ACTA GEOGRAPHICA SLOVENICA

GEOGRAFSKI ZBORNIK

2021
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61-2

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SLOVENSKE AKADEMIJE ZNANOSTI IN UMETNOSTI
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GEOGRAFSKI ZBORNIK

61-2

2021

Založba ZRC

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ACTA GEOGRAPHICA SLOVENICA

61-2
2021

ISSN: 1581-6613
UDC: 91
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Issued by/izdajatelj: Geografski inštitut Antona Melika ZRC SAZU
Published by/založnik: Založba ZRC
Co-published by/sozaložnik: Slovenska akademija znanosti in umetnosti

Address/naslov: Geografski inštitut Antona Melika ZRC SAZU, Gosposka ulica 13, p. p. 306, SI – 1000 Ljubljana, Slovenija

The article are available on-line/prispevki so dostopni na medmrežju: http://ags.zrc-sazu.si (ISSN: 1581–8314)

Ordering/naročanje: Založba ZRC, Novi trg 2, p. p. 306, SI – 1001 Ljubljana, Slovenija; zalozba@zrc-sazu.si

Annual subscription/letna naročnina: 20 € for individuals/za posameznike, 28 € for institutions/za ustanove.
Single issue/cena posamezne številke: 12,50 € for individuals/za posameznike, 16 € for institutions/za ustanove.

Cartography/kartografija: Geografski inštitut Antona Melika ZRC SAZU
Translations/prevodi: DEKS, d. o. o.
DTP/prelom: SYNCOMP, d. o. o.
Printed by/tiskarna: Present, d. o. o.
Print run/naklada: 400 copies/izvodov

The journal is subsidized by the Slovenian Research Agency and is issued in the framework of the Geography of Slovenia core research programme (P6-0101)/Revija izhaja s podporo Javne agencije za raziskovalno dejavnost Republike Slovenije in nastaja v okviru raziskovalnega programa Geografija Slovenije (P6-0101).

The journal is indexed also in/Revija je vključena tudi v: Clarivate Web of Science (SCIE – Science Citation Index Expanded; JCR – Journal Citation Report/Science Edition), Scopus, ERIH PLUS, GEOBASE Journals, Current geographical publications, EBSCOhost, Georef, FRANCIS, SJR (SCImago Journal & Country Rank), OCLC WorldCat, Google scholar, and CrossRef.

Design by/Oblikovanje: Matjaž Vipotnik.

Front cover photography: Slovenia's longest river, the Sava, bubbles to the surface in the crystal clear emerald waters of the Zelenci Nature Reserve in northwestern Slovenia near the Slovenia-Austria-Italy border triangle (photograph: Matija Komac).
Fotografija na naslovnici: Sava, najdaljša slovenska reka, prihaja na površje kristalno čiste smaragdne vode naravnega rezervata Zelenci, ki ležijo v severozahodni Sloveniji blizu slovensko-avstrijsko-italijanske tromeje (fotografija: Matija Komac).

ACTA GEOGRAPHICA SLOVENICA

ISSN: 1581-6613
UDC: 91
Number: 61-2
Year: 2021

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Acta geographica Slovenica, 61-2, 2021, 7–21

DOES GEOSITE INTERPRETATION LEAD TO CONSERVATION? A CASE STUDY OF THE SIĆEVO GORGE (SERBIA)

Đorđije Vasiljević, Milica Began, Miroslav Vujičić, Thomas Hose, Uglješa Stankov

The landscape of the Sićevo Gorge.

DOI: https://doi.org/10.3986/AGS.8753
UDC: 913:551.435.11:502.13(497.11)
COBISS: 1.01

Đorđije Vasiljević,[1] Milica Began,[1] Miroslav Vujičić,[1] Thomas Hose,[1,2] Uglješa Stankov[1]

Does geosite interpretation lead to conservation? A case study of the Sićevo Gorge (Serbia)

ABSTRACT: People have appreciated the beauty of natural landscapes, the result of the interplay of different natural processes, for at least three hundred years in Europe. Many have been inspired by this beauty to promote such places for visits by others. Some have understood the importance of individual places visited within the local or regional environmental system. This has led to definitions and the establishment of protected areas with special visitor rules and regulations. This article presents a case study of Sićevo Gorge Nature Park in Serbia and an opportunity to transform it into a geoheritage site, underpinned by developing its interpretation based on the results of a study using the analytical-hierarchy process (AHP) method.

KEYWORDS: geoheritage, interpretation, gorges, Sićevo, Serbia

Ali interpretacija območij geološke dediščine zagotavlja njihovo ohranjanje? Primer soteske Sićevo v Srbiji

POVZETEK: V Evropi ljudje že več kot 300 let občudujejo lepoto naravnih pokrajin, ki je rezultat medsebojnega učinkovanja različnih naravnih procesov. Mnoge je ta lepota spodbudila k temu, da so take kraje promovirali kot prostore, vredne obiska, nekateri pa so razumeli tudi pomen posameznih krajev, ki so jih obiskali, v lokalnem ali regionalnem okolju. Na tej podlagi so bila opredeljena in ustanovljena zavarovana območja s posebnimi pravili in predpisi za obiskovalce. V članku je obravnavan primer naravnega parka soteske Sićevo v Srbiji in možnost njegove preobrazbe v območje geološke dediščine na podlagi oblikovanja njegove interpretacije v skladu z izsledki raziskave, v kateri je bila uporabljena metoda analitičnega hierarhičnega procesa (AHP).

KLJUČNE BESEDE: geološka dediščina, interpretacija, soteske, Sićevo, Srbija

This article was submitted for publication on July 2nd, 2020.
Uredništvo je prejelo prispevek 2. julija 2020.

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1 Introduction

Geoconservation, as a fairly recently recognized discipline (Larwood 2016) within the Earth sciences, provides information useful for solving environmental problems of social relevance, such as inappropriate land-use planning and geo-exploitation (Hose 2011), which might endanger the physical integrity of geoheritage (Henriques et al. 2011). In addition, it designs suitable and specialized services necessary and appropriate for their mitigation. Geoconservation is an important discipline in conserving abiotic nature and, thanks to its various methods, it can be used as an educational tool. It also can be designed to simultaneously preserve nature, educate, and create profit. It thus defines a body of knowledge crucially important to the creation of products (interpretative geotrails, geo-reserves, and geoparks) that, in addition to guaranteeing the protection of abiotic nature, are capable of promoting economic and social development at every scale from local to global – that is, geotourism (Hose 1997; 2011) – extending to current interpretations of sustainable development. Activities undertaken in, and travelers' journeys into, wild and natural landscapes that would now be subsumed within geotourism can be recognized in Europe (Hose 2016), including Serbia (Vasiljević, Marković and Vujičić 2016), since at least the late seventeenth century.

This study presents research on three stakeholder groups (visitors, guides, and experts) that use various interpretation tools for different purposes during their visits to the case study area, the Sićevo Gorge in eastern Serbia. The aim is to discover how various users of natural areas perceive interpretation, and which of its instruments and tools they find most relevant. Such information is useful for managing protected areas and for nature-based tourism (such as geotourism and ecotourism) in creating enjoyable experiences for visitors and satisfying them while ensuring sustainability (in terms of nature conservation).

2 Geoheritage interpretation in brief

The use of suitable presentation techniques can make complex and difficult geological and geomorphological phenomena, as elements of geoheritage, both interesting and easier for the public to understand. Generally, there are two reasons why geoheritage needs to be presented. First, it is important in underpinning well-known landscapes and geodiversity. Despite this, geoheritage is farthest from the public in terms of knowledge, interests, and general presentation in comparison to other more easily identifiable aspects of natural heritage, especially biodiversity. However, similar to biodiversity, geoheritage is vulnerable to both human activities and various natural processes that might damage it (Komac, Zorn and Erhartič 2011). The damage is long-term and difficult, often impossible, to remediate. Therefore, only those people and local communities that are aware of their geoheritage, and can both identify with and relate to it, can contribute to its conservation and sustainable development. Geoheritage presentation has a clear role in establishing real links between biodiversity and geodiversity, and the equal need to preserve them.

Second, geoheritage presentation supports the opportunity that geodiversity offers for tourism development at the local and national levels. The sound explanation and presentation of geological and geomorphological phenomena will enhance the visitor experience and help boost geotourism potentials (Štrba, Baláž and Lukáč 2016). The interpretation of geoheritage is considered the art of explaining the meaning and significance of geosites to visitors (Xu et al. 2015). The modern idea of interpretation was born in the United States, where Tilden (1977) suggested that producing pamphlets could help tourists understand unfamiliar aspects of nature, including a geological phenomenon in Yellowstone National Park that was misunderstood by them. After the idea's success, guided tours by park rangers and concessioners were offered, and the first nature interpretation program by the United States National Parks Service (Nunes 1991; Began et al. 2016) was created. According to the World Tourism Organization (WTO) and United Nations Environment Programme (UNEP), education and interpretation are key elements of visitor provision used by administrators to better manage and provide for tourists (Making … 2005) and meet their needs.

Environmental interpretation (Pierssene 1999) is part of environmental education (Ballantyne 1998), being the term used to describe communication activities undertaken to better understand the natural environment in protected areas, nature parks, national parks, natural history museums, and other venues (Vasconcelos 2003). Its provision aims to preserve and conserve natural resources and seeks to increase visitor satisfaction, serving as a management tool. Ham (1992) argues that it is a form of communication, a language that translates technical science, environmental science, and related matters into readily understandable terms and ideas for people without scientific training or inclination. It aims to sensitize visitors to see, explore, observe, analyze, understand, and engender feelings for natural heritage, including geological heritage, that they visit. To reveal the deeper meaning of a historical reality or a landscape, it is essential to carry out research and follow its results. Thus, Werner (1996) explains that visitors should be offered interpretations of heritage, not inventions or distortions. Murta and Albano (2005) suggest that to interpret heritage is to present places and cultures to visitors and to enrich their experience. Environmental interpretation is »a technique flexible and malleable to different situations« (César et al. 2007). Thus, it can and should be performed to the advantage of the geology and geomorphology of an area with significant geoheritage. Generally, such interpretation is particularly necessary for the purposes of geotourism (Hose et al. 2011; Vasiljević et al. 2011), ecotourism (Mastrini et al. 2018), and sustainable tourism (Moreira 2012; Began et al. 2016).

3 Study area

The Sićevo Gorge (*Sićevačka klisura*) lies along the Nišava River (Figure 1). It connects the Bela Palanka Basin (*Belopalančka kotlina*) to the east with the lower Nišava Valley (*Ponišavlje*) to the west. The lithological basis of the Sićevo Gorge is Paleozoic, Mesozoic, and Tertiary–Neogene sandstones and limestones (Figure 2). Quaternary rock, primarily alluvial deposits, and scree frequently obscure them as well as creating their own landforms. Locally known as the »Serbian Cappadocia« (National Geographic Srbija, 2016) it is an oasis of rare plants and animals, the setting of various geosites, and an important cultural, historical, and religious location. A Roman military road, the *Via Militaris* (Figure 3b), was constructed here in the first century AD and was used later during Ottoman rule, from the fourteenth to the early twentieth centuries, in the Balkans. Hence, many different civilizations have traveled through this gorge, underpinning its historical and cultural significance.

Kostić (1954) distinguishes three morphological units (Figure 2) in the gorge. The easternmost part, about 7 km long, is called the Gradište Canyon (*Gradiški kanjon*, locally known as *Gradištanski kanjon*) after the nearby village of Gradište, although this part of the gorge also carries a number of other names: Upper Gorge (*Gornja klisura*), Big Sićevo Gorge (*Velika sićevačka klisura*), Ostrovica Gorge (*Ostrovička klisura*), Crnče–Gradište Canyon (*Crnačko-gradištanska klisura*), and Ostrovica–Gradište Canyon (*Ostrovičko-gradištanska klisura*). The second unit is the Ostrovica extension and the third is the Prosek Gorge (*Prosečka klisura*).

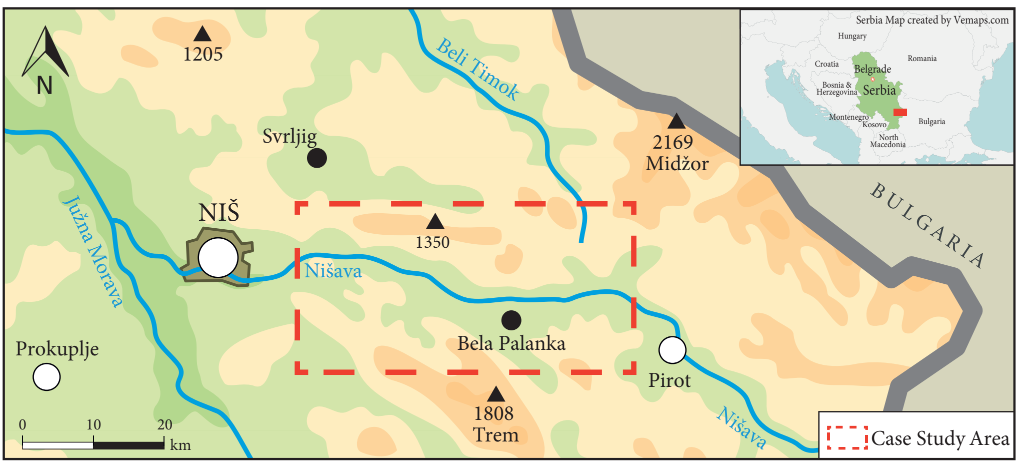
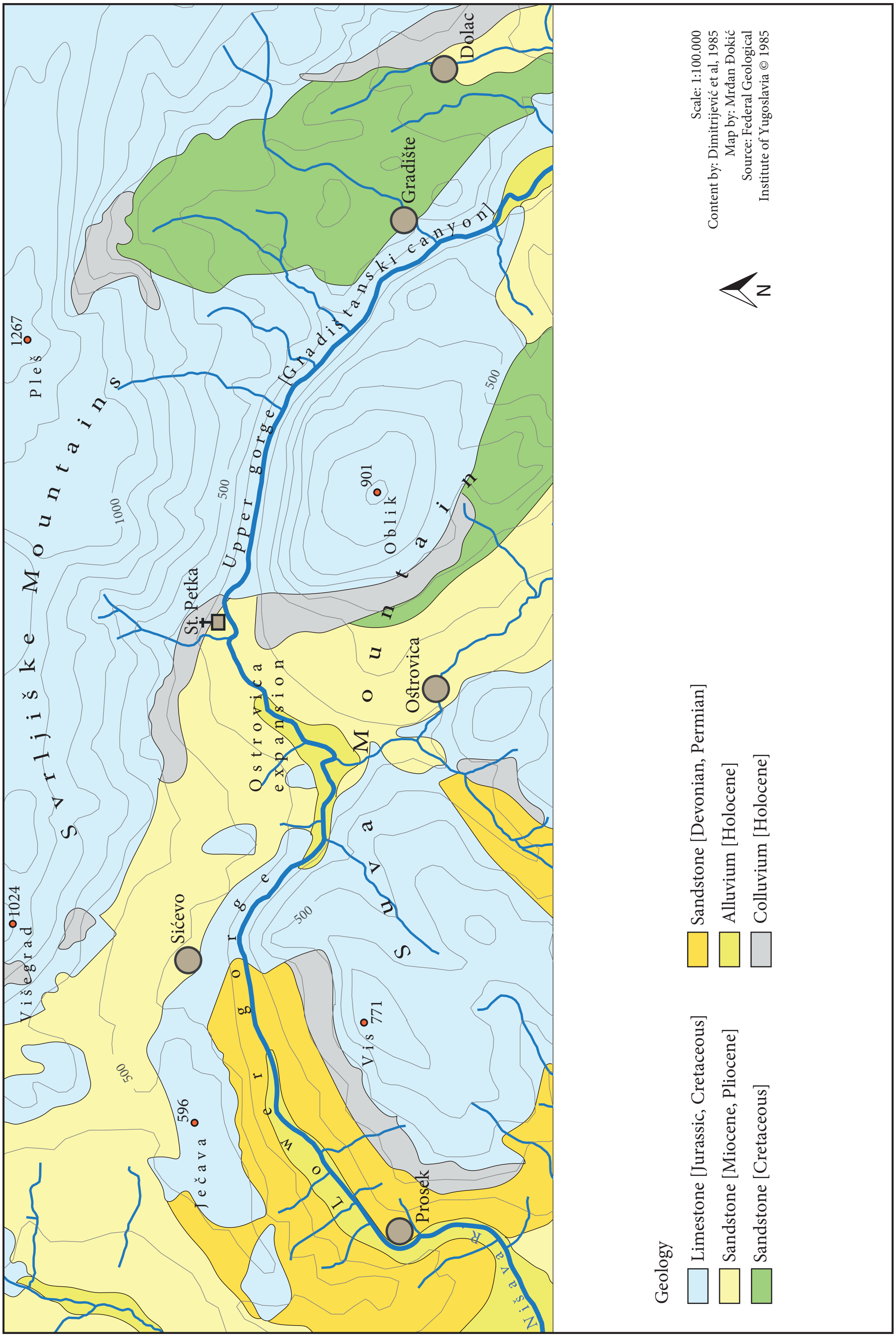


Figure 1: Geographical position of the Sićevo Gorge.

Figure 2: Geological composition of the Sićevo Gorge (adapted after Began 2019). ➤


Svrljiške Mountains
Pleš
1267
1000
500
Upper gorge [Gradištanski canyon]
Dolac
Gradište
Oblik
901
Suva Mountain
St. Petka
Oštrovica
Ostrovica expansion
Sićevo
Višegrad
1024
Lower gorge
Ječava
596
Vis
771
Prosek
Nišava R.
Geology
Limestone [Jurassic, Cretaceous]
Sandstone [Miocene, Pliocene]
Sandstone [Cretaceous]
Sandstone [Devonian, Permian]
Alluvium [Holocene]
Colluvium [Holocene]
N
Scale: 1:100.000
Content by: Dimitrijević et al, 1985
Map by: Mrđan Đokić
Source: Federal Geological
Institute of Yugoslavia © 1985

Mitić (2006) divided the Sićevo Gorge into two parts: the upper part (the canyon) and the lower part (the gorge). Ćirić (2006) distinguished four parts: the Svrljig Mountains (*Svrljiške planine*), part of the Ploče Plateau (*visoravan Ploče*) and the Kunovica area (with Mount Oblik and Mount Kusača), the Ostrovica Basin (*Ostrovička kotlina*), and the Sićevo Gorge. In the Sićevo Gorge, the same author distinguished three parts: the Gradište Canyon, the passage through the Ostrovica Basin, and again the Sićevo Gorge in the narrow sense (Began et al. 2016). The same author continues description of the study area: »*The canyon part of the Sićevo Gorge, Gradište Canyon, cuts between Mount Oblik (901 m) to the north and the Svrljig Mountains (Mount Golubnjak, 1,179 m; Mount Pleš, 1,267 m; and Mount Tupanar, 1,106 m) to the south. The canyon consists of steep and vertical, often terraced rocky cliffs. The width of the canyon at the bottom is mainly reduced to the bed of the Nišava River. The height of the rocky canyon walls reaches about 400 m on the north side of Mount Oblik, whereas the average direct canyon depth to the valley is about 250 m. The south side of the canyon extends continuously, with the exception of the valley of Babica Creek, where the Nišava River flows into the gorge. The north side is cut by the valleys of several small intermittent tributaries of the Nišava River, as well as steep longitudinal profiles and hanging valleys*« (Began 2019, 92).

Downstream from the Gradište Canyon, approximately between the St. Petka Monastery (Figure 3d) and the mouth of Ostrovica Creek (*Ostrovički potok*), the Nišava River flows through a basin extension, with a wide bottom and slightly sloping sides, about 2 km long. This extension is tectonically predisposed and built in the domain of the small Neogene Ostrovica Basin and St. Petka Basin, and then transformed by fluvial and denudation processes. The belt of lower terrain runs deep toward the southeastern countryside around the gorge along the valley of Ostrovica Creek, all the way to the village of Ravni Do (Mitić 2006).

Figure 3: Scenery and landmarks of the Sićevo Gorge. (a) The edge of the village of Sićevo; (b) The exit of the gorge toward Niš (part of the *Via Militaris* is best preserved here, but barely visible); (c) The slopes of the gorge seen from the river; (d) The St. Petka Monastery in the village of Ostrovica.

The part of the valley downstream from the St. Petka Basin is called the Prosek Gorge (*Prosečka klisura*). It is about 8 km long and is morphologically very diverse. The first, most upstream part of it, 1.5 km in length, is in the southeastern part of the gorge, next to vertical rocky cliffs over 200 m high and steep, occasionally vertical sections about 150 m high on the north (*Brljavski kamen* 'Dirty Cliff'). At the end of this narrowed sector of the valley, approximately at the line of the village of Sićevo, the Nišava River completely cuts through the complex limestone rocks and begins to cut into the substrate of Devonian and Permian sandstones, conglomerates, siltstone, and clays. Due to the lesser resistance of these rocks to erosional processes, the bottom parts of the valley lost their typical gorge features; that is, the valley sides are less steep and the valley floor widens. In the limestone rocks that build the upper, higher sections of the valley, the sides form rock sections, both on Mount Ječava to the north and Mount Kusača to the south. However, those sections away from the river, with the particularly impressive limestone excavations of Mount Kusača, are lined up in an arched, amphitheatrical series.

At the base of these sections there is a belt of steeply sloping screes, and below them slightly gentler sloping terrain constructed of Paleozoic rocks. Downstream from the line on which the limestones of both Mount Kusača and Mount Ječava end to the west, along the line from Red Hill (*Crveno brdo*) to the village of Prosek, in the double bend of the Nišava River, the valley is built of Permian red sandstones and, due to the steeper slopes and slightly narrower bottom, the river cut meanders (Krumin 2006; Mitić 2006; Began 2019).

Above the gorge, the limestone plateaus are pockmarked with dolines (Krumin 2006). The Sićevo Gorge is rich in underground karst features, mainly caves without speleothems. Most of the caves are preserved in their natural condition and are hydrographically dry. The rapid cutting of the Nišava River into the Sićevo Gorge and the onset of deep karstification did not allow more constant underground flows a given level and thus the development of larger cave channels. The most common Serbian term for these small caves is *dupke* (Jovanović 1891). Big Balanica Cave (*Velika Balanica*, 20 m long) and Little Balanica Cave (*Mala Balanica*, 12 m long) are the best known and most explored in the Sićevo Gorge, located near the village of Sićevo. The entrances to both caves are at an elevation of 332 m and they are only 7 m apart. Pleistocene deposits, mammalian fossils, and Paleolithic worked flint remains have been found in both caves. The remains date to the Middle Pleistocene: nine teeth and seven bones from hands and feet, as well as a human jaw, which has been described as a remnant of archaic *Homo sapiens* (Roksandić et al. 2011; Cvetković and Dimitrijević 2014); cave bear remains were also found here (Began 2019). In the gorge area there are a large number of springs with karst water or through which free water discharges in Neogene sediments and Paleozoic rock (Kostić and Martinović 1967).

4 Methods

In order to achieve the study's goals, the authors employed the analytical-hierarchy process (AHP), a systematic approach developed by Saaty (1980) and used in multi-criteria decision-making. The AHP presents a multi-criteria decision-making methodology that is noteworthy for its acceptance of the subjective nature of the information used in many decision-making contexts (Hsu, Tsai and Wu 2009). Through its operations, the subjectivities and biases given in individual responses can be factored into the model, allowing for the gradual refinement of decision-making criteria, which means that it is particularly relevant in the context of tourism development and planning, in which, for example, decisions about resource allocation and promotion can be contestable and problematic.

With complex decisions, due to different criteria and alternatives, the decision-making process becomes complex, comprising mutually connected and dependent factors, further influencing the final decision (Jandrić and Srđević 2000). The AHP provides solutions to complex problems and employs hierarchical structures through developing priorities for different alternatives determined by the decision-makers (Brushan and Rai 2004). Its final output is an evaluation model for decision-making, dependent upon weighted criteria. It integrates different measures into a single overall score for ranking decision alternatives (Hsu, Tsai and Wu 2009). It is used to simplify multiple criterion problems by deconstructing them into a multilevel hierarchical structure (Harker and Vargas 1987) because it gradually compares alternatives and measures their impact on the final decision-making goal; this helps decision-makers in their choices between competing alternatives (Saaty 1980).

Given a pairwise comparison, the AHP analysis involves three tasks: 1) developing a comparison matrix at each level of the hierarchy starting from the second level and working down, 2) computing the relative weights for each element of the hierarchy, and 3) estimating the consistency ratio (CR) to check the consistency of the judgment (Božić et al. 2018; Vujičić et al. 2020). If the consistency ratio (CR) is less than 0.10, the result is sufficiently accurate and there is no need for adjustments in comparison or for repeating the calculation. If the ratio of consistency is greater than 0.10, the results should be reanalyzed to determine the reasons for inconsistencies and to remove them by partial repetition of the pairwise comparison. When repetition of the procedure in several steps does not lead to reduction of the consistency to the tolerable limit of 0.10, all the results should be discarded and the entire procedure should be repeated from the beginning (Jandrić and Srđević 2000). In order to evaluate the criteria weight for attitudes toward interpretation means among respondents that have visited, researched, or worked at the Sićevo Gorge, the authors first developed a hierarchically structured model (Figure 4) based on certain indicators, adapted from Vujičić et al. (2011; 2018) and Petrović et al. (2013). They then applied the AHP model, a method with increasing application in tourism research literature (Scholl et al. 2005).

