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GIS METHODS AND ANALYSIS OF ARCHAEOLOGICAL LAYERS IN THE TOPLICA DISTRICT (SERBIA)

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Abstract: In this paper, we are explaining a decade long investigation of historical, sacral and archaeological sites in the Toplica District (Serbia) as one of the significant cultural heritage sites in Europe with more than 226 objects with different time of origin. The survey was carried out for the purpose of better recognizing the archaeological potential. In science like archaeology, static objects, if not dynamized, remain unrecognizable to the general public, regardless of their historical and archaeological importance. Historical changes during the period of more than 7,000 years, with many sites of cultural heritage in this district, were recognized. Ordinary kriging was employed through Quantum Geographical Information System (QGIS) and System for Automated Geoscientific Analysis (SAGA). The positions of historical objects are registered, from the Neolithic period to modern times. With the help of GIS and geo-statistical methods, archaeological and historical layers can be rediscovered and better recognized. GIS algorithm ordinary kriging was used to complete the cultural heritage potential and archaeological valorization of the objects with geo-spatial dispersion. As a final product, we have obtained maps with historical and archaeological locations. For the first time, we used a scientific name for contour lines (archlines) with an equal number of archaeological units per density. In the end, archaeological and historical objects and their features were shown with the support of geographical and GIS methods.

Keywords: mapping; archaeological objects; archlines; Toplica District; GIS

Introduction

The Web mapping of an area of archaeological resources has had an enormous growth today (Nivala, Brewster, & Sarjakoski, 2008). The precious web presentation is very important, especially when it presents many layers of history over the time scale and historical changes (Meethan, 2003). To present archaeological layers and sites may be very interesting for tourism purposes. In that way, the area of research would be interesting for new investigations and investments. In tourism it is important, not only that something has been interpreted, but how and by whom it is interpreted, thus creating a specific message about the value and the meaning of specific historical sites and the past they

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represent (Pavličić, 2016). With GIS methods we try to describe the dispersion of archaeological objects. In very similar research of Pompeian houses, such complex models were investigated and described with Puuc Region Archaeological Geographic Information System (PRAGIS) (McCool, 2014). In this paper we describe unique archaeological layers and their potential presentation for wider audience. The data collected during the project of digitization of cultural and sacral objects are mostly deposited in the base of eCatalog of cultural monuments in Serbia (National Center for Digitization, n.d.) of the Mathematical Institute of the Serbian Academy of Sciences and Arts situated in Belgrade (Mijajlović, Ognjanović, & Pejović, 2010). This is the largest internet database of cultural and historical monuments in Serbia, and one part belongs to the data collected in the Toplica District.

General database contains the data on more than 2,000 objects of different age, some of them with several hundreds of entries, texts, drawings, and references. More than 200 objects observed in the Toplica District have a very long period of research dating back to 7000 year B.C. The richness of cultural and historical locations in different time of history gives possibilities for a new approach for better recognition of cultural and historical resources. In the Toplica District, apart from historical sites, there are numerous sacral objects such as Orthodox churches, monasteries, and old pre-Christian sanctuaries, mostly from the Roman period from the 1st to the 5th century, others from the 10th to the 19th century (Jocić, 2007). Also, here are numerous remnants from the Ottoman period. Before new archaeological research in the Toplica District, we may divide history of this area into three periods—Prehistoric, Middle and New (the period after the First World War). The new remnants belong to the period between the 15th and the 19th century. The Toplica District was established in the 12th century as one of the main regions of the newly formed Kingdom of Serbia (Dimitrijević, 1969). The first capital was in Kuršumlija municipality. The Grand Prince Stefan Nemanja who founded the medieval Serbian state established the Kingdom on the territory along the Toplica River. There was the first foundation of the Nemanjić dynasty (Marjanović, 2008). In the area of Kuršumlija Municipality, the important churches and monasteries are the Monastery of St. Nikola (Saint Nicholas) and the Monastery of Presveta Bogorodica (Holy Mother of God). These churches were built around 1160. The Turkish traveler Evliya Çelebi from the 17th century and Austro-Hungarian Felix Kanitz from the second part of the 19th century gave the first overview of this district. The large parts of their travelogues were dedicated to the Toplica District. Their writings are important and valuable historical documents and sources. Evliya Çelebi's document is very difficult to interpret from the old maps and sources, and Felix Kanit's sources contained some errors, especially in determining geographical positions of places (Kanitz, 1868). Nowadays, many of these objects are ruins or very rusty sites often being at difficult places to visit. Our aim has been to preserve them at least in the digital form and present them to the general public and specialists in the fields of archeology, geography, tourism, and history. We also recorded settlements, positions of historical and sacral objects, collected the main data, described the main features of these objects, and converted them into a digital form and database. Finally, we presented the collected data on the maps (Figure 1 and 2).

