Carpathian Journal of Earth and Environmental Sciences, November 2014, Vol. 9, No. 4, p. 19 - 30

THEORETICAL MODEL FOR THE IDENTIFICATION OF HYDROLOGICAL HERITAGE SITES

Sava SIMIĆ[1], Boško MILOVANOVIĆ[2] & Tamara JOJIĆ GLAVONJIĆ[2]
[1]*Institute for Nature Conservation of Serbia, Dr Ivana Ribara 91, 11070 Belgrade, Serbia, e-mail: sava.simic@zzps.rs*
[2]*Geographical Institute Jovan Cvijić, Serbian Academy of Sciences and Arts, Đure Jakšića 9, 11000 Belgrade, Serbia*
e-mail: b.milovanovic@gi.sanu.ac.rs, t.jojic@gi.sanu.ac.rs

Abstract: The concept of geoheritage in general and hydrological heritage as its segment is reflected in representative examples of geodiversity - geoheritage sites. Accordingly, the issue of the identification of such extraordinary parts of the geographic mantle is one of the most important problems in this complex area of study. Assuming the universal value of water and water phenomena that result from specific characteristics, this study seeks to present and explain a theoretical pathway from an investigated water phenomenon to a concrete hydrological heritage site by stressing the importance of establishing the appropriate evaluation criteria; this pathway is necessary in order to reply the fundamental question: whether and why the observed water phenomenon does (or does not) merit the status of a hydrological heritage site. The research has resulted in universal theoretical model for the identification of hydrological heritage, which has a practical significance not only in this field, but in the identification of other types of geoheritage as well.

Key words: hydrological heritage, geoheritage site, evaluation criteria, theoretical model, hydrological heritage site

1. INTRODUCTION

One of the main synthesis objectives of the study in the areas of geodiversity and geoheritage is the identification of extraordinary geographic environment elements - geoheritage sites, whereas one of the ultimate objectives is their conservation (Simić et al., 2010a). What guidelines should be followed and what criteria should be used to confirm that the observed phenomenon is a representative segment of a certain part of geographic environment? A natural site may be assessed differently by experts of the same profile, particularly in case, which is not uncommon, when it has several diverse qualities – groups of values.

A subjective approach is one of the main problems related to research into geoheritage – protection of geodiversity but also nature conservation in general. To a certain extent, such an approach logically ensues from the character of the topic, which entails the predominance of qualitative methods in research. However, recently, a number of researchers involved in the evaluation of geodiversity segments in various areas have been trying to elaborate and establish appropriate evaluation criteria as the basis for the introduction of quantitative assessment methods. The origins of these methods should be sought in the works of Linton (1968), Fines (1968) and Leopold (1969), which are mainly engaged in the assessments of values (and aesthetics) of landscapes. Coratza & Giusti (2005) note that the main limitation of modern methods, which attempt to establish the exactness in the geoheritage area, is as was with the previous ones – the distinct subjectivity in the approach.

The main step in the study of geoheritage is to define and analyze the natural characteristics of the observed phenomenon (which should be followed by the analysis of social, cultural and other features). This step precedes the process of defining and establishing evaluation criteria and directly determines it. The mentioned segments of the research into geoheritage are required in order to create conditions necessary to answer the main question: whether and why the observed phenomenon does or (does not) merit the status of geoheritage?

Hydrological heritage is a rather new topic in hydrology – conservation of water resources; this is

also a separate area of study within geoheritage which focuses on the hydrological diversity of a particular area, studies it, evaluates it and identifies within it extraordinary segments, representative water phenomena – i.e. hydrological heritage sites (Simić et al., 2010b). Until recently, water phenomena and sites were not taken into consideration as a unique and separate whole within geoheritage and were merely discussed within related groups – primarily geomorphology. This hindered the development of hydrological heritage – a segment of geodiversity which is the most visible and the most important link with the "living" parts of nature.

In the area of hydrological heritage, no complex theoretical models for the identification of sites – spanning the path from the investigated phenomenon to the concrete heritage site – have been set in place so far, which is understandable having in mind that hydrological heritage is a newly established field within hydrology and geoheritage. On the other hand, the geomorphosites allocation models are significantly represented in the literature – they developed in parallel with the expansion and deepening of the geological heritage idea.

A generalized analysis of available models leads to the conclusion that the most of them seek to cover four large groups of values, i.e. criteria used in the "assessment" of geomorphological sites:

1) Scientific values;
2) Additional values, including educational, ecological, aesthetic and cultural values;
3) Potential for use (including tourism and other economic aspects);
4) Threat – protection need.

As far as the evaluation of geomorphosites is concerned, Panizza (2001) distinguishes among four main groups of values (criteria): (a) scenic, (b) socio–economic, (c) cultural and (d) scientific. Bruschi & Cendrero (2005) classify values into (a) intrinsic quality, (b) potential for use and (c) potential threats and protection needs; whereas Serrano & Gonzales–Trueba (2005) highlight (a) scientific value, (b) culture–related (or additional) values, i.e. aesthetic, cultural, educational, scientific and tourist values, and (c) use and management value. Pralong (2005), whose evaluation of geomorphosites is primarily based on an assessment of their tourist value – potential, distinguishes between (a) scenic/aesthetic value, (b) scientific value, (c) cultural/historical and (d) social/economic value; whereas Reynard et al. (2007) highlight (a) scientific value, (b) additional value (ecological, aesthetic, cultural and economic), which all together make the global value; in the synthesis, the authors supplement them with the educational value, threat factors and levels, as well as management measures. Pereira & Pereira Caetano Alves (2007) classify values into (a) scientific value, (b) additional value (cultural, aesthetic and ecological), (c) use value, (d) protection value; whereas Pereira & Pereira (2010) distinguish between (a) geomorphological value (scientific and additional values, cultural, aesthetic and ecological) and (b) management value (potential for use and protection value). According to Zouros (2007), the values of geomorphosites are classified into (a) scientific and educational value, (b) geodiversity, (c) ecological and aesthetic value, (d) cultural value, (e) potential threats and protection needs and (f) potential for use. Vujičić et al. (2011) distinguish between (a) main values – scientific/educational values, scenic/aesthetic values and protection and (b) additional values – functional values and tourist values (cited after Petrović et al., 2013); whereas Bâca (2011) highlights (a) scientific, (b) ecological, (c) aesthetic, (d) cultural, (e) economic, and (f) protection values. Finally, Purice et al. (2013), whose evaluation of geomorphosites is primarily based also on an assessment of their tourist value – potential, classify values into (a) scenic/aesthetic, (b) scientific (which includes the ecological value), (c) cultural and (d) economic.