4.1 Study sample

The sampling strategy for the AHP method can be based on a suitably chosen purposeful sample that is appropriate for generating qualitative data, useful for research focusing on a specific issue for which a large sample is not necessary, especially in tightly bounded case studies (Lam and Zhao 1998; Cheng, Li and Ho 2002). Purposeful sampling (Coyne 1997) was deemed appropriate for this research because of the limited need for generalization from the case study (Creswell 2007). Cheng and Li (2002) argue that the AHP method is in fact made impractical in research with a large sample size because »cold-called« non-expert respondents may have a great tendency to provide arbitrary answers, resulting in a very high degree of inconsistency, which invalidates the approach (Wong and Li 2008). The data were collected within a case study, in which questionnaires were distributed by the researchers into a purposefully selected sample population. These were subdivided into three groups: 1) ten guides (tour guides experienced in nature-based tourism); 2) ten experts (tourism experts, geosite experts, geoheritage experts, hikers, and geographers); and 3) ten individuals (respondents that had visited the Sićevo Gorge). Thus, the final sample consisted of thirty respondents of various ages, nationalities, and sexes.

4.2 Questionnaire design and research phases

Research design and implementation have been particularly well and concisely covered by the Tourism and Recreation Research Unit (1983) in the United Kingdom; it covers many of the research terms employed

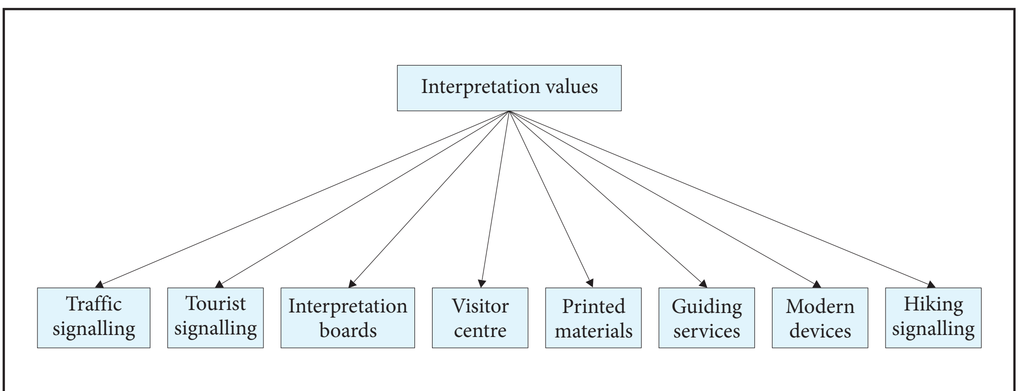


Figure 4: Scheme of various interpretation and signaling tools presented to respondents.

herein. The first phase of the research included a review of relevant previous literature (Vujičić et al. 2011, 2018; Petrović 2013; Višnić, Spasojević and Vujičić 2016) and the selection of all the factors defining interpretation tools, thus helping define the final model based on the modified indicators created by Vujičić et al. (2011). The authors selected eight indicators (Figure 4) to be measured by the AHP model. The indicators are formed according to the most relevant factors included in the decision-making process. After the selection of the factors and the design of the questionnaires, the second phase of the research was initiated; this included the interviewed respondents, as well as the entry of the collected data into the statistical computer program Expert Choice 2000 – AHP Software for Decision Making and Risk Assessment (expertchoice.com). Finally, the consistency of the overall research was determined, as well as the final ranking of the factors, by calculating the weight coefficients.

4.3 Procedure

The research for this case study was conducted in 2018, from March through to June. The respondents participated in the research on a volunteer basis. All of them were thoroughly informed about the purpose of the research, as well as the researchers' identities. They were advised that their contributions would be recorded anonymously and that the data would be used strictly and solely for the purposes of the research. A structured interview, based on a preprinted questionnaire, was employed in which the interviewer asked set questions, filling in the answers on the questionnaire. In this way, any possible misunderstandings of the carefully derived questions were eliminated.

Respondents were asked to express their attitudes toward interpretation tools when visiting geosites, measuring their importance factor by using Saaty's (1980) scale (Table 1). The authors gave brief standardized explanations of each criterion (or factor) before and during the structured interview. The respondents were required to assign a corresponding numerical value (Saaty's scale) to different factors based on the relative importance they considered the factor had for them.

Table 1: Saaty's scale for pairwise comparisons in AHP. An intermediate numerical value of 2, 4, 6, 8 and 1/2, 1/4, 1/6, 1/8 can be used as well (Saaty 1980).

Judgment term (elements A and B)	Numerical term
Absolute preference (A over B)	9
Very strong preference (A over B)	7
Strong preference (A over B)	5
Weak preference (A over B)	3
Indifference of A and B	1
Weak preference (A over B)	1/3
Strong preference (A over B)	1/5
Very strong preference (A over B)	1/7
Absolute preference (A over B)	1/9

In post–research group decision-making, an aggregation of each respondent's resulting priorities was computed using the geometric mean, which is more consistent with the meaning of priorities in AHP (Božić et al. 2017; Vujičić et al. 2018).

5 Results

The synergy of all responses (Figure 5) from the respondents shows that the most important factor for measuring interpretation tools is guiding services (0.161), followed by tourist signalization (0.144) and interpretative boards (0.138), whereas the least important factors are printed materials (0.102) and mountain signalization (0.106). The consistency ratio (CR) is 0.03, which indicates that the study is reliable and accurate, and therefore there is no need for adjustments in the comparison of criteria.

Figure 5 shows the significance of guiding services, which the respondents marked as far more important than all the other interpretation indicators. Guiding services can improve and bring interpretation to a completely new level. Irrespective of the available technology that can be employed, a competent guide will always be one of the best interpretation tools. Before taking any action for creating high-value interpretation in the Sićevo Gorge, it is necessary to offer appropriate geointerpretation training. There are a suitable number of tour guides in the city of Niš, but most of them do not have experience in geo-interpretation. There are also mountain guides, who lack experience in working with tourist groups. By setting up proper geo-interpretation training for both parties, it is possible to create high-quality geo-interpretation services.

Table 2 shows the weight of the preferences for interpretation tools among three different groups. Visitors rated guiding services (0.200) the most important interpretation tool, followed by tourist signaling (0.163) and interpretation boards (0.126), whereas the least important were modern devices (0.084) and hiking signaling (0.088).

Experts gave preference to and rated interpretation boards (0.165) as the most important factor, followed by modern devices (0.147) and hiking signaling (0.141), whereas the least important are printed materials (0.097) and guiding services (0.100). The guides gave the highest score to guiding services (0.231),

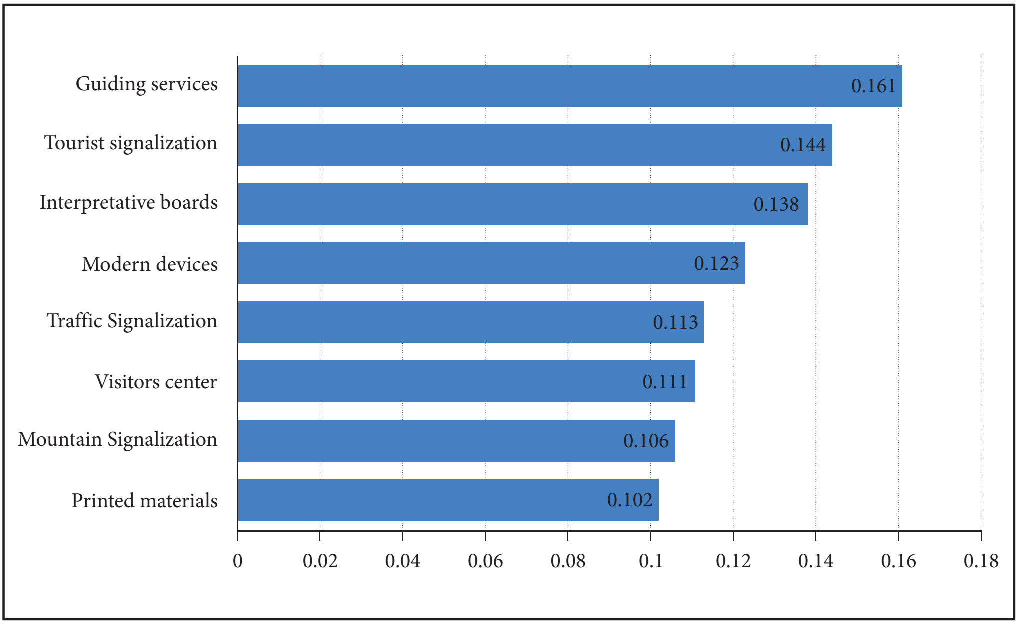


Figure 5: Synergy of all responses.

Table 2: Weight of preferences for interpretation tools among three different groups.

Visitors	Experts	Guides
Guiding services (0.200)	Interpretation boards (0.165)	Guiding services (0.231)
Tourist signaling (0.163)	Modern devices (0.147)	Modern devices (0.144)
Interpretation boards (0.126)	Hiking signaling (0.141)	Tourist signaling (0.129)
Printed materials (0.117)	Tourist signaling (0.132)	Interpretation boards (0.108)
Visitor center (0.113)	Traffic signaling (0.115)	Visitor center (0.108)
Traffic signaling (0.110)	Visitor center (0.102)	Traffic signaling (0.105)
Hiking signaling (0.088)	Guiding services (0.100)	Printed materials (0.088)
Modern devices (0.084)	Printed materials (0.097)	Hiking signaling (0.086)

followed by modern devices (0.144) and tourist signaling (0.129), whereas the least important are hiking signaling (0.086) and printed materials (0.088). The consistency ratio (CR) for the visitors is 0.02, for the experts it is 0.03, and for the guides it is 0.04, which means that this sample, as well as the result, is sufficiently reliable and accurate, and therefore there is no need for additional adjustments.

6 Concluding remarks: management implications

The interpretation of geoheritage and the dissemination of knowledge about the Earth is accomplished by various means and techniques, both *in situ* and *ex situ* and with or without the personal interaction of an interpreter (Hose 1995; 2000). The results of various indicators posed as questions to the respondents are presented in Tables 1 and 2. After considering the results, the authors propose various actions in order to improve geoheritage interpretation at the case study location.

The tourism-related respondents (visitors and guides) in general gave preference to guiding services and tourist signaling as important factors. This indicates that they consider these tools important elements of geoheritage protection and interpretation in the Sićevo Gorge. Highly trained and well-educated guides can both teach and develop visitors' positive feelings about the Sićevo Gorge, as well as showing them its best aspects. They can present visitors with geoheritage features and their values in the best way possible because they are in direct contact with the visitors. Because there are currently no specialized tour guides for the Sićevo Gorge, it is necessary to offer appropriate training for such guides and, following the example of best guiding practice in other geosites in Europe, teach them the skills of high-quality geoheritage guiding. The aforementioned Little and Big Balanica Caves are important and attractive archaeological sites, unique in Serbia. They should be evaluated, protected, and opened up to carefully managed visitors. The Balanica Caves' prehistoric finds have already attracted much attention; a properly developed interpretation scheme can both better present this site to current visitors and bring it to the attention of a wider audience.

What might also be useful in justifying interpretation as a tool for geoconservation is the high values assigned to signaling (in general) and interpretation boards by all three groups of respondents. Mountain signalization (even though this is basic signalization for any outdoor space) is least important for the respondents; the reason for this might be that most of the visitors that responded do not understand the meaning of this signalization. Tourist signalization and interpretative boards – which make the area more attractive when features that visitors see are explained – are the most important indicators for the respondents. The importance of interpretative boards must be emphasized, and significant attention should be paid to this means of interpretation. The organization and design of interpretation boards needs to be appropriate and follow one idea and storyline. Interpretation boards, or even QR codes that link to online resources as a more cost-effective solution, need to be installed at every attractive spot; however, overt visual intrusion should be avoided so that there are not so many boards that they become visually dominant in the natural landscape. They should interpret geological and geomorphological features in such a way as to provide visitors with interesting information that will engage them in further and future exploration. The information provided on the panels should contain facts of interest to various types of visitors, facts they did not already know, and facts specific to the area. The main idea should be a desire for visitors to leave the place satisfied, energized, more informed, and better aware of the significance of the place they have just visited. Special attention must be paid to this analogue interpretation means. Even though other better-developed and better-organized natural sites rely on modern digital devices (Stankov et al. 2019) more than on interpretation panels, the respondents' opinions show the importance of the interpretation panels, and this finding cannot be ignored.

Before explaining any kind of natural heritage to potential visitors, it is fundamentally necessary to waymark all the paths in the Sićevo Gorge and ensure that appropriate and adequate safety measures are in place. The Sićevo Gorge has always been a favorite place for many professional and amateur nature lovers, and so its paths are currently clearly marked with hiking signalization. All the signalization is clear and visible because it is remarked every spring and autumn. It should be noted that the hikers' signalization is for their specific purposes; this means that all potential visitors must know how to read and understand its specialized markings. However, it is possible to rely on this signalization to create paths for different types of visitors. Paths can be divided into sections, from easiest to hardest. The Kjugekull geosite (in Skåne county, Sweden) has established and marked paths throughout the entire geosite (e.g., yellow for easy, green for medium, and red for difficult). In this way, it is easy for visitors to follow the path most suited for them. At the start of every path, there is an information board with a map of the path, and information about its length and the approximate time needed to complete it. This idea can easily be implemented in the Sićevo Gorge because its terrain allows it to be marked and divided into easy, medium, and hard sections. This type of signage can also be attractive to visitors. The paths should include the most interesting features of the gorge along with interpretation panels that explain the most important and interesting facts about the features. The Sićevo Gorge is rich in cultural and historical heritage, biodiversity, geodiversity, and folk stories; including these within the overall interpretation will make it even more attractive and accessible to a wide range of visitors of different ages and interests.

Because the Sićevo Gorge was part of a historical Roman military road, the *Via Militaris* (Figure 3b), as well as part of the old Stambol road constructed during the Ottoman era, today it is possible to hike the paths that were parts of these roads, where visitors can feel a sense of history. This road also has attractive viewpoints and places of historical events that can be highlighted by attractive interpretation panels, maps, and photographs.

While creating and way-marking the walking and hiking paths, one must bear in mind health and safety precautions and do whatever is necessary to ensure that visitors will not experience any unwanted or serious events. Putting fences in dangerous places, constructing outdoor steps so that visitors can more easily tackle some of the hard inclines, and avoiding the most dangerous areas or constructing bridges over some of these can help visitors reach some of the parts that are attractive, but currently difficult and potentially dangerous. However, a balance needs to be struck between achieving greater and safer access for visitors other than hikers and avoiding damage to fragile habitats and detracting from the area's natural beauty with excessive artificial construction and signage; that is, sustainable ecotourism.

The results of this study should be taken into consideration when creating plans for protecting the Sićevo Gorge. It has already been protected as a nature park, but it needs to be further protected, especially for its geoheritage interest, by creating and implementing a detailed geoconservation plan. At the time of writing this article, only a few months after traffic was removed from the gorge to a new highway, the gorge is already fuller than in the past, with nature lovers using this new situation to better enjoy this incredible place. It is important to act quickly and implement all the geoconservation means, especially interpretation, in all future plans to protect this geological and geomorphological phenomenon for the benefit of future generations.

All three groups of respondents, with some essentially minor differences, gave preference to similar interpretation tools to raise awareness about these somewhat remote and rather fragile but attractive natural assets. In general, the case study results strongly indicate that interpretation tools can greatly assist in the conservation of geoheritage sites – that is, geoconservation. This is very much in keeping with the truism expressed some twenty years ago by the Greek geoconservationist Irini Theodossiou-Drandaki (2000) that there is »no conservation without education.« Although she touched upon environmental interpretation, she particularly focused on formal education and significantly noted that »listing a site will not guarantee its conservation and protection. This can only be accomplished by touching everybody's awareness and especially that of young people, who, learning of their home's geological heritage, will appreciate its value and will consequently protect it.« Environmental interpretation, as advocated by Tilden (1977) – with its emphasis on not just providing educational information but on building empathy by revealing meanings and relationships through illustrative media such as outdoor panels – appears to have been validated by the respondents' preferences in this case study.

ACKNOWLEDGMENT: This work was supported by the Ministry of Education, Science, and Technological Development, Republic of Serbia (grant 176020).

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Acta geographica Slovenica, 61-2, 2021, 23–40

AN INTEGRATED SWOT – EXTENDED PIPRECIA MODEL FOR IDENTIFYING KEY DETERMINANTS OF TOURISM DEVELOPMENT: THE CASE OF SERBIA

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Lešje Monastery near Paraćin, Serbia.

DOI: https://doi.org/10.3986/AGS.9271
UDC: 338.486:004.652(497.11)
COBISS:1.01

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An integrated SWOT – extended PIPRECIA model for identifying key determinants of tourism development: The case of Serbia

ABSTRACT: This paper proposes a new integrated model based on SWOT and extended PIvot Pairwise RElative Criteria Importance Assessment (PIPRECIA) that offers a systematic approach to strategic planning in tourism. The applicability of the proposed integrated model is demonstrated through a case study defining the main determinants of tourism development in Serbia. The result emphasizes the strategy *Improving the organization, management, and enhancement of tourism development* as the highest priority for implementation. The model facilitates decision-making in tourism, and its key advantages are its suitability for application in group decision-making and its simplicity.

KEY WORDS: extended PIPRECIA method, SWOT, Serbia, strategy, tourism

Integrirani model za določanje ključnih determinant turističnega razvoja, ki temelji na analizi SWOT in razširjeni metodi PIPRECIA: primer Srbije

POVZETEK: V članku avtorji predlagajo nov integrirani model, ki temelji na analizi SWOT in razširjeni metodi PIPRECIA (*PIvot Pairwise RElative Criteria Importance Assessment*) ter omogoča sistematičen pristop k strateškemu načrtovanju v turizmu. Uporabnost predlaganega modela je predstavljena s študijo primera, v kateri avtorji določijo glavne determinante turističnega razvoja v Srbiji. Izsledki kažejo, da je med različnimi strategijami najpomembnejša tista, ki se osredotoča na izboljšanje organizacije, upravljanja in krepitve turističnega razvoja. Model omogoča lažje odločanje v turizmu, njegova ključna prednost pa je ta, da je primeren za skupinsko odločanje in preprost za uporabo.

KLJUČNE BESEDE: razširjena metoda PIPRECIA, analiza SWOT, Srbija, strategija, turizem

This paper was submitted for publication on November 10th, 2020.
Uredništvo je prejelo prispevek 10. novembra 2020.

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1 Introduction

Serbia is a landlocked Balkan country. Despite not having sea access, it has significant potential for developing and enhancing various kinds of tourism. Today, the development potential of rural tourism in Serbia has attracted the most attention among researchers (Todorović and Bjeljac 2009; Dimitrovski, Todorović and Valjarević 2012; Petrović et al. 2018). Apart from rural tourism, other types of tourism suitable for development have also been studied (Košić et al. 2011; Vasiljević et al. 2011; Vujičić et al. 2011; Dragićević et al. 2012; Dragičević et al. 2013; Blešić et al. 2014; Vujko and Plavša 2014; Božić and Tomić 2016; Pavluković, Stankov and Arsenović 2020). Mulec and Wise (2013) and Armenski, Dwyer and Pavluković (2018) have also examined the competitiveness of the Vojvodina region and Serbia as a whole as tourism destinations.

Improving tourism in Serbia requires determining its positive and negative aspects, which could drive or hinder further development. In addition to other data on tourism and predictions for the future, the Tourism Development Strategy of the Republic of Serbia 2016–2025 (2016) also contains a SWOT (strengths, weaknesses, opportunities, and threats) analysis. It clearly outlines the internal and external factors important for further tourism development, as well as strategies to take advantage of strengths and opportunities, avoid threats, and overcome weaknesses. Despite its benefits, the qualitative nature of SWOT analysis is a shortcoming. This can be overcome by combining SWOT analysis with appropriate multiple-criteria decision-making (MCDM) methods.

This article proposes applying the SWOT – extended PIvot Pairwise RElative Criteria Importance Assessment framework, or PIPRECIA (Stanujkic et al. 2017a). PIPRECIA is a newly developed MCDM method that is convenient for application in a group decision environment. The paper proposes the SWOT – extended PIPRECIA integrated model as a convenient tool for strategic planning in tourism. The applicability of the model is presented through a case study based on tourism development data from the Tourism Development Strategy of the Republic of Serbia 2016–2025 (2016). This model determines the key SWOT influential factors, and it prioritizes strategies to improve tourism in Serbia. The paper proposes a new model based on SWOT and the relatively recently introduced MCDM method, whose possibilities in strategic planning have not been tested yet.

2 Literature review

SWOT analysis is widely used in tourism to appraise internal (strengths and weaknesses) and external (opportunities and threats) factors important for assessing the market position of certain destinations, and it is the first phase in strategic planning and creating a strategy. The applicability of this technique has been shown in various studies (Abdi and Azadegan-Mehr 2011; Sariisik, Turkay and Akova 2011; Ghazinoory, Reihanian et al. 2012; Cetin 2015; Gürel and Tat 2017; Cetin et al. 2018). Although SWOT analysis is the starting point in strategic planning, it is sometimes criticized for leading to the creation of unsuitable strategies (Hill and Westbrook 1997; Kurttila et al. 2000; Helms and Nixon 2010; Vlados 2019). Such criticism mainly addresses its qualitative nature, inability to express factors quantitatively, and inability to determine which factor has a decisive impact (Kajanus et al. 2012). These shortcomings can be resolved by applying MCDM methods.

MCDM methods have become increasingly popular in recent decades, having been applied in many different research areas (Zavadskas and Turskis 2011; Gavade 2014; Zavadskas, Turskis and Kildienė 2014; Stojčić et al. 2019). They are especially convenient for application in situations where a greater number of criteria are included, against which the decision-maker (DM) should perform the evaluation process and make the final decision (Stanujkic et al. 2017b; Stanujkic et al. 2017c; Popovic, Stanujkic and Karabasevic 2019). These techniques are useful in facilitating decisions and increasing the reliability of decisions. In addition to resolving various business problems, MCDM methods are also used to facilitate decisions in tourism with regard to policy (Liu, Tzeng and Lee 2012; Michailidou, Vlachokostas and Moussiopoulos 2016), competitiveness (Wu 2011; Zhang et al. 2011; Huang and Peng 2012; Gómez-Vega and Picazo-Tadeo 2019), sustainable tourism and ecotourism (Michalena, Hills and Amat 2009; Aliani et al. 2017; Arsić, Nikolić and Živković 2017), location and destination selection (Chou, Hsu and Chen 2008; Cheng, Su and Tan 2013; Morteza et al. 2016; Aksoy and Ozbuk 2017; Puška, Stojanović and Maksimović 2019), service quality

(Rozman et al. 2009; Tseng 2011; Zoraghi et al. 2013; Wu and Wang 2014), and website quality (Hu 2009; Akincilar and Dagdeviren 2014; Stanujkic, Zavadskas and Tamošaitienė 2015; Stanujkic et al. 2017b).

Combining one of these methods with SWOT analysis creates a hybrid model, preserving the benefits of SWOT analysis and eliminating the shortcomings explained above. The most popular and most frequently used hybrid model is the A'WOT model, based on combining SWOT analysis and the Analytic Hierarchy Process or AHP method (Saaty 1980). This model is often applied in strategic planning in tourism (Kajanus, Kangas and Kurttila 2004; Mimović, Kocić and Milanović 2012; Akbulak and Cengiz 2014; Nikolić et al. 2015; Demir, Esbah and Akgün 2016). In addition to the A'WOT model, other combinations of the MCDM methods and SWOT analysis have also been proposed as a decision-making aid in tourism (Arsić, Nikolić and Živković 2017; Ajmera 2017; Abadi et al. 2018; Khan 2018; Popović, Milovanović and Stanujkić 2018; Jiskani et al. 2020).

The extended PIPRECIA method is an improved version of the Step-Wise Weight Assessment Ratio Analysis or SWARA method (Keršuliene et al. 2010). It retains the benefits of the SWARA method and ameliorates its shortcomings. The SWARA method is not suitable for group decision-making environments, which may be its crucial disadvantage. This unsuitability arises from the fact that every DM should sort criteria according to their significance, which complicates obtaining the results from all DMs. The possibility that each DM could sort criteria in a different order makes evaluation more complex. Furthermore, the SWARA method does not anticipate consistency checking, and so the reliability of the results obtained is somewhat questionable.

Group decision-making requires a method that facilitates the process and is easy to apply. Extended PIPRECIA almost entirely meets these requirements. Namely, extended PIPRECIA does not require presorting of criteria. This method therefore automatically becomes more suitable for group decision-making. Then, the evaluation procedure is more straightforward than in the AHP method (Saaty 1980). The AHP method requires a more detailed explanation than extended PIPRECIA for DMs involved if they are unfamiliar with it. The AHP and extended PIPRECIA methods are similar in requiring consistency checking. For this purpose, consistency checking in extended PIPRECIA is conducted by using Pearson's or Spearman's correlation and by applying the bidirectional approach; that is, top-down and bottom-up evaluation of criteria. This bidirectional approach in consistency testing could be complicated for DMs because they have to change their way of thinking while evaluating criteria from both sides. It requires an analytic approach and measuring the importance that one particular criterion has in relation to the previous and next criterion (depending on the side the evaluation starts from). This manner of estimating criteria significance, however, contributes to the reliability of the results and the ranking order.

Extended PIPRECIA was used to facilitate decision-making in several areas. Plain PIPRECIA, which is an integral part of extended PIPRECIA, is very convenient for criteria weight determination (e.g., Karabasevic et al. 2019). Extended PIPRECIA was proposed for evaluating the quality of websites (Stanujkic, Karabasevic and Sava 2018) and for assessing consumer satisfaction with restaurant service (Stanujkic et al. 2019). Stević et al. (2018) also introduced a fuzzy extension of the PIPRECIA method that is also used in the decision process (Đalić et al. 2020a; Đalić et al. 2020b; Memiş et al. 2020; Vesković 2020). Extended PIPRECIA is applied for selecting an adequate mining method (Popović, Đorđević and Milanović 2019). In tourism, extended PIPRECIA is used to prioritize projects for developing accommodation facilities (Popović and Mihajlović 2018) and for ranking sustainable indicators for cultural heritage sites (Popovic et al. 2019).

