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KARST AREA OF ZABUČJE-GRADINA

Jovan Petronijević[1]*

Abstract: Karst areas of western Serbia, such as the Valjevo and Pešter karsts, are well known and researched, but there are smaller and less well-researched units, such as the Zabučje–Gradina karst unit. This paper presents the basic geomorphological characteristics of the Zabučje–Gradina karst unit. The focus of the research is on karstological characteristics, with a special emphasis on the distribution of sinkholes and valleys in the karst. Detailed analysis using GIS tools has enabled the definition and consideration of the processes that led to the creation of specific karst forms, including sinkholes and fossil valleys. The spatial distribution of sinkholes is also shown, as well as the relationship of their distribution to the slope of the terrain on which they are located. Analysis in QGIS has determined that, as in Miroč, sinkholes in this area are also located at small slope angles, up to 12° at most. In the research area, valleys are classified as active, dry and relict, and this characteristic and arrangement of them were used for further reconstruction of paleoflows. The existence of epigenetic incision of the Đetinja into the limestone bedrock was also established. Special emphasis was placed on speleological objects in the Drežnica Valley, such as the Potpećka, Pipalska and Todorova caves, which represent significant objects in the research of karst processes and karst hydrology of this area.

Keywords: karst, sinkhole, paleoflows, karst valley, epigeny

Introduction

Small karst units in Serbia, such as the Zabučje–Gradina karst unit on the right side of the Đetinja valley, between the Užice–Zlatibor highway in the west and the Roška ploča pass in the east, are interesting for geomorphological study due to the combined action of karst erosion, fluvial erosion and tectonic forces (Ćalić & Milošević, 2005). The Potpeć Cave, as part of this area, has been thoroughly explored, developed for tourism and is known to the general public throughout Serbia. However, its hinterland and immediate surroundings are unknown even to the local population, which leaves room for further research.

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Previous research in this area was related to geographical, geological and archaeological research of the Potpeć Cave and its hinterland. Žujović (1893) was among the first to explore the cave, and it was already known at that time that it was connected to the Drežnica Valley. It was established that the river descends in the Drežnica Valley and emerges in the Potpeć Cave (Živković, 1907). Cvijić explored the Potpeć Cave and stated that the Petnica River, which springs from it, receives its water not only from the abyss in the Drežnica Valley, but also from the surrounding area, based on the amount of water that gushes out from the springs (Cvijić, 1914). Further research into the Potpeć Cave continued in the second half of the 20th century (Lazarević, 1959), which led to the preparation of a report for the tourist development of the cave (Lazarević, 1981). In his 1959 paper, Lazarević described the basic speleological, hydrological and geomorphological characteristics of the cave, also writing about its hinterland (Drežnička dolina), while in his 1981 book he elaborated on the previously mentioned chapters in more detail and described the process of further research and tourist development of the cave (Lazarević, 1959; Lazarević, 1981). A significant contribution to the understanding of the geological, geographical and paleogeographic characteristics of this area was also made byRšumović (1960) in his doctoral dissertation "Relief of the Goliska Moravica Basin". Although this area does not currently belong to the aforementioned basin, but to the Đetinja basin, due to events in geological history, it describes in detail both the Drežnica Valley and the entire valley of the presumed Zlatibor River all the way to Mačkat.

The aim of the work is to supplement the current knowledge about this karst entity as well as to present it in a new way. This relatively small area has a certain number of interesting features: three karst surfaces, one large and several small dry karst valleys, hanging valleys, one large and several smaller speleological objects, two deep gorges cut by allogenic flows, etc. All of the above specificities, in a relatively small area, make the studied area significant for physical geography, speleology and karstology research.

Researched area

The Zabučje–Gradina karst unit is located in western Serbia, south and southeast of Užice (Fig. 1). The area has a Dinaric trend and covers an area of 63.3 km^2. The length of this karst unit is 16 km in the northwest–southeast direction, the maximum width is 6.5 km in its southeastern part, while it gradually narrows towards the northwest (Dimitrijević et al., 1978). The altitude of this karst unit ranges from about 400 m near the Potpećka Cave to 931 m at the top of Gradina. In addition to the Drežnica Valley, whose bottom is about 600 m above sea level, the rest of the karst unit mainly consists of three karst areas with an altitude of 700–800 m, which are differentiated by gorges of short and partly intermittent streams of the Bukovac and Derventa rivers. From the northwest to the southeast, there are the karst areas of Zabučje, Ljubanj and Košuta. In addition to the above, this unit also includes the hamlet of Rogandžići, in the far northwest, the Drežnička Valley and the Lipovec massif in the far south. Since the karst area of Zabučje is larger, more striking, intensively eroded and is located in the northwest, and the Gradina mountain in the far east, the entire karst unit is called Zabučje–Gradina. The northwestern and northern border is formed by the gorge of the valley side of the Đetinja River from Užice to Sevojno. In the east, the border is the end of the Middle Triassic massive limestones, where the basement-older Lower Triassic and Jurassic limestones are exposed (Dimitrijević et al., 1978). The southeastern border descends in several places to the course of the Veliki Rzav and reaches the course of the Pristavica River. The eastern and southeastern border is strongly

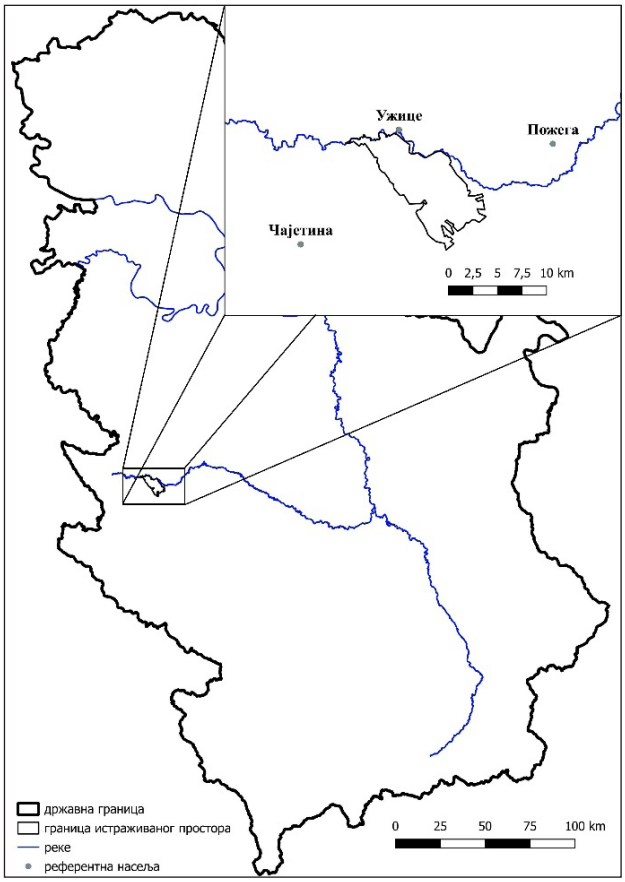

Figure 1. Location of the Zabučje-Gradina karst complex.

fractured by a fault system. To the southwest, this area rises gently towards a large area that Cvijić (1914) designated as the Mačkat abrasion surface.

The Zabučje–Gradina karst unit is geologically homogeneous: almost the entire surface is made up of layered and massive Middle Triassic limestones (T2) (Fig. 2). To the northwest, this zone continues across Đetinja, where it is broken by a series of faults (Dimitrijević et al., 1978). In addition to layered and massive Middle Triassic limestones, Miocene sediments can also be observed (conglomerates and sands with dolomite, 1M), then thinner sections of layered Lower Triassic limestones and dolomites (T12), sandstones, claystones, marls and limestones (T11) and quartz conglomerates, sandstones, quartz breccias and siltstones (T11) in the area towards Đetinja, which lie in the bed of the Middle Triassic limestones and are exposed only in the extreme border parts on steep sections. Below them, on the valley floor of Đetinja, Carboniferous phyllites (F) and metamorphosed sandstones are also present (Dimitrijević et al., 1978). The Potpeć Cave was formed at the contact of Triassic limestones and quartz conglomerates, sandstones, quartz breccias and siltstones (Dimitrijević et al., 1978). East and southeast of Gradina, the massive Middle Triassic limestones are lost and here, on the topographic surface, Lower Triassic limestones and shales are exposed, as well as highly folded Jurassic limestones, sandstones, hornfels and clays (J2,3) (Roška ploča pass). In the south and south-southwest, younger, Cretaceous layered and sandy-marly limestones (K22) also come to the surface, which are downgraded along the entire fault that forms the western border of the area, and to the northwest they are covered by Miocene sediments. These sediments also occur at the very bottom of the Drežnica Valley, around the abysses of the former Zlatibor River, as well as in Zbojštica. The fault that forms the western border almost along its entire length also follows the boundary between Miocene sediments and Middle Triassic limestones, except in the upper part of the Drežnica Valley where the sediments lie over Triassic sediments (Dimitrijević et al., 1978). This shows that sedimentation continued even after the faulting, i.e. that the river that flowed there continued to flow even after the intense faulting.

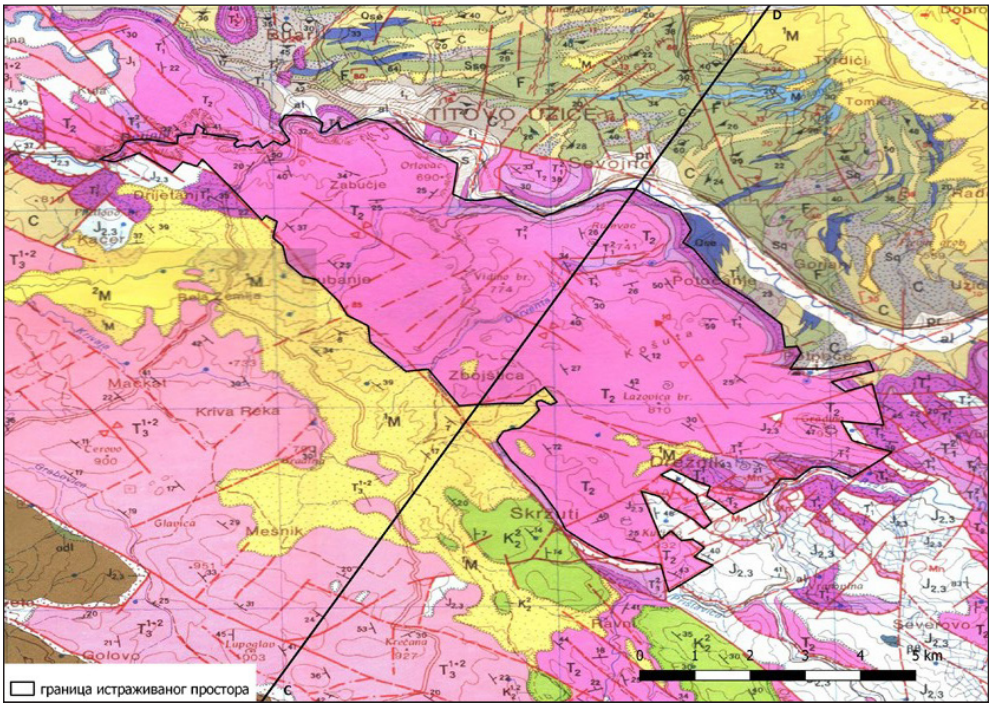

Figure 2. Geological map of the Zabučje–Gradina area (excerpt from the Basic Geological Map 1:100000, sheet K 34–4 Titovo Užice, edited by the author).

The Zabučje–Gradina karst unit can be morphologically divided into several smaller sub-units (Fig. 3). The small karst units alternate in the northwest–southeast direction and their boundaries are the valleys of watercourses. Their altitudes are between 700 and 750 m, while the valley floors of the Derventa and Bukovac rivers have an altitude of 650 to 400 m. The Drežnička valley is at 600–650 m, and the altitude of the Lipovec massif ranges from 700 to 930 m.

Going east-southeast, the first karst unit is the surface of Zabučje. Its border is the valley of an unnamed stream to the west, and to the north and east it is also limited by a steep section of the right valley side of the Đetinja, in places up to 300 m high, and in the southeast by the deep, in some places up to 150 m deep Bukovac gorge. In the southwest is the geological border of limestone and Miocene and Lower Triassic sediments. The area of this area of Zabučje is 6.6 km². It reaches its highest altitude in the far southwest, while its lowest is in the far east, around 620 m.

Figure 3. Hypsometric map of the Zabučje-Gradina karst area (Compiled by the author based on isohypses from topographic maps 1:25000 Titovo Užice 528–2–3 and 528–2–4).

Southeast of the Zabučje area is the Ljubanj area (9.5 km²), which is separated from it by the Bukovac gorge. The highest point is 792 m Šanac. On the northern border of the Ljubanj area, at the place where the Bukovac emerges from its gorge, there is a smaller amphitheatrical extension, at the bottom of which is the strongly karst-captured Živkovića spring, which drains one part of the area.

Further to the southeast, there is the largest and most sparsely populated area, Košuta (15.5 km²). This area also slopes gently to the northeast: in the southwest are Andrića brdo, Vrh, Lazovića brdo, Zeravsko brdo, Anište, and from there it begins to climb steadily to the peak of Gradina (931 m). In the northeast is Lakićevića rock. The marginal areas of Košuta have the most dry karst valleys, as many as 9, of which Prisoje, Pavlovića do and Mali do towards the Derventa gorge, and Dolovi above the Potpećka cave stand out. This surface is the most rugged and on it you can also notice the gorges, the "sea of rocks" that cover the gorges, the midriff that separate the two gorges (Fig. 4).

The Drežnica Valley is located between the Kosut plateau in the north and the Lipovec massif in the south. After the Đetinja valley, it is the lowest part of this area. The bottom around the last abyss is located at 590 m above sea level, while

Figure 4. The crater on the surface of Kosut (photo: A. Petrović).

the largest part of the valley is at an altitude of between 600 and 650 m. The valley is tectonically predisposed: covered faults are located on its northern and southern edges (Dimitrijević et al., 1978). Ršumović (1960) states that the Drežnica Valley was the most downstream part of the course of the former Zlatibor River. According to his hypothesis, the Zlatibor River flowed over the area that is now covered by Miocene sediments (west of the Zabučje–Gradina area), from the area of the Zlatibor peridotite massif, through the source parts of the present-day streams of the Gumbur stream, Bukovac and Derventa, and flowed into the Veliki Rzav in present-day Drežnik. The river flowed over Miocene lake sediments from an earlier period, but it also brought peridotite gravel (which is not indigenous to this area) from Zlatibor to them. The Zlatibor River valley was then severely fractured by transverse faults that it could have overcome for a time by cutting through the fault lines, but through backward erosion, the Bukovac and Derventa streams pirated the central parts of its course. After this disorganization, only a short stream of the Drežnička River remained, which originated near Zbojštica and flowed eastward, flowing into the Veliki Rzav. Over time, the Miocene cover was eroded and the Drežnička River came to a bed of massive Triassic limestones that it could not overcome and began to sink, first into the lowest abyss (Todorova pećina), then into Pipalska pećina, the abyss near Jezero and the abyss near Vidića bara, thus leaving a hanging valley, about 100 m above Veliki Rzav (Ršumović, 1960). The lowest part of this valley was succeeded by the Milutinovića stream, a left tributary of the Veliki Rzav, 1.75 km long.

Ršumović (1960) also states that there must have been a valley even older than the one through which the Zlatibor River flowed, and that it continued straight to the southeast (through today's Skržute) near today's Zbojštica (it did not turn into the Drežnica Valley) and ended at the Prištavica River, a left tributary of the Veliki Rzav, i.e. that the Drežnica Valley was marginally epigenetically incised due to the existence of Miocene sediments that covered the topographic surface. The downstream part of this paleovalley was inherited by the course of the Savića stream.

The last entity of this area is the Lipovec massif in the far south. Lipovec is about 2.2 km wide and elongated (about 5 km) mountain of the Dinaric direction, with an altitude of 932 m (Kućište) and a relative altitude of about 330 m. The northwestern

part of this massif is flatter and shorter, with the appearance of ravines, while further southeast it rises and is heavily dissected by shorter streams flowing north, east and south.

The hydrological characteristics of this area are similar to those in other areas where karst relief is present. The surface is relatively dry. Two streams, Bukovac and Derventa, rise southwest of the karst area, on Miocene sediments, then reach limestone where they cut deep gorges that differentiated this once homogeneous area. Both streams, in the gorges, become occasional streams (Ršumović, 1955).

Methodology and material

The research required for the preparation of this work can be divided into three phases. The first phase is the desk research phase, and it began with the study of satellite images and topographic maps, which allowed the author to examine the entire terrain, not just the area covered here. Also, during this phase, the existing literature dealing with this issue was researched. The second phase is the field research phase, which was carried out on three occasions: in May 2023, October 2023 and September 2024. Field research involves going to the field, visiting it, examining the entire area and collecting photographs. The last phase is again desk research, when the data collected in the first and second phases were shaped using GIS tools, mostly by analysis in the QGIS program (Novković, 2022). The density of boreholes was calculated based on data from topographic maps at a scale of 1:25,000 (TK25), while the Copernicus DEM layer with a resolution of 1″, i.e. about 30 m, was used to calculate the slope angles at which they are located.

The scientific research process was supplemented and rounded off by field research, which was particularly useful in observing certain phenomena and processes in this karst entity. Karst valleys can be classified into three types: active, dry and relict. Active valleys still have an active or periodically active river flow today. Dry valleys have retained their shape that existed before shortening, their bottoms have a constant slope towards the former mouth but do not have an active flow. Relict valleys are those whose bottoms have been completely destroyed by karst processes, most often by series of sinkholes. The only evidence of fluvial processes in these valleys is the highly dissected thalweg (Petrović et al., 2016). All this information helped in classifying karst valleys in the studied area, and examples are given for each type.

Although this karst unit cannot be considered a karst belt, some characteristics of contact karst can still be observed. Comparing the karst of the Dževrinske greda on Miroč, which is considered a perfect polygon for studying the karst belt (Ćalić

& Milošević, 2005), with this unit, it can be noted that both units have a non-karst environment, tectonic faults as their boundary, and allogenic flows that have created valleys in the form of gorges. However, the main characteristic that does not allow classifying this unit as a karst belt is its morphometry. Ćalić & Milošević (2005) state that karst belts have a ratio (γ) of length and average width of over 30, and in the Zabučje–Gradina karst unit this parameter is 4.04. Certainly, the characteristics of contact karst are present. Since contact karst itself occurs along the contact lines of carbonate and non-carbonate rocks (Ćalić, 2008), here specifically of Middle Triassic limestones and Miocene sediments, it is most pronounced in places where the Bukovac and Derventa streams pass from sediments to limestones and continue to flow, first as permanent and then as occasional streams. These streams, with their concentrated inflows that are not characteristic of karst areas (Ćalić, 2008), have cut two deep gorges (the Bukovac gorge with a maximum depth of about 150 m, and the Derventa gorge with a maximum depth of about 250 m).

The analysis of the distribution of the holes started from the assumption made by Tamas, Laszlo and Calic (2007) who analyzed the holes on Miroč and concluded that they are mostly located at angles of inclination up to 12°. This analysis was performed here using the QGIS program and the aforementioned Copernicus DEM layer. Another option for this analysis was to use a TIN layer with a resolution of 10 m, obtained based on isohipsis from TK25, but since an overly precise TIN layer can also take into account the sides of the holes themselves as uneven terrain and then show unrealistic data, it was decided to use a less precise DEM layer (Telbisz et al., 2007).

Using GIS, it is possible to partially reconstruct the paleodrainage network of this area, which was done by analyzing isohypses and the arrangement of boreholes from TK25 (Titovo Užice sheets 528–2–3 and 528–2–4), creating the effect of a three-dimensional terrain using a hypsometric map in combination with shaded terrain (Petrović, 2015). Also, using the same methodology, it is possible to categorize existing karst valleys into active, dry and relict (Petrović et al., 2016); all three types have been found in this area.

Results and Discussion

One important condition for the formation of sinkholes, in addition to the geological substrate, is a relatively flat or slightly sloping terrain. An analysis of a large number of sinkholes (over 5000) on Miroč showed that sinkholes are most often formed at slope angles of up to 12° (Telbisz et al., 2007).

Of the total of 573 holes, as many as 564 (98.4%) are located on a slope of 12° or less. By calculating the arithmetic means of all slope angles, the average value is 4.58°, and the largest number of holes is in the category between 3° and 4° (111, i.e. 19.37%). Analyzing the data for altitude, it is noted that the largest number of holes is at an altitude between 700 and 750 m (318, i.e. 55.5%), which corresponds to the altitude of all three karst surfaces. When the next category (corresponding to rounded hills of low relative height that rise from the surface) is added to this data, the altitude zone 750–800 m, in which 118 boreholes (20.6%) are located, it is concluded that a total of 436 boreholes (76.1%) are located in the altitude zone 700–800 m. The mean altitude at which the boreholes are located, obtained by calculating the arithmetic mean, is 720.4 m, while the standard deviation ranges between 678.1 m and 762.8 m (Table 1).

Figure 5. Example of a funnel-shaped (front) and pelvic-shaped (back) sinkholes in a series on the Ljubanj surface (photo: S. Popović)

Table 1. Sinkholes arrangement according to inclination angle and altitude

inclination (°)	Number of sinkholes (in %)	altitude (m)	Number of sinkholes (in %)
0–1	25 (4,36)	500–550	2 (0,35)
1–2	72 (12,57)	550–600	0 (0,00)
2–3	74 (12,91)	600–650	34 (5,93)
3–4	111 (19,37)	650–700	91 (15,88)
4–5	80 (13,96)	700–750	318 (55,50)
5–6	66 (11,52)	750–800	118 (20,59)
6–7	57 (9,95)	800–850	8 (1,40)
7–8	24 (4,19)	850–900	1 (0,17)
8–9	24 (4,19)		
9–10	10 (1,75)		
10–11	10 (1,75)		
11–12	10 (1,75)		
преко 12	9 (1,57)		

Source: Author's processing

The sinkholes at the bottom of the Drežnica Valley are specific, because they are not all on limestone, but on Miocene sediments, but since they are very thin and lie over limestone, sinkholes were also formed on them. These are suffusion sinkholes. Those in this area are also connected to the abysses of the former Drežnica River: Vidića Bara, the abyss near Jezera and Todorova Pećina are located at the bottom of the sinkholes, while Pipalska Pećina is at the end of a short blind valley cut into the valley bottom of the Drežnica River. As already mentioned, Bukovac and Derventa have cut two deep gorges that differentiate the surfaces of Zabučje, Ljubanj and Košuta. On the longitudinal profiles of these rivers, bends can be observed, at Bukovac at a point about 200 m upstream of the transition from sediments to limestones, and at Derventa about 1.2 km upstream. By graphically displaying these longitudinal profiles and converting them into decimals (Fig. 7), it can be concluded that both of these bends are at about 4/10 of the river course, and that they were created by a backward movement of the flow. This is also proven by the unusual phenomenon that the longitudinal profile is significantly flatter in the uppermost, source part of both streams, than in the lower and middle, where it shows the existence of significant drops.

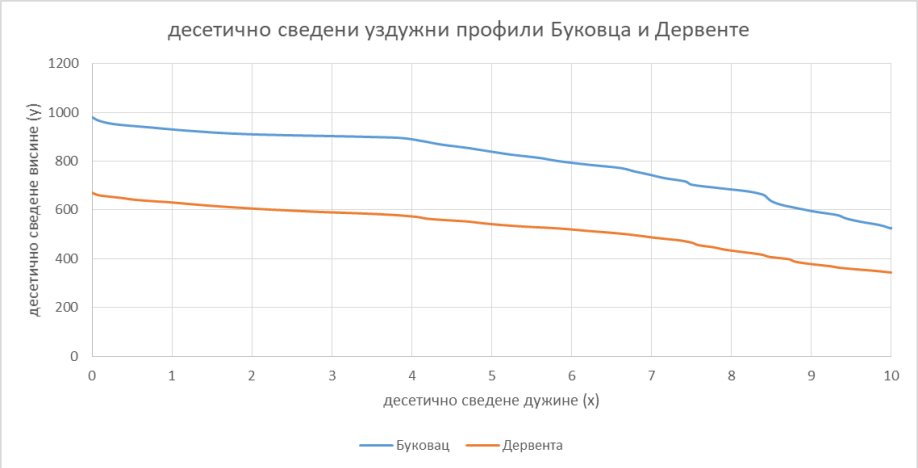

Figure 6. Decimalized longitudinal profiles of Bukovac and Derventa (Author)

Another specificity of this area is that the border of the massive Middle Triassic limestones to the north and northeast does not completely follow the Đetinja valley, but at one point it crosses over to its left side, which can be seen on Sekulića Hill, between Užice and Sevojno. Since the height of the valley sides of the Đetinja at this point is about 620 m above sea level, and at about 650 m northeast of there the height is about 535 m, it can be concluded that this narrowing is a consequence of the marginal epigenetic incising of the Đetinja (Fig. 8).

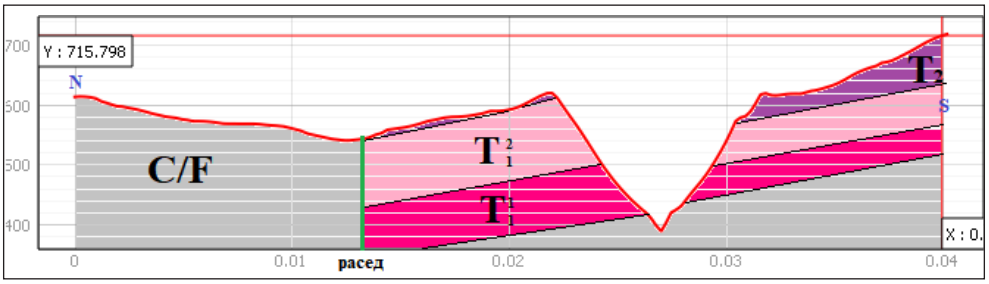

Figure 7. Transverse profile of the Đetinja epigeny near Sekulića Brdo (Compiled by the author based on the Basic Geological Map 1:100000 K 34-4 Titovo Užice).

Due to the specific circulation of water in the karst, river courses and valleys are relatively rare. Limestone and dolomite, as two highly soluble rock types, allow for intensive underground circulation, while the topographic surface is waterless. For this reason, active valleys in the karst are most often formed by allogenic flows that come from other geological substrates and cut through limestone massifs (such as Bukovac and Derventa). Other valleys in the karst are not active. In most cases, they are fossil. They were formed during the period when the limestone substrate was covered, in this case by lake sediments, and when this cover was eroded and when the flows came into contact with the underlying limestone, the flows and valleys were gradually fossilized. Such was the genesis of a large number of short valleys in this area.

The Drežnička Valley stands out as the largest paleovalley in this area, which, in addition to karst, was also formed by tectonic activity (it was lowered along faults) (Dimitrijević et al., 1978). The flow of the Drežnička River could not overcome the limestone bedrock and began to sink, which led to the creation of the so-called blind valley. An example of such valleys is the Pipalska Valley (Fig. 9). The Drežnička River's sinkhole is Todorova Pećina. The Drežnička River, which flowed in a west-east direction, left a gap east of Todorova Pećina up to 20 m high. Today, a short, occasional stream (east-west direction) flows along this slope, which also sinks in Todorova Pećina. The hanging part of this valley was inherited by the flow of the Milutinovića Stream. Due to the specific geological structure, the springs in the Drežnik Valley are located on the southern edge of the valley, while all the sinkholes are on the northern edge. An example of this phenomenon is the Pipalsko vrelo, which erupts near a small church in Drežnik, flows in a short course to the northeast and plunges into the Pipalska cave. This valley is short, only 120 m, but is significant as a blind valley. Above it is a flattened valley floor, with "sodomies", sinkholes formed by the salination of cave ceilings below them.

Figure 8. Pipalska Valley (photo: A. Petrović).