The analysis of these models shows that the authors adopt the opinion of Grandgirard (1999) that the most important criterion related to geoheritage, the scientific criterion, most commonly includes three groups of subcriteria: rareness, representativeness and integrity, and they further supplement them with the fourth criterion – diversity.

2. MATERIALS AND METHODS

Considering the fact that the presented study is theoretical in character, it is based on general scientific methods – principally analytical, comparative and synthetic methods. Appropriate evaluation criteria are established through an analysis of the essential features of water (water phenomena) and the identification of the groups of universal values. The theoretical model for the identification of hydrological heritage sites is gradually formed through the elaboration of fundamental and complex criteria, as well as the criterion of rareness, and determination of a phenomenon's value–based ranking, using simultaneously analytical and synthetic methods, which in certain phases of this cognitive process intermingle and supplement one another. Having in mind that heritage identification models applying

specifically to hydrological heritage have not been devised, particularly important for the presented research has been the application of the comparative method through the study of the (previously mentioned) evaluation and selection models that apply to "similar sites" of geomorphological heritage (or geomorphosites).

3. DISCUSSION

3.1. Essential characteristics – universal values of water as the basis for establishing evaluation criteria in hydrological heritage

Evaluation criteria and, consequently, the selection of heritage sites from a particular group of geoheritage are rooted in respective scholarly disciplines. Each group of geoheritage sites has its specific features; accordingly, it is logical that the criteria for their selection are somewhat different. The chief task related to hydrological heritage – a segment of hydrological diversity of an area that stands out among a multitude of water phenomena and sites for its significance (value) in scientific, ecological, educational, aesthetic, socio–cultural terms, as well as in terms of resource value (Simić et al., 2010b) – is to define and establish an appropriate system for the evaluation of hydrological phenomena which will result in the selection of representative heritage sites.

The path leading to a hydrological heritage site starts from the general – water – hydrosphere, i.e. its specific characteristics and importance for the geographic environment. In that respect, the essential characteristics of water and water phenomena may be divided into three groups:

a) *natural*: genesis (the age of the phenomenon), water discharge mode, position, morphometric features (width, length, height, depth, shape, etc.), abundance, physico–chemical properties of water (quality, physico–chemical and biological composition, temperature, etc.)

b) *aesthetic*, which arise from natural characteristics but due to their specific character and importance stand out as a separate group of characteristics: the visual appearance of the hydrological phenomenon and the landscape appearance;

c) *socio-cultural*: sociological, cultural and historical characteristics.

When evaluating and selecting hydrological heritage sites, each particular characteristic of water and water phenomena, no matter whether they are natural, aesthetic or socio–cultural, is one of the essential – *fundamental criteria*.

The universal values of water, its phenomena and sites, may include the following:

1) *scientific,*
2) *ecological,*
3) *educational,*
4) *aesthetic,*
5) *socio-cultural,*
6) *value as a resource (primarily in terms of water management and tourism),*

and they arise from the essential characteristics of water.

What is the relationship between individual groups of the essential characteristics of water and water phenomena and particular types of values? The scientific value of water directly arises from its natural characteristics, though it may also arise from socio-cultural characteristics, whereas the ecological value stems from its natural characteristics; the educational value, as well as the value of water as a resource may arise from all of the three groups of essential characteristics – natural, aesthetic and socio-cultural; the aesthetic value is determined only by the aesthetic characteristics of water, whereas the socio-cultural value of water is reflected in its socio-cultural characteristics (Fig. 1).

Scientific values are attributed to those hydrological phenomena that are significant and interesting from the perspective of scientific and scholarly research. Such forms are unique in terms of genesis, water discharge mode and other natural characteristics – water quality, abundance, temperature, morphometric characteristics – and they are, therefore, important for the reconstruction of natural history, as models that demonstrate processes, examples of the complementarity of bio– and geodiversity, etc. Apparent example of hydrological phenomena of high scientific values include rhythmic springs (ebb and flow springs, periodic springs or intermittent springs) typical of karst terrains. In these springs, fluctuations in water abundance, i.e. total interruptions in water flow are caused by specific karst underground features, namely the shape of underground channels and holes and their position. There are three known and scientifically confirmed intermittent springs in Serbia: Homoljska Potajnica in the village of Laznica near Žagubica, Promuklica in the Vidrenjak Gorge near Tutin, and Bjeluška Potajnica (Kojin Izvor) in the village of Bjeluša near Arilje. There are several other springs believed to have characteristics of intermittent springs: e.g. Banja near the Petnica Cave, Kučevska Potajnica and Mukavac in the Mali Rzav River valley (Fig. 2). Such springs are rare on

a global level – so far only a few dozens have been discovered and researched in the world, some of which are in the immediate surroundings (Slovenia, Croatia, Hungary, Romania, Bulgaria...).

Ecological value. Hydrological phenomena (sites of hydrological heritage) that have an ecological value are not important merely as elements of natural environment and Earth's mantle; their role predominantly determines the genesis, existence, development and the visual appearance of the observed area. The ecological value of water is best reflected in its importance as a life–giving element and the habitat of rare plant and animal species. Typical inland hydrological sites of a great ecological value include: lakes, ponds, swamps, oxbow lakes and mires. If it is reliably established that degradation or destruction of a hydrological phenomenon (water) may have significant negative effect on the existing ecosystem and the natural environment in general, then this becomes a reliable indicator of the phenomenon's ecological value.

