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EDITORIAL OFFICE

Faculty of Sciences
Department of Geography, Tourism and Hotel Management
Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia
tel. +381 21 450-105
fax +381 21 459-696
Official site: www.dgt.uns.ac.rs

CONTACTS

Lazar Lazić, PhD, full professor
Department of Geography, Tourism and Hotel Management, Serbia, lazarus@uns.ac.rs

Dragan Milošević, teaching assistant
Department of Geography, Tourism and Hotel Management, Serbia, dragan.milosevic@dgt.uns.ac.rs

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Using geoinformation tools for redistricting: Slovenian experiences

Boštjan Rogelj[A*], **Marko Krevs**[A]

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Abstract

Electoral districts are an important component of the electoral system, as they have a significant impact on election results. Due to the uneven spatial distribution of electoral support political parties receive, district magnitude and the geography of electoral districts can have a decisive influence on the electoral viability of individual parties and candidates. Districting and redistricting are not a simple bureaucratic process but a politically very sensitive process with outcomes that can have far-reaching political consequences.

Geoinformation tools can have a very important role in electoral district planning. In this article we aim to present the key advantages and disadvantages of their use. The presented results are derived from practical experience gained over the course of developing a new system of electoral districts in Slovenia.

Keywords: electoral geography; electoral districts; redistricting; geoinformatics; spatial decision support; Slovenia

Introduction

Electoral districts are one of the key elements of the electoral system. Together with the electoral formula, the structure of ballot papers and the electoral threshold, they determine how the votes are translated into parliamentary seats (Gallagher & Mitchell, 2005; Grad, 2004; Krašovec, 2007). District magnitude – the number of seats awarded within an electoral district – has a particularly significant effect on election results. In general, delimiting a territory into a larger number of smaller districts increases the impact of each vote on the election outcome. With reductions in magnitude, the importance of the geography and spatial dimensions of electoral districts increases. Due to the uneven spatial distribution of electoral support for political parties, the geography of electoral districts can have a decisive influence on the electoral prospects of individual parties and candidates. Districting and redistricting of electoral districts are therefore a very complex and often highly politicized process in which various actors want to assert their narrow political interests.

We roughly distinguish two ways to delimit electoral districts (ACE Project, 2020). In the first case, spatial dimensions of the electoral district are determined first, followed by a determination of its magnitude. Spatial dimensions are usually determined on the basis of existing administrative-territorial divisions within a territory, and the magnitude on the basis of the number of inhabitants or voters using simple mathematical formulas. This way of forming electoral districts is relatively simple and less susceptible to manipulation.

In the second case, the magnitude of districts is determined first, followed by a determination of their spatial dimensions. Spatial dimensions are deter-

[A] University of Ljubljana, Faculty of Arts, Department of Gerography, Slovenia, bostjan.rogelj@ff.uni-lj.si; marko.krevs@ff.uni-lj.si
[*] Corresponding author: Boštjan Rogelj; e-mail: bostjan.rogelj@ff.uni-lj.si

mined on the basis of various, often conflicting criteria. Due to the requirements to take into account different criteria and their arbitrary nature, such an approach of drawing districts is very complex and often subject to various manipulations. Drawing of electoral districts to the advantage of a particular political party or group is referred to as gerrymandering (Morrill, 1981).

Very early on electoral district planners realized the usefulness of geoinformation tools. These tools allow them to incorporate into the design process a broad spectrum of information, that can be used to develop a larger number of proposals in a relatively short timeframe. With the help of spatial and statistical analyses, they can more effectively and more quickly assess the suitability of different proposals. However, new tools increase the possibility of manipulation. Thanks to the tools it is now easier, quicker, and cheaper to design proposals that meet the specific political interests of individual actors (Eagles et al., 2000; 1999).

In this article we aim to present the key advantages and disadvantages of using geoinformation tools for districting and redistricting electoral districts. Both authors were members of an expert group that prepared a proposal for a new system of electoral districts in Slovenia. The presented results stem from practical experience gained while working in the expert group in the period from March 2019 to March 2020.

The article consists of four parts. The introductory part is followed by a brief presentation of some theoretical aspects of the use of geoinformation tools in districting and redistricting. The third part presents and critically evaluates the use of geoinformation tools in the reorganisation of the system of electoral districts in Slovenia. In the conclusion, an assessment of the usefulness of geoinformation tools in the process of districting and redistricting is provided.

Electoral district plans and geoinformation tools

Designing electoral district plans is a very complex and labour-intensive process that requires the processing of a myriad of spatial and statistical data. As manual data processing is time consuming, electoral district planners started using computers in their work very early on. The first examples of the use of geoinformation tools can be traced back to the 1960s (Nagel, 1965; Weaver & Hess, 1963), however, for a long time they were used in a limited way. This reflects that the tools were inaccessible, had limited capacities and were complicated to use, and above all, were extremely costly. The situation began to change in the 1990s, when the first commercial GIS tools appeared on the market (Altman & McDonald, 2019). These were more powerful and user-friendly. An important innovation was the development of graphical user interfaces, which enabled the visualization of spatial and statistical data. The next turning point in their development was the expansion of broadband internet, cloud services and open-source programs and applications. In the last decade, these changes have significantly reduced the cost and increased the availability of geoinformation tools (Altman & McDonald, 2019).

We can identify three roughly defined areas of application for geoinformation tools in electoral district planning processes:

- support for human planners,
- evaluation of district plans,
- automated districting and redistricting.

Geoinformation tools are of great help to electoral district planners at all stages of their work. They play an important role already in the preparation and processing of data, as they enable linking of statistical and spatial data. With the aid of the tools, planners can quickly and easily define the spatial dimensions of an electoral district, obtain basic statistical information about it (number of inhabitants, area, perimeter, etc.) and check whether it meets the established criteria. In the final phase, they enable the production of accurate cartographic representations of proposed solutions. Their use has greatly facilitated, accelerated and reduced the cost of districting and redistricting, and at the same time has reduced the number of various errors. The use of geoinformation tools was initially very limited, but with the advent of free open-source web applications, the whole process has been democratized. The drafting of electoral district plans is no longer restricted to a narrow circle of experts but is open to different actors (Altman & McDonald, 2019; Crampton, 2013). Today, an individual with basic computer skills and simple hardware can prepare a plan of electoral districts drawing on publicly available spatial and statistical data and with the help of open-source online applications.

Evaluating the suitability of proposed plans is another area of application for geoinformation tools. With their help, it is possible to quickly and easily check the extent to which an individual proposal meets set criteria. Furthermore, they can be used to identify different forms of manipulation more easily and quickly. This is particularly important when decision-makers and stakeholders need to consider and evaluate a large number of proposals. In addi-

tion to their many advantages, geoinformation tools also bring certain risks and pitfalls. Above all they increase the possibility of manipulation. The application of geoinformation tools in electorate planning has increased the incidence, efficiency, and sophistication of gerrymandering. Thanks to the tools, it is possible to design plans that satisfy the narrow interests of individual political actors much faster and more efficiently (Altman et al., 2005). Through spatial analysis of data on the socio-economic and demographic characteristics of the population and their electoral preferences, political actors can design electoral district maps that meet the prescribed legal criteria, while at the same time maximizing their own political interests. This problem was particularly acute in the past, when geoinformation tools were only accessible to a relatively narrow circle of users due to their high cost. The proliferation of free open-source web applications has not eliminated the gerrymandering problem, but has empowered civil society actors engaged in and monitoring (re)districting (Altman & McDonald, 2019; Crampton, 2013).

The third area of application of geoinformation tools is automated districting and redistricting. With the development of geoinformation tools, ideas have emerged to use them to automate electoral district planning (Altman et al., 2005). The idea is based on the assumption that the planning of electoral districts is fundamentally a mathematical problem (i.e. a partitioning problem) or a combinatorial optimization problem, which can be solved most quickly and efficiently with the help of computers. Proponents of automation argue that computers and geoinformation tools can be used to design optimal, transparent, and politically neutral electoral district plans (Browdy, 1990; Gudgin & Taylor, 1979; Hess et al., 1965; Vickrey, 1961; Weaver & Hess, 1963).

In practice, complete automation of districting and redistricting has proven to be much more difficult to implement than its proponents claim. The division of territory into electoral districts is a very complex mathematical problem that cannot be solved even with the help of state-of-the-art computers (Altman, 1998; 1997). What is more, automation has been shown not to provide politically neutral solutions. Altman (1997) notes that neutrality depends on three factors: 1. the process chosen; 2. goals of the system; 3. the outcomes from efforts to achieve these goals within specific demographic and political circumstances. Today, there is a growing belief that given a lack of general consensus on what constitute objectively neutral goals, no automation is neutral.

Use of geoinformation tools in electoral redistricting in Slovenia

The electoral system used in the elections of deputies to the National Assembly of the Republic of Slovenia is characterized by a unique electoral districts model. The territory of the country is divided into eight electoral districts and 88 constituencies for election purposes. Within each electoral district 11 seats are awarded, and accordingly, each district is subdivided into 11 constituencies. The National Assembly Election Act stipulates that electoral districts and constituencies be formed in accordance with the principle that each deputy is elected to represent approximately the same number of inhabitants. The law also stipulates that the formation of electoral districts and constituencies must take into account the geographical integrity along with common cultural and other characteristics.

In practice, these provisions are very difficult to harmonize. Significant regional fragmentation and uneven population density in the country make it impossible to create geographically consistent and equally populous spatial units. In the past, the first provision was the principal consideration in designing electoral districts (electoral districts have the same number of inhabitants though are not geographically consistent), while the second provision was taken into account when designing constituencies (the map of constituencies largely reflects the 1992 administrative-territorial division of the state into municipalities).

The system of electoral districts and constituencies has not undergone major changes since its introduction in 1992, this is despite the fact that there have since been significant changes in the spatial distribution of the population and the administrative system of the state. In 2017, a procedure was initiated at the Constitutional Court to review the constitutionality of the current system of constituencies. The Constitutional Court ruled that because of the large differences in the size of constituencies (in 2019 the most populous constituency had 31,694 voters, whereas the smallest had 7,945) and inconsistencies between constituency borders and the new administrative division of the state into municipalities, the existing system of constituencies is unconstitutional. The Constitutional Court therefore ordered the National Assembly to correct the unconstitutional situation within two years.

In April 2019, the Ministry of Public Administration established a working group tasked with preparing a proposal to amend the system of constituencies. The working group which was led by the authors of

this article prepared three proposals for a new system of constituencies. The use of geoinformation tools in the work of the working group is presented and critically evaluated below. Above all, we want to present where and how we used them as well as what problems we encountered.

The working group used geoinformation tools in all three previously discussed areas of application. Most of the work was completed using the desktop and online versions of ArcGIS. In the first phase, we used these tools to prepare the relevant spatial data consisting of geoinformation layers on census tracks, settlements, municipalities, administrative and statistical regions provided by the Surveying and Mapping Authority of Slovenia (Register of spatial units, 2019). Data on voters (these data are not publicly available) by house numbers were extracted from the National Population Register run by Ministry of the Interior (Number of voters…, 2019) and aggregated at different spatial levels (from census tracts as the smallest aggregation units, local communities and urban and village districts, settlements, to municipalities as the largest aggregation units). Aggregated data on the number of voters formed the basis for planning individual constituencies, as we wanted to create constituencies that were as similar in population as possible. Various spatial data layers (topographic maps in various scales, road maps, and detailed city plans) played an important role as we relied on them to create constituencies that were as geographically consistent as possible. Geoinformation tools were also used to check for possible inconsistencies in borders between neighboring constituencies or between the sums of voters in individual constituencies and the target number of voters in an electoral district. They were used to quickly and easily check how well the borders of proposed constituencies conformed with important natural geographical divides in regions and to existing administrative-territorial divisions of the state. In the final phase, they were used to prepare cartographic representations (Figure 1) and present the basic characteristics (number of voters, list of spatial units) of the proposed constituencies. We also used them to compare proposals and existing arrangements.

Evaluation of the suitability of the proposed redistricting was another area where geoinformation tools

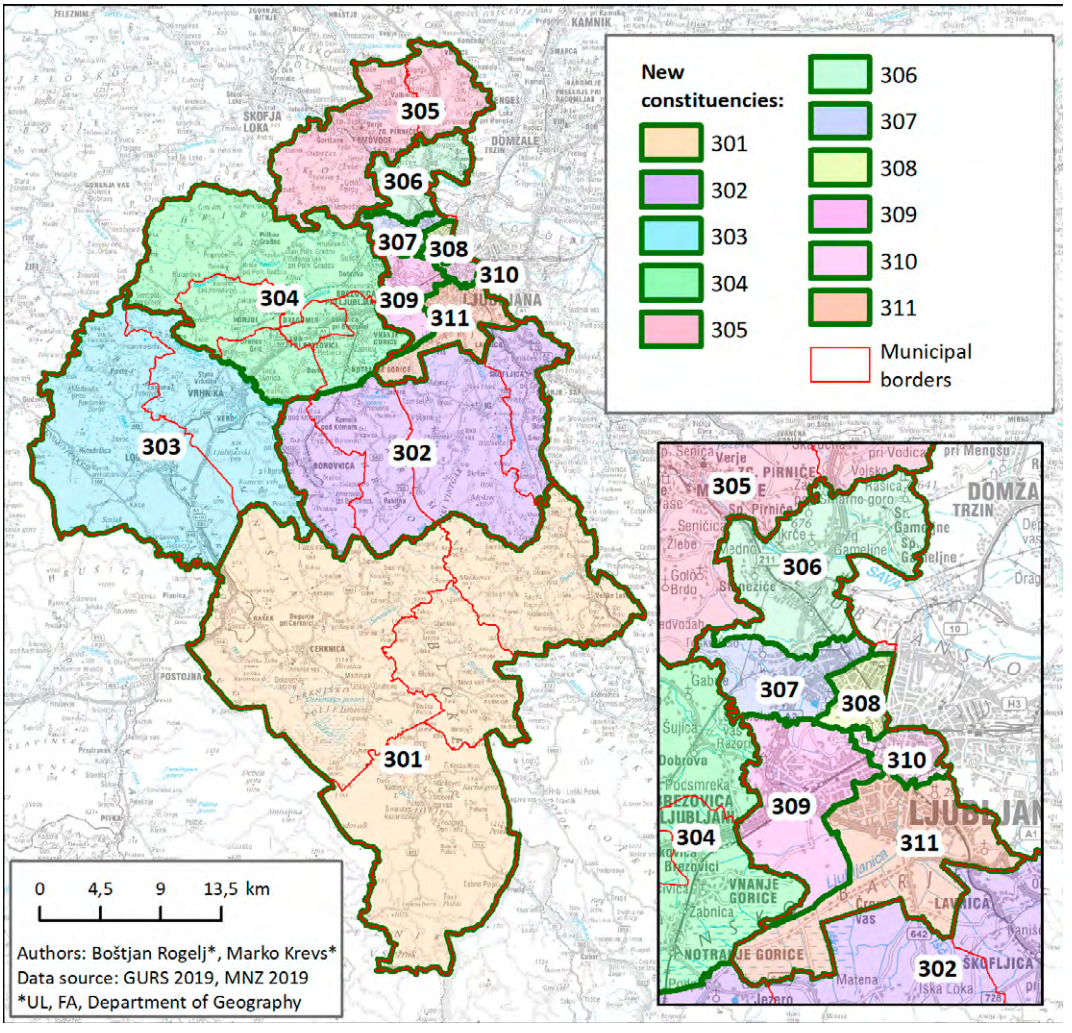

Figure 1. Map of the proposed system of constituencies in one of the electoral districts

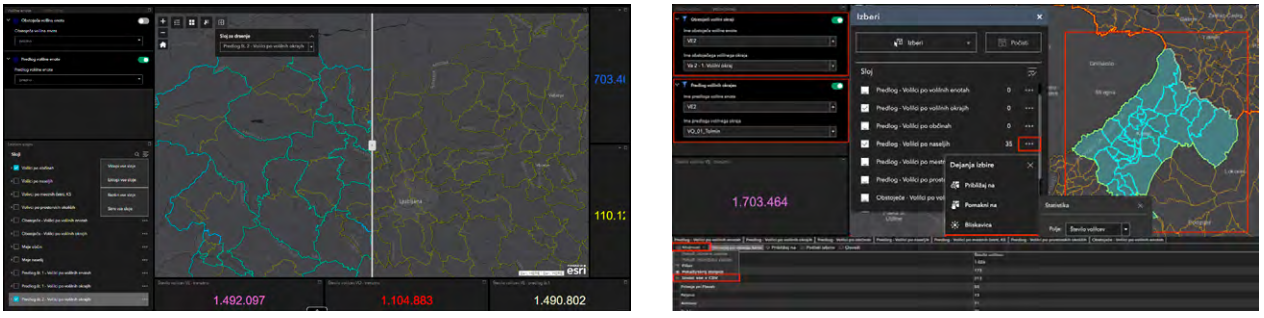

Figure 2. Web application for drafting proposals for new constituencies, that was made available to political parties in action **A)** visually comparing different proposed systems of constituencies and **B)** preparing to export a new proposal of a constituency, based on the materials and application carried out by external partners in the project (Jelen et al., 2019; Veršič & Jelen, 2019) [click on figure to enlarge]

were employed. Redistricting is a politically very sensitive issue, as it can have a significant impact on the electoral prospects of individual candidates (Webster, 2004). To guard against accusations of a lack of transparency and bias in the proposed solutions, the working group, in collaboration with external partners, developed a web application (Figure 2; Jelen et al., 2019) using ArcGIS Online, which provided parliamentary party representatives with a detailed overview of the proposed solutions, while it also enabled them to prepare alternative proposals.

Automated districting was the third area where the working group used geoinformation tools. The working group got external partners to develop a test version of an application for automated constituency redistricting. The first results of the application highlighted some problems that were impossible to solve within the set time frame and with limited resources (more on this below). While the idea of automation has not been fully realized, preliminary attempts have yielded some encouraging results.

The above highlights the versatile applicability of geoinformation tools using the example of redistricting of constituencies in Slovenia. In this regard, it is worth noting the irreplaceable assistance these tools provide to human planners. Without exaggeration, we can say that without their help it would have been impossible to prepare three proposals for a new constituency system in such a short time (the deadline for submitting the first proposal was two months, the same time frame applied for the preparation of amended proposals) (Rogelj et al., 2019a, 2019b). Their role in checking for and detecting possible errors is also very important. Thanks to the tools, we were able to quickly and easily check whether the proposed solution met the set criteria (in terms of the number of voters, harmonization of borders with the borders of different spatial units, etc.) and whether we made a mistake in determining the boundaries. The biggest shortcoming turned out to be the vague definition of a constituency (using terms such as geographical or cultural homogeneity used as defining principles, missing criteria for equal size of the constituencies) which meant that no relevant demographic, economic or data related to cultural characteristics were used. As a result, not all the possibilities offered by modern geoinformation tools were taken advantage of. For example, in planning constituencies, we could not take into account demographic trends (net changes in the number of voters by different territorial units would be especially helpful) and some aspects of functional connections present between settlements/municipalities (e.g. the number of daily migrants, access to different services).

Use of the web application for providing detailed insights into proposed solutions and for preparing alternative proposals turned out to be a very interesting experience. Despite training potential users of the application and urging parliamentary parties to make use of it to submit their proposals, uptake was very limited (Krevs et al., 2020). There were two reasons for this. The first was the great complexity of the task. Deputies had many ideas on how to transform individual constituencies, but when it came to finding a comprehensive solution at the level of the electoral district or the state, their proposals often proved to be deficient and inappropriate. In conversations, many admitted that the task - despite its apparent simplicity - was more difficult to accomplish than they had envisaged. The design of the application is another reason for the modest response. Given the short time frame available to us for its development, the application was not the most user-friendly. To use key functions users required some practice and a certain amount of geographical and computer skills and knowledge. While most users unfamiliar with geoinformation tools gave up very quickly, a few political parties took advantage of the application in coming up with some of their own proposals. The members of the working group and the developers of the application believe that with different (longer) time frames and sufficient financial support, it would be possible to create a more user-

friendly application that would be useful both for representatives of political parties and the general public. This would significantly increase the transparency of the whole process.

Most of the open questions that remain concern the use of geoinformation tools for automated districting. We mentioned that the idea of automation has not been fully realized. The first attempts yielded some encouraging results, while at the same time highlighted some key issues. Among them, it is worth mentioning the selection of appropriate criteria and determination of the hierarchy of selected criteria or measures.

We previously noted that the law very loosely sets out the criteria for districting constituencies. Constituencies are supposed to be the same size (by population) and geographically consistent, but nowhere is it specified what size deviations are allowed and what criteria should be taken into account when assessing the geographical consistency of constituencies. Defining more precise criteria was therefore the first task of the working group. After careful consideration, we identified seven basic criteria (Table 1). In practice, it turned out that the criteria were too ill-defined in certain situations, and they were not able to be used to come up with suitable solutions. In such cases, we used additional criteria such as transport connectivity, degree of urbanization, socio-economic characteristics of the population, location of important natural geographical divides, geographical consistency, etc. These are criteria that are to some extent already incorporated into the basic criteria, as they form the basis for regional administrative divisions of the state (see the sixth criterion in Table 1). With their help, we managed to create similarly sized and geographically more consistent constituencies.

When it came to automated districting of constituencies, given the time constraints, unavailability of relevant data and the fact that some criteria are very difficult to quantify and define, we did not take into consideration additional criteria. It is therefore not surprising that the proposed solutions conformed to a lesser degree to the principle of geographical consistency.

Another problem concerned the determination of weighting or ranking of selected criteria. Some criteria are mutually incompatible. Most problematic was harmonizing the requirement that constituencies be comparable in size (have the same number of voters) and be geographically consistent. This problem was solved "manually" by looking for solutions within the previously determined size limits, which preserved the integrity of spatial units (municipalities, settlements, town wards, and local communities). In practice, this meant that the geographical consistency (integrity of spatial units) was subject to given size constraints. Size restrictions were violated only in cases where strict adherence to them grossly violated the principle of geographical consistency for a large number of constituencies. In such cases, solutions deviating from the size limits were proposed. This underscores that during "manually" districting constituencies, the hierarchy of criteria was adapted to the specific situation, and in exceptional cases, minor deviations from the set criteria were permitted.

When employing automated districting of constituencies, such flexibility is not possible. The computer algorithm used is based on fixed rules and a clearly defined hierarchy of criteria. Having constituencies with approximately the same number of voters was defined as the most important criterion. In practice, it turned out that rigidly striving for the most comparable constituencies in terms of population size often leads to geographically consistent areas being broken up and the formation of geographically inconsistent constituencies.

Table 1. Key criteria used to develop proposals for a new system of constituencies in Slovenia (Rogelj et al., 2019a, 2019b)

1. size of constituencies (in terms of population) is determined based on the number of voters not on the number of inhabitants;
2. deviation in size of constituencies is determined in relation to the average size of a constituency at the national level (total number of voters divided by total number of seats (88)). a) in the first proposal, the maximum tolerance was +/– 15%. b) in the second proposal, the maximum tolerance was +/– 25%, exceptionally up to +/- 30%. c) in the third proposal, the maximum tolerance was +/– 25%, exceptionally up to +/- 45%.
3. municipalities and settlements serve as the foundational unit for districting constituencies; where possible, division of municipalities and settlements is avoided;
4. in the case of division of municipalities, the boundaries of settlements are taken into account;
5. only those settlements that are larger than the maximum permitted size for a constituency shall be divided; in the case of division of settlements, the boundaries of local, district or village communities are taken into account; exceptionally, census tracts are used for the districting of constituencies;
6. when merging spatial units, the boundaries of regional administrative divisions of the state are taken into account (boundaries of administrative units, statistical region, etc.);
7. the objective is to determine the best comprehensive solutions at the electoral district level.

Based on the test cases, it is difficult to predict what solutions would be reached if more time, resources, and relevant data were available. We would probably get better solutions, but it is unlikely that these would be comparable or even superior to those prepared by the working group. The extraordinary complexity of the task, the experience gained through the work of the working group and examples from abroad show that districting of constituencies requires a certain degree of flexibility, which is difficult to incorporate into computer algorithms.

Conclusions

How useful are geoinformation tools in districting and redistricting of electoral districts? Based on our experience, we can say that they have become an indispensable part of the process. With their help, we can simplify and speed up the whole process and greatly reduce the possibility of various errors.

That said, modern geoinformation tools, despite the many possibilities they offer, are not omnipotent. Their usefulness is often limited by various external factors. The first major limitation is input data. The preparation of appropriate electoral district plans is possible only if relevant data are available. Without this, even the most state-of-the-art and sophisticated tools are completely useless.

The second limitation is related to rules and criteria. Geoinformation tools can be best used when the rules and criteria are clearly defined. Ambiguity in the rules and criteria has a negative effect on the transparency of the entire process, as it prevents an objective and impartial assessment of individual proposals. In our case, most problems were caused by the unclear definitions of two key criteria (equally populous and geographical consistent) used in districting. This fact was often used to criticize solutions that did not suit the interests of certain groups and individuals.

The third and, in our opinion, most important limitation is the willingness of stakeholders to take advantage of the opportunities offered by modern geoinformation tools. Political parties, the most prominent actors directing and supervising the process of redistricting in Slovenia, showed very little interest in exploiting the potential of geoinformation tools. This is partly due to a lack of familiarity with the technology, and partly to fear of losing control of the process. Geoinformation tools enable stakeholders and individuals to be actively involved in verifying proposals and finding new solutions. However, this is not to the liking of political parties, as they would lose their primacy over the process.

Even though the plans prepared by our group in all probability will not be included in amendments to the law, the experience and knowledge we gained will be useful in the preparation of similar plans in Slovenia and other countries.

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Ecotourism Impact Assessment on Environment in Protected Areas of Serbia: A Case Study of Gornje Podunavlje Special Nature Reserve

Vladimir Stojanović[A], Maja Mijatov[A*], Jelena Dunjić[A], Lazar Lazić[A], Aleksandra Dragin[A], Dubravka Milić[B], Sanja Obradović[A]

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Abstract

Ecotourism is a nature-based type of tourism, especially represented within protected areas. No matter the fact, just like the other selective types of this sector, ecotourism might affect the environment. In a process of writing the Visitor Management Plan in the Gornje Podunavlje Special Nature Reserve (SNR) in 2019, one part of the study was related to general projection of the ecotourism development impact on eco-educational paths within this SNR. The research was conducted throughout November 2019, in the form of interviews. The sample obtained 12 experts for nature protection, who stated their attitudes on three important topics: tourism in protected areas in general, tourism in the Gornje Podunavlje SNR and ecotourism within three concrete sites: Karapandža, Štrbac and Bestrement.

Keywords: ecotourism; protected areas; impact assessment; experts' attitudes; nature protection; plant sensitivity; animal sensitivity

Introduction

Nature-based tourism, including ecotourism, has a range of negative effects on the environment (Buckley, 2004a, 2004b, 2004c). In order to minimize such negative effects, protected areas managers are following different infrastructural and technical details. Considering specific characteristics of localities, there are concrete measures that must be applied to each path separately (Hockett et al., 2017; Kidd et al., 2015; Tomczyk & Ewertowski, 2013). However, besides infrastructural and technical measures, it is also important to provide assessment of the impact of tourism activities on natural resources within the paths, which is strongly related to the process of monitoring the plant and animal species (Asmelash & Kumar, 2019; Blancas et al., 2016; Laimer, 2017; Kristjánsdóttir et al., 2018; Mapjabil et al., 2017).

Raising concern about the tourism impact on the environment initiated the need for more sustainable forms of tourism, which led to the ecotourism development in the late 1980s (Donohoe & Needham, 2006) and since than it became a growing industry (Carvache-Franco et al., 2020). One of the first of definitions of ecotourism explain that '*we may define ecological tourism or ecotourism as that tourism that involves travelling to relatively undisturbed or uncontaminated natural areas with the specific object of stud-*

[A] University of Novi Sad, Faculty of Sciences, Department of Geography, Tourism and Hotel Management, Trg Dositeja Obradovića 3, 21000, Novi Sad, Serbia; vladimir.stojanovic@dgt.uns.ac.rs; majamijatov@gmail.com; jelenad@dgt.uns.ac.rs; lazar.lazic@dgt.uns.ac.rs; sadragin@gmail.com; sanjaobradovic992@gmail.com
[B] University of Novi Sad, Faculty of Sciences, Department of Biology and Ecology, Trg Dositeja Obradovića 2, 21000, Novi Sad, Serbia; dubravka.milic@ube.uns.ac.rs
[*] Corresponding author: Maja Mijatov; e-mail: majamijatov@gmail.com

ying, admiring and enjoying the scenery and its wild plants and animals' (Ceballos-Lascurain, 1996). Ecotourism is a nature-based type of tourism where educational component is well emphasized. This means that tourists are given the opportunity to gain awareness and knowledge about nature and its conservation (flora, fauna, geology and ecosystems of an area), sustainable practices, the methods for participation of local communities and ethical planning, development and management (Šiljeg et al., 2019). It is one of the few opportunities for the poor to support and promote sustainable development (Goodwin, 2009).

The link between protected areas and tourism is as old as the history of protected areas. This connection is mutual, since both tourism and protected areas need each other in order to achieve their full potential (Eagles et al., 2002). Even though ecotourism is considered to be an activity with a low impact on nature (Pablo-Cea et al., 2021), the impacts of ecotourism on protected areas could still be negative (Buckley, 2001).

Nevertheless, there are many contributions that ecotourism development could generate for the biodiversity conservation. First, it could generate additional financial resources obtained from visitation fees and donations, which could be helpful to protected area management. Then, it could contribute to raising awareness of visitors, encouragement of community involvement and interest in conservation issues and generating political support for conservation through environmental education during travel (Christ et al., 2003). For some countries, benefits derived from interest in biodiversity is an especially important source of revenue. On the other hand, in some cases protected areas become so popular among visitors that there is cause for concern as to the consequences of high frequentation for the preservation of the sites (Lévêque & Mounolou, 2003).

In this study we investigate the major impacts of tourism development to natural resources of protected areas according to the experts in the field of nature protection. The main issue with tourism development in protected areas is that it puts certain pressure to the resources. On the other hand, it generates benefits for the destination as well. Therefore, identifying the major impacts and mitigating them in early stages of tourism development would have major contribution to achievement of sustainable development. There is a certain gap between realistic situation in the field and academic contribution to this problem. Therefore, this study aims to provide an insight into the attitudes of the experts for nature protection of the Gornje Podunavlje Special Nature Reserve (SNR), in order to emphasize the need for harmonizing the further activities of ecotourism and nature protection within the study area. The results are beneficial to multiple stakeholders, such as managers of other protected areas, giving them the starting point to creating visitors' guidelines, or establishing more restricted zones for tourists according to the vulnerability of the area or species. Other academics could use the results as the insight into the issues on field, which are often omitted in academic literature.

Study area

Gornje Podunavlje SNR is located within peripheral, northwestern part of Serbia (19,648 ha). It stretches along the left bank of the Danube River and includes numerous meanders, oxbow lake, canals, or more precisely aquatic, marsh, meadow and forest ecosystems (Figure 1).

Protected area of Gornje Podunavlje is the most recognizable by the well-preserved features of the floodplain along the Danube River (Panjković & Stojnić, 2011). The value of the ecosystems of Gornje Podunavlje Region is reflected in the fact that they represent one of the rarely preserved natural landscapes in predominantly agrarian environment of northern Serbia, as well as in the fact that this area provides numerous opportunities for development of tourism (Lazić et al., 2008; Stojanović et al., 2018).

