sub-indicator got such low ranking (0.124). The same situation, but with opposite ranking is with the surface sub-indicator, which is quite highly ranked within archaeologists (0.245). This can be interpreted as large-surface sites are more exposed to degradation and need more efforts and investments for efficient conservation. Unlike them, geoscientists could find some of the rarest and most important geological specimens, such as fossils or minerals, within small-scale sites.

What was clearly unexpected here is the high value of environmental fitting of sites sub-indicator (0.416) within archaeologists. This might be because the majority of archaeological sites are naturally fitted to their environment or are amended to fit it.

The fact that the CR is 0.08 for geoscientists and 0.04 for archaeologists indicates that the result is sufficiently accurate for the purposes of the research and there is no need for adjustments in the comparison or re-evaluation.

As is shown in Figure 4, after the synthesis of criteria weights for sub-indicators the results indicate that both archaeologists and geoscientists gave dominant importance to the sub-indicators that belong to the scientific/educational indicator. The most dominant sub-indicators are: representativeness (0.199), exploration and excavation of the site (0.181), level of interpretation (0.178) and rarity (0.177). The least important sub-indicators, which got the lowest weights, belong to the protection indicator: suitable number of visitors (0.010), protection level (0.025), surface (0.025) and vulnerability (0.034). The scenic/aesthetic indicators got weights which are closer to the protection indicators, and further from the sub-indicators which belong to the scientific/educational indicators. What is particularly interesting is that sub-indicators stayed in the well-structured hierarchy and are perfectly grouped, as seen in Figure 4. It can be said then that the grouped decision accords with the attitudes of a geoscientist as it gave the highest rank to the scientific/educational group, then the scenic/aesthetic group and lastly ranked is the protection group.

7 Conclusion and further applications

This exploratory study has sought to answer the question “Do geoscientist and archaeologist think alike, or what are their main attitudes towards the geosites regarding its scientific, educational, scenic, aesthetic and pro-
tection values?”. The main motive for this research was inspired by presented literature on geoarchaeology and long-standing collaboration between groups of geoscientists and archaeologists on similar topics and research. The method employed in the study was analytical hierarchy process; it gave interesting results and created hierarchy and criteria weights of indicators and sub-indicators. The results of the assessment indicate that both groups give most attention to the scientific and educational part of the geosite. While geoscientists give a higher importance factor to the scenic/aesthetic indicator than protection indicator, with archaeologist it is just the converse. Differences in the rankings can be found in the fact that archaeological sites are susceptible to degradation and the protection factor plays a larger role. Synthesis of criteria for sub-indicators gave a similar finding, and ranked as the first scientific/educational group, followed by scenic/aesthetic group and ranked last was protection group of sub-indicators. Interest finding is that all of the sub-indicators perfectly grouped and were in line with the indicator three main groups. It can be suggested that geoscientists and archaeologists mainly think alike with some minor differences in opinions which correlate with the type of site, nature, objective and final outcome of their profession and research.

Future research could concentrate on different research areas and a different sample profile, especially since this research was implemented locally. Further comparisons between different educational backgrounds, different educational systems, working surrounding, work ethics, financial capacity for research, equipment might give different weight criteria and reveal differences in respondents' attitudes and opinions. Finally, additional statistical measurements could be applied together with different socio-demographic characteristics of the respondents.

Acknowledgement: This research was supported by Project 176020 of the Serbian Ministry of Education, Science and Technological Development. TAH is especially grateful to the School of Earth Sciences, University of Bristol for research facilities' support.

We confirm that all the authors made an equal contribution to the study's development.

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