The *educational value* of water is often brought into relationship with the scientific value – namely in cases when the observed hydrological phenomenon shows extraordinary natural characteristics, but it may also be determined by the other two groups of fundamental characteristics of water – aesthetic and socio–cultural characteristics. This value is reflected in the importance of water – as a concrete hydrological phenomenon – in the educational sense (i.e. for the educational process). There are great possibilities for involving hydrological phenomena which have this type of value into field education for students of relevant profiles, school excursions and scientific and professional seminars. The existence of interesting phenomena of a high educational value, particularly if they are combined with other important natural phenomena within a rather small area, is one of the main factors and conditions that precede the planning of any type of field education or research (Vasiljević, 1983); they include representative examples of some hydrological phenomena, demonstration models showing some natural processes, sites of cultural and historical significance or ecologically important sites – examples of uniqueness and the interdependent functioning of natural environment, etc.

Aesthetic value The aesthetic characteristics of water and water phenomena arise from their natural characteristics. Aesthetic values are attributed to phenomena that are beautiful in themselves, but both as elements and in their unity with the environment. Although they arise from the natural features of a hydrological phenomenon, which can normally be expressed in quantitative terms, these values are almost exclusively qualitative: as a rule, they are a matter of the subjective experience of a researcher, which gives rise to differences in evaluation methods, as well as in the final outcome of the evaluation. Or how Panizza (2001) notes, scenic (aesthetic) value–criterion "is derived from feelings which, being personal perceptions are highly subjective, it is therefore difficult to value and compare with the feelings and perceptions of others". On the other hand, aesthetic characteristics of hydrological phenomena are the first and the most impressive elements noticed by an observer. Accordingly, this criterion is attributed a great importance even among experts – researchers. Those hydrological sites that have high aesthetic values were the first natural assets to have been preserved and protected and they have remained among the most attractive geoheritage assets. Cataracts and cascading waterfalls are the best examples for this.

Socio-cultural values are attributed to hydrological phenomena that are significant for an area's historical, cultural and social development. It is right to say that the socio–cultural importance of water arises solely from its socio–cultural characteristics. The sites selected based on this criterion have always been tightly linked with humans – with their life, history, culture and legends. The socio–cultural significance of water phenomena in the context of geoheritage is best illustrated by the Sources with Distinct Socio-Cultural Values, which in the official classification of the hydrological heritage of Serbia make a separate subcategory within the Sources category (Simić et al., 2010b). This subcategory includes: Sources as Traditional Gathering Places; Sources as Places of Significant Historical Events; Sources Mentioned in Folk Oral Tradition (stories, legends, poems); Springs as Cult and Religious Sites (holy waters).

The value of water as a resource is attributed to those hydrological phenomena that make an important water resource for various purposes: water supply to people and industry, energy production, irrigation, navigation, tourism, sports and recreation. It is well known that, along with other conditions and natural phenomena, water is an essential precondition of life; it has largely determined the places of human existence and, very often, their visual appearance. This has been the case not only with individual homes or small human communities but also with entire rural and even urban settlements. The compact type of settlements is typical of calcareous terrains of eastern Serbia; in this area,

villages often developed in the immediate vicinity of powerful karst springs. Some of them, such as Vrelo Mlave and Belopalanačko vrelo (Fig. 2), later developed into small towns – i.e. small urban settlements (Vasiljević, 1983). The water from springs and spring brooks has not been used only for drinking; its energy has also been used and numerous grain watermills, cloth fulling mills and sawmills were established in river valleys.

The use of fresh drinking water, the most important resource on Earth, may often be in conflict with conservation as one of the main ideas underlying the concept of hydrological heritage. As an example for this we may mention Water Sources – Water Reserves, parts of watersheds (namely 33 of these sites have been listed as hydrological heritage sites of Serbia within the Second Group – Rivers), i.e. hydrological heritage sites that are not considered merely natural phenomena – areas of extraordinary natural and hydrogeographical values, but also as unique strategic reserves of drinking water (Belij & Simić, 2008). The creation of hydrological, water reserves is an exigency and its ultimate goal will be the vital protection of water as a fundamental and unique value of an area, but also the protection of an entire complex of natural environment (Simić, 2011). In future, the utilization of water as a resource will potentially be one of the main functions of such assets but only under the condition that the highest standards be met in preserving hydrogeographical and all other natural values. Accordingly, from the perspective of hydrological heritage, water reserves, which are foreseen by the Law on Nature Conservation of the Republic of Serbia as a separate type of natural assets (within Special Nature Reserves), are considered a good example meant to prove in practice that it is possible to harmonize two seemingly conflicting activities – use and conservation.

The use of water and water phenomena for tourism is a particularly important topic in the discussion of the values of water and water phenomena as a resource. In the context of hydrology, tourism is often discussed within water management; however, it is a specific form of the exploitation and use of hydrological sites as resources – for human needs. As usual, humans in this context appear as users, but not users who merely exploit the natural values of such sites, but tourist users, who visit, explore, learn and enjoy in them. Within the framework of the functional classification of tourist attractions as the essential factor that primarily determines the development of tourism in a certain area, Jovičić & Brankov (2009) have singled out hydrological assets as a separate type. Water phenomena, as assets of hydrological heritage which have been classified depending on their predominant value, may be a subject of interest to various groups: scientists, experts and students, if their scientific value predominates; children and school children, if their educational values are the most pronounced; and ordinary people, if they have distinct aesthetic values. Even when they are not the central part of a tourist programme, geoheritage assets and hydrological heritage sites may be very interesting as segments of wider tours. The idea of geoparks has been meant to highlight the significance of geodiversity sites in science and nature conservation, but also to place them in the focus of certain types of tourist trends (Simić et al., 2012).