The living world of Gornje Podunavlje SNR is rich, diverse, specific and unique, with a large number of rare and unthreatened plant and animal species of national and international importance. Its vegetation is built of 57 herbaceous, forest, and shrubby plant communities. Another part of diversity of the living world of the Gornje Podunavlje SNR is reflected in the presence of 60 species of diurnal butterflies, 55 species of fish, 11 species of amphibians, nine species of reptiles, over 230 species of birds and 51 species of mammals. This SNR is also a hatchery ground for fish, as well as a nesting place for white-tailed eagle and black storks. Finally, this protected area is perhaps the best known as a habitat with the regionally richest population of marsh deer and wild boar (Ministry of Environmental Protection, 2007).

The Gornje Podunavlje SNR is also an area of international importance: Ramsar site (wetland of international importance), IBA – Important Bird Area, IPA – Important Plant Area (Panjković & Stojnić, 2011). SNR is part of the Bačko Podunavlje Biosphere Reserve, which was declared in 2016 (Tucakov, 2018).

The ecotourism policy highlights three main zones of ecotourism development in the Gornje Podunavlje SNR: Karapandža, Štrbac and Bestrement. These

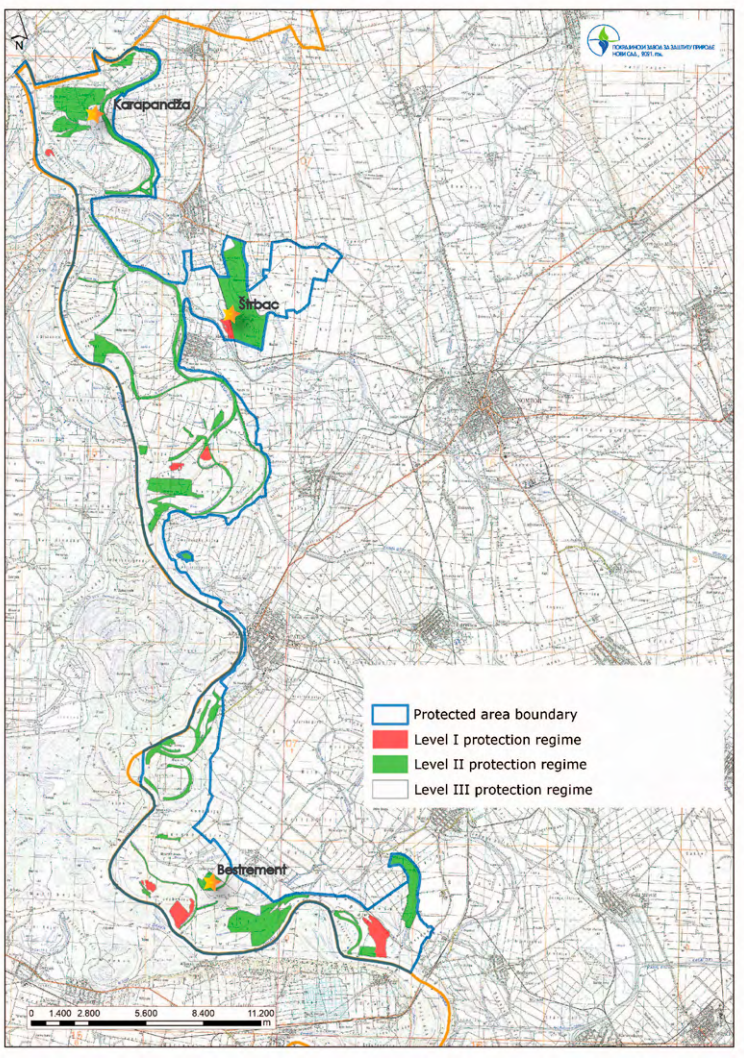

Figure 1. Special Nature Reserve "Gornje Podunavlje"
[click on figure to enlarge]

zones enable approximate distribution of contents of ecotourism on the level of this SNR, considering that Karapandža is located in its northern part, Štrbac in the central part and Bestrement in its southern part.

Methodology

Procedure

The research was conducted in November 2019, as a part of the of the wider study "Visitor Management Plan in the Gornje Podunavlje Special Nature Reserve (SNR)" (2019). The main idea was to conduct preliminary (pilot) study which aimed to identify the main challenges that experts from the SNR Gornje Podunavlje are facing with, as well as key impacts of ecotourism on protected area and priority areas for protection. The first draft of the questions in the questionnaire was created according to the similar problem mentioned in the academic literature (Blancas et al., 2016; Hockett et al., 2017; Tomczyk et al. 2013). Later we conducted the first round of the interviews with the experts from the SNR Gornje Podunavlje, and according to their real-life challenges, we added variables to the questionnaire. Second round of the interview was conducted among the experts with the final questionnaire. The final questionnaire was conducted on the basis of the exploratory design with semi-structured interview protocol. Collected data were coded by using the thematic analysis with data driven inductive-realistic epistemological approach (Robson & McCartan, 2016; Terry et al., 2017) and they were summarized on the basis of the meaning condensation (Kvale, 1996). Such approach was identified as the most appropriate one, considering the main goal of this research, focused on discovering the attitudes of the experts for nature protection of specific

environment, in this case the Gornje Podunavlje SNR. Besides that, the research was oriented towards coding the collected data, in order to fill the gap in the lack of theoretical frameworks for the assessment of the ecotourism impact on the environment in this SNR. During the procedure of data collecting, the respondents preferred to answer the interview questions by e-mails.

Sample

The main idea was to gather the relevant data, based on the attitudes of 12 experts for the nature protection, who are introduced with the real situation of ecotourism impact on the environment within the study area. Therefore, the main idea of the research was to provide reliable findings, based on the attitudes of the experts who are involved in managing and monitoring the situation of ecotourism in the Gornje Podunavlje Special Nature Reserve, as well as in biological and geographical research of the study area, in order to provide the real assessment and proposals for reduction of ecotourism negative effects on the environment. The sample could be divided into the three groups. The first group gathered four employees in the Gornje Podunavlje SNR Authority (the Public Enterprise 'Vojvodinašume'). Besides that, four experts from the Institute for Nature Conservation of Vojvodina Province (INCVP) in Novi Sad, the leading institution for nature protection in Vojvodina (North Serbia), are introduced with the main characteristics of the Gornje Podunavlje SNR and they represent the second group of the sample. Finally, the third group gathered the University professors, biologists and geographers – experts for nature protection, as the main researchers dealing with the issues of importance for the environment preservation of the study area.

Instrument and Data Analysis

The questions for the interview were formed precisely for the purpose of this research. On the one hand, they were based on the literature review on the main issues of ecotourism impact on the environment in protected areas worldwide (Blancas et al., 2016; Hockett et al., 2017; Tomczyk et al. 2013), while on the other hand they also represent a result of the previously conducted field research that provided an insight into the real situation of nature protection in SNR Gornje Podunavlje and which served as guidance for further research of ecotourism impact on nature protection. All together resulted in 17 defined question items. All thematic codes with the same meaning were grouped into the several themes that were used during the data analysis and interpretation procedures. The first theme referred to the respondents' general attitudes on tourism in protected areas and it was researched on the basis of five items (*Tourism in protected areas might contribute to a better understanding of nature protection; Tourism represents a threat to protected areas; Tourists in protected areas should always be under the Protected Areas Managers' supervision; Projects of nature protection might be financed by the incomes gained for providing tourism services; The local community has important role in tourism of protected areas*). The second theme obtained five items regarding tourism in the Gornje Podunavlje SNR (*Tourism in the Gornje Podunavlje SNR represents a chance for successful and active nature protection; Tourism in the Gornje Podunavlje SNR might be a threat for protected natural values; Development of tourism in the Gornje Podunavlje SNR is on satisfying level; Ecotourism in the Gornje Podunavlje SNR is optimally developed; The local community is sufficiently involved in tourism of the Gornje Podunavlje SNR*). The final third theme included seven items related to ecotourism, within three concrete sites in this SNR, or more precisely in Karapandža, Štrbac and Bestrement (*Tours across the educational paths in Karapandža represent a threat for protected species and habitats; Tours across the educational path in Štrbac represent a threat for protected species and habitats; Tours across the educational path in Bestrement represent a threat for protected species and habitats; Karapandža, Štrbac and Bestrement encompass some of the most important values of the Gornje Podunavlje SNR; Ecotourism within Karapandža, Štrbac and Bestrement might contribute to gaining complete experience of the Gornje Podunavlje SNR; Ecotourism (education, interpretation) should be developed on the other localities within the Gornje Podunavlje SNR, outside three researched ones; Ecotourism within Karapandža, Štrbac and Bestrement encourages nature protection.*). All gathered responses were summarized in order to briefly represent the attitudes of the experts for nature protection of the Gornje Podunavlje SNR. Respondents expressed their attitudes on the scale, ranging from 1 (completely disagree) to 5 (completely agree). They were asked three additional open-ended questions for expressing their wider attitudes related to the plant and animal species sensitivity and necessary measures in further ecotourism development (*Are some plant species and communities in Karapandža, Štrbac and Bestrement particularly sensitive in relation to ecotourism tourism activities (walking, education, volunteering) and which ones? Are some animal species in Karapandža, Štrbac and Bestrement particularly sensitive in relation to ecotourism tourism activities (walking, education, volunteering) and which ones? In your opinion, is it necessary to implement concrete special measures in the process of realization of ecotourism in Karapandža, Štrbac and Bestrement in order to avoid the negative influences of tourism and which ones?*).

Results

The research results of conducted interviews and further analysis of collected data will firstly be represented in the form of the findings for three defined themes separately, which will be followed with the representation of findings in a summary form. Findings will be discussed as a whole, while thematic relationship patterns will be elaborated and linked to a formal body of knowledge on the topic of the ecotourism impact on the Gornje Podunavlje SNR.

Tourism in protected areas

Employees of the Gornje Podunavlje SNR Authority completely agreed with the fact that tourism within protected areas might contribute to a better understanding of nature protection (Table 1). A slightly lower average score (M = 4.75) was recorded for this item within the group of INCVP experts and University professors.

Most of the employees in the Gornje Podunavlje SNR Authority (M = 4.50) and INCVP experts (M = 4.25) completely agreed with the fact that tourists in protected areas must always be under the supervision of their Authorities. University professors are sharing their opinions (M = 4.25).

University professors completely agreed with the fact that nature protection projects might be financed from the incomes realized on the basis of providing tourism services (M = 5.00), while INCVP experts expressed slightly lower mean value (M = 4.00). Much lower mean value and almost indefinite attitude was recorded in the case of the employees in the Gornje Podunavlje SNR Authority (M = 3.00).

Besides that, INCVP experts, as well as University professors, fully agreed with the fact that local population has an important role in tourism within protected areas (M = 5.00). Majority of the employees in the Gornje Podunavlje SNR Authority share the same attitude (M = 4.75).

The lowest scores were recorded in the case of the respondents' attitudes regarding the fact that tourism might be a threat to protected areas (INCVP experts: M = 3.25; University professors: M = 2.25; employees in the Gornje Podunavlje SNR Authority: M = 1.75).

Tourism in the Gornje Podunavlje SNR

Employees in the Gornje Podunavlje SNR Authority and INCVP experts, completely or partially agreed with the fact that tourism development within this SNR is a chance for active nature protection (M = 4.50) (Table 2). University professors indicated complete agreement (M = 5.00).

INCVP experts and University professors partially agreed with the fact that tourism within this SNR might be a potential threat for protected natural species (M = 3.25). Employees in the Gornje Podunavlje SNR Authority mainly believe that, in its current form of development, tourism does not represent a threat (M = 2.00).

Lower scores were recorded for INCVP experts' and University professors' attitudes on whether tourism in the Gornje Podunavlje SNR is sufficiently developed (M = 2.25). Mean value for the employees in the Gornje Podunavlje SNR Authority is even lower (M = 1.75). Similar attitudes were recorded regarding the optimal development of ecotourism in this SNR.

Table 1. Respondents' attitudes on tourism in protected areas

Item	Employees in the Gornje Podunavlje SNR Authority		INCVP experts		University professors	
Tourism in protected areas	Mean Value	Standard Deviation	Mean Value	Standard Deviation	Mean Value	Standard Deviation
Tourism in protected areas might contribute to a better understanding of nature protection.	5.00	.00	4.75	.50	4.75	.50
Tourism represents a threat to protected areas.	1.75	1.50	3.25	.96	2.25	1.26
Tourists in protected areas should always be under the Protected Areas Managers' supervision.	4.50	1.00	4.25	1.50	4.25	.50
Projects of nature protection might be financed by the incomes gained for providing tourism services.	3.00	.82	4.00	2.00	5.00	.00
The local community has important role in tourism of protected areas.	4.75	.50	5.00	.00	5.00	.00

Table 2. Respondents' attitudes on tourism in the Gornje Podunavlje SNR

Item	Employees in the Gornje Podunavlje SNR Authority		INCVP experts		University professors	
Tourism in the Gornje Podunavlje SNR	**Mean Value**	**Standard Deviation**	**Mean Value**	**Standard Deviation**	**Mean Value**	**Standard Deviation**
Tourism in the Gornje Podunavlje SNR represents a chance for successful and active nature protection.	4.50	1.00	4.50	.58	5.00	.00
Tourism in the Gornje Podunavlje SNR might be a threat for protected natural values.	2.00	1.41	3.25	.96	3.25	.96
Development of tourism in the Gornje Podunavlje SNR is on satisfying level.	1.75	.50	2.25	.50	2.25	.50
Ecotourism in the Gornje Podunavlje SNR is optimally developed.	2.00	.82	1.75	.50	2.75	.96
The local community is sufficiently involved in tourism of the Gornje Podunavlje SNR.	2.75	.50	2.00	1.41	2.75	.50

Majority of the employees in the Gornje Podunavlje SNR Authority and University professors, believe that members of the local community are not sufficiently involved in development of tourism in this protected area (M =2.75), while even lower mean value was recorded in the case of INCVP experts (M = 2.00).

Ecotourism within Karapandža, Štrbac and Bestrement

In the case of the attitudes of INCVP experts and University professors regarding the ecotourism development within three researched sites (Table 3), it should be noted that all of them agreed with the fact that Karapandža, Štrbac and Bestrement obtain some of the most important natural resources of this SNR (M = 5.00). Slightly lower mean value for this statement was recorded in the case of the employees in the Gornje Podunavlje SNR Authority (M = 4.75).

Most of INCVP experts and University professors completely or partially agreed with the fact that ecotourism needs to be developed in other sites of this protected area, besides within the territory of Karapandža, Štrbac and Bestrement, as three localities of the Gornje Podunavlje Special Nature Reserve, obtained by this research (M = 4.75). Employees in the Gornje Podunavlje SNR Authority expressed indefinite attitude or complete disagreement with this statement (M = 2.50).

Furthermore, employees in the Gornje Podunavlje SNR Authority and INCVP experts expressed the same attitude regarding the fact that ecotourism in these three mentioned sites encourages appropriate nature protection (M = 4.50). University professors showed slightly lower positive attitudes on the same claim (M = 4.25).

INCVP experts partially agreed with the fact that visits to educational paths n Karapandža might threat protected species and habitats (M = 3.25). Employees in the Gornje Podunavlje SNR Authority expressed complete or partial disagreement with this statement (M = 1.25), while similar attitude was recorded for University professors (M = 1.75).

Slightly lower score was recorded for the item related to INCVP experts' attitudes on whether the visits to educational paths in Štrbac and Bestrement might threat protected species and habitats (M = 3.00). Similar mean values were recorded for University professors (M = 2.00) and the employees in the Gornje Podunavlje SNR Authority (M = 1.50).

Finally, attitudes of INCVP experts on whether the ecotourism in Karapandža, Štrbac and Bestrement might contribute to gaining the overall experience of the Gornje Podunavlje SNR remains undefined. Attitudes of the employees in the Gornje Podunavlje SNR Authority (M = 4.50) and University professors (M = 4.25) are more concrete.

Interview Summary

The interview data revealed that experts for nature protection of the Gornje Podunavlje SNR share the attitude that plant and animal species, especially the protected ones, are not endangered by the current level of ecotourism development in this Protected Area, primary within three researched sites, Karapandža, Štrbac and Bestrement. However, it could be said that all of them are aware of potential negative effects that might be caused by increased number of tourists' visits. Besides the current efforts in terms of the ecotourism activities, they indicated expressed awareness of the need for systematic and planned activities in the field of further ecotourism development, with special reference to raising the education of the visitors in terms of nature protection and involvement of the

Table 3. Respondents' attitudes on ecotourism in Karapandža, Štrbac and Bestrement

Item	Employees in the Gornje Podunavlje SNR Authority		INCVP experts		University professors	
Tourism in Karapandža, Štrbac and Bestrement	**Mean Value**	**Standard Deviation**	**Mean Value**	**Standard Deviation**	**Mean Value**	**Standard Deviation**
Tours across the educational paths in Karapandža represent a threat for protected species and habitats.	1.25	.50	3.25	1.50	1.75	.96
Tours across the educational path in Štrbac represent a threat for protected species and habitats.	1.50	1.00	3.00	1.41	2.00	.82
Tours across the educational path in Bestrement represent a threat for protected species and habitats.	1.50	1.00	3.00	1.41	2.00	.82
Karapandža, Štrbac and Bestrement encompass some of the most important values of the Gornje Podunavlje SNR.	4.75	.50	5.00	.00	5.00	.00
Ecotourism within Karapandža, Štrbac and Bestrement might contribute to gaining complete experience of the Gornje Podunavlje SNR.	4.50	.58	3.00	1.41	4.25	.96
Ecotourism (education, interpretation) should be developed on the other localities within the Gornje Podunavlje SNR, outside three researched ones.	2.50	1.00	4.75	.50	4.75	.50
Ecotourism within Karapandža, Štrbac and Bestrement encourages nature protection.	4.50	.58	4.50	.58	4.25	.50

local community in such activities. Causal thematic network illustrates this summary (Figure 2).

Besides that, respondents showed positive attitudes on tourism in protected areas (Table 4), especially in terms of the fact that the local community should be involved in further development (M = 4.92), as well as the fact that tourism in protected areas might contribute to a better understanding of nature protection (M = 4.83). The lowest mean value was recorded for the item which is indicating that tourism represent a threat for protected areas (M = 2.42). Findings are also indicating the fact that tourism in the Gornje Podunavlje SNR represents a chance for active nature protection (M = 4.67), which is not sufficiently utilized, considering the fact that tourism development in this SNR still did not reach the satisfying level (M = 2.08).

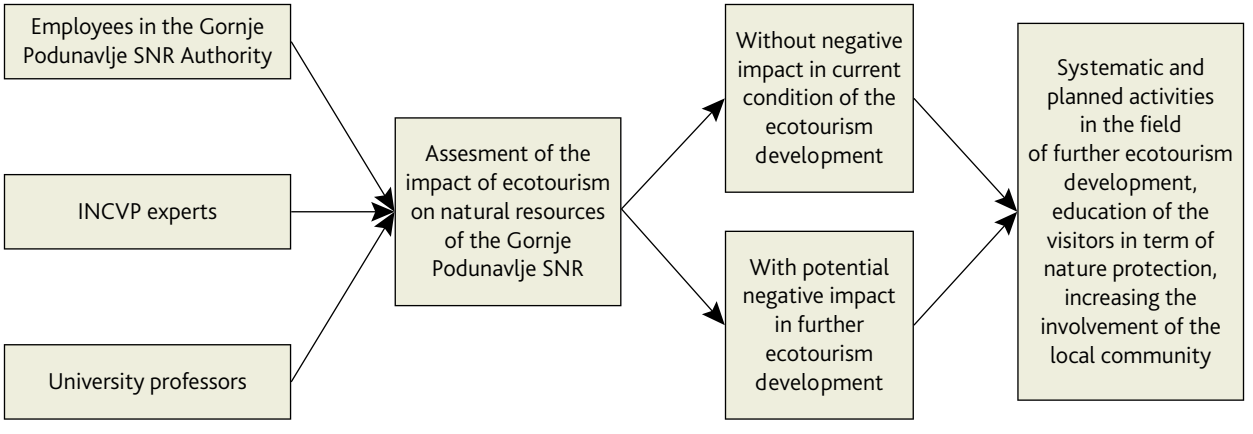

Figure 2. Key constructs in ecotourism development within the Gornje Podunavlje SNR

Table 4. Summarized respondents' attitudes

Item	Mean Value	Standard Deviation
Tourism in protected areas	**4.10**	**.54**
Tourism in protected areas might contribute to a better understanding of nature protection.	4.83	.39
Tourism represents a threat to protected areas.	2.42	1.31
Tourists in protected areas should always be under the Protected Areas Managers' supervision.	4.33	.99
Projects of nature protection might be financed by the incomes gained for providing tourism services.	4.00	1.41
The local community has important role in tourism of protected areas.	4.92	.29
Tourism in the Gornje Podunavlje SNR	**2.85**	**.54**
Tourism in the Gornje Podunavlje SNR is a chance for successful/active nature protection.	4.67	.65
Tourism in the Gornje Podunavlje SNR might be a threat for protected natural values.	2.83	1.19
Development of tourism in the Gornje Podunavlje SNR is on satisfying level.	2.08	.52
Ecotourism in the Gornje Podunavlje SNR is optimally developed.	2.17	.84
The local community is sufficiently involved in tourism of the Gornje Podunavlje SNR.	2.50	.91
Tourism in localities Karapandža, Štrbac and Bestrement	**3.36**	**.55**
Tours across the educational paths in Karapandža represent a threat for protected species and habitats.	2.08	1.31
Tours across the educational path in Štrbac represent a threat for protected species and habitats.	2.17	1.19
Tours across the educational path in Bestrement represent a threat for protected species and habitats.	2.17	1.19
Karapandža, Štrbac and Bestrement encompass some of the most important values of the Gornje Podunavlje SNR.	4.92	.29
Ecotourism within Karapandža, Štrbac and Bestrement might contribute to gaining complete experience of the Gornje Podunavlje SNR.	4.10	.99
Ecotourism (education, interpretation) should be developed on the other localities within the Gornje Podunavlje SNR, outside three researched ones.	4.00	1.28
Ecotourism within Karapandža, Štrbac and Bestrement encourages nature protection.	4.42	.52

Discussion

According to the main findings of the previous research, assessment of the impact of tourism activities on natural resources within the paths, including the monitoring the plant and animal species, represents important step in minimizing negative effects of ecotourism (Asmelash, & Kumar, 2019; Blancas et al., 2016; Laimer, 2017; Kristjánsdóttir et al., 2018; Mapjabil et al., 2017; Pablo-Cea et al., 2020). Considering the fact that ecotourism represents a growing industry, further research of this type are of particular importance (Carvache-Franco et al., 2020).

Experts for nature protection expressed their attitudes on whether the plant species within Karapandža, Štrbac and Bestrement are sensitive in relation to ecotourism activities.

Employees in the Gornje Podunavlje SNR Authority believe that plant species are not sensitive or endangered, because they are not located in immediate vicinity of the walking paths, nor do visitors move without the supervision of guides' professional service. Most of INCVP experts also believe that plant species are not threaten. However, these experts believe that potential impact on sensitive plant species is possible in the narrowest zone of the visitors' movement, where visitors usually stay longer. University professors consider that adequate spatial planning of the walking paths might reduce the negative impact of further tourism development. Planning should be careful and under the professional supervision, considering the fact that some threats for the plant species are not obvious and they

are not easy to predict. For example, trampling might contribute to dispersing invasive plants, which is confirmed in the study conducted by Buckley (2004a). Besides that, Ballantyne and Pickering (2012) considered the ecotourism as a threatening process for wild orchids, on the basis of other human activities, such as direct collecting and habitat clearance. Authors of the same study suggested that it is important to provide comprehensive evaluations of the range of impacts and species affected by tourism and the field assessments of tourism impacts, in order to provide a basis of knowledge for reducing the negative impacts of ecotourism (Ballantyne & Pickering, 2012). In terms of the protected plant species within the Gornje Podunavlje SNR, University professors indicated that water-violets or water-lilies, for example, are not endangered, considering the fact that info boards are set across the protected localities, while the entire destination have the image related to nature conservation.

In case of the animal species sensitivity within Karapandža, Štrbac and Bestrement, in relation to ecotourism activities, experts for nature protection pointed out that it is necessary to consider the main characteristics of these important sites.

The same as in the case of the plant species, employees in the Gornje Podunavlje SNR Authority also believe that animal species are not endangered at the moment. However, they also believe that there is a potential threat in the case of opening the additional localities for tourists. This is important to keep in mind, considering the fact that there are periods during the year when reproduction of the animal species takes place and when all activities are suspended, including the movement of people, employees and local population. These findings are in line with the previously conducted studies which indicated the importance of considering the main characteristics of localities and protected species, when prescribing concrete measures for each path separately (Hockett et al., 2017; Kidd etal., 2015; Tomczyk & Ewertowski, 2013).

INCVP experts are indicating that Karapandža is characterized by the animal species, such as wild cats, Štrbac is a specific site where deer and other game species are inhabited, while Bestrement is a habitat of butterflies – such as freyer's purple emperor (*Apatura metis*). In that regard, Lemelin and Jaramillo-López, (2020) researched the role of tourism in a conservation of the Monarch butterfly and they also highlighted the need to design a special protection measures for tourists' behavior within the site of protected species (Lemelin & Jaramillo-López, 2020).

University professors indicated that the most important bird species in the Gornje Podunavlje SNR are white-tailed eagle and black stork, that are extremely sensitive to the people's presence in a relatively large radius around the nest (there are different recommendations for restricting the movement in different European countries - from several hundred meters, up to more than one km).

Specific measures in the process of the ecotourism realization need to be adjusted to concrete sites and natural resources that are dominant within each of them.

Employees in the Gornje Podunavlje SNR Authority indicated that scope of the visit is not so large to endanger the most important natural values at the moment. In later stages (when the number of visits per day would account more than 200 visitors), some of the additional measures will certainly be needed. INCVP experts highlighted that there is a need to accurately prescribe the time dynamics of eco-tours, considering the time allowed for staying within the sensitive points of the Gornje Podunavlje SNR, together with controlling the size of the group of visitors. Besides that, they also emphasized the importance of limiting the visits during the week, especially during the critical periods, when plant and animal species are sensitive to disturbance. Finally, University professors indicated that protection of species and habitats must remain the primary function of the area, while ecotourism should be implemented only in a sustainable manner. There are many examples of a good practice of ecotourism development in particularly important natural areas around the world, and especially in Europe. All of these examples are indicating the fact that, during development of ecotourism, the emphasis should be on educating the visitors, as well as on sustainable involvement of the local community (Šiljeg et al., 2019).

Gornje Podunavlje SNR represents an important protected area, not only in Serbia, but also in wider terms, considering its international importance. No matter the fact, this protected area is still in the initial base of developing the ecotourism, which imposes the contribution of this research to a very limited literature regarding the assessment of tourism development to protected natural values of this site. Besides that, current circumstances caused by the COVID-19 pandemic indicated the fact that nature will have important role in further tourism recovery (Spalding et al., 2021). It means that it is expected that number of visitors in protected areas will increase in the following years, which imposes the additional contribution of this research, reflected in terms of providing the real assessment of the natural values before its further intensive tourism development. Finally, considering the previously mentioned fact that ecotourism represents a growing industry, further research of this type is of particular importance, especially from the experts for nature protection points of view.

Conclusion

This research was oriented towards the assessment of the ecotourism impact on the environment within a destination that is in the process of development. The assessment of potential impacts was based on the attitudes of experts in the field of nature protection, who are introduced with the main characteristics of the Gornje Podunavlje SNR, primary with all characteristics of habitats, ecosystems, plant and animal species. The research results indicated that protected plant and animal species are not endangered by the current level of ecotourism and related tours across the educational paths, while potential negative impact could appear on the basis of further development. Besides theoretical contribution related to formation of the new questionnaire, the main findings of this research could find their practical implication in adjustment of further ecotourism activities to protection of natural values. Finally, it is important to indicate that this is a preliminary research that provided a knowledge basis on the experts' experience in the ecotourism development, which is highlighting the fact that monitoring of plant and animal species within ecotourism sites should be a priority. Interestingly, employees in the Gornje Podunavlje SNR Authority see less opportunities regarding the fact that nature protection projects might be financed from the incomes realized on the basis of providing tourism services, comparing to the perception of the other two groups of the nature protection experts within the sample. This is not surprising, keeping in mind that there are isolated cases in Serbia that have succeeded in ecotourism regarding the financial issue. Therefore, it is necessary to encourage them and train them through examples of a good practice to position themselves more adequately on the tourism market.

Besides theoretical contribution in the field of providing the knowledge base related to insufficiently researched ecotourism assessment on protected area with expressed potential for further tourism development, such as Gornje Podunavlje SNR, this research also provides potential for practical implication of the research results. More precisely, it provides the basic findings regarding the main issues in terms of the nature protection, which might be used in the form of guidance for further tourism development that will not endanger vulnerable resources, such as plant and animal species. The research results also provided a basis for establishing the further research frame that will be constructed in line with the main issues of nature protection in protected areas. Findings might serve not only to Gornje Podunavlje SNR, but to other widely spread protected areas. Besides theoretical and practical contributions, this research also contains several limitations, mainly related to the number of the respondents within the sample and general construction of the question items for the purpose of the pilot study. Removals of these limitations are planned within the next more detailed study, while similar researches might be conducted within other protected areas.

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Spatio-temporal Changes in the Heatwaves and Coldwaves in Spain (1950-2018): Influence of the East Atlantic Pattern

David Espín-Sánchez[A*], Carmelo Conesa-García[A]

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Abstract

The Iberian Peninsula has a complex orography, which determines an important altitudinal gradient and alternation of valleys and mountains, and periodic cold/warm advections air. In the present investigation the evolution of the characteristics of heatwaves (HWs) and coldwaves (CWs) (number of events, frequency, duration, magnitude, and amplitude) was analyzed. A total of 28 homogeneous-period weather stations (1950-2018), grouped into six regions (cluster). After submitting the meteorological series to a process of homogenization and data quality control, various ET-SCI indices were estimated in order to obtain evolution trends in each climatic region. In all cases, there was an increase, often significant, in the recurrence of HW events (0.3 / 10 yrs) as well as a decrease in CW events (-0.2 / 10 yrs). In addition, the evolution of the above indices and anomalies was correlated with the evolution of the global index of the East Atlantic (EAi).

Keywords: Iberian Peninsula; cluster; advection; indices; teleconnection; East Atlantic

Introduction

Heatwave (HW) and coldwave (CW) events are some of the most impacting situations of the global climate. These are extensive, and sometimes very intense, advections of hot/cold air that reach extreme temperatures over a long period of time, after exceeding predetermined thresholds for each territory. This type of situation has seemed to evolve periodically during recent decades, linked to the consequences of climate change (Cubasch et al., 2013; Liss et al., 2017; Mora et al., 2017).