This indicates that there is enough room to further examine and test the possibilities of extended PIPRECIA. Moreover, no examples of a combination of SWOT analysis and extended PIPRECIA have been found in tourism.

3 Methodology

Developing the integrated model is performed in two phases. The first phase involves preliminary evaluation of the SWOT factors using the PIPRECIA method, determining the five most important ones from each group, and defining the appropriate strategies. The main reason for selecting five is to avoid an excessive example that would exacerbate the understanding of the proposed approach. The second phase develops and applies the extended model based on the SWOT technique and extended PIPRECIA. Figure 1 shows the guiding concept of building the integrated SWOT – extended PIPRECIA model. The crucial benefits and main shortcomings of both techniques are examined below.

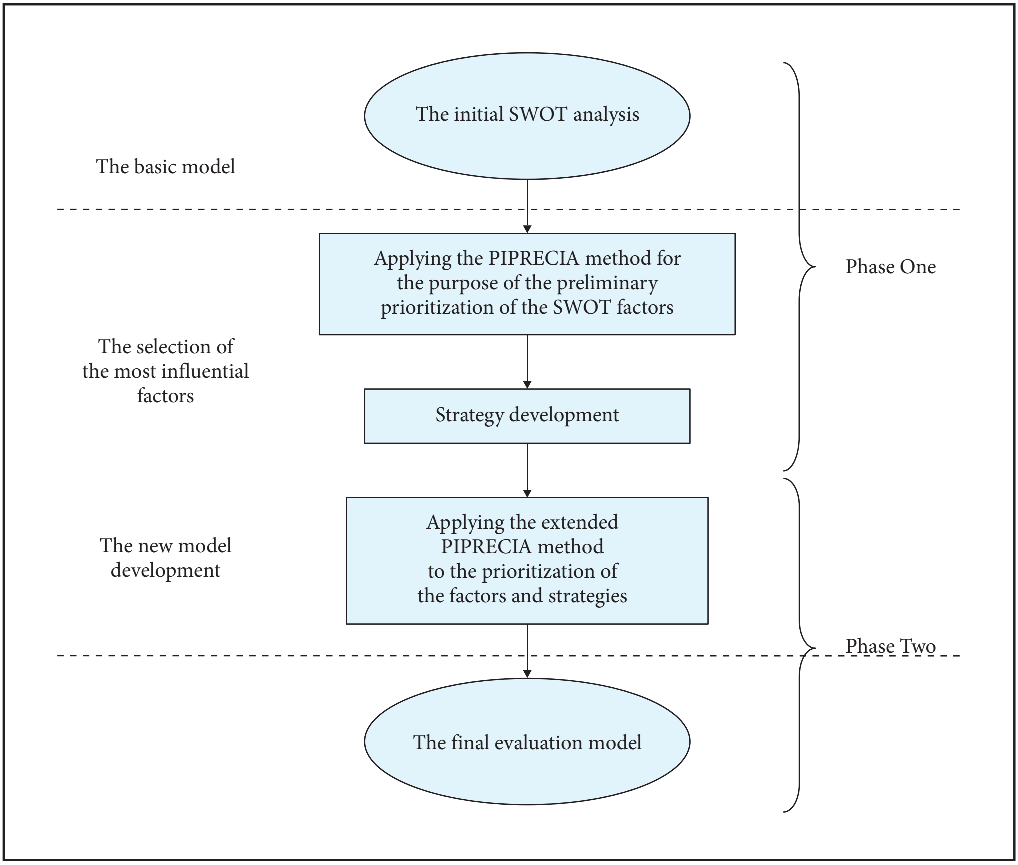

Figure 1: The proposed methodology.

3.1 SWOT analysis

SWOT analysis gained popularity because it makes it possible to simultaneously scan internal strengths and weaknesses and external opportunities and threats for proper diagnosis of a current state to develop an appropriate strategy.

Although SWOT analysis could be considered an inevitable technique for screening a business situation and determining convenient strategies, some consider it to have certain flaws (Kurttila et al. 2000; Yüksel and Dagdeviren 2007; Kajanus et al. 2012).

In the present case, a SWOT analysis was used in the first phase to evaluate opportunities for tourism development in Serbia. The SWOT analysis is very extensive and contains many SWOT factors. To avoid complexity, the evaluation is divided into two phases. In the first phase, the five most influential factors from each group are determined based on the complete list of SWOT factors. A questionnaire was distributed to six private hotel managers and eight tourist board managers for selected municipalities. Complete data for further processing were obtained from five DMs (three tourist board managers and two hotel managers), which showed how the model can be used in a group decision environment. The significance of all SWOT factors was determined by applying the PIPRECIA method. In this phase, DMs defined the strategies that best meet the advantages and disadvantages of tourism development in Serbia. The five most influential factors from each group and proposed strategies were the entry data for phase two.

3.2 Extended PIPRECIA

Extended PIPRECIA (Stanujkic et al. 2017a), which includes the PIPRECIA and inverse PIPRECIA methods, was used in the second phase of evaluating opportunities for tourism development in Serbia. The five DMs assessed the given factors and strategies individually by using extended PIPRECIA. The overall significance of the factors and strategies were then determined and, by multiplying the results obtained, the importance of degrees of strategies were determined. The computational procedure, based on Stanujkic et al. (2017a), is presented below.

***Step* 1.** Select the criteria for evaluation. In this case, the criteria are SWOT factors and strategies.

***Step* 2.** Determine the relative significance s_j starting from the second criterion in the following manner:

$$s_j = \begin{Bmatrix} >1 & when & C_j \succ C_{j-1} \\ 1 & when & C_j = C_{j-1} \\ <1 & when & C_j \prec C_{j-1} \end{Bmatrix}, \tag{1}$$

where s_j denotes the significance of criterion j, C_j denotes the importance of criterion j, and C_{j-1} denotes the importance of the previous criterion.

This means that s_j has values greater than 1 when C_j dominates a previous criterion C_{j-1}; that is, when it is more important than the previous criterion, whereby a higher value of s_j means a higher level of dominance and $s_i = (1,1.8]$. Similarly, s_j has a value less than 1 when the criterion C_j is dominated by C_{j-1} and then $s_i = (1,0.2]$. Finally, s_j has a value of 1 when both criteria are of the same importance.

***Step* 3.** Calculate the adjusted significance k_j as follows:

$$k_j = \begin{Bmatrix} 1 & j=1 \\ 2-s_j & j>1 \end{Bmatrix}. \tag{2}$$

where k_j denotes the adjusted significance of criterion j.

***Step* 4.** Define the relative adjusted significance q_j by using Eq. (3):

$$q_j = \begin{Bmatrix} 1 & j=1 \\ \frac{q_{j-1}}{k_j} & j>1 \end{Bmatrix}. \tag{3}$$

where q_j denotes the relative adjusted significance of criterion j.

***Step* 5.** Determine the relative weights w of the estimated criteria j in the following manner:

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_k}, \tag{4}$$

where w_j denotes the relative weight of criterion j.

***Step* 6.** Compute the inverse relative significance s'_j starting from the penultimate criterion as follows:

$$s'_j = \begin{cases} >1 & when & c_j > c_{j+1} \\ 1 & when & c_j = c_{j+1} \\ <1 & when & c_j < c_{j+1} \end{cases}. \tag{5}$$

***Step* 7.** Define the inverse adjusted significance k'_j in the following manner:

$$k'_j = \begin{cases} 1 & j = n \\ 2 - s'_j & j < 1 \end{cases}. \tag{6}$$

***Step* 8.** Determine the inverse relative adjusted significance q'_j by using the following equation:

$$q'_j = \begin{cases} 1 & j = n \\ \dfrac{q'_{j+1}}{k'_j} & j < n \end{cases}. \tag{7}$$

***Step* 9.** Detect the inverse relative weights of the evaluated criteria as follows:

$$w'_j = \frac{q'_j}{\sum_{k=1}^{n} q'_k}, \tag{8}$$

where w'_j denotes the inverse weight of criterion *j*.

***Step* 10.** Confirm the reliability of the results obtained by using Spearman's rank correlation coefficient:

$$\rho = 1 - \frac{6\sum_{i=1}^{n} d_j^2}{n(n^2-1)}, \tag{9}$$

where denotes the correlation coefficient, d_j denotes the distance between the ranks of w_j and w'_j, *n* is the number of criteria, and $\rho \in = (-1,1]$.

***Step* 11.** The total weight of the criteria is computed by applying the following equation:

$$w''_j = \frac{1}{2}(w_j + w'_j), \tag{10}$$

where w''_j denotes the complete weight of criterion *j*.

***Step* 12.** When the decision process is performed in a group environment, then the final weights of the criteria are obtained in the following manner:

$$w^*_j = \left(\prod_{r=1}^{R} w_j^{nr} \right)^{1/R}, \tag{11}$$

$$w_j = \frac{w^*_j}{\sum_{j=1}^{n} w^*_j}, \tag{12}$$

where w^{nr}_j denotes the weight of criterion *j* obtained from respondent *r*, *R* is the number of the respondents, w^*_j is the group weight of criterion *j* before adjustment to fulfill the condition $\sum_{j=1}^{n} w_j = 1$, and w_j is the final group weight of criterion *j*.

4 Results

This section presents the results of the evaluation procedure. In using the proposed framework, the most influential SWOT factors are determined and strategies that will lead to a better position for Serbia on the global tourism market are emphasized.

4.1 Preliminary evaluation: phase one

This preliminary evaluation is performed by using the plain PIPRECIA method, which is part of extended PIPRECIA. The computational procedure is performed by using equations (1)–(4) and equations (11)–(12). The results obtained, as well as the proposed strategies, are presented in Table 1.

Table 1: SWOT matrix for developing tourism in Serbia (Tourism Development Strategy 2016).

Internal factors	
Strengths (S)	Weaknesses (*W*)
S_1 – Various resources and the tourist attraction structure in Serbia as the basis for developing a diversified tourist product portfolio. S_2 – A modern legal framework for planning tourism destinations. S_3 – A continuous trend of increasing overnight stays by foreign tourists in Serbia, primarily in Belgrade. S_4 – Internationally positioned and professionally organized events that raise tourists' awareness of Serbia as a tourism destination. S_5 – Several airfields that could become usable for low-budget air companies by making a small investment.	W_1 – Disrespect for environmental protection measures in protected natural areas, neglecting structures and monuments under state protection, numerous examples of squalor, environment pollution, and space degradation, and insufficient coordination of tourism development and environment protection. W_2 – A low budget for promoting tourism in Serbia. W_3 – Enterprises operating in tourism and hospitality are insufficiently informed about EU funds and do not make use of them. W_4 – The inadequate domestic internet platform and information and communications technology (ICT) applications for promoting tourist attractions, virtual guides, and presentations. W_5 – Serbia's competition further lagging behind and losing a potential market.
External factors	
Opportunities (*O*)	Threats (*T*)
O_1 – Serbia's foreign policy: abolishing visas and visa facilitation for some countries; facilitating visa issuance at the border (for Turkey and China). O_2 – Changing habits and tourist motivations on the global market and seeking new experiences, attractions, and products, and a preserved environment. O_3 – Using resources for social programs for the staff surplus in public administration for work reintegration in tourism. O_4 – Dynamic growth and development of air transport and reaching new destinations. O_5 – Strengthening regional cooperation and creating regional tourism products for better positioning of tourism and attracting tourists from distant overseas markets.	T_1 – Political tensions in the Balkans. T_2 – Losing the opportunity to use government reforms and abandoning the longstanding policy of exclusively supporting public institutions. T_3 – Abandoning the sale or licensing of every unprofitable property whose owner is Serbia or public enterprises in tourism, which could be used for supporting current or new small and medium-sized enterprises. T_4 – Lack of management and coordination reforms in developing tourism in Serbia. T_5 – Disconnected and uncoordinated activity in implementing the Strategy and Action Plan for the Implementation of the Tourism Development Strategy of the Republic of Serbia 2016–2025.
Strategies	
SO strategy	*ST* strategy
SO_1 – Improving tourist and traffic infrastructure in Serbia. SO_2 – Improving tourist products and services in Serbia.	ST_1 – Improving the organization, management, and enhancement of tourism development.
WO strategy	*WT* strategy
WO_1 – Improving human resources and the labor market.	WT_1 – Networking with other sectors. WT_2 – Improving the national tourism marketing system.

After defining the most influential factors and forming strategies, the final evaluation procedure with extended PIPRECIA is performed in phase two.

4.2 Final evaluation: phase two

Table 2 shows the priorities for each SWOT group computed by applying Eqs. (1)–(12). The reliability of the responses is checked with Spearman's coefficient and, based on the results, the DMs' responses are fully justified and consistent in all iterations.

Table 2: Importance degrees of SWOT groups.

	w''^{1}_{j}	w''^{2}_{j}	w''^{3}_{j}	w''^{4}_{j}	w''^{5}_{j}	w_j
S	0.2173	0.2437	0.2689	0.2035	0.3106	0.2459
W	0.3545	0.2437	0.2689	0.1912	0.2535	0.2572
O	0.2508	0.2563	0.2195	0.2937	0.2070	0.2436
T	0.1775	0.2563	0.2427	0.3116	0.2289	0.2394
ρ	1.00	1.00	1.00	0.80	1.00	

The overall results obtained by using equations (11)–(12), however, show that the Weaknesses Group is assigned the highest priority.

The importance degrees for the factors from the Strengths Group are determined by using Eqs. (1)–(12), and the results are presented in Table 3. The equations are used to determine the further results.

The importance degrees show that the most significant factor from this group is S_5 – *Several airfields that could become usable for low-budget air companies by making a small investment* (Table 3).

Table 3: Importance degrees of the Strengths Group.

	w''^{1}_{j}	w''^{2}_{j}	w''^{3}_{j}	w''^{4}_{j}	w''^{5}_{j}	w_j
S_1	0.1193	0.2241	0.2253	0.2881	0.1455	0.1907
S_2	0.2268	0.1793	0.1840	0.1659	0.1455	0.1784
S_3	0.1847	0.1793	0.2034	0.1659	0.1981	0.1858
S_4	0.1351	0.1982	0.2034	0.2191	0.2426	0.1960
S_5	0.3341	0.2191	0.1840	0.1610	0.2683	0.2254
ρ	0.80	1.00	0.90	1.00	1.00	

The results obtained for the Weaknesses Group are presented in Table 4. The highest priority in this group is assigned to factor W_1, which is connected to disrespect for environmental protection measures in protected nature areas and neglecting state-protected structures and monuments.

Table 4: Importance degrees of the Weaknesses Group.

	w''^{1}_{j}	w''^{2}_{j}	w''^{3}_{j}	w''^{4}_{j}	w''^{5}_{j}	w_j
W_1	0.1811	0.2699	0.2122	0.2818	0.2570	0.2372
W_2	0.1543	0.2116	0.1919	0.1571	0.2098	0.1832
W_3	0.2053	0.2019	0.1919	0.1813	0.1898	0.1939
W_4	0.2597	0.1774	0.1919	0.2129	0.1717	0.2004
W_5	0.1995	0.1392	0.2122	0.1669	0.1717	0.1760
ρ	0.70	0.95	0.90	1.00	1.00	

Table 5 shows the results of evaluating factors from the Opportunities Group. In this case, the most influential factor is O_4 – *Dynamic growth and development of air transport and reaching new destinations.*

Table 5: Importance degrees of the Opportunities Group.

	w''^1_j	w''^2_j	w''^3_j	w''^4_j	w''^5_j	w_j
O_1	0.1559	0.2554	0.2164	0.1874	0.1759	0.1953
O_2	0.1337	0.2004	0.2164	0.2294	0.1945	0.1916
O_3	0.2013	0.1813	0.1767	0.1621	0.1759	0.1790
O_4	0.2970	0.1906	0.1953	0.2211	0.2155	0.2209
O_5	0.2122	0.1724	0.1953	0.2000	0.2382	0.2025
ρ	0.70	1.00	1.00	0.80	0.94	

Table 6 shows the local importance degrees for the Threats Group. It shows that the factor with the highest weight is T_4 – *Lack of management and coordination reforms in developing tourism in Serbia.*

Table 6: Importance degrees of the Threats Group.

	w''^1_j	w''^2_j	w''^3_j	w''^4_j	w''^5_j	w_j
T_1	0.2155	0.2588	0.1659	0.1778	0.2035	0.2018
T_2	0.1518	0.1898	0.2032	0.2349	0.2249	0.1986
T_3	0.1994	0.1898	0.2032	0.1918	0.2035	0.1975
T_4	0.2538	0.1898	0.2032	0.2215	0.1841	0.2090
T_5	0.1795	0.1717	0.2246	0.1739	0.1841	0.1858
ρ	0.70	1.00	1.00	0.90	0.94	

The factor priority within the groups and the overall factor priorities are presented in Table 7.

Table 7: Overall priority scores of SWOT factors.

SWOT group	Group priority	SWOT factors	Factor priority within group	Overall factor priority
S	0.2459	S_1	0.1907	0.0469
		S_2	0.1784	0.0439
		S_3	0.1858	0.0457
		S_4	0.1960	0.0482
		S_5	0.2254	0.0554
W	0.2572	W_1	0.2372	0.0610
		W_2	0.1832	0.0471
		W_3	0.1939	0.0499
		W_4	0.2004	0.0515
		W_5	0.1760	0.0453
O	0.2436	O_1	0.1953	0.0476
		O_2	0.1916	0.0467
		O_3	0.1790	0.0436
		O_4	0.2209	0.0538
		O_5	0.2025	0.0493
T	0.2394	T_1	0.2018	0.0483
		T_2	0.1986	0.0476
		T_3	0.1975	0.0473
		T_4	0.2090	0.0501
		T_5	0.1858	0.0445

Each of the six strategies considered are evaluated relative to each SWOT factor estimated as the most important in phase one. By multiplying these results by the overall factor priority, the importance degrees of the strategies are defined (Tables 8a and 8b).

Table 8a: Importance degrees of strategies according to SWOT factors.

	S_1	S_2	S_3	S_4	S_5	W_1	W_2	W_3	W_4	W_5
SO_1	0.1880	0.1499	0.1491	0.1421	0.1895	0.1187	0.1437	0.1259	0.1470	0.1632
SO_2	0.1874	0.1537	0.1620	0.1599	0.1638	0.1312	0.1600	0.1401	0.1490	0.1739
WO_1	0.1427	0.1590	0.1528	0.1522	0.1509	0.1403	0.1598	0.1489	0.1586	0.1601
WT_1	0.1373	0.1626	0.1635	0.1507	0.1562	0.1598	0.1645	0.1517	0.1620	0.1446
WT_2	0.1630	0.1705	0.1754	0.1956	0.1615	0.1920	0.1805	0.1791	0.1936	0.1743
ST_1	0.1816	0.2042	0.1971	0.1995	0.1782	0.2580	0.1915	0.2544	0.1898	0.1839

Table 8b: Priority scores of strategies according to SWOT factors.

	O_1	O_2	O_3	O_4	O_5	T_1	T_2	T_3	T_4	T_5
SO_1	0.1820	0.1744	0.1332	0.2083	0.1462	0.1690	0.1551	0.1528	0.1646	0.1890
SO_2	0.1907	0.1435	0.1679	0.1830	0.1517	0.1635	0.1713	0.1397	0.1519	0.1585
WO_1	0.1725	0.1434	0.1945	0.1469	0.1516	0.1689	0.1738	0.1636	0.1672	0.1584
WT_1	0.1517	0.1728	0.1712	0.1370	0.1616	0.1516	0.1634	0.1548	0.1583	0.1673
WT_2	0.1500	0.1876	0.1524	0.1553	0.1747	0.1748	0.1673	0.1771	0.1702	0.1611
ST_1	0.1531	0.1782	0.1809	0.1695	0.2141	0.1722	0.1691	0.2120	0.1877	0.1657

Table 9 shows the overall priority of the strategies considered. Figure 2 shows the final ranking order of the strategies evaluated.

Table 9: Overall priority of the strategies.

Strategy		Overall priority	Rank
SO_1	Improving tourist and traffic infrastructure in Serbia	0.1553	4
SO_2	Improving tourist products and services in Serbia	0.1556	3
WO_1	Improvement human resources and the labor market	0.1537	5
WT_1	Networking with other sectors	0.1528	6
WT_2	Improving the national tourism marketing system	0.1685	2
ST_1	Improving the organization, management, and enhancement of tourism development	0.1879	1

Figure 2 shows that the highest overall priority is assigned to strategy ST_1 – *Improving the organization, management, and enhancement of tourism development.* This result is fully justified, especially when taking into account the most influential factor from the Threats Group, T_4 – *Lack of management and coordination reforms in developing tourism in Serbia.* There is a need to seriously improve tourism management, modernize tourism organizations, and renovate tourism infrastructure. Based on the results, the strategy that should be implemented last is WT_1 – *Networking with other sectors.* This does not mean that this strategy is the least important, but that the appropriate conditions must be created that will allow the coordinated action of all sectors.

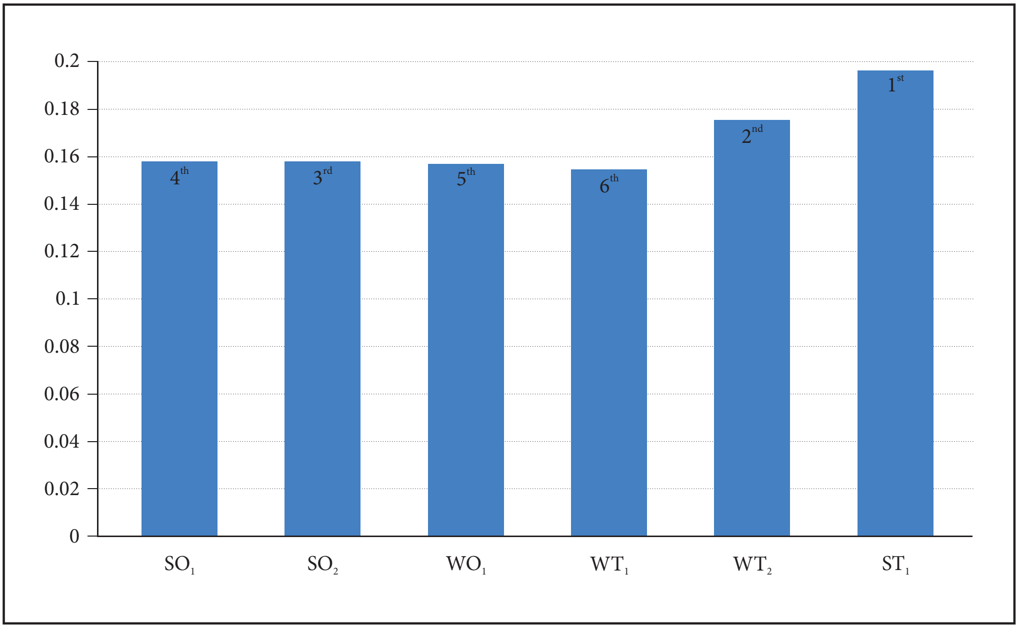

Figure 2: Final ranking order of strategies.

5 Discussion

The reason for proposing a model based on the SWOT and PIPRECIA methods is that, although SWOT analysis is a proven strategic tool, it has certain flaws. SWOT analysis has a qualitative nature and cannot reveal the importance of factors or their impact on the final decision (Yüksel and Dagdeviren 2007; Kajanus et al. 2012; Vlados 2019). This is resolved by combining the SWOT technique with extended PIPRECIA. This new integrated model clearly shows the significance of the SWOT factors as well as which of them is the most influential.

Compared to the A'WOT model, which is often used for prioritizing strategies (Kajanus, Kangas and Kurttila 2004; Akbulak and Cengiz 2014; Kişi 2019; Bottero, D'Alpaos and Marello 2020), the proposed integrated model has certain advantages. The proposed approach uses a decision-making procedure adjusted for a group decision environment and, although extended PIPRECIA is somewhat complicated, it is easy for respondents to understand.

The proposed model has certain benefits relative to the SWARA method, which is also used in combination with SWOT analysis (Popović, Milovanović and Stanujkić 2018). Although the SWARA method, which represents the core of extended PIPRECIA, has a computational procedure that is much easier, it is not suitable for a group decision environment. This is mainly because the SWARA method requires pre-sorting of the criteria considered, and so all DMs can give their ranking orders, which complicates obtaining the results. Extended PIPRECIA does not involve pre-sorting the criteria in the evaluation procedure, which facilitates gathering and calculating the results from a greater number of DMs. Furthermore, extended PIPRECIA predicts verifying the reliability of the results, which is not the case with the SWARA method.

The proposed model was applied to a case study examining the advantages and disadvantages of tourism in Serbia. The SWOT analysis used in this work is taken from the Tourism Development Strategy of the Republic of Serbia 2016–2025 (2016). Because this analysis contains many factors, the evaluation was conducted in two phases. In phase one, the five most important factors from each SWOT group were determined by using the PIPRECIA method and group decision-making. In phase two, the final priority scores of the factors and the final ranking of the strategies relative to the given factors were calculated. The evaluation process in both phases was entrusted to tourism experts, who are familiar with the tourism situation in Serbia. The strategy assigned priority under current conditions is strategy ST_1 *–Improving the organization, management, and enhancement of tourism development.* This is justified because, although Serbia has great tourism potential, it should improve organization and management in tourism and improve its position on the world tourism market.

Comparing the results with those obtained by other researchers shows a certain disparity among countries regarding the priority of strategies for tourism development. For example, Ajmera (2017) inferred that the *SO* strategy is the best choice for medical tourism development in India. Büyüközkan, Mukul and Kongar (2020) also emphasize the *SO* strategy for health tourism development in Istanbul, Turkey. Abadi et al. (2018) defined the *WO* strategy as the best for medical tourism in Iran. For ecotourism in Djerdap National Park in Serbia, the most important strategy is *ST*, as in our case (Arsić, Nikolić and Živković 2017). The fact that these studies focus on different types of tourism does not influence the conclusion that the methodology used does not affect the result but depends on the tourism situation in a given country. As stated, there are many issues to resolve in Serbian tourism, which leads to the result presented here.