Each of the six mentioned universal values is at the same time a *complex criterion*, which has an important role in the assessment of a water phenomenon. Complex criteria are expected to show the overall, complex values of a water phenomenon. Therefore, it should be pointed out that in the context of hydrological heritage, these criteria belong to various ranks. According to most studies on geoheritage that deal with evaluation criteria, the leading criterion guiding the selection of heritage assets should be the scientific criterion. The same criterion is applied to hydrological heritage, especially from the standing point of geoscience and nature protection. The following criteria according to their importance are: the ecological and educational criterion, then the aesthetic and, finally, the socio–cultural criterion and the criterion arising from the resource value of water. The purpose of the ranking of the complex values / criteria is to direct researchers appropriately towards a final assessment of a water phenomenon's value. The ranking of criteria is very important because it should serve as the basis for future quantification: the rank of a criterion should determine its potential quantitative value.

However, it should be borne in mind that the mentioned importance ranking of particular complex criteria is subjective in character; accordingly, individual researchers may have different approaches to this issue. Their approach largely depends on the final purpose of their research – whether it be science, nature conservation, tourism; the studied region – a state, a protected area or some other defined region; the author and the intended users of the model – experts, students, school children, tourists, planning professionals: "the choice of the assessment method and criteria depends on the objectives of the research" (Grandgirard, 1999). How complicated the value assessment of heritage assets may be at this level is best shown by the fact that the explored hydrological phenomenon may meet only one complex criterion, e.g. socio–cultural, but in such a manner that this

criterion makes it more apparently a hydrological heritage site than some other phenomenon that meets, for example, scientific, educational and ecological criteria. Erhartić (2010) gives the example of a waterfall or a landform that meet only one criterion, but of such great importance that it places them first on the ranking list.

It should be pointed out that complex criteria also include a significant number of *derived – indirect criteria*, which stem from complex criteria and make their component parts but when considered individually, they may play an important role in establishing the value of the observed phenomenon. Such criteria include, for example, the importance (of a phenomenon / a potential geoheritage site) for natural history, the importance as a habitat, potential use as a process–demonstration model, etc.

Experience shows that a significant number of hydrological heritage sites have more than one distinct complex value. It is clear that the values intermingle, but it is also a fact that the most of phenomena show a single dominant value. Accordingly, hydrological heritage sites may be classified as follows:

– *hydrological heritage sites of a scientific value;*
– *hydrological heritage sites of an ecological value;*
– *hydrological heritage sites of an educational value;*
– *hydrological heritage sites of an aesthetic value;*
– *hydrological heritage sites of a socio-cultural value;*
– *hydrological heritage sites having the value of a resource.*

The theoretical pathway from the observed hydrological phenomenon to the concrete hydrological heritage site would look like this: a hydrological phenomenon has been observed and during an investigation, its essential characteristics have been determined; on the basis of these, it has been established which fundamental criteria the phenomenon meets. Further analysis, carried out so as to take into consideration different ranking levels of complex criteria (their importance), has enabled us to determine some of the phenomenon's universal values – often more than one. However, there are still a significant number of such hydrological phenomena. Is there a concrete method/criterion, to enable us to identify hydrological heritage sites among a large group of water phenomena which are (extraordinarily) valuable from one or several aspects?

3.2. The concept of rareness in geoheritage, hydrological heritage and nature conservation as a universal evaluation criterion

One of the most often mentioned criteria used in the selection of geoheritage, as well as in nature conservation is *rareness*. All extraordinarily valuable hydrological phenomena / hydrological heritage sites should, to a certain degree, meet the criterion of rareness. Although they seemingly belong to different categories, the concept of rareness as a criterion and one of the fundamental and oldest concepts in nature conservation – that of *natural rarity*, are fully interchangeable.

Since it is subject to different interpretation, it is essential to explain the essence of this concept. Lazarević (1998) has pointed out that the concept of a natural rarity is "undefined and flexible" and that it may be interpreted in two ways: as rare – scarce, and as rare – extraordinary. In his explanation of this opinion, Lazarević mentions as examples springs and karst sinkholes in Dinaric karst, as well as caves on Kučaj Mountain, a karst area in eastern Serbia: They can be found in great numbers and only some of them can considered rare – extraordinary. On the other hand, some phenomena are so scarce that they are always considered rare, such as the three intermittent springs in Serbia, which are "great hydrological rarities, regardless of their physical characteristics".

Most commonly, the concept of (natural) rarity indeed implies the mentioned meanings. However, even the arguments presented above lead us to the conclusion that the concept of rareness can be fully contained in and explained by the concept of extraordinariness. From the perspective of geoheritage or nature conservation, the mentioned scarcity is a subcategory, because even the scarcity of e.g. a hydrological phenomenon, or some plant species, is an extraordinary quality: something scarce is in itself extraordinary. A complex interpretation of the concept/criterion of rareness shows that it also contains many other criteria frequently used in nature conservation and geoheritage; e.g. originalness and a good state of preservation may be factors of rareness, which is most commonly the case nowadays; the same applies to diversity and representativeness. A large number of some geographic phenomena or living species in a certain area may be factors of rareness, making them interesting for nature conservation, science, or geoheritage.

The criterion of rareness in hydrological heritage also arises from essential characteristics / universal values of water, and it is to a certain degree intertwined with essential and complex criteria. The fact that (one or more) complex criteria

are met may mean that the observed hydrological phenomenon is a rarity but this is by no means a rule. This may be illustrated by the example of waterfalls in Vojvodina, a region in the Republic of Serbia, located in the Pannonian Plain, on mountain Fruška Gora: Vodopad na potoku Almaš, Vodopad na Čerevićkom potoku, Dumbovački vodopad i Šakotinački vodopad, which would certainly not merit high ranking based on an analysis of the most of the six universal values of water (complex criteria), or a comparison with other waterfalls in Serbia, but they certainly merit consideration as potential hydrological heritage sites because they are a rarity within a rather small defined area, namely the Pannonian Plain (Fig. 2). In this particular case, this also shows the direct relation between the criterion of rareness and the value-based ranking of a phenomenon, which is determined by a certain spatial framework.