In Spain, according to Meteorology Statal Agency (AEMET) studies, there are 59 cold waves and 57 heat waves in the period 1975-2019 (Chazarra et al., 2020). The attributable risk (%) associated with mortality due to cold waves in Spain (2000-2009) reaches 26% in regions of the center-south of the peninsula, and between 19 and 21% for heat waves in western provinces (Linares et al., 2017). Extreme temperature events have been observed on a recurring basis in recent years, especially HWs. Their analysis has been given a major boost at the global and regional scales, due to the growing concern about global warming (Huth et al., 2000, Beniston et al., 2007, Chauvin & Denvil, 2007; Vautard et al., 2007). There is an extensive literature on the health impact and additional effects of such events (D'Ippoliti et al., 2010; Anderson & Bell, 2011; Gasparrini & Armstrong, 2011; Barnett et al., 2012). At the local scale many cities have also had to support HWs, which are often intensified due to the existence of urban heat islands (Basara et al., 2010, Gabriel & Endlicher, 2011, Li & Bou-Zeid, 2013). In some major European cities, the population, not accustomed to extremely high temperatures, is especially vulnerable to their effects - such as in Par-

[A] Department of Physical Geography, University of Murcia, Spain
[*] Corresponding author: David Espín Sánchez e-mail: david.espin1@um.es

is in August 2003 (Lemonsu et al., 2015). Until now, numerous indices based on the apparent temperature (Kalkstein & Valimont, 1986; D'Ippoliti, 2010) and percentile-based indices (Meehl & Tebaldi, 2004; Fischer & Schär, 2010) have been used to evaluate this type of episode.

However, the cold events have been less studied in recent years, and this work has mainly focused on the proposal and application of cold indicators of cold and heat waves. Similar indices were suggested by Frich et al. (2002) and Keevallik and Vint (2015) to detect climate change. These works generally show tendencies towards a decrease in the occurrence of cold indicators, although there is no common position in the scientific community.

Furthermore, extreme events (HWs or CWs) do not experience the same space-time evolution throughout the planet, as has been addressed in recent decades (Karl et al. 1996; Karl & Knight, 1997; Karl & Easterling, 1999; Meehl & Tebaldi, 2004). Liu et al. (2018) showed that the annual number of frost days did not follow a sufficiently clear pattern, globally, during the period 1982-2012, with decreases in northern Siberia, the Tibet Plateau, and northwestern North America, while a certain increase was observed in some European regions. In fact, changes in atmospheric circulation patterns are altering in an uneven way around the planet the characteristics of extreme thermal events, concerning their frequency, magnitude, and duration (Barriopedro et al., 2006; Dong et al., 2008; Garcia-Herrera et al., 2010). The connections between extreme temperature indices and large-scale circulation patterns, such as the North Atlantic Oscillation (NAO) and the East Atlantic (EA) and East Atlantic/West Russia (EA–WR) patterns, have been analyzed by various authors, with different results according to the areas studied in Europe (El Kenawy et al., 2011; Burić et al., 2014; Doderović & Burić, 2015; Arsenovic et al., 2015; Ciarlo & Aquilina, 2016; Trbić et al., 2017; Milosevic et al., 2017; Burić et al., 2019).

The objective of the present research is to determine the heat waves (HWs) and cold waves (CWs) trends in the southwest of the European continent (Iberian Peninsula) from the analysis of extensive and reliable meteorological series. For this purpose, indices belonging to a set of extreme climatic indicators proposed by Nairn and Fawcett (2013) and Perkins and Alexander (2013).

In addition, another objective is to analyze the connection between the East Atlantic index (EAi), as an influential large-scale circulation pattern, and the ET-SCI (Expert Team on Sector-Specific Climate Indices) regarding HWs and CWs. The EAi is an index that marks the latitudinal mobility of the subtropical high pressure belt in relation to Western Europe. This is an index similar to the NAO index, although its center of action is more the southeast of the Atlantic Ocean and its dipole in the pressure field is between Iceland and the United Kingdom (Barnston and Livezey, 1987; Murphy and Washington, 2001). The EAi, in its positive phase, reflects positive anomalies in the subtropical North Atlantic during winter, in surface atmospheric pressure (SLP) and in the Geopotential 500 hPa (Z500). Hence, the influence of this index on temperatures in Western Europe has been corroborated (Moore et al., 2012). As indicated by other authors, the EAi is more reliable than the NAO index in the correlation with peninsular temperatures (Lorenzo et al., 2008).

Data and methods

The study area refers to the Iberian Peninsula (Figure 1), a transition zone between both extratropical and subtropical influences and Atlantic and Mediterranean climates. The climatic variability ranges from temperate climates with regular Atlantic rainfall (2000 mm/year) to the southeast semi-arid climates with less than 200 mm rainfall, with a significant thermal gradient of up to 20°C in the annual average temperatures (Gómez-Zotano et al., 2015).

Observation data

In the thermal analysis, the daily maximum and minimum temperatures (1950-2018) of 28 meteorological stations belonging to the State Meteorological Agency of Spain (AEMET) and the National Meteorological Service of France (Météo-France) were used (Table 1). In addition, the pattern teleconnection (PT) of the EAi was estimated, using monthly data from 1950 to 2018 (https://www.cpc.ncep.noaa.gov/data/teledoc/ea.shtml).

Data quality control (DQC)

As a previous step of information quality control a process of homogenization and subsequent reconstruction of the meteorological series, including data gaps, was performed using the *homogen* function (Eq. 1) of the Climatol 3.1.1 package (https://CRAN.R-project.org/package=climatol) (Guijarro, 2011; Guijarro 2018). This function includes missing data filling and detection and correction of outliers and shifts in the mean of the series. Input data were provided in two text files, one with the daily temperature values and another with the station coordinates. The base data fields were the acronym of the analyzed variable, the

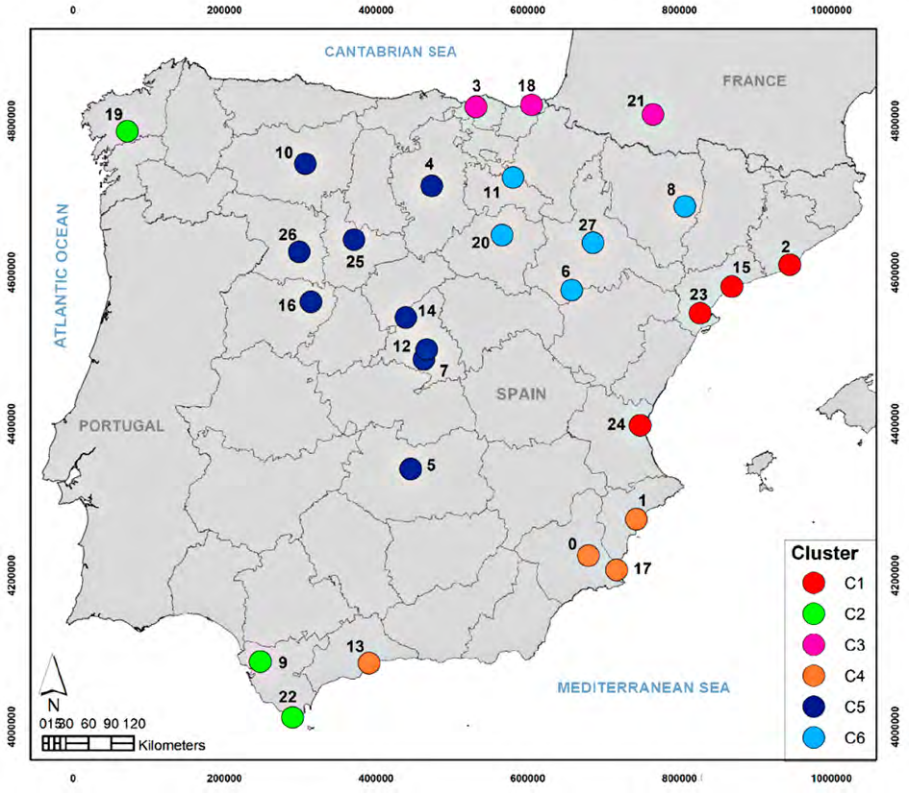

Figure 1. Spatial distribution of the meteorological observatories grouped by cluster, for the period 1950-2018.

Table 1. Characteristics of the meteorological observatories in the study (1950-2018).

ID	Name of Station	Altitude (m)	ID	Name of Station	Altitude (m)
0	Alcantarilla / Murcia	85	14	Navacerrada	1894
1	Alicante	81	15	Reus / Airport	71
2	Barcelona / Fabra	412	16	Salamanca / Airport	790
3	Bilbao / Airport	42	17	Murcia / San Javier	4
4	Burgos / Villafría	890	18	S. Sebastián / Igueldo	251
5	Ciudad Real	628	19	S. de Compostela	370
6	Daroca	779	20	Soria	1082
7	Madrid / Getafe	617	21	Tarbes / Ossun	360
8	Huesca	541	22	Tarifa	32
9	Jerez de la Frontera	27	23	Tortosa	44
10	León	916	24	Valencia	11
11	Logroño / Agoncillo	353	25	Valladolid / Airport	846
12	Madrid / Retiro	667	26	Zamora	656
13	Málaga / Airport	7	27	Zaragoza / Airport	247

initial and final years of the data series as set in the parameters of the following call:

Homogen ('variable acronym', initial year,
final year, snht, snht2) (1)

where snht is a inhomogeneities by moving windows and snht2 the general inhomogeneity of the series

Climatol applies a cluster analysis in its initial checks of the data, but the number of clusters is automatic, according to the final Root Mean Squared Error (RMSE) and the standard normal homogeneity test (SNHT). The RMSEs are calculated by comparing the estimated and the observed data in each series and the dendrogram of clusters thus obtained is based on their correlation coefficients. Six groups of stations have been produced at a dissimilarity level of

Table 2. Climate regions proposed by the *Climatol* clustering process for the analyzed weather stations.

Region code	Denomination	Stations
C1	Northern Mediterranean Coast	Tortosa, Valencia, Reus /Airport, Barcelona / Fabra
C2	Western Atlantic Area	S. de Compostela, Jérez de la Frontera, Tarifa
C3	Northern Atlantic Area	Igueldo, Tarbes, Bilbao/ Airport
C4	Southern Mediterranean Area	Alcantarilla / Murcia, Alicante, Málaga /Airport, Murcia / San Javier
C5	Western-Central Interior Region	Navacerrada, Madrid / Retiro, Salamanca / Airport, León, Burgos / Villafría, Zamora, Madrid / Getafe, Valladolid / Airport, Ciudad Real
C6	Northeastern Interior (Ebro Basin)	Daroca, Logroño / Agoncillo, Soria, Huesca, Zaragoza / Airport

1.20 (Table 2). The homogeneous series from stations sharing a common climate (temporal evolution) were clustered, resulting in six different regions.

Trend methods

In order to determine trend patterns in Spain, standardized indices belonging to the Expert Team on Sector-specific Climate Indices (ET-SCI), and subject to an annual analysis, that refer to the magnitude, amplitude, frequency, and duration of the heat waves (HWs) and cold waves (CWs) were adopted here (Table 3). For their calculation, the ClimPACT2.0 software program (GUI R Studio software) of the Pacific Climate Impact Consortium (PCIC) of the University of Victoria (Australia) (Alexander & Herold, 2016) was applied to the datasets of daily temperatures https://www.wmo.int/pages/prog/wcp/ccl/opace/opace4/ET-SCI-4-1.php . This is an R software package that calculates the ET-SCI HW and CW indices, as well as additional climate extreme indices, from data stored in text or netCDF files.

The algorithms included in ClimPACT2 to estimate the HW characteristics are based on Perkins and Alexander (2013), hereafter PA13, with some slight modifications to the EHF (Perkins, 2015). The Excess Heat Factor (EHF) is an intensity measure that categorises heatwaves by their severity. The calculation of the EHF (°C2) is based on a three-day averaged daily Tmean, in relation to the 95th percentile of long-term average temperatures, and the recent (prior 30-day) temperatures, for a particular location (Nairn and Fawcett, 2014). The EHF (Eq. 4) consists of a combination (Eq. 2 and Eq. 3) of two excess heat indices (EHI):

$$EHI\ (accl.)=[((TMi+(TMi-1)+(TMi-2)))/3]-[((TMi-3)+\ldots+(TMi-32))/30] \quad (2)$$

$$EHI\ (sig.)=[((TMi+(TMi-1)+(TMi-2)))/3]-TM95 \quad (3)$$

where TMi represents the average daily temperature for day i and TM95 is the 95th percentile of TM, which is also calculated within a user-specified base period, over the calendar year and using a 15-day running window. TM = (TX + TN)/2, where TX is maximum daily temperature and TN is minimum daily temperature, in the meteorological summer (JJA).

Table 3. Climatic indices used in the analysis of the temporal trends and evolution of the standardized anomalies of the heat waves (HWs) and cold waves (CWs).

	Code	Name	Definition	Unit
HW	EHF_HWN	Heatwave number	The number of individual heatwaves that occur each summer	events
	EHF_HWF	Heatwave frequency	The number of days that contribute to heatwaves as identified by HWN	days
	EHF_HWD	Heatwave duration	The length of the longest heatwave identified by HWN	days
	EHF_HWM	Heatwave magnitude	The mean temperature of all heatwaves identified by HWN experiences TX>90th percentile	°C²
	EHF_HWA	Heatwave amplitude	The peak daily value in the hottest heatwave (defined as the heatwave with the highest HWM).	°C²
CW	ECF_HWN	Coldwave number	The number of individual coldwaves that occur each winter	events
	ECF_HWF	Coldwave frequency	The number of days that contribute to coldwaves as identified by ECF_HWN	days
	ECF_HWD	Coldwave duration	The length of the longest coldwave identified by ECF_HWN	days
	ECF_HWM	Coldwave magnitude	The mean temperature of all coldwaves identified by ECF_HWN experiences TN<10th percentile	°C²
	ECF_HWA	Coldwave amplitude	The minimum daily value in the coldest coldwave (defined as the coldwave with the lowest ECF_HWM).	°C²

$$EHF = EHI(sig) \times \max(1, EHI(accl)) \quad (4)$$

For each index, a map was obtained with the temporal trend by seasons (1950-2018), the temporal evolution by cluster, and an evolution of the standardized anomalies.

The calculation of CWs was performed through the ECF (Excess Cold Factor), developed by Nairn and Fawcett (2013) (Eq. 7). The calculation of the ECF EHF ($^oC^2$) is based on a three-day averaged daily Tmean, in relation to the 5th percentile of long-term average temperatures, and the recent (prior 30-day) temperatures, for a particular location The ECF is a combination (Eq. 5 and Eq. 6) of two cold indices (ECIaccl.) and (ECIsig.), which represent the degree of acclimatization and the climatological significance of cold, respectively. The ET-SCI CW indices were derived from studies on human responses to extremely cold climates. According to these, three consecutive very cold days are needed to significantly increase the mortality rate above its previous value (Wang et al., 2016, Piticar et al., 2018).

$$CI(accl.) = [((Tmi + (Tmi-1) + (Tmi-2)))/3] - [((Tmi-3) + \ldots + (Tmi-32))/30] \quad (5)$$

$$ECI(sig.) = [((Tmi + (Tmi-1) + (Tmi-2)))/3] - Tm05i \quad (6)$$

where Tmi is the average daily temperature of day i and Tm05i is the 5th percentile of Tm estimated for each day (i) of the season considered (from November to March). The ECF (Eq. 5) is defined as:

$$ECF = -ECI(sig.) \times \min(-1, ECI(accl.)) \quad (7)$$

The ECIsig. index measures the degree of excess cold, while the ECIaccl. measures cold stress. Negative ECF values indicate CW conditions, and a period of at least three consecutive days with negative ECF values defines a CW event.

Finally, for the analysis of the EA index, and its correlation with the temporal evolution of the indices, the Kendall concordance coefficient (Kendall, 1938) was adopted, using a significance level (p-value) of 0.99. The monthly data of the EA index were obtained from https://www.cpc.ncep.noaa.gov/.

Results and discussion

Results from the homogenization of temperature data

The poor quality of the meteorological series -with erroneous data, missing data, changes in the location of the weather checkpoints, and changes in meteorological sensors- generates meteorological series with a large number of breaks (Acquaotta & Fratianni, 2014). The stations chosen here comply with the consensus of the scientific community (Klein Tank et al., 2002), with maximum and minimum temperature values for at least 80% of the analyzed daily data (Table 4).

The exploratory analysis of the meteorological series with Climatol showed relatively high SNHT values in some cases. This forced the choice of more aggressive thresholds, of snht1 (140) and snht2 (800) for maximum temperatures, and snht1 (150) and snht2 (1100) for minimum temperatures in the "homogen" function (see Material and methods). In the analysis of the maximum temperatures, some of the series analyzed, such as those of Tarifa (22) and Zamora (26), have had up to nine ruptures since 1950, which led to an intense homogenization process (Figure 2). However, the majority of the stations hardly registered ruptures, with inhomogeneity values from 0 to 1 in 25 of the 28 study stations - as exemplified by Zaragoza (27) and Tarbes (21), whose series hardly contained aberrant anomalies (Figure 3).

After the homogenization process, a drastic reduction in the SNHT values was observed, with an average percentage of original data (POD) of 87.5% (considered quite acceptable). For the vast majority of stations there was hardly any change, resulting in POD values between 95 and 100%. However, some had very low percentages of POD, among which Navacerrada (14), Tarifa (22), and Zamora (26) (20-62%) stand out (Table 4).

The meteorological series of minimum daily temperatures showed fewer ruptures or inhomogeneities: only the stations of Tarifa (22), which had four ruptures, and Ciudad Real (5), with two, exhibited more than one inhomogeneity. The number of inhomogeneities was 0 or 1 for the majority of observatories (Table 4). Therefore, the homogenization process (Climatol) was less complex for the minimum temperatures, since the software had to deal with twice as many total breaks for the maximum temperatures (25) compared to the minimum temperatures (12).

The number of breaks in the minimum temperatures was lower than for the maximum values. This could be due to the greater influence of the changes in the meteorological booths on the maximum values, since their conditions are especially sensitive to the presence of solar radiation. For the maximum temperatures the breaks were distributed homogeneously during the analysis period (1950-2018), although they were drastically reduced after 2005 onwards (Figure 4).

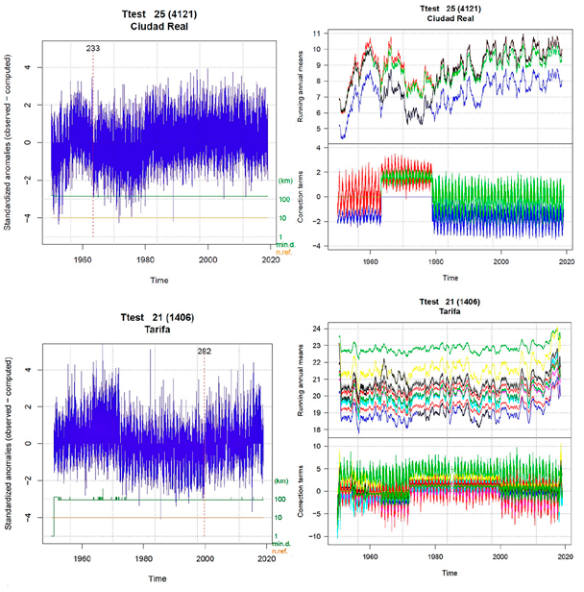

Figure 2. Histograms of SNHT values found in the complete series (right), before and after the homogenization process. The Tarifa and Ciudad Real meteorological observatories are shown as examples
[click on figure to enlarge]

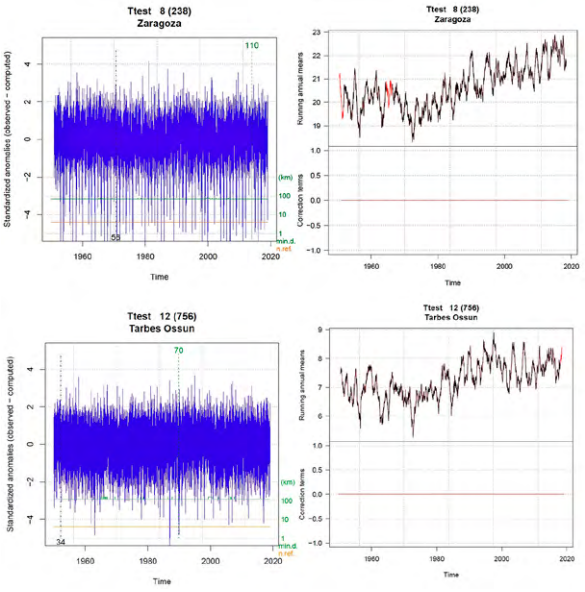

Figure 3. Histograms of SNHT values found in overlapping stepped windows (left), before and after the homogenization process. The Zaragoza and Tarbes-Ossun meteorological observatories are shown as examples
[click on figure to enlarge]

Table 4. Statistical summary of the DQC applied by the ClimPACT2.0 software, for the 28 weather stations used, indicating % of NA or percentage of missing data for maximum (TX) and minimum (TN) temperatures, split numbers, global SNHT values, and final percentage original date (POD) after the homogenization process

ID	NA TX (%)	NA TN (%)	Split number TX	Split number TN	Windowed SNHT TX	Windowed SNHT TN	Final POD TX	Final POD TN
0	0.0	0.0	0	0	160.5	411.4	99	99
1	0.0	0.0	1	0	286.6	189.5	68	99
2	0.0	0.0	1	0	278.5	781.6	100	99
3	0.5	0.8	0	0	169.4	468.6	99	99
4	0.1	0.1	0	0	509.6	96.2	99	99
5	0.0	0.0	0	2	209.8	222.0	99	58
6	0.0	0.0	0	0	170.9	539.3	99	99
7	1.4	1.4	0	1	329.0	58.1	98	77
8	1.9	1.9	0	0	314.8	236.7	98	98
9	0.6	0.7	0	1	168.1	375.7	95	82
10	0.2	0.2	1	0	106.0	211.0	52	99
11	0.0	0.0	0	0	97.6	932.9	99	99
12	0.0	0.0	0	0	477.7	595.9	100	99
13	0.3	0.3	0	0	77.0	493.4	99	99
14	0.0	0.0	3	1	147.1	73.4	37	62
15	0.4	1.1	0	0	340.5	1143.6	95	94
16	0.0	0.0	1	1	918.0	245.5	62	70
17	0.5	0.4	0	0	610.9	123.6	99	99
18	0.0	0.0	0	0	243.0	166.5	100	100
19	0.3	0.4	0	0	151.0	416.6	99	99
20	0.2	0.2	0	0	455.7	228.3	99	99
21	0.1	0.1	0	0	93.5	34.2	99	99
22	4.5	5.2	9	4	491.5	332.2	38	41
23	0.0	0.0	0	0	532.0	90.4	100	99
24	0.0	0.0	0	1	364.5	131.5	100	81
25	0.1	0.1	0	0	1050.3	308.1	99	99
26	0.0	0.0	9	1	144.7	127.9	20	54
27	0.0	0.0	0	0	56.6	1058.6	98	98

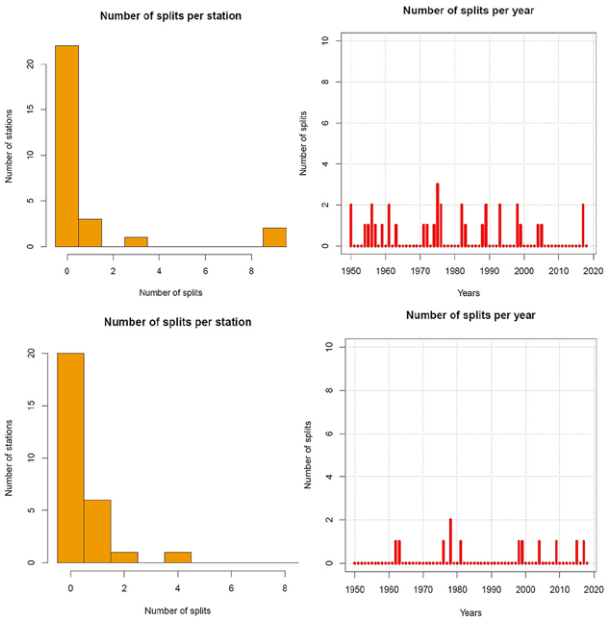

Figure 4. Number of "breaks or splits" or inhomogeneities detected by Climatol in relation to the number of affected stations and the analysis period (1950-2018), concerning the TX (upper graphs) and TN (lower graphs) values
[click on figure to enlarge]

Spatio-temporal trends of the ET-SCI HW and CW indices

Spatio-temporal heatwaves (HWs) variations and trends are described based on the indices number (EHF_HWN), frequency (EHF_HWF), duration (EHF_HWD), magnitude (EHF_HWM), and amplitude (EHF_HWA). The number of heat waves events (EHF_HWN) significantly increased, with 0.3 events/10 yrs in numerous areas, especially in the northern mediterranean coast (C1) and western atlantic area (C2) (Table 5).

Despite the rise in HW events, the average temperature (EFH_HWM) does not seem to have changed excessively during recent decades (0.3°C² / 10 yrs). In the northern mediterranean coast (C1) and western atlantic area (C2) west there was a somewhat more significant increase (0.4°C²/10 yrs).

The number of days of heatwaves per year (EHF_HWF) has significantly increased since 1950, at an overall rate of 1.9 days / 10 yrs. This has been especially relevant in the observatories C1 (northern Mediterranean coast) and C2 (western Atlantic area), with a rise of up 2.8 to 3.2 days / 10 yrs (Table 5).

The EHF_HWD tended to increase, becoming longer (0.7 days / 10 yrs), although without a statistically significant change. The increase was greatest in the northern Mediterranean (C1) and southern mediterranean area (C4) regions, again on the coast, and also for some observatories of the peninsular center (Madrid), with values of 1.0 to 1.1 days / 10 yrs (Figure 5).

Finally, the amplitude, or maximum peak of absolute temperature in the hottest HW (EHF_HWA), has increased during the last few decades, a statistically significant way (1.5°C² / 10 yrs). The increase was significant on the northern Atlantic area (C3) and southern mediterranean area (C4), and the observatories of Santiago de Compostela and Jérez de la Frontera, with an increase of 2.9°C² / 10 yrs.

The parameters that refer to the characteristics of coldwaves (CWs) have undergone significant changes during the last eight decades. The number of events (ECF_HWN), since 1950, has decreased significantly throughout the Iberian Peninsula (-0.2 events/10 yrs), especially in the C1 cluster (northern Mediterranean coast) (Figure 6).

However, the magnitude of the CWs (ECF_HWM) did not undergo many changes, the average temperature of these events showing only a slight rise (0.2°C² / 10 yrs) in recent decades. In addition, there were territorial differences, between more marked ascents (C3 in the northern atlantic area, with 0.5°C² / 10 yrs) and descents (-0.1°C² / 10 yrs, in the C2 western Atlantic

Table 5. Temporal trends (/10 yrs) of the ET-SCI HW and CW indices for the climate regions defined by cluster, in the period 1950-2018. In bold, confidence level < 0.05

Index	C1	C2	C3	C4	C5	C6	Average
EHF_HWN (events)	**0.5**	**0.5**	**0.3**	**0.4**	**0.3**	**0.3**	**0.3**
EHF_HWF (days)	**2.8**	**3.2**	**1.4**	**2.1**	**1.5**	**1.4**	**1.9**
EHF_HWD (days)	**1.2**	**0.7**	**0.5**	**0.8**	**0.6**	**0.6**	**0.7**
EHF_HWM (°C²)	**0.4**	**0.4**	0.5	**0.3**	0.2	0.1	0.3
EHF_HWA (°C²)	**1.5**	**1.8**	**2.2**	**2.0**	**1.2**	**1.4**	**1.5**
ECF_HWN (events)	**-0.3**	**-0.2**	**-0.2**	**-0.2**	**-0.2**	**-0.1**	**-0.2**
ECF_HWF (days)	**-2.0**	**-1.7**	**-1.2**	**-1.9**	**-1.5**	**-1.6**	**-1.6**
ECF_HWD (days)	**-0.7**	**-0.6**	-0.3	**-0.8**	**-0.8**	**-0.6**	**-0.6**
ECF_HWM (°C²)	0.3	-0.1	0.5	0.3	0.3	0.2	0.2
ECF_HWA(°C²)	**2.6**	1.1	3.8	**2.2**	2.1	2.6	2.4

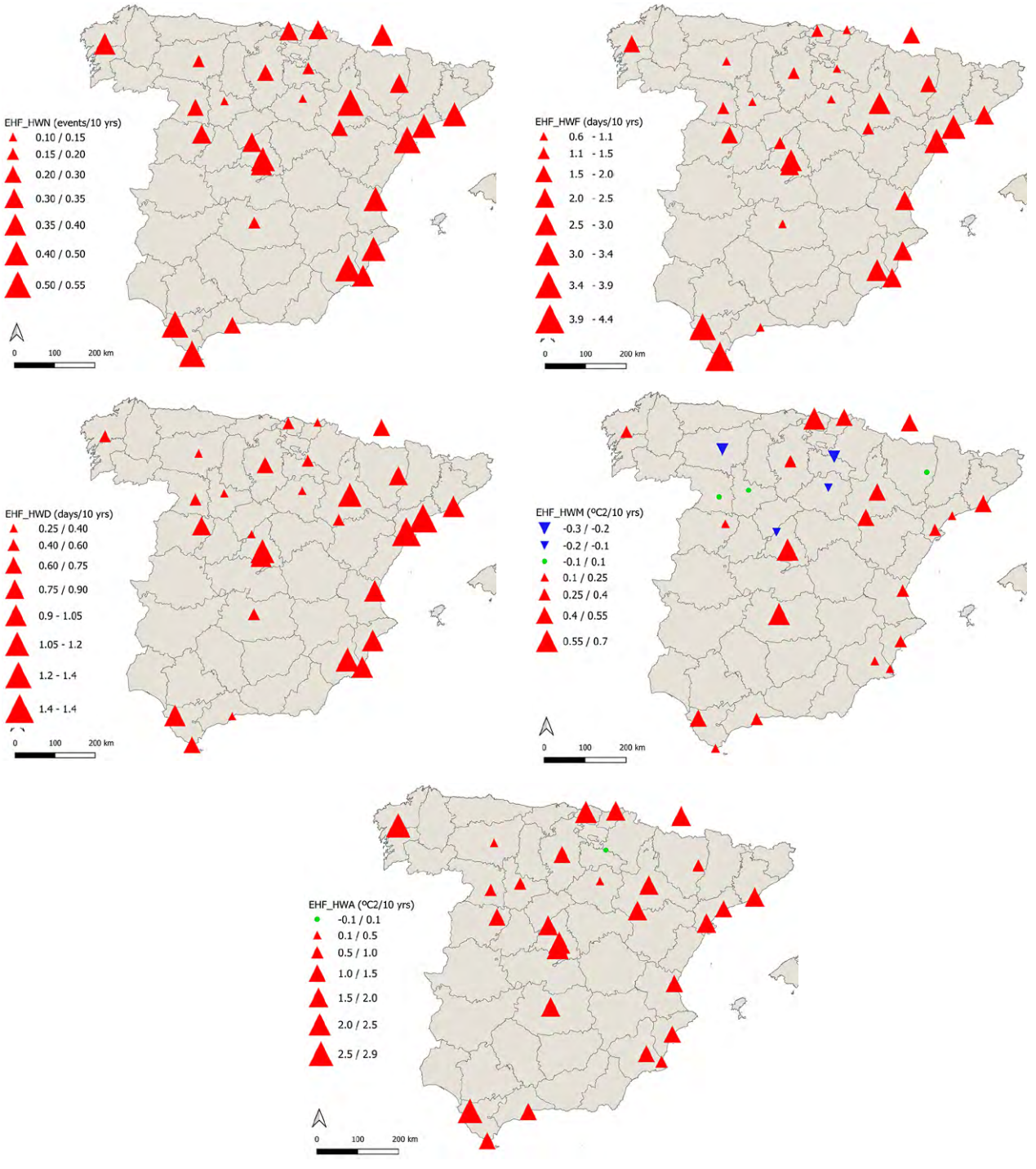

Figure 5. Maps of the spatio-temporal annual trends of the heatwave indices (EHF_HWN, EHF_HWF, EHF_HWD, EHF_HWM, and EHF_HWA) for the period 1950-2018

area), the latter being recorded especially in the observatories of the peninsular southwest (Tarifa and Jérez) (Figure 6).