The valley floors of fossil valleys, especially on the surfaces of Zabučje, Ljubanj and Košuta, are dissected by numerous boreholes, which are arranged in rows. These rows help in the reconstruction of the paleo-relief of the mentioned area. Apart from the allogenic streams of Bukovac and Derventa, there are no active valleys in this area, because all the streams were too short and with too little water to withstand the shortening of the terrain. There are no dry valleys on the surfaces, but they are connected to dry and hanging valleys, with steep slopes and sides, and large height differences between the source and the mouth. Such valleys are called "dolovi" in this area. Named examples of these valleys are on the right side of the Derventa valley: Prisoje, Pavlovića do, Mali do, as well as Dolovi, a paleovalley at the exit point of which into the Đetinja valley is the Potpećka cave. There are many more unnamed ones, such as the valleys below the hamlets of Negovanovići and Nenadići in Zabučje, the valley southeast of Lakićevića stenae, through which the Potočanje road was traced, and others. Relict valleys are present on the surfaces themselves, they are very shortened, but paleorelief reconstruction is carried out on their basis. Using GIS, it is possible to reconstruct the paleodrainage network (Fig. 10) of this area. It shows a dense network of relatively short paleostreams, which failed to overcome shortening when coming into contact with massive Middle Triassic limestones. Some of these paleovalleys are also hanging, such as those on the northern side of the karst surface of Zabučje, which once flowed into an unnamed stream, and today their valleys remain 100–150 m above the stream bed. More examples of these hanging valleys are two valleys on the northern side of the Ljubanj Karst surface, one above the Živković spring, and the other about 850 m further east, which remain to "hang" about 100 m above the present-day valley floor.

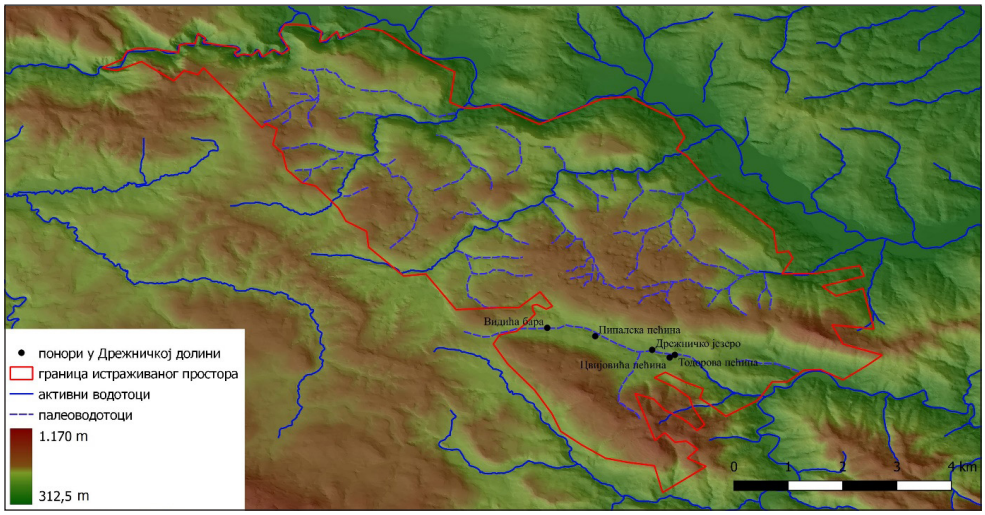

Figure 9. Paleodrainage network of the Zabučje–Gradina karst unit (Author)

Four speleological objects have been identified in the area of the karst complex. The largest and most famous of them is the Potpećka cave, and the only one located on the northern side of the karst surface of Košuta. The others are the Pipalska (Rajkova) cave and the two Cvijovića caves, Todorova and Bezimena. These three caves are located in the Drežnica valley, on the southern side of Košuta.

The Potpećka cave is one of the most famous speleological objects in western Serbia. It has been well researched and numerous geologists and geographers have written about it, which is why the emphasis is placed on the other caves mentioned above.

Figure 10. Pipalska Cave (left) and Cvijovića Cave (right)

The Pipalska (Rajkova) cave is the second most upstream sinkhole in the Drežnica valley, located about 900 m east of the Vidića pond (the most upstream sinkhole). It is a chasm with a short, intermittent stream that springs about 120 m south of the Pipalski Vrel spring, and the end of a blind valley. The cave begins with a 36 m long

cave channel, followed by a 16 m deep chasm (Lazarević, 1959). After the chasm, the channel is narrow and cascading, and then turns into a shallow one (0.3–0.6 m). A total of 1712 m of the main cave channel has been explored. The White Hall in the cave is particularly noteworthy (Lazarević, 1981).

Todorova pećina is the lowest sinkhole of the Drežnica Valley. It is located at an altitude of 592 m, at the lowest point of the Drežnica Valley. Its entrance is 0.5 m high and less than 0.5 m wide. Two short periodic streams (Lazarević, 1981) descend into it, one of which flows opposite to the flow of the former Drežnica River. The channel descends in a cascade while its height decreases over an estimated length of 15 m. It is believed that it connects even deeper with the channel from Surdup (Lazarević, 1981). The second Cvijovića pećina (Fig. 15) has no specific name, it is located about 115 m southwest of Todorova and is cut into the bottom of the ridge where the hamlet of Cvijovići is located. It is very short (shorter than 2 m).

Vidića bara (the most upstream) and Drežničko jezero–Surdup (between Pipalska and Todorova pećina) are two sinkholes that are not passable and therefore are not considered speleological objects. Locals say that they can often become clogged, creating smaller lakes (hence the name), especially in winter. There was a watermill on Vidića bara that is no longer in operation. According toRšumović (1960), the first activated sinkhole was Todorova pećina, then Pipalska, Surdup and finally Vidića bara. When all four sinkholes became active, the Drežnička River was completely disorganized.

Conclusion

The paper presents in detail the geological, geomorphological and speleological characteristics of the studied area, as well as its development through different geological periods. The karst processes that shaped the mentioned karst unit are analyzed, with special emphasis on the distribution of sinkholes, abysses and blind valleys. The mentioned speleological objects indicate the richness of the underground karst system, while the presence of sinkholes provides insight into the hydrological reorganization of the river system. The Zabučje–Gradina karst unit represents a unique unit in the area of western Serbia. This paper presents a recapitulation of previous understandings of the genesis of this area, confirmation of these understandings, but also some new conclusions are drawn. A brief description of each of the more important units of this area is given, the longitudinal profiles of Bukovac and Derventa are analyzed, and the epigeny of Đetinja between Užice and Sevojno is described. In the section on sinkholes, a new indicator for this unit is given, namely the density and number of sinkholes, and it is confirmed that sinkholes

develop most intensively here too at relatively low gradients. It is also stated that a large number of sinkholes are located in rows, which is explained by the existence of paleowatercourses, on whose ravines later, after shortening, sinkholes developed. A new map was also made there, which is a map on which a detailed representation of the paleodrainage network of this area is made. And finally, a brief overview of speleological objects and sinkholes of this area is given.

Certainly, this work is not a complete and comprehensive analysis of the Zabučje-Gradina karst unit and it leaves room for further research. In future research, the hydrological connection between different speleological objects should be studied, in order to gain a more detailed insight and understanding of underground watercourses. Some of the questions that arise are: Where does the water from the karst surface of Zabučje and Ljubanj drain underground? Are there any other speleological objects in this area, especially in the Derventa and Bukovac gorges? What exactly is the underground connection of the abyss in the Drežnica Valley? What exactly was the genesis of the entire area, and what was the paleodrainage network on the karst surfaces? It is also important to emphasize the importance of preserving these natural objects that have both geological significance and significance for the development of tourism.

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IMPACT OF THE MEDITERRANEAN OSCILLATION ON CLIMATE ELEMENTS AND STREAMFLOW IN THE SOUTH MORAVA RIVER BASIN

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Abstract: This study investigates the relationship between climate elements and river flow in the South Morava basin, emphasizing their dependence on the Mediterranean Oscillation Index (MOI). Data from the Korvingrad hydrological station, the Vranje synoptic station, and MOI records were analyzed over a 30-year period (1991–2020). Results indicate a positive trend in mean monthly temperatures across all months, with significant increases in February, March, and April. Significant trends were also observed in mean annual temperature and precipitation. Flow trends exhibited notable changes in March, with an annual flow value of 3.265 m^3s^{-1}. The Pearson correlation coefficient revealed significant seasonal relationships between flow and precipitation, particularly in winter, summer, and autumn, while flow-temperature correlations were significant in summer and autumn. To further quantify these relationships, multiple linear regression was applied, using temperature and precipitation as independent variables and river flow as the dependent variable. The results demonstrated statistically significant associations in 11 out of 12 months, with the strongest linkage observed in November. Seasonal models indicated that precipitation had a dominant influence on flow in winter, spring, and autumn, while temperature had a relatively greater impact during the summer. The autumn model yielded the highest explanatory power ($R^2 = 0.517$). These findings underscore the Mediterranean Oscillation's role in shaping both climate variability and hydrological dynamics in the South Morava basin, while highlighting the importance of integrating statistical modeling to better understand seasonal patterns of flow response to climatic drivers.

Keywords: Temperature, precipitation, streamflow, standard multiple linear regression model, Mediterranean Oscillation, South Morava River

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Introduction

Changes in climate elements and global warming have been the focus of extensive research by scientists worldwide. Historical evidence supports the theory that climate variability is a natural phenomenon. However, many scientists agree that human activities contributed to the rise in global temperatures during the 20th century (Loo, Billa and Singh, 2015). The IPCC AR6 confirms that human influence has unequivocally warmed the atmosphere, ocean, and land, leading to widespread and rapid changes in the climate system (IPCC, 2021). Climate changes impact both natural and anthropogenic systems. The global increase in average temperature intensifies temperature differences between land and sea, as well as between northern and southern latitudes. Precipitation patterns are also shifting, with an increase observed at higher latitudes, while tropical and subtropical land regions experience a decline in precipitation (IPCC, 2007). These alterations are consistent with observed changes in the water cycle, including more intense rainfall and associated flooding, as well as more intense droughts in many regions (IPCC, 2021).

Human-induced climate change is expected to significantly affect the distribution, frequency, and intensity of precipitation, as well as the occurrence of floods and droughts (O'Gorman and Schneider, 2009; Trenberth, 2011; Dankers et al., 2014; Cahyono, Astuti and Rahmat, 2018). Global circulation models confirm a warming trend, and IPCC AR6 projects increasingly extreme weather events—hot spells, heavy rainfall, and droughts—with further warming (Easterling et al., 1997; IPCC, 2007; Fabiano, Meccia, Davini, Ghinassi and Corti, 2021; IPCC, 2021). Air temperatures rose across most of Europe in the 20th century, especially in Southern and Southeastern regions, primarily due to human activity (Brazdil et al., 1996; Brunetti, Buffoni, Maugeri and Nanni, 2000; IPCC, 2007). Future projections show higher summer temperatures and lower annual precipitation in Southern Europe, with warming exceeding global averages and more frequent heat extremes (IPCC, 2021).

Changes in climate elements significantly affect river flow regimes and regional weather patterns. Modeling studies show that river flows respond strongly to climatic shifts, particularly snowmelt dynamics, and may be more influenced by climate change than dam construction by 2050 (Adam et al., 2009; Adam, Hamlet and Lettenmaier, 2009; Doll and Zhang, 2010; Fung, Lopez and New, 2011; Arnell and Gosling, 2013). Historical data link global temperature variations to flow changes, with a 4% increase in river discharge per 1°C warming (Labat, Godderis, Probst and Guyot, 2004). In Southern Europe and the Mediterranean, cyclones moving from west to east, particularly during the winter months, significantly influence precipitation patterns (Sušelj and Bergant, 2006; Burić, Ducić and Luković, 2011; Burić, Ducić, Luković and Doderović, 2014; Martić-Bursać et al., 2017), while climate variability is largely governed by the Mediterranean Oscillation (MO) and its connection to

the North Atlantic Oscillation (NAO) (Corte-Real, Zhang and Wang, 1995; Trigo et al., 2006; Cenk and Turgay, 2020). The NAO has a stronger impact on precipitation in the Iberian and Apennine peninsulas and significantly influences temperatures in Serbia and other regions (Piervitali, Colacino and Conte, 1998; Brown, Caesar and Ferro, 2008; Unkašević and Tošić, 2013; Criado-Aldeanueva and Soto-Navarro, 2020).

The Mediterranean Oscillation (MO) is an atmospheric teleconnection that influences weather conditions in the Mediterranean region (Dunkeloh and Jacobeit, 2003; Cenk and Turgay, 2020). Often, the MO is associated with a pattern of favorable weather and high temperatures in the western Mediterranean, and rainy conditions with low temperatures in the eastern Mediterranean (Maheras and Kutiel, 1999; Burić et al., 2014). During the positive phase of the MO, precipitation is below average across most of the Mediterranean, except along the coasts of the Aegean Sea and the Levant. In contrast, during the negative phase of the MO, the depression center typically shifts near the British Isles or north of the Iberian Peninsula. In this phase, a moist and unstable air mass from the west brings substantial precipitation to the western Mediterranean (Dunkeloh and Jacobeit, 2003; Burić et al., 2014). High temperatures in both the western and eastern Mediterranean are a result of warm air masses circulating from North Africa (Maheras and Kutiel, 1999).

Future changes in air temperature are anticipated across Europe, but similar trends cannot be confirmed for precipitation. Precipitation and flow trends in Serbia require careful analysis, as the European Environmental Protection Agency identifies the Pannonian Basin as a transitional zone between higher latitudes, where increased precipitation is expected, and Southern Europe, where a decrease in precipitation is anticipated (Burić, Stanojević, Luković, Gavrilović and Živković, 2012). Smadi (2006) highlights that the trend of increasing mean annual air temperatures is a result of global warming and changes in atmospheric circulation. Gocic and Trajkovic (2013) concluded that future temperature increases will influence evaporation rates and the frequency of droughts in Serbia. Malinovic-Milicevic, Radovanovic, Stanojevic and Milovanovic (2016) determined that dry periods were more frequent than wet periods in Serbia between 1961 and 2010. They also noted that the temperature shift occurred in the 1980s, followed by a warmer regime at most stations in Serbia.

The primary objective of this study is to identify the trends in average monthly, seasonal, and annual temperatures and precipitation at the Vranje synoptic station, as well as to determine the trends in average monthly, seasonal, and annual streamflows at the Korvingrad hydrological station. The main goal was to apply specific statistical methods to assess the relationship between changes in meteorological and hydrological parameters and variations in the Mediterranean Oscillation index (MOI). To facilitate a clearer understanding of the influence and dependence of the MOI on

the examined climate variables and hydrological flow, parameters were selected to define this relationship using a standard multiple linear regression model.

Database and study area

A dataset was used that includes average monthly air temperature values, total precipitation, streamflow, and the MOI index for the standard 30-year climatic period (1991–2020) (Table 1). The Mediterranean Oscillation index (MOI) is defined as the standardized difference in sea level pressure between stations located in the western and eastern Mediterranean. The index consists of two distinct indicators. The first indicator, denoted as MOI-1, represents the pressure difference between Algeria (36.4° N, 3.1° E) and Cairo (30.1° N, 31.4° E). The second indicator, denoted as MOI-2, represents the pressure difference between Gibraltar (36.1° N, 5.3° E) and Tel Aviv, Israel (32° N, 34.5° E) (Conte, Giuffrida and Tedesco, 1989; Maheras and Kutiel, 1999; Palutikof, 2003; Burić et al., 2014).

Table 1. List of institutions from which data were taken and their relation to the study purpose

Institution	Website	Data	Relation to the study purpose
Republic Hydrometeorological Service of Serbia (RHMSS)	https://www.hidmet.gov.rs	Air temperature, total precipitation, streamflow	Analysis of linear trends, significance, correlation, multiple linear regression, and spectral analysis of fundamental periodicity
University of East Anglia website (Climatic Research Unit)	https://crudata.uea.ac.uk/cru/data/moi/	MOI-1 (MOI: Algiers and Cairo) MOI-2 (MOI: Israel and Gibraltar)	Correlation analysis with the mentioned climatic elements and streamflow, as well as spectral analysis of fundamental periodicity

Average monthly data were obtained from the Vranje synoptic station (MS Vranje) and the Korvingrad hydrological station (HS Korvingrad) (Figure 1), both located within the South Morava Basin, which covers an area of 15,469 km² (Pavlović, 2019). The basin includes parts of southern, eastern, and southeastern Serbia. A small portion extends into North Macedonia, covering the northern slopes of Skopska Crna Gora. Additionally, the upper basin of the Nišava River, the largest right tributary of the South Morava, extends into western Bulgaria (Đokić, 2015). MS Vranje (42° 33’

N, 21° 55' E) is situated on the edge of the Vranje Basin at an altitude of 432 m a.s.l. It receives relatively low annual precipitation (less than 600 mm), evenly distributed between the summer and winter halves of the year. The duration of snow cover typically lasts up to 30 days per year. According to the Köppen Climate Classification (KCC), the Vranje synoptic station falls under the *Cfb* climate type, characterized as a temperate climate without a dry season and with a warm summer. Its specific climatic formula is *Cfs'w'bx* (Mihajlović, 2018). HS Korvingrad is located on the South Morava River at an altitude of 188.09 m a.s.l., approximately 105.7 km from its confluence. The catchment area draining into HS Korvingrad covers 9,396 km².

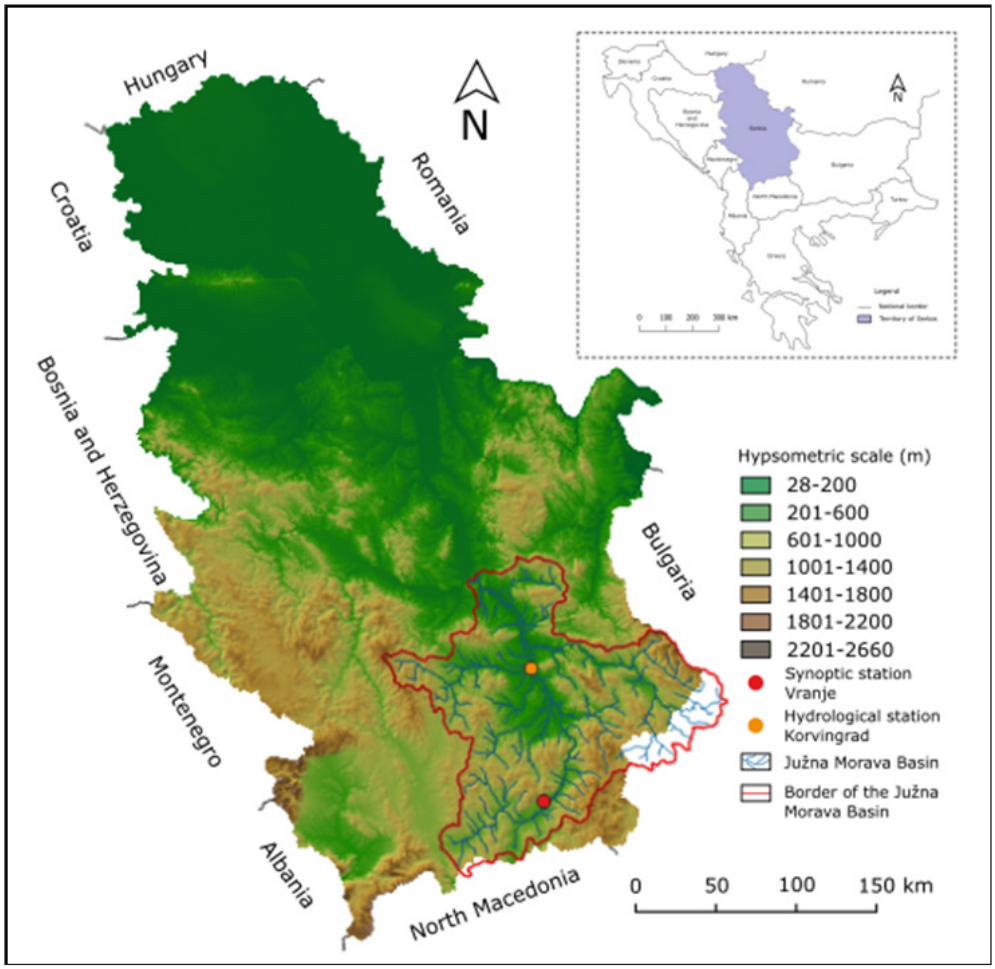

Figure 1. Location of the Vranje synoptic station and the Korvingrad hydrological station relative to the South Morava Basin

For data processing and graphical representation, the software packages Microsoft Office Excel 2003 and PAST[2] 5.1 were used, while Figure 1 was created using the free GIS software QGIS 3.28.2.

Methodology

To better observe changes in the dynamics of air temperature, total precipitation, and streamflow during the 1991–2020 period, the trend line was graphically represented using simple linear regression. Linear regression is a forecasting method that mathematically establishes the relationship between two phenomena, i.e., between a dependent variable and another factor that influences its behavior (independent variable). If the dependent variable exhibits a clear trend over time, the least-squares regression line or linear trend line can be used to predict the dependent variable. The general form of the linear equation is:

$$y = a + bx, \tag{1}$$

where a is the value on the y-axis when x is zero, b is the slope of the line, x represents the time period, and y is the predicted value of the variable for the given x period. The slope is positive if an increase in x corresponds to an increase in y, and negative if an increase in x corresponds to a decrease in y.

The statistical significance of the correlations was determined using a two-tailed Student's t-test, while the trends were assessed using the following equation:

$$y = R\sqrt{\frac{n-2}{1-R^2}}, \tag{2}$$

where R is the Pearson correlation coefficient[3], R^2 is the coefficient of determination, and n is the length of the series.

To better determine and understand the influence and dependence of the examined climatic elements (temperature and precipitation), as well as streamflow, on the MOI index, parameters that define this relationship were determined using the standard multiple linear regression model in PAST (Hammer, Harper and Paul, 2001; Press, Teukolsky, Vetterling and Flannery, 1992) , whose general regression equation is:

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[2] https://www.nhm.uio.no/english/research/resources/past/

[3] The Pearson simple linear correlation coefficient (p) is defined as follows:

$$p = \frac{n\sum xy - \sum x \sum y}{\sqrt{n\sum x^2 - (\sum x)^2}\sqrt{n\sum y^2 - (\sum y)^2}}$$

where n is the sample size, and x, y are the variables.

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i}, \quad (3)$$

Where:

- y_i: The dependent variable or response variable for observation *i*. It's what you're trying to predict or explain.
- x_{1i}, x_{2i}: The independent variables (also called predictors, features, or explanatory variables) for observation *i*. These are the inputs used to predict y_i.
- β_0 (b0): The intercept term. It represents the expected value of *y* when both x_1 and x_2 are zero.
- β_1 (b1): The coefficient for x_1. It represents the change in *y* for a one-unit increase in x_1, holding x_2 constant.
- β_2 (b2): The coefficient for x_2. It represents the change in *y* for a one-unit increase in x_2, holding x_1 constant.

This equation models how *y* depends linearly on two predictor variables, x_1 and x_2.

Results and discussion

The average annual air temperature at the Vranje synoptic station during the study period (1991–2020) was 11.2°C. Throughout the year, temperatures rose steadily until July and August, followed by a consistent decline through December. The highest average monthly temperatures, 21.5°C, were recorded in July and August, while December had the lowest average monthly temperature at -0.2°C. The trend in annual temperature change from 1991 to 2020 was 0.058°C, with the ten-year trend change reaching 0.558°C. The results indicate that the trend in the change of the average annual air temperature over the analyzed period is statistically significant (Table 2).

A positive trend in average monthly air temperatures was observed for all months. Statistically significant trends were identified in February, March, and April. The highest mean monthly trend, at an annual rate of 0.092°C, was recorded in April. Turkes and Sumer (2004) and Tabari and Marofi (2011) found a positive trend in mean monthly and annual air temperatures in the eastern Mediterranean, which aligns with the results of this study. The significant trend observed in March also corresponds with an increasing precipitation trend in the same month.

Positive air temperature trends were recorded across all seasons, with the most pronounced change occurring in spring (Table 2). On an annual basis, the trend in average spring temperatures was 0.063°C. Significant changes were also observed in winter and autumn. These findings are consistent with those of Gocic and Trajkovic (2013), who also reported significant increases in mean seasonal temperatures during spring and autumn for the period 1980–2010.

Table 2. Seasonal and Annual Values of Temperature Trend Change (1991-2020)

Season	Winter	Spring	Summer	Autumn	Annual
A	0.069	0.063	0.034	0.058	0.058
B	0.690	0.625	0.341	0.575	0.558
T	2.525*	3.576*	1.674	2.500*	4.831*

Note: A – Temperature change trend expressed in °C; **B** – The trend of change at the ten-year level expressed in °C; **T** – *t*-test value; *Values marked with an asterisk (**) are considered significant.

During spring, a statistically significant trend was recorded in March, which largely contributed to the overall spring temperature trend being classified as statistically significant (Table 2). Significant seasonal and monthly trend changes also influenced the increase in mean annual temperatures over the analyzed period. The observed rise in temperatures across all months and seasons directly contributes to the occurrence of droughts. The increasing temperature trend may help explain the frequency of droughts between 1991 and 2020. Tošić and Unkašević (2014) analyzed drought periods and concluded that drought events became more frequent toward the end of the 20th and the beginning of the 21st century.

The average annual precipitation in Vranje during the period 1991–2020 was 613.5 mm. The highest average monthly precipitation was recorded in May, June, and November, while the lowest values occurred during the summer and winter months. Analyzing the average monthly precipitation reveals two distinct maxima and two minima throughout the year. The second hydrological maximum, observed in late spring and early summer, is more pronounced than the first, which occurs in November. The first minimum appears at the beginning of winter and lasts until early spring, while the second, more pronounced minimum occurs in mid-summer, peaking in August.

During the analyzed period, average annual precipitation showed an increasing trend (Table 3), with an annual rise of 5.6 mm, which was statistically significant. Over a decade, this trend amounted to an increase of 55.99 mm. Anđelković et al. (2018) found that higher annual precipitation amounts were more frequent in the late 20th and early 21st centuries, aligning with the findings of this study for the period 1991–2020.

Negative values of precipitation trend change were recorded in April, July, August, and September. The lowest precipitation trend value during the analyzed period was recorded in April. The annual trend value was -0.366 mm. Although there is a trend of decreasing precipitation in April, it was not statistically significant. The negative precipitation trend in July had an annual value of -0.181 mm. There is some agreement with the results obtained by Milovanović, Schuster, Radovanović,

Vakanjac and Schneider (2017), who analyzed the spatial and temporal variability of precipitation in Serbia from 1961 to 2010 and observed a decrease in monthly precipitation in certain regions. The negative value of the precipitation trend in April can be attributed to the shift of the precipitation maximum to earlier months, primarily in March.

Table 3. Seasonal and Annual Values of Precipitation Trend Change (1991-2020)

Season	Winter	Spring	Summer	Autumn	Annual
A	2.154	2.145	0.177	1.133	5.599
B	21.541	21.454	1.770	11.326	55.986
T	2.728*	1.928	0.118	0.777	2.076*

Note: A – Temperature change trend expressed in °C; **B** – The trend of change at the ten-year level expressed in °C; **T** – *t*-test value; *Values marked with an asterisk (**) are considered significant.

Analysis of seasonal precipitation revealed a significant trend of change during winter. The trend of change was 2.154 mm on an annual level. Other seasons also recorded positive precipitation trends, but these could not be considered significant. The lowest trend value of 0.177 mm at the annual level was recorded during the summer (Table 3). This was primarily influenced by the negative values of the precipitation trend in July and August. The trend value in June was positive but not significant.

The average annual flow at the Korvingrad hydrological station for the period 1991–2020 was 50.9 m^3/s. The average monthly flows during the winter and spring months were high. The highest average monthly flow of the South Morava at the hydrological station was recorded in March (112.2 m^3/s). The flow value in April was 108 m^3/s, which resulted from snowmelt in the higher parts of the South Morava basin. Higher flows in the spring period are influenced by the second hydrological maximum of precipitation, which occurs in May and June. The values of average monthly flows decline during the summer and early autumn. The lowest average monthly flow was recorded in September, at 14.5 m^3/s.