Fully aware of the importance of defining evaluation criteria for the overall development of geoheritage, Dangić (1998) has noted that rareness must be the crucial criterion: "The first indispensable step in the evaluation of geoheritage is the identification of objects; in order to do this it is necessary to define appropriate criteria. The main condition for a site to be selected as a geoheritage site is to have features that are very rarely or rarely found in other sites. Or, as Marković (1991) simply put it: "If forms and phenomena in nature are rare, this means that they are valuable."

It should be pointed out that the concept/criterion of rareness has always been, both theoretically and practically, one of the common grounds of research for nature conservation and geoheritage. As opposed to nature conservation, in the context of geoheritage, rareness is commonly discussed within the scope of scientific values – as a sort of a subcriterion, thereby neglecting its individual significance and diminishing its overall importance. The presented facts inevitably lead to the conclusion that the unique criterion of rareness in the sense of extraordinariness, which is common to geoheritage / hydrological heritage and traditional nature conservation, is a multilayered – independent criterion, that it is a fundamental criterion, that it contains a great number of indirect criteria, and that it is a sort of a conditional and control criterion.

At the beginning and the end of the selection of the most important water phenomena stands the concept, condition and criterion of rareness in the sense of extraordinariness.

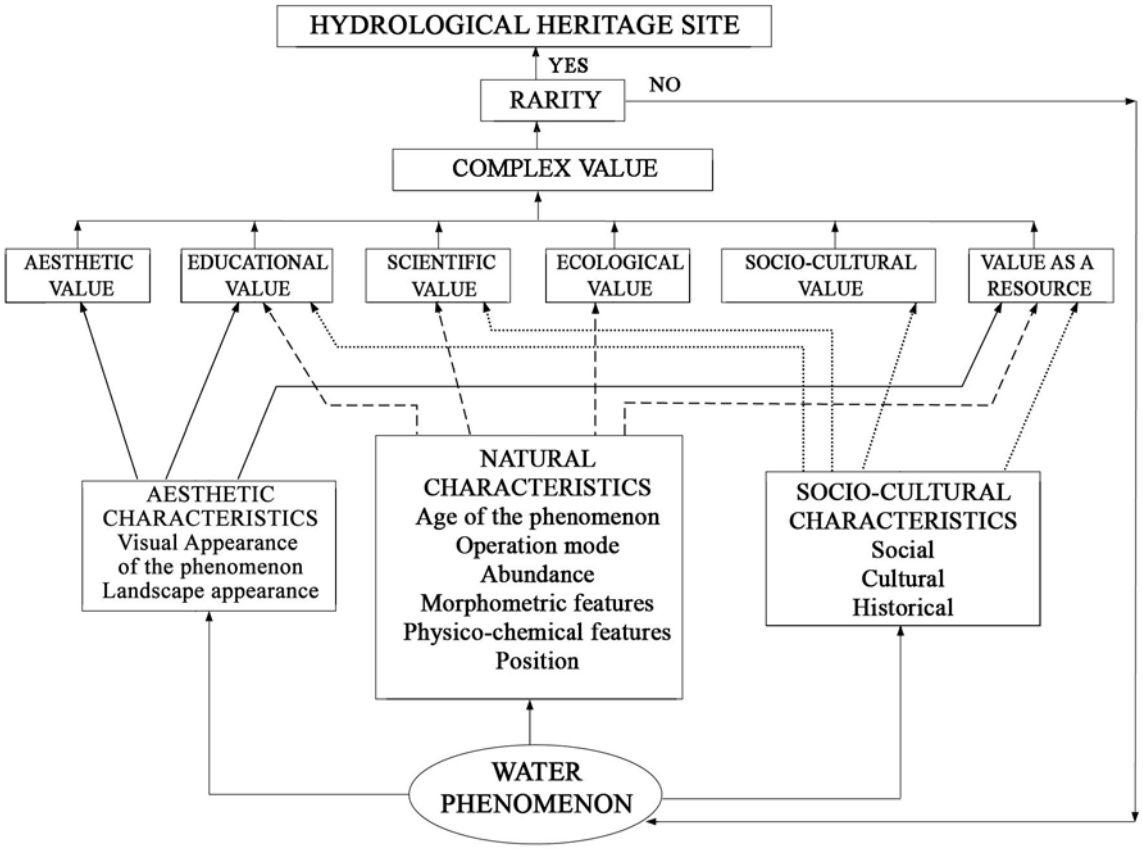

Figure 1. Scheme: Path towards a hydrological heritage site

Complemented by fundamental and complex criteria, it represents the main guideline towards achieving this fundamental goal of hydrological heritage. Starting from the essential characteristics of a hydrological phenomenon and the degree to which fundamental criteria are met, we determine its essential values, whereas an analysis of the degree to which complex criteria are fulfilled leads to determining the phenomenon's complex value. Then the criterion of rareness has to be considered, after which it should be possible to determine the overall value and significance of the hydrological phenomenon and, consequently, to answer the question whether it merits designation as a hydrological heritage site.

In order to enable the introduction of the presented model into hydrological practice, the criterion of rareness should also be subdivided into subcriteria that already exists in an appropriate form – scarcity, diversity, originalness, independence, rarity within a closer area, numerousness, etc., and then such subcriteria should be ranked.