The frequency, or number of days of CWs per year (ECF_HWF), showed a statistically significant decrease of -1.6 days / 10 yrs, being generally uniform throughout the study area, although with more marked drops in C1 and C4 (northern Mediterranean coast and southern Mediterranean coast).

The duration of the CW events (ECF_HWD) has also altered during recent decades, with the same evolution pattern as the ECF_HWF. They underwent a general shortening (an average of -0.6 days / 10 yrs), which was more important in the southern mediterranean coast (C4) and the western-central interior region (C5). Specifically, the greatest rates of shortening (ECF_HWD < -0.8) were in Ciudad Real, Barcelona-Fabra, Madrid-Retiro, Burgos and Murcia-San Javier.

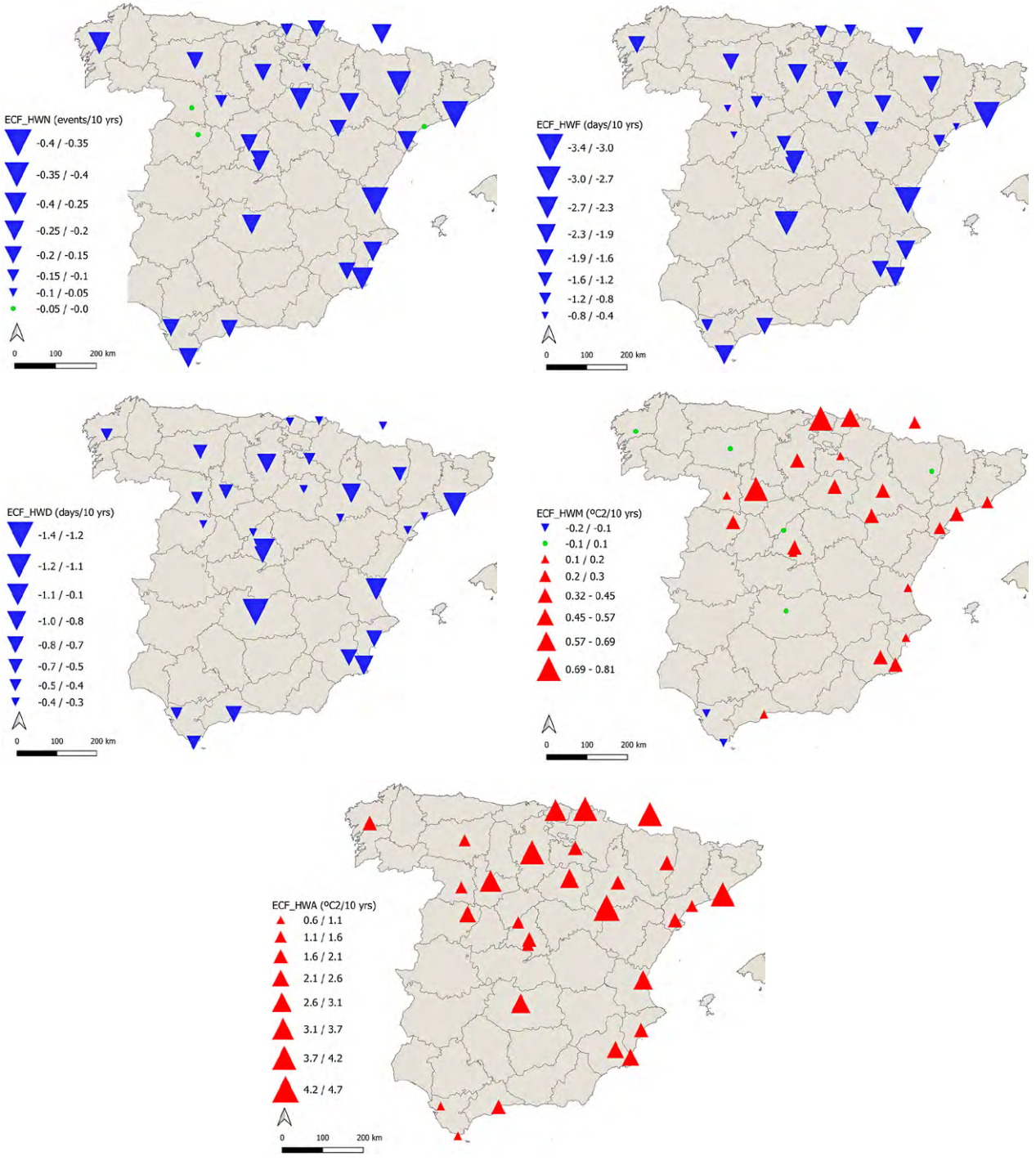

Figure 6. Maps of the spatio-temporal annual trends of the coldwave indices (ECF_HWN, ECF_HWF, ECF_HWD, ECF_HWM, and ECF_HWA) for the period 1950-2018

In addition, the amplitude of the CWs (ECF_HWA) has shown an important increase during the last few decades (2.4ºC² / 10 yrs), especially in some observatories located in C3 (Bilbao, San Sebastian, and Tarbes), C5 (Burgos), and C6 (Zaragoza) (Figure 6).

In summary, the HW indices show a greater increase in the frequency, duration, and intensity of HW events in the northern Mediterranean (C1) and western Atlantic area (C2), specifically at observatories where there is a maritime influence.

For his part, the ET-SCI CW indices showed a homogeneous behavior, with a trend towards less frequent and less intense CWs; although, it was in the northern Atlantic region (C3), where the greatest increases in amplitude and magnitude occurred, while the western Atlantic region (C2) was the one that experienced the smallest changes (Table 5).

Relationships between the EAi and the ET-SCI HW and CW indices

The results of the present study demonstrate that the EAi has a significant relationship with the temperature records in this territory, which is consistent with the correlations found in other areas of southern Europe (Arsenovic et al., 2015; Buric et al., 2018).

The EAi, from 1950 to 2018, showed a temporary upward trend during the winter months (0.1/10 yrs), 1977 being quite significant as a year of rupture, according to the SNHT homogenization test. In addition, during the summer months, the trend was similar (0.1/10 yrs) and also had a statistical consistency at a level of significance of 0.05. In recent years, there has been a winter migration of the jet stream from the North Atlantic to more northern regions (200-300 hPa) (Comas-Bru et al., 2016), which is reflected by above-average surface temperatures in southwest Europe (Wallace and Gutzler, 1981).

Since 1950, the seven years with the highest number of HWs in the Iberian Peninsula correspond to the most positive values of EAi; namely, the years 2017 (2.0), 2003 (0.8), 2015 (0.8), 2012 (0.8), 2006 (0.1), 2018 (1.2), and 2005 (0.0)The years with the most positive EAi values recorded the lower number of cold events: 2014 (1.8), 2007 (1.6), 2002 (1.6), 2016 (1.4), and 1966 (0.9) (Figure 7). It should be noted that a positive EAi indicates the presence of positive anomalies in the surface atmospheric pressure (SLP) and in the geopotential at 500 hPa (Z500) in the subtropical North Atlantic during winter.

The analysis of the relationships between EAi and HWs indicator, by observatory, revealed a higher correlation for those located on the Mediterranean and atlantic coast (Reus, Barcelona-Fabra, Tortosa, Valencia and San Javier) or on the southwestern Atlantic coast (Tarifa and Jerez), and a very low correlation for the northern observatories (Figure 8). With regard to the CWs, the spatial distribution pattern of

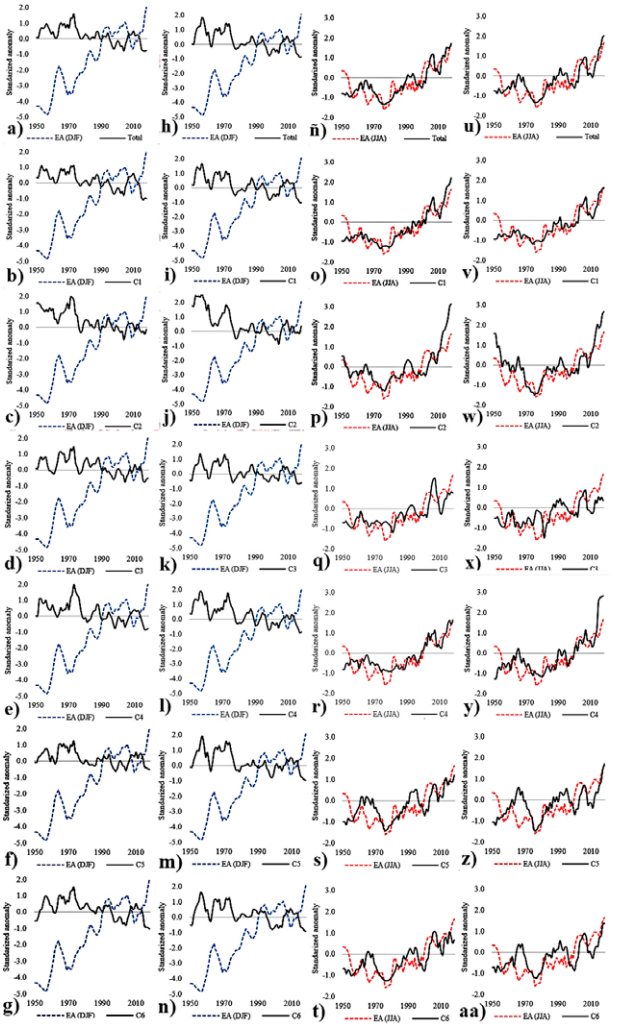

Figure 7. Temporal variability (1950-2018) of the standardized anomalies of the EAi (DJF/JJA) and a-g) ECF_HWN, h-n) ECF_HWF, ñ-t) EHF_HWN and u-aa) EHF_HWF in the study area and different cluster
[click on figure to enlarge]

Kendall's τ coefficients in relation to the EAi is quite similar, although with slight nuances. The observatories with the highest correlation coefficients contin-

Table 6. Kendall's τ coefficients between the EAi and the ET-SCI HW and CW indices. In bold, significance level (p-value) of < 0.05.

Index	Average	C1	C2	C3	C4	C5	C6
EHF_HWN	**0.68**	**0.76**	**0.73**	**0.68**	**0.69**	**0.57**	**0.62**
EHF_HWF	**0.66**	**0.75**	**0.71**	**0.62**	**0.66**	**0.47**	**0.56**
EHF_HWD	**0.62**	**0.75**	**0.68**	**0.49**	**0.63**	**0.39**	**0.48**
EHF_HWM	0.33	**0.53**	**0.39**	0.26	0.46	0.25	0.22
EHF_HWA	**0.57**	**0.70**	**0.65**	**0.46**	**0.54**	**0.42**	**0.43**
ECF_HWN	**-0.75**	**-0.76**	**-0.82**	**-0.61**	**-0.80**	**-0.61**	**-0.59**
ECF_HWF	**-0.74**	**-0.71**	**-0.77**	**-0.58**	**-0.86**	**-0.68**	**-0.62**
ECF_HWD	**-0.71**	**-0.67**	**-0.64**	**-0.29**	**-0.79**	**-0.75**	**-0.53**
ECF_HWM	0.33	0.30	0.11	0.21	**0.45**	0.31	0.24
ECF_HWA	**0.53**	**0.47**	**0.53**	0.35	**0.71**	**0.48**	**0.48**

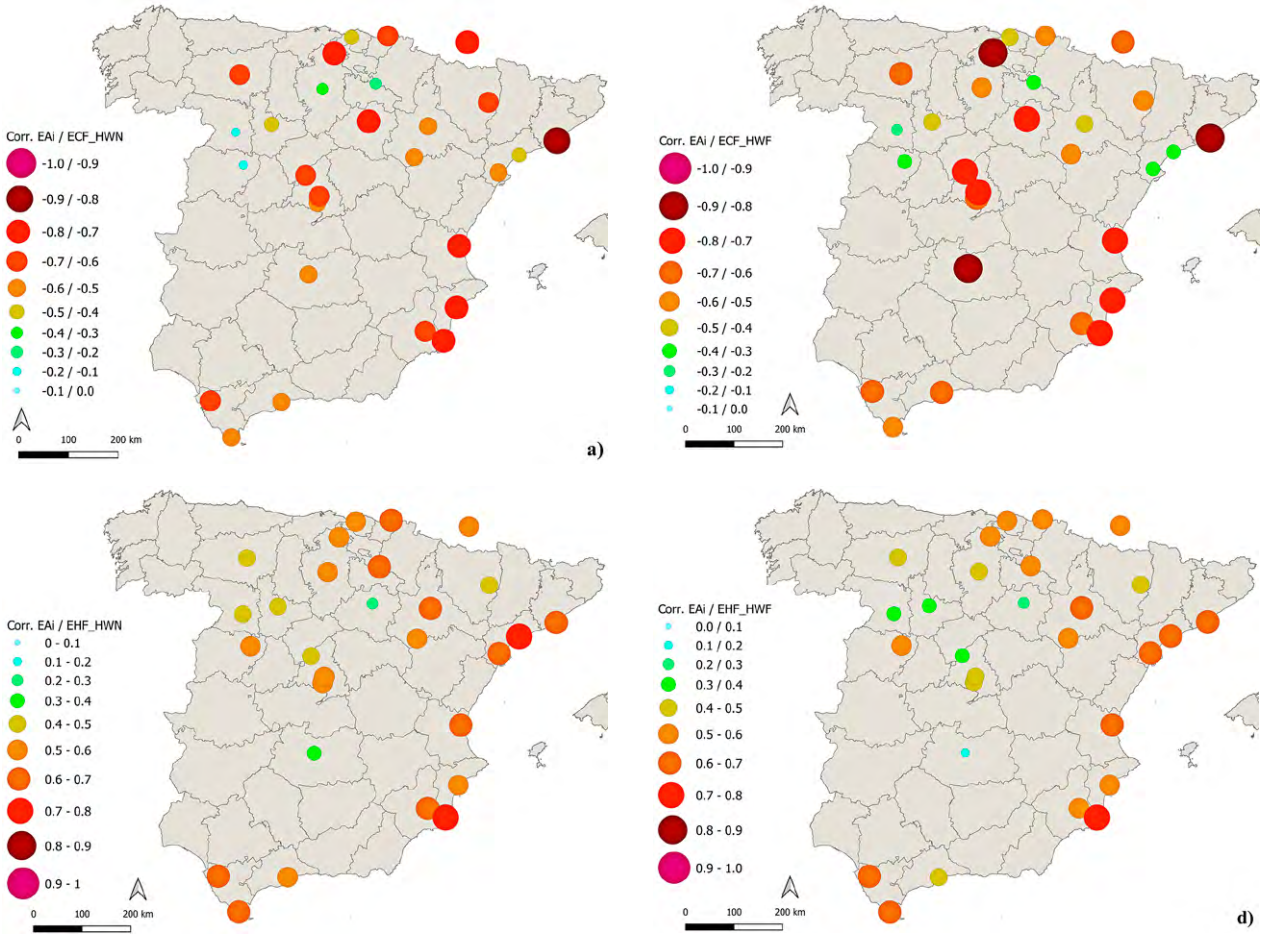

Figure 8. Kendall rank correlation coefficients between the EA index vs. a) ECF_HWN, b) ECF_HWF, c) EHF_HWN and d) EHF_HWF, displayed for each observatory (1950-2018)

ued to be located exclusively on the Mediterranean coast (from Barcelona, Alicante and Valencia), including pre-coastal areas in the peninsular Southeast (e.g. Murcia-Alcantarilla). By contrast, the worst correlations were obtained in the northern sub-plateau (Castilla and León) and the Ebro basin (Huesca, Zaragoza, and Logroño).

Generally, in all the regions derived from the cluster analysis there was a significant correlation (with a confidence level of 0.05) between the evolution of the EAi and that of any ET-SCI index (Table 6).

The highest average correlations were found for the number of events, frequency (number of days), and duration, with values up to -0.86 in C4 (ECF_HWF) (Table 6). Considering the relationships between the EAi and the ET-SCI indices by region, it is worth highlighting the highest correlation (-0.82) for ECF_HWN in C2 and C4 and for EHF_HWF in C4.

Discussion and Conclusion

The homogenization, quality control, and completion of the daily temperature series for the Iberian Peninsula during the period 1950-2018 improved substantially the quality of these datasets and thus our ability to detect the characteristics and trends of the HWs and CWs that have occurred recently in this territory.

The spatio-temporal analysis of the ET-SCI HW and CW indices led to the identification of different patterns of evolution according to the six regions previously defined by clustering. The HWs, although not showing important variations in their average temperature (which, in fact, decreased slightly in observatories in the north of the peninsular), experienced an increase in the peaks of their absolute temperature values, especially in western Atlantic observatories (Santiago de Compostela and Tarifa) and in the peninsular center (Madrid-Retiro). Previously, a similar trend of the HW ratio (0.56 per decade) was shown by Labajo et al. (2014) in the central area of the Iberian Peninsula during the period 1961-2010, and, on a

larger scale, by Lhotka and Kyselý (2015) in Central Europe since 1990. Nevertheless, during this century the HWs have tended to be more frequent, longer, and more intense in a large area of the Iberian Peninsula, as has occurred in the rest of southern Europe (Schär et al. 2004; Clark et al. 2006; Alexander, 2010; García Herrera et al., 2010).

Compared with studies conducted in countries with a European continental climate, we have observed here a similar pattern for the HWs (more frequent, longer, and more intense). The seasonal HW trends obtained in the west-central area of the Iberian Peninsula are comparable with those found by Spinoni et al. (2015) in the Carpathian Region, and more particularly in the Hungarian Plain and Southern Romania, where the most severe HWs occur in summer. In addition, most of the HW trends defined for the Iberian Peninsula in this study are quite consistent with the patterns found by Kuglitsch et al. (2010) in the eastern Mediterranean region (e.g. Balkans, Greece, Turkey). They are mainly in accordance with statistically significant increases since the 1960s in the HW number (HWN95), HW length (HWL95), and HW intensity (HWI95). In contrast, the average temperature estimated for this type of event does not seem to have changed as much as in the eastern Mediterranean.

During the last few decades the number of CWs has decreased significantly in the Mediterranean region (C1, C4), including the Ebro basin (C6), and on the western Atlantic coast (C2). Regarding the magnitude, two trends were observed: 1) a little variation in the average temperature of EHF_HWM, and 2) an increase in the absolute minimum temperatures recorded (ECF_HWA) in the northern peninsula (C3) and in observatories of the interior of the Ebro basin (C6) and Barcelona (C1).

Furthermore, a significant relationship between the EAi and the ET-SCI HW and CW indices and their standardized anomalies was corroborated in relation to the number, duration, and frequency of each type of event. The closest relationships with the evolution of the EA pattern, based on correlation coefficients from -0.86 to -0.82, were obtained in the Southwestern mediterranean areas and coastal western atlantic area and for the parameters ECF_HWF and ECF_HWN. Consequently, from all of the above, it is inferred that the temporal evolution of the EAi could be a good indicator for the analysis of future trends in the number of HW/ CW events and their frequency (number of days), associated with climate changes, especially on the Mediterranean coast and western atlantic area of the Iberian Peninsula.

Coldwaves have become less frequent but exhibited variable intensity patterns, according to the Peninsula region, with a significant increase in the average CW temperature in the northern zone and a slight decrease in the southeastern zone under the Atlantic influence. It is striking that in the period 1972-1982 the variations in the HW indices were the slightest of the last 70 years. The same finding was made by Lhotka and Kyselý (2015) when they analyzed the daily temperature series throughout this period in numerous observatories of Central Europe. This behavior was also evidenced in various countries of Central Europe, such as Poland (Tomczyk 2015), the Czech Republic (Kyselý 2010), and Germany (Tomczyk & Sulikowska, 2018).

Many of them correspond to cold periods identified by Labajo et al. (2014) for different meteorological observatories in the center of the Iberian Peninsula during the period 1961-2010. In general, the progressive decline in CWs throughout this period coincides with such a decline in eastern Europe -in both the north, such as Poland (Wibig, 2018; Tomczyk and Bednorz, 2014), and the south, such as areas of the Carpathian region (Spinoni et al., 2015). In winter 2009/2010, a series of extreme cold spells hit northern and western Europe (Cattiaux et al., 2010).

The influence of the EAi on the variability of winter weather in Europe has been widely demonstrated in recent years, linked to the geographical positions of the NAO dipole. When the EA is positive, the action centers migrate to the northeast, while, during the opposite sign phases, they move to the southwest. The EA is, therefore, an excellent indicator of the latitudinal position of the jet stream. With a positive EAi, there is an intense flow of zonal winds from the west over the Iberian Peninsula, with an increase in thermal values in southwest Europe (Mikhailova & Yurovsky, 2016). This corroborates the results obtained here, showing an increase in the frequency and intensity of HWs in summer, and a decrease in CWs in winter in the study area.

Acknowledgments

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Media Outlets in Vojvodina and Slovenia: Demographic-economic Indicators and Media Pluralism

Dinko Gruhonjić[A*], Smiljana Milinkov[A], Miloš Katić[B]

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Abstract

The paper analyzes the relationship between demographic-economic indicators in the Autonomous Province of Vojvodina and the Republic of Slovenia. Both societies have relatively organized regulatory and political frameworks for the development of media pluralism. It has been established that there is a clear cause-effect relation between the number of media outlets in certain local self-governments and the average net salary: the municipalities and towns with the highest average salaries also boast the highest number of media outlets. However, our analysis has shown that the criteria and mechanisms for identifying risks to media pluralism are not provided: the variety of population representing different political, ideological, cultural and social groups and the variety of interests and standpoints relevant to the local and regional community.

Keywords: media outlets; economics; demography; pluralism

Introduction

In terms of their territorial coverage, media outlets are classified as national, regional or local. In this paper, our focus is on local media outlets, i.e., on the classification and statistical data treatment related to the number of registered media outlets in relation to the local self-government in which they are registered, using the examples from the Autonomous Province of Vojvodina in the Republic of Serbia and the Republic of Slovenia.

According to the Statistical Office of the Republic of Serbia (2019), the population of the Autonomous Province of Vojvodina in 2019 was 1,852,093. According to Eurostat, the population of Slovenia on January 1, 2020 was 2,095,900 (Eurostat, 2020).

Even though these two territories have a different constitutional-legal status (a province within a stat vs. an independent state), Vojvodina and Slovenia were selected for this quantitative analysis due to similar population, similar size (the Republic of Slovenia[1] – 20,271 km², the Autonomous Province of Vojvodina[2] – 21,506 km²), and the common past that the two entities shared during two Yugoslav state unions (1918-1991). On the other hand, the social-political context within which the media system operates is different:

[1] Data from the official site of the government of the Republic of Slovenia. https://www.gov.si/podrocja/drzava-in-druzba/o-sloveniji/. Visited on January 8, 2021.

[2] Data from the site of the provincial government. http://www.vojvodina.gov.rs/sr/%D0%B0%D1%83%D1%82%D0%BE%D0%BD%D0%BE%D0%BC%D0%BD%D0%B0-%D0%BF%D0%BE%D0%BA%D1%80%D0%B0%D1%98%D0%B8%D0%BD%D0%B0-%D0%B2%D0%BE%D1%98%D0%B2%D0%BE%D-0%B4%D0%B8%D0%BD%D0%B0. Visited onJanuary 8, 2021.

[A] University of Novi Sad, Faculty of Philosophy, Department of Media studies, Vojvodina, Serbia; dinko.gruhonjic@ff.uns.ac.rs; smilinkova@ff.uns.ac.rs;
[B] Executive director of the Independent Journalists' Association of Vojvodina, Novi Sad, Serbia; milos.katic@ndnv.org
[*] Corresponding author: Dinko Gruhonjić; e-mail: dinko.gruhonjic@ff.uns.ac.rs

the Republic of Slovenia has been a member of the European Union since 2004, while the Republic of Serbia has had the status of a candidate country for EU membership since 2012.

There are 45 municipalities and towns on the territory of Vojvodina, functioning as units of local self-government within seven districts, whose centers are the cities of Subotica, Zrenjanin, Kikinda, Pančevo, Sombor, Novi Sad and Sremska Mitrovica (Provincial Government). The municipalities and towns are run by the assemblies of local self-governments, town/municipal councils and the mayor/president of the municipality.

In the Republic of Slovenia, local self-governments function within municipalities and other local communities. The municipalities are run by three independent bodies: the mayor, the municipal council and the supervisory board. There are 212 municipalities in Slovenia, 11 of which have a status of city municipalities (Government of the Republic of Slovenia).

Pursuant to the Recommendations of the Council of Europe (2018), apart from independent and sustainable public broadcasting services, local media outlets can be a counterpoise to the increasingly dense concentration of media outlets. Furthermore, the media in local communities are particularly suitable for meeting the interests of local users. That is why states, as the final guarantors of media pluralism, need to provide suitable regulatory and political frameworks as a necessary precondition for the development of media pluralism. Consequently, states are obliged to provide the criteria and mechanisms for identifying the risks to medial pluralism: the diversity of ownership of media sources and media outlets themselves; the diversity of media outlet types; the diversity of population representing various political, ideological, cultural and social groups, as well as the diversity of interests and standpoints relevant to the local and regional community.

The aim of this paper is to use a comparative analysis of the number of registered media outlets and their territorial distribution to compare the specific features of the media market in the Republic of Slovenia and the Autonomous Province of Vojvodina.

The main investigative question is whether the average net salary per capita in the municipalities and cities has an impact on the number of local media outlets in local self-governments in Slovenia and Vojvodina. Furthermore, the paper analyses the factors that impact the functioning of media market and survival of media outlets on the local level. By analyzing the average number of media outlets in Vojvodina and Slovenia per one unit of self-government and the average net salary in the same local self-government, authors wanted to establish whether there is a cause-effect relation between the two criteria or whether we are talking about demographic-economic deviations and anomalies. Through such analysis, authors wanted to show how all that is reflected on the media pluralism in Vojvodina and Slovenia, i.e., to answer the investigative question whether the number of media outlets is in direct relation towith meeting the media pluralism criteria or not.

Methodological framework

A theoretical-empirical approach was used in the paper, through a descriptive method and comparative analysis of statistical data.

The necessary information regarding the number of local media outlets is provided by submitting a request to the Serbian Business Registers Agency, since it is the institution in charge of keeping records of legal entities operating on the territory of Serbia. The information regarding the average net salary was obtained through the portal of the Parliamentary Budget Office. The information regarding the average salary in the Republic of Slovenia and the number of media outlets in the municipalities and cities in this country was obtained through the portal of the Statistical Office of Slovenia.

The data were processed statistically using the statistical open-source software - Jamovi softwareversion 0.9.2.8 (2018). A t-test was used, with the level of statistical significance set to $p<0.05$. A statistically significant difference was noticed in relation to the number of registered media outlets between the analyzed units of self-governments on the territory of Vojvodina ($p<0.001$). A statistically significant difference was noticed in relation to the number of registered media outlets in the analyzed municipalities on the territory of the Republic of Slovenia ($p<0.00001$).

Role of local media outlets in society

The media outlets that are territorially defined towards the community in which they were established, regardless of the type of ownership and financing are called local media outlets. As explained by Milojević and Krstić (2012), these media outlets are an expression tool of pluralism and diversity of a society and

a mediator in the dialogue between local population and representatives of authorities. "They are a forum for voicing opinions and specific problems of local communities, which are not given enough space in the agenda of national and regional media outlets" (Milojević& Krstić, 2012, str. 104).

Local media outlets are very important for media pluralism in a society. This claim is confirmed by numerous international documents, such as the recommendations of the Council of Europe, which encourage the development of local media outlets.

"Different types of media, along with different genres or forms of editorial content or programming, contribute to the diversity of content. Although content focusing on news and current affairs is of most direct relevance for fostering an informed society, other genres are also very important. Examples include cultural and educational content and entertainment, and content aimed at specific sections of society, such as local content and content aimed at vulnerable groups, such as minorities or persons with disabilities" (Recommendation of the Council of Ministers of the Council of Europe).

According to the same recommendation, states should encourage and support the establishment and functioning of minority, regional, local and not-for-profit community media by providing financial mechanisms to foster their development. Such independent media give a voice to communities and individuals on topics relevant to their needs and interests. Thus, such media are instrumental in creating public exposure for issues that may not be represented in the mainstream media.

Local media should contribute significantly to the development of local public sphere. Lang (2004) states that local political communication, whose important segment are local media, is the necessary precondition for citizens' engagement and democratic practice.

According to Mihajlov Prokopović (2018), unlike the socialist period in Yugoslavia, when local media were mostly state-owned in a sense that they were established and financed by local self-governments, during the last decade of the 20th century commercial media were being established rapidly and there were around 1,200 of them on the territory of Serbia in 2002, most of which (90 percent) were radio and TV stations. The 2002 Broadcasting Act envisaged a limited number of frequencies for electronic media. The procedure of granting licenses ended in 2008, by which time the broadcasting permit had been issued to 467 media outlets, 376 of which were local broadcasters (Mihajlov Prokopović, 2018).

Demographic and economic indicators

In 2019, according to the data of the Statistical Office of the Republic of Serbia, the province of Vojvodina had a population of 1,852,093, living in 45 municipalities and cities, i.e. in 467 settlements. The total area of Vojvodina is 21,506 square kilometers and 86 citizens live on one square kilometer. The largest city in Vojvodina is Novi Sad, which, according to the same source, had a population of 360,925 in 2019. It is followed by Subotica (population 136,475), Pancevo (119,509), Zrenjanin (115,797), Sombor (78,472) and Sremska Mitrovica (75,241). The Statistical Office estimates that the population of Vojvodina decreased by 139,924 between 2012 and 2019, with Novi Sad the only of the listed cities to record a trend of growing population (its population increased by 17,277). All other major cities recorded a decrease in population.

According to Eurostat, on January 1, 2020, the population of Slovenia was 2,095,900, living in 212 municipalities and cities. The total area of Slovenia is 20,271 square kilometers and 103 citizens live on one square kilometer. The population increased by 40,404 in comparison to 2012. According to the data of the Statistical Office of Slovenia, the most populated city was Ljubljana (286,475), followed by Maribor (96,211), Kranj (37,941), Celje (37,872), Koper (25,753), Velenje (25,594), Novo Mesto (24,183) and Ptuj (17,959). Among all the aforementioned cities, Ljubljana recorded the highest increase in population (13,921) in comparison to 2012. Most other major municipalities and cities recorded slight increases in population (around one thousand).

The estimated population is calculated based on the data obtained from a census, information about the population growth and about internal migrations.

Based on the analyzed data regarding the number of registered media outlets in Vojvodina, it was established that only two municipalities in Vojvodina do not boast a registered media outlet and those municipalities are Ada and Čoka. According to the records of the Serbian Business Registered Agency, the total number of registered media outlets in 2019 was 761. The highest number of media outlets were registered in Novi Sad (371), followed by Subotica (68) and Pančevo (42).