The position of the Toplica District

The Toplica District is located in the south-east part of Serbia. It is surrounded by the districts: Raška, Niš, and Rasina and it partly borders with Kosovo. The total number of inhabitants is 91,754 with an average density of 41.1 inhabitants per km^2 (Statistical Office of the Republic of Serbia, 2014). The Toplica valley is situated between the mountains, with peaks up to 1,300 m (Maćejka & Tanasković, 2008). A river of the same name runs through the valley and its basin lies in the middle

of the Toplica District. The central part of the Toplica Valley lies between the mountains of Veliki Jastrebac, Sokolovica, and Pasjača. On the south there are small settlements by the Toplica River: Donje Krčmare, Grabovnica, Bogojevac, Barlovo, Donje Točane, Pločnik, Tulare, Donja Konjuša, Donja Toponica, and the city of Prokuplje (Rudić, 1978). The Toplica River continues its flow on the northern slopes of Pasjača Mountain, next to the villages of Podina, Vojčince, Badnjevac and the smaller regional center Žitorađa, and flows into the South Morava River, which belongs to the densely populated region of South Pomoravlje.

Some important historical objects depicted on the maps

One of the main issues in the science of heritage is the question of its origin. Modern profile discourse on this subject knows two basic answers to it: national (owned by one nation) and worldwide (belongs to humanity) heritage. Frequent are examples of ethnic, regional, and local heritage (Mazurov & Slipenchuk, 2016). This is also a subject of geographical analyses. By investing in such a survey of the territory of Serbia, we want to point out the need for a detailed geographical assessment including all the visited and explored historical and sacral objects in the Toplica District. While surveying this region, several archaeological sites not yet mentioned in the literature were discovered. They are included in the maps, too. Here is a selection of the most important archaeological and sacral sites, and archeology-history sites (Figure 1) (Stanojević, 1992).

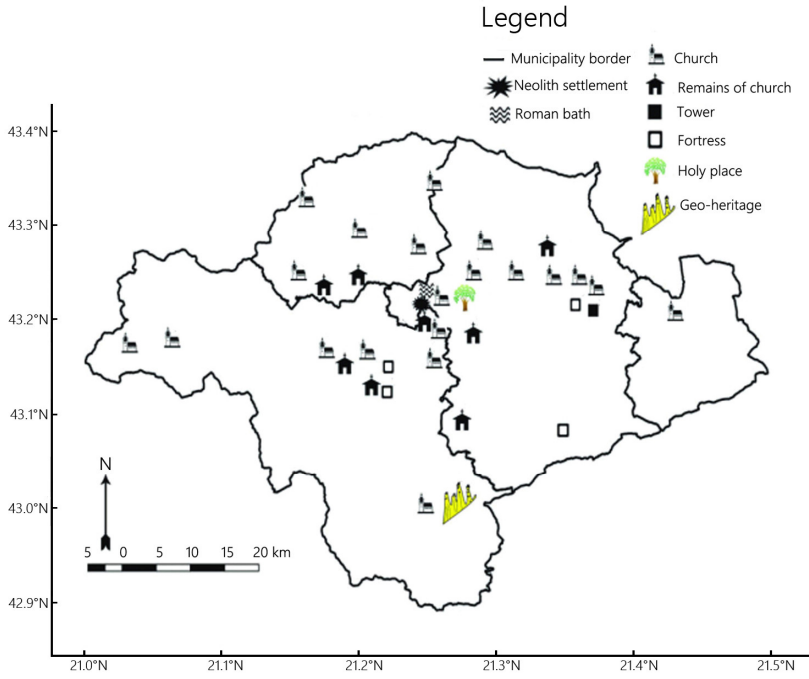

Figure 1. The map of investigated archaeological and historical objects in the Toplica region for the period of expeditions (2002–2006, 2009–2012), with cultural heritage sites within the period of 7,000 years.