In this particular case, decision-making is performed by five DMs. By involving a greater number of DMs from different tourism structures, the results are more reliable. It would be desirable to perform a new SWOT analysis taking into account the current situation caused by the COVID-19 pandemic. A disadvantage of the proposed model is the use of precise numbers. Decision-making is conducted in an environment characterized by uncertainty and vagueness, and so it is important to include this incertitude in the decision process. By introducing fuzzy sets (Atanassov 1986), gray systems (Deng 1982), or neutrosophic numbers (Smarandache 2005), the reliability of the analysis and the decisions will increase because the vagueness and uncertainty of the environment will be better included.

6 Conclusion

Decision-making in tourism and other research areas requires a methodical approach to achieve appropriate decisions. Mathematical tools such as MCDM methods are often used to increase the level of certainty of the decisions. As stated previously, this article proposes applying an integrated model based on SWOT analysis and extended PIPRECIA as a decision-making aid for strategic planning in tourism. The possibilities of the integrated model are tested using a case study to identify the key determinants for tourism development in Serbia. The results are appropriate and in line with current positions on tourism in Serbia.

By introducing the new integrated SWOT – extended PIPRECIA model, the theoretical and practical dimensions of MCDM are enhanced and the possibilities of its application are clearly outlined. The crucial advantages of the model lie in its suitability for application in a group-decision environment, its relatively simple and understandable procedure, and the systematic approach for DMs in identifying and implementing strategies for tourism development. Applying the integrated model to tourism in Serbia offers a completely different perspective from one based only on SWOT analysis. An obsolete and generalized SWOT analysis, the small number of DMs involved in the evaluation, and the use of precise numbers are the main limitations of this article.

As the literature review shows, the proposed model has not been widely explored and discussed yet, and so the directions for future research lie in examining this model in various research areas. Future research should also address integrating the model with rough, fuzzy, intuitionistic, or gray numbers. This would acknowledge the uncertainty that is always part of the decision process at a higher level.

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Acta geographica Slovenica, 61-2, 2021, 41–71

PRECIPITATION VARIABILITY, TRENDS AND REGIONS IN POLAND: TEMPORAL AND SPATIAL DISTRIBUTION IN THE YEARS 1951–2018

Robert Kalbarczyk, Eliza Kalbarczyk

Crowns of Scots pine trees in the clouds.

DOI: https://doi.org/10.3986/AGS.8846
UDC: 913:551.435.11:502.13(497.11)
COBISS: 1.01

Robert Kalbarczyk[1], Eliza Kalbarczyk[2]

Precipitation variability, trends and regions in Poland: Temporal and spatial distribution in the years 1951–2018

ABSTRACT: The goals of this work were to assess differences in precipitation totals (Pr) in Poland in both time and space and to distinguish regions based on precipitation variability in the years 1951–2018. To assess precipitation conditions, the study used statistical and spatial analyses implemented in ArcGIS Desktop and STATISTICA software. The largest number of significant, positive correlations describing the linear Pr trend were found for March. The lowest monthly Pr, which represents only approximately 6% of the multi-year precipitation totals, was recorded in October 1951; the highest monthly Pr, which represents as much as approximately 355% of the multi-year precipitation totals, was recorded in October 1974. The study distinguished three precipitation regions of Poland.

KEY WORDS: climate change, precipitation conditions, number of days with precipitation, precipitation regions, Poland.

Spremenljivost, trendi in območja padavin na Poljskem: časovna in prostorska porazdelitev med letoma 1951 in 2018

POVZETEK: V članku so proučene razlike v skupni količini padavin na Poljskem v času in prostoru, na podlagi česar so določena glavna padavinska območja med letoma 1951 in 2018. Padavinske razmere so ocenjene na podlagi statistične in prostorske analize, opravljene v programskih orodjih ArcGIS Desktop in STATISTICA. Največ statistično značilnih korelacij, ki nakazujejo linearni trend v skupni količini padavin, je bilo odkritih za mesec marec. Najmanjša mesečna skupna količina padavin (samo približno 6 % večletnega mesečnega povprečja) je bila zabeležena oktobra 1951, najvišja (približno 355 % večletnega mesečnega povprečja) pa oktobra 1974. Določena so tri padavinska območja na Poljskem.

KLJUČNE BESEDE: podnebne spremembe, padavinske razmere, število dni s padavinami, padavinska območja, Poljska

The paper was submitted for publication on August 3rd, 2020.
Uredništvo je prejelo prispevek 3. avgusta 2020.

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1 Introduction

Despite many years of research on climate change, there are no clear indications as to the direction and intensification of precipitation variability. The scenarios and models presented in the literature all assume a global, albeit varied, increase in air temperature. On the other hand, research results on the direction and range of precipitation (Pr) variability in the future (including in Poland) remain burdened with much higher uncertainty (Kundzewicz and Kozyra 2011; IPCC 2014; Kalbarczyk et al. 2018).

Analyses of historical data that contains precipitation totals and the number of days with precipitation or extreme precipitation values indicate that in the 20th century and at the turn of the 21st century there were no clear regularities in their patterns (Halimatou, Kalifa and Kyei-Baffour 2017; Pathak et al. 2018; Caloiero, Caloiero and Frustaci 2018). Many reports frequently point to the lack of a significant trend of precipitation totals in Europe; however, regional occurrences of both positive and negative Pr trends have been reported (Kundzewicz, Radziejewski and Pińskwar 2006; Labudová, Faško and Ivaňáková 2015; Łupikasza 2017). Also, previous research on the multi-year variability of Pr conducted for various regions of Poland did not produce any unambiguous results so it is not certain how it will develop in the future (Majewski, Przewoźniczuk and Kleniewska 2010; Żarski et al. 2014; Ilnicki et al. 2015; Ziernicka-Wojtaszek and Kopcińska 2020). Precipitation variability occurring in Central Europe is mostly explained by its dependence on atmospheric circulation, which determines the prevalence of continental or oceanic weather trends and shapes the global and regional climates (Degirmendžić, Kożuchowski and Żmudzka 2004; Twardosz, Niedźwiedź and Łupikasza 2011; Młyński, Cebulska and Wałęga 2018). Out of the remaining factors shaping precipitation variability in Poland research studies included e.g. the importance of cloud cover and terrain (Bokwa and Skowera 2008; Żmudzka 2009). Knowledge of precipitation variability is vital for many sectors of the economy. The sum of precipitation and its temporal distribution affect the functioning and development of, for example, agriculture, fisheries, forestry, water transport, hydropower generation and tourism, thereby influencing the quality of life in a given country (Kalbarczyk, Kalbarczyk and Raszka 2011; Marcinkowski and Piniewski 2018; Radzka, Jankowski and Jankowska 2019). Recognizing the degree of Pr variability is essential for climate risk management (Marković et al. 2014; Šebenik, Brilly and Šraj 2017; Młyński, Cebulska and Wałęga 2018; Stefanova et al. 2019; Ziernicka-Wojtaszek and Kopcińska 2020). Floods resulting from sudden atmospheric precipitation are one of the biggest climatic threats to cities (Pedrozo-Acuña et al. 2017; Szewrański et al. 2018; Olsson et al. 2019), therefore determination of precipitation trends can be useful when planning adaptation measures to climate change for urban and rural areas (Hardoy et al. 2014; Reckien et al. 2015; Chu, Anguelovski and Roberts 2017). Knowledge of precipitation variability in a multi-year and spatial perspective requires continuous updating, so research studies are conducted anew for the changing climatic conditions in various regions of the world.

The aims of this paper were to determine the temporal and spatial variability of precipitation and to distinguish regions of Poland based on specific variability of precipitation totals.

2 Materials and methods

The paper used daily precipitation totals which were collected at 74 meteorological stations located across Poland (Figure 1). Precipitation totals (Pr, mm) were calculated for each year in the analyzed period between 1951 and 2018 for each individual month in each of these years. The initial data were made accessible by the Polish Institute of Meteorology and Water Management which is responsible for systematic measurements and observations with the use of their basic network of stations and special-purpose measurement networks.

Single missing daily precipitation totals were added on the basis of complete measurement series from the nearest stations. Longer series of missing daily totals (at least 10 days long) were determined by means of linear or non-linear regression equations whose calculated determination coefficients described at least a 64% fit of the empirical data to the regression function.

Precipitation patterns were described with the following indices: the mean ($\bar{x}$), standard deviation (SD), variation coefficient (V), and extreme values, i.e. the minimum (MIN) and the maximum (MAX) calculated on the basis of all the analyzed annual periods and months during the entire analyzed 1951–2018 period (further accepted also as the norm). Spearman's coefficient (r) was used to describe the linear precipitation trend. Precipitation conditions for chosen 2 years and the 24 months with the lowest and highest

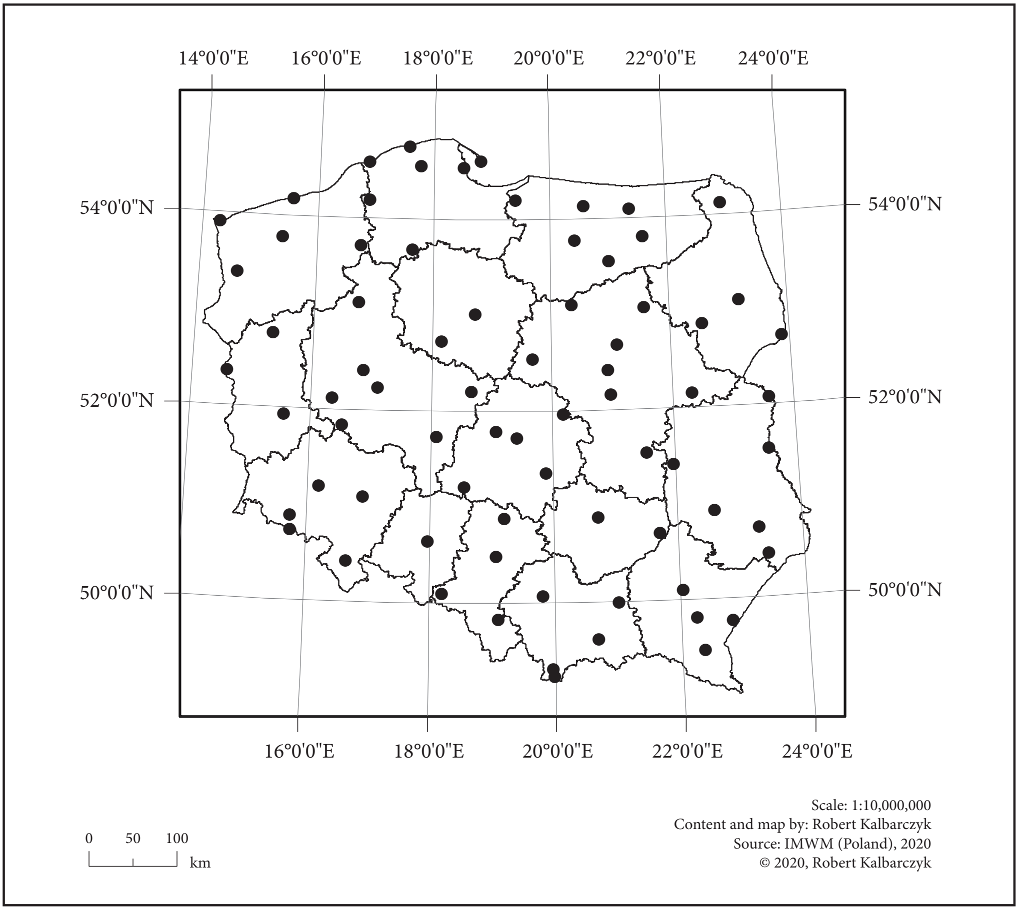


Figure 1: Locations of meteorological stations used in the research study.

precipitation totals were characterized by an index that expressed extreme values as a percentage of the sum of multi-year precipitation and the average number of days without precipitation (0.0) and with precipitation in the following ranges: 0.1–1, >1, >2, >5, >10, >20 and >50 mm (Olechnowicz-Bobrowska 1970; Bochenek 2020).

Maps presenting statistical characteristics of precipitation conditions in Poland in various time functions with a borders of the 16 administrative provinces were prepared using inverse distance weighting in *ArcGIS Desktop 10.6.1* software. Due to the fact that very high precipitation variability occurs in only one region of Poland, some maps were supplemented with a legend which does not use the same range of values in all intervals. Therefore, on the color scale the last two ranges of values were marked with grey and black. The legend showing the linear trend of precipitation totals gives critical values of Spearman's coefficient for $\alpha \leq 0.1$ and $\alpha \leq 0.01$, which amount to 0.201 and 0.311, respectively.

The regions in Poland with a similar variability of precipitation were determined on the basis of hierarchical clustering in 3 multi-year periods: 1951–1984 (the first half of the entire examined multi-year period), 1985–2018 (the second half of the entire examined multi-year period), and 1951–2018 (the whole examined multi-year period). The analysis took into consideration 24 variables: average multi-year precipitation totals and their average multi-year standard deviation values, both of which were calculated separately for each month for each meteorological station and each analyzed multi-year period. Before the analysis, the values of all variables (Z) were standardized according to the equation:

$$Z = \frac{(x_i - \bar{x})}{SD}$$

where x_i is the observed value of a variable from a given station in a given month and multi-year period, $\bar{x}$ is the arithmetic mean for all stations in a given month and multi-year period, and SD is the standard deviation from all stations in a given month and multi-year period.

The study used an agglomerative method of clustering to classify meteorological stations into groups so that the degree of correlation of a given station with stations from the same group would be possibly the strongest, and with stations from the remaining groups possibly the weakest. Distances between stations in multidimensional space were calculated by means of the city block distance (Manhattan distance), thanks to which the effect of outliers is reduced. Distances between new clusters were determined by Ward's method. The accepted measure of the linkage amounted to 110. The method aims to minimize the sum of the squared deviations of any two clusters which may be formed at any stage.

Regression and cluster analysis were carried out in *STATISTICA 13.3* software.

3 Results

3.1 Precipitation distribution

In 1951–2018, the average precipitation total (Pr) for the whole of Poland was approximately 634 mm (Table 1). In some months, Pr fluctuated from approximately 31 mm in February to approximately 90 mm in July. Pr of up to 40 mm was also recorded in January and March, and Pr of over 70 mm was recorded in June and August. The annual standard deviation for multi-year precipitation totals amounted to ~82 mm, but in February it was only ~13 mm, and in July as much as 34 mm. A high standard deviation of Pr, i.e. >25 mm, was calculated for August and October. The highest variability of precipitation, expressed by variation coefficient V, was characteristic of precipitation in October (60.5%), and the lowest – precipitation in June (27.3%), with the variability of annual precipitation sums at a level of 13%. A significant positive increase in Pr for the whole country was found only for March ($r=0.25$, $\alpha \leq 0.05$).

In Poland, the spatial distribution of average multi-year precipitation totals was very varied (Figure 2). The lowest Pr was observed in the central strip of Poland and amounted to <550 mm.

Precipitation increased latitudinally northwards and southwards, where the observed totals were the highest, namely >1300 mm. In some months, the spatial structure of Pr was slightly different than for the entire year (Figure 3).

Table 1: Characteristics of precipitation totals variability in Poland, 1951–2018.

	Characteristics		
Period / month	$\bar{x}$±SD	r	V
January–December	634.1±82.3	0.17^{ns}	13.0
January	36.3±15.0	0.15^{ns}	41.3
February	31.3±13.1	0.04^{ns}	41.9
March	35.4±13.5	0.25^{1}	38.1
April	41.0±14.4	-0.11^{ns}	35.1
May	62.5±20.3	0.03^{ns}	32.5
June	75.8±20.7	-0.07^{ns}	27.3
July	89.6±34.0	0.05^{ns}	37.9
August	72.0±25.1	-0.09^{ns}	34.8
September	56.3±23.7	0.11^{ns}	42.1
October	46.1±27.9	0.13^{ns}	60.5
November	44.9±16.4	0.01^{ns}	36.5
December	42.7±16.3	0.04^{ns}	38.2

Notes: $\bar{x}$ – arithmetic mean (mm), SD – standard deviation (mm), r – Spearman's correlation coefficient for a linear trend, V – coefficient of variation (%), ^{1} – significant at $\alpha \leq 0.05$, ^{ns} – non-significant at $\alpha \geq 0.1$

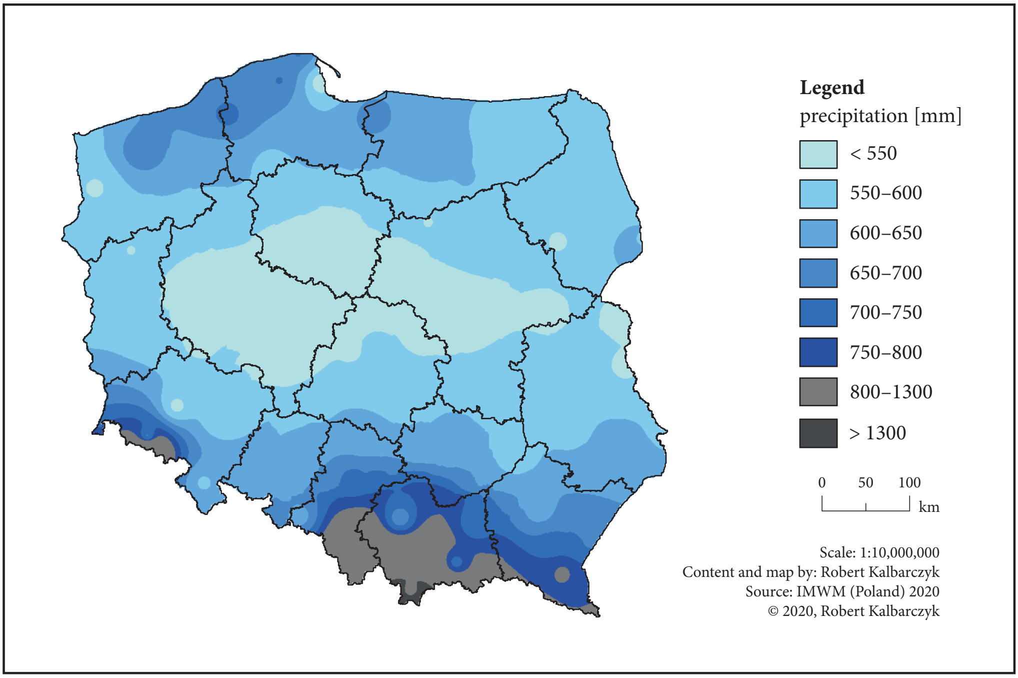


Figure 2: Spatial distribution of average multi-year annual precipitation totals in Poland, 1951–2018.

Figure 3: Spatial distribution of average multi-year precipitation [mm] totals by months in Poland, 1951–2018. ➤ p. 48–49

From January to March, the lowest value of precipitation (<30 mm) occurred mainly in central-east Poland; the highest, i.e. >80–90 mm, occurred in the southern part of the country. From April to June, the lowest Pr was observed in the Polish Plains (from <40 mm in April to <60 mm in May), and the highest was in the south (from >105 mm in April to >170 mm in June). In July, Pr oscillated from <80 mm to >180 mm, with the lowest values in the central-west and central-east parts; in August Pr oscillated from <60 to >150 mm, with the lowest values in central-west Poland; in September Pr oscillated from <50 to >110 mm, with the lowest values in the central-west part. In October in the central strip of Poland, which stretches horizontally, precipitation amounted to <40 mm; in the north and south it amounted to >85 mm. Finally, in November and December, a Pr of <40 mm occurred in central-east Poland, and a Pr of >90–95 mm occurred in the south.

3.2 Variability and precipitation trend

In 1951–2018, the annual standard deviation of Pr for whole of Poland fluctuated from <100 to >210 mm (Figure 4).

In the areas with the highest annual precipitation totals, the calculated standard deviation values (SD) were also the highest. In particular months, the standard deviation of Pr oscillated from <15 mm in January to >90 mm in July (Figure 5).

Figure 5: Spatial distribution of the standard deviation for monthly precipitation [mm] totals in Poland, 1951–2018. ➤ p. 50–51

The lowest SD was calculated for precipitation in 3 months: January, in some stations located in central Poland; February, in north-east and central Poland; March, in central Poland. The highest SD in all months was calculated for precipitation in the southern part of the country, i.e. in high-mountain areas, and also in October in the northern part of Poland. In the analyzed multi-year period, annual precipitation totals clearly decreased or increased only in some parts of Poland (Figure 6).

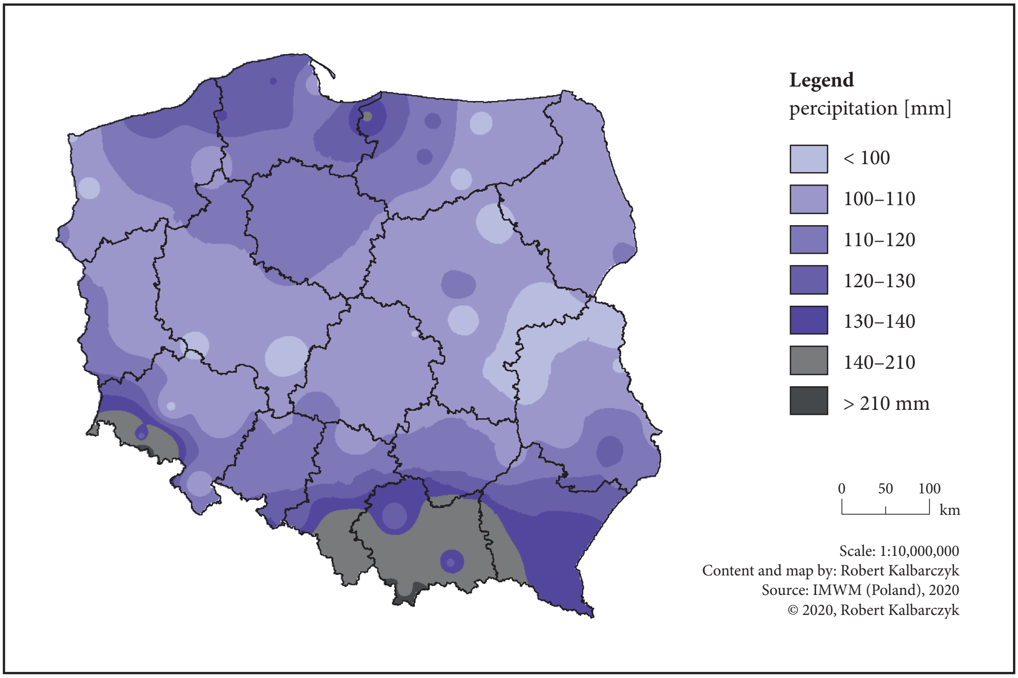


Figure 4: Spatial distribution of the standard deviation for annual precipitation totals in Poland, 1951–2018.