The annual trend in flow change for the period 1991–2020 had a positive value of 0.606 m^3/s (Table 4). This value was positive but not significant. Only in March was the flow value significant. An increase in flow was observed, with an annual value of 3.265 m^3/s. One reason for the increase in flow in March is the increase in precipitation during the same period, which was also significant. Additionally, a significant increase in the average monthly air temperature was recorded in March, contributing to snowmelt. As a result, the water balance of surface waters, reflected through flows at the Korvingrad hydrological station, increases.

The average flow values in April showed a negative trend, though it was not statistically significant. The annual decreasing trend was -0.177 m³/s. In the other months, the mean flow values recorded positive trends, but these were also not significant.

Table 4. Seasonal and Annual Values of flow Trend Changes at the Korvingrad Hydrological Station (1991-2020)

Season	Winter	Spring	Summer	Autumn	Annual
A	0.710	1.228	0.317	0.169	0.606
B	7.097	12.276	3.174	1.688	6.059
T	1.073	1.343	1.393	0.720	1.500

Note: A – Temperature change trend expressed in °C; **B** – The trend of change at the ten-year level expressed in °C; **T** – *t*-test value

The trend in flow changes during these seasons showed positive values, although they were not statistically significant. The highest trend value was recorded in the spring period (Table 4), with an annual value of 1.228 m³/s. This increase is likely influenced by the significant flow observed in March, which contributed to the rise in average seasonal flow. The spring period (especially May) is known for the occurrence of the second hydrological maximum of precipitation, as well as snowmelt in the higher elevations of the South Morava basin. The lowest annual trend value of 0.169 m³/s was recorded during the autumn.

The Pearson correlation coefficient was calculated by analyzing the average seasonal discharges at the Korvingrad hydrological station and the average seasonal air temperatures and precipitation at the Vranje synoptic station. The Pearson correlation coefficient between flow and precipitation was statistically significant for the winter, summer, and autumn seasons. The highest coefficient value was recorded in autumn, at 0.7. The correlation coefficient was 0.43 in winter and 0.40 in summer.

A decrease or increase in precipitation during autumn was accompanied by a corresponding change in flow. Discrepancies occurred in two periods. The first period, from 2003 to 2005, saw high precipitation values, but these did not lead to an increase in flow (Figure 2 – A). One possible explanation is that the precipitation occurred in the part of the basin where the Vranje weather station is located, i.e., in the upper reaches of the South Morava basin. Lower precipitation in the middle basin of the South Morava, downstream of Vranje, along with a negative water regime in that area, may explain the lower flows recorded during this period. The second period of disagreement occurred in 2016. A soil moisture deficit, high temperatures, and the size of the catchment may explain the discrepancy in flows.

The Pearson correlation coefficient between flow and temperature during the winter period was 0.05, though it was not statistically significant. The correlation

coefficient values for spring, summer, and autumn were negative. The lowest value of the flow-temperature correlation coefficient was recorded in the summer at -0.51 (Figure 2 – B). A negative Pearson coefficient indicates an increase in one parameter accompanied by a decrease in the other, which helps to understand the climatic conditions in the South Morava basin. The absolute value of the t-test statistic was 3.13, which was statistically significant. A statistically significant correlation was also observed in the autumn, with a coefficient of -0.44.

The correlation coefficient between MOI-1, temperature, and precipitation did not show statistically significant seasonal values. However, the correlation coefficient between MOI-1 and winter flow was statistically significant at -0.4 (Figure 2 – C). Periods when one parameter increased while the other decreased occurred every 2–4 years, which can be explained by the cyclicity of MOI-1.

The correlation coefficient between MOI-2 and temperature was statistically significant during the summer, with a value of 0.39. In contrast, the correlation was lower during the other seasons. The lowest correlation value, recorded in winter, was -0.17, but it was not statistically significant. The correlation coefficient between MOI-2 and precipitation did not show statistically significant values, which aligns with the results for MOI-1 and precipitation. The agreement between MOI-2 and flow was significant during both winter and summer. The correlation value in winter was -0.39, consistent with the correlation between MOI-1 and flow. The lowest correlation value of -0.40, recorded during summer, was statistically significant (Figure 2 – D).

Multiple linear regression requires the definition of one dependent variable and two independent variables. In this analysis, data on average monthly, seasonal, and annual flows recorded at the Korvingrad hydrological station were used as the dependent variable. Data on average monthly, seasonal, and annual precipitation and temperatures recorded at the Vranje synoptic station served as the independent variables.

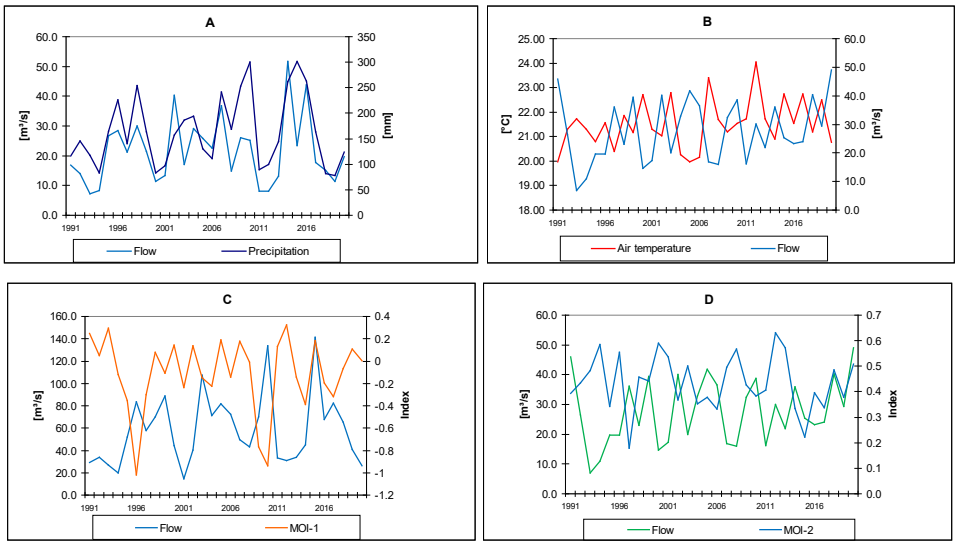

Figure 2. Time series of flow at the Korvingrad hydrological station [m³/s] and precipitation at the Vranje synoptic station [mm] in autumn (A); Time series of flow at the Korvingrad hydrological station [m³/s] and temperature at the Vranje synoptic station [°C] in summer (B); Time series of MOI-1 and flow at the Korvingrad hydrological station [m³/s] in winter (C);Time series of MOI-2 and flow at the Korvingrad hydrological station [m³/s] in summer (D) for the period 1991–2020

Analysis of the results from the multiple linear regression revealed that the values were significant during 11 months, during which the interdependence between flow, precipitation, and temperature was established. The highest *t*-test statistic was recorded in November, indicating a significant relationship between precipitation, temperature, and flow. In contrast, October was a month in which the relationship between flow, precipitation, and temperature was not statistically significant; however, a stronger influence of temperature on flow was observed during that month.

Temperatures had a greater impact on flows in July and August. Measured temperatures in July at the Vranje synoptic station accounted for a 2.21% impact on flows, while measured precipitation had a 0.15% impact on the South Morava flows at the Korvingrad hydrological station. In the other months, the interdependence between runoff and precipitation was greater compared to temperatures. November was the month in which the dependence of flow on precipitation was 48.62%.

The mean annual value of the multiple linear regression is represented by the function:

$$y_i = 50.335 + 0.081x_{1i} - 4.193x_{2i} \quad (4)$$

The coefficient of determination (R^2) was 0.312, meaning the model explains 31.2% of the variation in flow. The *t*-test value of 3.562 exceeded the critical value, indicating statistical significance. Based on the results, it was determined that 2.88% of the annual precipitation at the Vranje synoptic station affects the flow of the South Morava at the Korvingrad hydrological station.

To facilitate a clearer determination and understanding of the influence and interdependence of the examined climatic elements (precipitation and temperature) on streamflow at the seasonal level, parameters were identified that can define streamflow using a standard multiple linear regression model. The corresponding regression equations are as follows:

spring (MAM): $y_i = 137.9 + 0.305x_{1i} - 7.941x_{2i}$, (5)

summer (JJA): $y_i = 126.6 + 0.019x_{1i} - 4.721x_{2i}$, (6)

autumn (SON): $y_i = 32.8 + 0.101x_{1i} - 2.311x_{2i}$, (7)

winter (DJF): $y_i = 12.7 + 0.330x_{1i} - 1.104x_{2i}$ (8)

The results of seasonal multiple linear regression showed that the lowest R^2 value occurred in spring (0.150), while the highest value (0.517) was recorded in autumn. The *t*-test values for all seasons were above the critical value, confirming statistical significance. During winter, spring, and autumn, flows were predominantly influenced by precipitation. The greatest interdependence between flow and precipitation was observed in autumn, where the dependence of flow on precipitation was 4.95%.

In contrast, the interdependence of runoff from precipitation and temperature during summer was different. During the summer, flows were more influenced by temperature, with a dependence of 2.57%, while precipitation contributed 1.07%. The weak interdependence of runoff with both precipitation and temperature in the summer can be attributed to the large area of the South Morava basin up to the Korvingrad hydrological station, as well as the location of the Vranje synoptic station, which is situated in the upper reaches of the South Morava River.

Conclusion

This study analyzed data on average monthly, seasonal, and annual temperatures and precipitation at the Vranje synoptic station for the period 1991–2020. Additionally, data on average monthly, seasonal, and annual flows at the Korvingrad hydrological station on the South Morava River, as well as the Mediterranean Oscillation Index (MOI-1 and MOI-2), were examined.

The results indicate a positive trend in average monthly, seasonal, and annual temperatures, with significant values observed in February, March, and April. These

significant trends in the specified months also led to the significance of winter and spring seasonal temperature trends. The trend values for temperature, precipitation, and runoff were notably significant in March. A significant increase in precipitation was recorded both on an annual basis and during the winter period.

The correlation analysis revealed a clear seasonal pattern of precipitation and runoff, with a strong correlation during the winter, summer, and autumn periods. The Pearson correlation coefficient recorded its highest value of 0.7 in the autumn. A significant correlation between flow and temperature was observed during the summer and autumn.

To complement the correlation analysis, multiple linear regression was employed to quantify the influence of precipitation and temperature on river flows. The analysis confirmed statistically significant relationships during 11 months of the year, with the strongest association found in November. Seasonal regression models demonstrated that autumn had the highest coefficient of determination ($R^2 = 0.517$), indicating that nearly 52% of the variation in flow could be explained by climatic variables. While precipitation predominantly influenced flows in winter, spring, and autumn, temperature had a relatively greater impact during the summer months. These findings underscore the complex seasonal dynamics between climatic factors and hydrological response in the South Morava River basin, highlighting the importance of region-specific modeling in water resource management.

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PRESENTATION OF ENVIRONMENTAL CONTENT IN GEOGRAPHY TEXTBOOKS FOR ELEMENTARY SCHOOLS: A CASE STUDY ON A SAMPLE OF ZUNS PUBLICATIONS

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Abstract: The formation of functional knowledge in geography lessons is made possible by the use of quality textbooks. Didactic apparatus significantly contributes to the quality of textbooks, however, its influence from this aspect has not yet been sufficiently explored. Bearing in mind the methodological importance of photographs as part of the didactic apparatus of textbooks for the presentation of phenomena and processes related to environmental protection, research was conducted with the aim of determining their characteristics in geography textbooks for elementary school. The research was conducted on a sample consisting of two editions of geography textbooks (approved in 2007 and 2021) for elementary school by the publishing house ZUNS. Bearing in mind the educational importance and function of photographs as a source of information and a means of solving questions and tasks related to environmental protection, qualitative and quantitative analysis of photographs in the editions of geography textbooks approved in 2021 was first performed. In the second stage of the research, their comparative analysis was performed with the photos used in the textbook editions approved in 2007 with the aim of determining changes in the features selected for observation. Changes were found regarding the increase in the quantity of photos showing environmental content, the increased share of photos functionally related to the main text, and the absence of photos with a decorative function. However, the didactic apparatus retained certain negative features (prevalence of photographs, their unbalanced relationship with other elements of the didactic apparatus, etc.), so it is necessary to improve it. At the end of the paper, a set of measures was given for the effective inclusion of photographs in the didactic apparatus, so that they would have the best possible educational function.

Keywords: geography textbook, didactic equipment, ecological contents, photographs, comparative analysis, primary school

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Introduction

The emergence of the Internet represents a turning point in the development of modern society. The easy and quick availability of a large amount of information has brought changes in all domains of human activity, including education. Thus, certain research has determined that the use of the Internet in geography classes contributes to a better development of students' cognitive abilities (Jovanović et al., 2018). Nevertheless, the textbook has retained its role as the main teaching tool in many countries of the world (Tracz & Rodzoś, 2015).

The textbook is the most commonly used textual teaching tool for learning and teaching, which articulates the latest teaching ideas proposed by the curriculum (Hadar, 2017). The rapid growth of the human population accompanied by increasing pressure on natural resources and the environment, intensification of climate change, increased pollution of all elements of the environment and the emergence of new environmental problems caused the need to integrate education for sustainable development into curricula (Kumar et al., 2024). In this regard, within the Agenda for Education for Sustainable Development until 2030, the importance of including environmental content in the curricula of all teaching subjects was highlighted (UNESCO, 2017; UNESCO, 2021). The specific multidisciplinary and holistic approaches of geography as a science have enabled it to be recognized as one of the key teaching subjects for educating young people for sustainable development (UNESCO, 2020). Geography enables the study of current environmental problems through a comprehensive analysis of human-environment interactions, taking into account the economic and social aspects of those interactions as well as spatial and ecological relationships (García-González et al., 2021). Contemporary environmental education promotes the acquisition of procedural, functional knowledge, values and attitudes, thanks to which students are encouraged to actively engage and act towards solving existing environmental problems (Anđelković, 2018). Young people are expected to use their environmental awareness to prevent the emergence of new environmental problems in the future, but also to make it concrete by actively participating in the creation of a sustainable future (Stanišić et al., 2023). In this context, viewed at the level of all teaching aids, textbooks have proven to be the most expedient in the educational process (Nurlaili et al., 2019). Those textbooks whose contents include numerous examples of environmental problems from the local environment are particularly significant. As the local environment is close and familiar to the students, textbooks with content designed in the way mentioned earlier most expediently enable the development of ecological awareness (Laaloua, 2023).

Although it has a prominent place in the teaching process, since it enables the achievement of the outcomes and goals established by the curriculum, the textbook should be only one of the teaching tools that can be used in class (Justin et al.,

2003; Stará et al., 2017). In the context of education for sustainable development, some studies have proven that relying entirely on textbooks without organizing practical activities will not motivate students to behave environmentally responsibly in the long run (Muliana et al., 2018). In accordance with the traditional approach to teaching, the textbook is a means of one-way transfer of information. With the modern constructivist approach, the role of textbooks has been expanded and improved (Anđelković, 2018; Horsley & Sikorova, 2014). From a means for passive transfer of knowledge, the textbook becomes a means that supports active transfer of knowledge, acquisition of knowledge, development of competences, skills and values (Stará & Krčmářová, 2014; Kukanja-Gabrijelčić, 2015). As a result, the number of functions assigned to the textbook in the teaching process has increased and it becomes multifunctional. The textbook should enable students to independently conduct research, learn independently, organize their work, use different sources to collect information, analyze data, discover, recognize, define and solve problems, draw conclusions. The research, motivational, integrative and coordinative functions of textbooks derive from all of the above (Stará et al., 2017; Tracz & Rodzoś, 2015).

Principles of implementation of ecological content in geography textbooks

In order to successfully fulfill the assigned functions and be used in all stages of the teaching process, the textbook must be well designed (Mithans & Ivanuš Grmek, 2020). Creating geography textbooks is a kind of challenge due to the great diversity of the content of this science (Tracz & Rodzoś, 2015). In this work, it was of interest to determine how ecological content is presented in geography textbooks. Previous research, based on the evaluation of the content organization and the didactic apparatus used, has shown that many geography textbooks are of questionable quality from the point of view of the integration of ecological content (e.g. Jovanović et al., 2010; Purwanto et al., 2015; Guo et al., 2018; Phuong Nguyen, 2019; Biström & Lundström, 2020; Trahorsch et al., 2022; Blagdanić et al., 2024). This confirmed the necessity of applying certain principles when designing the ecological content of textbooks in order to achieve adequate quality (Grossman & Thomson, 2008). Based on the observed omissions, it is suggested to apply the following principles when implementing ecological content in geography textbooks:

- The textbook should contain basic facts, definitions and concepts of the respective scientific fields. The presented facts, used examples, comparisons and explanations in the textbook must be adequate and accurate (Purwanto et al., 2015). It follows from all the above that the textbook should represent a summary of selected scientific knowledge (Jovanović et al., 2010; Cigler, 1997). However, that summary must by no means be the result of a rough didactic reduction of scientific content into its smaller, simpler variant (Kovač et al., 2005).

- The teaching contents of the textbooks should be relevant, current, useful and easy to adopt, regardless of the learning style that the student prefers (Mithans & Ivanuš Grmek, 2020; Pešić, 2005). They must represent a true reflection of the current level of knowledge in science and it is necessary to harmonize them with the most modern didactic-methodical recommendations (Trahorsch, 2022).
- The selected teaching content should be aligned with the mental abilities of students at a certain stage of development, pre-knowledge, life experience and needs of students (Mithans & Ivanuš Grmen, 2020; Antić, 2009). Teaching content should be connected with the experience and everyday life of students through the use of examples related to the local environment. This achieves greater interest in the material and creates a sense of personal responsibility in environmental action (Guo et al., 2018).
- The writing style should be clear and adapted to the age of the students (Simsekli, 2015), but also challenging enough to encourage the expansion of students' vocabulary through independent, meaningful acquisition of knowledge. That is why the writing style should be freed from encyclopedism and redundant descriptions, and the teaching content should be designed so that it contains almost no factual and declarative data (Mithans & Ivanuš Grmen, 2020; Tracz & Rodzoś, 2015). For lower grade students, it is recommended to present teaching content in the form of interesting stories (Aura et al., 2021).
- The structure of the textbook must be well organized, in a clear and systematic way. Environmental contents must not be fragmented, limited to separate sections. It is necessary to integrate them well pedagogically, which is achieved through the application of a wider range of topics and cross-curricular connections (Blagdanić et al., 2024; Biström & Lundström, 2020). The educational function of textbooks should be in the service of forming functional knowledge. Functional knowledge is the most fundamental knowledge, because the student reaches it by independent reasoning and understanding of content and legality (Živković et al., 2010). In order to encourage students to actively acquire knowledge, with understanding, and discourage them from memorizing facts and definitions, it is necessary to establish a high degree of hierarchy of teaching topics and units in textbooks (Tracz & Rodzoś, 2015; Kramar, 2005).
- Environmental content should be presented in such a way as to develop students' critical thinking and encourage them to take active environmental action. That is why it is important to emphasize the cause-and-effect aspects of human-environment interaction (Phuong Nguyen, 2019). Relying on the outcomes of the curriculum, the teaching content should be organized and designed to equip students for independent research (they know how to ask questions, recognize and define problems, propose measures to solve them, etc.) (Tracz & Rodzoś, 2015).

For this purpose, each teaching unit should contain a lot of problem questions, tasks and exercises (Jovanović et al., 2010). Headings and subheadings should be formulated in such a way that they attract students' attention (e.g. in the form of questions), increase their interest and motivate them to independently acquire new knowledge (Mithans & Ivanuš Grmek, 2020; Morgan 2014).

- Aesthetic experience affects attention, so artistic graphic design of textbook covers is recommended (Ivanuš Grmek, 2003), as well as the use of colorful colors wherever possible. In this way, a greater interest in the material is primarily achieved among students of lower grades (Cekaite & Björk-Willén, 2018).
- The didactic apparatus of textbooks must be properly designed. It is desirable to use as many different types of visual displays as possible. Photos are best used to display physical-geographical topics, drawings and diagrams can simplify complex phenomena and processes and explain their mode of action, and tables and graphs are suitable for a clear and impressive presentation of statistical data. All used visual representations should have their own name, be listed in the text and be functionally connected to it in order to ensure their educational function as a whole (Janko & Peskova, 2013; Poljak, 1983).

The use of ecological photographs in geography textbooks and the results of research conducted in this area

Didactic apparatus is an extremely important component of every textbook. With its characteristics, it significantly contributes to the overall quality of the textbook and its educational efficiency. Photographs are of special importance as visual representations of objective reality (Janko & Peskova, 2013). Namely, most teachers in their classes almost exclusively use visual representations from textbooks, although there are incomparably more of them on the Internet (Vojíř & Rustek, 2022).

The photographs represent important elements of the didactic apparatus of the textbook. Numerous studies have established that photos increase the effectiveness of learning (Janko & Knecht, 2014) and contribute to better achievements (Balluerka, 1995). The reason for this should be found in the fact that a person remembers and understands what he sees and can imagine more easily (Schwartz & Heiser, 2006), even when it comes to some complex scientific concept (Paivio, 2007). The mentioned phenomenon is supported by the theory of dual coding. According to the theory of dual coding, when using a textbook, students encounter two different types of information - textual (ie verbal) and visual (ie non-verbal). Different types of information are not processed in the same brain centers and different cognitive processes are responsible for their processing (Paivaio, 2014). In the context of learning efficiency, the best results are achieved by using textbooks in which both textual and visual content

are proportionately represented (Mayer, 2009; Eitel et al., 2013; Peterson, 2016). On the other hand, the prevalence of only one type of information in the textbook negatively affects the effectiveness of learning - the dominance of text demotivates students (Behnke, 2017), while excessive use of images turns the textbook into an aesthetically attractive album with a weak educational function (Rodzoś, 2011).

In order for the photos to have their full educational potential, it is important to connect them in a functional way with the basic text in the textbook. That's why it is recommended that each photo has its own name, its own number, and its reference is linked to the main text. Without a textual explanation, the photographs have more of a decorative than an educational function. Students tend to skim over such photos because they perceive them as less important elements of the textbook content (McTigue & Flowers, 2011). The names of the photographs should clearly indicate the specific geographical phenomenon (occurrence or process) to which the content of the photograph refers. In this sense, using too general names is considered a bad practice (Tracz, 2014). It is also a bad practice to use visuals that are in no way connected to the basic text. Therefore, their purpose is not to facilitate the adoption of new material, since they are not functionally connected with it, but is purely decorative (Rodzoś, 2011). Textbook authors try to replace unwritten text through the use of illustrative content, because in this way the volume of the lesson is reduced. That's why the photos used most often represent an obvious example or proof of explaining what is highlighted in the main text. In order to preserve their functional connection with the textual contents, the basic text of the textbook should contain precise instructions for the analysis of photographs. In this way, students would be encouraged to think critically and acquire knowledge independently, which is not possible to obtain based on the text alone. Therefore, in order for the photographs to have an informative, and not just a decorative and entertaining function in the textbook, it is necessary that the authors of the textbook ask questions for each photograph. The questions should encourage students to actively observe the visually presented content, which would mean noticing, extracting and logically connecting important details and drawing relevant conclusions. (Jovanović, 2010).

Photographs are considered realistic visual representations and in a specific way affect the adoption of geographic content of various topics (Trahorsch & Bláha, 2019; Janko & Knecht, 2014; Janko & Peskova, 2013). Thus, certain studies have shown that photographs are the best type of visual representations for the effective acquisition of physical-geographical topics (Michaelidou et al., 2004; Klonari, 2012). Previous research has shown that the quantity of photographs in textbooks is increasing at the expense of text (Behne, 2016) and that they are disproportionately represented in geography textbooks compared to other types of visual representations (Yasar & Seremet, 2007; Jovanović, (2010); Janko & Knecht, 2013; Janko & Peskova, 2013;

Janko, 2015; Tracz & Rodzoś, 2015; Trahorsch et al., 2018). The prevalence of photographs as a type of visual representation has its downsides. Namely, photographs in themselves do not encourage the development of abstract thinking, especially if they are not connected to the basic text in a functional way, but encourage the acquisition of factual knowledge (Postigo & Rozo, 2004). Also, it is problematic that photos can influence the creation of wrong ideas about the content shown. It turned out that students tend to interpret the content shown in the photo in their own way, without reading the name of the photo or connecting it to the corresponding parts of the main text (Watkins et al., 2004). In order to avoid the aforementioned, it is necessary to pay more attention to enabling students to interpret pictures as well as words (Peeck, 1993). Although the didactic apparatus consists of various illustrative and graphic contents (Trahorsch & Bláha, 2019; Janko & Knecht, 2014; Jovanović, 2010), bearing in mind the frequent use of photographs, the importance they have in the teaching of geography, as well as the limited scope of this work, we decided to conduct a research in which we emphasized the analysis of photographs that show content about environmental protection in geography textbooks.

Analyzing photos that show content related to the environment, students become familiar with the components of the environment, their position in space, arrangement, boundaries and characteristics. Using the prompts, tasks and questions given with the environmental photos, students are trained to think critically and discover cause-and-effect relationships, connection spaces and connections between environmental components (Antal et al., 2020). Also, ecological photographs contribute to the building of knowledge about sustainable development, the development of critical thinking and ecological awareness (da Silva et al., 2024), however, the essence of modern education for sustainable development is responsible ecological behavior in everyday life and providing functional solutions for current environmental problems (Özer-Keskin & Aksakal, 2020). Several studies have shown that photographs allow students to emotionally identify with the environmental protection topics shown, which motivates them to solve existing environmental problems (Zhang & Li, 2023). Thus, it was concluded that marine photographs contribute to the development of students' awareness of the importance of ecosystem and biodiversity protection. That is why their more frequent use in textbooks is recommended (Hassan et al., 2023). Nevertheless, numerous studies have indicated the existence of an imbalance between the quality of the photos used and their cognitive function. It was found that in some geography textbooks in Poland, the Czech Republic, Turkey and Indonesia, photos with an exclusively decorative function are still used (Yasar & Seremet, 2007; Janko & Knecht, 2013; Janko, 2015; Purwanto et al., 2015; Tracz & Rodzoś, 2015; Trahorsch & Blaha, 2019).

In contrast to numerous researches related to the use of photographs in geography textbooks used abroad, little research has been done in Serbia regarding this topic. The most recently published research by Jovanović (2010), which examined the characteristics of the didactic apparatus used to present ecological content in the geography textbooks of the publishing house Zavod za sdukbibiki i nastavna nastavna (ZUNS), approved in 2007. In this research, a qualitative analysis of the use of photographs for the presentation of environmental content was performed, which was particularly interesting for the purposes of this research. With the aim of determining the tendencies of the implementation of ecological content in elementary school geography textbooks through the use of photographs, we conducted a new research using the editions of elementary school geography textbooks approved in 2021 by the already mentioned publishing house. Since there are few studies of this type in Serbia, the importance of our research lies precisely in the fact that it contributes to shedding light on an important, but so far little-examined methodological problem. Also, it is important that the results of our research can be practically applied. They were used as a basis for creating a framework of measures to improve the didactic apparatus that presents ecological content in geography textbooks for elementary schools in Serbia. Therefore, this research contributes to the improvement of the quality of textbooks as a whole. The limitation of the research is related to the size of the sample used. Since textbooks from only one publishing house were used for the purposes of the research, in the future the research sample should be expanded to more publishing houses.

Materials and methods

The research was designed to rely on several tasks. When creating the tasks, we took care that they derive from the goal of the research, that they provide results on the basis of which it is possible to check the accuracy of the set hypotheses and that they serve as a kind of instruction according to which the course of the research is organized. Accordingly, the tasks are divided into two groups. The first group of tasks aims to determine certain characteristics of ecological photographs used on the entire research sample and corresponds to the first stage of the research. The second group of tasks was singled out with the aim of determining the qualitative and quantitative differences between the ecological photographs used in different editions of the textbook by applying a comparative analysis. These are the following tasks:

The first stage of research:

1. Determine the representation of teaching units that contain ecological content in the analyzed textbooks.

2. To examine whether photographs are most often used as the dominant form of visual representation of environmental contents.
3. To analyze changes in the representation of environmental photos in textbooks for different grades of elementary school.
4. Determine the ratio of text and photos used to present environmental content in textbooks.
5. Examine the representation of ecological photographs by teaching units, with and without ecological content.
6. Check that each photo showing environmental content has a name assigned to it.
7. Assess the quality of the used ecological photographs through the analysis of their functional connection with the basic text.
8. Examine the presence of photographs that have a purely decorative function in the presentation of environmental themes.
9. Check to what extent environmental photos were used in the tasks and questions in the textbooks.