Neolithic site and Roman bath in the village of Pločnik

The Pločnik Neolitic site is one of the most important on the Balkan Peninsula. It is located on the bank of the Toplica River and 21 km away to the west from Prokuplje and 14 km to the east from Kuršumlija. One of the theories includes this archaeological complex as a part of Starčevo culture, which was established in 6000 B.C. (Whittle, Bartosiewicz, Borić, Pettitt, & Richards, 2002). The Pločnik archaeological site dates back to the Early Neolithic period from 5500 to 4700 B.C. The artifacts bear witness that the people who lived there knew about trade, handicrafts, art, and metallurgy. One important conclusion established a theory that there was a big lake near Pločnik settlement in that ancient time. In the valley of this lake, 100 different forms of wonderful pottery items and amazing figurines have been found. The Pločnik archaeological site was discovered in 1927 by Miodrag Grbić, and rediscovered by Julka Kuzmanović in 1997. In the present time, with the help of the Municipality of Prokuplje and the Republic of Serbia, Pločnik village, with its authentic model of life in the past, has been reopened (Vasić & Marinković, 1999). The remnants of a Roman bath may be found in the vicinity of the Backa River, which is located approximately 500 m away from this site to the north. They are estimated to belong to the period between the 3rd and the 5th century. The lower parts of the bath belong to the Roman period, whereas its upper parts belong to the early Byzantium.

The Monastery of Saint Nicholas and the Monastery of Virgin Mary in Kuršumlija

These monasteries belong to the endowment of the Nemanjić dynasty dating from the middle of the 12th century. Beside the monastery, which is nowadays known under the name of St. Nicholas, the Church of the Virgin Mary was also built at the confluence of the rivers Kosanica and Toplica. All the objects in Toplica then belonged to the dynasty of Nemanjić, who were on the rise at the time. The monastery of Saint Nicholas is located on a plateau above Kuršumlija and is facing the place where the Banjska River flows into the Toplica. Kuršumlija became the first capital of the Nemanjić dynasty. St. Sava, being the main religious figure of the dynasty, had personal insight into the construction of all the sacral objects in the Toplica District in that period. Felix Kanitz wrote about their existence and wealth in some of his documents. The Monastery of Virgin Mary is now ruined, without roof and walls, but its value is in the specific style of building, which is the one between Byzantine and Raška school. From time to time, floods affected the plate of the Monastery, because it lies on 237 m of elevation, almost in the bed of the river Kosanica. The Monastery of St. Nicholas lies on a higher elevation, at 395 m. This monastery is now reopened for active Orthodox church service. Architecturally, it stands out as a special and enigmatic type of building and belongs to the Raška style. According to the roofs of this monastery, which were made of lead, the name of Kuršumlija was created.

Materials and Methods

GIS interpolation and numerical techniques

In the European frames, the Toplica District has significant cultural heritage resources. There are more than 226 objects with different time of origin. GIS algorithm ordinary kriging was used to complete cultural heritage potential and archaeological valorization of the objects with geo-spatial dispersion. GIS and geospatial modeling has become a powerful tool not only in geographical

science but also in history and other social sciences (Franke & Nielson, 1991). All geo-spatial data can be used for mapping and modeling the positions of objects. Ordinary kriging with global interpolator was used through open source QGIS 2.18.21 and SAGA 3.2 extension of Geo-Spatial Analyst. The map of the average number of cultural heritage objects is given with the positions (longitude, latitude) of the objects. For the first time we called contour line (isoline) for archaeological objects *archlines* to present the density of all archaeological locations in the researched territory (Figure 2).

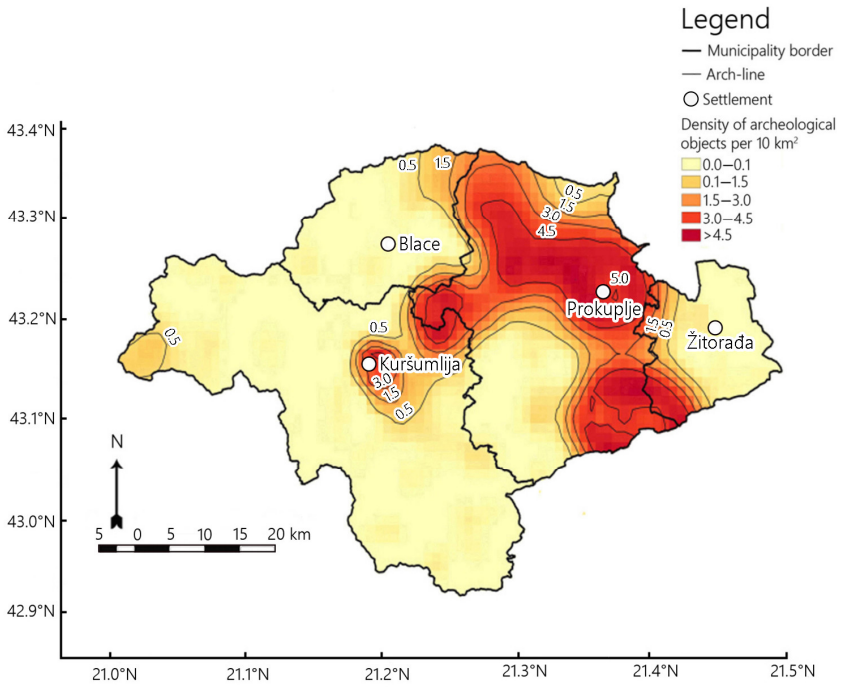

Figure 2. Density of archeological objects on the territory of Toplica (Milentijević, Valjarević, Vukoičič, & Cimbaljević, 2016).