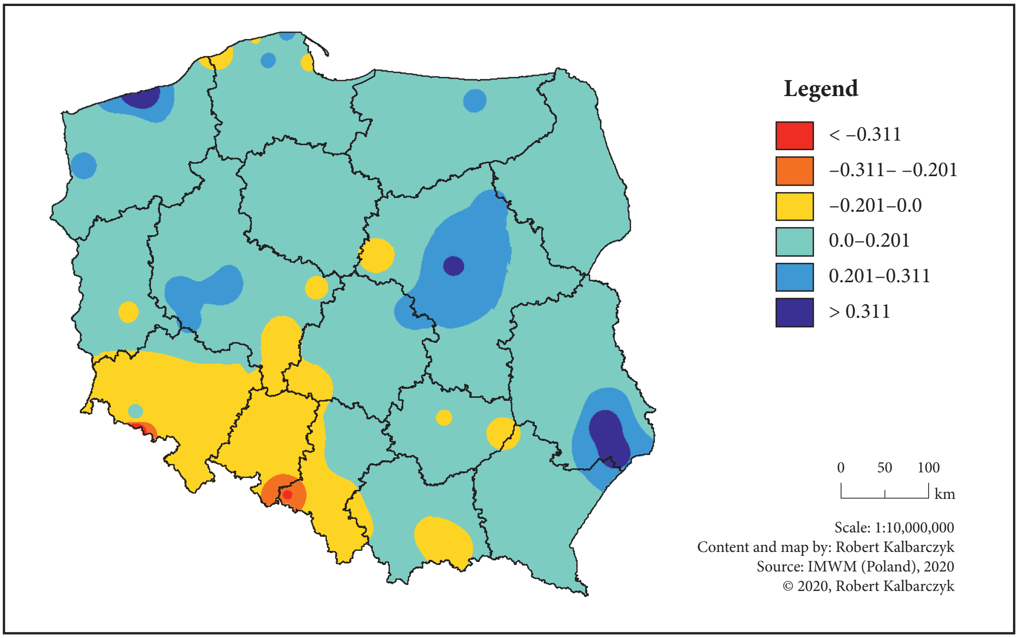
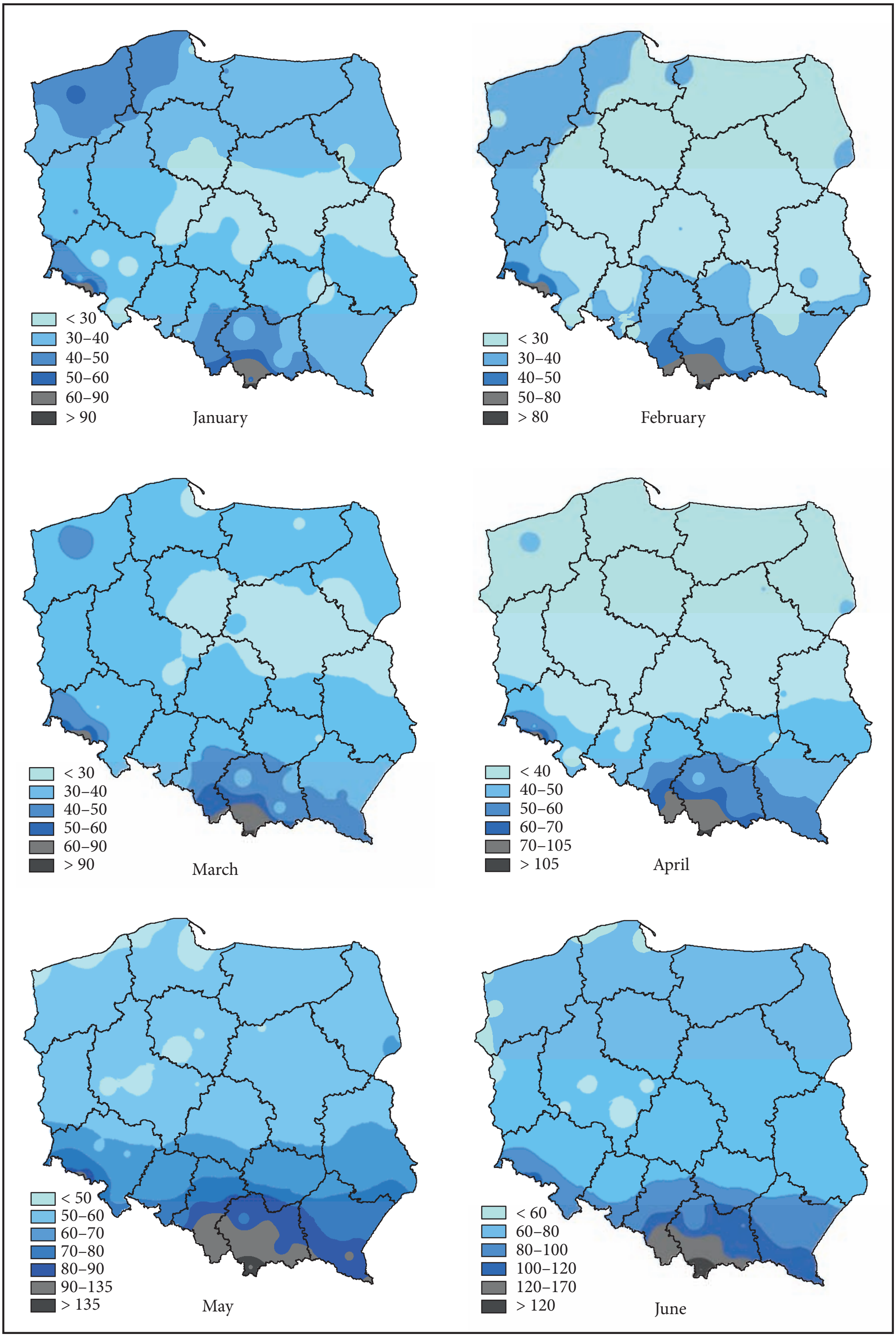
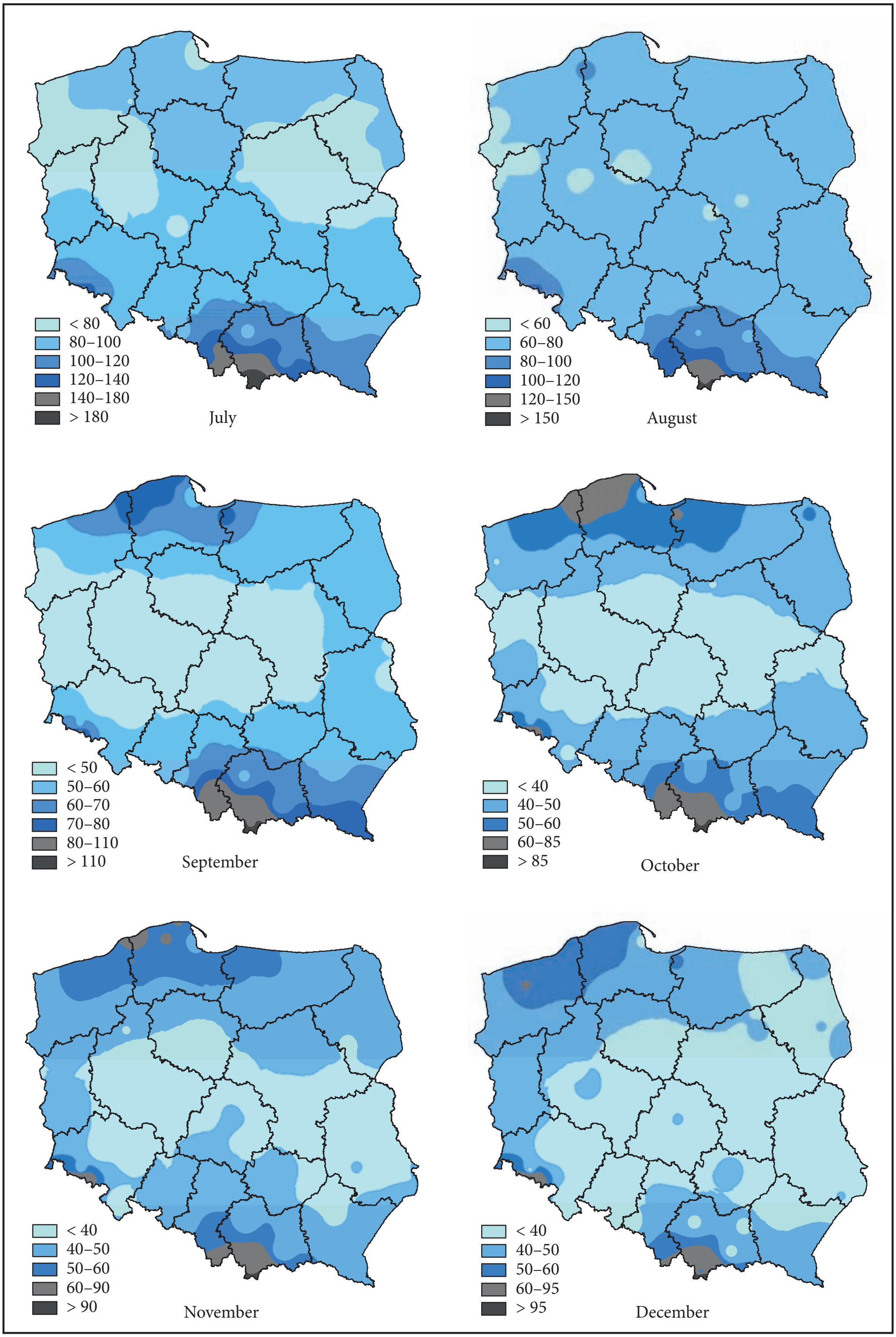


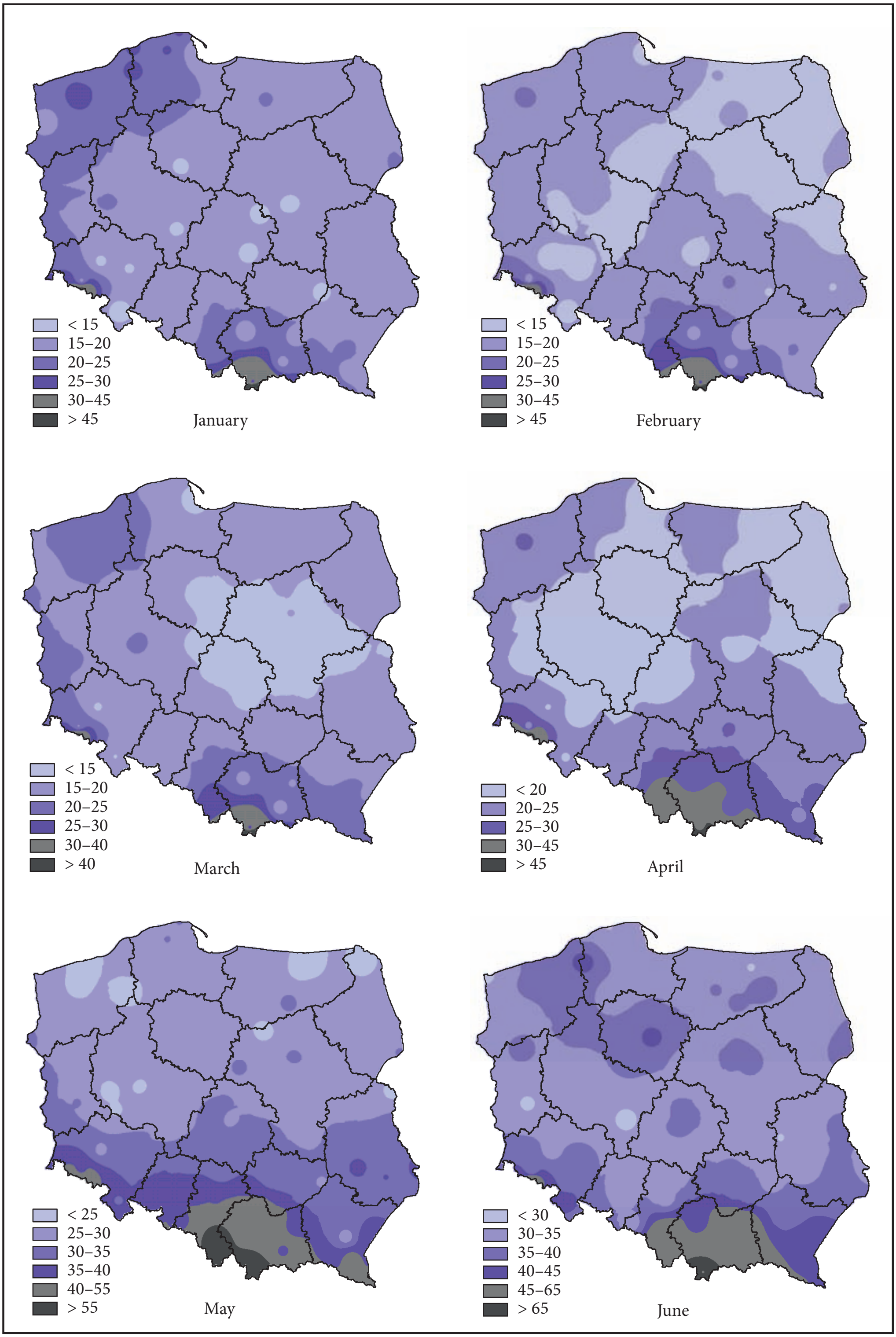
Figure 6: Spatial distribution of the Spearman correlation coefficient of the linear trend for annual precipitation totals in Poland, 1951–2018.

Figure 7: Spatial distribution of the Spearman correlation coefficient of the linear trend for monthly precipitation totals in Poland, 1951–2018. ➤ p. 52–53


< 30
30–40
40–50
50–60
60–90
> 90
January
< 30
30–40
40–50
50–80
> 80
February
< 30
30–40
40–50
50–60
60–90
> 90
March
< 40
40–50
50–60
60–70
70–105
> 105
April
< 50
50–60
60–70
70–80
80–90
90–135
> 135
May
< 60
60–80
80–100
100–120
120–170
> 120
June



< 80
80–100
100–120
120–140
140–180
> 180
July
< 60
60–80
80–100
100–120
120–150
> 150
August
< 50
50–60
60–70
70–80
80–110
> 110
September
< 40
40–50
50–60
60–85
> 85
October
< 40
40–50
50–60
60–90
> 90
November
< 40
40–50
50–60
60–95
> 95
December


< 15
15–20
20–25
25–30
30–45
> 45
January
< 15
15–20
20–25
25–30
30–45
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February
< 15
15–20
20–25
25–30
30–40
> 40
March
< 20
20–25
25–30
30–45
> 45
April
< 25
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May
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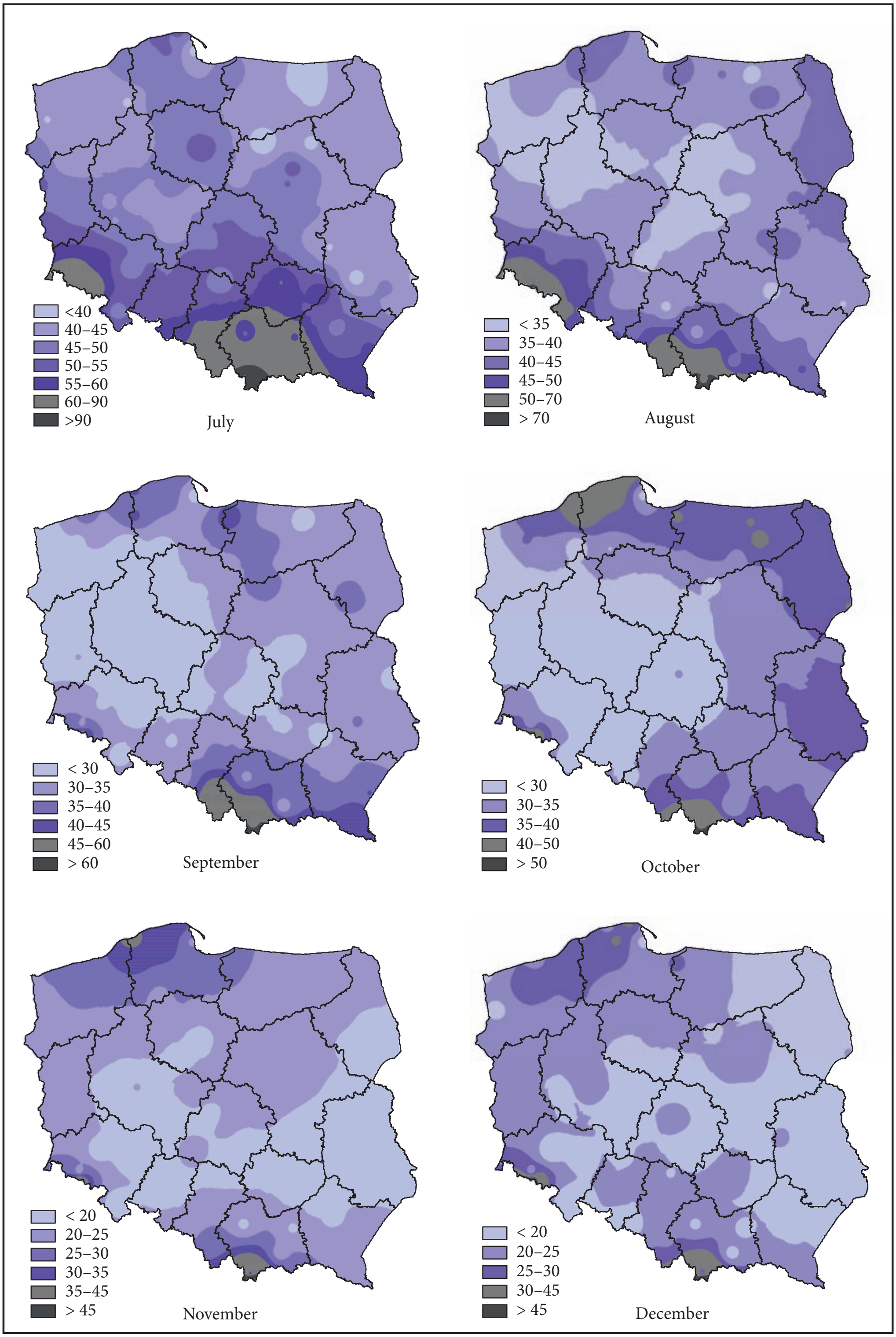
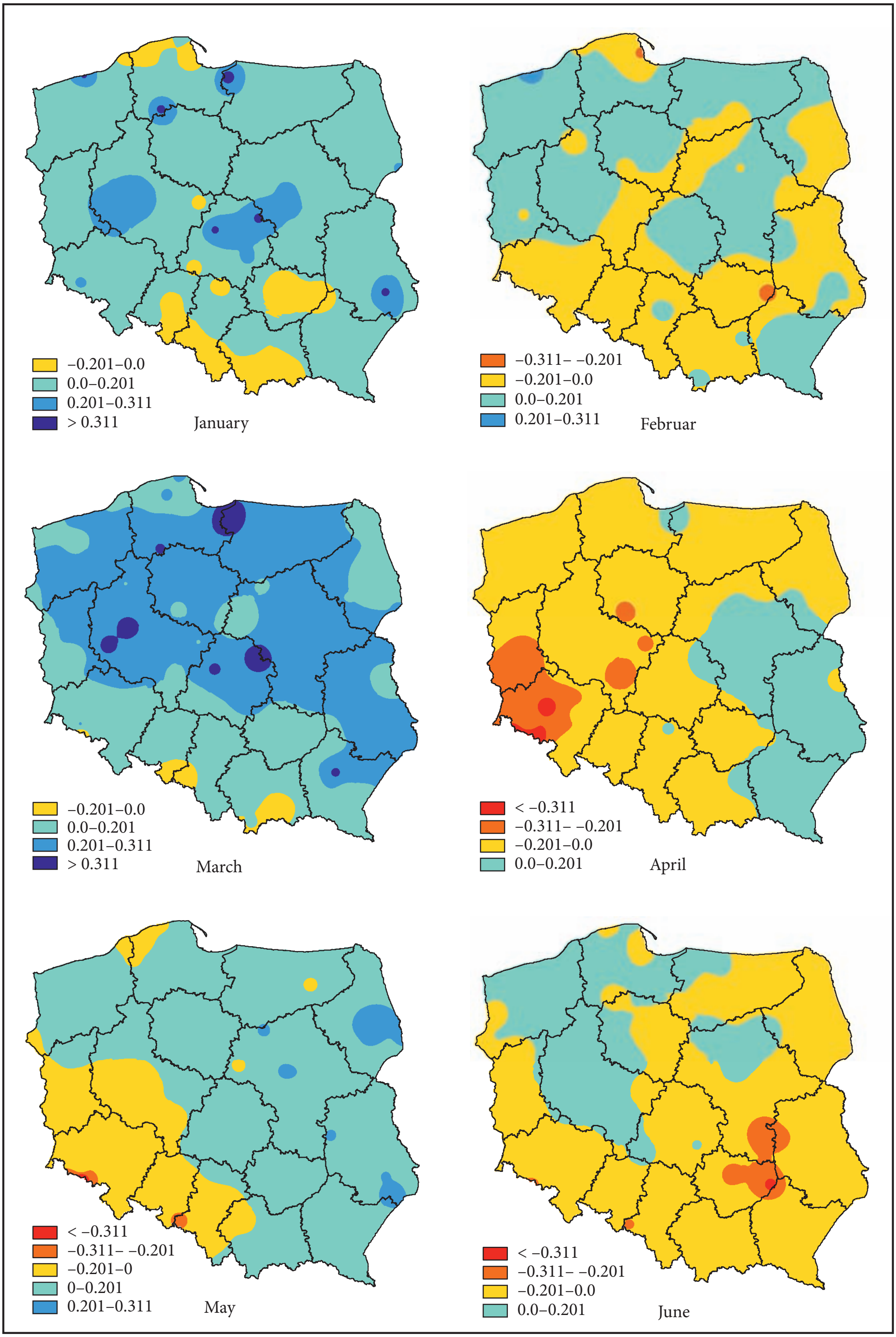
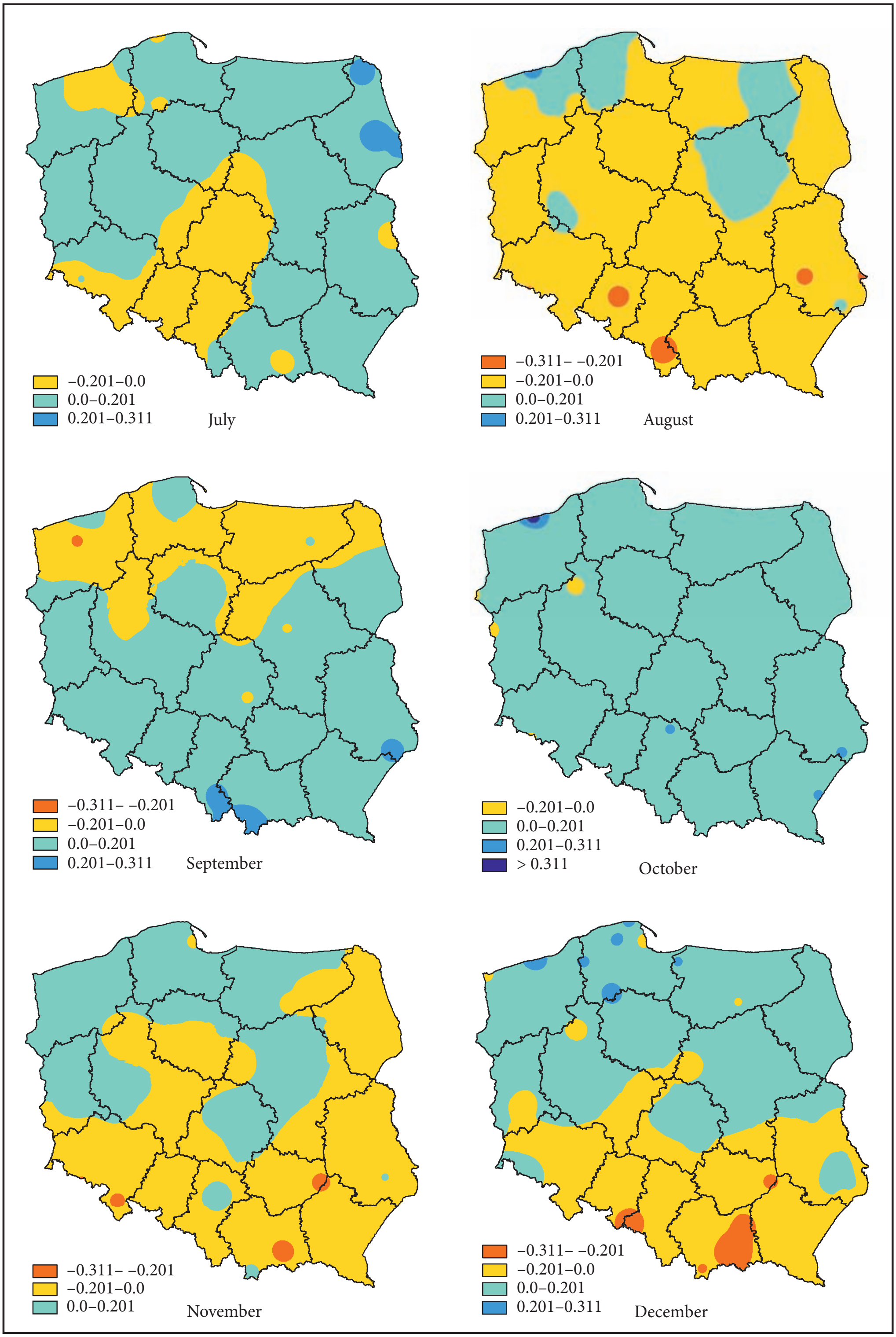
40–45
45–65
> 65
June



<40
40–45
45–50
50–55
55–60
60–90
>90
July
< 35
35–40
40–45
45–50
50–70
> 70
August
< 30
30–35
35–40
40–45
45–60
> 60
September
< 30
30–35
35–40
40–50
> 50
October
< 20
20–25
25–30
30–35
35–45
> 45
November
< 20
20–25
25–30
30–45
> 45
December


−0.201–0.0
0.0–0.201
0.201–0.311
> 0.311
January
−0.311– −0.201
−0.201–0.0
0.0–0.201
0.201–0.311
Februar
−0.201–0.0
0.0–0.201
0.201–0.311
> 0.311
March
< −0.311
−0.311– −0.201
−0.201–0.0
0.0–0.201
April
< −0.311
−0.311– −0.201
−0.201–0
0–0.201
0.201–0.311
May
< −0.311
−0.311– −0.201
−0.201–0.0
0.0–0.201
June


−0.201–0.0
0.0–0.201
0.201–0.311
July
−0.311– −0.201
−0.201–0.0
0.0–0.201
0.201–0.311
August
−0.311– −0.201
−0.201–0.0
0.0–0.201
0.201–0.311
September
−0.201–0.0
0.0–0.201
0.201–0.311
> 0.311
October
−0.311– −0.201
−0.201–0.0
0.0–0.201
November
−0.311– −0.201
−0.201–0.0
0.0–0.201
0.201–0.311
December

A significant (at least at a level of α≤0.1) positive Spearman's coefficient of ≥0.201 that was calculated for Pr was found, for example, in Masovia region (central-east), Roztocze region (south-east) and the central part of the Slovincian Coast (north-east). A significant negative Spearman's coefficient was found in small areas of south-west Poland.

In March, a significant positive increase in Pr was found in northern and central Poland (Figure 7). An increase in Pr was found for 8 months, mainly in northern and eastern Poland: January, February, May, July, August, September, October and December. A significant decrease in Pr in 1951–2018 was proved in a small area of the country, mainly in western and southern Poland, also in 8 months: February, April, May, June, August, September, November and December.

3.3 The lowest and highest precipitation

The lowest and highest annual precipitation totals in the entire analyzed multi-year period were respectively recorded in 1982 and 2010, amounting to approximately 454 and 852 mm (Figure 8).

In subsequent months of the year (Figure 9), the highest Pr values in some months occurred in different years than the lowest totals. The lowest annual precipitation total in Poland, which was recorded in 1982, constituted ~72% of the multi-year precipitation average (Table 2).