The average net salary on the territory of AP Vojvodina in 2019 was RSD 51,965 net (Parliamentary Budget Office, 2019), i.e., EUR 441,94(according to the middle exchange rate of NBS for 2019). The units of local self-government with average net salaries higher than the average salary in the province are Novi Sad (EUR 514,24), Vršac (EUR 480,13), Pančevo (EUR

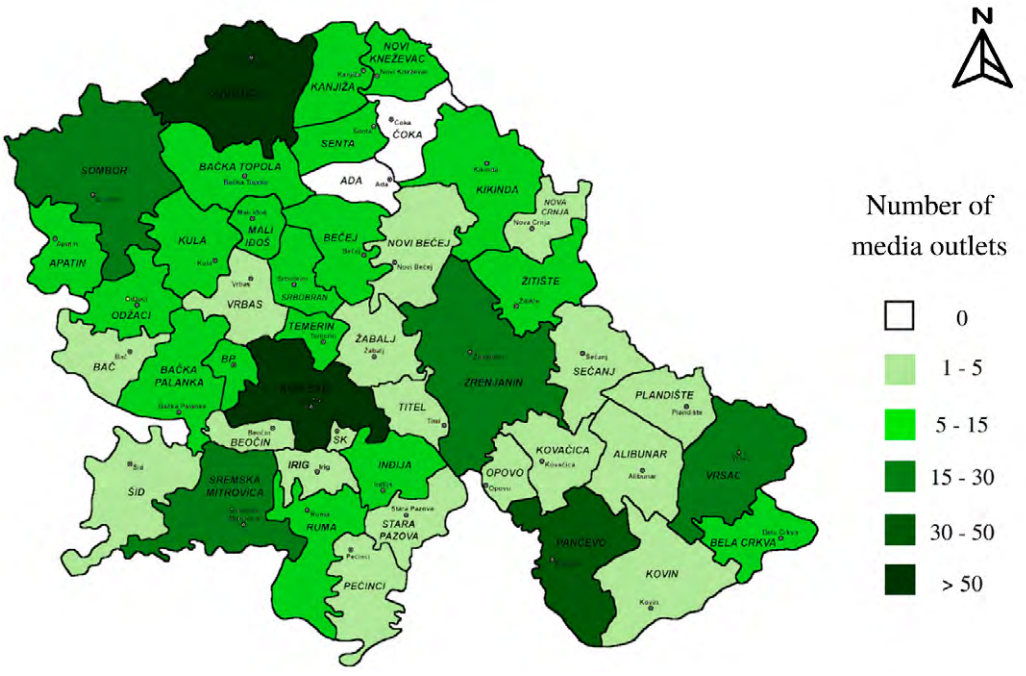

Figure 1. Number of media outlets in local self-governments in Vojvodina

460,38), Titel (EUR 450,11), Zrenjanin (EUR 448,35) and Kovin (EUR 443,33).

The units of local self-governments with net salaries above the provincial average boast 459 media outlets, i.e., 60.31 percent of the total number of registered media outlets are located in those six municipalities and cities.

According to the analyzed data related to the media outlets in Slovenia, the number of registered outlets in this country is 2,052. Most media outlets have been registered in Ljubljana - 1065, followed by Maribor (167) and the municipality of Koper (56 registered media outlets).

The average net salary in 2019 in Slovenia was EUR 1,133.50.[3]The municipalities with net salaries higher than the state average in Slovenia areNovo mesto (EUR 1,286), Ljubljana (EUR 1,282), Podlehnik (EUR 1,236), Mežica (EUR 1,196), Komenda (EUR 1,194),

[3] https://pxweb.stat.si/SiStatData/pxweb/sl/Data/-/0772615S.px, visited on December 20, 2020.

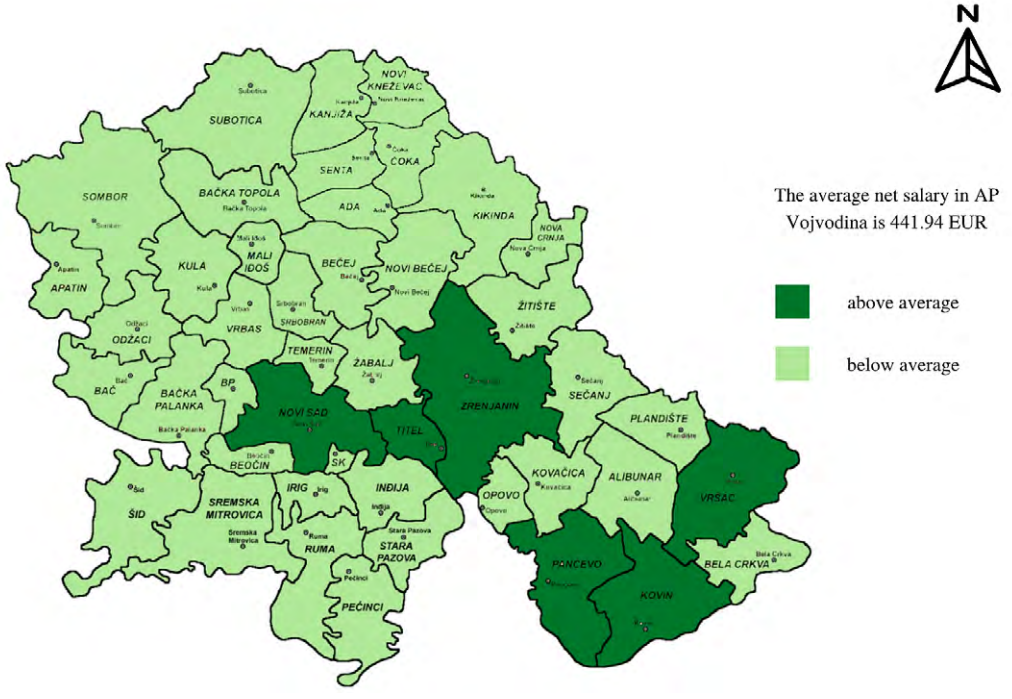

Figure 2. Average net salary in local self-governments in Vojvodina

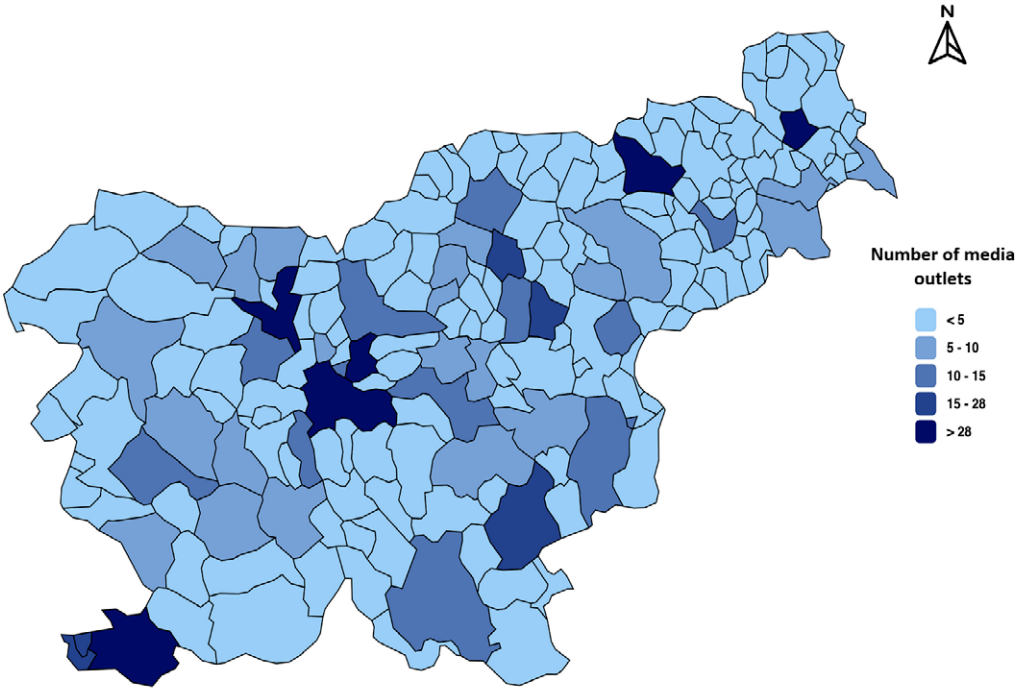

Figure 3. Number of media outlets in local self-governments in Slovenia

Dol pri Ljubljani (EUR 1,183), Štore (EUR 1,177), Koper (EUR 1,176), Završč (EUR 1,174), Krško (EUR 1,169), Lukovica (EUR 1,165), Škofja Loka (EUR 1,163), Idrija (EUR 1,162), Šentjernej (EUR 1,156), Šempeter – Vrtojba (EUR 1,151), Nova Gorica (EUR 1,140), Ravne na Koroškem (EUR 1,138), Križevci (EUR 1,134) and Šenčur (EUR 1,134).

The total number of registered media outlets in the municipalities with net salaries above the state average is 1,227, i.e., 59,79 percent of the total number of registered media outlets are located in these municipalities.

In relation to the number of local self-governments, more media outlets are registered in Vojvodina than in Slovenia: 16.9 and 9.68 media outlets per one unit of self-government, respectively, despite the fact that the average net salary in Slovenia is 2.57 times higher than in Vojvodina and despite the fact that, as a consequence, the commercial potential of the media market in Slovenia is much bigger than in Serbia. Only two local self-governments in Vojvodina do not have a single media outlet registered in them. On the other hand, in Slovenia, 36 local self-

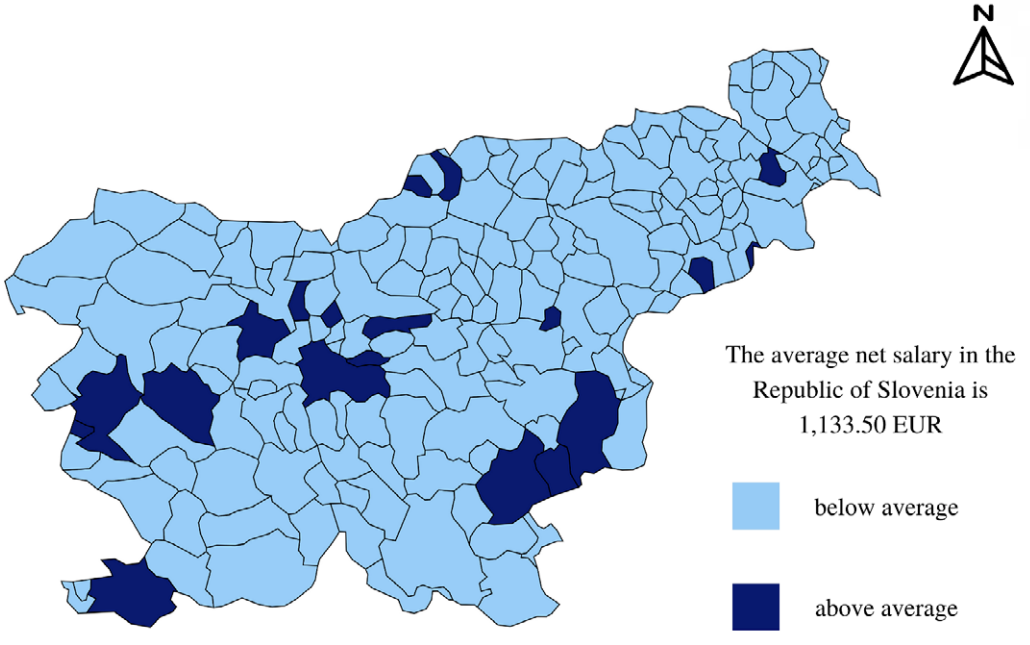

Figure 4. Average net salary in local self-governments in Slovenia

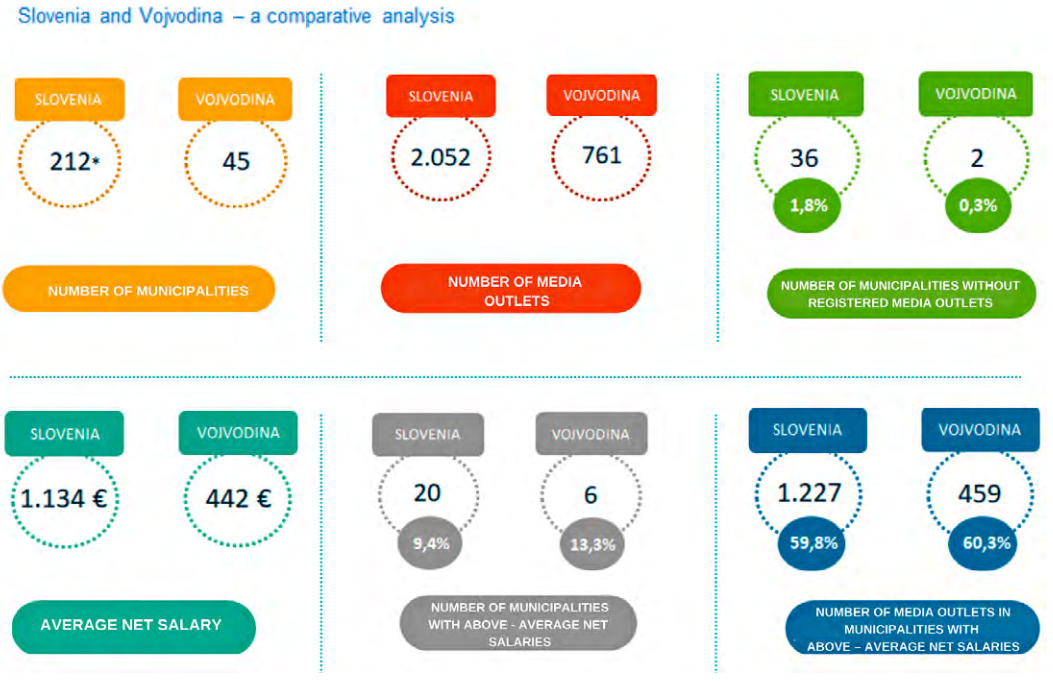

Figure 5. Comparative analysis of various quantitative indicators

governments do not have a single registered media outlet.

In Slovenia, there are 20 local self-governments with a higher average net salary than the state average, which is 9.4 percent of the total number of municipalities and cities, while there are six local self-governments in Vojvodina with a higher average net salary than the provincial average, which is 13.3 percent of the total number of municipalities and cities.

The number of media outlets in the municipalities with an above-average net salary in Vojvodina is 459, i.e., 60.3 percent, while there are 1,227 registered media outlets in the municipalities with an above-average net salary in Slovenia, which is 59.8 percent of the total number of registered media outlets in this country. In other words, the percentage is rather similar in Vojvodina and Slovenia, which is in line with the logic of media market, because a higher purchasing power provides a greater potential for advertising in media, which is the most important source of income for media outlets.

The main problems on the media market in Slovenia

In an analysis called "Monitoring of media pluralism in the digital era" (Milosavljevic & Biljak Gerjevic, 2020), it is stated that, in a quantitative sense, the pluralism of media in Slovenia is satisfactory. The regulations for ensuring media pluralism are mostly clearly defined by laws and legal acts, but the implementation is often faulty. The reason for this is that many media outlets are publicly owned by political parties, their (former) members or open supporters of certain political options. This type of conflict of interest is particularly visible at local and regional levels. There are no efficient regularly protective mechanisms that would guarantee autonomy when it comes to appointing and releasing editors-in-chief. The state institutions in charge regularly publish annual calls for co-financing media content, but the amounts granted are very small, bearing in mind the number of media outlets.

The same analysis also states that there is a high risk when it comes to the concentration of media ownership, as well as the risk of controversial purchase and/or merging of media outlets. Even though a consent of the Ministry of Culture is necessary when someone wishes to own more than 20 percent of a media outlet, breaches are still happening, since the ownership is easily concealed through off-shore companies. That is why expert analyses (Milosavljevic & Biljak Gerjevic, 2020) emphasize the need for more resolute control of the authorities in charge, because four owners almost completely control the market of audio-visual products and print media in Slovenia.

This indicator of the concentration of online platform ownership also suggests a high level of risk related to media pluralism. In this field, there are no special rules about the control or prevention of media outlets merging and, consequently, concentra-

tion of ownership. Some recent cases show that the concentration of ownership in media is growing stronger. This issue emerged when a telecommunication company "Telekom Slovenije" was allowed to establish a TV station *Planet TV* in 2012. There are many other companies engaged in multiple and simultaneous media activities and which continue to be issued licenses, despite legal restrictions. There were other, similar cases, such as the merger of the *PoP TV* broadcaster and *Kanal A*, which was an acquisition of Pro Plus, owned by the United Group, which owns the second largest telecommunication and cable operator *Telemach*. A similarly problematic situation was recorded when dailies *Dnevnik* and *Večer* were merged. "A high concentration of media ownership weakens pluralism and encourages self-censorship among journalists", it was reported in the 2019 World Press Freedom Index (Reporters without borders, 2019).

Another high risk is related to the independence of media when it comes to the impact of commercial advertising on editorial policy. This field is also marked by a noticeable lack of regulations that would protect the independence of editorial policy. There are no regulations in place to ensure that the decisions regarding the appointment and release of editors-in-chief are not affected by commercial interests. Many cases of concealed advertising have also been recorded.

There is also a noticeable influence of Hungarian companies on the ownership of Slovenian media outlets. The Hungarian government is recognized in Europe as one of the greatest enemies of media freedom. This trend was also noticed by *Freedom House*, which stated that, having established almost a complete control over the media in Hungary, the ruling party in Hungary had started spreading the influence of the neoliberal policy of the Hungarian Prime Minister, Viktor Orban, in North Macedonia and Slovenia (Freedom House, 2019).

Poverty and unregulated market of local media in Serbia

The fact that a simple quantitative indicator related to the number of registered media outlets does not represent a solid base for concluding that there is media pluralism in a society is confirmed by numerous deviations on the media market in Serbia, where local media outlets are those in the most difficult financial situation, which often makes them exposed to various pressures and mechanisms of economic blackmailing.

The Law on Public Information and Media (2014) stipulates that a media outlet cannot be state-owned, except in the case of public broadcasting services. Therefore, according to the law, the media cannot be "directly or indirectly founded by the Republic, an autonomous province or a unit of local self-government, nor by an institution, company or other legal entity completely or partly owned by the state, i.e., which is completely or partly financed from public revenue".

In other words, the aforementioned law envisages the transformation of ownership over state-owned media, owned by the Republic of Serbia, an autonomous province, a unit of local self-government or public institutions and companies, which are financed from public revenue. The law obliges a buyer of a media outlet to ensure the continuity of placement of media content of public interest. "The privatisation of media referred to in paragraph 1 of this Article shall be organised in a manner which would enable the continuity in the production of media content of public interest over a period of five years from the conclusion of the agreement on the sale of capital, while other liabilities of the buyer stipulated in the contract may be defined for a period of up to five years since the concluding the agreement on sale of capital" (Law on Public Information and Media, Article 142).

Furthermore, the aforementioned law envisages co-financing of projects that would secure public interest in the field of public information. "The Republic of Serbia, Autonomous Province and local self-government unit shall provide from their budgets part of the funding for realising public interest in the public information sector (hereinafter: public competition) and shall allocate the funds on the basis of public competitions and by way of allowances, in accordance with the principles of non-discrimination and the rules for state aid allocation and protection of competition." (Law on Public Information and Media, Article 17).Thereby, the Rulebook on co-financing projects related to ensuring public interest in the field of public information was adopted, which explains in details the mechanisms of project co-financing of public interest in the field of public information.

However, as stipulated in the Strategy of development of the public information system in the Republic of Serbia for 2020-2025 (the Media Strategy), a comprehensive analysis of the effects of project co-financing content related to ensuring public interest has not been conducted. Reports on various elements of project co-financing reveal problems in the following fields: 1) method of announcing competitions and refusal of local self-governments to announce competitions, 2) method of selecting committee members and the composition of committees,

3) non-transparency of competitions, 4) inclusion of discriminatory conditions, 5) inadequate monitoring system, 6) lack of evaluation of the quality of co-financed content.

When it comes to the functioning of media market, the Media Strategy recognized the following most prominent problems: penurious media market, saturation due to a large number of outlets, advertising problems, contradictories and inconsistent enforcement of laws, non-transparent distribution of state funds based on vague criteria.

Previous research in Serbia (Matić, 2012; Milivojević et al., 2011) point at the monopolistic position of agencies dealing with selling advertising space and, thus, endangering the free market and, first and foremost, the position of local media outlets (according to Milojević & Krstić, 2012). These problems are also stipulated in the Media Strategy. The document stipulates that local and regional media outlets are losing the battle with those which have national coverage, and which are always included in opinion polls. To be more precise, as stipulated in the Media Strategy, as much as 89 percent of share in TV advertising belongs to TV stations with national coverage, while most of the remaining funds for advertising goes to foreign programs distributed through the cable network (Ipsos Strategic Marketing, 2015).The data show that out of 15 largest commercials advertisers in Serbia, not a single one advertises on local or even regional TV stations. Consequently, since local media outlets do not often attract interest of major advertising agencies, without which it is impossible to secure income from large advertisers, the pressure is further increased on the outlets to turn to various types of budget and state financing, including project co-financing, contracts with public companies, sponsorships and donations as the main source of income, thus introducing the state back on the stage as the dominant subject. According to a 2018 analysis of the Novi Sad School of Journalism, this situation diminishes the autonomy of local media outlets and creates a great space for various types of pressure, which are most commonly reflected in the impact on the media outlet's editorial policy and diminishment of its independent editorial policy. Hence, regional, local and civil society media outlets, have little or no income from advertising, which is why they are forced to generate income almost exclusively through co-financing competitions. In that manner, the competitions for media content financing are becoming almost the only source of income for local and regional media outlets. Project co-financing has, thus, turned into a social category, instead of competitions serving their primary function – to provide funds for ensuring that public interest is met.

When it comes to the position of local media, the Media Strategy notes that the economic pressure imposed by local authorities, the lack of competitions, insufficient funds for project co-financing, disrespect towards laws and by-laws and favoring of certain media outlets when allocating funds have become the dominant forms of pressure on the independent editorial policy of local media outlets. This is also noted in the negative reports of the European Commission on the progress of Serbia towards EU, which state, among other problems, that "co-financing of media content to meet public interest obligations needs to be implemented in line with the legislative framework, using transparent and fair procedures, and without interference by the state administration, especially at local level,"(European Commission (2016), "Transparent ownership and funding of private media, state funding of media outlets and co-financing of media content need to be effectively monitored, including at local level, and implemented according to existing legislation,"[4],"Serbian authorities should ensure that informal pressure on editorial policy is not exerted through the distribution of advertising funds, including from public companies, as well as project co-funding from local budgets." (European Commission, 2018).

Apart from being extremely fragmented, the local media market is also economically unsustainable. Local media outlets have been in an extremely difficult situation for several years and they are operating on small, limited and extremely poor local/regional economic markets. They are making very little income from advertising and sales, while the transfer onto digital broadcasting of TV signals imposed new expenses on TV stations, which were not accompanied by increased revenue (Matić, 2016). Project co-financing, thus, becomes a model of financial sustainability of media outlets and serves as a tool for financing regular activities of the outlets, instead of being a tool to finance the missing content of public interests. Consequently, regular market relations cannot be developed, i.e., market relations are disturbed, especially on the local level.

[4] „Non-Paper" on current state of affairs regarding chapters 23 and 24 for Serbia, November, 2017, pp. 8.Available at: https://bit.ly/2BVp8TO, visited onDecember 20, 2020.

Conclusion

As already mentioned by quoting the recommendations of the Committee of Ministers of the Council of Europe", "Different types of media, along with different genres or forms of editorial content or programming, contribute to diversity of content." It is, therefore, not enough to have a lot of media outlets to claim there is media pluralism in a society, but there need to be various genres and program and editorial content for a society to be truly pluralistic when it comes to media. It is also not enough to have a legislative and political framework, which in theory is the main precondition for the development of media pluralism, but only under the condition that it is consistently enforced, which is a very common problem in Serbia in terms of the legislative framework. As a former commissioner for information of public importance and personal data protection, Rodoljub Šabić, noticed at a public event, the laws that are not enforced are not laws, but essays.

A statistical analysis of the number of media outlets in the Autonomous Province of Vojvodina and the Republic of Slovenia and of the economic indicators related to the average net salary in municipalities and cities, clearly shows that the average net salary per capita in the municipalities and cities has an impact on the number of local media outlets in local self-governments in Slovenia and Vojvodina. However, it is also clear that there are many more registered media outlets in Vojvodina than in Slovenia. This is undoubtedly an anomaly, because the average net salary, and consequently the potential for advertising in media, is more than two times higher in Slovenia than in Vojvodina. So, why are there so many media outlets in much poorer Vojvodina?

One of the reasons is definitely the fact that "the past two centuries have shown that without the support of mass media, traditional or internet, it is almost impossible to win the election or remain in power. Citizens (who are also voters) do not only experience the events in complex modern societies through their own experience, but they also create a picture of the world through media content: what, where, how and why did it happen?" (Kučić, 2019). If we add numerous problems related to the transparency of media financing on the local level, which are much more prominent in Vojvodina than in Slovenia, there is no other option, but to conclude that those are media outlets that do not take part in a fair competition. If we also consider the facts revealed in various research related to the deviations present in the process of project co-financing of media content, where the media outlets close to the current authorities are favored, the lack of media pluralism becomes even more apparent. The editor of *Kikindske*, Željko Bodrožić, once estimated that project co-financing has turned into a "social category" and "bribing of their own media", while completely ignoring the law (beta.rs). The position of local media outlets in Vojvodina is made even more difficult by the fact that by far the largest part of income from advertising is taken by national media outlets, especially TV stations.

Along with an independent and sustainable public broadcasting service, the recommendations of the Council of Europe state that local media can also be a counterpoise to the increased concentration of media and that they could also be suitable for meeting the interest of local users. The results presented in this paper clearly show that it is not the case in Vojvodina, as part of Serbia. On the one hand, there is a relatively regulated legislative and political framework for the development of media pluralism. On the other hand, there are no criteria and mechanisms for identifying risks to media pluralism: diversity of media ownership and media outlets themselves; diversity of standpoints that represent political, ideological, cultural and social groups and the diversity of interests and standpoints relevant to local and regional communities.

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A Forgotten Tributary of the Danube – The Vajas River

István Pánya[A*]

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Abstract

During the examination of the historical geography of the Danube-Tisza Interfluve, the reconstruction of the medieval landscape was carried out, within which the channel conditions of the main watercourses were sketched. The Vajas River is assumed to be the most important medieval tributary of the Danube. It can be located based on historical maps, medieval and modern written sources. During the research, it turned out - based on our sources so far – that there was no tributary called Vajas on the right bank of the Danube. Only the tributaries/branches on the left bank of the river were called Vajas. The Vajas River was not uniform but consisted of at least four sections in an area of about 140 km from Kalocsa to Plavna.

Keywords: medieval Danube; Vajas River; medieval environment; historical geography

Introduction

The medieval Danube differed significantly from today's river, which is confined between flood-control dikes. Today's river is characterized by "permanence", as the riverbed barely changes and its water flows within controlled conditions. The medieval, constantly changing, meandering river was lined with extensive forests, swampy alluvial plains, and numerous abandoned oxbow lakes. Its water was drained by smaller tributaries and canals of artificial and natural origin in the floodplain, which was used by the medieval population for floodplain economy, especially fishing. One such natural tributary was the Vajas River. During the investigation of the medieval Bodrog county, the historian GyörgyGyörffy established that the Vajas was actually a tributary of the Danube, which enclosed an island-like tract of land together with the Danube from Kalocsa to Bács/Bač (Györffy, 1963; Györffy, 1970). On the map attached to his book, he also outlined the Vajas River accompanying the Danube from the east (Figure 1). Since the publication of Györffy'shistorico-geographical repository, the idea of the Vajas has been taken over in countless places, mostly without any substantive criticism. However, Györffy's theory can be supplemented and clarified in several points. Thanks to the digitally available manuscript maps and medieval written sources, it is clear that there were several Vajas Rivers along the Danube, but – contrary to the historian's opinion - these did not form a single watercourse (Figure 2).

The geographical, historical, and archeological literature of the Danube and its surroundings can be claimed to be very rich (Pécsi, 1959; Ihrig, 1973; Marosi & Szilárd, 1967; Marosi & Somogyi, 1990). However, to the best of our knowledge, no summary study has been conducted specifically on the Vajas River. Nonetheless, there are plenty of scientific publications, repositories, and unpublished historical written and map sources from which we can outline the location and history of the Vajas. Among these, the old 18th-19th century manuscript maps depicting watercourses before the river regulation works are very important (MNL OL S12 D11. No28:1-2.). Related to this is the 19th century Danube Survey which was recently released on DVD (DM; MNL OL S81 1554/376). Un-

[A] Katona József Museum of Kecskemét, Kecskemét 6000, Bethlen blvd. 1., Hungary; panyaistvan@gmail.com

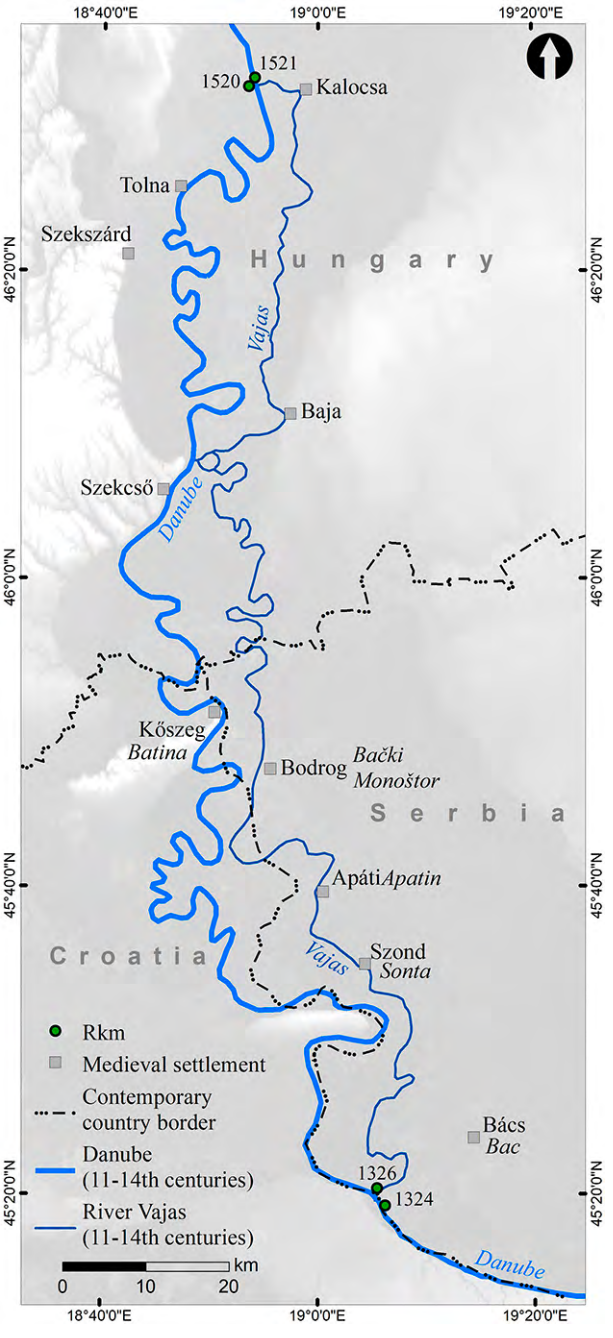

Figure 1. The River Vajas on GyörgyGyörffy's map
Source: Györffy, 1963

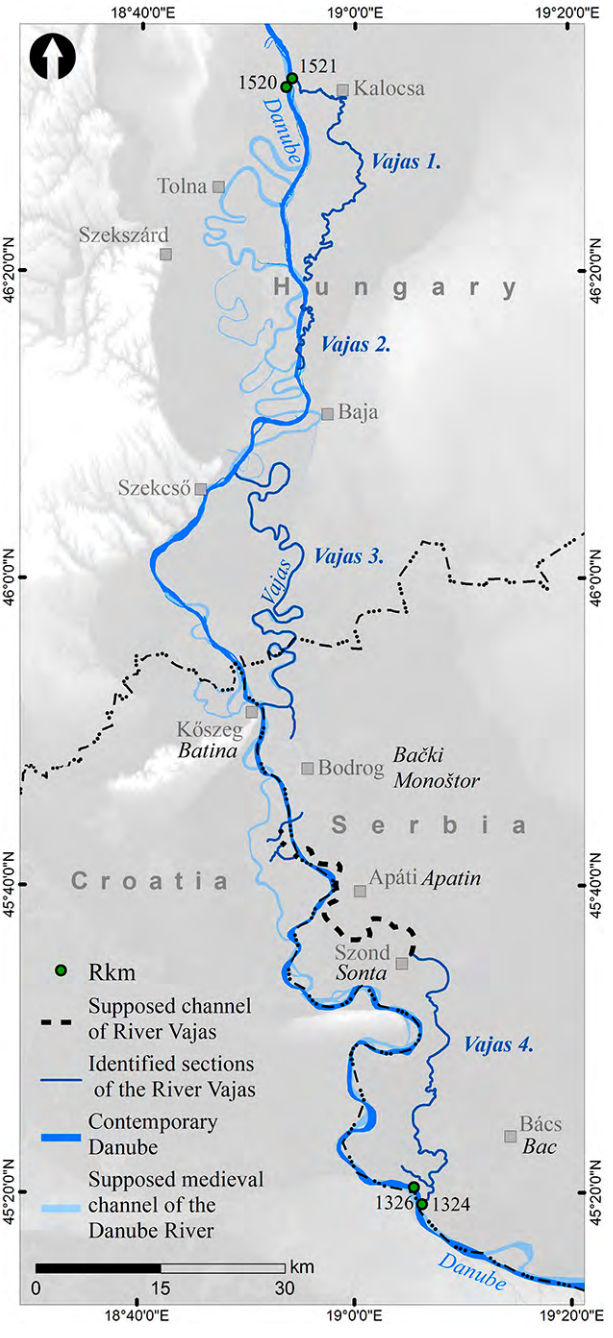

Figure 2. The identified sections of the River Vajas

fortunately, the maps of the survey are incomplete, as a significant part of the sheets was lost or destroyed in the last century. Fortunately, the missing sections can be replaced based on maps made from the originals, representing larger areas (MNL PML Pmt018; HM HIM BIXb 122/2; BIXb 134). The descriptions made for the sections of the Danube Survey also contain a very large amount of data, which is of particular interest from a water and regulatory point of view (DM; see the descriptions in MNL OL S81 VízrajziIntézet, iratok 1/b.).