II stage of research:

10. To compare the quantity of photographs intended for the display of ecological content in the textbook editions from 2007 and 2021.
11. To compare the quality of photographs depicting environmental content in textbooks from 2007 and 2021 based on relevant parameters.

The tasks were carried out on a research sample consisting of a total of 8 geography textbooks for elementary school. Two editions of the publishing house ZUNS, approved in 2007 and 2021, were used. They include textbooks for grades V, VI, VII and VIII:

editions from 2007:

- Geography for the fifth grade of primary school (Tadić & Sitarica, 2007a),
- Geography for the VI grade of primary school (Tadić & Sitarica, 2008),
- Geography for the VII grade of primary school (Tadić & Sitarica, 2007b),
- Geography for the eighth grade of elementary school (Stamenković & Gatarić, 2007),

editions from 2021:

- Geography for the 5th grade of primary school (Tadić et al., 2023),
- Geography for the 6th grade of elementary school (Tadić, 2023a),
- Geography for the VII grade of primary school (Tadić, 2023b),
- Geography for the eighth grade of elementary school (Bubalo-Živković & Gatarić, 2024).

As it was already seen on the basis of the set tasks, the research was carried out in two stages, in which appropriate methods were applied in each stage. In the first stage of the research, textbooks approved in 2021 were used. Using the textual content analysis technique, with the help of appropriate descriptors (Jovanović et al., 2010), the representation of teaching units with ecological content in textbooks was determined. Then the didactic apparatus used for their presentation was examined. Qualitative analysis determined what types of visual representations were used to display environmental content with the aim of examining the extent to which photographs were used. The classification of visual displays is aligned with the relevant research conducted so far regarding the characteristics of didactic apparatus (Trahorsch & Blaha, 2019; Janko & Knecht, 2013; Jovanović, 2010). After identifying the types of visual displays used, quantitative analysis established the relationship between photographs and other types of visual displays in textbooks. Throughout the work, quantitative analyzes are based on statistical data processing through the calculation of arithmetic mean and percentage shares. The explanation of the obtained results and the verification of the set hypotheses was done using the descriptive method.

This paper relies on eleven hypotheses. They were selected on the basis of the research objective and aligned with the set tasks. The following hypotheses are in question:

1. Photographs were mostly used for the visual presentation of environmental content.
2. Environmental photos are evenly represented in geography textbooks for all four grades.
3. The representation of teaching units dealing with environmental content varies among the analyzed geography textbooks.
4. Environmental photos are predominantly found in teaching units that explicitly deal with environmental content, while they are rarely present in units without such content.
5. Geography textbooks are dominated by ecological textual content in relation to ecological photographs.
6. Each photo used to display ecological content has its own name.
7. Most of the photos used to display environmental content are functionally connected to the basic text of the textbook.
8. Photos that are not functionally related to the text were not used to present ecological content.
9. Environmental photos in the function of tasks and questions are the least used category of photos in textbooks.

10. The total number of photographs showing ecological content is higher in the editions of geography textbooks approved in 2021 compared to the editions from 2007.
11. The environmental photographs used in the latest editions of the geography textbooks of the publishing house ZUNS have been improved in a qualitative sense compared to the photographs used in the editions approved in 2007.

Since photographs are considered a particularly important element of didactic apparatus, they are the most analyzed type of visual representations in this research. First, their quantity was assessed, and then their quality. Quantitative analysis determined: the average number of ecological photos per teaching unit, the average number of ecological photos per teaching unit with ecological content and the percentage share of teaching units in which ecological photos are present in relation to the total number of teaching units in the textbook. For the purposes of this paper, the quality of environmental photographs is related to their cognitive function, i.e. with their functional structure. Functional structure means the functional connection of photos with the basic text, questions and tasks in the textbook. Qualitative analysis examined the existence of a name for each photo, numerical identification, the indication of which in the basic text established the connection with the numbered photo and the substantive connection of the photo with the basic text, questions and tasks. Therefore, the photographs are divided into the following categories (Jovanović et al., 2010):

1. photos in the function of the text - their content illustrates the basic text and there are corresponding references for them,
2. photographs indirectly in the function of the text - their content does not fully illustrate the basic text and there are no appropriate references for them in the text (e.g. the photograph is not assigned a name or lacks a numerical identification),
3. photographs as a task - a question or task for independent analysis and conclusion is posed in relation to the photograph,
4. photos that are not in the function of the text - their content is not connected to the basic text and they do not have appropriate references in the text.

After determining the characteristics of the photos used to display ecological content in the 2021 editions of the geography textbooks of the publishing house ZUNS, the second stage of the research is moved on. In the second stage, both editions of geography textbooks for elementary school (from 2007 and 2021) were used, so all eight textbooks. The central method of this stage is comparative analysis. With its application, all the parameters mentioned in the first stage of the research were investigated. The goal was to determine the differences and similarities in the use of photographs as a type of visual representation for the presentation of environmental content in geography textbooks. The time frame for ascertaining changes is a

fourteen-year period. On that occasion, certain negative principles related to the application of ecological photographs were also noted, which remained even after fourteen years. Based on the identified problems and existing recommendations for the application of ecological photographs improved in a qualitative sense, a number of measures were proposed to improve the quality of geography textbooks from the point of view of presenting ecological content. The measures are presented in the appendix of the work.

Results and discussion

The first stage of research - characteristics of the didactic apparatus of the textbooks approved in 2021

In the first stage of the research, we wanted to, in accordance with the research hypotheses and tasks, determine the qualitative and quantitative characteristics of the didactic apparatus in the geography textbooks of the publishing house ZUNS for elementary schools approved in 2021. Qualitative analysis determined which types of visual representations were used to present environmental content. Then, the percentage shares of participation of each type in the total didactic apparatus for displaying ecological contents were determined in order to establish the representation of photographs in the didactic apparatus of textbooks. It turned out that only three types of visual representations were used to display environmental content: photographs, maps and diagrams. Presentations of content on environmental protection using graphs, tables and drawings were missing.

Out of a total of 936 elements of didactic apparatus in the total sample, which included geography textbooks from grades V to VIII, 91 are devoted to environmental content (9.75%). With a share of 86.81%, photographs are the most frequently used element of didactic apparatus for displaying environmental content, but they are also the most frequently used element of didactic apparatus as a whole. This proves the first research hypothesis. In terms of representation, cards are in second place (12.09%), while schemes have the least representation (1.1%). This state of affairs speaks of the marked prevalence of photographs in the didactic apparatus. The observed phenomenon is negative for several reasons - the prevalence of photographs encourages the acquisition of factual knowledge instead of active learning through the development of critical thinking (Postigo & Rozo, 2004; da Silva et al., 2024). The aforementioned phenomenon is problematic because the absence of critical thinking entails a misunderstanding or a complete misunderstanding of the cause-and-effect relationships between man and the environment. If the student does not understand what human activities lead to the emergence of environmental problems, he will

not be able to participate in solving them in any way, therefore the development of his ecological awareness through photographs is also called into question. A similar problem is related to certain geography textbooks used in Turkey, the Czech Republic, Poland and Indonesia (Yasar & Sermet, 2007; Janko & Knecht, 2013; Tracz & Rodzoś, 2015; Purwanto et al., 2015; Trahorsch et al., 2018).

Bearing in mind the dominance of environmental photos in the didactic apparatus, the authors of this research paid special attention to them, analyzing them according to several criteria (three quantitative and one qualitative). Quantitative criteria were used first. The following were observed: the percentage representation of ecological photographs in the total number of photographs used in the didactic apparatus for each of the four classes (Table 1), the average number of photographs with ecological contents per teaching unit, the average number of photographs with ecological contents per teaching unit in which ecological photographs are present and the percentage representation of teaching units in which ecological photographs are registered (Table 2).

Table 1. Representation of ecological photos in the geography textbooks of the publishing house ZUNS, for elementary school, approved in 2021.

Textbook	V grade	VI grade	VII grade	VIII grade
Environmental photos (number)	18	16	27	18
Share in %	16.1	14.54	18.12	13.22
Total number of photos	112	110	149	136

Source: Authors.

As can be seen from table 1, the most ecological photos are in the textbook for Grade VII (27), at least in the textbook for Grade VI (16), while the same number of ecological photos (18) were used in Grades V and VIII. It follows from the above that environmental photos are not equally represented in the geography textbooks for all four grades, so the second hypothesis of the research has not been proven. The uneven distribution of environmental photos by class cannot be linked to the recommendation of many authors that the number of visual displays should be adjusted to the age of the students, so that at younger ages more photos are used for easier knowledge acquisition. Therefore, according to that rule, there should be the most ecological photos in the textbook for grade V, and the least in the textbook for grade VIII (Trahorsch & Bláha, 2019), however, this is not the case in our sample. The distribution of ecological photographs in the observed sample is related to the type of teaching topics, their representation in textbooks for certain classes and the author's need to connect these topics with ecological aspects, and not with the age of the students and their cognitive abilities. In the 6th grade, the

focus is on socio-geographic topics, for the visualization of which photographs are not used, but some other types of visual representations (Michaelidou et al., 2004; Klonari, 2012). Therefore, topics related to population, economy and settlements that dominate the structure of geography textbooks for grade VI are presented without much reference to the ecological aspects associated with them. Therefore, for their visualization, photographs were used to a lesser extent. On the other hand, the physical-geographical topics that are covered in grade V and the geography of the homeland, which is taught in grade VIII, are presented in such a way that they shed more light on the ecological aspects with which they are connected. The reasons should be sought in the goals and outcomes, as well as in the instructions for the authors found in modern curricula, which do not explicitly instruct the authors to connect the features of the economy, population and settlements with the problems of preservation and protection of the environment (Jovanović et al., 2010). The highest degree of connection between geographical and environmental topics was achieved in the 7th grade, when regional-geographical topics are covered. By studying them, students get to know different regions of the world. That is why, in order to gain a better insight into their specificities, greater attention is paid to the state and problems of their environment. However, care should always be taken to ensure that there are as many examples of environmental problems from the local environment as possible in the textbooks, because due to the sense of belonging and identification with the local areas, students develop better environmental awareness and achieve greater motivation to actively form solutions for a sustainable future (Freeman et al., 2022). In this context, the pronounced dominance of examples of environmental problems related to certain regions of the world was recognized as a type of bad practice within the group of analyzed Chinese geography textbooks. The introduction of examples of pollution at the level of the local environment is cited as a potentially good solution for achieving a more purposeful development of environmental awareness among students (Guo et al., 2018).

Table 2. Representation of ecological photos and teaching units that deal with ecological content in the geography textbooks of the publishing house ZUNS, for elementary school, approved in 2021: (a) average number of photos with ecological content per teaching unit, (b) average number of photos with ecological content per teaching unit in which ecological photos are present, (c) percentage representation of teaching units in which ecological photos are registered.

Textbook	V grade	VI grade	VII grade	VIII grade	Average
a	0.62	0.39	0,57	0,4	0,48
b	2.57	3.2	1,5	2	2,02
c	24.13%	12.19%	38,3%	20%	24,07%

Source: Authors.

The relationship between ecological photos and teaching units was examined based on their representation in textbooks. As can be seen from Table 1 and Table 2,

both the number of ecological photographs and the number of teaching units dealing with ecological content varies among textbooks for different grades, on the basis of which the third research hypothesis is accepted. Quantitative characteristics of ecological photographs were determined based on several criteria shown in table 2. First, the average number of ecological photographs per teaching unit was determined. Observed for all four geography textbooks from 2021 together, this parameter is 0.48. This means that, on average, every second teaching unit has one ecological photo, that is, for every 5 photos there is one ecological photo. In the case of each individual textbook, the situation is somewhat different. Textbooks for grades V and VII have a higher average number of ecological photos per teaching unit (0.62 and 0.57), while the observed parameter is below the calculated cutoff (0.48) in textbooks for VI and VIII grade (0.39 and 0.4).

The average number of ecological photographs per teaching unit containing ecological photographs is higher than the previously observed parameter and amounts to 2.02. Based on this, the fourth research hypothesis is accepted. Also, this parameter is significant because it can be used to assess the degree of integration of environmental topics in textbooks. As its value is higher than the average number of ecological photographs per teaching unit, it can be concluded that the ecological contents in the analyzed textbooks are fragmented since they are limited to special sections. That is why it is necessary to pedagogically improve their integration in teaching content through the application of a wider range of topics and cross-curricular connections (Blagdanić et al., 2024; Biström & Lundström, 2020). Unlike the previously observed parameter, although the textbook for 6th grade has the fewest teaching units dedicated to environmental content, it is precisely in it that environmental photos are used most frequently. This practice is not in accordance with the established opinion that photographs are mostly used to show physical-geographic topics and at the lowest age (Klonari, 2012), therefore the observed parameter does not have the expected highest value for the V grade textbook. The mentioned does not represent an example of good practice because it can have negative consequences for the development of environmental awareness. Students in lower grades have less developed cognitive abilities, so the use of visual representations such as photographs is crucial for easier acquisition of complex concepts such as cause-and-effect relationships of environmental pollution (Antal et al., 2020).

The percentage share of teaching units in which photos with ecological content are registered is added to the previous parameter. It amounts to 24.07%, which means that in a sample of 100 photos, approximately every fourth one is ecological. Since the best practice is to most intensively develop the environmental awareness of students at a younger age (Jovanović et al., 2010), it is expected that the most teaching units with ecological photos will be in the geography textbook for the 5th grade. However,

the highest representation of teaching units with ecological photos is found in the textbook for grade VII (38.3%), in which regional geography topics dominate. In order to get to know more fully the specifics of the regions covered in grade VII, the authors of the textbooks decided to present the characteristics of their environment in more detail by using appropriate textual content and ecological photographs. Therefore, it can be said that the personal decision of the author influenced the value of this parameter, and not the already mentioned pedagogical recommendation for creating textbooks. When it comes to the values of the examined parameter for the remaining three grades, the situation is as follows: in the textbook for grade V, the share is 24.13%, in the textbook for grade VIII, it is 20%, and in the textbook for Grade VI is 12.19%.

After quantitative analyses, the ratio of the basic text and photographs in relation to environmental content was evaluated. The pages of the textbook were observed and the ratio of the pages occupied by the textual contents and photographs was assessed accordingly. In the case of all four textbooks, the environmental photos occupy a smaller area on the pages on which they are located compared to the text used. The fifth research hypothesis is hereby accepted. Similar research was conducted by Trahorsch and Bláha (2019) on a sample of several Czech textbooks and they obtained the same results as we did in their study.

In this work, the quality of environmental photographs is related to their cognitive function, i.e. with their functional structure. In the observed sample, the majority of environmental photos were in the function of text (73.24%), which proved the seventh hypothesis of the research. The dominant representation of ecological photos in the function of the text is one of the indicators of a well-constructed didactic apparatus. It has been proven that students superficially pass over visual content if their functional connection with the basic text is small (Peeck, 1993). That is why it is important to arouse the attention of students, that is, to make them interested in the photos used (Watkins et al., 2004). It was mentioned as a prerequisite for realizing the cognitive function and educational potential of photography, and it is realized by using queries in the basic text or the name of the photograph (Postigo & Rozo, 2004). With the questions, students are encouraged to look critically, analyze the displayed visual content and gain insights about the environmental content that cannot be obtained based on the text alone (Antal et al., 2020; Jovanović et al., 2010). Second in terms of representation are photos indirectly in the function of text (25.35%), while photos in the function of tasks are the third (2.41%). Environmental photos that are not in the function of the text were not used at all in the textbooks, which proved the eighth hypothesis of the research. Since such photographs play a minor role in the formation of analytical and logical reasoning skills, it is a distinct positive that they are not used at all (McTigue & Flowers, 2011).

It is interesting that in the entire sample, only one photo appears in the function of the task (in the V grade textbook). The low representation of photos in the task function is extremely unfavorable and is an indicator that the educational potential of photos in textbooks is not being used in the right way (Tracz & Rodoś, 2015). Through the use of photos, on the one hand, textbook authors try to reduce the amount of textual content in the lesson, while on the other hand, they stimulate the imagination, creativity and critical thinking of students by instructing them to analyze the given photos (da Silva et al., 2024). The absence of photographs, the analysis of which would solve tasks related to environmental problems, is unfavorable because it reduces the possibility of acquiring knowledge in a functional way and does not take advantage of the possibility of getting students used to applying the acquired knowledge practically, whenever they can (Živković et al., 2010; Özer-Keskin & Aksakal, 2020). Therefore, it can rightly be expected that students accustomed to the passive possession of environmental knowledge will not be ready for active participation in solving environmental problems in the future (Stanišić et al., 2023). As photos in the function of tasks are the least represented category of environmental photos in textbooks, the ninth hypothesis of the research has been proven.

When it comes to photos that indirectly function as text, there are 18 of them and all of them are present in the textbook for grade VIII. For them, as for all the photographs in that textbook, there are no references at all in the main text because they have no assigned names. Nevertheless, their content almost completely illustrates the content of the basic text. In this way, the cognitive function of the photos is reduced, and the decorative function is more pronounced. Using photos with a purely decorative function is an example of bad didactic practice because the use value of such photos, from the point of view of functional acquisition of knowledge, is extremely small (Rodzoś, 2011). It is important to point out that the existence of names next to each photo does not in itself guarantee their cognitive power, but the way in which the names are formulated is also important. That is why names should be used that accurately and concretely describe the ecological photographs to which they refer (Tracz, 2014). As the names in the analyzed sample are missing along with the photographs in the eighth grade textbook, the sixth hypothesis of the research is rejected. It is important to point out that a similar result was reached when analyzing the didactic apparatus of geography textbooks in the Czech Republic (Janko & Knecht, 2013).

The second stage of research - comparative analysis of the didactic apparatus used in the textbooks approved in 2007 and 2021.

The goal of the second stage of the research was to determine the tendency of implementation of didactic apparatus for the presentation of ecological content in geography textbooks for elementary school. In order to achieve this, a comparative analysis was made of the didactic apparatus for presenting ecological content used in the geography textbooks of the ZUNS publishing house approved in 2007 and 2021. In this regard, all the qualitative and quantitative parameters that were examined in the first stage of the research were also examined in the second in order to establish similarities and differences between the two editions.

The comparative analysis began by comparing the variety of categories of visual displays used to display environmental content. It was found that the number of categories of visual representations used in the editions approved in 2007 was higher compared to the editions from 2021, because the didactic apparatus at that time included graphs in addition to photographs, maps and schemes (Jovanović et al., 2010). However, since it is only one graph (used in the VII grade textbook), the observed difference can be ignored. On the other hand, the change in the quantity of visual representations for the presentation of environmental content is significant. Namely, a total of 108 visual representations were used in the editions approved in 2021, and only 47 in the editions from 2007. At the level of individual categories, 37 more photos and 8 more maps were used in the 2021 editions, while the number of schemes remained unchanged (1 scheme). It is important to highlight the change in the number of ecological photos by class. Thus, in the new edition of the geography textbook for grade V there are 18 ecological photographs instead of the original 6, in the textbook for grade VI there are 16 instead of 13 ecological photographs, in the textbook for grade VII there are 27 instead of 15 and in the textbook for grade VIII there are 18 ecological photographs instead of the original 8. From this it follows that the didactic apparatus for displaying ecological content in the new editions of geography textbooks has been improved in a quantitative sense. Therefore, the total number of photographs for displaying ecological contents is higher in the editions of textbooks approved in 2021 compared to the editions from 2007, thanks to which the tenth hypothesis of the research is accepted. However, it remains unfavorable that: photographs are still the most used element of the didactic apparatus, although according to some research, such a situation does not guarantee the optimal development of critical thinking towards environmental problems, the textbook for grade V does not use enough ecological photographs, considering that the environmental awareness of students should be developed at the youngest age possible (Jovanović et al., 2010), the variety of abstract types of visual representations is small, the absence of tables, graphs and diagrams suggests that in textbooks still

use little statistical data related to ecological content (Klonari, 2012), the absence of drawings and a small number of schemes is unfavorable because their educational potential for simplifying and bringing complex concepts closer to students is not used (Jovanović, 2010).

The comparative analysis established several more changes related to the use of ecological photos in textbooks, both in terms of quantitative and qualitative parameters. The total number of ecological photos used has increased in the latest editions, however, parameters such as the average number of ecological photos per teaching unit, the average number of ecological photos per teaching unit in which ecological photos are present and the percentage representation of teaching units in which ecological photos are registered are also affected by the number of teaching units that deal with ecological content, so it is necessary to check them. As can be seen from table 3, the percentage representation of teaching units in which ecological contents are dealt with has increased in the new editions of textbooks for grades V and VII, while the number of teaching units with ecological content has increased in all textbooks except for the textbook for grade VI.

Table 3. Comparative analysis of the number and percentage representation of teaching units with ecological content in geography textbooks for elementary school approved in 2007 and 2021.

Geography textbook	Percentage representation of teaching units that deal with environmental content in %		The number of teaching units that deal with environmental content	
Grade	Editions from 2007	Editions from 2021	Editions from 2007	Editions from 2021
V	36.37	55.27	8	16
VI	69.09	46.34	38	19
VII	79.41	91.49	27	43
VIII	76.31	71.11	29	32

Source: (Authors; Jovanović et al., 2010).

Taking into account the changes in the number of ecological photographs and teaching units that deal with ecological contents, in the new editions of the geography textbooks, all three quantitative parameters related to the application of ecological photographs increased, which can be seen by comparing the data from table 4 and table 2. Observed at the level of individual classes, the geography textbook for grade VII approved in 2007 had the maximum values for all three parameters.

Table 4. Representation of ecological photographs in the geography textbooks of the publishing house ZUNS, for elementary school, approved in 2021: (a) average number of photographs with ecological contents per teaching unit, (b) average number of photographs with ecological contents per teaching unit in which ecological photographs are present, (c) percentage representation of teaching units in which ecological photographs are registered.

Grade	V	VI	VII	VIII	Prosek
average number of photos with ecological content per teaching unit	0.27	0.24	0.44	0.21	0.29
average number of photos with ecological content per teaching unit in which ecological photos are present	0.3	0.29	0.75	0.23	0.39
percentage representation of teaching units in which ecological photos are registered	9.09	16.67	41.18	10.53	19.37

Source: Jovanović, 2010.

The increased quantity of ecological photos in textbooks is important, but it is even more important to evaluate their quality. That is why a comparative analysis of the ecological photos used in the editions approved in 2007 and 2021 was made in relation to their functional structure. The analysis revealed a lot of differences. Namely, in the sample from 2007, only 5.37% of photos were in the function of text, 30% were indirectly in the function of text, and 33.3% were not in the function of text (graph 1). When it comes to the use of names with photos, in the new editions there was a deterioration in the quality of this parameter because the number of photos without names increased from 5 (Jovanović, 2010) to 18. The negative change refers to the reduced number of photos in the function of tasks. On the other hand, positive changes in the creation of didactic apparatus in the new editions are: the absence of photos that are not in the function of the text, a marked increase in the share of photos in the function of the text and a decrease in the share of photos indirectly in the function of the text. This has achieved greater utilization of the educational potential of photographs through easier memorization of information (Mayer & Gallini, 1990), stimulation of cognitive processes (Peeck, 1993) and increased motivation to learn even when the accompanying textual content is complex (Rodzoś, 2011). Nevertheless, as positive and some negative tendencies were observed in the change in the quality of environmental photos used in textbook editions approved in 2021, the eleventh hypothesis of the research cannot be accepted.

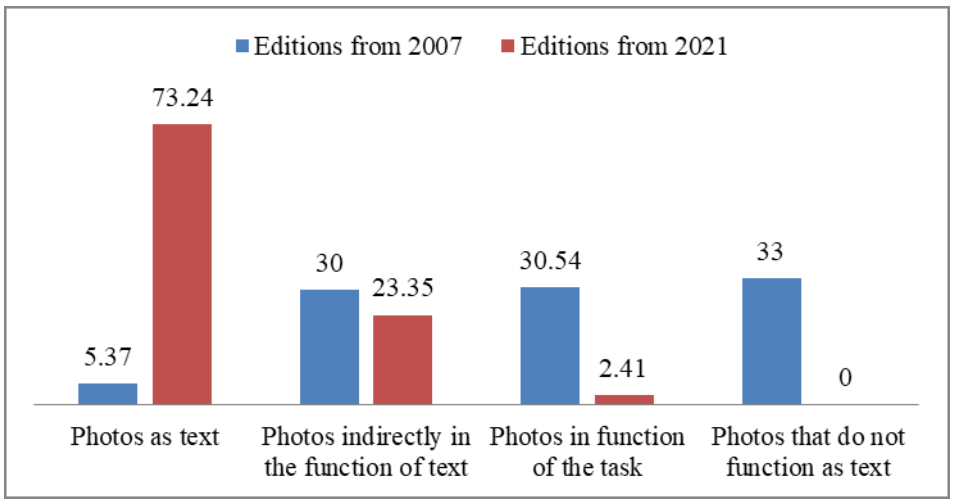

Figure 1. Functional structure of photographs used to present environmental content in geography textbooks approved in 2007 and 2021. Source: Authors.

From the conducted comparative analysis, it follows that the didactic apparatus used in the latest editions of the textbook has been improved in a quantitative sense and partially in a qualitative sense compared to the apparatus used in the editions approved in 2007. The mentioned can be seen on the basis of: a greater number of visual representations for the presentation of environmental content, an increased share of photos that are functionally connected to the basic text, and a decrease in the share of photos with a purely decorative function. Although improved compared to the editions from 2007, the didactic apparatus in the latest editions of the textbooks retained some negative qualitative features, such as: a small variety of the types of visual displays used to present environmental content, the absence of tables, drawings, graphs from the didactic apparatus, the dominant representation of photographs in the didactic apparatus, an increase in the share of untitled photographs, a small representation of photographs in the function of tasks.

Conclusion

The essential determinant of education for the XXI century is the functionality of acquired knowledge. The student is expected to apply what he has learned in practice and through active participation, as a responsible citizen of the global society, to contribute to the development and prosperity of the human community. The development of technologies, which accompanied the increasing accumulation of human knowledge, brought with it the abuse of man's power over nature, so man

became one of the main polluters of the environment and caused an ecological crisis. Precisely on the example of the existing environmental crisis, it was understood that knowledge by itself, without promoting and encouraging responsible behavior in everyday life, has no real educational value and as such is not aligned with the needs of the XXI century (Anđelković, 2018). Based on this idea, the concept of education for sustainable development was developed based on the development of ecological awareness and ecologically responsible actions in everyday life (Kumar et al., 2024). Education for sustainable development is integrated into the curricula of numerous teaching subjects, and in particular, purposeful competences and educational and educational outcomes are realized in the teaching of geography thanks to its holistic approach to the study of the relationship between man and the environment (UNESCO, 2021).

From the point of view of didactics and methodology, it was important to determine the contribution of different teaching aids to the development of environmental awareness among students in geography classes. As the textbook is one of the most commonly used tools in teaching, studies examining its contribution to the development of environmental awareness in geography classes are numerous and mostly confirm its importance in this context (Tracz & Rodzoś, 2015). However, research dealing with the characteristics of didactic apparatus and their contribution to the overall quality of textbooks are few. Photographs are issued as an extremely important element of didactic apparatus (Janko & Knecht, 2014). They have great cognitive potential, direct the student's attention to the teaching content, motivate him to independently develop critical thinking and functionally build his knowledge. When properly used in textbooks, photographs become a powerful tool for developing students' environmental awareness (Jovanović et al., 2010). Bearing in mind the importance of the mentioned topic, as well as the paucity of research related to it, we conducted research with the aim of determining the characteristics of environmental photos used in geography textbooks for elementary school. The idea was to gain insight into the tendencies of their implementation in textbooks, so we conducted a comparative analysis of the textbook editions of the same publishing house, ZUNS, approved in 2007 and 2021.Sprovedenim istraživanjem konstatovane su kako pozitivne, tako i negativne tendencije pri konstruisanju didaktičke aparature za prikaz ekoloških sadržaja.