In that dry year, precipitation was not recorded on ~233 days. For ~53 days, Pr values were within a range of 0.1–1 mm, and for ~79 days they were >1 mm. In 1982, the average number of days with precipitation of >5, >10, >20 and >50 mm amounted to 27.9, 10.0, 2.4 and 0.1 days, respectively. In some months,

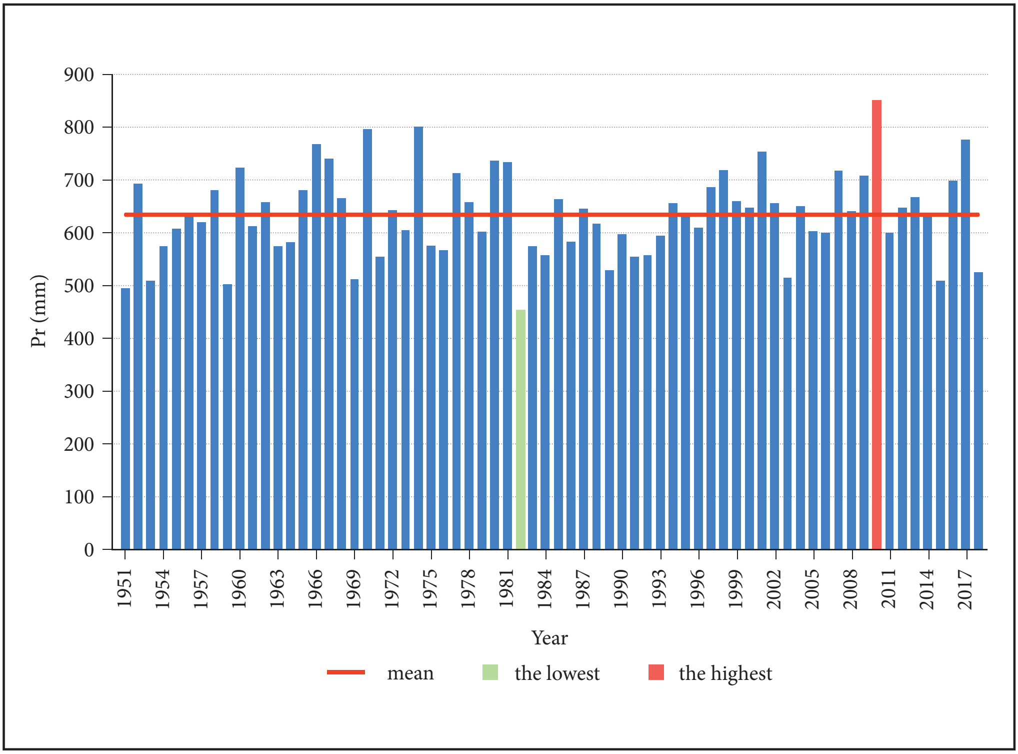
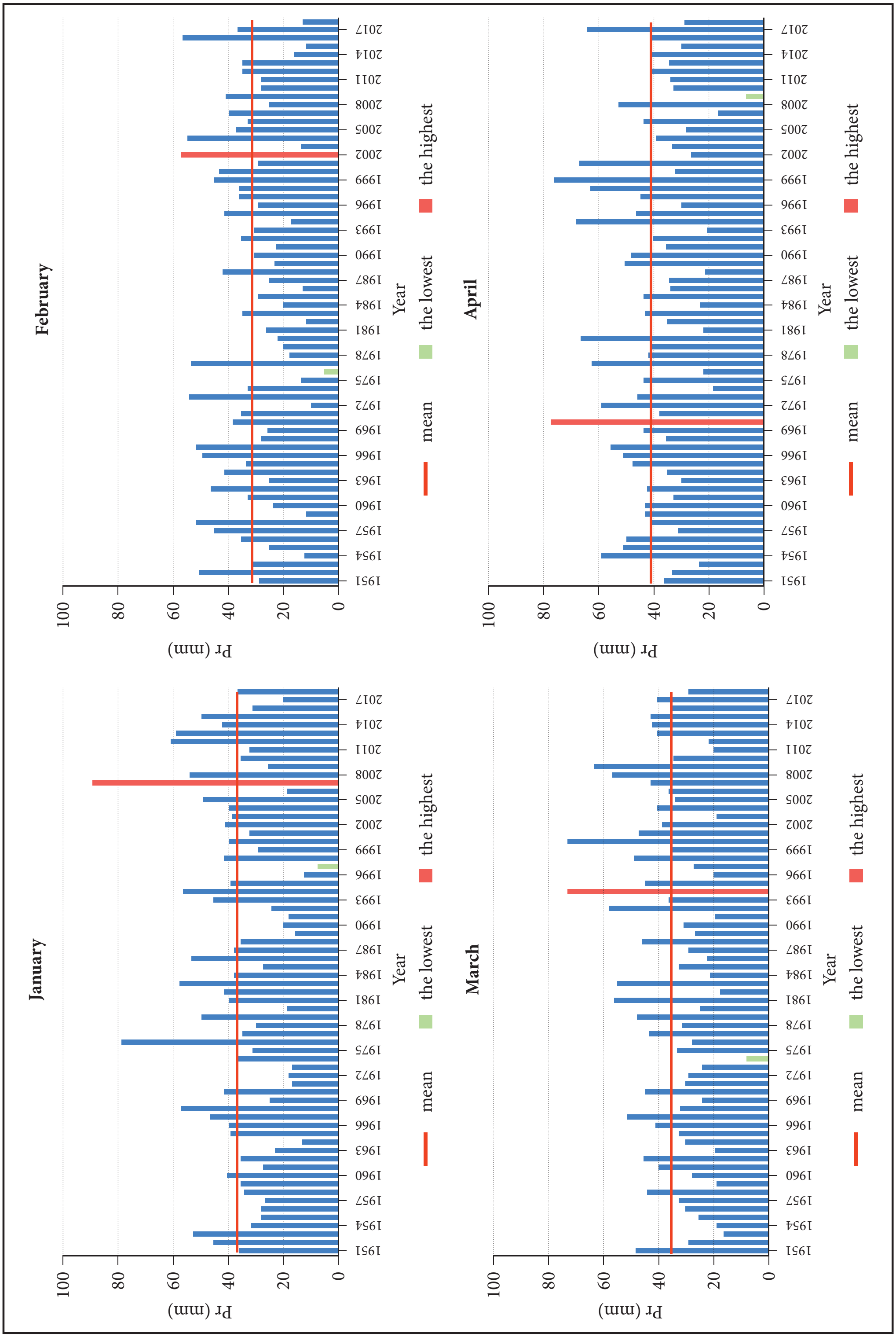
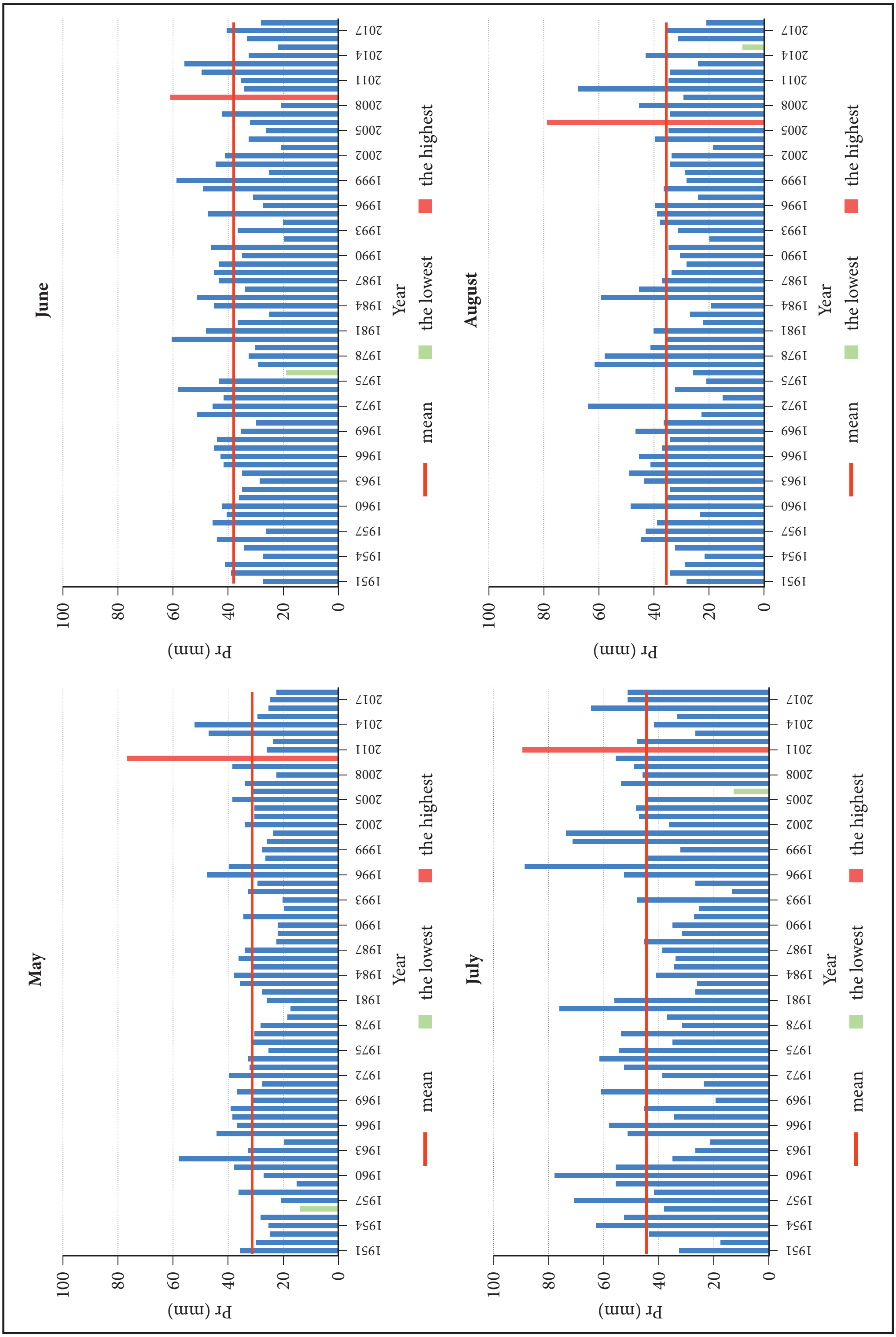
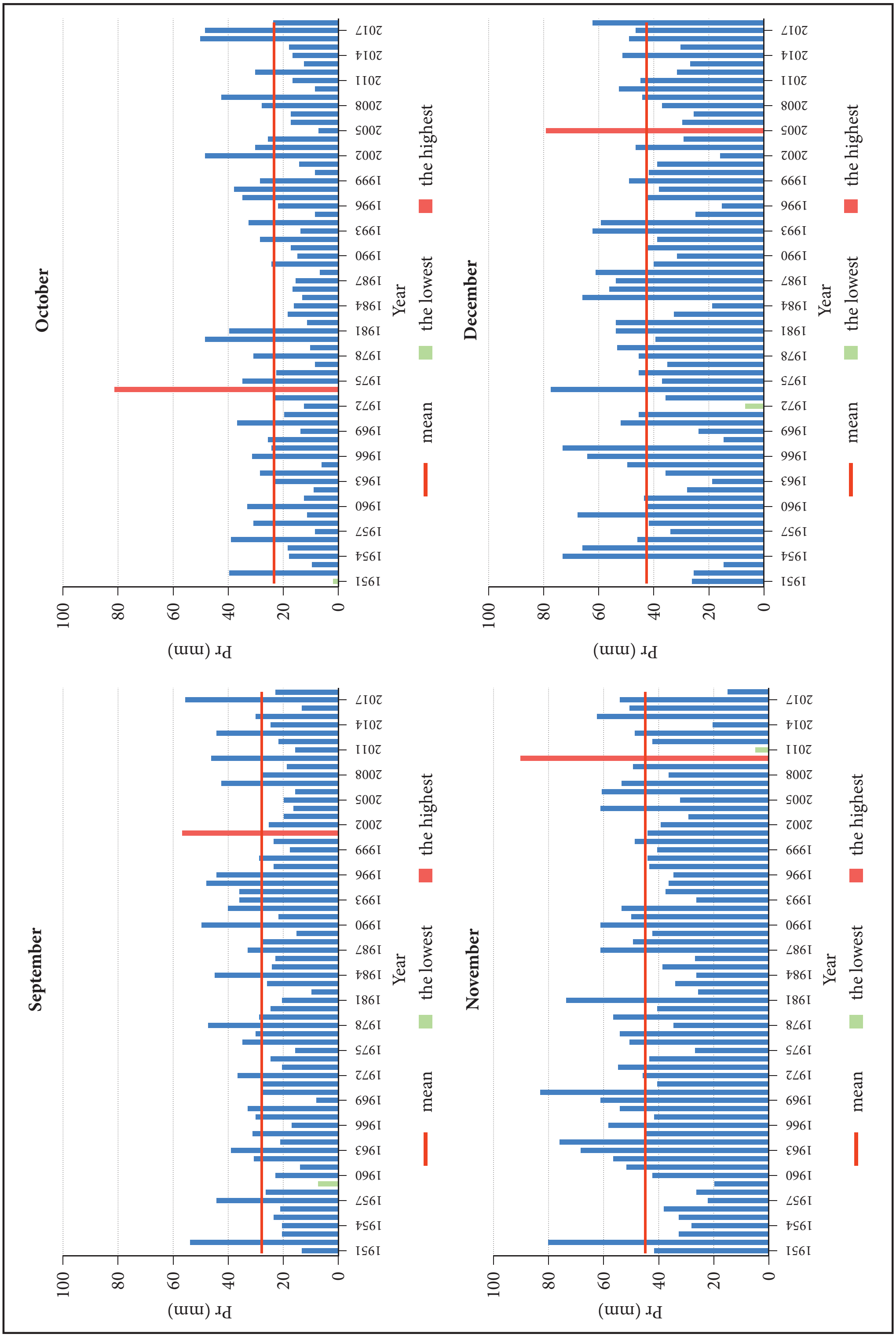


Figure 8: Temporal distribution of annual (January–December) precipitation totals in Poland, 1951–2018.

Figure 9: Temporal distribution of monthly precipitation totals in Poland, 1951–2018. ➤ p. 55–57


January
February
March
April
Pr (mm)
Year
mean
the lowest
the highest


May
June
July
August
Pr (mm)
Year
mean
the lowest
the highest


September
October
November
December
Pr (mm)
Year
mean
the lowest
the highest

Pr constituted only about 6% of the norm in October (in 1951) to about 51% of the norm in June (1976). In the months of the lowest Pr, the average number of days without precipitation fluctuated from 22 days in June (1976) to 29 days in October (1951). The average number of days with precipitation within a range of 0.1–1 mm oscillated from 1.2 days in October (1951) to 6.6 days in January (1997). On the other hand, the average number of days with precipitation of >1 mm fluctuated from 0.8 days in October (1951) to 5.6 days in June (1976); the average number of days with precipitation of >2 mm varied from 0.3 to 4.7 days in October (1951) and June (1976), respectively. Higher Pr values, i.e. >5 mm, in dry months were observed much more rarely as the average number of days with such precipitation oscillated between 0.1 and 2.8 days.

The spatial distribution of the lowest annual and monthly precipitation totals in Poland is presented in Figures 10 and 11. In 1982, the totals fluctuated from <400 mm in central-west and central-east Poland to >1200 mm in the south (Figure 10). The lowest Pr values, which were recorded in 1982, were on average 150 mm lower than in the multi-year period of 1951–2018 (Figure 2). In particular dry months, Pr values oscillated from <5 mm to >105 mm (Figure 11).

Depending on the month, precipitation of <5 mm was recorded mainly in the cold half of the year in various parts of Poland, namely in the strip stretching from the north-west to the central-east (January 1997), in the east (February 1976), in the south-east (March 1974), in the central strip stretching from the north to the south (April 2009), in most of the country (October 1951), in the south and the central strip situated along the west-east axis (November (2011) and mainly in central-east Poland (December 1972).

On the other hand, Pr of >105 mm occurred in May (1956) and June (1976) in the south of Poland. In other dry months, the highest Pr was recorded in different parts of Poland, e.g. >15 mm in February (1976) in central-west Poland, >25 mm in April (2009) in the south-east, >60 mm in September (1959) in the north, and >70 mm in November (2011) in the north-west.

The highest annual Pr in Poland was registered in 2010 and constituted ~135% of the norm (Table 3).

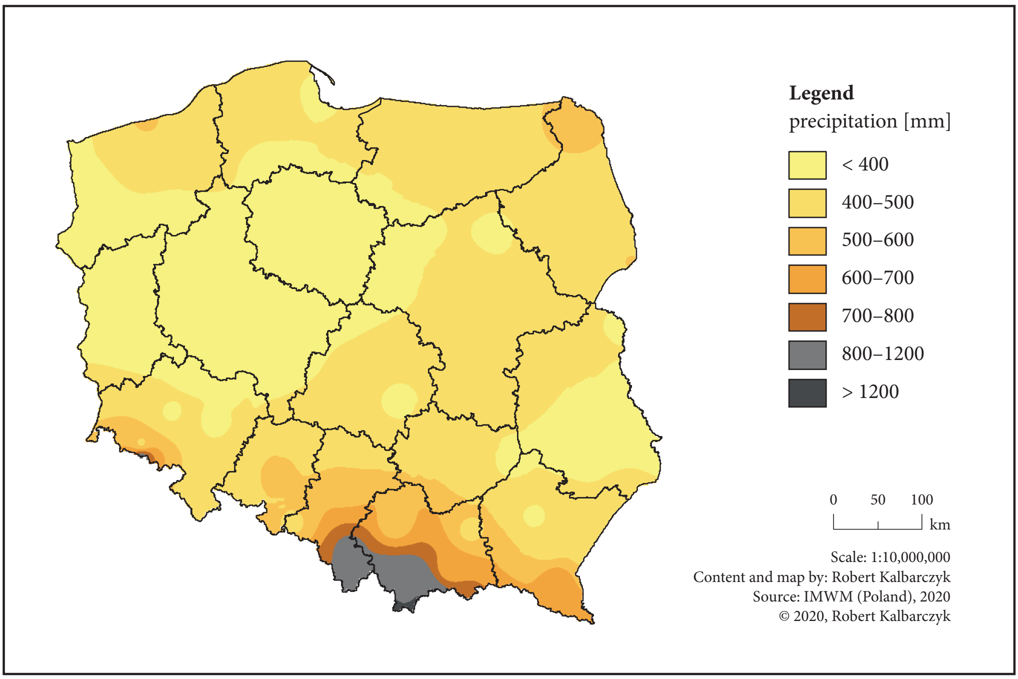


Figure 10: Spatial distribution of the lowest annual precipitation totals in Poland in all the analyzed years, 1951–2018.

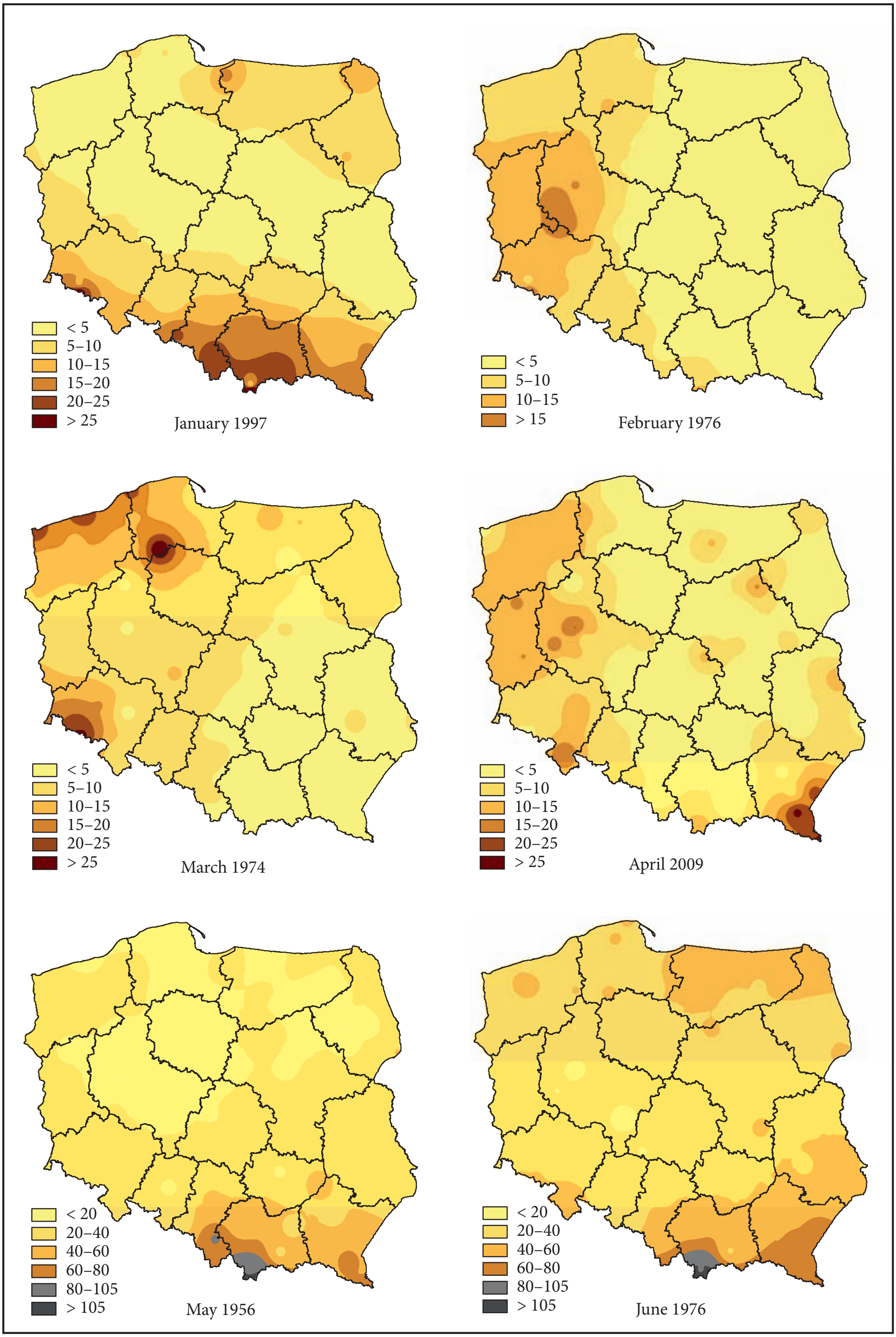
Figure 11: Spatial distribution of the lowest monthly precipitation [mm] totals in Poland in all the analyzed months, 1951–2018. ➤ p. 60–61

Table 2: Characteristics of the structure of the lowest precipitation totals in Poland, 1951–2018.

Period / month	Year with the lowest precipitation totals	% of multi-year precipitation total	Average number of days without precipitation and with precipitation							
			0.0 (mm)	0.1–1	>1	>2	>5	>10	>20	>50
January–December	1982	71.6	232.5	53.4	79.1	57.8	27.9	10.0	2.4	0.1
January	1997	20.5	22.7	6.6	1.7	1.0	0.3	0.1	0.0	0.0
February	1976	15.2	24.5	3.0	1.5	0.8	0.1	0.0	0.0	0.0
March	1974	21.4	26.7	2.4	1.9	1.3	0.4	0.0	0.0	0.0
April	2009	15.9	27.3	1.4	1.3	0.9	0.3	0.2	0.0	0.0
May	1956	44.7	22.3	3.4	5.3	3.8	1.4	0.6	0.1	0.0
June	1976	50.5	22.0	2.4	5.6	4.7	2.8	1.2	0.1	0.0
July	2006	28.6	25.4	2.3	3.3	2.7	1.5	0.8	0.2	0.0
August	2015	22.5	25.3	2.6	3.1	2.2	0.9	0.3	0.1	0.0
September	1959	25.6	22.6	3.6	3.8	2.3	0.6	0.1	0.0	0.0
October	1951	6.4	29.0	1.2	0.8	0.3	0.1	0.0	0.0	0.0
November	2011	11.1	25.7	3.4	0.9	0.5	0.1	0.0	0.0	0.0
December	1972	15.8	24.0	5.0	2.0	1.0	0.1	0.0	0.0	0.0

Table 3: Characteristics of the structure of the highest precipitation totals in Poland, 1951–2018.