The sections of the Vajas River and the associated artificial and natural channels were important mainly for fishing in the Middle Ages. In numerous medieval charters, controversial issues related to fishing and fish farms occur. In the 16th-century Turkish tax registers fishing on the Vajas River is mentioned in several settlements (Káldy-Nagy, 2008). Ede Solymos and Márta Göldner (Solymos & Göldner, 1978) researched the 18th-century fishing contracts of the Archbishop of Kalocsa, from which data on fishing in the Danube region after the Turkish conquest can be obtained (Solymos & Göldner, 1978). There are also valuable studies at the local history level, through which we gain an insight into the surroundings of each settlement and the conditions of the sections of the Va-

jas River located near the settlements (Gallina, 2016; Romsics, 2016). The historical geography of Dusnok was written by local historian Kálmán D. Szabó (d. Szabó, 1992), and in many places, he mentions the Vajas and the related Hungarian and South Slavic historical toponyms. Medieval charters from the Szeremle area were published in full Hungarian translation by Nándor Kapocs and Mihály Kőhegyi (Kapocs & Kőhegyi, 1980). The research by Andrea Kiss (Kiss, 2012) is also based on historical sources, from which we can obtain valuable data on floods of the Danube and the Vajas River in the medieval Solt and Bodrog counties.

The Vajas River is often referred to as the Vajas Canal (Hungarian 'fok' – literally notch, also canal, ditch, crevasse). It is important to emphasize that the meaning of the word 'fok' differs significantly from a historical-ethnographic and geographical point of view. BertalanAndrásfalvy (Andrásfalvy, 2002) and AndrásDeák (Deák, 2002a/b/c) addressed the issue in their publications.

The origin of the name Vajas is a particularly interesting question, which has been studied by many authors from the 18th century to the present (like MátyásBél see in Ihrig, 1973; Andrásfalvy, 1973; Andrásfalvy, 1975). According to MátyásBél, the name Vajas comes from the Hungarian verb 'vájni' (Vajas - Vájás), which means 'to hollow out, to carve' (Mindszenthy, 1831; Mindszenthy, 2020). Andrásfalvy (1989, 2002) drew attention to the fact that the ditches (Hungarian 'fok') along the Danube have traditionally been 'hollowed out', so there can be a connection between the word 'vájás' (hollow) and the name of the Vajas River.

It can be seen from this brief overview, that a lot of indirect and direct sources are available for Vajas River, but this watercourse has not been intensively explored. A prime example of such in-depth investigation is the recent interdisciplinary research of the Mostonga River in Serbia, in the course of which numerous archeological, ethnographical, and geographical data has been collected of the river (Lazic, 1998). In the present study, it is not possible to review the Vajas River in such detail, therefore I only intend to briefly outline each section of the river and its main geographical and hydrographic features.

Study area

The floodplain of the Danube begins south of Budapest and accompanies the river in varying widths to Titel, the confluence of the Danube and the Tisza. The territory of the floodplain - apart from the micro-regional classification used in Hungarian and Serbian geography - can be basically divided into two, significantly different main units. The northern part extends from Dunavarsány to Baja and the southern part from Baja to Titel.

The formation of the two plains began roughly 300,000 years ago, at the end of the Pleistocene. At the end of the last glaciation, the meltwater of the glaciers increased the flow of the Danube, thus increased the stream power of the river. At Dunaharaszti and Dunavarsány, the ancient Danube split into several meandering branches, and in the next few thousand years, the water transported away the sediment accumulated by aeolian processes during the Pleistocene. Simultaneously, the water deposited its sediment on the surface, which is gravel in the northern part of the floodplain, sandy gravel in the eastern part, and sandy in the southern section. The boundaries of the floodplain thus shifted further and further eastward, to the present-day edge of the ridge between the Danube and the Tisza. As a result of fluvial processes, the 4-6 km wide high floodplain and the 10-15 km wide low floodplain bordering it from the east wereformed. From Kiskunlacháza to Baja, the floodplain is interwoven with the old meandering river branches of the Danube, which have been abandoned for thousands of years (Marosi & Szilárd, 1967; Marosi & Somogyi, 1990).

The surface of the southern part of the floodplain - from Baja to the confluence of the Danube and the Tisza - differs from the northern part, as in the south the Danube is bordered by a low floodplain and a high floodplain slowly rising to the east. The width of the latter is only a few below Baja, but it is almost 40 km around Titel.

Data and methods

The most evident and geographically best sources for researching the sections of the Vajas River are the 18th and 19th-century historical maps. The Hungarian National Archives and county archives have very richcollections of maps and related written materials. A survey of the ca. 140 km-long area between Kalocsa and Plavna can be found in the first, second, and third military surveys and on 20th-century maps, like the 1:10 000 and 1:25 000 stereographic, Gauss-Krüger and EOV/HD72 projection maps. Georeferencing of each survey was necessary for their interpretation. The GIS works were performed in ArcGIS

10.4 in EOV (Hungarian Datum 1972) projection. The maps provided several data on the former channel of the Vajas River, but the translation of the medieval (Latin) documents and their interpretation in a GIS system was also needed to determine the former channel conditions. The Vajas 1 and 2 rivers still exist, but only a few historical documents survived that mention these two river sections. However, the northern section of the Vajas 3 – from its confluence with the Danube to Dávod could be clarified based on medieval sources. The Vajas 4 was divided into several sections due to the early-modern and modern changes of the Danube. One of the sections is currently located on the right bank of the Danube. The channel of Vajas 4 could be broadly determined by GIS analysis.

Results

Based on the sources and GIS research, four sections of the River Vajas can be determined:

Vajas 1 (Main Canal of Sárköz I)

It originated from the Danube at Foktő between river kilometres1520 and 1521 (MNL OL S12 D14 no38). According to Bél (1982) – who had a different opinion – Lak (northwest of the present-day Géderlak), Szentbenedek, Uszód, and Fajsz villages north and south of Foktő also lay next to the Vajas. The famous geographer was certainly mistaken, as the above-listed settlements – proven by local historical and geographic data – were not related to the River.

The Vajas 1 flowed eastwards from the village of Foktő towards Kalocsa, then turned south and meandered towards Bátya, Miske, and Dusnok (Bárth, 1999). To the west of the latter, at the so-called Vajastorok ('mouth of the Vajas'), between river kilometres1494-1495, it flowed into the Danube, next to the former medieval village of Csepcs (Asbóth, 1999; Asbóth, 2004; Mindszenthy, 1831; MNL PML XV. 6. (PMT) 8; MNL OL S101 No400; MNL OL S12 D13 No646.). In modern written sources and maps, the section below Dusnok was called Fekete ('Black') Vajas (Solymos & Göldner, 1978; D. Szabó, 1992), probably indicating high organic matter content of water. At the beginning of the 18th century, the so-called Kis-Vajas ('Small Vajas') was still known, which formed the eastern border of Fajsz in the direction of Dusnok (Borosy & Szabó, 2000). According to 19th-century maps, the length of the Vajas 1 was about 50 kilometers. At Csepcs, due to the lateral erosion of the Danube, some parts of the mouth section (and the village of Csepcs) were destroyed by the River Danube at the turn of the 18th and 19th centuries (Mindszenthy, 1831).

Numerous medieval, early modern, and modern historical sources and folk traditions have survived in connection with this section of the Vajas River (1447: DL 106509;1502: Ipolyi et al., 1873 394.; DL 107288; Katona, 2001; Deák, 2004). On his way to the Great Plain, AntalMindszenthy recorded that "before the Ottoman occupation, the development of Kalocsa was significantly influenced by this river, because at that time people sailed from the Danube to the city in small boats. The Vajas was possibly made navigable artificially, just as PéterVárdai, the Archbishop of Kalocsaturned another watercourse [the Mostonga] in the archdiocese navigable. The floods on the Danube filled the Vajas with mud so that even smaller boats could not sail on it, but the floods are sometimes so great that even the largest boats could sail on the river" (Mindszenthy, 1831). It is possible that the Archbishop of Kalocsa, likewise the Mostonga, repaired the upper section of the Vajas River up to the Danube and made it suitable for navigation and, if necessary, for towing boats.

In the Ottoman era, the Vajas 1 remained important as a fishing ground due to its abundance of fish. It was mentioned in the Turkish tax register ('defter') of 1578 as Irmak-su ('river'). In 1570, the people of Kalocsa paid 150 akce for fishing the Vajas. At Doboka, which existed on the site of today's Dusnok built-in area, a very significant tax of 4,100 akce was paid for the use of the Vajas (D. Szabó, 1992). In the Turkish defter, the mouth of the river was mentioned as a "place rich in fish" and the inhabitants of Csepcs paid 50 excise taxes for its use (Káldy-Nagy, 2008). Turkish censuses suggest that even the people of Miske, Hontoka, Karász, and Dalocsa used the Vajas for fishing (Káldy-Nagy, 2008). Later, after the Turkish wars, it was still considered an important fishing place in the 18th century (Bárth, 1969; Borosy & Kiss, 2004). In the modern age, some branches of the Vajas were given different names. In Dusnok, Izsák-Vajas, Borsoshát-Vajas, Buzsák-Vajas and Homoród-Vajas were distinguished (Szabó, 1992).

Vajas 2

It originated in the present-day Gemenc forest (river kilometres1491-1492), around the so-called Black Forest at the confluence of Kerülő-fok and the Danube (Figure 3) It appears from several sources that the upper section of the Vajas 2 became muddy by the turn of the 18-19th centuries, and it was difficult to recognize in the swampy floodplain (Kothencz, 2012; MNL OL S81 VízrajziIntézet - iratok, no. 1469. sz. §306).

Figure 3. The channel of the Vajas 1 and 2

The Vajas 2 flowed into the Danube at the former village of Kákony (around 1484 rkm), (MNL OL S12 D13 No448:03; S12 D13 No371). At Kákony, there is a watercourse branching out from the Vajas River and flowing southwards. On some maps, it was marked as Vajas, but mostly as Lake Csíkos (Kemény, 2008; MNL OL S12 DXIX No196:1; MNL OL S12 D13 No0163; KFL.VIII.2.a. No.1345; MNL OL S101 no857). Its former mouth and the village of Kákony that lay on the riverbank were destroyed by the Danube in the first half of the 19th century. In 1805, László Kollonich, Archbishop of Kalocsa, relocated the inhabitants of Kákony to present-day Bajaszentistván (Borovszky, 1910). His memory was preserved in the Vajas hunting lodge (Vajas J[agd] H[aus] on the 2nd military survey).

Vajas 2 can be found under several names in historical sources: the section at Sükösd was called Kerülő-Vajas, the section winding next to Csanád was called Csanádi or Görbe Vajas (Solymos & Göldner, 1978). In the Turkish defter of 1578, it was mentioned as Irmak-su ('river') at Csanád (Halasi-Kun, 1971). Mátyás Bél (Bél, 1982) mentioned that Csanád also lay next to the same Vajas as the above-mentioned (Géder) Lak, (Duna) Szentbenedek, Uszód, and Fajsz. Bél is partly wrong, as there was indeed a Vajas section here, but this is not the same as the Vajas meandering around Kalocsa.

Vajas 3 (Baracskai-Danube/ Bajski-kanal)

The channel of the Vajas 3 can be sketched based on medieval sources (mainly border descriptions) and 18-19th century manuscript maps (Pánya et al., 2020; Kapocs & Kőhegyi, 1980). According to charters, the Danube branched out in three directions between the market town of Báta and Szeremlén (now Szeremle village), somewhere about 2-3 km west of the rkm1469. The two western branches flowed southwards, towards Dunaszekcső/Mohács, and the eastern branch (on the southern border of medieval Szeremlén, today's Szeremle) flowed southwards forming large meanders and touching the market town of Bátmonostora (today's Bátmonostor). After about 81 kilometers (around 1426 rkm), it joined with the western Szekcső/Mohácsi-Danube branch (Figure 4). The 19th-century maps, Vajas-fok is shown southwest of Bezdan, which may be a section of the old Vajas that was cut off because of channel changes.

The Danube branch bordering Mohács Island from the east was known in the Middle Ages as Vajas (Wayas, Voyos, Vayas, Sebesvayas) (1382: Nagy et al. 1872 231., 232). In some cases, it was referred to as the Danube but with the name of Vajas (Danubio Vayas-vocato), or simply as the Danube/Sebesduna ('Swift-Danube'). Its oxbow lakes were also named after the Vajas and the Danube. From the charters we know the Holtduna (Holthduna, Fintaholtdunája formed with the male name Finta), Holtvajas (Hothvayas, Mizseholtvajassa formed with the male name Mizse) (1366: Nagy et al., 1872 318.; 1373: Nagy et al.1872 492.; 1405: Nagy, 1888 389.). The Baracskai Danube, in contrast with the many Vajas river branches, seems to be clearly considered as part of the Danube by the contemporary population. The name of the Vajas river branches north and south of the Baracskai Danube, however, has always been merely Vajas.

In the Middle and Early Modern Ages, the Vajas 3/ Baracskai-Danube was the main branch of the Danube, and its memory is preserved in folk tradition

Figure 4. The channel of the Vajas 3

(Brodarics, 1983; Andrásfalvy, 1975; Gosztonyi, 1891). The river was sailed, boat mills, and from the beginning of the 16th century a cloth mill was also operated on the Vajas (1348: Nagy et al., 1872, 298., 319., 377., DL 76901; 1391: Nagy et al., 1872 471.; 1405: Nagy, 1888 389., DL 82376, DL 82377).

The channel of the Vajas 3 changed significantly due to the 19th-century river regulation works. The first intervention took place at Báta, where the lateral erosion of the Danube gradually undermined the bankline near the inland area of Báta. To protect the settlement, the bend of the Danube was cut off, and artefacts (spur dikes) were built to make the water of the eastern branch flow into the new channel of the Danube. Afterward, the western branch (Mohácsi/Szekcsői-Duna) widened, and simultaneously with this change, the eastern branch narrowed, and its water discharge decreased significantly (Konkoly, 2012; Konkoly, 2015).

Subsequently, regulation works were carried out between Baja and Bezdán during the construction of the Ferenc Canal (Bajskikanal in Serbian) (Faludi, 1997; Csóka, 2011). The 44.6-km-long canal was built using a significant part of the channel of the medieval Vajas. Cut-offs were made southwest of Bátmonostor and west of Hercegszántó (Lóczy et al., 2014). The canal follows the channel of the medieval Sár River (fluvium Saar, Szurdokvíz in the early modern age), and then reaches the Vajas River at present-day Bátmonostor.

Vajas 4

In historical sources, it was mentioned as Vajas (Woyas, Vayos, Voyos, Vájas, Vaish) (Györffy, 1963). On the Second Military Survey, a ca. 6-km-long Vajas was shown on the left side of the Danube, west of Kupuszina/Kupusina (1407-1411 rkm), which joined an oxbow lake called Csorna. This Csorna is probably identical to the Churnahorda ~ Csornahorda watercourse mentioned in 1338 during the border investigation between the medieval villages of Papi and Hetes (1338: Nagy,1883 482.; Piti, 2012 264., 321.; Györffy, 1963). South of the Csorna oxbow lake another watercourse meandered, also called Vajas (Vajs canal on today's maps), which was ca. 4 km long. Approximately 17 km southeast of the Csorna oxbow lake, on the old maps the Vajas River is depicted at Szonta/Sonta (medieval Szond), and reached the Danube at Palona (present-day Plavna) about 46 km farther (KFL. VIII.2.a. No.149.). Between these two sections, we do not know the exact channel of the Vajas, however, written sources provide some important clues. The earliest mention of the Vajas dates from the 11th century. Lake Vajas (stagnum Woyas) is mentioned in the document of 1093 by King László I (Wenzel, 1867 69.). It was mentioned as lake (stagnum Vayos) in 1192 at Apos (south of the present-day Apatin) and in 1211 at Aranyán (north of the present-day Apatin), and as watercourse (fluvium Voyos) at Szond (Szonta/Sonta) in 1206 (1192, 1211: Györffy, 1963;1206:Ipolyi et al., 1880 2.). It can be found in the 16th-century Turkish tax registers at Fonó (south of Szonta/Sonta) as Irmag-I Tuna ('River Danube') (Halasi-Kun, 1971). According to historical sources and manuscript maps, the river section between Kupuszina/Kupusina and Szonta/Sonta may have been approximately 31 km long (Figure 5).

The Hungarian population of Bodrog and Bács counties disappeared by the first third of the 16th

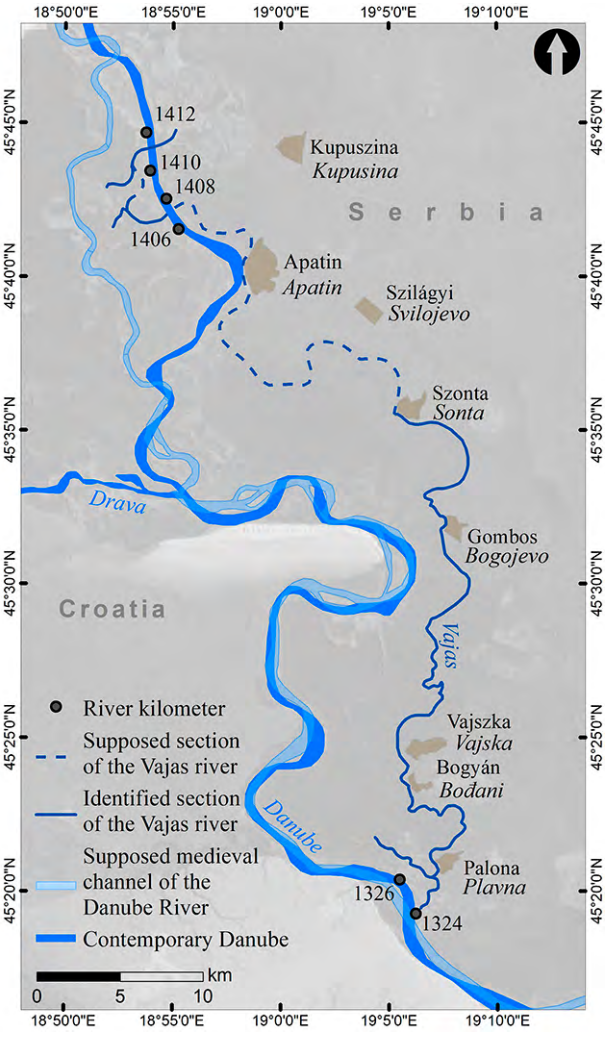

Figure 5. The reconstructed channel of the Vajas 4

century and was replaced by Balkan peoples (South Slavs and Vlachs) (Pánya, 2019; Stepanovic, 2020). However, not only some of the Hungarian settlement names survived, with some distortion, in the Turkish tax registers but also the names of watercourses and fishponds (Pánya, 2019; KFL.VIII.2.a. No.149.). In 1570, the name of Vajas fishpond next to Budinofce (today's Bogyán/Bođani) and Nagyplavna (medieval Palona, today's Plavna) was mentioned (Káldy-Nagy, 2008). The Vajas toponym survived the Turkish occupation and the migrations during the liberation wars (OSZK TK 1158). In the middle of the 19th century, the name Vajas was used in several places by a mixed German, Hungarian and South Slavic population: in 1864 at KaravukovoVajas/Vájas, near Plavna Vaish, at Bogyán Vais (Papp & Rajsli, 2006; MRT 586. 593-595.) was used. Vaiszka/Vaiska was recorded as having taken its name from a fishing place called Vais (Papp&Rajsli, 2006; OSZK TA 183/022.).

Compared to the conditions in the 19th century, the channel of the Danube has changed significantly. Along this section (Vajas 4.) the Danube shifted eastwards and started to meander in a north-south direction. As a result, some parts of the Vajas 4 were destroyed by the Danube. The changes of population and the channel of the Danube may have resulted in the disappearance of some parts of the previously continuous, approx. 82-km-long Vajas. Other sections survived but were given a new name by the migrating Slavic population (Dunavac west of Apatin, Kruskovac west of Szilágyi/Svilojevo).

Conclusion

The analysis of the Vajas River research yielded important results from two aspects. On the one hand, the Vajas was not a single continuous river. Several smaller and larger tributaries were called by the name Vajas, and all of them existed in the middle and lower sections of the Danube in the Carpathian Basin, and they were found on the left bank of the river. However, based on historical data, it is obvious that between the 11th and 16th centuries, their channels may have differed from those marked on the 18-19th century manuscript maps. The outletsection of the Vajas 1 probably shifted to the east due to changes in the channel of the Danube. Its original mouth may have been to the west of its present-day location. The Vajas 2 may have originated close to the mouth of the Vajas 1 and therefore it can be assumed that there may have been a connection between Vajas 1 and 2. The Vajas 3 separated from the Danube near Báta (approx. 10-11 kilometers south of the Vajas 2). From medieval sources, it is known that the River Sár meandered south of Baja, on the eastern border of the market town of Szeremlén (the predecessor of today's Szeremle), so there was no connection between the Vajas 2 and Vajas 3. Besides, medieval and modern sources suggest that the Vajas 3 was the main branch of the Danube, therefore it was larger and more significant than other narrow tributaries of the Danube. This is also confirmed by the fact that boat mills and fulling mills (or tuck mills) were used on it, and larger boats could also use them. We currently know two sections of the Vajas 4 (a shorter one west of Kupusina/Kupuszina and a longer one between Szonta/Szond and Plavna/Palona). In the area between the two sections, the name Vajas does not appear, instead, various South Slavic names can be found on the maps.

On the other hand, it is important, from a methodological point of view, that mass digitization started in the Hungarian archives around 2010. As a result, data from

historical archives that were previously difficult to search became widely available (online and on CD / DVD). These include thousands of manuscript maps, many of which depict sections of the Danube in the Carpathian Basin. As a result of digitization, a greater amount of data can be accessed in a very short time than in previous, "traditional" archival research. Not only has data access time been shortened, but data quality has improved due to good scanning and detailed data entry. It is important to note that it is not enough to examine the manuscript map material of the last nearly 300 years for medieval landscape history research. In many cases, these reflect the results of early modern and modern changes, and the older, medieval features of the landscape cannot always be traced. The study of the Vajas River highlighted the need for thorough archive research and the study of medieval and early modern written sources in Latin (or in some cases German / Hungarian). This is greatly facilitated by the archival portal hungaricana.hu, where photographs of charters from medieval Hungary can be viewed. The other online archive portal is the adatbazisokonline.hu ('databases online'), which contains the written sources of Hungary from 1526 to the Modern period, such as Turkish tax registers, Hungarian tax registers, etc. Thus, in recent years, the ever-expanding, freely searchable data repositories of the written and map sources required for landscape history research in the Carpathian Basin have been created.

Abbreviations

- DL – Hungarian National Archive Diplomatic Archive
- HM HIM – HM Military History Institute and Museum Map Archive
- KFL – Archdiocesan Archives of Kalocsa
- MNL BéML – Hungarian National Archive Békés County Archives
- MNL OL – Hungarian National Archive
- MNL PML - Hungarian National Archive Pest County Archives
- OSZK – National Széchenyi Library

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New Landscape Conceptualization as a Guideline for Spatial Development: a Case Study from Serbian Spatial Planning Practice

Vladimir Pihler[A], Nevena B. Vasiljević[A*], Dejan Đorđević[B], Luka Bajić[C], Dragana Dunčić[BD]

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Abstract

This paper is focused on clarification of the basic principles for the establishment of an innovative approach in the field of landscape research through its application in spatial planning documents in Serbia. The key question is: how the practice of considering landscape character could direct new spatial arrangements, based on the development of strategic spatial planning documents? The paper describes the results of analysis undertaken during the development of the "Spatial plan for a special-purpose area The Cultural Landscape of Sremski Karlovci". The landscape character assessment was the main methodology taken to define value of landscape character as the starting point for defining border of cultural landscape and "representative landscape units", as well as for guiding sustainable land use management which is opposed to the traditional approach of land-use decision making. Based on landscape character value, this research provides the elements for creating a different conceptual framework for spatial planning in Serbia which is one of the most effective model of the implementation of the European Landscape Convention.

Keywords: Landscape conceptualization; landscape character; strategic spatial planning; European Landscape Convention

Introduction

The spatial transformation processes has impacted upon change in landscape pattern resulting in a loss of landscape character and recognizable identity. The causes and consequences of this loss of diversity have become a subject of interest among researchers, planners and policy makers (Council of Europe, 2000; Antrop, 2000; Van Eetvelde & Antrop, 2007; Selman, 2006; 2010). There have been extensive research on approaches to landscape analysis, in particular development of methods through spatial planning practice (De Montis, 2014). The research on the specific character of European landscapes and the modalities of protection within the framework of spatial planning and management are the focus of the European Landscape Convention (ELC) (Council of Europe, 2000). It is explicitly based on sustainable development, highlighting its spatial dimension and spatial planning principles.

Contemporary theories consider the landscape as a holistic, hybrid entity in which natural and cultur-

[A] University of Belgrade, Faculty of Forestry, Department of Landscape Architecture and Horticulture; Spatial planner at the Urban and Spatial Planning Institute of Vojvodina, Novi Sad; pihlervladimir@yahoo.com; nevena.vasiljevic@sfb.bg.ac.rs
[B] University of Belgrade, Faculty of Geography, Department of Spatial planning; dejandj@gef.bg.ac.rs
[C] University of Novi Sad, Faculty of Agriculture, Department of horticulture and landscape architecture; luka.bajic@polj.uns.ac.rs
[D] Urban and Spatial Planning Institute of Vojvodina, Novi Sad; duncicd@gmail.com
[*] Corresponding author: Nevena Vasiljević; e-mail: nevena.vasiljevic@sfb.bg.ac.rs; tel.: +381-64-1153-857

al processes are unified and where economic, social and environmental objectives become intertwined in a sustainable spatial development approach (Ahern, 2011; Antrop, 2006a; Mayer, 1997; Selman, 2006, 2010; Steinitz, 2005). The starting point for landscape research, seen as an important part of contemporary spatial development activities, is recognition of the landscape evaluation processes. In line with changes in the contemporary spatial planning paradigm towards integration of spatial planning and environmental policies (Van den Broeck, 2004), understanding and interpreting landscape is becoming a medium for integration of dynamic spatial change.

This standpoint has stimulated efforts towards the development of modalities for the assessment of landscape character as an important tool for a spatial analysis. Landscape character assessment is, therefore, to purposefully identify and assess social, cultural, economic and environmental interactions and relationships in order to determine a value in a particular context. As a result, landscape assessment activities are shifting from the identification of "extraordinary landscapes" towards all landscapes which in general represent the context-responsive environment. As such it is no longer purely the subject of research, but also an important operational and strategic instrument for spatial planning (Vasiljević, 2018).

The strategic planning approach offers a good basis for applying landscape thinking to regional planning, due to its distinct processes: a dynamic and sustainable long-term perspective, process-supporting actions, a decision-making process involving all possible actors, and a process of empowering people to improve their living conditions and participate in society (Semančíková, 2007). Research has shown that strategic spatial planning, as a framework for land-use distribution has the capacity to integrate diverse sectoral objectives and bring them closer to one another (Antrop, 2000; Roe, 2008; Pihler et al., 2013; Selman, 2006).

Our argument is that landscape characterization has a potentially important role to play in operationalizing strategic spatial development, but that current approaches to spatial planning practice are not utilizing this potential. The challenge for spatial planning practice is how to determine a set of landscape objectives in relation to different sectoral interests (infrastructure, forestry, agriculture, energy, etc.). That affect the distribution of different land-use and combinations of landscape elements, which make a particular contribution to distinctive landscape character. Since the landscape approach to spatial planning involves the identification and understanding of complex relations between spatial systems, the integration of landscape assessment into planning documents can be seen as an essential framework for spatial management. We came to this conclusion primarily as spatial planners, recognizing the importance of situating constituting spatial elements in their own landscape and realizing that this dimension was often inadequately, or not at all, reflected in current spatial planning approach in Serbia. Therefore, the new challenges and new opportunities for Serbian planners is to place landscape formulations at the cross-point of spatial planning, community management and activities related to enhancement of environmental quality (Pihler et al., 2017).

Ratification of the ELC in 2011 created a more favorable context for Serbian planners to apply the holistic approach of landscape conceptualization which has been implemented in The Spatial Plan of the Republic of Serbia for the period from 2010 to 2020. Legislative measures for the implementation of The Spatial Plan of the Republic of Serbia for the period from 2010 to 2020, foresee the development of landscape character assessment at the regional and local spatial planning levels. There is also a growing trend towards area-specific regional development planning practice which is reflected through the elaboration of a number of Spatial Plans for special-purpose area. This type of planning documents accommodates new ideas on spatiality which is an improvement compared to traditional, sectoral planning documents.