3.3. Determining the value-based ranking of hydrological heritage sites

Procedures for determining the value–based ranking of a hydrological phenomenon, as well as other natural assets, have been a long-used practice not only in geoheritage. From the perspective of geoheritage and hydrological heritage, it is obvious that the determination of value criteria for the selection of heritage assets and their value–based ranking are connected ant intertwined issues. It is impossible to approach a water phenomenon considered as a potential hydrological heritage site entirely objectively, without prior experience. This is particularly apparent while determining the value–based ranking – local, regional, national, etc. – which is yet another important step in the selection of hydrological heritage sites. It was expected that the determination of the value–based ranking of a water phenomenon be the final step, the one that follows the assessment of the overall value and the inclusion of hydrological heritage sites (within a geographical area) into an appropriate list. However, this step may precede the selection of a concrete site because experience may often suggest the value–based ranking of a site in advance. The majority of Serbian hydrogeographers would rank the waterfalls of Fruška Gora in the Pannonian Plain, as local (regional) hydrological heritage sites, while Đerdap, the most famous and important antecedent breakthrough gorge in Europe and one of the cradles of European civilization, would be ranked as a European (hydrological) heritage site, as a hydrographic point (Fig. 2). Gavrilović et al. (2008) define hydrographic points as "a geographic group in the hydrological heritage of Serbia". They might be points in a literal sense, but these authors see them primarily as nature (land) parts dominated by water, which determines their appearance and all their peculiarities. This "contradiction" in the order of steps also arises from the character of the topic.

The importance of the spatial framework in the assessment of geoheritage sites is illustrated by the observations of Wimbledon et al., (1995), one of the contemporary founders of the concept of geoheritage. In the conclusion to his discussion on determining the value–based level (rank) of heritage assets, he has pointed out that a site (an asset) which may not merit consideration and assessment at a national level and which could be lowly ranked at a regional level, could nevertheless be a highly ranking and even unique site if it were assessed and considered at a local level. The value–based ranking results primarily from the essential characteristics and, accordingly, from the universal values of the observed hydrological phenomenon, as well as from its rareness in a given spatial framework. This last statement clearly shows that another important element must be taken into consideration when determining the value–based ranking – the comparison with similar, as well as with different hydrological phenomena in a given area.

The value–based ranking of a hydrological heritage site is determined on the basis of its complex value and extraordinariness compared to other, primarily similar, but also different hydrological phenomena, and all of this should be considered in its relationship with – or, more precisely, as being determined by – a given spatial framework. The value ranks of geoheritage sites – from local to world–ranking – are determined depending on a site's relationship with the explored area, its size and characteristics.

It seems that the path leading from the study of essential characteristics of a hydrological phenomenon (analyses of its individual values), through an assessment of the synthetic (complex) value as a heritage site and the application of the criterion of rareness is logical and that it offers a sound theoretical model for the correct selection of hydrological heritage sites. The introduction of quantitative evaluation has been adopted in geoheritage as an important tool in overcoming the negative consequences of relying solely on qualitative methods in research, i.e. of the subjective approach on the part of researchers. Undoubtedly, a pronouncedly subjective approach in geoheritage is

further intensified by the character of the topic, which is not easily susceptible to a majority of exact scientific methods. Logically, this problem extends to one of its most delicate segments – the selection of heritage sites. One should not neglect the fact that quantification facilitates the comparison of sites; in geoheritage, this is an important step in their analysis and research which subsequently enables their ranking.