Digital map

For better understanding of archeology, most valuable layers were presented in geographical position, geo-spatial availability and historical and archaeological richness (Berlin, 1960; Landeschi et al., 2016; Laurini, 1998; Scharstein & Szeliski, 2003). All the known objects in this region related to archaeological, sacral and historical sites were depicted. By means of GPS tracking, the geographical coordinates (in Universal Transverse Mercator coordinates system) of these objects were collected and recorded. The metadata related to these sites are included.

The map is vectorized and has a very useful functionality (Valjarević, Djekić, Stevanović, Ivanović, & Jandziković, 2018) (Figure 1 and 2). It is not the first time that we have performed modern analysis in the area of archeological layers in Serbia by applying advanced GIS methods. GIS methods and numerical approach were successfully applied in the site of Caričin Grad (Ivanišević, Bugarski, &

Stamanković, 2018). Many important methods and applicable GIS algorithms, especially in archaeology were successfully established by Marić (2011). Appropriate layers, one or more, can be visible with the connected metadata (Pebesma & Wesseling, 1998). After applying these software tools, the grid was obtained which consisted of points not only referring to their latitude and longitude, but to the average altitude as well. The method is very helpful for potential tourism marketing and also for calculating the potential traveling time and availability of the present sites (Figure 2). It appears that this process of transforming contour lines into the set of elevated points is rather precise, and it may provide better results for future calculations.

Results and discussion

After GIS and archaeological analysis, we got some scientific results which would be useful in future research of this area. The average altitude of the objects together with the supplementary infrastructure shows the objective accessibility of the archaeological and cultural objects. The highest concentration of the objects lies in the altitude belt between 300 m and 600 m. Within that zone there are 79% of all the objects, whereas the object percentage lower than 300 m is 12% and 9% for those higher than 600 m. This fact is important because it indicates that the majority of the cultures and people have been located just by the structural basin or on the banks of the Toplica River. The old culture and ethnic groups near the basin of the Toplica had the semi-nomadic style of life. In the areas on the edge of hills far away from the river of Toplica this style was nomadic. The GIS numerical analysis showed that settlements and citizens are concentrated in the north-east part of the district and in the central areas.

This concentration is connected with the density of citizens, it being the highest in the municipality of Prokuplje and to some extent in the municipality of Kuršumlija. According to the data from Figure 2, the huge concentration was between 43.0°N–43.5°N and 21.2°E–21.4°E. These concentrations were covering the belts between 220 and 500 m of altitude. Also, we found isolated islands with a high level of density 2 km up to the north from Prokuplje and 3 km up to the south. Other isolated islands existed in the center of the settlement of Pločnik and the village of Glašinac. In the Neolithic age, Pločnik was just by the river, as well as, for instance, the Roman thermae. The future historical and archaeological research should be aimed at examining why some settlements have been found beyond that zone, the cause perhaps being in the former paleoclimate or the plant cover.

This investigation will be useful for further study of the historical and archaeological area following new exploration in the future. Potential visitors to the Toplica District will have possibilities to visit some of the objects with information of historical significance, regardless the age of the layers. There are some possibilities for creating database not only for the web portals, but also for mobile devices in API (Application Programming Interface) forms (Ivanišević, Kablarević, Ikonović, & Gojšina, 1996). Archeology is a phenomenon of great importance in the globalizing world—not only because it is in accordance with the patterns of the global economy, but also because it produces an interest in specific experiences, artifacts and local narratives.

Conclusion

The Toplica District in southeastern Serbia is among a few regions with a large number of archaeological and historical sites. Special methods such as GIS and numerical analyses provide a more precise estimate of the number of archaeological sites and the density of the archeological

belt. Certainly, these experimental methods give better results in combination with other methods such as kriging methods. The novelty of these methods is in the faster processing of data and in possibilities for recovering data directly from digital maps and database. These methods are successful in obtaining the maximum information from the archaeological locations by potential users.

Future research could explore ways to obtain better insights into quantitative and qualitative layers in the Toplica District. Our study should further contribute to the development of a digital database which could show the relationship of various factors such as archaeological locations and geographical dispersion of objects. Digital Cartography and GIS methods in the future may present one powerful tool for analyzing archaeological potentials. It is a good introduction to a more detailed future study assessing the whole Serbia.

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