The comparative analysis established that:

- Photographs are the most commonly used type of visual representations for presenting environmental content.
- Environmental photos are not evenly represented in geography textbooks.
- The share of ecological photos is the highest in the textbook for grade VII, and the smallest in the textbook for grade VI, which is a consequence of adapting

visual representations to the type of teaching topics, and not to the cognitive abilities of students depending on their age.

- In elementary school geography textbooks, every fifth photo is ecological.
- The textbook for grade VII has the highest number of ecological photos in the teaching units that deal with ecological content, because it shows ecological problems specific to certain regions of the world.
- The largest share of teaching units with ecological photos has a textbook for the VII grade, and the smallest textbook for the VI grade.
- Geography textbooks are dominated by textual content, and photographs occupy less than 1/3 of the page surface.
- Almost 3/4 of the environmental photos are functionally related to the basic text of the textbook.
- Ecological photos with a purely decorative function were not used in textbooks.
- Environmental photographs in the function of tasks and questions are the least used category of photographs in textbooks.
- All ecological photographs in the textbook for grade VIII do not have a name assigned, while this is not the case with the ecological photographs in the remaining three textbooks.

Along with positive tendencies, certain negative tendencies were also retained when constructing the didactic apparatus for presenting ecological content in new editions of textbooks. This situation indicates the need to take appropriate measures in the future in order to improve the quality of didactic equipment for the presentation of environmental content. Based on the research results, the following measures were created:

- improve the didactic apparatus by using as many different types of visual displays as possible to present environmental information,
- to balance the ratio of photographs and abstract types of visual representations by reducing the number of environmental photographs,
- increase the representation of tables, schemes, maps, drawings and graphs in didactic equipment,
- increase the number of ecological photos and teaching units that deal with ecological content in order to more easily and effectively develop environmental awareness among students and reduce the fragmentation of ecological content,
- increase the use of abstract types of visual representations in connection with ecological content related to socio-geographical topics in the VI grade textbook,
- avoid the use of untitled environmental photos,

- the names of ecological photographs should be formulated in such a way that they describe the phenomenon/process they depict as precisely as possible,
- avoid the use of ecological photos with a decorative function,
- increase the number of environmental photos related to the tasks in order to encourage students to acquire functional knowledge through and through active self-engagement in working with teaching contents and elements of the didactic apparatus.

The importance of this research is reflected in the possibility of practical application of its results for the sake of improving the quality of textbooks. As the textbook is the most commonly used teaching tool, and environmental education is recognized as key for the development of ecologically aware individuals and the overall development of personality (Vuletić & Miletić, 2024), the conclusions and measures of this research can serve as guidelines for the construction of better didactic apparatus for the presentation of ecological content in geography textbooks in the future. The limitation of the research is related to the sample, because it includes textbooks from only one publishing house. Namely, with a larger and more diverse sample, the adoption of more expedient measures to improve the quality of the didactic apparatus would be achieved, so in the future the analysis should be extended to the textbooks of several publishing houses. Also, in addition to a more diverse sample from the point of view of publishing houses, the survey should also be extended to geography textbooks for secondary education. Due to the great contribution of the didactic apparatus to the overall quality of the textbooks, in the future the characteristics of the didactic apparatus for the presentation of the remaining geographical topics should be investigated, because gaining insight into this issue would enable the construction of a more balanced and high-quality didactic apparatus more in line with the outcomes set by the existing curriculum.

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THE CARTOGRAPHIC INVISIBILITY OF THE ŠARANSKA RIVER IN KOSOVO AND METOHIJA

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Abstract: In the basin of the Binačka Morava (Binač Morava) in Kosovo and Metohija lies the Šaranska River, which flows into it as a left tributary. It is about 23 kilometers long and begins in the territory of the municipality of Gnjilane, in the area of the village of Paralovo. On geographical maps along its course, the hydronyms Brasaljska reka and Livočka reka are inscribed. The main focus of this paper is the analysis of available cartographic and written material about the Šaranska River, as well as a comparison with data collected during field research of its valley and the course itself. The paper aims to determine the occurrence of the hydronym Šaranska Reka on geographical maps throughout history and field research of its valley with a survey of the local population on the use of the hydronym Šaranska Reka, as well as laying the foundations for similar research in the future.

Keywords: Šaranska reka, Brasaljska reka, Livočka reka, Brasaljce, Livoč, Kosovo and Metohija, hydronyms, cartography

Introduction

The discrepancy in the naming of river courses on geographical maps and in written literature, in relation to the "situation on the ground", i.e. how the local population calls them, is a topic that has been researched to a lesser extent in the Balkan Peninsula.

In her book "Hydronyms of Serbia", Dr. Zvezdana Pavlović presents a very detailed overview of all hydronyms that appear among the people and on geographical maps. Pavlović does not explain the reasons for the different names, but from her book, we have an insight into all the hydronyms used to name individual river courses.

In his doctoral dissertation from 2023, "Historical Cartography of Serbia and Old Serbia in the Second Half of the 19th and Early 20th Centuries", author Žarko Ilić deals with the issue of cartography of the territory of Serbia and analyzes historical inaccuracies found on maps.

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Dejan Miloradov, in his manuscript of the book "Šargan (is) not a carp" (in Serbian: Šargan (ni)je šaran), cites two examples of different naming of river courses among the people and on geographical maps – Šaranka (Slijepi potok) between Kneževo and Travnik and Šaranica (Praštava reka) on the slopes of the Rila mountain in Bulgaria.

The following is a list of available literature dealing with this topic:

1. Pavlović, Z. (1996). Hydronyms of Serbia, vol. 13. Belgrade: Institute of Serbian Language, Serbian Academy of Sciences and Arts.
2. Žarko, I. (2023). Historical Cartography of Serbia and Old Serbia in the Second Half of the 19th and Early 20th Centuries. (Doctoral Thesis). Belgrade: University of Belgrade, Faculty of Philosophy.
3. Miloradov, D. (manuscript). Šargan (is) not a carp. Novi Sad: Matica srpska

This study, grounded in available research and data, presents the first comprehensive investigation into the naming of individual river courses in both scholarly literature and fieldwork and observations.

Description of the river flow

The source of the river is located at a location known as Markova Česma at about 800 m above sea level. The Brasaljska River flows from there towards the south in the immediate vicinity of the hamlets (mahalas) of Vučini, Živinci, Mečkari, Došljaci and Petkovići or through them. On the left bank, the Brasaljska River receives several tributaries: Žljebić (300 m upstream of the mahala of Živinci) and Svinjarnik (about 300 m upstream of the mahala of Mečkari). On the right bank, the Đokin stream flows into the Brasaljska River (near the hamlet of Došljaci) (Priština 631-4-3, 1972).

Figure 1. Part of the Šaranska River near the village of Paralovo (Source: private archive, Snežana Dančetović, village of Paralovo)

The hamlet of Hodžovići begins in the village of Brasaljce, after which the river was named. In this part of the stream, it flows near or through the hamlets (neighborhoods) of Hodžovići, Redžovići, Šešivarci and Maljok Mala. On the left bank, it receives the tributaries Hajdučki kladenac (near the Hodžovići neighborhood) and Latinac (about 1 km southwest of the hamlet of Donje Brasaljce). On the right bank, it receives the Kopiljački potok (near the Hodžovići hamlet) and Gušavac (about 1 km southwest of the village of Donje Brasaljce). From here, the Brasaljska River is known as the Livočka River and continues to flow in a south-easterly direction. It flows through the neighborhood of Mejir Mala (village of Brasaljce), then through part of the village of Koretište and the hamlet of Jabučje (hamlet within Gornji Livoč), where downstream there is a small artificial reservoir - Livočko Lake (Priština 631-4-4, 1972; Uroševac 681-2-2, 1972). The lake was built for water supply and recreation purposes in 1968 (Kojić, 2018).

About 500 meters downstream from the dam, the Livočka River receives its right tributary, the Duboki Potok, and downstream from the village of Gornji Livoč - the Nisin and Stojanov Potok. Parallel to the Duboki Potok, the Kalifa Potok flows in from the left. There are no significant tributaries up to the mouth. The Livočka River also flows through the village of Donji Livoč, continues southeast, and about 1 km east of the village of Donja Budriga, flows into the Binačka Morava as its left tributary. The mouth is located at about 470 m above sea level.

Written sources about the Šaranska River and the villages in its valley

In the Middle Ages, the Šaranska River is not mentioned, but records do exist concerning the villages located in its valley, primarily present-day Brasaljce and Gornji and Donji Livoč (at that time a single settlement). Brasaljce is mentioned in the Ottoman registers "Ottoman defter of the District of Branković (1455)", under the name Brajisaljci (Turkish transcr. brayslx), i.e. Brajsalić. At that time, the village was deserted and was repopulated by the Arbanasi at the end of the 18th and during the 19th centuries (Stamenković, 2011; Hadžibegić, 1972; Urošević, 1996).

Livoč is mentioned in the 14th century in the "Panteleimon Charter of Princess Milica" (Urošević, 1931), where it is listed under the name Livoča (село Ливочю на Биньчь Моравь - village of Livoč on Binč Morava) (Reading in the Imperial Society, 1846: 244/33). Interestingly, the village is "located" on the Binačka Morava, which was expected since it was the main stream in the 14th century in the area of Kosovo Pomoravlje, and Livoč is 2 to 3 kilometers away as the crow flies. Today, these areas are mostly inhabited by Arbanasi, and the Serbian population is present in Gornji Livoč.

It is particularly interesting to highlight a document from the first half of the 16th century, more precisely from 1531, where Domenik Kuripešić, a Slovenian diplomat in the Austrian service, in his travelogue "Itinerarium, Wegrayß Kün. May. potschafft gen Constantinopel zu dem Türckischen keiser Soleyman. Anno XXX - MLXXXI" most likely mentions the present-day village of Brasaljce or its immediate surroundings. Namely, since the travelogue was written in German, its later translations also provide certain interpretations by the author-translator. The first interpretation is by Petar Matković, a Croatian geographer and professor at the University of Zagreb (Matković, 1881):

> "…Od Prištine (*Priscina*), u polju Kosovu, podjoše kroz nekoliko sela, pa sa brda *Farma*, vidiše Novobrdo (*Novowerdu*) i spustiše se zatim u dolinu k selu Livoč (*Livotz*). Odovud krenu poljem pa preko brda *Presa* u selo *Roboto*. Iza toga u liepo i dobro obradjeno polje Topolnicu (*Topolnitza*), pa onda opet preko gore Bresa (sic!) u selo *Khatum*.
>
> (…) Od Prištine dakle udariše putnici jugoiztočno, vjerovatno putem, što vodi uz Grčanicu i Bresaljicu (šarenu) u Livoč. (…)"
>
> (ENG),,...From Priština (Priscina), in the field of Kosovo, they rode through several villages, then from Farma hill, they saw Novobrdo (Novowerdu) and then descended into the valley to the village of Livoč (Livotz). From here, they went through the fields and over the hill of Presa to the village of Roboto. Beyond that, into a beautiful and well-cultivated field of Topolnitza, and then again over Bresa Hill (sic!) to the village of Khatum.
>
> (...) From Priština, the travelers therefore continued to the southeast, probably along the road that stretches near Grčanica and Bresaljica (šarena - colorful) to Livoč. (…)"

Interestingly, Matković explains that Kuripešić very likely traveled along the valley of the Bresaljica River, which he "labels" with the epithet "šarena" (colorful). Since the translation is from 1881, and on Austro-Hungarian maps the Šaranska (Brasaljska) River appears under the name "Šarena" (Scharena), it is very certain that Matković found his explanation there. More will be said about the hydronym "šarena" itself in the second part, which deals with cartographic sources.

A later translation of Kuripešić's travelogue is from the mid-20th century, where the translator Đorđe Pejanović provides additional explanations and interpretations (Kuripešić, 1950):

> U ponedjeljak, 26 septembra, krenusmo iz Lovača poljem, pa preko brda Bresalja (Presa) i sela Rapatova (Roboto) dođosmo u lijepo obrađeno polje, Topolnicu. (Topollnitza), pa opet preko brda Bresalja (Presa, Bresa)[123] u selo Katun (Khatum) i tu prenoćismo.

(123) *Matković misli da je to ime sačuvano u današnjem mjestu Bresalju na Bresaljnici nedaleko od Gnjilana*.

(ENG) On Monday, September 26, we started from Lovač through the field, and over the hill of Bresalje (Presa) and the village of Rapatova (Roboto) we came to a beautifully cultivated field, Topolnica. (Topollnitza), Then again, over the hill of Bresalja (Presa, Bresa)[123] to the village of Katun (Khatum) and spent the night there.

(123) Matković thinks that this name is preserved in the present-day village of Bresalje on Bresaljnica, not far from Gnjilane.

In addition to the new version of the name of the village of Brasaljce (Bresalj), from the mentioned source, we learn another version of the name of the Šaranska (Brasaljska) river – Bresaljnica. In the original work in German, the river is not mentioned anywhere, but only the hill Presa/Bresa (Curipeschitz, 1551), so both translators actually have original interpretations, which can very likely be correct if we take into account the geographical designations of the surrounding villages.

The Šaranska River has been discussed as a hydronym by several authors from the late 19th century to the present. In their letters, notes, dictionaries, monographs, and books, this stream is mentioned under different names, including the Brasaljska River and Livočka River.

Todor Stanković, Serbian consul in Priština (1890-1892 and 1897-1898), in his work entitled "Travel Notes from Old Serbia", mentions the Šaranska River (Stanković, 1910):

Положај на којем је Лабљански хан, вододелница је између речице Шаранске, која иде на југ као Моравина приточица и речице Сутеске, која иде у почетку северно, па окрене западно, где са Мраморском постане једна под именом Грачанка, која утиче у Ситницу а ова у Ибар. Шаранска река према томе шаље воду Морави, која извире из Кара-Дага т. ј. са северне стране Скопске Црне горе, а Сутеска пак преко Ситнице и Ибра шаље воду Морави која извире из планине Голије у Краљевини Србији. Положај на коме је Лабљански хан, управо је вододелница обе Мораве.

(ENG) The location of Labljanski Han is the watershed between the Šaranska River, which flows south as a tributary of the Morava, and the Suteska River, which initially flows north, then turns west, where it becomes one with the Mramorska River under the name Gračanka, which flows into the Sitnica River and the latter into the Ibar River. The Šaranska River, therefore, sends water to the Morava River, which springs from Kara-Dag, i.e. from the northern side of Skopska Crna Gora, and the Suteska River, in turn, via Sitnica and Ibar, sends water to the Morava River, which springs from the Golija Mountain in the Kingdom of Serbia. The location of Labljanski Han is precisely the watershed between both Morava rivers.

From the above description, it can be concluded that the Šaranska River originates near the Labljanski han in the village of Labljan. Today, there is a service facility at the site of the Labljanski han, and the watershed is the ridge of an unnamed hill with the highest point at 867 m above sea level (Priština 631-4-3, 1972). All waters that flow from the northern slopes flow towards the Labljanska River and further towards the Gračanka basin, while waters from the southern slopes flow towards the Šaranska River.

Branislav Nušić, as Serbian consul in Priština, mentions the Šaranska River in one of his letters. He sent a letter to Tadeus Terkan on July 4, 1893 (Peruničić, 1985):

> У Шаранској реци Ђоки Мечкаревиђу, доброме домаћину, лопови су везали руке и ноге усијаним ланцем, и тражили паре. Ђока је грдно осакаћен, а за лоповима не трага нико.
>
> (ENG) In the Šaranska River, thieves tied Đoka Mečkarević's hands and feet with a red-hot chain and demanded money. Đoka was badly mutilated, and no one is looking for the thieves.

The letter also represents a plea for assistance, reflecting the dire situation of the Serbian population in the Gnjilane Kaza of the Ottoman Empire at that time. Here, Nušić emphasizes the Šaranska River as a microregion within the Kosovo region, and not explicitly as a hydronym.

Dr. Zvezdana Pavlović, in her dictionary "Hydronyms of Serbia" from 1996 lists the Šaranska River, but also its synonyms (Pavlović, 1996):

> Брасаличка р., г. ток Брасаљице л. Биначке Мораве л. сас. Ј. Мораве […].
> Брасаљица р. = Брасаљска р. = Ливочка р. = Љивочка р.
>
> Шаранска р., л. Биначке Мораве л. сас. Ј. Мораве […].
>
> Брасаљска р. = Брасаљица р. = Ливочка р. = Љивочка р. =
> Шаранска р., л. Биначке Мораве л. сас. Ј.Мораве […].
>
> Ливочка р. = Брасаљица р. = Љивочка р., л. Биначке Мораве
> л. сас. Ј. Мораве […].
>
> Љивочка р. = Ливочка р. = Брасаљица р., л. Биначке Мораве
> л. сас. Ј. Мораве […].
>
> Шаранска р. = Брасаљска р. = Брасаљица р. = Ливочка р. =
> Љивочка р., л. Биначке Мораве л. сас. Ј. Мораве […].
>
> (ENG) Bresalička R., upper course of Bresaljica R., left tributary of Binač Morava, left headstream of S. Morava [...].
>
> Brasaljica R. = Brasaljska R. = Livočka R. = Ljivočka R.
> Šaranska R., l. t. of Binačka Morava l. hs. of S. Morava […].
>
> Brasaljska R. = Brasaljica R. = Livočka R. = Ljivočka R. =
> Šaranska R., l. t. of Binačka Morava l. hs. of S. Morava […].
>
> Livočka R. = Brasaljica R. = Ljivočka R., l. t. of Binačka Morava

l. hs. of S. Morava […].

Ljivočka R. = Livočka R. = Brasaljica R., l. t. of Binačka Morava

l. hs. of S. Morava […].

Šaranska R. = Brasaljska R. = Brasaljica R. = Livočka R. =
Ljivočka R., l. t. of Binačka Morava l. hs. of S. Morava […].

From the attached, we see that Brasaljica, Brasaljska reka, then Livočka and Ljivočka reka are all synonyms for Šaranska reka. Further analysis of the above sourc- es cited by Pavlović in her dictionary reveals that Šaranska reka is mentioned by Atanasije Urošević in the book "Novobrdska Kriva Reka" in two places (Urošević, 1996):

Под именом Криве Реке подразумева се планинска област северно од Горње Мораве и Изморника. У њој се поред целог слива Криве Реке, северне притоке Јужне Мораве, убрајају још и сливови Брасаљске или Шаранске реке.

Старинаца у њему (Паралово) нема, јер је село поред пута са Косова за Мораву, преко спојених долина Мраморске и Шаранске Реке, те се често избегавао овај положај и на тај начина вршила смена његова становништва.

(ENG) The name Kriva Reka refers to the mountainous area north of the Gornja Morava and Izmornik. In addition to the entire Kriva Reka basin, a northern tributary of the South Morava, it also includes the basins of the Brasaljska or Šaranska River.

There are no old people in it (Paralovo), because the village is located next to the road from Kosovo to Morava, across the connected valleys of the Mramorska and Šaranska River, and this location was often avoided, thus changing its population.

In the first part, where the location of the Kriva Reka microregion is described, Urošević emphasizes that the Brasaljska and Šaranska River are synonyms. In the text about the village of Poneš (Urošević, 1996), it is stated that "Muadžerska Ma- hala is next to the Brasaljska River". The same hydronym is also found in the description of the location of the villages of Brasaljce and Paralovo (Urošević, 1996). In these places, the Šaranska River is not mentioned as its synonym.

In his second book, "Gornja Morava i Izmornik", Urošević mentions the Brasaljka River but under the name Brasaljka, describing the transport connection between the Morava and Kosovo regions (Urošević, 1931). On the other hand, the Livočka River appears in three places (Urošević, 1931).

The hydronyms Brasalička reka, Brasaljica and Brasaljska reka appear as synonyms of the same stream, and are also mentioned by Jovan Mišković, general of the Serbian army and president of the Serbian Royal Academy, in his book "Hydrography of the Independent Principality of Serbia" from the end of the 19th century (Mišković, 1880):

> Брасаљица или Љивочка Река. Има два крака: десни има свој почетак под селом Жеговом, протиче кроз село Понеж и зове се Понешка Река. Леви крак долази са брда Гламе, тече кроз село Паралово, и ту се зове Марков Поток, а испод села Брасаловаца прими с лева Брасаличку Река; па се под Марковачким Брдом оба крака састају, одакле се зове Брасаљица или Љивочка Река, протичући кроз село Љивоч, па код села Великинаца утиче у леву обалу Мораве.
>
> (ENG) Brasaljica or Ljivočka Reka. It has two branches: the right one begins below the village of Žegovo, flows through the village of Ponež and is called Poneška Reka. The left branch comes from the Glame hill, flows through the village of Paralovo, and is called Markov Potok. And below the village of Brasalovci, it receives the Brasalička Reka from the left; then below Markovačko Brdo (Hill) both branches meet, from where it is called Brasaljica or Ljivočka Reka, flowing through the village of Ljivoč, and near the village of Velikinac it flows into the left bank of the Morava.

Mišković gives the first detailed description of the entire course of the river, listing many source streams and the hydronym Markov Potok, by which the local Serbian population in modern times calls the source of the Šaranska River. Zvezdana Pavlović, in her book "Hydronymic System of the South Morava River Basin", gave a more detailed description and meaning of the hydronyms of the Brasaljska R. and Livočka R. (Pavlović, 1994):

> БРАСАЛИЧКА РЕКА (г. ток Брасаљице, I).- Мишк. 46. име није мотивисано неким топонимом. Оно је суфиксални дериват хидронима Брасаљица чији је, као ток, саставни део. Имамо случај да су изворишни део реке и њен ток деривати истог корена. Исп. Брасалица р.
>
> БРАСАЉИЦА р. (л. Биначке Мораве, I) = ЛИВОЧКА РЕКА = ЉИВОЧКА РЕКА. — […]. Према ојкониму Брасалце, ИмМ. Ојк. је од породичног имена Брасалци изведеног од антропонима *Брасал из Браслав < Братислав.
>
> ЛИВОЧКА РЕКА (1. Биначке Мораве, I) = БРАСАЉИЦА р. = ЉИВОЧКА РЕКА.- […]. Река је именована према селу које се првобитно звало Ливоча, потврђено у XIV в. „... село Ливочю на Биньчь Моравь" „... По том су биле двије, а двије су и сада, горња и доња, код садашњега Гилана" (РКС). Данашњи ојконими су у мушком роду, Горњи и Доњи Ливоч, ИмМ. Ојк. је грађен суфиксом -оч. Њиме се означава место на коме се на специфичан начин обавља глаголска радња: место на коме је разливена вода; вода која лије; ток који се разлива. Ојк. је изведен од глаголске основе **lei*- 'лити, тећи'. […].
>
> (ENG) BRASALIČKA RIVER (upper stream of Brasaljica, I).- Mišk. 46. The name is not motivated by any toponym. It is a suffixal derivative of the hydronym Brasaljica of which, as a stream, it is an integral part. We have a case where the source part of the river and its stream are derivatives of the same root. Ex. Brasalica R.

> BRASALJICA r. (l.t. of Binačka Morava, I) = LIVOČKA RIVER = LJIVOČKA RIVER. — […]. According to the oikonym Brasalce, ImM. Oik. is from the family name Brasalci derived from the anthroponym *Brasal from Braslav < Bratislav.
>
> LIVOČKA RIVER (l.t. Binačka Morava, I) = BRASALJICA R. = LJIVOČKA RIVER.- […]. The river is named after the village originally called Livoča, confirmed in the 14th century. "... село Ливочю на Биньчь Моравь (village of Livoča on Binč Morava)"... According to that, there were two, and there are two now, the upper and the lower, near the present-day Gnjilane" (RKS). Today's oikonyms are in the masculine gender, Gornji and Donji Livoč, ImM. Oik. is formed with the suffix -oč. It denotes a place where a verbal action is performed in a specific way: a place where water is spilled; water that flows; a stream that flows. Oik. is derived from the verb stem *lei- 'to pour, to flow'. […].

Here we learn that the listed hydronyms are synonyms of the same stream, and that their origin is the oikonym for all three rural settlements – Brasaljce and G. and D. Livoč. With certainty, based on all of the above, we can conclude that both names are of Serbian origin. The hydronym Šaranska reka, nor its origin of the name, is not mentioned anywhere in this book by Pavlović. In the monograph "From the Murmur of the Šaranska River", the author Stanislav Kojić, a professor of biology, describes the villages of Poneš, Paralovo, Labljane and Gornji Livoč, also pro- vides information about the Šaranska River. Kojić explains that the listed villages are "along the main road Gnjilane-Priština along the Livočka River, which in its source course consists of the Brasaljska River, with a tributary of the Šaranska River" (Kojić, 2018). It remains unclear in what sense the author uses the word "tributary" here, since this completely changes the "hierarchy" of the streams.

Later in the monograph, in the section on the village of Paralovo, it is mentioned that the settlement is located "on both sides of the Brasaljska River, which in its upper reaches is called Paralovačka, and in its lower stream Livočka River" (Kojić, 2018). Here we learn for the first time that there is another hydronym – "Paralovačka Reka", but we do not find it anywhere else in the literature.

Dejan Miloradov, an expert associate in the Department of Literature and Language of Matica srpska, explains the origin of the hydronym Šaranska Reka in the manuscript of his book "Šargan (ni)je šaran" (The Šargan is not the carp). The author states that "šaran" is a phonetic variant of the old Serbian word for the poisonous snake Vipera ammodytes (horned viper), which in the past was called "šargan" (Miloradov, manuscript). Since the Šaranska River valley is the natural habitat of the horned viper, hence its name. Therefore, the origin of the hydronym is in the herpetonym, not the ichthyonym, which would be the first assumption. As evidence, it is also stated that the carp fish (Cyprinus carpio) does not live in these waters, nor have there ever been conditions for it to live in them in the past.

Finally, the "Rules on the Determination of Water Bodies of Surface and Groundwater" from 2023, published by the Ministry of Agriculture, Forestry and Water Management, lists the Brasaljska and Livočka Rivers as watercourses on the territory of Serbia, but this document does not mention the hydronym Šaranska River, either as a synonym or as a separate stream (Legal Information System, 2023).

Cartographic sources about the Šaranska River

Considering the length of the Šaranska River and its hydrographic importance, its course was depicted on medium and large-scale geographical maps (topographic maps). Early and late medieval maps of this area were not detailed enough, so the first mention of the river's name must be "searched" for in modern cartography from the 18th and 19th centuries, and onwards.

The oldest map found on which the course of the Šaranska River is drawn and its name is inscribed is a work of French cartography, more precisely by the cartographer Pierre Lapie from 1822. On the aforementioned map we encounter the hydronym Savona reka (Lapie, 1822). This toponym is very likely a mistake in transcription or field recording and it is most likely that the name Šarena reka has been changed.

Figure 2. Fragment of a French map from 1822 showing the Šaranska River (Source: Lapie, 1822)

The source used by Lapie to compile this map was very likely a descrip- tion by the French officer Guillaume de Vaudoncourt, who produced a detailed map of European Turkey with an accompanying document describing the administrative division into sanjaks (de Vaudoncourt, 1818). It is unusual that the name Lacco R. appears further down the map, and it seems to refer to the Binačka Morava, but this is difficult to conclude and confirm from the source.

a) Austro-Hungarian and German cartography

The oldest Austro-Hungarian geographical map showing and recording the course of the Šaranska River dates from approximately 1830, and the author is the Austrian cartographer Franz Fried. The map of Serbia, Bosnia, Turkey, Croatia, Herzegovina and the country of Montenegro published by Artaria from Vienna shows the course with the name Savona reka (Fried, 1830?). It is almost certain that the main source for the creation of this map was the map by P. Lapie. In 1861, the German diplomat and philologist Johann Georg von Hahn published a "croquis" of the South Morava basin, which he calls "Bulgarian Morava" in his travelogue (von Hahn, 1861). The course of the Šarans- ka River is also drawn on the map, and it is marked with the name Šar(e?)nka (Croquis des westlichen Gebietes der Bulgarischen Morava, 1861). Based on the notes of J. G. von Hahn, the German cartographer Heinrich Kiepert made a map of the Drim and Vardar river basins, and on it we find the name Scha- rena (Kiepert, 1867). The map by Friedrich Handtke from 1877, which shows European Turkey, is very interesting, and there we encounter the hydronym Scharanka (Handtke, 1877).