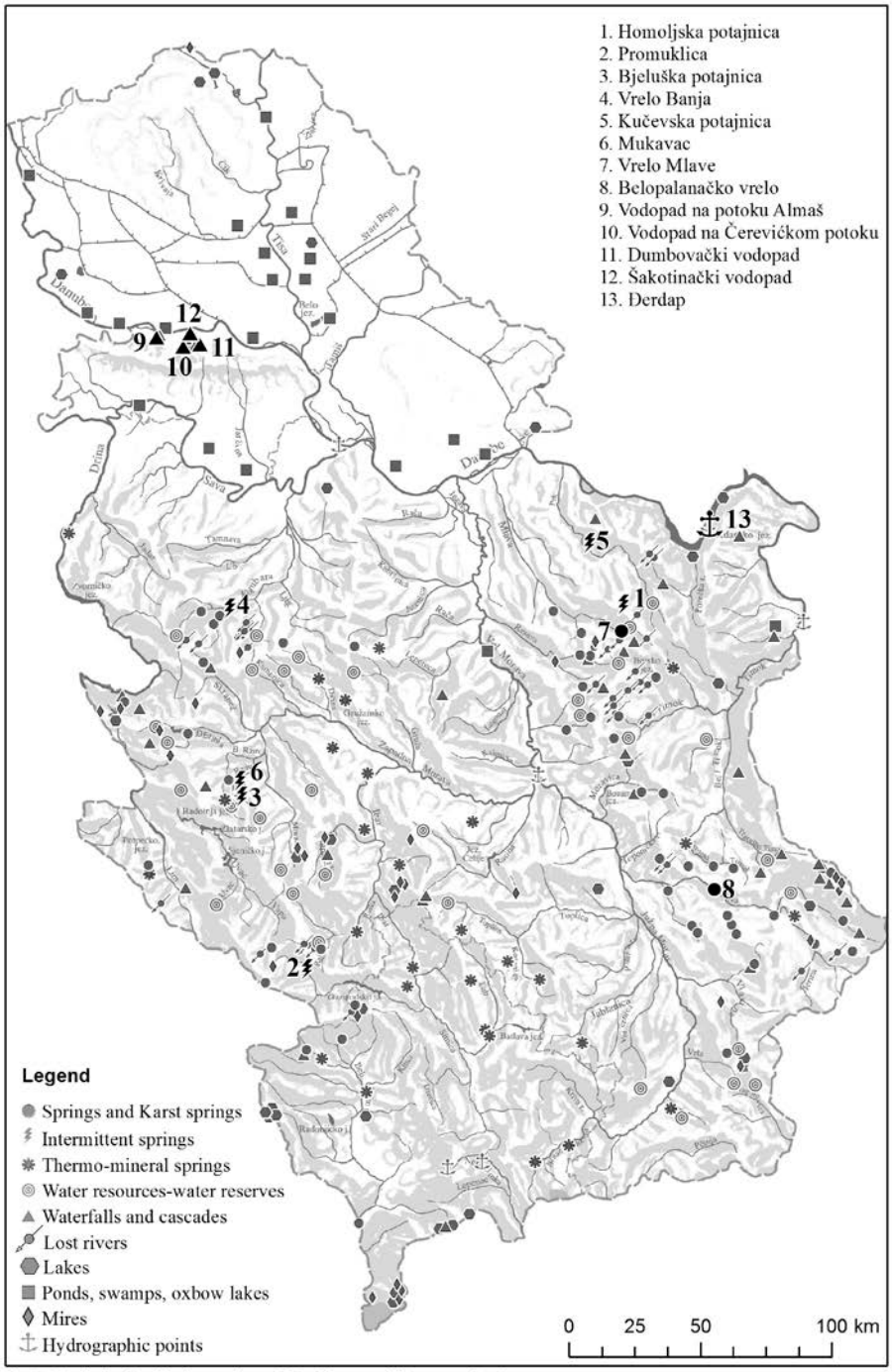

Fig 2. Hydrological heritage sites of Serbia - specific examples*

* singled out in this paper

Figure 2. Map: Hydrological heritage sites of Serbia – specific examples (singled out in this paper)

The theoretical scheme of the "path leading from a water phenomenon to a hydrological heritage site", based on an analysis of water into classes – essential characteristics (fundamental criteria), formation of new classes – universal values, and their synthesis, is a tangible progress towards the introduction of a universal – both qualitative and quantitative – system for the evaluation of water phenomena. In order to achieve this, it is necessary to determine a sort of a universal numerical or an appropriate descriptive evaluation system in each of the mentioned steps – from individual characteristics (fundamental criteria, such as the genesis, abundance, water discharge mode, visual appearance of a hydrological phenomenon, its historical significance, etc.), through the universal value (complex criteria such as scientific, ecological, educational, aesthetic, socio–cultural and resource values), to the criterion of rareness (scarcity, diversity, originality, independence, rarity within a rather small defined area, numerousness, etc.) taking into consideration their various ranks. On the basis of this system, hydrological assets would be (or would not be) designated as hydrological heritage sites.

The need for the introduction of a standardized model into the entire area of study is also illustrated by great differences in the approach to the crucial issue: the selection of heritage sites, even in countries where geoheritage practices are considerably developed. The selection is often carried out (almost) solely on the basis of a qualitative evaluation. In order to overcome such problems, at least partially, expert bodies including competent researchers are formed (for example, the National Council for the Geoheritage of Serbia includes sixteen work groups) to present their opinions – evaluate concrete sites that belong to a particular group of geoheritage. Based on a large number of such expert opinions a decision is subsequently made for each particular site. The chief task of such national (or international) bodies would be to establish a universal model for the selection of hydrological heritage sites (and phenomena falling into other categories of geoheritage) similar to the model presented in this study; that model would be adjusted to a defined area and would imply (to a certain degree) an elaborate system of quantitative assessment, which would help regulate this important segment of hydrological heritage and other areas of geoheritage.

4. CONCLUSIONS

The concept of geoheritage in general, including hydrological heritage, is reflected in concrete examples of geodiversity – geoheritage sites. Accordingly, it is very important to identify them correctly as extraordinary segments of geographic environment. Although the number of studies on geoheritage dealing with this topic is not insignificant, in many countries, just like in Serbia, the issue of the evaluation of heritage sites has not been dealt with due attention. Due to the lack of theoretical and methodological basis for the identification of heritage sites, the selection is often limited solely to qualitative methods and, accordingly susceptible to a subjective approach on the part of researchers. On the other hand, quantitative assessment methods, which have found application in geoheritage, are not always based on adequate, standardized theoretical models. This gives rise to differences in the approach to the topic and, consequently, to vagueness in defining tasks and aims of geoheritage and methods to achieve them. Therefore, the issue of reliability and applicability of the results achieved so far logically arises.

The evaluation (selection) of heritage sites is to a certain degree specific and different for each area of geoheritage. What all these variants of selection have in common is that evaluation must arise from the universal basis of a relevant discipline. Hydrological heritage is a segment of geodiversity focused on hydrosphere – water phenomena and sites. It highlights their value as: [1] "separate natural forms and phenomena – scientific, educational and aesthetic values; [2] component and elementary parts of the natural system – ecological value; [3] phenomena that are necessary preconditions for the existence and development of the humankind and society (in a general and not purely existential sense) – resource and socio-cultural values, while setting their preservation and conservation as ultimate aims" (Simić et al., 2010b). Therefore, the first step on the path leading from the observed water phenomenon to a hydrological heritage site involves research and the study of the phenomenon's essential characteristics and universal values – from the scientific value, to the value as a resource – which contain a series of "fundamental, indirect and complex criteria" that should guide a researcher in the right direction. By applying the criterion of rareness – extraordinariness, one gets a more complex idea of the observed water phenomenon's value, which can be made complete by determining the rank based on value – the rank (significance) of a water phenomenon within an area.

In this study, a universal theoretical model for the identification of hydrological heritage sites has been presented. It should serve as the basis for the elaboration of specific models used in the identification of representative water phenomena depending on the purpose – e.g. the purpose of site

identification, area in which selection is made or the profile of those who use the model. This model, which starts from the general and qualitative: analysis of water as a phenomenon into classes – essential characteristics / universal values, provides the basis for the introduction of a quantitative evaluation of water phenomena; it could ensure the balance and an optimal relationship between the two approaches in research. This also shows the model's practical significance in regulating and enhancing activities related to hydrological heritage and corroborates the idea that it could be an example to be followed in other segments of geoheritage.

REFERENCES

Bâca, I. 2011. *Contributions to Inventory and assessment of the geomorphosites from Calimani National Park. Case stuy: Bistricior massif.* Analele Universităţii din Oradea – Seria Geografie (year XXI), 1/2011, 5-15.