Period / month	Year with the highest precipitation totals	% of multi-year precipitation total	Average number of days without precipitation and with precipitation							
			0.0 (mm)	0.1–1	>1	>2	>5	>10	>20	>50
January–December	2010	134.4	180.7	66.6	117.7	91.5	50.3	22.1	7.2	0.9
January	2007	245.3	6.0	8.2	16.8	12.1	5.6	2.0	0.3	0.0
February	2002	184.1	10.6	5.5	11.9	8.5	4.0	1.0	0.1	0.0
March	1994	207.2	8.6	6.9	15.5	11.6	4.7	1.2	0.0	0.0
April	1970	190.1	10.7	6.7	12.6	9.6	5.6	2.3	0.3	0.0
May	2010	246.0	8.8	4.9	17.3	14.7	9.3	4.4	1.6	0.2
June	2009	160.7	9.2	5.8	15.0	12.2	7.8	4.1	1.0	0.1
July	2011	200.3	10.8	4.8	15.4	13.5	9.9	6.2	2.5	0.2
August	2006	220.1	9.8	5.2	16.0	13.7	8.9	5.2	2.1	0.2
September	2001	203.4	10.0	5.3	14.7	12.2	7.3	3.7	1.0	0.0
October	1974	354.9	7.5	6.2	17.3	14.8	10.1	5.7	1.8	0.1
November	2010	201.4	9.5	6.5	14.0	11.3	6.4	2.6	0.3	0.0
December	2005	186.3	8.4	7.8	14.8	11.3	5.2	1.9	0.2	0.0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January 1997
< 5
5–10
10–15
> 15
February 1976
< 5
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10–15
15–20
20–25
> 25
March 1974
< 5
5–10
10–15
15–20
20–25
> 25
April 2009
< 20
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May 1956
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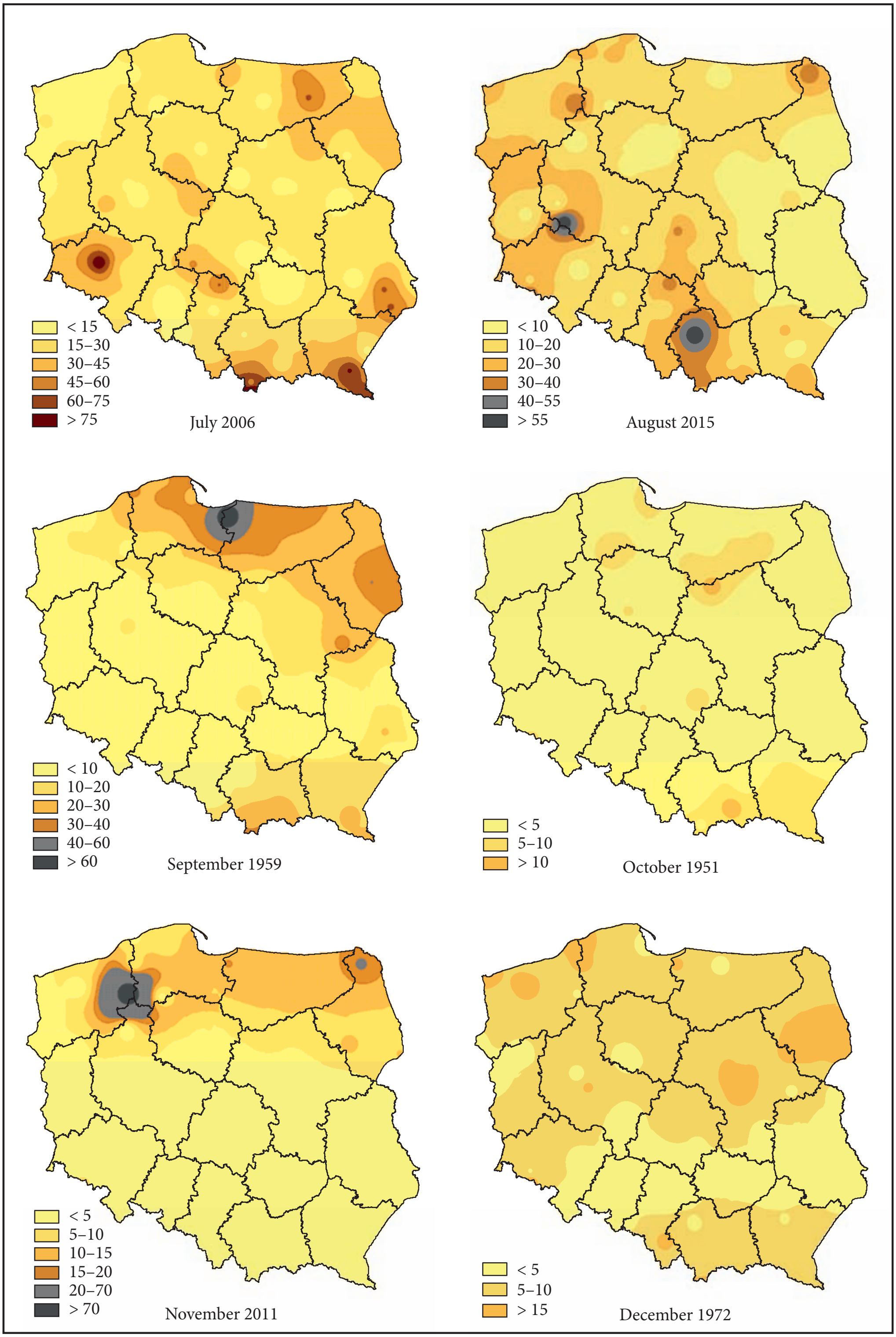
60–80
80–105
> 105
June 1976


< 15
15–30
30–45
45–60
60–75
> 75
July 2006
< 10
10–20
20–30
30–40
40–55
> 55
August 2015
< 10
10–20
20–30
30–40
40–60
> 60
September 1959
< 5
5–10
> 10
October 1951
< 5
5–10
10–15
15–20
20–70
> 70
November 2011
< 5
5–10
> 15
December 1972

In wet 2010 year, no precipitation was registered on ~181 days. In 2010, the average number of days on which precipitation was registered in Poland was the following: >1 mm (~118 days), >2 mm (~92 days), >5 mm (~50 days), >10 mm (~22 days), >20 mm (~7 days), and >50 mm (~1 day). The highest monthly Pr ranged from about 164% of the multi-year precipitation in June (2009) to as much as approximately 355% in October (1974). In both these months, there was no rain only for 8–9 days. Precipitation of >1 mm per day was observed on about 15 and 17 days in June and October, respectively: >5 mm – about 8 and 10 days, >10 mm – about 4 and 6 days, and >20 mm – about 1 and 2 days.

In 2010, which has the highest Pr in the multi-year period, precipitation fluctuated from <750 mm in the central strip and the north to >1700 mm in the south of Poland (Figure 12).

The highest Pr in consecutive months of the year was observed in various parts of Poland, most frequently in the south (Figure 13). High precipitation values also occurred in the north (e.g. in January 2007 and October 1974), in the north-west (e.g. in February 2002 and April 1970), in the north-east (e.g. in August 2006 and October 1974) and in the east (e.g. in August 2006 and October 1974). The biggest differences in Pr occurred in May, when the totals oscillated from <100 to >375 mm, and July when the totals oscillated from <100 to >320 mm; the highest totals were recorded in the southern and eastern parts of the country.

3.4 Precipitation regions

In Poland, the area of each of the three regions (separated based on precipitation totals and precipitation variability) changed depending on the analyzed multi-year period (Figure 14).

In the first half of the examined multi-year period, i.e. in 1951–1984, the region with the lowest Pr (Cluster I) mostly covered the central-east part of Poland; the second Pr region (Cluster II) covered a bigger part of the country, namely the north, west and partly the south of Poland; the third Pr region

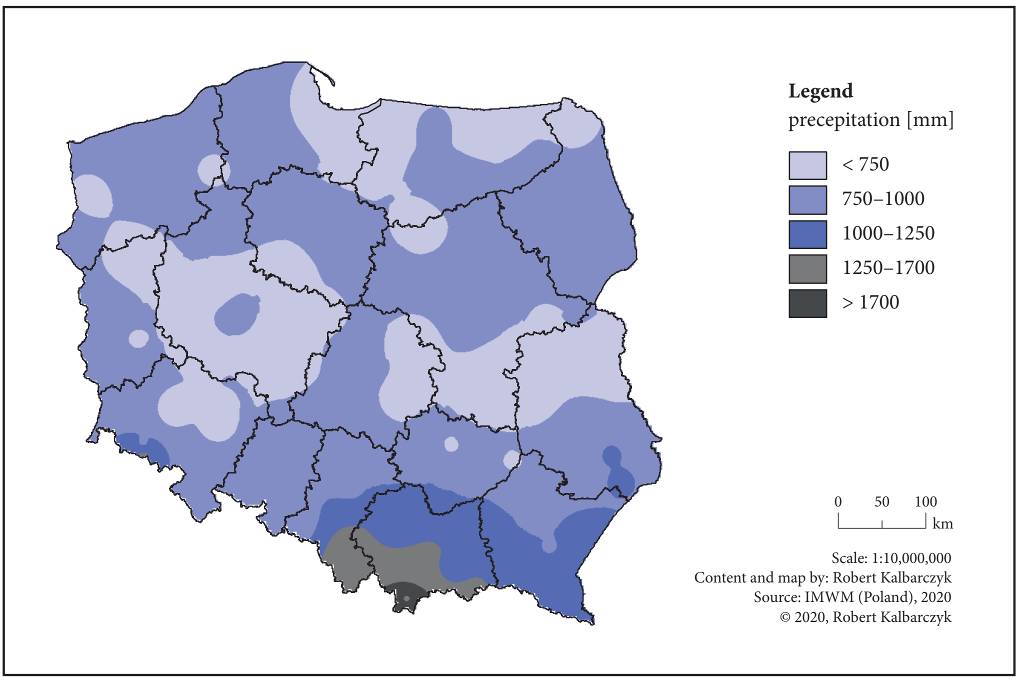


Figure 12: Spatial distribution of the highest annual precipitation totals in Poland in all the analyzed years, 1951–2018.

Figure 13: Spatial distribution of the highest monthly precipitation [mm] totals in Poland in all the analyzed months, 1951–2018. ➤ p. 64–65

(Cluster III) encompassed a small area in the south and the south-west of Poland. In the second half of the considered multi-year period, i.e. in 1985–2018, regions with a characteristic precipitation variability covered slightly different areas of Poland. In 1985–2018, the first Pr region was approximately 50% larger than in 1951–1984 and covered the entire central strip of Poland up to the north-western and north-eastern parts of the country. The second Pr region shrank at the cost of the first region and covered areas only in the north and the south of the country; the third region, on the other hand, slightly shrank at the cost of the second region. As expected, in the whole analyzed multi-year period (1951–2018) the distribution of the distinguished precipitation regions was similar to the distributions in the first and second halves of the entire multi-year period. In 1951–2018, the first and second Pr regions covered almost the same area in terms of size. The first Pr region covered central Poland, while the second one covered the northern and southern parts. The third Pr region was situated in the south and the south-west of Poland and its area was slightly smaller than in 1951–1984.

In all the three analyzed multi-year periods, the stations of the lowest precipitation totals were classified as the first Pr region, while the stations of the highest totals were classified as the third Pr region (Table 4).

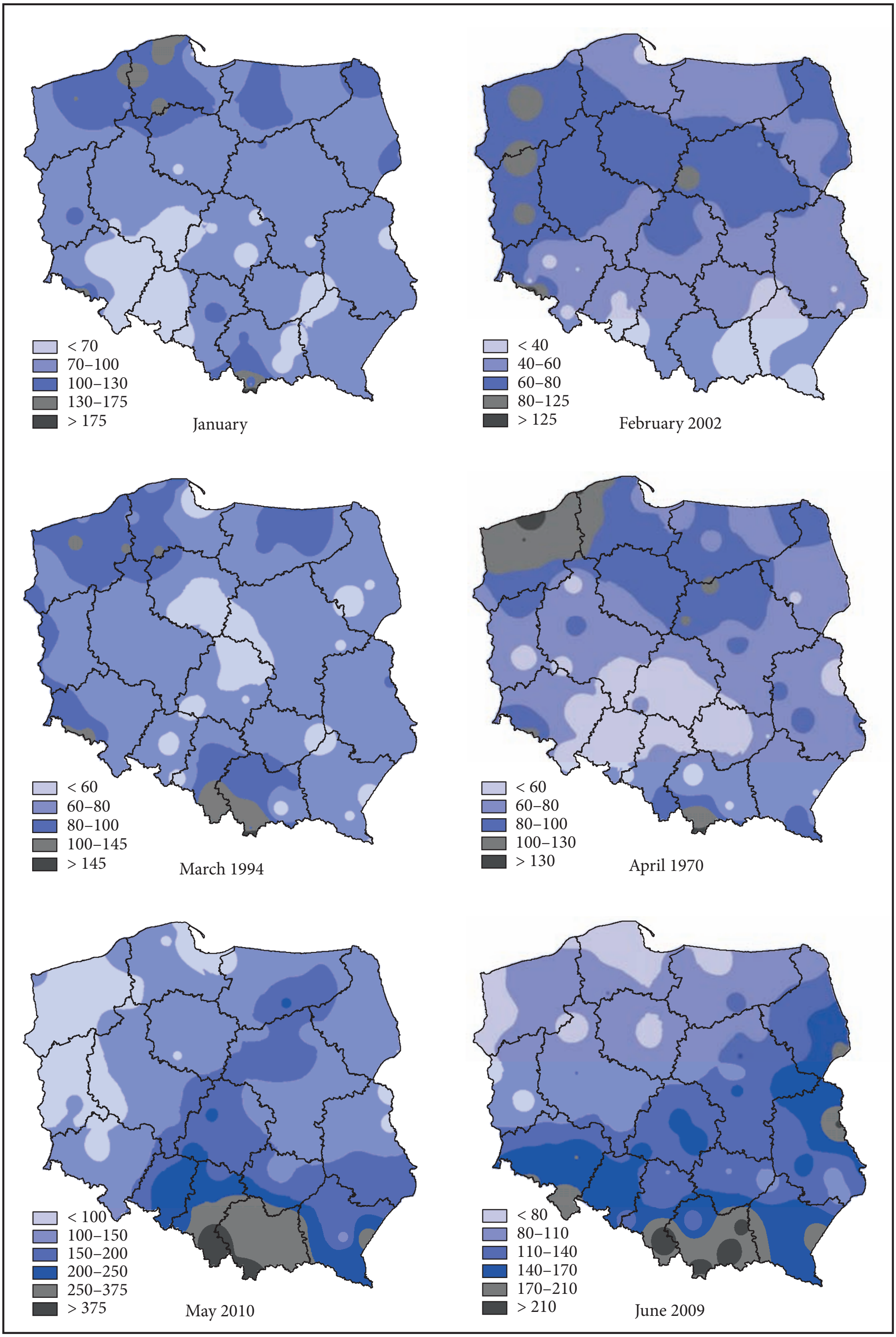
In 1951–1984, average precipitation totals were ~550 mm in the first region, ~650 mm in the second and ~1310 mm in the third; in 1985–2018 these values were ~577, ~713 and ~1237 mm, respectively. In all the separated regions, lower Pr values in 1951–1984, in comparison with 1985–2018, occurred only in three months: March, May and September. Comparing the two examined sub-periods, a higher average standard deviation of Pr was calculated in 1985–2018 in Region I and Region III and in 1951–1984 in Region II. In particular months, Pr variability determined on the basis of the standard deviation was lower in as many as 10 months in 1951–1984 in Region II, 8 months in Region I, 6 months in Region III, and in 5 months, i.e. March, April, May, July and September, in all regions.

In the multi-year period of 1951–2018, average annual Pr oscillated from 567 mm in Region I to about 1272 mm in Region III (Table 4). In Region I, i.e. in central Poland, average monthly Pr values fluctuated from about 28 to 82 mm; in Region II they fluctuated from about 33 to 95 mm, and in Region III they fluctuated from about 73 to 172 mm; the lowest totals occurred in February and the highest were in July. The highest variability of Pr in 1951–2018, as in the years 1951–1984 and 1985–2018, was noted in Region III.

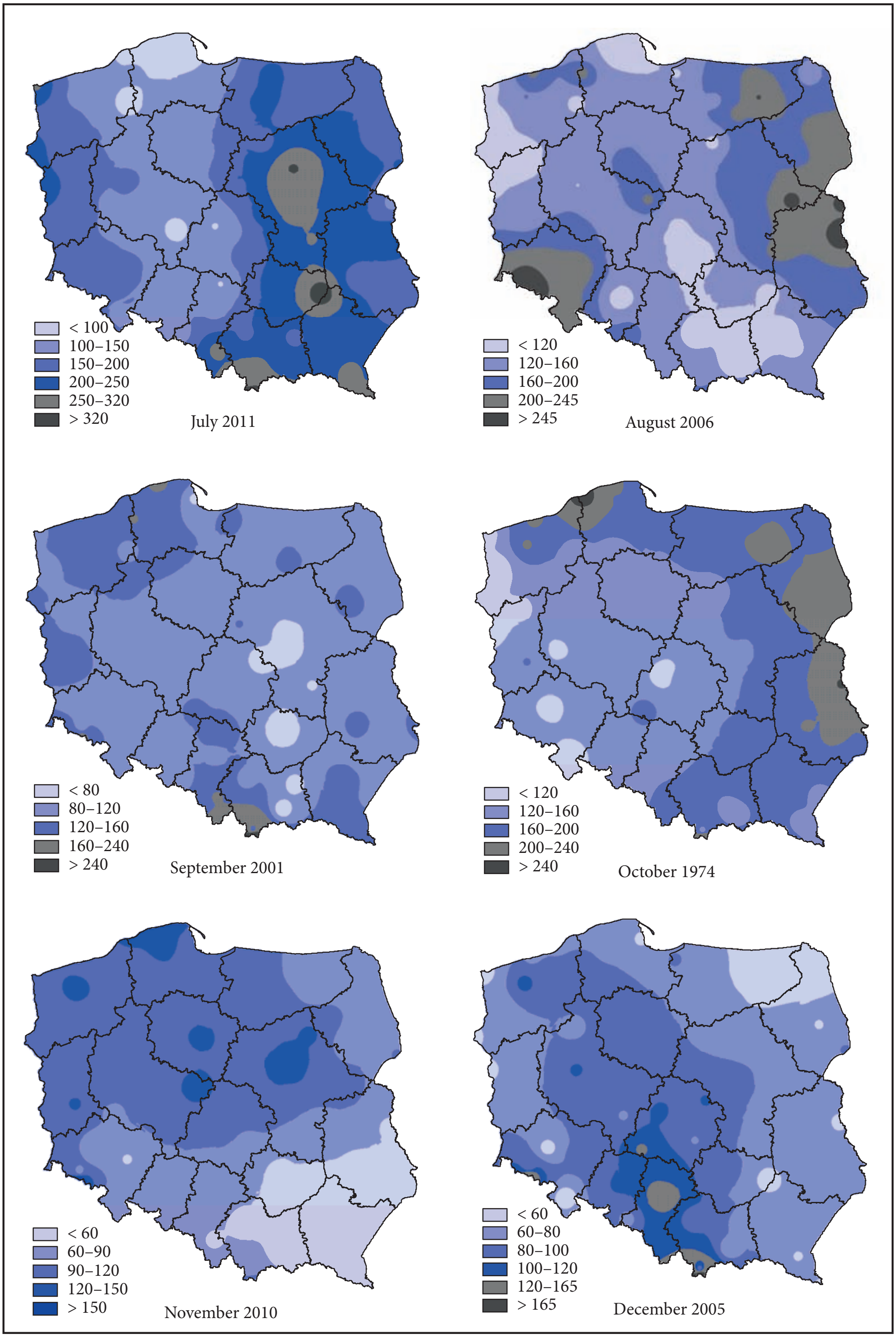
Table 4: Characteristics ($\bar{x}\pm SD$) of precipitation totals in Poland by regions (I, II, III) in 1951–1984, 1985–2018, 1951–2018.

Period / month	1951–1984 Region			1985–2018 Region			1951–2018 Region		
	I	II	III	I	II	III	I	II	III
January–December	549.7± 28.6	649.1± 58.7	1306.3± 335.9	577.1± 44.6	713.4±38.2	1236.7±352.6	567.0±36.4	693.3±41.4	1271.5±338.2
January	29.6±15.3	38.4±19.4	79.1±40.3	33.5±18.3	40.6±21.6	73.6±40.3	32.0±17.1	40.5±21.4	76.3±40.5
February	26.0±15.3	31.0±18.5	75.6±45.7	28.6±14.7	34.8±16.7	69.4±34.7	27.6±15.2	33.3±18.2	72.5±40.7
March	27.3±14.6	33.3±18.3	78.3±36.9	35.1±17.4	40.5±20.3	79.3±38.2	31.5±16.5	37.6±20.2	78.8±37.6
April	36.4±18.6	41.8±22.8	101.8±42.9	35.8±20.5	43.9±23.7	84.3±44.6	36.4±19.8	43.1±23.9	93.0±46.6
May	55.3±26.9	60.5±29.4	129.1±53.7	57.3±29.5	69.8±35.9	130.7±66.1	56.7±28.8	64.4±31.9	129.9±63.6
June	67.7±32.7	76.6±36.0	176.1±69.0	67.7±34.7	80.6±39.7	147.9±61.9	67.9±33.8	80.2±38.4	162.0±67.1
July	80.5±43.7	90.0±48.1	176.2±89.9	82.6±47.3	96.2±55.2	168.3±93.5	81.7±45.6	95.0±52.2	172.3±93.2
August	64.4±36.6	75.3±39.8	143.5±72.8	64.8±37.1	80.2±40.9	125.7±70.1	65.0±37.0	79.1±41.0	134.6±71.8
September	45.6±27.6	58.1±31.5	93.6±48.2	52.4±31.8	72.7±41.8	113.0±64.1	49.5±29.9	66.5±37.2	103.3±57.6
October	40.7±34.2	50.6±37.6	81.0±53.5	40.1±27.3	56.8±36.3	81.5±45.2	40.5±30.7	55.3±37.7	81.3±49.4
November	39.9±20.7	49.0±25.4	87.7±43.3	39.7±19.8	49.6±25.7	80.7±37.2	40.1±20.3	50.6±26.1	84.2±40.5
December	36.2±19.7	44.5±23.4	84.6±37.8	39.5±18.6	47.7±22.4	82.1±42.7	38.1±19.3	47.6±23.4	83.4±40.5

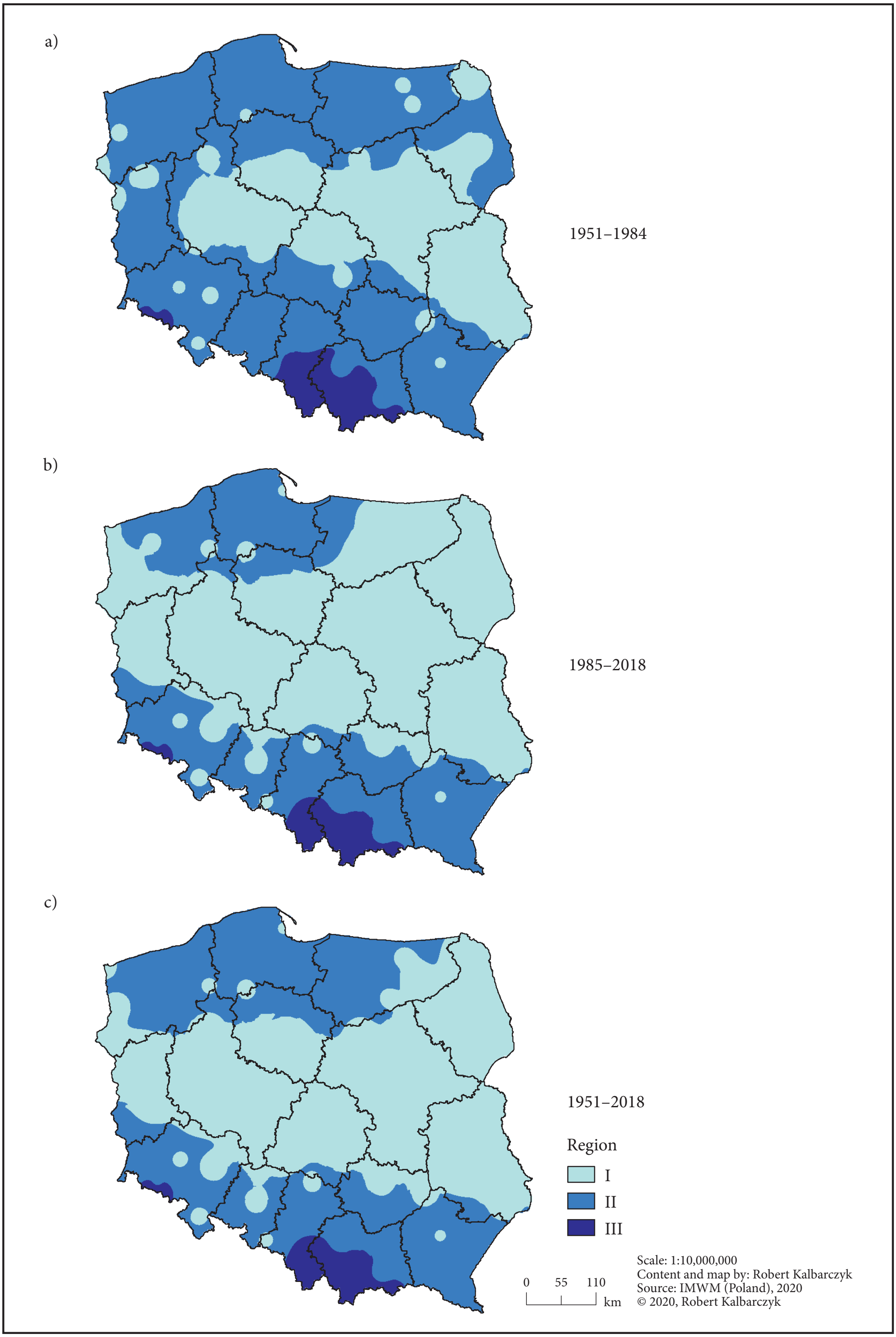
Figure 14: Regions (I, II, III) of Poland of similar precipitation totals and precipitation variability in 1951–1984, 1985–2018 and 1951–2018. ➤ p. 66



< 70
70–100
100–130
130–175
> 175
January
< 40
40–60
60–80
80–125
> 125
February 2002
< 60
60–80
80–100
100–145
> 145
March 1994
< 60
60–80
80–100
100–130
> 130
April 1970
< 100
100–150
150–200
200–250
250–375
> 375
May 2010
< 80
80–110
110–140
140–170
170–210
> 210
June 2009



< 100
100–150
150–200
200–250
250–320
> 320
July 2011
< 120
120–160
160–200
200–245
> 245
August 2006
< 80
80–120
120–160
160–240
> 240
September 2001
< 120
120–160
160–200
200–240
> 240
October 1974
< 60
60–90
90–120
120–150
> 150
November 2010
< 60
60–80
80–100
100–120
120–165
> 165
December 2005


a)
1951–1984
b)
1985–2018
c)
1951–2018
Region
I
II
III
0 55 110
km
Scale: 1:10,000,000
Content and map by: Robert Kalbarczyk
Source: IMWM (Poland), 2020
© 2020, Robert Kalbarczyk

In autumn and winter months, the standard precipitation deviation was higher than in the spring and summer months and fluctuated from approximately 15 to 46 mm in Region I, from approximately 18 to 52 mm in Region II, with the lowest values in February and the highest in July; in Region III it oscillated from ~38 mm in March to ~93 mm in July.

4 Discussion

In Poland in the multi-year period the annual precipitation totals have changed significantly only in some areas of the country. In the south-east, central-east and north-west Poland, precipitation increased significantly, while the sum of precipitation was only locally reduced in south-west Poland. An increase in precipitation totals was confirmed only regionally. The observed significant positive increase in Pr in March had the biggest spatial range. The high increase in precipitation in March and the slight increase in annual precipitation totals in Poland in 1951–2013 were also confirmed by Szwed (2018).