Figure 3. Fragment of an Austro-Hungarian map from ~1830 showing the Šarnska River (Source: Fried, 1830?)

The Military Geographical Institute in Vienna published several detailed geographical maps of the Balkan Peninsula in the period from 1876 to 1918. In all editions, the Šaranska River appears with different names. The first collection of maps at a scale of 1:300,000 dates from 1876 and on it we notice the hydronym Bresaljca r (M.12 Pristina, 1876). On the map from 1877, the river is inscribed as Bresaljica (Šarena) (Pristina, 1877), and in 1912 as Bresaljica (39°43' Pristina, 1912), while on the edition from 1918 the hydronym is recorded – Bresalce R (39°43' Pristina, 1918).

It is interesting to note that the lower course of the Šaranska River appears on some Austro-Hungarian maps under the names Livoč (39°42' Skopje, 1898) and Livoča (39°42' Skopje, 1900; 39°42' Skopje, 1906; H 8 Skopje, 1910; 39°42' Skopje, 1916 & 39°42' Skopje, 1917).

The hydronym Livoča appears on several other Austro-Hungarian maps from the beginning of the 20th century by various publishers. The Viennese publisher "Rudolf Lechner," in a map of the Balkan Peninsula issued after the Second Balkan War (1913/14),[2] labels the entire course of the Šaranska River with the hydronym Livoča (Übersichtskarte des südlichen Kriegsschauplatz, 1915?). "Freytag & Berndt" from Vienna published two geographical maps, one in 1916, where the upper course of the Šaranska River was named Bresaljica, and the lower course as Livoča (G. Freytags Karte von Bulgarien, 1916), and the other two years earlier (1914), with a very interesting error. Namely, on that map the river is written as Liboča (G. Freytags Karte von Serbien, 1914), and the explanation most likely lies in the incorrect transcription from Cyrillic to Latin: вb. This error is also unusual due to the fact that the village of Livoč is written completely correctly on the same map – Livoč.

A war map from 1914 showing positions and fortifications in Serbia and the central Balkans had an unusual printing error, so the Šaranska River became "oča" (Übersichtskarte der Befestigungen auf dem Balkán, 1914). Two years later, another map in German showing the course of the Šaranska River contained a major material error. Next to the stream where the name Šaranska River should be written, there is the hydronym Leskovica (Mittel-Serbien, 1916). Leskovica is another (older) name for the Kriva River (Mišković, 1880), so here there was an error in writing the name next to the corresponding streams. On the same map, near the course of the Kriva River, there is the hydronym Desivojka, and Desivojka is the left tributary of the Kriva River (Stanojević, 1929).

In the first half of the 20th century, several maps of Albania were printed in Vien- na, showing part of the Kosovo Pomoravlje region and even the course of the Šaranska River. On the oldest map, from 1917, we encounter the hydronyms Breslace r. and Livoča (Albanien, 1917), while on the later ones from 1928 and 1940, only the second name appears – Livoča (Karte von Albanien, 1928; Karte von Albanien, 1940).

An analysis of all available maps in German has revealed a frequent occurrence of incorrectly transcribed toponyms from the wider area of Novo Brdo, Priština and Gnjilane. The most realistic explanation for such omissions can be found in poorly collected field data, "rewriting" of previously incorrectly recorded names, and inadequate transliteration and adaptation to the spirit of the German language.

[2] In the bibliographic information on the official website where the geographic map was published, the year of publication is listed as 1880; however, the map's content and the depiction of state borders clearly indicate that the map could not have been created earlier than 1913.

b) Ottoman cartography

Ottoman cartographers generally presented their territories in Europe as a depictedwhole, without showing details (rivers, settlements, administrative divisions), and until the end of the 19th and the very beginning of the 20th century, no geographical map showing the Šaranska River can be found in Ottoman sources.

The first modern Ottoman atlas, the Cedid Atlas, was printed in Istanbul in 1803. It shows the Balkan Peninsula, but without too much detail, and the Binačka Morava valley is not shown in it.

A detailed map of the Kosovo Vilayet from 1883 shows the entire Binačka Morava basin, with all tributaries, including the Šaranska River. Along the course of the Šaranska River, there is a name in Ottoman Turkish: Berese(liçe, ?) suyu (Kosova vilayeti haritası, 1883). The name of the stream clearly points to the village of Brasaljce, while the second part of the name "suyu" means "stream". Translated into Serbian, it would mean Brasaljski potok, which confirms the motiva- tion for naming river courses from the nearest oikonyms.[3]

A map of the Balkan Peninsula was published in the Ottoman atlas of 1893 (Yeni Coğrafya Atlası, 1893) in which the Kosovo Vilayet is shown, but not the Šaranska River, while the map from the atlas of 1898 shows the course of the river, but its name is not written (Yeni Coğrafya Atlası, 1898). About a decade later (1909) in the new Ottoman atlas the Kosovo Vilayet is shown in detail, but there are no other river courses in it except the Morava River (Memâlik-i mahrûse-yi şâhâne'ye mahsûs mükemel ve mufassal atlas, 1909).

Between 1900 and 1902, a series of detailed topographic maps of the remaining territory of the Ottoman Empire on the Balkan Peninsula was produced by the Presidency of the General Staff of the Empire. The mentioned maps are distinguished by very detailed orography and hydrography. The "Priština" sheet presents the course of the Binačka Morava with its tributaries, one of which is the Šaranska River, which is designated by the hydronym – Lîvôç deresi (transl. Livoch deresi), which translated into Serbian would mean – Livočki potok (Rumeli-i şahane haritası, 1901–02).

Shortly after the last published atlas, the Balkan Wars began, which also led to the liberation of the territories of Kosovo and Metohija from Turkish rule, and this area also "left" the sphere of interest of Ottoman cartographers.

[3] Translation and interpretation from Ottoman Turkish by Dr. Ognjen Krešić, Institute for Balkan Studies, Serbian Academy of Sciences and Arts (SASA).

c) Russian and Soviet cartography

The oldest Russian map that shows the territory of Serbia and its surroundings in detail was created in 1828, and is the work of Major General Hatov. The map is very informative for the beginning of the 19th century and on it we also find a detailed division of the Ottoman Empire into sandzaks. In the then Vučitrn sandzak there is also the Šaranska River, and along its course there is the following hydronym: P. Савонорiька (transcr: R. Savonoreka) (Hatov, 1828). We can assume that Hatov used Lapje's map from 1822 as a model and basis, so the mentioned hydronym is a translation or transcription into Russian of the name Savona reka.

Figure 4. A fragment of a Soviet map from 1976 showing the Sharan River (Source: Pristina K-34-16, 1976)

The Balkan Peninsula came into the sphere of more intense interest of Russian cartographers in the second half of the 19th century, especially after and during the Crimean War (1853–1856). The first detailed map of the European part of Turkey of that era was created in 1876 in Saint Petersburg and brings us a very informative view of the Binačka Morava basin. The Šaranska River is also drawn, and at the end of its course is the name Брешска (transcr: Breshska) (Map of European Turkey, 1876).

The origin of this name and what exactly it refers to is not clear, since this is the first and only appearance. The question remains whether it is a "corrupted" version of the hydronym Brasaljska, since no similar term has been found in the literature and sources, or whether it is more likely a writing error. In the following period, from 1905 to 1916, the Šaranska River is regularly shown on maps of the Balkan Peninsula and the border areas of Austria-Hungary, but its hydronym is absent on them. The same situation is found on the map of the southern part of the Balkan Peninsula from 1929 (Strategic Map of Central Europe, 1929).

Later Soviet topography brings us more detailed maps of Yugoslavia and the Balkans, and on two maps from 1976 we find the following data: the upper course of the river is called Баесоличка (transcr: Baesolichka), and the lower course Ливочка (transcr: Livochka) (Pristina K-34-55, 1976; Pristina K-34-16, 1976).

It is not clear how the hydronym Baesolichka "emerged" in the Russian language, so we can only assume that this name is a mistake, especially since the village of Brasaljce is named completely correctly on the map – Brasaljce (*Брасаљце*).

d) Serbian and Yugoslav cartography

One of the oldest Serbian maps showing the course of the Šaranska River, but not its name, is the work of Professor Vladimir Karić from 1888 and shows the then territory, relief and hydrography of the Kingdom of Serbia (Karić, 1888).

The first maps showing the name of the river were created in 1893 as part of the first military mapping of the territory of Serbia. In the same year, two maps were published showing the course of the Šaranska River under the name Бресаљица река (transcr: Bresaljica reka) (VIII. Gr. Kuršumlija, 1893) and one with a slightly different name – Бресаљца река (transcr: Bresaljca reka) (General Map of the Kingdom of Serbia, 1893). The same hydronym – Bresaljca River can also be found on the Traffic Map of the Kingdom of Serbia from 1897 (Traffic Map of the Kingdom of Serbia, 1897).

Figure 5. A fragment of the General Staff Map (Kuršumlija sheet) from 1893 showing the Šaranska River
(Source: General Map of the Kingdom of Serbia, 1893)

Croquis were one of the first methods of mapping the territory of Serbia at the end of the 19th century, and were done by military officials. One such croquis was created at the very beginning of the 20th century and shows the Gnjilane area during the Serbian-Turkish wars of 1877/78 (Kroki Gnjilanske okoline […], 19??). The drawing shows the valley of the Šaranska River in great detail. Between Paralovo and the village of Markova, the stream is inscribed as Марков поток (trancsr: Markov potok), and from Brasaljce (Bresalovci) to Gornji Livoč as Бресаљичка река (transcr: Bresaljička reka). The lower course from G. Livoč to the confluence with Binačka Morava is called Ливочка река (transcr: Livočka reka).

At the very end of the 19th century, more precisely in 1900, Dimitrije Antula created the Mining Map of the Kingdom of Serbia at a scale of 1:400,000, and the Šaranska River is recorded with the hydronym Бресаљца р. (transcr: Bresaljca r.) (Antula & Simeonović, 1900).

Dragutin Deroko, a geographer and cartographer, a contemporary of Jovan Cvijić, published in 1904 the General Map of Old Serbia and Macedonia in 12 sheets. On two sheets, one can see the course of the Šaranska River, where in the upper course is the hydronym Бресалце р. (transcr: Bresalce r.) (Derok, sheet II, 1904), and in the lower course Livoča (Derok, sheet V, 1904). The same two names are found on the map from the period 1910-1916, published by the Geographical Department of the General Staff at a scale of 1:150,000. The listed hydronyms can be seen on sheet E7 Priština (Map of the Kingdom of Serbia and neighboring countries, 1910–16).

Stevan Bošković, a surveyor and cartographer, a general in the Serbian and Yugoslav armies, prepared a very informative map of the Serbian kingdoms and neighboring regions in 1914. On it, the course of the Šaranska River is named by only one hydronym – Ливоча (Livoča) (Bošković, 1914).

During the First World War, the Geographical Department of the Supreme Command based in Corfu produced a map of the Yugoslav lands at a scale of 1:200,000. On the Z-5 Priština sheet, the Šaranska River is drawn with two hydronyms – Бресаљица (Bresaljica) (upper course) and Ливоча (Livoča) (lower course) (Map of the Yugoslav lands, sheet Z-5, 1916–18). In the same period, another interesting series of maps was created at a scale of 1:100,000, and on the Priština sheet, we encounter the hydronyms Бресалце р. (Bresalce r.) (upper course) and again Livoča (lower course) (Topographic map of southern Serbia and northern Albania, 1916?).

The period after the First World War brought a new series of detailed maps, now of the common state – the Kingdom of Yugoslavia. In the period from 1929 to 1940, the Military Geographical Institute of the Kingdom of Yugoslavia issued a series of topographic maps at a scale of 1:100,000. The course of the Šaranska River appears on two sheets – Kumanovo-Skopje and Lebane. The first sheet shows the upper course of the river with the hydronym Бресаљица (Bresaljica) (Kingdom of

Yugoslavia, sheet Kumanovo-Skopje, 1939), and the second sheet shows the lower course and the hydronym Ливочка река (Livočka reka) (Kingdom of Yugoslavia, sheet Lebane, 1939).

After the Second World War and the change in the social and political system, new maps were produced for the needs of the Military Geographical Institute of the then FPRY and SFRY. In the period from 1950 to 1958, the Institute published an album of maps of the Federal People's Republic of Yugoslavia at a scale of 1:150,000. The course of the Šaranska River is drawn on sheets Lebane 155-3 and Kumanovo 166-1. In the upper part of the course, it is called Bresaljička reka, and in the lower part Livočka reka (Album of maps of the FNRJ, 1950–58).

The Yugoslav Lexicographic Institute in Zagreb published an eight-volume Encyclopedia of Yugoslavia during the 1960s. Volume 6 also presents a map of Priština and its surroundings at a scale of 1:300,000, and the course of the Šaranska River is named Livočka reka (Encyclopedia of Yugoslavia, 1965).

During the period from the beginning of the 1960s to the end of the 1980s, several editions of topographic maps of the SFRY were printed and published at scales of 1:25,000 (Priština 631-4-4, 1972; Priština 631-4-3, 1972; Uroševac 681-2-2, 1972),

1:50,000 (Priština 631-4, 1985; Uroševac 681-2, 1985) and 1,100,000 (Priština 631, 1987; Uroševac 681, 1987). All editions show the course of the Šaranska River, in great detail with all tributaries from the source to the mouth. The 1:25,000 scale map is particularly detailed and comprehensive. Regardless of scale, all maps contain two hydronyms – Bresaljička reka (upper course) and Livočka reka (lower course).

e) Other cartographic sources

In addition to the above, the Šaranska River is also drawn and inscribed in several other individual cartographic sources – British, Russian, French, Italian and American cartography.

Particularly interesting, although it does not have the river's name inscribed, is the map by the French cartographer and military engineer in Napoleon's army, Gaetano Palma, from 1811, on which the course of the Šaranska River. The map is very detailed for the very beginning of the 19th century, and it is specific that it is bilingual, with toponyms written in French and Greek.

A British map from the beginning of the 19th century shows the Balkan Peninsula during the Ottoman rule. Although at first glance quite detailed, the map has many shortcomings and a large number of material errors, so in the vicinity of Priština there is a place called Kassovo and the non-existent Metrovitza river. The course of the Ibar is not drawn, and South Morava is called East Morava. The location of most of the settlements and the entire hydrographic network are very questionable. At the

place of the Šaranska River, however, there is a stream named – R. Lacco, for which no source has been found that would explain its origin (Turkey in Europe, 1832). This British map was created about ten years after Lapie's map and it is clearly visible from the style and toponymy that it was "copied" from it, since the hydronym Lacco is also found there, but in a different location, slightly upstream.

One map in Hungarian from 1914 shows the territory of the entire Serbia. It is quite detailed with a large number of different toponyms, especially in terms of settlements. The Šaranska River is drawn and shown on this map, and next to its course is the name – Livocsa (transcr. "Livoča") (Szerb háború kézi keréké, 1914).

During World War II (1941), the Italian Military Geographical Institute (Italian: Istituto geografico miltare) published a series of 40 maps showing the territory of the then Kingdom of Yugoslavia at a scale of 1:100,000. The Lebane sheet also shows the Šaranska River, and the hydronym Bresalička potok is inscribed next to it (Carta Jugoslavije, 1941).

In the same historical period, the Geographical Section of the General Staff within the British War Office published a series of detailed topographic maps of the Kingdom of Yugoslavia in 1943, in cooperation with the American Cartographic Service. On the 1:250,000 scale map, the hydronym Livočka appears (Yugoslavia-Skoplje, 1943), while the more detailed edition at the 1:100,000 scale contains two names – Bresalička R., in the upper part of the course (Yugoslavia-Lebane, 1943) and Livočka R., in the lower part of the course (Yugoslavia, Kumanovo-Skoplje, 1943). It should be noted that the latter maps are reproductions of the Yugoslav ones from 1939.

After the NATO aggression on the Federal Republic of Yugoslavia, the National Imagery and Mapping Agency of the USA produced maps at the scale of 1:100,000 for the needs of American troops stationed in Kosovo and Metohija. On one of them, the Šaranska River is represented by the already established toponym Brasaljska Reka (Priština, Serbia 3280, 2000).

f) Modern digital cartographic sources

In modern digital cartography of the 21st century, numerous online programs and applications provide detailed maps of practically the entire world. One of the most well-known such tools is Google Maps. Today, state geodetic authorities maintain geoportals offering extensive detailed data displayed on interactive maps—cadastral information, settlements, administrative divisions, hydrography, topography, and more.

On the geoportal of the Republic Geodetic Authority of Serbia, you can view a topographic map at a scale of 1:250,000, which shows the course of the Šaranska River, and next to it are the hydronyms Брасаљска река (Brasaljska reka) (upper

part of the stream) and Ливочка река (Livočka reka) (lower part of the stream) (Geoportal Serbia).

The geoportal of the temporary institutions in Pristina contains a topographic map at a scale of 1:250,000 for the territory of the Autonomous Province of Kosovo and Metohija. In the valley of the Šaranska River, hydronyms in Albanian can be seen - Lumi Bresalc and Lumi Livoç. On a more detailed topographic map of a larger scale (1:25,000), five different hydronyms can be seen along the river's course. In the vicinity of the river source, next to the village of Paralovo - L. Parallove, then around Brasaljce - L. Bresalc, and from Poneš to the mouth, there are as many as three variants - L. Livoq, L. Livogj and L. Livoç (Geoportal Kosova). It is noticeable that there are no names written in Serbian on the maps.

Several free tools with cartographic content are available on the Internet, among which Google Maps, OpenStreetMaps, MapCarta and BingMaps stand out. The most popular and most used are certainly Google Maps, and on them you can see the almost exclusive representation of the Albanian language for the area of Kosovo and Metohija. The Šaranska River is marked with two names, Lumi i Livoqit and a particularly interesting hydronym between the villages of Gornji and Donji Livoč – Lumi i Muhaxherve (Google Maps). The latter name is certainly related to the Muadžerski mahala of the village of Gornji Livoč.

OpenStreetMaps, MapCarta and BingMaps have a common feature with Google Maps in terms of naming the Šaranska River. The Albanian language is dominant on all tools and only one, already seen hydronym appears – Lumi i Livoqit (OpenStreetMaps; MapCarta; BingMaps).

It is noticeable that in all publicly available and free cartographic applications, the Albanian language completely dominates in toponymy, and there are almost no names in Serbian. This disproportion and obvious favoritism of one language has the consequence that Serbian toponyms, and especially hydronyms, are gradually "dying out" in the virtual (online) world, which is certainly more frequently used today than in printed and written cartographic materials.

It would be expedient and useful to do everything possible to "return" Serbian names primarily in areas where the Serbian population is the majority or has a certain percentage. This would achieve at least a minimal "toponymic linguistic balance" that has been completely disrupted in the last decade or two.

Field research of the Šaranska River valley

During the summer of 2024, a field research was conducted along the upper and middle course of the Šaranska River, during which the local Serbian population was

surveyed in the villages of Labljane, Paralovo, Poneš, Izvor and Jasenovik. Data from the villages in the lower reaches – Donja Budriga and Gornji Livoč – were collected "remotely" (Appendix No. 6).

Table 1. List of villages and their neighborhoods visited during the field research

Village	Neighborhood
Labljane	Đorgovci
Paralovo	Stamenkovci, Došljaci, Perići
Poneš	Museljačka
Izvor	Dimovići
Jasenovik	Filipovac
Gornji Livoč	/
Donja Budriga	/

The target group of the survey was the elderly population from the aforementioned villages (at least 80 years old), who had spent most of their lives in that area. During the survey, an identical question was asked: "What is the name of the stream that flows through the valley along the main road towards Gnjilane?" The survey collected responses from twenty people from all villages. The answers of almost all respondents were the same – "Šaranska reka". A respondent from Donja Budriga confirmed that the lower part of the stream is indeed called Livočka reka among the Serbian population, and the upper part is called Šaranska reka.

Table 2. Number and percentage of responses received from respondents according to hydronyms

Total number of respondents	Šaranska reka	(%)	Brasaljska reka	(%)
20	19	95	1	5

The only exception was the respondent from Gornji Livoč, who confirmed that the lower part of the river is known as Livočka (emphasizing that this name begins at the confluence of the Gušavac stream and the Brasaljska river). This also provided us with the first field data that someone among the Serbian population calls the Šaranska reka - Brasaljska reka.

All other respondents were not familiar with the hydronym Brasaljska reka and/or Brasaljica, nor had they encountered it. We received this confirmation in all villages and hamlets where Serbs live in the upper and middle reaches of the river. The villages of Izvor and Jasenovik are geographically oriented towards the Novo Brdo region, but the population also is economically linked towards the Šaranska river valley, and this is why the locals know this river. A respondent from Poneš said about the Brasaljska River that it is: "probably a tributary of the Šaranska River that flows through the village of Brasaljce".

The research was not carried out in the eponymous village of Brasaljce, because there has been no Serbian population there since the mid-20th century, nor in Donji Livoč, for the same reason. It is precisely the village of Brasaljce that is potentially key to the "problem" of naming the Šaranska River on maps. Namely, this village is the only settlement positioned on the Šaranska River itself along the Priština-Gnjilane highway and, as such, is ideal for field research. Other villages along the river valley are located on the surrounding hills and are relatively inaccessible, unless you turn off the main road.

The Šaranska River valley is gorge-like in its upper and middle parts, and from Livočko Lake it opens widely towards the Gnjilane Basin. In this part there are two more larger villages – Gornji and Donji Livoč, which are positioned on the river itself. The village of Donja Budriga is located a few hundred meters from the mouth of the Livočka River into the Binačka Morava.

During field research, moving from one hamlet (mahala) to another took about twenty to thirty minutes, although the distance between them, in some cases, was less than one kilometer. The reason is the very poor roads, made mainly of crushed stone. Researchers of the 19th and 20th centuries, while these areas were still under Ottoman rule, almost certainly faced an even worse transport infrastructure. The main road at that time was the Priština-Gnjilane highway, and the only settlements along the road were Brasaljce and Livoč.

We can safely say that researchers (travel writers, cartographers, etc.) who visited these regions obtained most of their data precisely by visiting the aforementioned village, and since there were no Serbs in it, but exclusively Albanians, the answer they could get was that the stream was called the Brasaljska reka.

In Albanian, the Šaranska (Livočka) river is called lumi i Bresalcit and lumi i Livoçit (Tahiri et al, 2012; Pešikan, 2010). Translated into Serbian, the names mean – Brasaljska reka and Livočka reka. The above findings indicate that the Šaranska River was named among the Albanian population after the villages through which it flows – Brasaljce and Livoč, whose names are certainly of Serbian origin.

In order to present a clear picture of the ethnolinguistic situation during the 19th and early 20th centuries in the Novo Brdo region and the upper Morava, based on which one can speak about the influence of some of the languages on the researchers of that time, it is necessary to consult official censuses.

We know from sources that Brasaljce was a deserted village in the middle of the 15th century (Serbian Encyclopedia). In the 17th century, the Novo Brdo mines were active in the immediate vicinity of the settlement, and mining colonists – Catholics – also moved in. In the middle of the 18th century (around 1730), the settled Arbanasi found a Serbian population that eventually left the village. At the beginning of the 19th century, the last Serbian family left Brasaljce (Urošević, 1996).

The Ottoman registry book from 1850 does not list the Christian population of Brasaljce, which suggests that there were no Serbs in it (Üsküb eyaleti Priştine kaymakamlığı […], 1850). According to the census data from 1901, only a Muslim population lived in Brasaljce (Rumeli İslâm Araştırmaları Dergisi, 2020). A source from 1935 confirms that even in that period, no Serbs lived in the village, but exclusively Albanians (Urošević, 1996).

Table 3. Ethnic composition of the Brasaljce settlement according to the results of the 1948-2011 census.

Year	Total population	Serbs	Albanians	Other
1948.	2.913	1.086	1.821	6
1953.	3.192	1.222	1.925	45
1961.	1.694	7	1.679	8
1971.	2.071	13	2.056	2
1981.	2.399	0	2.396	3
2011.	2.823	0	2.823	0

Sources: Population Census 1948; 1953; 1961; 1971; 1981; 2011

At first glance (Table 3), it is noticeable that in the 1948 and 1953 censuses, the share of Serbs in Brasaljce was around 40%, but this is a consequence of various administrative-territorial reforms of districts and municipalities during the first years after World War II (Official Gazette of the People's Republic of Serbia, 1955). The ethnic and religious structure of the village of Brasaljce in the last approximately 200 years largely suggests that its homogeneous population composition and favorable location had a decisive influence on researchers, travel writers and geographers/ cartographers who moved through these areas.

Conclusion

From all of the above, it can be concluded that the situation "on the ground" and the cartographic and bibliographical picture do not match. The Šaranska River as a hydronym is present among the Serbian population of the Kosovo Pomoravlje, but despite this, it is not found on any map in the Serbian language from the beginning of the 19th century to the present day.

It is a fact that in Austro-Hungarian cartography at the beginning and middle of the 19th century, various forms of hydronyms associated with the Šaranska River appeared – Šarenka, Šaranska and Savona reka. The hydronym Šaranka (Scharanka) is particularly important here, because it best reflects the spirit of the Serbian language

in naming natural phenomena, processes and geographical objects through the use of the folk herpetonym "šaran" for the snake species - horned viper (in Serbian scientific literature: poskok).

However, despite the initial closeness to the hydronym Šaranska reka, the name of this stream in the second half of the 19th century, both in the Austro-Hungarian and in all other cartographies, is lost to the oikonym of the village of Brasaljce. Certainly, the influence of the Albanian form of the hydronym, the proximity of the village of Brasaljce to the main road and the "laziness" of the explorers of that time influenced the herpetonym "šaran" to disappear from the maps.

Most geographical maps of the 19th and 20th centuries were created by copying and translating the first ones. Such is the case with the French map by Pierre Lapie from 1822, which was the source for most maps in the next 30–50 years, which was clearly noticeable in the style, design and toponyms. The once incorrectly written hydronym "Savona reka" appears in the following decades on Austro-Hungarian, French and Russian maps, without any verification and revision of toponyms.

If foreign cartographers can be "justified", it remains unclear why the hydronym Šaranska reka is unknown in Serbian cartography. The first maps of these areas did, in principle, follow the Austro-Hungarian ones, but despite this, we did not encounter the "copying" of the hydronym Šaranka, but the oikonymically derived hydronyms Brasaljska reka, Brasaljica, Bresalce, etc. immediately appear.

Even after the liberation of the territory of Old Serbia and its incorporation into the Kingdom of Serbia, field research did not lead to the "discovery" of the Šaranska River, but rather, it apparently continued with the "rewriting" of existing toponyms and hydronyms.

We can confidently say after four days spent on field research of the Šaranska River valley that field work is not easy – it requires time, patience, great effort and good organization, and certainly getting to know the local population. All of this was much more difficult for our colleagues in the 19th and early 20th centuries, who traveled from neighborhood to neighborhood on horses and in carts.

In the 21st century, the Šaranska River has still not been "discovered" on modern maps. Despite the existence of digital topography, various possibilities for recording terrain and, in this case, most importantly, fieldwork and surveying the local population, toponyms that are 150-200 years old are still being copied today, without checking the "local" condition.

Based on the fieldwork conducted, research of all available maps, conversations with the local population and a review of available written sources, the Brasaljska reka should be renamed on maps to the name Šaranska reka, both for historical and contemporary reasons that support this. For all of the above, a new geographical map of the Šaranska River valley is attached to this paper (Figure 6).

Figure 6. Geographical map of the Šaranska River Valley (Source: Author)

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EDUCATIONAL AND TOURISTIC POTENTIAL OF THE GEOGRAPHICAL CENTER OF SERBIA

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Abstract: The geographical center of Serbia is one of the points whose coordinates are significant in geostrategic, but also cultural and educational terms. Many countries in the world have managed to take advantage of the fact that some of the important geographical points are located on their territory and turn them into one of the tourist attractions. The paper presents one of the countless possibilities for spatial planning of the geographical center of Serbia - as a geographical polygon, which is confirmed by the adjective "geographic" in the name of the point, and on the other hand, it represents a universal way of marking such important points, which can find their place in tourism, but also in the development of primary and secondary education, through various types of teaching in nature (fieldwork, one-day trip, excursion, outdoor classroom).