The general objectives of this research is to present the conceptual framework for the interpretation of the Cultural landscape of Sremski Karlovci and the way landscape character assessment has been implemented in the Spatial plan for this special-purpose area It is the first Spatial planning document in Serbia to take landscape characterization approach with the aim to emphasize the value of landscape character as the basis for: a) defining boundary of cultural landscape; b) defining 'representative landscape units', as a special purpose areas; c) setting the planning objectives according to 'landscape quality objectives'. Finally, we believe that contribution of this paper is to point out to the ground for transformation of spatial planning practice in Serbia which is aiming to realize the full potential of landscape characterization.

Materials and Methods

Study area

Sremski Karlovci is an important historical town on the right bank of the Danube between Novi Sad and Belgrade (Figure 1). The town developed into an important cultural and economic hub after 1699 and the signing of The Treaty of Karlowitz. For two centuries it was the main engine of Serbian cultural and religious life. The town developed between the Danube river and the slopes of the Fruska gora mountains (which today hold the status of a national park), constantly balancing between several natural restrictions such as frequent flooding and landslides.

tackled by the regional government and most recently the town was strategically designated as part of the area that represents European Capital of Culture in 2021 (together with the city of Novi Sad and two more municipalities).

The area considered by the planning document covered 64,16 km² containing the diverse landscapes of the forested slopes of the Fruska gora massif and one of the widest alluvial plains of the middle Danube (Special Nature Reserve Koviljsko-petrovaradinski rit). The contact zone between these two dominant spatial entities has determined the specific

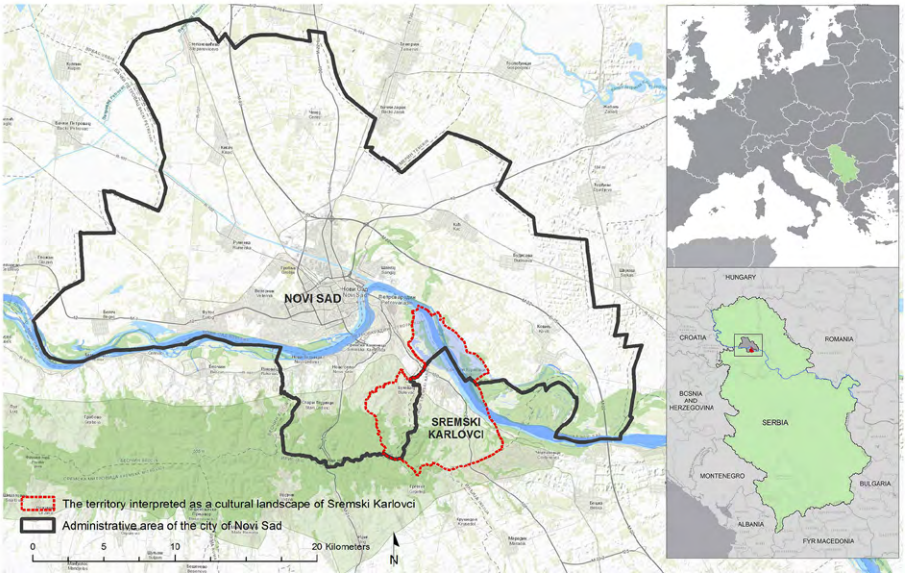

Figure 1. The position of Sremski Karlovci in the regional context. Basemap source: ESRI World Topographic Map
[click on figure to enlarge]

Besides multi-layered cultural and natural values, the importance of the area rests on the unique insight into the historical processes of migration and settlement within the Habsburg Empire and the aspirations for disparate groups towards political and religious autonomy.

In the previous century geopolitical changes led the town to decay, causing imbalances in the landscape quality and the overall quality of life. The lack of adequate development strategies and gaps in the national and local legislation further exacerbated this deterioration. Demographic change and the formation of urban sprawl of the city of Novi Sad throughout last decades triggered transformations of the landscape character of Sremski Karlovci and its hinterland. Although the town and its community showed significant resilience sustaining itself through local initiatives, the fear of accelerated deterioration has been

form of the landscape characterized by the compact morphology of the historical settlements of Sremski Karlovci and Bukovac and the particularities of their agricultural surroundings. The settlement structure is characterized by a rural matrix, traditionally dependent on the agrarian hinterland and adaptation to the morphology of the erosive relief of the highly fertile slopes of the Fruska gora (Spatial Plan for the Special Purpose Area "The Cultural Landscape of Sremski Karlovci", 2017).

Methods

The methodological approach for the development of the spatial planning solutions was based on the decision to incorporate landscape considerations in the spatial planning process by conducting landscape character assessment (LCA) for the selected area according to the techniques and criteria provided by the

general methodology of landscape characterization (Swanwick, 2020).

The objective of LCA application was to move from the descriptive types of spatial analysis towards more action-oriented analysis (Antrop, 2006b). This approach involved a site-selection analysis which viewed a landscape unit as a potential site for a specific development and protection measures. The question addressed here was "How do we classify homogeneous areas or delineate landscape in order to find the best possible sites with the best potential to represent landscape characteristics of the area designated as a cultural landscape". The "nested hierarchical approach" was taken for the area classification. The classification into homogeneous areas took place on two or more levels. The diversification of the landscape composition at the regional scale was defined in relation to the value of the homogeneity of the landscape structure (represents the nonspatial aspect of a landscape- number and abundance of landscape elements). The diversification of the landscape configuration, at the local scale, was defined in relation spatial arrangement and context of the specific and unique landscape elements. Landscape character means distinctiveness of the landscape pattern which was simultaneously formed by: "contrasting" geomorphologic features, configuration of relief and hydrographic features, spatial arrangement of vegetation and land use, spatial arrangement of the cadastral parcels, settlement structure, road links, rail infrastructure and rural byways, visual arrangement of landscape features and administrative units.

The indicated elements were combined to define the landscape character types (that feature on regional scale) and landscape units (on the local scale). A landscape unit is understood here as a combination of elements that generates, on the local scale, a particular, visible physiognomy, a distinguishable and differentiable morphological and functional arrangement which makes one part of the territory different from another. This understanding of a landscape unit implies that an individual physiognomy — a specific arrangement and combination of the parts defining the appearance of a territory and granting it its special character— may be seen as an "illustration" of the territory. Landscape character types were identified at the scale 1:25,000, while landscape units identification and profiling were treated at the scale 1:10,000.

The procedure involved both the office and field work. The draft for the delineation was prepared at the office based on GIS juxtaposed digital cadastral maps and topographic maps on a scale of 1:25,000 and 1:10,000 with generated clear terrain contours. To enhance the classification into homogeneous areas, the analysis also included same-scale 18 and 19 century historical Austro-Hungarian military maps (Mapire, 2014), soil maps and geomorphologic maps. The boundaries of each landscape area were checked and modified through the field work and the draft classification of landscape types and units was validated. Following the field work, single GIS geo-data-base containing multiple features on landscape types and units was merged and applied to generate maps presenting multiple landscape unites combined into 3 landscape types, each with its own distinctive character. The final product of the analysis was a selection and description of landscape units that figured as the "illustration" of the territory and its major landscape types. Maintaining their stability was the main task for the spatial planning directives (land use change, development guidelines and measures for protection, construction regulation and development priorities) and guidelines for proper realization (implementation) and coordination by regional and local authorities.

Results

According to the performed methodology of landscape character assessment, the Spatial Plan for Special Purpose Area defined 3 landscape types at the regional scale, and 9 (nine) landscape representative units at the local scale, which are meant to provide a synthetic, but sufficiently detailed view of the region's landscape configurations and they provide a good reflection of its cultural profile (Table 1: Figure 2). Each unit is the outcome of a group of landscape units which landscape features are repeated in the territory and together form one of 3 identified landscape types at the regional scale.

The Danube River with its inundation area includes a unique water-scape (ecosystem) that (together with

Table 1. Landscape types and representative landscape units

Landscape types	Representative landscape units
The landscape of the arable slopes of the Fruska gora with settlements	1. City center of Sremski Karlovci
	2. West approach from Tekija
	3. East approach from Banstol
	4. Ešikovac valley
	5. Panoramic trail
The forested slopes of the Fruska gora National park	6. Stražilovo
	7. Bukovac plateau
The Danube river with its inundation area	8. Karlovac riverbank
	9. Boggy trail

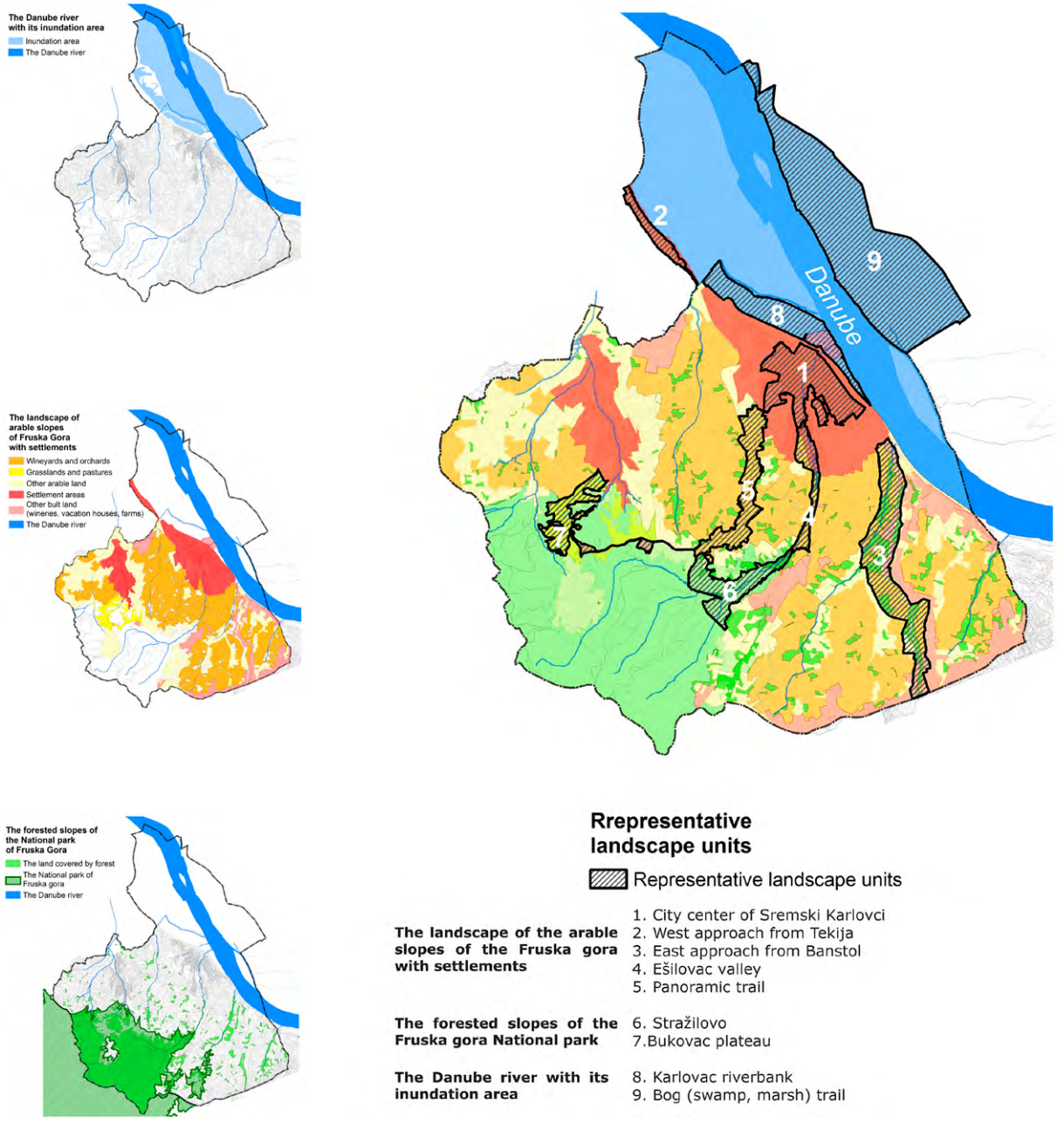

Figure 2. Landscape types and landscape units. Source: The map was created by authors from the GIS database used for the elaboration of the Spatial plan
[click on figures to enlarge]

the main river flow) form multiple branch channels, islands, ponds, swamp forests and shrubs (Figure 3). The magnitude of the Danube, its continuity and cohesion creates the dominant influence on the composition of the structure of this landscape type. In addition to these landscape elements, which are, in origin, close to the natural, integral part of this spatial system is a mosaic of spatial elements of anthropogenic origin: agrarian complexes and agroforestry areas, hydro-technical facilities for flood protection, transport infrastructure and fragments of urban greenery. The configuration of this type of landscape structure belongs to an organic form, primarily created by the changing dynamics of the river banks. This integral organic form is one of the main features of the composition of this type of landscape, and its sensitivity can be expressed through distortion of this configuration, which is the bearer of the diversity of the ecosystem. One of the essential characteristics of this area is the dynamic nature, and seasonal variability of water levels of the river with its periodic extremes.

The composition of the landscape of the arable slopes of Fruska gora with settlements is characterized by the settlements and their hinterlands - agricultural areas of the northern slopes of the mountain range (dominantly composed of vineyards, orchards,

Figure 3. Inundation area of the Danube river
Source: Vojvodina Environmental Movement, Sremski Karlovci

fields and fragments of agroforestry). The configuration of this landscape structure is the consequence of the morphology of the terrain formed by the erosion of soils developed from alluvial and proluvial relief, intensive leaching and dredging, descending ultimately to the banks of the Danube. The basic geometry of the terrain is formed of relatively short watercourses which descend vertically from the top to the foot of the hills, forming stream valleys. The first phases of settlement in Bukovac and Sremski Karlovci grew up along these streams (Figure 4). The contemporary structure of the settlements in this area is also characterized by large areas of low density sprawl, consisting of vacation houses developed on relatively small plots of previously agricultural land and not supplied with appropriate infrastructure. The urban sprawl has extended until it is almost continuous between the historical urban agglomerations. This urban expansion occurred over the last decades and was predominantly an informal process which today has become a significant factor in the composition of the region's character. This phenomenon is an indicator of the deteriorated condition and represents a significant deviation from the historical matrix of settlement and land use. The coherence of the elements involved in the composition of the landscape structure (valleys of the watercourses, agricultural area of vineyards and orchards, agroforestry areas, the historical centers of the settlements, urban sprawl), which are the major holders of the identity, represent entities that will have to be considered in the formulation of the cultural landscape. Formulation of the landscape quality objective and the degree of vulnerability of this type of landscape character can be seen through a series of parameters that should be the focus of spatial intervention:

- The configuration of the buildable land structure in terms of the relation between built-up and open space, population density, land use, urban development control, the character of the settlement fronts and the sustainable use of open, green spaces;
- The preservation of agricultural land use for vineyards and orchards;
- The continuity of local ecological corridors as the holders of habitats along watercourses and their capacity to expand and form continuous links between the forest habitats of the Fruska gora and aquatic habitats of the Danube;

Figure 4. The city Center of Sremski Karlovci (landscape units)
Source: Vojvodina Environmental Movement, Sremski Karlovci

- The control of the urban sprawl expansion and greater control of densification.

The forests of the Fruska gora are deciduous and dominate the composition of the landscape stretching along the mountainous massif. The homogeneous and compact structure of the forest in the east turns into a mosaic structure of alternating complexes of agricultural land, agroforestry areas, arable land, orchards and vineyards that were created on former forest land. The configuration of this type of landscape is formed by a relief of moderate leaching. The geometry of the landscape is formed by multiple stream lines with a relatively slow flow. The stability of this type of landscape is indicated by the surface forest cover, its density, the total area of the nature protection zones and the length of the forest edge. Forest areas, as the major holder of this type of the landscape, indicate a potential source of instability: forest vegetation and habitats may not represent the potential natural vegetation, and therefore have an impact on the authentic landscape value.

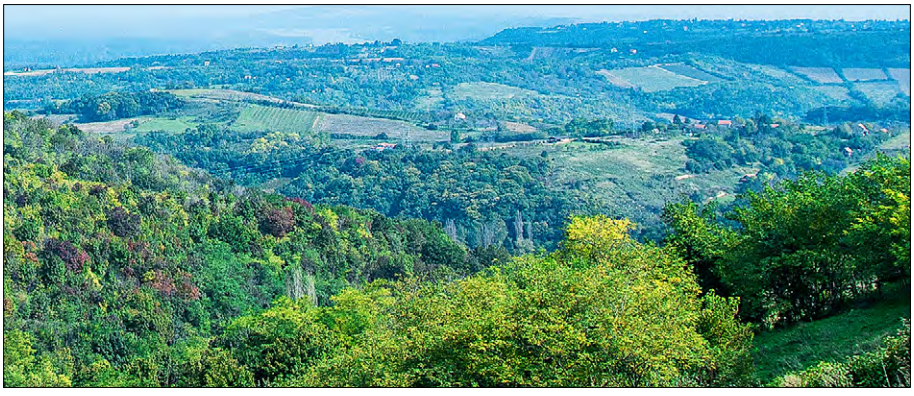

Figure 5. The forested slopes of the Fruska gora National park (landscape type)
Source: Vojvodina Environmental Movement, Sremski Karlovci

The purposeful methodology of landscape characterization enabled profiling of certain characteristics as strategically relevant for spatial planning interventions. Landscape character assessment is provided "quality problem identification" which led to the definition of 'the landscape quality objectives'. That generated two crucial elements for the spatial planning document:

- Firstly, the spatial scope of the planning document defined the institutionalized border of the Cultural Landscape of Sremski Karlovci. It appeared to be different from the initial (hypothetical) spatial frame defined by the regional planning board on the initiation stage. The territory is seen as an interaction of spatial elements that appear in a broader spatial context, the meaning of which is defined through the integration of spatial entities formed by the dominant landscape character of the Fruska Gora, the river Danube and the specific characteristics of the "Vojvodina-Pannonian-Danube macro-region".
- Secondly, 'representative landscape units' were identified and declared as 'special purpose area' with the aim to represents 'landscape quality objectives'. Furthermore, the planning document managed to synchronize landscape objectives with the guidelines and measures of different sectoral agendas such as local environmental protection plans, tourism development strategies, agriculture, forestry, water management and heritage protection.

As the result of the described methodology, we could conclude that landscape formulations, representative landscape unit and landscape type identification and mapping, are placed at the cross-point of spatial planning objectives – land use change, development guidelines and measures for protection, construction regulation and development priorities. Next to the technical specification for each landscape unit, as a strategic tools, the planning document provided systematic development guidelines and protection measures, related to the multiple components that form the main landscape character value such as: land use (existing structures, possible alterations, compatible use), building parameters, vegetation, heritage features, morphological aspects of agricultural parcels (size, accessibility), urban parameters (density, heights, regulations, accessibility to hinterland) roads and rural byways, dynamics of change and other relevant spatial arrangement data. Guidelines are designed to serve the local authorities in the spatial development planning processes and frameworks (urban planning, forestry planning, environmental and nature protection, etc.).

Discussion

The landscape characterization provided identification of landscape types and representative landscape units on different scale levels and gave sufficiently detailed assessment of the territory as a whole. It determined what were important features of the landscape and why. The quality objectives in order to be meaningful were linked to particular problems of landscape quality. Scientific literature frequently mentions the ability of spatial planning to place landscape quality objectives in the context of social, cultural, economic and environmental problems (Ahern, 2011; Selman, 2010; Vasiljević, 2018). The methodology of landscape character assessment, implemented through the elaboration of the Spatial Plan for the Special Purpose Area of the Cultural Landscape of Sremski Karlovci, enabled the merging of landscape objectives with the guidelines and measures of different sectoral agendas such as environmental protection plans, tourism development strategies, agriculture, forestry, energy, natural and cultural heritage protection. This provided the basis for defining land use assessments, building parameters and sectoral development plans.

In line with the presented approach, the concept of spatial development of this area will focus on: the preservation of functionality, diversity and the visual experience of the landscape form, better articulation of land use to safeguard the area against uncontrolled constructions, infrastructure improvements, arrangement of historical settlement cores, continuous functional connections between the forests of the Fruska gora and the Danube, development of recreational areas and educational pavilions integrated with the protection of natural and cultural resources and the Fruska gora National park.

Landscape character approach enabled the changing of the border, in which, the cultural landscape of Sremski Karlovci has been seen as a multifunctional spatial entity, and its formation is considered as a public interest in the field of culture, ecology and the environment, as well as at the social level. Accordingly, the landscape character as a major part of the cultural identity is seen as a public domain, and its improvement is in the interest of all participants in the planning process. The design concepts and visions proposed by the planning document look for spatial interventions which do not consume the potential of the territory but rather irrigate the territory with potential as Kollhaas (1995) and Corner (2006) disused within researches regarding future of sustainable urban planning. Extracted landscape units were taken on the basis of strategic choices, as surfaces that have the capacity to be examples which emphasize operational logic over direct compositional design.

By touching on policy domains, over the course of this research, the discussion will also serve to underline the effort put into establishing changing arrangements between institutional frameworks in different sectors: cultural and natural heritage management, water and infrastructure management, spatial planning and environmental protection. According to Giddens (1984:227), "institutional change is mostly a process of gradually altering interactions that is resulting in new policy practices with the aim to promote and institutionalize new policy concepts that will lead to the re-articulation of policy arrangements".

Conclusion

This research gives an overview of contemporary landscape conceptualization that has been read and interpreted in a holistic manner as a multifunctional and multidimensional entity the character of which should be protected and enhanced according to local and regional values, while challenging current development trends. Landscape unit and landscape type identification and mapping were the basis for spatial development guidelines based on qualitative indicators, value and quality objectives for future development.

The development of the Spatial planning document is interpreted in this paper in relation to the Serbian spatial planning systems` ability to recognize landscape character assessment as an important activity and a valid approach in guiding spatial development. Through the analysis of the results of the landscape conceptualization approach, it has been confirmed that spatial change can be directed through considerations of landscape dynamics where landscape character represents the major medium for intervention.

Therefore, strategic application of landscape character assessment in the existing spatial planning documents in Serbia can be recommended for the proper application of the European Landscape Convention. It represents a tool for testing the structuring capacity of the landscape features as a new infrastructure for urbanization. Landscape-based concepts propose spatial development which negotiates the contrasting realities of the urban/suburban/rural structures. Such

an approach towards landscape interventions in a territory intertwined with water, forest and agriculture should result in a sustainable spatial structure that is capable of accepting and rationalizing new development trends and new production systems.

The challenge for further analysis would be to replicate and test the presented approach in a different context within the Serbian spatial planning policy framework and examining the approach in other countries with similar spatial planning system.

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Surface Water Pollution with Nutrient Components, Trace Metals and Metalloidsin Agricultural and Mining-affected River Catchments (A Case Study for Three Tributaries of the Maritsa River, Southern Bulgaria)

Kalina Radeva[A*], **Kalin Seymenov**[A]

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Abstract

This work analyses changes in the content of nutrient components and trace metals and metalloids at three tributaries of the Maritsa River flowing in Southern Bulgaria with catchments affected by mining and agricultural activities. Input data includes information about 14 chemical water quality parameters (N-NH_4, N-NO_3, N-NO_2, N-tot, P-tot, P-PO_4, Al, As, Fe, Cu, Mn, Ni, Pb, and Zn) obtained from the Executive Environment Agency for the period 2015–2018. Two documented methods were used in this work to determine the pollution status of river waters – Heavy metal pollution index (HPI) and CCME Water Quality Index. The results based on the CCME WQI ranked water quality as "Poor" (WQI values range from 31.2 to 39.9). The HPI ratings achieve scores exceeding the critical pollution value of 100 for some of the metals (Al, Cu, Mn, and Zn), which indicates that water is seriously polluted concerning those variables. Therefore, it can be summarized that the river waters are not appropriate for safe drinking, agriculture, and household use because of significant nutrient and metalloids and trace metalscontamination.

Keywords: water pollution; water quality index; nutrient components; trace metals and metalloids; Bulgaria

Introduction

The surface waterbodies are among the most sensitive sources that areprone to impacts from human activities which may cause degradation of the resource in the future (Roshan et al., 2013; Afkhami et al., 2013). Among the variety of human practices causing deterioration in water quality worldwide, two seem to be particularly troubling – agriculture and mining activities (Novotny, 1999; Reza & Singh al., 2010). The excessive use of chemical agents in agriculture aims to achieve an accelerated yield of crops or to protect the same crops from pests, but it is a major source of diffuse water pollution, which underpins a lot of hydro-ecological issues (Novotny, 1999; Hutchins, 2012; Okumah et al., 2019). The increased levels of nutrients like nitrates and phosphates provoke structural changes in aquatic ecosystems and lead to eutrophication (Khan & Ansari, 2005; OECD, 2012). No less harmful are the effects caused by mining activities.

[A] Sofia University "St. KlimentOhridski", Faculty of Geology and Geography, Department of Climatology, Hydrology and Geomorphology; kradeva@gea.uni-sofia.bg, kalin.seimenov@abv.bg
[*] Corresponding author: KalinaRadeva; e-mail: kradeva@gea.uni-sofia.bg

The extraction of valuable minerals like ore and coal is often accompanied by unregulated discharges of waste products containing metalloids and heavy metals that are a serious source of water pollution. This problem concerns mining and metallurgical waste dumps, as well as mine tailing dumps (Reza & Singh, 2010). The elevated concentration of trace metalsand metalloids in water bodies is treated as one of the most dangerous and burdensome environmental issues (Kar et al., 2008; Shanbehzadeh et al., 2014; Islam et al., 2015). The health effects of metalloids and trace metalscontamination do not cause immediate symptoms, but manifest themselves after years and still are not fully understood(Lee et al., 2007; Adams et al., 2008; Vinodhini & Narayanan, 2008). The combined effect of nutrient and heavy metaland metalloid pollution results in a decline of ecosystem health and loss of biodiversity (Bourg et al., 1996). In the context of those problems, one of the objectives of the European Union Water Framework Directive (WFD) is to ensure good water quality status in all water bodies (Fritsch et al., 2017).The report of EEA (2018), regarding chemical pollution, concluded that Europe is not on track to minimize the significant adverse effects of chemicals on the environment by 2020. It noted that 62% of the Europe's water bodies are not in good chemical status and the risks from chemical pollution on the environment are "likely to be greatly underestimated" (EEA, 2018). Therefore, regular monitoring of pollutants is necessary in order to assess and limit the potential health risks for humans and aquatic ecosystems from water contamination.

A substantial amount of studies have focused on trace metaland metalloid contamination and nutrient pollution of surface waters all around the world (Nasrabadiet al., 2009; Petrović et al., 2011; Ramos et al., 2012; Dunca, 2018; Chen et al., 2019). Several Bulgarian reports refer to the heavy metal distribution and ecological status of the rivers in the investigated region (Rabadjieva et al., 2009; Velcheva et al., 2012; Georgieva et al., 2014; Varbanov et al., 2015). Most studies performed on the quality of surface waters present the results using differentwater quality indices among them the Heavy metal pollution index (HPI) (Prasad and Kumari, 2008; Reza & Singh,2010; Manoj et al., 2012) and the Canadian Water Quality Index (CCME WQI) (Lumb et al., 2012; Espejo et al., 2012; Mohebbi et al., 2013; Jafarabadi et al., 2016; Venkatramanan et al., 2016). Those indices can provide information in a form that water resources managers and water regulatory agencies can use to evaluate future alternatives and to make effective management decisions (Sutadian et al., 2016).

Both organic pollution and trace metal and metalloids contamination remain unsolved problems facing the water resources management sector in Bulgaria. Thus, the objective of the current work is to analyse the simultaneous impact of two anthropogenic practices influencing the chemical composition and quality status of river waters in mining-affected catchments with agricultural land use through the application of CCME Water Quality Index and Heavy Metal Pollution Index (HPI).

Study area

The investigated region includes the drainage basins of three tributaries of the Maritsa River situated in Southern Bulgaria – the Topolnitsa River, the Luda Yana River, and the Chepelarska River (Figure 1).The Maritsa River is one of the biggest rivers on the Balkan Peninsula. The region is densely populated and highly industrialized with intensive agriculture. The selected rivers have become one of the most seriously polluted streams in Bulgaria over the past few decades due to discharges from agricultural lands, livestock farms, mining and metallurgical industries bearing nutrients and heavy metals into the river systems.

The Topolnitsa River is a left tributary of the Maritsa River with a total length of 154 km. Its catchment covers an area of 1789 km^2 (Hristova, 2012). The main river body springs from the northeastern slopes of the Bunaya Peak in the Sredna Gora Mountain at an altitude of 1413 m, drains the westernmost part of the Upper Thracian Plain and flows into the Maritsa River about 2 km west of Pazardzhik (Figure 1A). The mean annual flow is 10 m3/s with maximum discharge values in April and minimum flow volume in August (Hristova, 2012). In the catchment area are located 45 settlements, including the towns of Koprivshtitsa, Zlatitsa, Pirdop, and Ihtiman.

The Luda Yana River, a left tributary of the Maritsa River, flows in length of 74 km and has a drainage area of 685 km2 (Hristova, 2012). The Luda Yana River originates from the western slopes of the Bich Peak in the Sredna Gora Mountain at an altitude of 1449 m. Later it runs through the Upper Thracian Plain and flows into the Maritsa River approximately 8 km east of Pazardzhik (Figure 1B). The mean annual flow is around 4 m^3/s with maximum flow volumes in March and April and minimum discharge value in August and September (Hristova, 2012). In the river basin are situated 12 settlements, including the towns of Panagyurishte and Strelcha.