Belij, S. & Simić, S. 2008. *Category of hydrologic heritage in the system of geoheritage and nature protection of Serbia*. (in Serbian) Protection of nature, 58/1-2, 27-36.

Bruschi, V.M. & Cendrero, A. 2005. *Geosite evaluation; Can we measure intangible values?* II Quaternario, Italian Journal of Quaternary Sciences, 18 (1) – Volume Speciale, 293–306.

Coratza, P. & Giusti, C. 2005. *Methodological proposal for the assessment of the scientific quality of geomorphosites.* Il Quaternario, Italian Journal of Quaternary Sciences, 18 (1) – Volume Speciale, 18 (1), 307–313.

Dangić, A. 1998. Geological heritage of Serbia – identification, categorization and protection of the heritage objects. (in Serbian) Protection of nature, 48–49, 71–78.

Erhartić, B. 2010. *Geomorphosite assesment (Vrednotenje geomorfološke dediščine).* Acta geographica Slovenica, 50–2, 295–319.

Fines, K.D. 1968. Landscape evaluation: a research project in east Sussex. Reg. Studies, 2:41.

Gavrilović, Lj., Belij, S. & Simić, S. 2008. *Hydrological heritage of Serbia – Preliminary list.* (in Serbian) Protection of nature, 60 (1–2), 387–396.

Grandgirard, V. 1999. *L'évaluation des géotopes.* Geologia Insubrica 4:59–66.

Jovičić, D. & Brankov, J. 2009. *Tourism attractions: Key elements of tourism resource base.* Bulletin of the Serbian Geographical Society, 89 (1), 3–20.

Lazarević, R. 1998. *Speleological values of Serbia.* (in Serbian), Protection of nature, 48–49, 47-52.

Leopold, L.B. 1969. *Landscape aesthetics.* Nat. History, 10:35.

Linton, D.L. 1968. *The assessment of scenery as a natural resource.* Scottish Geographical Magazine, 84:218.

Marković, J. 1991. *The importance of the complete protection of nature.* (in Serbian) Protection of nature, 43–44, 7–19.

Panizza, M. 2001. *Geomorphosites: concepts, methods and examples of geomorphological survey*. Chinese Science Bulletin, 46, 4–6.

Pereira, P. & Pereira Caetano Alves, M.I. 2007. *Geomorphosite assessment in Montesihno Natural Park (Portugal).* Geographica Helvetica, Jg. 62, 3, 159–168.

Pereira, P. & Pereira, D. 2010. *Methodological guidelines for geomorphosite assessment (Indications methodologiques pour l'evaluation des geomorphosites).* Geomorphologie: relief, processus, environnement 2, 215–222.

Petrovic, M. D., Vasiljević, Đ. A., Vujičić, M. D., Hose, T.A., Marković, S. B. & Lukić, T. 2013. *Global geopark and candidate – comparative analysis of Papuk mountain geopark (Croatia) and Fruška gora mountain (Serbia) by using GAM model.* Carpathian Journal of Earth and Environmental Sciences, 8 (1), 105–116.

Pralong, J.P. 2005. *Méthode pour l'évaluation du potential et de l'utilisation touristiques de sites géomorphologiques*. Géomorphologie: Relief, Processus, Environnement, 3, 189–196.

Purice, C., Romanescu, Gh. & Romanescu, Ga. 2013. *The protection of the Geomorphosites within the Măcin Mountains National Park (Romania) and their Touristic Importance*. International Journal of Conservation Science, 4 (3), 373–383.

Reynard, E., Fontana, G., Kozlik, L. & Scapozza, C. 2007. *A method for assessing „scientific" an „additional values" of geomorphosites.* Geographica Helvetica, Jg. 62, 3, 148–158.

Serrano, E. & Gonzales-Trueba, J.J. 2005. *Assessment of geomorphosites in natural protected areas: the Picos de Europa National Park (Spain).* Geomorphologie: relief, processus, environnement, 3, 197–208.

Simić, S., Gavrilović, Lj. & Đurović, P. 2010a. *Geodiversity and geoheritage – New approach to the interpretation of the terms*. Bulletin of the Serbian Geographical Society, 90 (2), 1–14.

Simić, S., Gavrilović, Lj. & Belij, S. 2010b. *Hydrological heritage: New direction in hydrology and geoheritage.* Bulletin of the Serbian Geographical Society, 90 (4), 83–102.

Simić, S. 2011. *Hydrological heritage within protection of geodiversity in Serbia – legislation history.* Journal of Geographical Institute „Jovan Cvijić" SASA, 61 (3), 17–32.

Simić, S., Gavrilović, B., Živković, N. & Gavrilović Lj. 2012. *Protection of Hydrological Heritage Sites of Serbia – Problems and Perspectives.* Geographica Pannonica, 16, 3, 84–93.

Wimbledon, W. A., Benton, M. J., Bevins, R. E., Black, G. P., Bridgland, D. R., Cleal, C. J., Cooper, R. G. & May, V. J. 1995. *The development of a methodology for the selection of British geological sites for conservation: part 1.*

Modern geology, vol. 1, Amsterdam.

Vasiljević, B., 1983. *The particular values of the hydrological phenomena and some aspects of their protection in the socialistic republic of Serbia* (in Serbian). Protection of nature, 36, 111–126.

Vujičić, M.D. 2011. *Preliminary geosite assessment model (gam) an its application on Fruška Gora mountain, potential geotourism destination of Serbia*. Acta geographica Slovenica, 51–2, 361–377.

Zouros, N.C. 2007. *Geomorphosite assessment and management in protected areas of Greece Case study of the Lesvos island – coastal geomorphosites.* Geographica Helvetica, 62, 3, 169-180.

Received at: 26. 08. 2013
Revised at: 07.07. 2014
Accepted for publication at: 14. 07. 2014
Published online at: 25. 07. 2014