Keywords: geographical center, Serbia, spatial planning, geographical polygon

Introduction

The central point of Serbia has been known for a long time, but only among geographers. In addition to the fact that the term "geographic center" appears in introductory Geography classes in the eighth grade of elementary school, or in the third grade of high school, it is generally given little importance. The geographic center could be said to be one of the characteristic points, which differ from other points in space by their position. Examples of such points are: the westernmost point of the continent, the deepest point in the world, the highest peak in the world, the territory through which the equator passes (the Mitad del Mundo site in Ecuador), "Zero Island" (the intersection of Greenwich and the equator in the Gulf of Guinea), state borders (relict and current) and others. Therefore, one of the characteristic points is certainly the geographic center of a territory (continent, region, state, city), object, phenomenon.

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Neglecting the importance of such an important point in space is probably the main reason why there have been no works on its marking in Serbia so far. Although, in fact, there are countless ideas and ways. Therefore, this is one of the first attempts to solve this problem, which is described in more detail in the final paper of the author of this text. In addition to representing an important geostrategic location, the geographical center can also be used as a tourist attraction, which is one of the goals of this paper. "The geographical center is a kind of symbol of the territory and increases the attractiveness of the region from the perspective of tourist and recreational use" (Kalyuzhin et al., 2020). There are indeed many examples of characteristic points converted into tourist attractions in the world (some of them have already been mentioned). The topic of the tourist potential of characteristic points is interesting to authors around the world, which is reflected in a large number of papers. For example, the "Golden Triangle", the tri-border of Thailand, Laos and Myanmar and a region known for its opium production, the remains of the Berlin Wall and Checkpoint Charlie, the border between North and South Korea and other invisible spatial points and lines, have been turned into tourist attractions (Löytynoja, 2008; Więckowski, 2022). However, almost all of them have an identical feature – a monument. The difference is reflected only in the dimensions and appearance. People are attracted by characteristic points, the ends, or rather the beginnings of certain countries, regions, geomorphological objects, and the like. They find it interesting to climb the highest peak in the world, cross from one hemisphere to another, stand at the extreme point of a continent, but it must be admitted that the method of marking in the form of a monument is monotonous and simple. It is necessary to show a certain measure of uniqueness, and a monument, whatever its dimensions, is not. We should strive for originality and turn the entire space into something different from an ordinary landmark. A good example is the aforementioned "Golden Triangle". Since the border of the three countries is located on the Mekong River, the main landmark is a large-sized ship with numerous cultural and entertainment facilities (a giant statue of the Golden Buddha, a park). Something like this should be applied to the arrangement of the geographical center of Serbia and mark it worthy of its name. In order for the entire space to be a unique example of spatial planning, in addition to knowledge of geography, in this case, it is necessary to apply knowledge from landscape architecture, ethnology, botany, spatial planning and other scientific disciplines. A type of such arrangement is a geographical polygon or "open-air geography cabinet", which is not often found in schoolyards throughout Serbia, which speaks volumes about its popularity as a facility for teaching geography. The idea for this type of arrangement, in addition to the aforementioned "Golden Triangle", was also the "Science Park" on Ada Ciganlija in Belgrade, where some of the elements of the geopolygon can be seen (an analemmatic sundial, a model of the Earth on which the daily course of the Sun can be followed).

Also, one of the goals of the work is to prove that, in addition to tourism, such an important space as the geographical center can also be exploited for educational purposes. In this way, it would contribute to the development and popularization, primarily, of geography as a science, and then of the settlement in whose vicinity it is located. A geopolygon as a landmark would represent a good example of how geographical knowledge can be used and presented in an interesting and creative way, bringing one of the more complex sciences closer to the common man and encouraging him to take a greater interest in and explore geographical contents.

Methodology

"The geographic center represents a location point that is, on average, closest to other points of a given territory" (Ilić and Stanković, 2007). Greater interest in the central point of a territory began only in the second half of the 19th century, more precisely in 1872, when the American engineer Julius Erasmus Nilgard was the first to apply and develop the centrography method, which is today an integral part of statistics, in order to determine the demographic center of the United States (Kellerman, 1981). However, the development of technology and engineering, the development of GIS, led to the complete neglect of centrography, because the determination of central points of various categories has been accelerated, data is more accessible, and the analysis of the obtained data has been extremely simplified.

From the pioneering work of engineer Hilgard to the present day, within the framework of centrography, several auxiliary methods for determining the central point of a territory have been developed, of which seven are most commonly used (Ilić and Stanković, 2007):

1) Method of extreme points of a given territory (method of extreme boundary points),

2) Method of centroid,

3) Method of isofronts,

4) Method of translation,

5) Combined isofront-translation method,

6) Method of point grid,

7) Integral method of determining centroid.

The development of a large number of auxiliary centrographic methods testifies to the fact that each previous method has a drawback, and is not always applicable. For example, the application of the first method involves determining the northernmost, southernmost, easternmost and westernmost points of the observed territory, that is, the coordinates of two meridians and two parallels. Therefore, the first drawback is

the insufficient number of points taken to determine such an important location as the geographical center. The second drawback is reflected in the fact that the method of extreme boundary points is useless for territories that do not have a regular shape (USA, Somalia) or consist of a mainland and island part (Italy, Croatia). This drawback can also be observed when applying the isofront method.

Every metric operation requires precision, which is achieved by forming a high-density grid, which is obtained by separating a larger number of points located at the same latitude or longitude, because the more complex the method, the more accurate the data obtained, and as the final product of the measurement, a point is obtained that can be called the "geographic center". This is achieved by applying the last two methods - the point grid method and the integral method of determining the center of gravity. It was precisely by applying the integral method that it was measured that the geographic center of Serbia is located in the area of the village of Drača in the vicinity of Kragujevac, which is a generally accepted data, calculated by the formula:

$$\varphi_c = \frac{\iint_{(F)} \varphi \, N \, dF}{\iint_{(F)} N \, dF} \qquad \lambda_c = \frac{\iint_{(F)} \lambda \, N \, dF}{\iint_{(F)} N \, dF}$$

φc, λc – geographical coordinates of the geographic center,

φ, λ – geographical coordinates of the centers of elementary surface,

N – density of elementary particles,

dF – elementary surface area calculated by the formula: $dF = R2 \cos\varphi \, d\varphi \, d\lambda$.

Table 1. Geographical center of Serbia – location information

Geographical center of Serbia	
Settlement	Drača
Municipality	Kragujevac
Coordinates	φ = 44° 01' 14,33'' λ = 20° 49' 02,58''
Cadastral Municipality	Drača
Exact Location	Đermovac
Plot number	1944/2
Area (m^2)	9382
Land Use	Arable field 2nd Class
Land Type	Agricultural

Source: Republic Geodetic Authority - eCadastre (https://www.rgz.gov.rs/e-katastar)

Figure 1. Orthophoto of the location of the geographical center of Serbia in the wider area (green triangle) (retrieved from: https://a3.geosrbija.rs/)

As already mentioned, other methods have more or less shortcomings in determining the central point. The method with the most shortcomings is the method of the extreme border points of the surveyed territory. In order to obtain the coordinates of the central point, only four locations are taken into account – the northernmost, southernmost, easternmost and westernmost points. For Serbia, these are the following four points (Tadić, 2010):

- *Kelebia – northernmost (46°11'25" N)*
- *Bezdan – westernmost (18°49'13" E)*
- *Srebrna Glava – easternmost point (23°00'43" E)*
- *Restelica – southernmost point (41°51'05" N)*

Applying the formula below, we find that the central point of Serbia is located almost in the very center of Kragujevac (44°01'15" N, 20°54'58" E). The obtained point is not that far from the point obtained by the integral method, but it cannot be considered correctly obtained, precisely because of the small number of points taken for determination.

$$\varphi c = \frac{\varphi n + \varphi s}{2} \qquad \lambda c = \frac{\lambda e + \lambda w}{2}$$

The isofrontal method can, to some extent, compensate for the shortcomings of the first method. An isofrontal is a line that connects points that are at an equal distance from the border of a given territory. In this way, difficulties are overcome in

determining the central point of a territory whose shape is irregular. However, this method should not be applied to territories consisting of a mainland and an island part. The centroid method, translations and point networks require, in addition to the analysis of a geographical map, the availability of appropriate precise data for each elementary surface that makes up a geographical unit (Petrašević, 2005). Therefore, along with the integral method, they are considered the most precise methods for determining the central point.

Based on the examples given, it can be seen that the shape of the observed territory is of great importance, primarily. Countries like Hungary, North Macedonia, Slovakia, and others have a relatively regular shape, so any of the above methods could be used to determine their central point. On the other hand, countries like Croatia, Somalia, and the USA (the distance of Alaska from the rest of the territory), due to their irregular shape, there is a possibility that their central point is not located within their own territory, but on the territory of a neighboring country (the geographical center of Croatia is located on the territory of Bosnia and Herzegovina). For these countries, it is very important to choose the appropriate working method.

Possibilities for spatial planning of the geographical center of Serbia

Figure 2. Geographical Center of Hungary (Source: https://www.flickr.com/photos/100954775@N03/10783340394)

As already mentioned, such an important point requires a landmark worthy of its name and meaning, and a monument does not fully meet this requirement. Moreover, placing a monument in such a place would be just one of countless cases that creates the effect of "already seen" (examples of the use of different types of memorials are presented in Figures 2 and 3). Therefore, such thinking and acting is extremely monotonous, that is, repulsive.

Since this is, among other things, about the development of tourism and the enrichment of the tourist map of Serbia with natural and cultural-educational content, we should strive for something unique, yet simple, which would attract the attention of the youngest population, but also people who are at the top of the age pyramid. We must not forget the adjective "geographic" in the name of the site, but even that can be achieved through an extremely simple type of arrangement. An example of something so simple, yet complex

enough to match the features of the site such as the geographical center and the links between cultural and educational content is a geographical polygon.

Figure 3. Geographical Center of Finland (Source: https://www.outinthenature.com/where-is-the-center-of-finland/)

A geographical polygon is a type of theme park (in this case, the theme is geography), constructed with the aim of introducing and facilitating the understanding of certain geographical phenomena and processes. Some of the elements of a geopolygon (an analemmatic sundial, terminator) can be seen in the "Science Park" on Ada Ciganlija. The educational nature of geopolygons is reflected in the fact that they are most often constructed in schoolyards, as they enable "modern geography teaching to cover a large number of teaching topics in the immediate geographical space, since the main purpose of the geographical polygon is to implement the curriculum through the participation of students in practical work, the result of which will be the formation of concrete representations, concepts in geography teaching" (Živković et al., 2015). Of all the instruments of geopolygons, the most important are those for "forming spatial performances, instruments used in the formation of spatial orientation skills, astronomical equipment, meteorological equipment, etc." (Vujinić and Nišić, 2017). Based on this, Živković et al. (2015) distinguish three types of its application:

- Occasional observations – when students form an awareness of space, develop observation skills, acquire knowledge about absolute altitude, geographical coordinates, master the search for the North Star in the sky, etc.
- One-time practical work and observations – working with equipment as well as with equipment located on the range (sundial, model of the Earth with a network of meridians and parallels).
- Systematic observations – collecting data and monitoring and reading meteorological indicators from automatic or standard meteorological stations in order to train students to work with meteorological equipment, which will make it easier and better for them to understand the importance and role of climatic elements and their influence on atmospheric conditions.

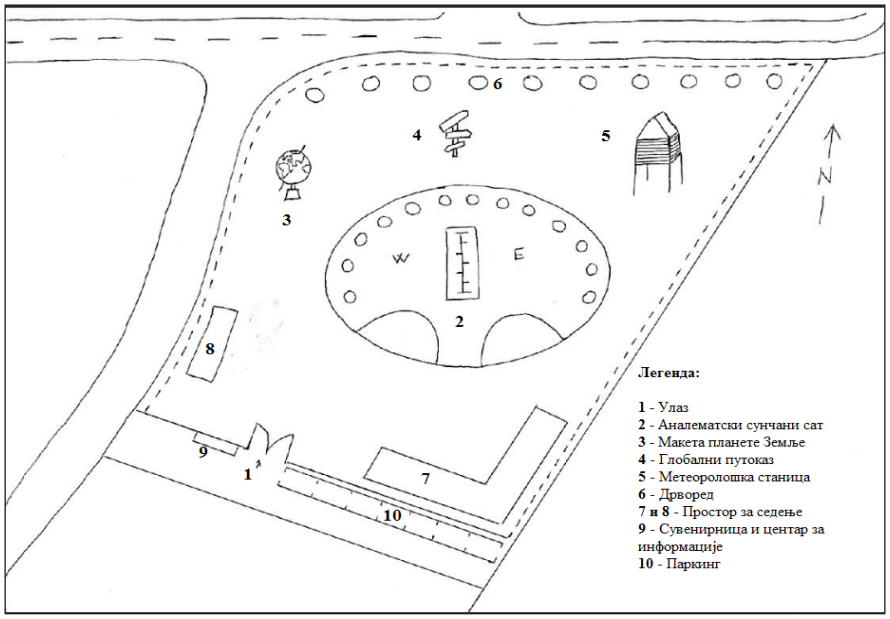

Figure 4. Sketch of the arranged geographical center of Serbia (author)

The geopolygon, which would adorn the geographical center of Serbia, would include the following elements: a model of the Earth, on which one of the consequences of rotation would be observed (the alternation of day and night - the terminator), a global signpost showing the distances between the geographical center of Serbia and some of the world's largest cities (mathematical geography), a meteorological station with basic measuring instruments (thermometer, weather vane, anemometer, rain gauge, barometer, hygrometer) (climatological and hydrological character of the geopolygon), while in the very center of the polygon, at the coordinates corresponding to the central point of Serbia, an analemmatic sundial would be placed, a type of sundial in which the shadow caster is a human.

A sundial is an inevitable element of every geographical polygon, which has a multiple role - as a teaching tool, as a decorative detail on the south wall of a building, a tourist attraction, etc. The main role of sundials is to show the exact time during daylight hours, that is, while the Sun is shining, because it is their main mechanism. How interesting people are to sundials (here the emphasis is primarily on educational institutions) is shown by the fact that only a few schools in Serbia have their own sundials – the "Laza Lazarevic" Elementary School in Šabac, the "Žikica Jovanovic – Španac" and "Andrija Rušo" Elementary Schools in Valjevo, the "Sonja Marinkovic" Elementary School and the High School in Zrenjanin, and others (Petrović, 2009). There are three basic types of sundials, depending on where

they are placed – horizontal, vertical, and analemmatic. Of all the types of sundials, analemmatic sundials are the least common, although their educational character is the most pronounced. The elements of analemmatic sundials are a horizontal ellipse and a date scale in the middle. On the north side of the ellipse, numbers are written, or full hours. The measurer needs to stand at the appropriate place on the scale (depending on the month of the year) and "read" the position of the shadow. Tadić (2010) highlights an example of using an analemmatic sundial as a teaching tool in the first and second cycles of education. In the first cycle of education, students could use such a clock to master orientation in space and time, while it would help students in older grades of primary school to more easily and better master some abstract or not so visible concepts from geography and mathematics, such as coordinate systems, the apparent motion of the Sun, the change of seasons, the construction of an ellipse, measuring angles, and others.

Table 2. Example of an active lesson for second grade elementary school students (part)

Grade	2nd
Subject	Svet oko nas (World around us)
Teaching Unit	Snalaženje u okolini (Finding your way in surroundings)
Class Type	Processing a new teaching unit with the consolidation of old material
Class Goal	Acquiring knowledge and skills necessary for navigating the environment and connecting them with acquired knowledge about monitoring changes in nature and the characteristics of sunlight
Operational Class Assignments	- Educational: Acquiring knowledge and skills necessary for navigating the environment - Functional: Developing spatial orientation skills - Educational: Encouraging a spirit of inquiry and independence in learning.
Teaching forms of work	Frontal, individual and practical form of work
Teaching methods	Conversational method, demonstrative method
Teaching aids	Analemmatic sundial

Example: Petrovic, A., Petrovic B. (2009)

Table 3. Elements of the analemmatic clock for the geographical center of Serbia

Drača (44° 01' 51,73" N, 20° 49' 14,74" E), a = 200 cm, b = 139 cm									
Time (h)	t (°)	t' (°)	ρ (cm)	α (°)	x (cm)	y (cm)	**Date**	q	Zodiac
5	-105	-99.18	198.84	-96.0	-197.44	-22.18	**1.I**	-61.21	
							21.I	-52.51	Aquarius
6	-90	-84.18	199.48	-86.0	-199.0	14.10	**1.II**	-44.80	
							20.II	-28.42	Fish
7	-75	-69.18	193.28	-75.1	-186.9	49.41	**1.III**	-18.89	
8	-60	-54.18	181.03	-63.0	-162.2	81.35	**21.III**	0.86	Aries
9	-45	-39.18	166.01	-49.5	-126.35	107.75	**1.IV**	11.69	
							21.IV	30.45	Taurus
10	-30	-24.18	151.06	-33.0	-81.92	126.81	**1.V**	38.97	
							22.V	53.59	Gemini
11	-15	-9.18	140.86	-13.0	-31.9	137.23	**1.VI**	58.37	
12	0	5.82	139.79	8.5	20.28	138.29	**21.VI**	62.34	Cancer
13	15	20.82	148.30	29.0	71.09	129.93	**1.VII**	61.29	
							23.VII	52.37	Leo
14	30	35.82	162.41	46.0	117.05	112.72	**1.VIII**	46.56	
							23.VIII	28.85	Virgo
15	45	50.82	178.77	61.0	155.03	87.82	**1.IX**	20.66	
16	60	65.82	191.43	73.0	182.45	56.94	**23.IX**	-0.46	Libra
17	75	80.82	198.84	84.0	197.44	22.18	**1.X**	-8.28	
							23.X	-29.25	Scorpio
18	90	95.82	199.45	94.1	199.0	-14.10	**1.XI**	-37.23	
							23.XI	-53.46	Sagittarius
19	105	110.82	193.19	105.0	186.94	-49.41	**1.XII**	-57.63	
20	120	125.82	181.03	117.0	162.17	-81.35	**22.XII**	-62.33	Capricorn

Calculation:author (according to: Tadić, 2010)

Of course, since the geopolygon is not an ordinary landmark, the clock would not look like other clocks. While the main role of standard clocks is to show the exact time, this clock would also have the role of an "identity card" of Serbia, representing everything that makes Serbia famous around the world, in its hour scale. Namely, each hour on this clock would represent a certain symbol of Serbia, such as folk instruments, national drinks, pearls of architecture and construction, famous personalities, endangered plant and animal species, etc. The dial would consist of a series of wooden figures, made of oak (the national tree of Serbia), with a maximum height of up to 30 centimeters, and the figures themselves would be placed on columns, up to 20 centimeters high, which are specimens of rocks found on the territory of Serbia, arranged from the oldest to the geologically youngest rocks, thus giving the geopolygon another element - a geological column.

Table 4. Example of dial layout

Time (h)	Figure	Explanation
5 (6)	Šljivovica, traditional shoes (opanci) and cap (šajkača)	National symbols of Serbia
6 (7)	Stevan Stojanović Mokranjac and Stanislav Binički	The most famous Serbian composers
7 (8)	Nikola Pašić and Svetozar Miletić	The most famous politicians in Serbian history
8 (9)	Saint Sava and White Angel	The most famous figure from the Nemanjić dynasty and the most famous fresco from Serbia
9 (10)	Vuk Karadžić and Dositej Obradović	Symbols of Enlightenment, reform, and development of Serbian language and literature
10 (11)	Karađorđe and Prince Miloš	The Serbian Revolution (1804–1815)
11 (12)	Candle, bread, and wheat	Slava – a custom unique to Serbs
12 (13)	Tennis racket and basketball	Symbols of sports and athletes (basketball and tennis as most popular)
13 (14)	Mihajlo Pupin and Nikola Tesla	Prominent Serbian scientists
14 (15)	Flute, kaval, and gusle	Old Serbian instruments
15 (16)	Gračanica Monastery	One of the most famous monasteries in Serbia
16 (17)	Desanka Maksimović and Nadežda Petrović	Two of the most important Serbian women – symbols of all notable women
17 (18)	Monument 'V – 3'	Symbol of Serbian suffering during wars of the first half of the 20th century
18 (19)	Isidora Sekulić and Mika Antić	Among the most famous Serbian writers
19 (20)	Brown bear and beaver	Endangered and legally protected animals in Serbia

Proposal: author

We must not forget the biogeographical sphere of the geopolygon, since biogeography is a very important part of geography. The biogeographical character would be reflected in "living" plant specimens, which would consist of rare flower species that can be found on the territory of Serbia, such as Natalia's ramonda, Kosovo (red) peony, yellow linden and other flowering plants, which would be planted between the "dial" and the date scale of the clock, while the northern side of the polygon would be decorated with specimens of woody species, so as not to disrupt the daily course of the Sun and the direction of the shadow of the "living gnomon" (Pančić spruce, European yew, alder, linden, elm, etc.). The possibility of having a dog on the property (a specimen of an animal species native to Serbia)

should be considered, which would guard the property and which would tour the geopolygon together with tourists. Examples of Serbian breeds according to the Serbian Kennel Club are: Serbian Hound, Serbian Tricolor Hound, Šarplaninac and Serbian Yellow Hound. With a pair of benches, arranged to reflect the arrangement of benches in an amphitheater, this space would be transformed into a real small "open-air classroom".

Educational and tourist potential

The geopolygon can be used to conduct simple experiments, where students would be able to learn and remember some processes much faster and better through play, the definitions of which they would learn by heart. The results of one study show that children remember only 10% of what they read, about 20% of what they hear, and almost 90% of what they see and apply at the same time (Vujinić and Nišić, 2017), so a geopolygon in this location would be the right solution for conducting practical geography lessons for students from nearby elementary and secondary schools. First of all, it is necessary to animate students, that is, to move them from the position of passive listeners to active participants in the lesson. The results of the PISA and TIMSS surveys also show that student activity in the lesson is very important, indicating a high level of reproductive, but a very low level of functional knowledge. It could be said that students are able to read, learn and repeat certain material, but they are not able to connect and apply what they have learned, which calls into question the quality of knowledge acquired in school (Kuleto, n.d.). The annual plan and program of each school, which provides for the implementation of student excursions, the geographical center of Serbia, transformed into a geopolygon, would certainly become one of the inevitable destinations for students of all grades of primary and secondary education. In this way, the geopolygon represents a perfect learning environment through which every student (whether in primary or secondary school) would go through and master each level of Bloom's Taxonomy.

Figure 3. Bloom's pyramid (Source: http://www.skolskidnevnik.net/2009/03/blumova-taksonomija/)

Table 5. Example of a one-day trip for eighth grade elementary school students

Time (h)	Destination	Description
8:00 – 10:00	Belgrade – Kragujevac	Departure in front of the school
10:00 – 10:40	Museum 'Old Foundry'	/
10:50 – 12:00	Memorial Park 'Kragujevac October' and Museum '21 October'	/
12:00	Departure towards Drača	/
12:15 – 13:00	Geographical Center of Serbia	Walking tour from the Center to the museum
13:30 – 14:15	Ethnographic Museum in Drača	
14:50 – 15:10	Divostin Monastery	Walking tour to the monastery
15:10	Departure towards Kragujevac	/
15:20 – 16:00	Lunch	/
16:15 – 16:45	Ždraljica Waterfall	Walking tour from the waterfall to the hill
16:45 – 17:40	Metino Hill	
18:15	Departure for Belgrade	/
20:00 – 20:30	Arrival in Belgrade – end of program	Arrival in front of the school

Proposal:author

When it comes to tourism, there are certain obstacles related to the geographical center. In order for a regulated and adequately marked geographical center to receive the status of a tourist site, it is necessary to fulfill a number of property - legal, logistical and organizational requirements. The first thing that can be noticed in Figure 1 is the location of the geographical center. As mentioned above, the geographical center is located within the territory of a rural settlement, on a plot of land that is categorized as a class II field, so it is an arable area. Therefore, it is clearly visible in the image that there is no paved road leading to the plot, but only dirt roads. One of the main criteria for a place to become a tourist destination is adequate transport infrastructure, i.e. easy accessibility to tourists from all over the world. Another very important thing, when organizing tours and excursions that include a visit to a large number of sites, is to make sure that they all form a whole, that is, that they are relatively close to each other, in order to avoid the danger of tours being reduced to staying in a bus and panoramic sightseeing along the way.

"Many central points were originally located "in the middle of nowhere", but were moved to a more convenient location for better accessibility or image reasons. One of the main motives for relocation was usually the potential of the location as a tourist attraction" (Löytynoja, 2008). The same procedure should be applied in the case of the geographical center of Serbia. It is necessary to find a plot of land that

is close enough to the central point, so that the coordinates do not differ much from the true center, and that is along the main road, so that it can be easily reached, and, finally, to "move" the geographical center of Serbia to a better place, which could easily become an unavoidable destination for numerous tourists in the future. An example of a new location for the central point of Serbia is located just a few meters away from the true center, also in Durres, but along the main road and closer to Kragujevac, the first major urban settlement in the area.

Figure 5. New location of the geographic center of Serbia (red triangle) in relation to the true geographic center (green triangle) (taken from: https://a3.geosrbija.rs/)

Table 6. Information on the location of the new geographical center of Serbia

Settlement	Drača
Municipality	Kragujevac
Coordinates	φ = 44° 01' 51,73" λ = 20° 49' 14,74"
Cadastral Municipality	Drača
Exact Location	Divostin
Plot number	1386/1
Area (m^2)	1975
Land Use	Arable Field II Class
Land Type	Agricultural Land

Source: Republic Geodetic Authority - "GeoSerbia" portal

The plot is ideally located along the main road and is large enough to create a thematic park of geographical content with accompanying elements, such as a sufficient number of parking spaces and souvenir shops. The second reason is that it is relatively close to the sites for which Kragujevac is best known – the Šumarice Memorial Park and the 21st October Museum, so it would fit perfectly into the ambient whole of Kragujevac and its wider area. The third and not least reason is that the plot is located in Drača, which is also the location of the real center, and moving the center to Divostin or to the very center of Kragujevac would be incomprehensible (in a geographical, but not in a tourist sense), but also inaccurate, since the information has become accessible to everyone and easily verifiable, so such an attempt at data manipulation would be unsuccessful from the start.

It has already been said that the immediate vicinity of the geographical center abounds in rich natural and cultural-historical content, but it is always necessary to look at the bigger picture when it comes to planning and designing destinations that have the potential for a long-term contribution to tourism. Therefore, some localities in the wider vicinity of the geographical center should be highlighted and see whether and how the developed geographical center fits into the tourist mosaic, primarily of Šumadija, at the regional level, and then of the entire Serbia, as the highest territorial scale. There is no need to go too far and discover content in, for example, Subotica or Prizren, it is enough to observe the territory of Šumadija and understand that a marked geographical center would be another pearl in the tourist offer, primarily of Kragujevac, and then of the entire region. Arandjelovac and its surroundings (Risovača Cave, Orašac, Topola and Oplenac, Bukovicka Banja, Bukulja Mountain, Venčac, the "Marble and Sounds" event, Bukulja and Garaško Lakes), Gornji Milanovac and its surroundings (Rudnik Mountain, "Prljuša" archaeological site, Ostrovica, Takovo, Museum of the Second Serbian Uprising, Milošev konak, Vraćevšnica Monastery), Gruža (Borac Karst, Gružan Lake, "Colonel Vranić's House"), are just some of the examples of destinations with rich natural and cultural and educational content with which the developed geographical center of Serbia would certainly fit in perfectly.