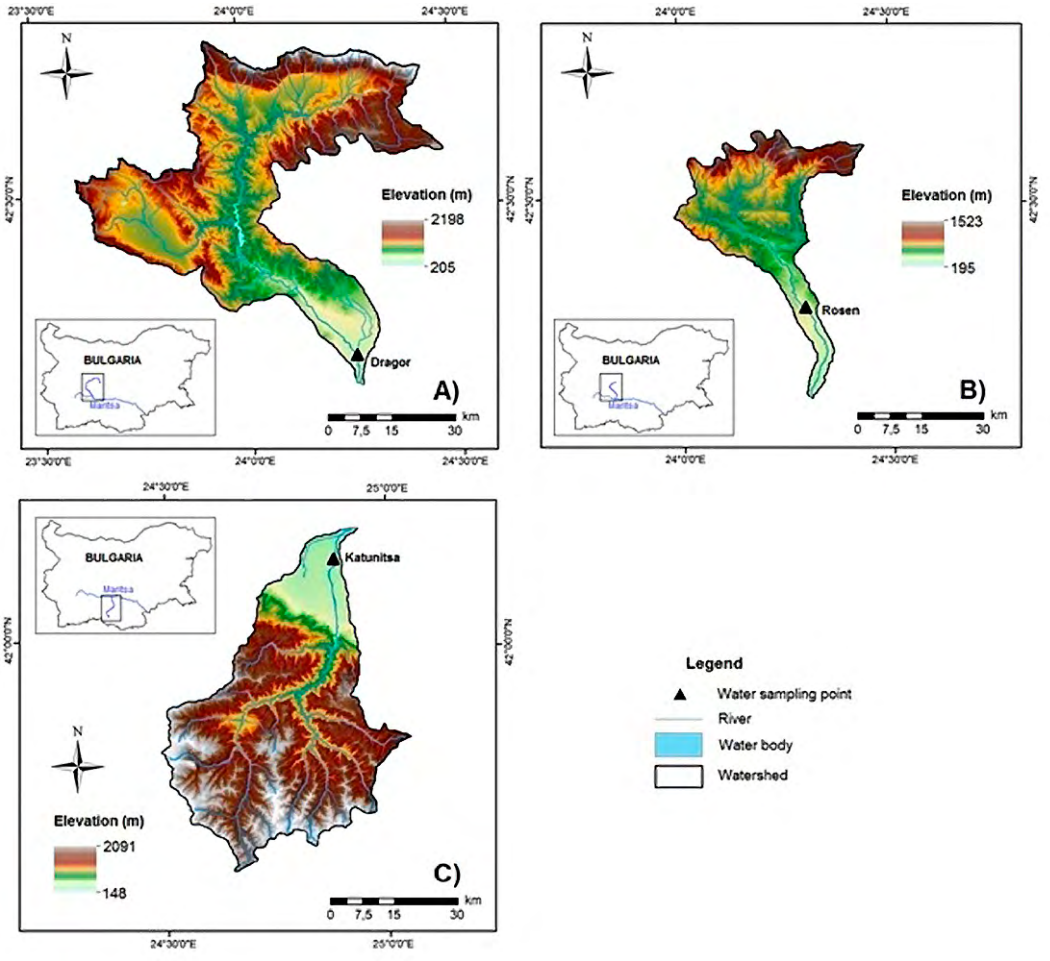

Figure 1. Maps of the relief and the drainage network showing the location of water sampling points: A) Topolnitsa River basin; B) Luda Yana River basin; C) Chepelarska River basin

The Chepelarska River is a right tributary of the Maritsa River with a length of 86 km. Its drainage basin covers an area of 1010 km² (Hristova, 2012). The main river springs from the western slopes of the Rozhen Peak in the Western Rhodope Mountains at an altitude of 1550 m. Upper part flows in a deep and narrow gorge valley, while downstream section runs through a shallow and wide valley in the Upper Thracian Plain. The Chepelarska River flows into the Maritsa River about 10 km east of Plovdiv (Figure 1C). The mean annual flow reaches 12 m³/s. The runoff regime is characterized by a high flow phase in April and May and a low flow period in August and September (Hristova, 2012). The catchment area concentrates 22 settlements, including the towns of Chepelare, Laki, Asenovgrad, and Kuklen.

Data and Methods

Research information about the values of 14 chemical water quality parameters has been used. Time-series data include statistical information about the concentration of six nutrient compounds: ammonium nitrogen ($N\text{-}NH_4$), nitrate nitrogen ($N\text{-}NO_3$), nitrite nitrogen ($N\text{-}NO_2$), total nitrogen (N-tot), orthophosphates ($P\text{-}PO_4$), total phosphorus (P-tot), and eight metalloid and heavy metal parameters: aluminum (Al), arsenic (As), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb), and zinc (Zn). Between 14 and 16 samples for each variable have been in-situ collected and then processed in an ISO/IEC 17025:2006 Accredited Laboratory following a standardized procedure. The basic measurements were conducted by the Executive Environment Agency at three water sampling sites during the period 2015–2018. The measuring points have been selected so that they are located in downstream river sections in order to present a full picture of surface water pollution within the examined catchment areas (Figure 1, Table 1).

Water quality status in terms of nutrients has been assessed according to the reference values for surface

Table 1. Information about the location of water sampling points

River – Water sampling point	Elevation (m)	Latitude (°)	Longitude (°)
Topolnitsa – Dragor	218	42.2308	24.2918
Luda Yana – Rosen	260	42.3132	24.3624
Chepelarska – Katunitsa	162	42.1033	24.8665

Table 2. Reference threshold values for the concentration of nitrogen and phosphorus compounds in surface water bodies of type R5 as stated in Regulation 4/2012

Surface water body type		Water quality status	Nitrogen and phosphorus concentration (mg/l)					
Code	Description		$N\text{-}NH_4$	$N\text{-}NO_3$	$N\text{-}NO_2$	N-tot	$P\text{-}PO_4$	P-tot
R5	Semi-mountain streams in Ecoregion 7 (Eastern Balkans) dominated by a gravel substrate	Excellent	<0.04	<0.5	<0.01	<0.5	<0.02	<0.025
		Good	0.04– 0.4	0.5– 1.5	0.01– 0.03	0.5– 1.5	0.02– 0.04	0.025– 0.075
		Moderate	>0.4	>1.5	>0.03	>1.5	>0.04	>0.075

water body of type R5 stated in the National regulatory standard – Regulation 4 of 14 September2012 for characterization of the surface waters (Table 2).

The Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) for an overall assessment of nutrient water pollutionhas been applied. This index is calculated as follows:

$$\text{CCME WQI} = 100 - \sqrt{\frac{F_1^2 + F_2^2 + F_3^2}{1.732}},$$

where: F_1 – Scope (the percentage of variables whose objectives are not met); F_2 – Frequency (the percentage of samples whose objectives are not met); F_3 – Amplitude (the total amount by which the objectives are not met). The first two components are expressed as a ratio between the number of "failed variables" and "failed tests" to the total number of variables and samples, respectively. The calculation of the third factor requires some additional steps (CCME, 2001).

Water quality parameters are calibrated with a certain limit and thenthe amount of deviation is determined. Inthis work the calculations have been conducted according to the maximum permissible limits for "Good status", stated in Regulation 4/2012 (Table 2).

Denominator 1.732 is chosen to express the result of CCMEWQI as a number between 0 (worst status) to 100 (best status). Table 3 shows a ranking system based on the CCME WQI values.

The CCME WQI is an advantageous approach because its formula allows it to be applied at different scales and locations. In addition, the obtained index ratings can be easily interpreted by using a clearly defined ranking system based on the concept for "desirable levels" (Table 3).

Water quality status with respect to arsenic and trace metals has been assessed following the European guidelines stated in Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on Environmental quality standards for priority substances and some other pollutants (amended in Directive 2013/39/EC), and their equivalent criteria in Bulgaria transposed into Regulation 4/2012 (Table 4). Generally, the Environmental quality standard (EQS) indicates an average annual reference value. Unless otherwise specified, it applies to the total concentration of a given chemical parameter (Directive 2013/39/EC).

Table 3. Ranking system and interpretation of water quality based on CCME WQI (CCME, 2001)

Rating	WQI values	Interpretation
Excellent	95–100	Water quality is protected with a virtual absence of threat or impairment; conditions very closer to natural or pristine levels
Good	80–94	Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels
Fair	65–79	Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels
Marginal	45–64	Water quality is frequently threatened or impaired; conditions usually depart from natural or desirable levels
Poor	0–44	Water quality is almost always threatened or impaired; conditions very often depart from natural or desirable levels

Table 4. Environmental quality standard for priority substances and some other pollutants

Guidelines of Reg. 4/2012and Directive 2013/39/EC	Metalloid and trace metal concentration (µg/l)							
	Al	As	Cu	Fe	Mn	Ni	Pb	Zn
Environmental quality standards (EQS)	15	10	10*	100	50	34**	14**	75*

**The reference level has been defined in accordance with the value of calcium carbonate hardness (CaCO3)*
***Maximum contaminant level pointed out in Directive 2013/39/EC*

In order to evaluate the overall status of waters in terms of arsenic and trace metals, the Heavy metal pollution index (HPI) has been applied. The HPI is a rating method that shows the composite influence of individual metalloid and trace metal parameters on the overall water quality (Mohan et al., 1996). The following formula is usually used to calculate this index:

$$HPI = \frac{\sum_{i=1}^{n} W_i \cdot Q_i}{\sum_{i=1}^{n} W_i},$$

where: n is the number of parameters considered, W_i is the unitweightage of the i-th parameter, and Q_i is the sub-index of the i-th parameter. Q_i is expressed by the equation:

$$QI = \sum_{i=1}^{n} \frac{M_i(-)I_i}{S_i - I_i} \cdot 100,$$

where: M_i, I_i, and S_i are the monitored average value, the ideal value (I_i = 0 for each heavy metal), and the standard value of the i-th parameter, respectively. In this formula, the unit weightage (W_i) is computed as a value inversely proportional to the recommended standard (S_i) of individual parameters (Table 4).The obtained ratings of HPI can be classified into three categories: low (less than 100), medium (equal to 100), and high pollution (more than 100). If the HPI rating is more than the critical pollution index value of 100, water cannot be used for drinking and domestic use (Mohan et al., 1996).

Results

Increased levels of nitrogen and phosphorus compounds compared to the reference norms at all measuring sites during the period under review are observed (Figure 2, Table 5). Despite some exceptions, in general terms, nitrate and phosphorus content in surface waters is marked by seasonality – the highest measured values occur in summer and autumn, while the lowest concentrations are detected in winter and spring months. Although runoff data are not used, we can point out that those seasonal changes are inversely related to flow regime.

Excepting the described similarities, based on the analysis of collected samples, some differences from one monitoring point to another are established. For example, with respect to ammonium nitrogen, the most serious exceeding is detected at the Topolnitsa River near Dragor, where the measured maximum concentration is 9.00 times higher than the maximum permissible limit for "Good status" stated in Regulation 4/2012 for characterization of the surface waters and about 56.2% of the recorded samples do not meet the same reference norm. In contrast, the highest observed value of this variable at the Luda Yana River

Table 5. Descriptive statistics of the nitrogen and phosphorus concentration (mg/l) in surface waters

River – water sampling point	Values	Nitrogen and phosphorus concentration (mg/l)					
		$N\text{-}NH_4$	$N\text{-}NO_3$	$N\text{-}NO_2$	N-tot	$P\text{-}PO_4$	P-tot
Topolnitsa – Dragor	Minimum	0.033	0.250	0.005	0.600	0.006	0.067
	Average	0.827	0.645	0.018	2.193	0.064	0.229
	Maximum	3.600	1.400	0.069	5.200	0.257	0.466
Luda Yana – Rosen	Minimum	0.010	0.190	0.004	0.500	0.020	0.061
	Average	0.095	0.933	0.023	1.348	0.087	0.195
	Maximum	0.450	1.800	0.084	2.550	0.210	0.340
Chepelarska – Katunitsa	Minimum	0.120	0.280	0.007	0.770	0.012	0.044
	Average	0.368	2.126	0.048	2.875	0.067	0.117
	Maximum	1.040	4.770	0.201	5.300	0.310	0.320

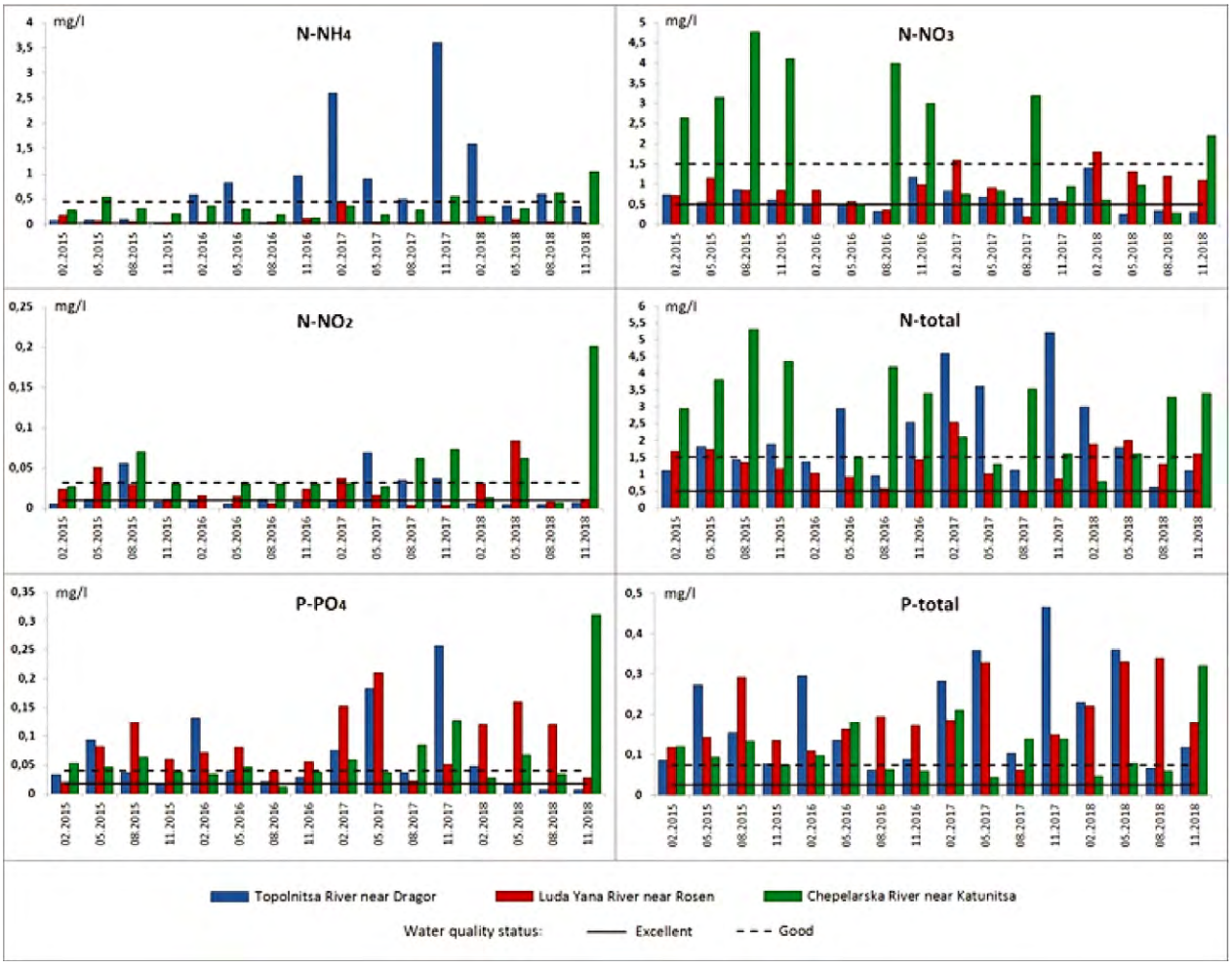

Figure 2. Dynamics in the concentration of nitrogen and phosphorus compounds compared to the maximum permissible limits pointed out in Regulation 4/2012 for characterization of the surface waters

near Rosen slightly exceeds 1.12 times the norm, and it is the only sample not falling within the recommended standard.As regards nitrate nitrogen, most affected appears the Chepelarska River near Katunitsa, where the highest monitored concentration exceeds 3.18 times the maximum permissible limit for "Good status" and about 53.3% of the collected samples remain above the norm. At the same time, values exceeding the critical pollution level of this chemical parameter for the Topolnitsa River near Dragorare not ascertained. Unlike nitrogen compounds whose concentrations show some contrasts from one sampling site to another, analysing the content of total phosphorus and orthophosphates we find that those variables almost constantly exceed the reference norms at all water measuring points. An illustrative example is total phosphorus whose samples with thefollowing frequency do not meet the norm: 81.2%(the Topolnitsa River at Dragor), 93.7% (theLuda Yana River at Rosen), and 62.5% (the Chepelarska River at Katunitsa) (Figure 2, Table 5).

The results based on CCME WQI rank water quality as "Poor" (WQI values range from 31.20 for the Chepelarska River near Katunitsato 39.91 for the Topolnitsa River near Dragor) (Table 6). The obtained index ratings indicate water quality of the selected rivers is frequently endangered and conditions very often deviate from natural or desirable levels. Water appears critically polluted with nutrient compounds and it is unsuitable for drinking and domestic uses.

Similar assessments were reported from Varbanov et al. (2015). Exploring the human impact on water quality and calculating the CCME WQI ratings of the rivers Topolnitsa and Luda Yana for the period 1981–2010, the authors concluded that water quality is seriously impaired and index values fall in range "Poor" to "Marginal" due to the effect of various anthropogenic pressures. The results from our work show that the water quality is not improving for 2015–2018, which ranks the examined rivers into "highest concern" category about their hydro-ecological status (EEA, 2018).

The analysis of the metalloids and trace metals content reveals that among eight analyzedvariables, five to seven of them at a given point do not meet the EQS (Table 7). In the waters of theTopolnitsa River at Dragor, the largest excess is marked by manga-

Table 6. Obtained ratings of the CCME WQI and basic statistics used in the calculations

River – water sampling site	Total variables	Failed variables	Scope (F_1)	Total tests	Failed tests	Frequency (F_2)	Amount (F_3)	CCME WQI
Topolnitsa – Dragor	6	5	**83.3**	96	43	**44.8**	**43.4**	**39.91**
Luda Yana – Rosen	6	6	**100.0**	96	39	**40.6**	**34.6**	**34.55**
Chepelarska – Katunitsa	6	6	**100.0**	93	48	**51.6**	**39.2**	**31.20**

Table 7. Descriptive statistics of the metalloid and trace metal concentration (µg/l) in surface waters

River – water sampling point	Values	Metalloids and trace metal concentration (µg/l)							
		Al	As	Fe	Cu	Mn	Ni	Pb	Zn
MohanTopolnitsa – Dragor	Minimum	24.0	*<0.5	15.0	1.8	41.0	*<0.5	*<0.4	8.6
	Average	187.1	*~2.1	74.4	56.3	405.4	*~5.2	*~0.6	62.8
	Maximum	386.0	4.1	233.0	462.2	2610.8	21.8	1.0	213.0
Luda Yana – Rosen	Minimum	52.0	*<0.5	30.0	9.9	42.0	*<0.5	*<0.4	3.6
	Average	368.6	*~4.6	79.0	76.7	254.2	*~4.7	*~0.5	28.0
	Maximum	1108.0	12.8	180.0	275.0	950.0	43.2	0.8	120.3
Chepelarska – Katunitsa	Minimum	4.5	*<0.5	20.0	1.8	56.0	*<0.5	*<0.4	32.0
	Average	20.8	*~3.9	31.5	5.2	1210.8	*~1.2	*~5.2	227.0
	Maximum	86.0	14.0	69.0	12.2	13240.0	16.6	55.0	1160.0

** The measured minimum levels of arsenic (As), nickel (Ni), and lead (Pb) remain under the detection limit. The obtained average values have been calculated accepting the detection limit as a measured minimum concentration, so those mean numbers should be perceived with some conditionality.*

nese and copper whose maximum concentrations remain 52.2 and 46.2 times above the EQS. The Luda Yana River at Rosenappears to be most contaminated with aluminum and copper – up to 73.8 and 27.5 times above the EQS. The contaminants of the Chepelarska River near Katunitsa include manganese and zinc – their maximum values remain 264.8 and 15.4 times higher than the EQS (Table 7). The measured concentrations of copper, lead, and zinc during 2015–2018 fall within or seem to be slightly lower than those recorded in 2004 and 2005 (Bird et al., 2010). The cited authors, exploring the dispersal of heavy metals in surface water, channel sediment, and floodplain sediment within the investigated area, concluded that those landscape components suffer from significant and widespread enrichment with metalloids and trace metals as a result of mining-related point sources of contamination. Our work confirms past results, shows a partly similar picture for a more contemporary period and assumes that mining activities continue to affect river systems.

The calculated values of the HPI vary from 179.97 (the Chepelarska River at Katunitsa) up to 626.54 (the Luda Yana River at Rosen), which indicates "High

Table 8. Obtained ratings of the HPI and basic statistics used in the calculations

River – water sampling site	Indices	Metalloids and trace metal parameters							
		Al	As	Fe	Cu	Mn	Ni	Pb	Zn
Topolnitsa – Dragor	Wi (1/Si)	0.07	0.10	0.01	0.10	0.02	0.03	0.07	0.01
	Qi (Mi /Si*100)	1247.52	20.63	74.43	563.25	810.89	15.34	4.76	83.73
	Wi .Qi	83.17	2.06	0.74	56.33	16.22	0.45	0.34	1.12
	HPI	**390.48**							
Luda Yana – Rosen	Wi(1/Si)	0.07	0.10	0.01	0.10	0.02	0.03	0.07	0.01
	Qi(Mi /Si*100)	2457.73	46.40	79.00	767.80	508.33	13.82	3.90	37.34
	Wi.Qi	163.85	4.64	0.79	76.78	10.17	0.41	0.28	0.49
	HPI	**626.54**							
Chepelarska – Katunitsa	Wi(1/Si)	0.07	0.10	0.01	0.10	0.02	0.03	0.07	0.01
	Qi (Mi /Si*100)	139.21	39.23	31.45	51.76	2421.67	3.64	37.38	302.70
	Wi.Qi	9.28	3.92	0.31	5.18	48.43	0.11	2.67	4.04
	HPI	**179.97**							

pollution" (Table 8). The results show that the metalloids and trace metals parameters exceeding the critical pollution index level of 100 are arranged as follows: aluminum, manganese, copper (Topolnitsa); aluminum, copper, manganese (Luda Yana); manganese, zinc, aluminum (Chepelarska). Those variables form the largest composite influence and most strongly affect the overall HPI rating, which means that the river waters are seriously contaminated with respect to listed metalloids and trace metals.

Discussion

An important factor, affecting water quality status in a catchment area is a land use/land cover structure. The predominant land cover class in the selected river catchments is "Forest and semi-natural areas", which occupies up to 78.03% of the drainage basins(Figure 3, Table 9). The forest vegetation improves water quality by minimizing erosion, reducing turbidity, maintaining naturally high levels of dissolved oxygen, and absorbing the chemical pollutants (Muscutt et al., 1993). In general terms, the upper river courses are located in mountainous regions with protected natural forest landscapes and relatively low population density.

However, in this part there are serious sources of heavy metals and metalloidenvironmental pollu-

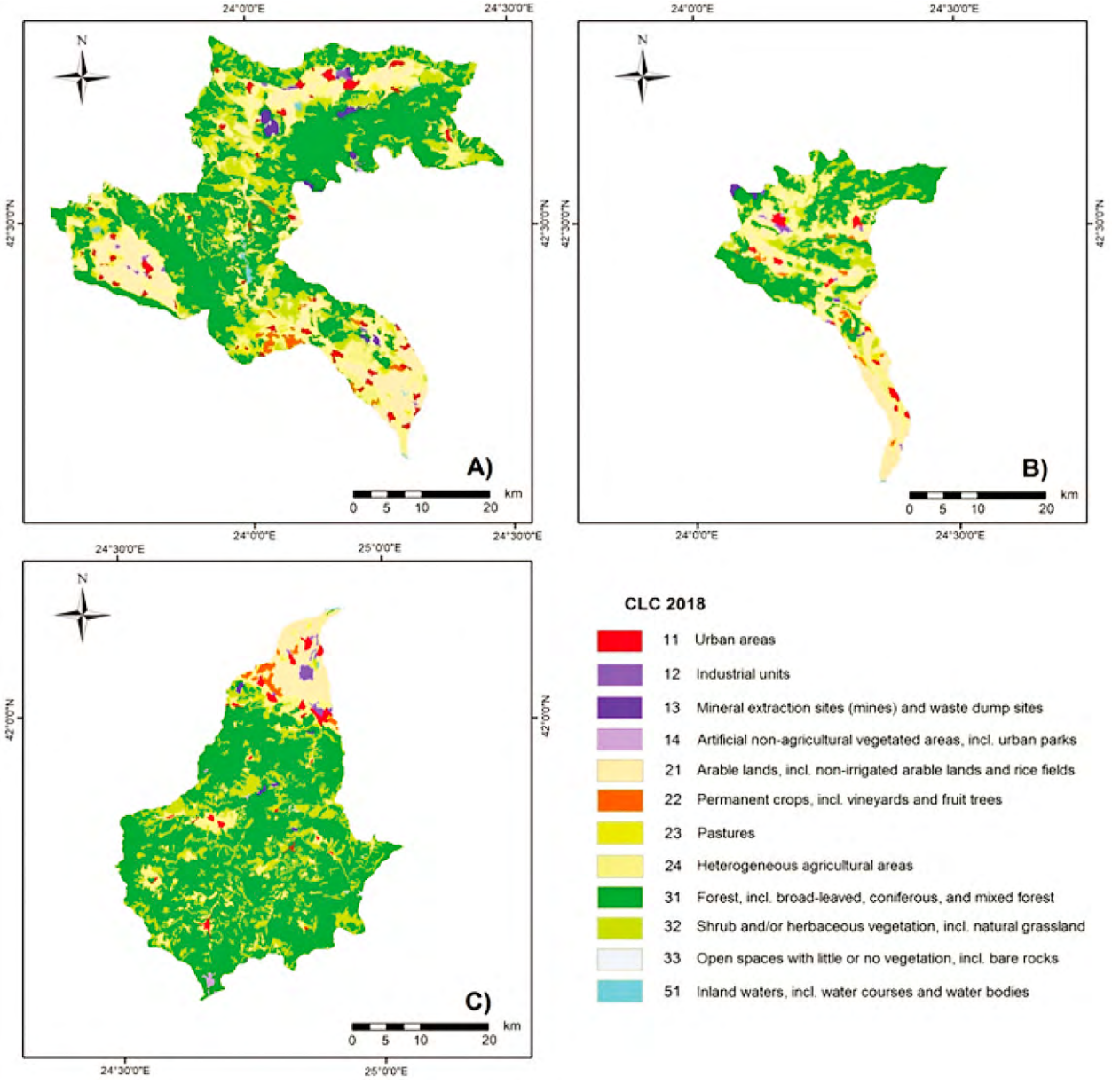

Figure 3. Maps ofCORINE Land Cover (2018): A) Topolnitsa River basin; B) Luda Yana River basin; C) Chepelarska River basin

Table 9. Distribution of CORINE Land Cover Classes 2018 (% of catchment areas)

CORINE Land Cover Classes	Catchment areas		
	Topolnitsa	Luda Yana	Chepelarska
1. Artificial surfaces	**3.26**	**2.82**	**3.51**
1.1 Urban areas	2.06	1.80	1.94
1.2 Industrial units	0.45	0.53	0.88
1.3 Mineral extraction sites (mines) and waste dump sites	0.73	0.46	0.34
1.4 Artificial non-agricultural vegetated areas, incl. urban parks	0.02	0.03	0.35
2. Agricultural areas	**29.53**	**38.86**	**18.42**
2.1 Arable lands, incl. non-irrigated arable lands and rice fields	14.22	23.68	8.39
2.2 Permanent crops, incl. vineyards and fruit trees	0.94	0.77	1.45
2.3 Pastures	2.29	0.86	0.62
2.4 Heterogeneous agricultural areas	12.08	13.55	7.96
3. Forest and semi-natural areas	**66.75**	**58.25**	**78.03**
3.1 Forest, incl. broad-leaved, coniferous, and mixed forest	48.74	41.53	63.21
3.2 Shrub and/or herbaceous vegetation, incl. natural grassland	17.85	16.72	14.54
3.3 Open spaces with little or no vegetation, incl. bare rocks	0.16	–	0.28
4. Water bodies	**0.46**	**0.07**	**0.04**
4.1 Inland waters, incl. water courses and water bodies	0.46	0.07	0.04

tion – ore-extraction mines, dressing factories, and metallurgical enterprises that are not connected with mining wastewater treatment plants or if they are connected the effluents appear to be inadequately treated.Such examples in the catchment area of the Topolnitsa River include the copper-extraction mines "Medet", "Elatsite", and "Elshitsa" whose wastewaters enter into the main river through its tributaries. Additionally, the effluents discharging from the ore-processing enterprises near Chelopech ("Dundee Precious Metals") and Pirdop ("Aurubis Bulgaria"), as well as the raw wastewaters flowing out from industrial lagoons and tailing dumps, also influence water quality. It is important to note that the majority of the mining sites are situated before the "Topolnitsa" Reservoir. Although the monitoring point near Dragor is located after the dam, increased values of heavy metals and metalloids in river waters can still be observed. In the catchment area of the Luda Yana River the main source of metalloid and trace metal pollution is "Asarel", a copper mine located before the village of Oborishte, whose wastes get into the main river through its right tributary - the Banska Luda Yana River. The drainage basin of the Chepelarska River is affected by mining as well. The Chepelarska River and its tributaries drain through part of the Rhodope zone with deposits of lead-zinc ore. The produced wastes from the zinc mines "Laki" and "Dzhurkovo" are initially discharged into small gullies and tributaries, which subsequently bear the mining wastewaters into the main river. Additionally, the industrial effluents released from the ore-processing factory "Gorubso – Laki" and the non-ferrous metals plant "KCM – Plovdiv" also influence water quality of the Chepelarska River. We can summarize that the unregulated discharge of untreated or inadequately treated effluents from ore-extraction mines, dressing factories, tailing dumps, industrial lagoons, and metallurgical dumps explains the elevated concentrations of trace metals and metalloidsin the river waters (Table 7). An implication can be drawn that although the mines occupy less than 1% of the catchment areas, they strongly affect water quality (Figure 3 C, Table 9). Downstream sections of the investigated rivers cover parts of the western half of the Upper Thracian Plain, also known as Pazardzhik-Plovdiv lowland area, which is an important agricultural region. There are situated the most extensive arable lands of Bulgaria with rice paddies, vegetable crops, vineyards and fruit trees, as well as a lot of livestock farms. Agricultural activities are linked to water quality, as discharged effluents help to enrich water bodies with nutrients. In the investigated catchment "Agricultural areas" are the second most characteristic land cover class, constituting up to 38.86% of drainage basins (Figure 3, Table 9). Sources of water pollution by ammonia and ammonium nitrogen include raw wastewaters released from farm complexes as a result of animal husbandry practices. Along the Topolnitsa River are situated livestock farms that are not connected with wastewater treatment plants, which explain the increased values of ammonium nitrogen in the river waters (Figure 2, Table 5). Similarly, water pollution by nitrate nitrogen usually indicates an inflow of soil runoff formed

as a result of flushing from agricultural lands treated with chemical agents like artificial fertilizers or pesticides. The agricultural effluents released from the surrounding arable lands in addition to the produced wastewaters from the vermicomposting enterprise near Asenovgrad explain the elevated values of nitrate nitrogen in the waters of Chepelarska River (Figure 2, Table 5).According to the results phosphor appears to be the most significant pollutant (Figure 2). The main sources of phosphorous pollution are the leaking of urban sewage and septic tanks, usage of phosphorus-rich fertilizers in agriculture, and decomposition of biomass and erosion. The results obtained give us a reason to argue that one of the problems facing the settlements in the region remains the undeveloped public sewerage systems, the uncontrolled deposition of biodegradable wastes into illegal garbage dumps, resulting in poor water quality.

Conclusion

The results show that among the 14 observed chemical parameters, the majority of them do not meet the requirements of Water Quality Standards for Surface Water Environmental Quality. The application of CCME and HPI confirms this result and reveals that river waters are in the "Poor quality" category with respect to nitrogen and phosphorus content and they are "High polluted" with respect to heavy metals (Al, Cu, Mn and Zn). The selected indices prove to be sensitive tools for evaluating water quality depending on given objectives – the index scores indicate water is critically polluted and it is inappropriate for drinking and domestic uses. Adoption of stricter wastewater treatment methods in order to remove the unregulated discharge of raw effluents from mining sites and industrial enterprises, promotion of sustainable agricultural practices, as well as renovation and expansion of sewage systems in the settlements are crucial measures to reduce the impact of various anthropogenic activities on water quality.Furthermore, a comprehensive research of the environmental health status is another step that has to be taken to better control and further protection of river ecosystems. Regular monitoring of pollutants in affected zones and evaluation of pollution effects on human health and aquatic ecosystems are essential steps to abate water contamination in the region.

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