Legal and organizational regulation

All of the above cannot be implemented without previously resolved legal and organizational norms. In other words, without resolved legal requirements, the entire plan is in the realm of theory. Therefore, the planning of the development of the geographical center of Serbia is divided into several steps, starting from the idea, to the opening of the geopolygon, as the final product. The idea exists, and the first step has been taken. The next step is the involvement of appropriate state institutions, namely discussions and presentation of the plan to the authorities of the City of

Kragujevac, since the geographical center is located in that region. This is the first of the two most important steps in the entire project, because if the proposal is adopted, the third step can be taken. This involves obtaining Location Information, which provides insight into whether construction work can be carried out on the plot in question. It is necessary to remove doubts as to whether, according to the Spatial Plan of the City of Kragujevac, the plot is located in a zone of any protection or risk (e.g. sanitary protection zone, green area, landslide occurrence, danger of river overflow and flooding, etc.), in order to carry out construction works on it and, most importantly, whether the conversion of agricultural land into construction land is possible.

Once the requested requirement is met, the second most important step follows – a conversation with the owner of the plot, with the help of a legal intermediary, in order to comply with all legal norms. Since it is private property, it is inadmissible to carry out any activities on the plot without the knowledge and consent of the owner. On the other hand, the authorities should make a decision as to whether the observed territory is of public importance, in order to take the next steps. The owner's occupation should also be taken into account. If the owner is primarily engaged in agricultural production, does he/she want to consciously renounce the rights to the plot, losing the share of arable land. Assuming that the geographical center of the site is of public importance and that the owner of the plot wants to cede it to the state, the next step is taken. After the previously fulfilled requirements, it is necessary to carry out the expropriation of the property, respecting the provisions of the Expropriation Law. Then it is necessary to determine the contractors and the procurement of materials, by announcing a tender and reach an agreement with public and public utility companies regarding the maintenance of the site, which includes the maintenance and repair of exhibits and instruments, maintenance of plant crops, supplying the site with water, removing garbage, appointing a professional as a supervisor, who would tour the site and provide tourists with basic information about the site, etc. It is possible that the previous owner may be involved in some of the above activities (souvenir sales, lawn maintenance, security guard), provided that there is interest from both parties (city authorities and the owner). Only under these conditions is it possible to implement the project and consider further steps, in order to create the best possible tourist offer. For example, an ethno-restaurant could be opened near the geopolygon, serving specialties from all parts of Serbia, as well as a "Museum of Serbia", which would exhibit valuable artifacts from all periods of Serbian history. The best solution would be an ethno-village near the polygon, within which the aforementioned facilities would be located.

Conclusion

Based on everything presented in the paper, it can be concluded that the geographical center is an important point of every state and that it should be marked in a worthy manner, in the spirit of geography, inherent to the name it bears. Geography is complex and has the charm that, unlike other sciences and scientific disciplines, it presents its contents in an extremely interesting and creative, and educational way. Therefore, it would be nice if the geographical center of Serbia, one day, was marked in an unusual way, which does not contradict geography, and can also be connected with other sciences, which can be concluded based on the text presented above. The desire to launch an initiative for the development of the geographical center was expanded by the idea of developing the space around the geographical center in order to promote and improve the educational and tourist offer through the application of various activities and scientific disciplines with an emphasis on geography. The ultimate goal would be to put such a developed place on the map of tourist sites and on the list of mandatory destinations for school excursions in most elementary and secondary schools in Serbia, and to increase tourist traffic and the popularity of this part of the country. However, in order to achieve this, it is necessary to regulate all legal and organizational norms, which is not an easy task in the entire project, since just one negative answer is enough for the project not to be implemented. Considering that the immediate and distant surroundings of the geographical center of Serbia abound in rich contents of exceptional importance, both natural and anthropogenic origin, but the center itself can also represent an independent tourist attraction, it would be a shame and a lightly missed opportunity not to make this place a beautiful and unusual environmental whole.

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TRANSPORT AS TOURISM: CONCEPTUAL OVERVIEW

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Abstract: This article explores the concept of "transport as tourism," emphasizing how mobility modes, from historic trains and gondolas to luxury cruises and themed rides, evolve beyond mere infrastructure into experiential, symbolic, and emotionally resonant elements of the tourism product. Drawing on theories of tourist motivation, experiential value, and cultural consumption, the paper highlights how transport intersects with heritage, landscape aesthetics, media representation, and identity performance. It examines the socio-economic, cultural, and environmental implications of this phenomenon, with attention to sustainability, destination branding, and the hybridization of travel and tourism. Through diverse case studies and interdisciplinary insights, the article argues that understanding transport as an active tourism experience demands new planning frameworks that integrate cultural preservation, economic viability, and ecological responsibility. Ultimately, the study positions transport not just as a logistical enabler, but as a critical site of tourist engagement, storytelling, and value creation.

Keywords: transport as tourism, experiential travel, heritage mobility, sustainable tourism, tourist motivation

Introduction

Transport is a foundational element of both international and domestic tourism, enabling the spatial mobility that underpins the modern travel experience (Duval, 2020; Hall, 2008). As Stradling and Anable (2009) note, all tourist movement relies on three primary categories of human transport – self-propelled, augmented, and fueled modes – each contingent on the availability of suitable infrastructure. Without these systems, contemporary tourism would not be possible. Despite its central role, transport is often underexamined in tourism research, overshadowed by more visi-

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ble aspects such as attractions, accommodations, and activities. However, the global expansion of tourism is inseparable from advancements in transport technologies and infrastructure, which have significantly increased destination accessibility and reshaped spatial interactions across local, regional, and global scales (Page, 2009).

Historically, travel was associated with exploration, commerce, and elite pursuits, constrained by time, cost, and risk. With technological progress, however, travel has evolved into a routine and predictable activity, especially in the context of leisure and annual holidays. Tourism today is a highly elastic economic activity. Demand is sensitive to fluctuations in transport costs, making affordable and efficient mobility systems essential to the sector's continued growth. In response, major investments in transport infrastructure and logistics are required to accommodate the increasing number of travelers. This reciprocal relationship, where transport facilitates tourism, and tourism drives transport development, highlights the growing interdependence between the two sectors (Rodrigue, 2024).

Tourism is also increasingly understood through a systems approach and tourism system is observed as a set of interrelated components acting in coordination toward shared goals (Baggio & Del Chiappa, 2017; Jere Jakulin, 2017; Lumsdon & Page, 2004; Rodriguez-Giron & Vanneste, 2019). Mill and Morrison (1985) emphasize four key elements: market, travel, destination, and marketing. Those elements are linked through flows of information and people, enabled by intermediaries and transport providers. Transport plays a pivotal role not only in the logistical facilitation of travel but also in shaping the tourism experience itself. Notably, beside generating region and destination region, as well as tourists and tourism industry, Leiper's (1979, 1990) tourism system includes a critical additional component—the transit region—which underscores the spatial and experiential significance of movement between origin and destination. Page (1999) further conceptualizes the tourism transport system as a continuum of factors influencing the travel experience from pre-trip planning to the final return journey, highlighting the structural and procedural embeddedness of transport within the wider tourism system. The relationship between transport and tourism is complex, with transport facilitating tourism growth while also potentially causing negative impacts such as congestion and pollution (Pellegrino, 2021).

While "transport for tourism" emphasizes the instrumental role of mobility, "transport as tourism" marks a conceptual shift: mobility becomes the experience (Clarke, 2010; Lumsdon, 2000; Pellegrino, 2021). In such cases, the transport mode itself, whether a vintage steam train, scenic ferry, or themed monorail, serves as a central attraction. This phenomenon intersects with cultural tourism, heritage preservation, and experience-based consumption, challenging the conventional division between travel as function and tourism as destination. As this paper explores, "trans-

port as tourism" reveals how vehicles, routes, and transit spaces can evolve into meaningful, symbolic, and emotionally resonant tourism products.

Through a multidisciplinary lens, this paper examines how certain modes of transport operate not only as enablers of tourism but as core elements of the experience itself. It investigates how transport intersects with tourist motivation, identity, memory, and cultural value, across heritage, scenic, luxury, adventure, and themed tourism sectors, and assesses the broader socio-economic and environmental implications of this evolving phenomenon.

Conceptual Framework

Understanding why individuals travel, and how they assign value to different aspects of the tourism experience, remains a foundational concern in tourism research (Uriely, 2005). Over the past decades, a wide range of conceptual frameworks have emerged to explain tourist motivation, behavior, and satisfaction, evolving in tandem with broader societal, technological, and cultural shifts. Traditional models offer valuable insights into the psychological and social drivers of travel, while more recent approaches highlight the growing importance of experiential, emotional, and symbolic dimensions of mobility itself. Within this evolving theoretical landscape, the concept of transport as tourism offers a productive lens for exploring how transport modes become not merely functional tools for accessing destinations but integral, meaning-laden components of the tourism experience. The following review synthesizes key theoretical contributions, from classic motivation theories to contemporary work on experiential value and travel satisfaction, with particular attention to how mobility intersects with identity, memory, and emotion in tourism today.

As Heitmann (2011) writes, tourist motivation refers to the internal and external factors that drive individuals to travel, encompassing psychological needs, personal desires, and social influences. Early theories emphasized motivation as a response to internal disequilibrium, with Iso-Ahola (1982) and Dann (1977) identifying escape and seeking as dual motives rooted in both psychological and social contexts. Crompton (1979) expanded this framework with seven psychological "push" and two cultural "pull" motives. The resulting push-pull model became central in tourism studies, positing that internal drives (e.g., need for relaxation or status) interact with external destination attributes to shape behavior. Maslow's hierarchy of needs (Maslow, 1943) has also been applied to tourism to explain how various levels, from physiological to self-actualization, can shape travel decisions, although the model's rigid structure has often been critiqued in tourism contexts. Pearce's (1988) Travel Career Ladder (TCL) builds on Maslow, suggesting that tourists' motivations evolve with life stage and experience, with different needs becoming dominant at differ-

ent phases of a traveler's "career." Motivation can also be examined through the purpose of travel, such as cultural enrichment, personal growth, or social bonding. Collectively, these models affirm that tourism decisions are multifaceted, shaped by a complex interplay of personal, social, and cultural dimensions that influence both destination choice and travel behavior (Heitmann, 2011).

More recent research emphasizes how youth travel motivations are increasingly shaped by digital culture, identity formation, and global consciousness (Yousaf et al., 2018). While traditional models like Maslow's and Pearce's TCL retain conceptual relevance, their practical application must now account for emerging motivational triggers such as the pursuit of authenticity, environmental awareness, and the desire for purposeful engagement. Social media platforms not only affect destination choice but also mediate how young tourists document and share their experiences, fulfilling needs for self-expression and social validation. Furthermore, new theoretical perspectives suggest that youth motivation is increasingly tied to experiential consumption, transformational travel, and value-oriented decision-making. Voluntourism, eco-travel, and digital nomadism, for example, are not fleeting trends but manifestations of deeper motivational shifts toward personal development, community connection, and ethical responsibility. Research also highlights the role of hybrid identities among young travelers who blend leisure, education, and remote work in flexible, mobile lifestyles. While Yousaf et al.'s (2018) study remains a critical reference, it is evident that emerging realities require motivational models that integrate technological, ecological, and cultural factors into tourism behavior.

Chang (2018) contributes to this evolving discourse by exploring the role of gain and loss perception in how tourists evaluate services and experiences. Drawing on the concept of the experience economy (Kahneman, 2003; Kahneman & Tversky, 1979; Pine & Gilmore, 2011), Chang investigates how tourists assign value to different elements of their trips, particularly those involving intangible, emotional, and experiential components, compared to traditional service offerings. The study is grounded in survey data from 543 adults in South Korea, who assessed both past and anticipated travel experiences in terms of gain value (willingness to pay) and loss value (the emotional impact of missing the experience). Findings reveal a strong asymmetry: while basic services such as lodging or transportation command higher average gain values, the loss value associated with missing out on experiential components, especially those related to relaxation, novelty, and escape, is substantially greater. This indicates that emotional and psychological responses to the absence of experiences may outweigh the perceived value of more tangible offerings. Chang also identifies notable demographic and regional differences, with respondents from areas like Jeonra-do placing greater emphasis on hedonic and aesthetic values. In a broader theoretical context, the study underscores the need to transcend traditional

utility-based models and embrace behavioral economics in tourism planning. The emotional cost of missing a valued experience has important implications for how destinations price and promote their offerings. Chang's work provides practical insights for tourism marketers aiming to enhance the distinctiveness and irreplaceability of experiential products. It also opens the door to further cross-cultural research on how diverse traveler populations assess and prioritize experiential versus service components, especially in the context of Millennial and Gen Z preferences, which are increasingly driven by emotion, novelty, and socially conscious consumption.

Acharya et al. (2023) advance the conversation by directly linking the journey itself to tourism satisfaction and loyalty, thereby reinforcing the relevance of "transport as tourism". Their research shows that affective and cognitive experiences during the travel phase can have a greater influence on overall satisfaction and intention to revisit than the attributes of the destination itself. This highlights the journey not as a passive interlude, but as a site of meaningful engagement. Elements such as scenic routes, aesthetically designed rest stops, comfortable and reliable infrastructure, and transport modes with tailored tourist services significantly enhance travel satisfaction. In doing so, they transform mobility into a tourism product in its own right. The authors advocate for tourism planners to consider the quality and design of transport systems alongside traditional attractions, viewing them as experiential spaces that shape tourist perceptions and long-term loyalty. This aligns with broader trends in the experience economy, where emotional resonance and value creation are no longer confined to static destinations but distributed across the entire travel process.

Taken together, these contributions reflect a profound shift in how motivation, mobility, and experience are conceptualized within contemporary tourism. Classical theories such as the push-pull model, Maslow's hierarchy, and Pearce's TCL continue to offer foundational insights into why people travel. However, emerging perspectives place greater emphasis on the symbolic and emotional value of the journey itself. In this evolving context, the idea of transport as tourism assumes renewed significance. Mobility is no longer simply a means of reaching a place—it becomes an embodied, aesthetic, and even transformational aspect of the tourist experience. Studies by Yousaf et al. (2018) and Chang (2018) underscore that modern travelers, especially youth, are motivated by authenticity, emotional connection, and the desire to narrate and share their journeys. Acharya et al. (2023) deepen this understanding by showing that journey-based experiences can exert greater influence than destination attributes when it comes to repeat visitation. As tourism becomes increasingly experience-driven, integrating transport into the heart of tourism planning is both necessary and strategic. Transport infrastructure, ambiance, and service quality must be treated not merely as logistics, but as emotionally and symbolically rich components that satisfy evolving tourist motivations and enhance the overall value of travel.

Typologies and Examples of Transport as Tourism

The concept of "transport as tourism" reflects a growing recognition that mobility itself can constitute a central component of the tourist experience, not merely a means of reaching a destination (Kovačić & Milošević, 2016). Rather than existing as a separate domain, transport increasingly intersects with a wide range of tourism sectors, including heritage tourism, scenic tourism, luxury tourism, adventure tourism, and themed or media-influenced tourism. These sectors are not mutually exclusive; in many instances, a single mode of transport simultaneously embodies multiple tourism functions. A historic steam train may operate both as a vehicle of nostalgia and a platform for scenic observation; a luxury cruise might deliver themed entertainment while granting access to remote cultural heritage sites. The boundaries between functional transit, immersive experience, and symbolic representation are often blurred, resulting in hybrid tourism products that address diverse motivations, ranging from aesthetic enjoyment and emotional resonance to thrill-seeking and status performance. This multidimensionality underscores the need to understand transport as an active and dynamic element in tourism design, interpretation, and consumption.

Contemporary heritage tourism increasingly emphasizes experiential and emotional engagement, positioning the journey itself, particularly when undertaken via historically significant modes of transport, as central to visitor involvement. This trend reflects a broader desire among tourists not simply to observe history, but to immerse themselves in it through sensory, embodied experiences that link personal memory with collective heritage (Timothy & Boyd, 2006). Heritage transport modes, such as steam trains or vintage trams, are not only attractions but emotionally resonant spaces that evoke collective memory, identity, and cultural continuity. These experiences are shaped by affective connections to the past, where travel becomes a form of storytelling, intergenerational dialogue, and embodied heritage preservation (Geoghegan, 2013). For instance, Japan's Oigawa Railway in Senzu functions both as a heritage journey and a gateway to tea tourism, integrating steam train travel with traditional architecture and local products. This case exemplifies how slow, heritage-based transport can support sustainable, place-based tourism (Khaokhrueamuang et al., 2022).

John Urry's (1997) notion of the tourist gaze offers an instructive lens for understanding the appeal of heritage and landscape-oriented transport. He argues that tourists are not passive observers but active seekers of novelty, authenticity, and meaning through visual and sensory engagement. This helps explain the enduring popularity of nostalgic transport, such as steam trains and historic trams, which provide emotionally charged, historically framed journeys that connect travelers to imagined pasts and cultural legacies. These experiences align with Urry's "romantic gaze,"

privileging solitude, slow movement, and personal reflection. His framework is also applicable to scenic transport modes like Alpine railways, fjord ferries, and panoramic cable cars, where immersion in sublime landscapes is a central draw. These travel forms not only grant access to remote locales but also function as elevated platforms for aesthetic appreciation. Visual elements, including changing scenery and glimpses of local life, are crucial in forming transport tourism experiences (Rhoden & Kaaristo, 2020). However, Urry warns that the act of gazing can commodify place and culture, potentially transforming authentic heritage into stylized spectacle shaped more by curated imagery than historical continuity. Thus, while transport is emerging as curated, aestheticized, and marketed experience, this transformation also warrants critical examination.

The experiential modes discussed above are grounded in emotional and sensory appeal, some drawing from the past, others from spatial spectacle. In contrast, or sometimes in addition, luxury and comfort-oriented transport, epitomized by cruise ships and iconic trains like the Orient Express, foreground exclusivity, hedonism, and social status. These experiences are less about arrival and more about indulging in curated opulence and high-end services that transform travel into a marker of prestige and lifestyle. While heritage and scenic forms often cater to nostalgic or nature-focused tourists, luxury transport represents a performative facet of tourism, where privacy, material comfort, and symbolic capital define the journey's essence.

Adventure and novelty-based transport, such as hot-air balloons, helicopter tours, or dog sledding, complement these modes by appealing to tourists driven by excitement, risk, and the pursuit of unique, once-in-a-lifetime experiences. In such cases, the journey itself becomes the primary source of emotional intensity and storytelling, prioritizing novelty over comfort or tradition.

Themed and staged transport occupies a distinct intersection between mobility and narrative. These forms of travel are deliberately designed or recontextualized to evoke fantasy, fiction, or symbolic worlds. The Glenfinnan Viaduct in the Scottish Highlands is a striking example: its association with the Hogwarts Express in the Harry Potter films has turned it into a pilgrimage site for fans. With annual visits rising from 200,000 in 2014 to over 460,000 in 2019 (Garrison & Wallace, 2021), many tourists now visit to witness the Jacobite steam train crossing the viaduct, reliving a cinematic moment. This example shows how themed transport, amplified by media exposure, can elevate local or heritage infrastructure into globally significant, emotionally resonant destinations, blurring distinctions between fiction, cultural heritage, and tourism.

In the discourse on "transport as tourism," certain urban mobility modes transcend their functional role to become iconic symbols and immersive experiences. Venice's gondolas are a quintessential case: more than waterborne transit, they rep-

resent the city's romantic imagery and cultural identity. Their presence in visual media constructs a timeless, aestheticized vision of Venice (Staiff, 2006), where travel becomes a journey into a curated emotional narrative and symbolic consumption.

In many cities, transport vehicles function as visual emblems of place identity, especially in metropolises with strong media presence: London's red double-decker buses and black cabs, New York's yellow taxis. Frequently featured in souvenirs and tourism materials, they have become cultural icons. Their popularity is reflected in the widespread sale of miniature models and memorabilia, underscoring their emotional resonance with visitors. However, their primary function remains practical mobility for residents and tourists alike. While they enhance experiential quality, research shows limited evidence that they are used exclusively for leisure. Their status thus lies at the nexus of practical use and symbolic representation (Robbins, 2003).

The historic cable car system in San Francisco similarly bridges past and present, with technical restoration and selective modernization serving both heritage preservation and tourism demand. The vehicles are not merely means of transport but functioning exhibits that reflect the city's unique identity, drawing thousands of visitors and reinforcing its image as a space where tradition and innovation converge (Lupiz & Rice, 2004).

Lisbon's tram line 28 illustrates a fusion of function and tourism. These vintage trams traverse steep, narrow streets to connect cultural landmarks while offering a nostalgic ride through the cityscape. Their continued operation reflects Lisbon's balancing act—preserving authenticity while navigating modern pressures (Cordeiro, 2011). Collectively, these examples highlight how transport systems can evolve into powerful cultural icons that mobilize not just people, but also memory, identity, and imagination.

Socio-Economic and Cultural Implications

The development of tourism and transportation carries profound socio-economic and cultural implications for host communities. The expansion of tourism-related transport can significantly influence both economic structures and socio-cultural dynamics, even though stakeholders are not always fully aware of the extent of these impacts (Cheuk et al., 2010) . Tourism can lead to shifts in value systems, individual behavior, family dynamics, and patterns of community organization (Jovičić, 2011; Pizam & Milman, 1986). In the context of Central and Eastern Europe, tourism has functioned as a form of invisible export, contributing to economic development, with transport playing a pivotal role in facilitating tourist mobility and providing essential services at destinations (Hall, 1994). The socio-cultural impacts of tourism are multifaceted and often indirect, making them difficult to quantify and assess (Pizam & Milman,

1986). A comprehensive evaluation of tourism's effects should address both tangible economic benefits and intangible social and cultural consequences. Understanding the dynamic interactions between tourists and host communities is crucial for assessing the scope and nature of socio-cultural transformations at the local level (Jovičić, 2011). Tourism has both positive and negative socio-economic and cultural impacts on host communities (Berondo, 2023; Paul, 2012; Thullah & Abdulai Jalloh, 2021). The emergence of transport as tourism brings a diverse range of socio-economic and cultural impacts, influencing both host communities and tourism systems. From an economic standpoint, these forms of tourism generate revenue not only through direct ticketing but also via ancillary spending on hospitality services, including restaurants, accommodation, and souvenir sales. In heritage-based contexts, the income derived from transport-related tourism helps support the preservation and ongoing operation of historical vehicles and infrastructure, such as steam locomotives, paddle steamers, and funicular railways, thereby safeguarding technical and cultural heritage for future generations. These preservation efforts are frequently sustained through a combination of public subsidies, tourism-generated income, and the volunteer labor of enthusiast networks and heritage associations.

Culturally, iconic transport modes become embedded within the symbolic identity and visual landscape of destinations. Systems such as the gondolas of Venice, San Francisco's cable cars, or Lisbon's tram line 28 serve dual roles: as practical mobility solutions and as powerful cultural markers central to destination branding and tourist imaginaries. Yet the increasing commercialization of these symbols introduces critical tensions. The commodification of transport heritage can lead to the dilution of authenticity, overcrowding, and a shift in functional priorities away from local needs and toward tourist consumption. In many cases, these systems face seasonal demand peaks, rising maintenance costs, and the challenge of navigating preservation imperatives alongside modernization pressures. Such circumstances often necessitate complex governance frameworks and hybrid funding models. Accordingly, while transport-as-tourism can stimulate local economies and contribute to the safeguarding of cultural heritage, it also introduces structural vulnerabilities, ranging from over-tourism and symbolic exploitation to socio-technical strains on urban and regional infrastructure.

Environmental and Sustainability Considerations

Transport plays a critical role in shaping tourism's environmental footprint, while negative impacts from tourist transport include traffic congestion and noise, accidents, air pollution, greenhouse gas emissions, resource depletion, and other environmental problems (Becken, 2006). The COVID-19 pandemic has catalyzed

a renewed focus on the environmental implications of mobility, prompting a shift toward proximity-based tourism, slower modes of travel, and more environmentally friendly transport alternatives (Więckowski, 2021). Tourist satisfaction with transportation is an important indicator of destination performance, while the availability and quality of transport modes directly influence tourist mobility patterns and access to key attractions (Tan & Ismail, 2020). Both the transport and tourism sectors face growing pressure to enhance their environmental performance, particularly given projections of continued growth despite existing sustainability constraints (Becken, 2006). Evolving tourist preferences, especially the rising demand for sustainable tourism experiences and low-emission flights, are reshaping the design of tourism products and altering patterns of leisure travel. This trend underscores the importance of integrating innovative technologies and sustainability principles into the transport-tourism nexus (Tan & Ismail, 2020).

Despite frequently being associated with environmentally conscious or "slow" forms of travel, particularly in the case of rail-based scenic routes or electrically powered heritage trams, the environmental impact of transport-as-tourism varies considerably across different modalities. High-impact forms of experiential transport, such as luxury cruises, helicopter tours, and hot-air balloon rides, contribute significantly to carbon emissions, fuel consumption, and localized ecological degradation. For example, cruise tourism often exerts substantial pressure on coastal and marine ecosystems, while simultaneously burdening port cities with air and water pollution, waste management challenges, and urban congestion.

In light of these concerns, sustainability has become a central theme in both policy and industry discourses on tourism transport. Rail travel is experiencing renewed interest as a lower-emission alternative for long-distance and scenic journeys, bolstered by technological advancements in electric and hybrid propulsion systems. Efforts are also being made to retrofit historical transport vehicles for greater energy efficiency, and to introduce green infrastructure, such as solar-powered boats or eco-certified transit terminals, into heritage and scenic travel networks. However, sustainability in this context must be understood as multidimensional, encompassing not only environmental performance but also social inclusivity, equitable distribution of economic benefits, and the long-term resilience of tourism systems. Balancing these priorities requires integrated planning approaches that align environmental stewardship with cultural preservation and economic viability. As such, advancing "transport as tourism" in a sustainable direction involves addressing the complex interdependencies between ecological responsibility, cultural integrity, and socio-economic equity.

Conclusion

The phenomenon of "transport as tourism" underscores the increasingly intertwined relationship between mobility and leisure, whereby travel is no longer perceived merely as a functional necessity but is instead embraced as an integral and often central element of the tourism experience. Within this evolving paradigm, diverse modes of transport, ranging from heritage steam trains and panoramic cable cars to luxury cruise liners and themed monorails, are being reimagined as symbolic, aesthetic, and emotionally resonant spaces. These forms of mobility not only enable physical access to destinations but also serve as platforms for sensory immersion, emotional engagement, and the performance of identity. This redefinition of movement challenges long-standing dichotomies between transportation and tourism, revealing a complex, hybridized tourism landscape in which the journey itself acquires intrinsic value.

Understanding transport as an experiential product creates opportunities for innovative destination development and more targeted market segmentation. Destinations that preserve iconic transport modes or design immersive and story-rich mobility experiences can appeal to niche tourist segments while extending the spatial and temporal distribution of tourism flows. For instance, historic tramlines or mountain funiculars fulfill utilitarian roles while simultaneously reinforcing destination identity and contributing to heritage conservation. Furthermore, such transport-based attractions can generate substantial economic impacts through direct revenues from fares, increased demand for hospitality services, and growth in creative industries tied to branding and cultural production.

Nevertheless, the growth of transport-oriented tourism raises important challenges that necessitate proactive planning and strategic governance. Chief among these are concerns around environmental sustainability, particularly with regard to high-emission modes such as cruise ships, scenic flights, and helicopter tours. Other critical issues include the risk of authenticity dilution, the commodification of culturally significant symbols, and the potential exacerbation of over-tourism. In managing these dynamics, it becomes imperative for tourism stakeholders to balance experiential innovation with ecological responsibility and cultural preservation.

To support both theoretical development and practical application, future research should aim to establish more nuanced typologies of transport-as-tourism experiences, accounting for differences in tourist motivation, geographic context, and degrees of integration with other tourism sectors. Comparative analyses across urban, rural, and natural environments can further illuminate how transport functions within distinct socio-spatial configurations. Additionally, interdisciplinary approaches that draw on behavioral economics, cultural geography, and sustainability science

offer valuable insights into how tourists assign meaning and value to transport-based experiences.

Ultimately, fully integrating the concept of "transport as tourism" into tourism policy and planning demands a cross-sectoral strategy that bridges transport engineering, heritage management, environmental stewardship, and tourism development. As contemporary tourists increasingly seek immersive, emotionally resonant, and ethically aligned travel experiences, the mobility systems that facilitate and shape these encounters will become central to constructing more sustainable, inclusive, and future-ready tourism landscapes.

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