A decrease in monthly precipitation totals was also frequent in some regions. Regional differences related to the trends of precipitation totals and the number of days with precipitation are a very common phenomenon. In Slovakia, regional differences in the temporal distribution of precipitation were shown by Labudová, Faško and Ivaňáková (2015); in Czechia, some regional differentiation in annual precipitation totals of daily maxima was also found (Květoň and Žák 2008). Some examples of regional differences in precipitation variability can also be found in studies by, for example, Skowera, Kopcińska and Kopeć (2014), Tošić et al. (2016), Kivinen et al. (2017) and Pathak et al. (2018).

In the examined 1951–2018 period, differences between the lowest and highest values of annual and monthly precipitation totals and the long-term average (norm) were very high. The highest annual precipitation total in Poland was recorded in 2010 and constituted ~135% of the norm. The highest monthly precipitation total constituted from about 164% in June (2009) to as much as about 355% in October (1974) of the multi-year monthly values. The lowest annual precipitation total in Poland, which was recorded in 1982, constituted ~72% of the multi-year annual precipitation. In particular months, precipitation totals constituted from as little as about 6% of the monthly norm in October 1951 to about 51% of the norm in June 1976. Although undertaken quite often, studies on values that deviate from the norm are still a challenge for researchers (Hundecha and Bárdossy 2005; Młyński, Cebulska and Wałęga 2018; Kalbarczyk and Kalbarczyk 2020b). Differences in the extent of atmospheric precipitation in Poland are primarily explained by the effect of certain types of atmospheric circulation; high importance is attributed to cloud cover (Degirmendžić, Kożuchowski and Żmudzka 2004; Żmudzka 2009; Twardosz, Niedźwiedź and Łupikasza 2011; Młyński, Cebulska and Wałęgaet 2018). For extreme phenomena it is difficult to prove the significance of a trend and regularities in the development of a given phenomenon (Pfeifer et al. 2015; Zeyaeyan et al. 2017). The observed differences in temporal distribution of precipitation totals between particular years result in irregular periods of drought and excessive precipitation, whose negative social and economic effects cannot be prevented (Kundzewicz, Radziejewski and Pińskwar 2006; Dumrul and Kilicarslan 2017; Brázdil et al. 2019). According to some researchers, the frequency of droughts in Poland is increasing and will continue rise until the end of the century (Kalbarczyk 2010; Kuchar and Iwański 2013; Somorowska 2016). Similar predictions concerning the increased intensification of drought conditions until 2100 have been made for, among others, California (Pathak et al. 2018), South Europe and North Africa (Caloiero, Caloiero and Frustaci 2018), and Thuringia in summer (Krause and Hanisch 2007). On the other hand, North Europe is expected to experience increased precipitation (Szwed et al. 2010). It is also reported that in spring Poland may expect an increase in precipitation (Mezghani et al. 2017).

Spatial distribution of annual precipitation totals in Poland shows a clear regularity. The lowest precipitation is characteristic of the central part of the country and increases northwards and southwards, with maximum values in the southernmost mountain areas. The determined precipitation regions display a fairly close similarity to the pluviothermal regions of Poland presented in Schmuck's (1965) as well as in Ziernicka-Wojtaszek and Zawora's (2008); the fundamental difference is the range of the lowest precipitation region reaching also the north-east of the country. In the Köppen's classification nearly the whole Poland is located in the Dfb zone, only a small fragment in the south is included in the climatic zone Dfc (Beck et al. 2018). Thus, the present regionalization provides additional information about spatial differences of precipitation in Poland. In particular months and seasons, spatial distribution of precipitation totals slightly diverge from this regularity; however, the areas with the lowest precipitation totals are continually located in the strip of central lowlands with a shift to the west or east of the country. The highest monthly Pr values in the examined multi-year period occurred in various parts of the country, most frequently in the south of Poland. This kind of spatial distribution of precipitation in Poland is consistent with previous research studies conducted on the basis of different multi-year periods, as well as research on the early decades of the 20th century (Twaróg 2016; Szwejkowski et al. 2017; Szwed 2018); this indicates stable regularities of Poland's spatial distribution of precipitation.

The determined precipitation regions may be useful for climatic risk management and preparation of regional and local adaptation plans aimed at balancing the effects of climate change (Twaróg 2016; Kalbarczyk and Kalbarczyk 2020a).

5 Conclusion

In Poland, average annual precipitation totals in 1951–2018 were only ~634 mm and fluctuated from <550 mm in the central part of the country to >1300 mm in the south. The lowest average monthly precipitation (Pr), was observed in February and was about 2.9 times as low as the highest average values observed in July. The highest variability of Pr, both annual and monthly, usually occurred in the areas of the highest precipitation totals, primarily in the south of Poland.

In 1951–2018, in most parts of Poland apart from the south-west, annual precipitation totals rose year by year, but a significant increase of at least at a level of $\alpha \leq 0.1$ was found only in small areas in the north-west, central-west and south-east. This increase was caused by the rising Pr in March which occurred mainly in northern and central Poland.

Extreme annual precipitation totals in Poland occurred in 1982 and 2010. They constituted about 72% and 134% of the norm, respectively. The lowest monthly Pr, which constituted only ~6% of the norm, was recorded in October 1951; the highest monthly Pr, which constituted as much as ~355% of the norm, was recorded in October 1974.

In the months of the lowest Pr (dry months), the average number of days without precipitation varied from about 22 days in June 1976 to 29 days in October 1951; in the months of the highest Pr (wet months), it varied from 6 days in January 2007 to 11 days in July 2011, April 1970 and February 2002. In the months with the lowest precipitation, the average number of days with precipitation of >5 mm and the average number of days with precipitation of >10 mm were mostly observed in June and amounted to 2.8 and 1.2 days, respectively. Spatial distribution of the lowest and highest Pr in particular months of the year in comparison with average multi-year values differed not only in precipitation totals but also in spatial distribution, which mostly resembled a latitudinal arrangement in the case of dry months or an irregular arrangement in wet months.

Three precipitation regions were distinguished in Poland on the basis of precipitation variability in each of the different multi-year periods: 1951–1984, 1985–2018, and 1951–2018. The lowest and least variable Pr values were classed as Region I, which in 1951–1984 covered the central-east part of Poland, whereas in 1985–2018 it was in the central, north-west and north-east parts of the country. The highest and most variable Pr was classed as Region III, which in all the analyzed multi-year periods was in the south-west and south Poland. The results may prove useful while planning water management measures, as well as in the management of flood risks and prevention of drought effects.

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Acta geographica Slovenica, 61-2, 2021, 73–90

A COMPARISON OF THE BEGINNINGS OF EXONYM STANDARDIZATION IN CROATIAN AND SLOVENIAN

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ARCHIVE OF THE ZRC SAZU GIAM GEOGRAPHICAL MUSEUM

The exonym *Jakin* 'Ancona', formerly established in both Croatian and Slovenian, in Cigale's *Atlant* (Atlas), the first world atlas in Slovenian.

DOI: https://doi.org/10.3986/AGS.9678
UDC: 811.163.6'373.21
811.163.42'373.21
COBISS: 1.01

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A comparison of the beginnings of exonym standardization in Croatian and Slovenian

ABSTRACT: This paper compares the beginnings of exonym standardization and some characteristics of the oldest exonyms in two similar Slavic languages, Croatian and Slovenian. It uses the comparative and exemplar methods. It is found that these processes were influenced by the sociopolitical environment of the time, especially language policies. It is shown that the nineteenth century was favorably inclined toward exonyms. They were often written inconsistently and unsystematically because there were no spelling norms for their writing and use. For some, the influences of foreign languages (German, Italian, etc.) are obvious. Numerous transitional forms also appeared, which did not become established.

KEY WORDS: exonyms, exonym standardization, geographical names, geography, linguistics, Croatian, Slovenian

Primerjava začetkov standardizacije eksonimov v hrvaškem in slovenskem jeziku

POVZETEK: Članek obravnava začetke standardizacije eksonimov in identifikacijo najstarejših eksonimov v dveh podobnih slovanskih jezikih, hrvaškem in slovenskem, s primerjalno in vzorčno metodo. Ugotavlja, da je bila standardizacija eksonimov plod družbeno-političnih okoliščin, še posebej jezikovnih politik, in da je bilo 19. stoletje naklonjeno eksonimom. Pogosto so jih zapisovali neenotno in nesistematično, saj pravopisna pravila za njihovo rabo še niso bila izoblikovana. Pri nekaterih so očitni vplivi tujih jezikov (nemškega, italijanskega in drugih). Pojavljale so se tudi številne prehodne oblike eksonimov, ki pa se niso uveljavile.

KLJUČNE BESEDE: eksonimi, standardizacija eksonimov, zemljepisna imena, geografija, jezikoslovje, hrvaščina, slovenščina

The paper was submitted for publication on February 24th, 2021.
Uredništvo je prejelo prispevek 24. februarja 2021.

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1 Introduction

Exonym standardization is the process of adapting (i.e., nativizing) original geographical names from a donor language (i.e., endonyms) to a changed (or adapted or nativized) form in a recipient language. Because it takes place within a particular language, exonym standardization reflects the characteristics and development trends of that language in a certain period (Kladnik 2007a; 2009; Kladnik et al. 2017). This is also the case in Croatian and Slovenian, two similar Slavic languages that were influenced by external sociopolitical factors and different language policies during the Austro-Hungarian period (Kladnik et al. 2017). In both languages, certain exonyms were used long before the first half of the nineteenth century – perhaps as soon as certain places became relevant for people speaking Croatian and Slovenian – but until then were not standardized in any way. The first half of the nineteenth century was a period marked by national awakening, state formation, the building of national identities, and intense advocacy for the establishment of distinct languages and standard orthographies. Exonyms were used more and more frequently in different publications, and therefore the first attempts of exonym standardization appeared. This paper compares exonym standardization and some characteristics of the oldest exonyms in both languages during the nineteenth century. It is established how the broader sociopolitical context, especially normative policy, influenced exonym standardization in both languages, what the similarities and differences were in these processes, and why they exist.

Croatian and Slovenian researchers have discussed exonyms, mostly addressing modern usage (e.g., Kladnik 2007c; Kladnik and Bole 2012; Perko and Kladnik 2017; Crljenko 2018; 2019; 2020; Kladnik, Geršič and Perko 2020), general issues (e.g., Kladnik 2006; Kladnik 2007d; Kladnik et al. 2013; Perko, Jordan and Komac 2017; Kladnik, Geršič and Perko 2020), relationships between endonyms and exonyms (e.g., Kladnik 2009), and sometimes also their use in literature (e.g., Geršič 2019).

Research on the oldest exonyms is mainly found in (top)onomastics, and less often in cartography and historical geography. Toponymic papers focus on specific language problems supported by a small number of examples, not systematically. Dinu Moscal (2018) deals with the complete or partial translation of foreign toponyms into Romanian at the beginning of the nineteenth century. In an analysis of translated toponyms in three historical texts from the Romanian premodern period (1780–1830), Ana-Maria Gînsac and Mădălina Ungureanu note that translation was influenced by different language systems, differences in pronunciation and writing between Romanian and the donor language of the names, differences among the donor languages (French, German, Italian, etc.), the variety of proper names, translators' knowledge, and so on. The same authors (2020) also dealt with the adaptation of foreign toponyms to Romanian through an intermediate language (Greek or Latin) during that period. The oldest sources of Hungarian exonyms were studied by Béla Pokoly (2006), who cites some examples. In an analysis of the first Dutch school atlases to explore how Greece was depicted in them, Ferjan Ormeling (2015) also refers to the writing of exonyms in the nineteenth century.

The most extensive collections of exonyms are found in world atlases and geographical textbooks, as well as in orthographic manuals. They also appear in encyclopedic publications, monographs on geography, newspapers, and journals; the first Croatian exonyms appear in translations of the medieval book *Lucidarius*, and the first Slovenian ones in the works of Protestant writers in the sixteenth century (Kapetanović 2005; Kladnik, Geršič and Perko 2020). Systematic research on geographical names in various publications from this period is relatively modest. The first world atlas in Slovenian was published between 1869 and 1877. It was called *Atlant* (Atlas), and the Slovenian text for it was edited by Matej Cigale (Fridl et al. 2005; Kladnik et al. 2006; Urbanc et al. 2006). The names in it were carefully analyzed by Drago Kladnik, and the findings were published in several places (e.g., Kladnik 2005; Kladnik 2007b; Kladnik and Geršič 2016). The names in the oldest world atlases by Blaž Kocen from the end of the nineteenth century (starting in 1887) that were prepared for Croatian users have not been analyzed so far. Although Marćel Kušar briefly refers to the basic principles of exonym standardization in his Science of the Orthography of the Croatian or Serbian Language (photenic and etymologic; Kušar 1889), the third edition of Ivan Broz's 1904 *Hrvatski pravopis* (Croatian Orthography, edited by Dragutin Boranić) can be considered the first Croatian orthographic manual with rules on adapting names from other languages. Ankica Čilaš Šimpraga and Ivana Crljenko (2017) reviewed the rules of exonym standardization in it, as well as in other Croatian orthographic manuals. The first Slovenian orthographic manual in Slovenian, which also contains a section on the Slovenianization of geographical names, was published in 1899 in Vienna by Fran Levec (Figure 1; right). The exonyms in this manual were analyzed by Matjaž Geršič (2020). Some features of exonyms in the multidisciplinary geographical work Images from General Geography (Hoić 1888–1900) were addressed by Crljenko (2014). The large number of exonyms in the geographical textbook *Zemljepisna začetnica za gimnazije in realke* (Basic Geography for High Schools; Jesenko 1865; Figure 2; right) have not yet received scholarly analysis. The writing of selected exonyms (e.g., Great Britain, Ireland, Scotland, and England) in Croatian newspapers from the first half of the nineteenth century was studied by Dora Riffer-Maček (1962). In a similar manner, Irena Orel (2004) compared the use of geographical names in the newspapers *Ljubljanske novice* (Ljubljana News, 1797) and *Kmetijske in rokodelske novice* (Farmers' and Craftsmen's News, 1797 and 1850). Her research is based on bachelor's theses by Breda Bernetič (1990) and Mojca Podobnikar (2004) and on her own research. Interestingly, the author states in a footnote that comparison with contemporary foreign newspapers would be necessary. Marko Jesenšek (2013) studied the writing of geographical names, as well as exonyms, in the first Prekmurje newspaper *Prijatel* (The Friend), which was published from 1875 to 1879 (and appeared from 1877 onward in the Gaj alphabet).

Based on the literature reviewed, it was determined that there are many discussions about the topicality of the use of exonyms, but researchers rarely focus on the very beginnings of exonym standardization – and, if they do, they focus on sources in their own language. This paper aims to fill the research gap in this area and compare the process of exonym formation in two different but closely related Slavic languages. Comparing exonyms in historical sources helps in determining what their development was and in the application of typology of exonymization.

This study is a direct result of bilateral two-year cooperation between Slovenian and Croatian researchers, the objective of which was, among other things, to compare Croatian and Slovenian exonyms and social, political, and linguistic influences on their formation (Kladnik et al. 2017).

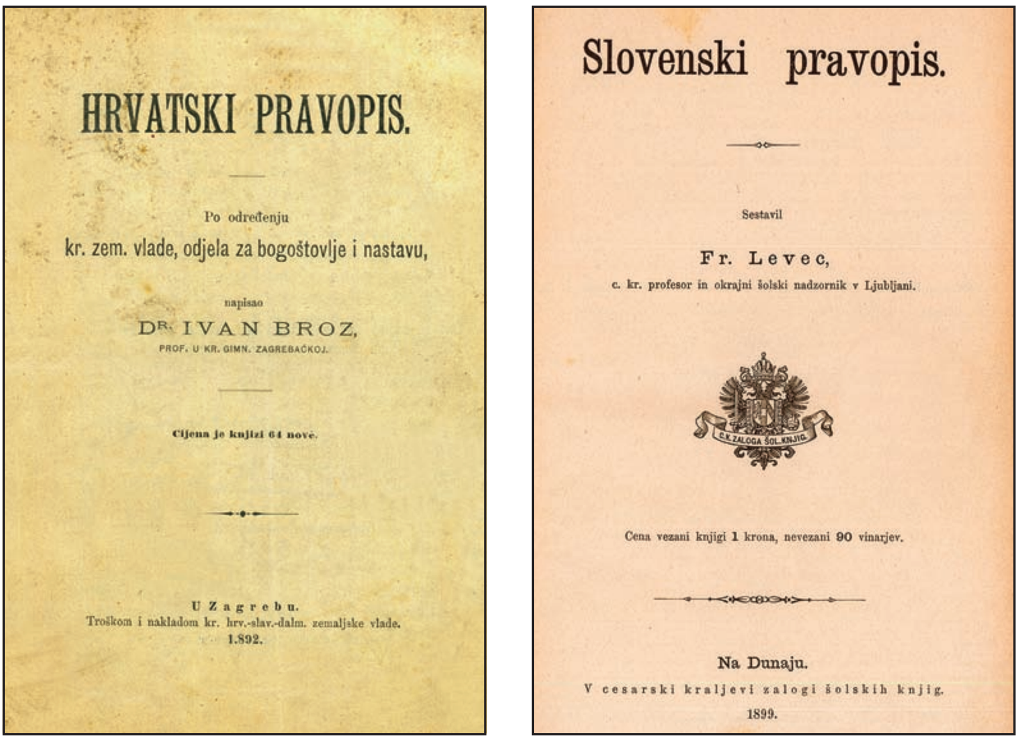


Figure 1: Title pages of the first orthographic manuals in Croatian (1892; left) and Slovenian (1899; right).

2 Methodology

A comparative method is used to compare exonyms in Slovenian and Croatian sources, and an exemplar method is used to substantiate claims (examples of exonyms). Exonyms selected from the oldest geographical sources (atlases, textbooks, and monographs), linguistic sources (orthographic manuals), and old newspapers are analyzed.

A set of exonyms for further analysis was compiled in two phases. In the first phase, we identified 422 exonyms from various Croatian sources, which various authors used to name 285 topographic features. Croatian exonyms were identified in several geography textbooks by Bradaška (1867), Mařik (1868; 1870), Klaić (1875; 1881), Hoić (1888–1900), and Rožić (1842), and in Kocen's atlases (1887; 1900; 1911; 1919), in the newspapers *Il Regio Dalmata / Kraglski Dalmatin* (Royal Dalmatian, 1807; 1808) and *Narodne novine* (The People's Newspaper, 1843), in the booklet *Nauka o pravopisu jezika hrvackoga ili srpskoga (fonetičkom i etimologijskom)* (Kušar 1889), and in Broz's orthographic manual (1892; 1904; 1906). In the second phase, Slovenian exonyms were sought in selected Slovenian sources that would correspond to the Croatian ones. The Slovenian set of sources is less numerous, but at least one source was selected for each type of source. The choices were Cigale's atlas *Atlant* (1868–1877), Jesenko's textbook *Zemljepisna začetnica za gimnazije in realke* (1865), the first Slovenian orthographic manual, prepared by Franc Levec (1899), and the newspapers *Kmetijske in rokodelske novice*, edited by Janez Bleiweis, and *Ljubljanske novice*, edited by Valentin Vodnik.

In the selected Slovenian sources, exonyms were identified for 161 topographic features, which were identified in the first phase in the Croatian sources. The final set for the name corpus, which was the subject of further analysis, included 232 Croatian exonyms and 250 Slovenian exonyms for 161 topographic features. Based on their comparison, the individual characteristics were determined for the beginning of exonym standardization in the two languages.

3 The emergence of exonyms

At the beginning of the nineteenth century, the most accessible source of exonyms for the Croatian public was Croatian newspapers. Although they were just being established and their reach was limited, their spread certainly contributed to the use of exonyms. The first bilingual Italian–Croatian newspaper, *Il Regio Dalmata / Kraglski Dalmatin*, was published from 1806 to 1810 once a week in Zadar. Although this was the first newspaper in Croatian, the geographical names written in the newspaper's Croatian column were clearly strongly influenced by other languages, Italian as well: either Italian names were used verbatim or (semi-) Croatianized forms were written based on Italian (*Pragha* – Italian *Praga* 'Prague', *Parigi* 'Paris', *Nizza* 'Nice', *Napuli* – Italian *Napoli* 'Naples', *Italia* 'Italy'). In 1823, the first geographical textbook in Croatian was published by Antun Rožić, *Kratki zavjetek zemelyzkoga-izpiszavanya Horvatzke y Vugerzke zemlye* (A Short Manual on Geography of Croatian and Hungarian Lands; Figure 2; left), in which the oldest exonyms in geographical literature can be found; for example, *Europa* 'Europe', *Turzko Czeszarztvo* 'Ottoman Empire', *Franczuzko Kralyeztvo* 'Kingdom of France', and *Stajerzka* 'Styria'.

The authors of newspaper and geographical texts adapted exonyms in different ways. The reason for this is the fact that several graphically different, nonstandard orthographies were used, which were not unified in terms of the letters used in the spelling, let alone in determining the writing and use of geographical names for foreign features. In 1830, Ljudevit Gaj's orthographic manual *Kratka osnova horvatsko-slavenskoga pravopisaňa* (Brief Basics of Croatian-Slavic Orthography) was published, which at least partially overcame the previous particularisms. It standardized Croatian Latin script, but there were still problems with spelling rules, which were often applied intuitively or following customary use (e.g., capitalization; Badurina 2012).

Exonym standardization increased in Croatia starting in the 1830s, which is associated with the beginning of the Croatian national revival – a national, cultural, and political movement that supported national awakening, integration of Croatian territories, affirming Croatian identity, and thus strengthening the role of the Croatian language. The official beginning of the movement is considered 1835, when Ljudevit Gaj received permission to publish a political newspaper, *Novine horvatzke* (Croatian Newspaper) with the literary supplement *Danicza horvatzka, slavonzka y dalmatinzka* (The Croatian, Slavonian, and Dalmatian

Daystar). The idea of »linguistic and orthographic unification of all Croatian regions – along with that of Slavic reciprocity« (Badurina 2012) was one of the fundamental components of this (Illyrian) movement.

After partial unity in language policy was achieved, the Croatian national revival was further strengthened by ideas about the importance of knowing and using Croatian. Therefore, after initial resistance to its use in the 1830s, Croatian finally became the official language in general use in 1847. It began to be used in schools, in the Croatian parliament, and in public services, and books, newspapers, textbooks, and geographical literature began to be published in it. Consequently, exonym standardization became more intense, and reception of exonyms became more favorable at the expense of endonyms. Not only were Croatian names created and used for familiar, nearby geographical features, but the names of more distant, non-European, lesser-known geographical features were also increasingly adapted (e.g., in the newspaper *Narodne novine* of 1843 one finds the exonyms: *Antiliban* 'Anti-Lebanon Mountains', *Zapadna India* 'West Indies', *Tibet*, *Tatarska* 'Tatarstan', *Kairo* 'Cairo', and *Hindostan* 'Hindustan').

In the second half of the nineteenth century, several different orthographic manuals and various grammars were still used. However, they generally do not mention the problem of writing exonyms, and so there are no corresponding rules for their writing and use. If these do appear, they cite exonyms with only a few examples. Thus, in the booklet *Nauka o pravopisu jezika hrvackoga ili srpskoga (fonetičkom i etimologijskom)* from 1889, Marćel Kušar mentions only a few exonyms (*Azija* 'Asia', *Evropa* 'Europe', *Kavkaz* 'the Caucasus'; Kušar 1889; Čilaš Šimpraga and Crljenko 2017). The use of multiple orthographic manuals without clear rules led to the appearance of inconsistent names in various publications (Crljenko 2008; 2014).

When the board of education determined that »one orthographic manual should be used« (Broz 1892) in Croatian schools for the first time in 1862, and then again in 1864, 1877, and 1889, Ivan Broz was given the task of putting it together. Thus, in 1892, the first graphically standard Croatian orthographic manual, *Hrvatski pravopis*, was created, which finally »standardized the Croatian phonological-morphological orthographic norm« for the first time (Badurina 2012, 66; Figure 1; left). With later complement by Dragutin Boranić, it went through six editions and was used until the 1920s. In it, however, even Broz does not state the rules for adapting names from foreign languages, and in the dictionary section only a few exonyms are recommended (e.g., *Mletci*, not *Venecija* 'Venice'; and *Njemadija* or *Njemčadija*, not *Njemačka* 'Germany'; Broz 1892; Čilaš Šimpraga and Crljenko 2017).

Only in the third (1904) and unchanged fourth edition (1906) of Broz's orthographic manual, prepared by Dragutin Boranić, were the rules on adapting names from other languages adopted. It is pointed out that words that entered Croatian long ago are written like domestic Croatian names, and those that entered more recently either completely retain their foreign form or are adapted to Croatian. However, it warned that historical exonyms such as »*Monakov* for *München* 'Munich', *Draždani* for *Dresden*, and *Kopenhagen* for *Kjöbenhavn* 'Copenhagen' … should not be used because these names are not pronounced this way by the people they belong to« (Broz 1906, 51; Čilaš Šimpraga and Crljenko 2017), from which it follows that as early as the beginning of the twentieth century it was cautiously recommended to reduce the use of (historical) exonyms in favor of endonyms.

Although there was still no language standard from the 1860s to the 1880s, the historical moment required geographers to create and/or translate school textbooks and atlases into Croatian. Several geographers prepared school textbooks on general (i.e., world) and on regional (the Austro-Hungarian Monarchy) geography: Franjo Bradaška (1867), Vjenceslav Zaboj Mařik (1868; 1870), Petar Matković (1875), Vjekoslav Klaić (1875; 1881), and Ivan Hoić (1888–1900).

In 1887, the first edition of the first atlas translated into Croatian was published: *Kozenov geografijski atlas za srednje škole* (Kozen's Geographical Atlas for Secondary Schools), adapted by Augustin Dobrilović and Petar Matković. Blaž Kocen was a Slovenian geographer and cartographer that published geographical atlases in German, Czech, Polish, Croatian, Hungarian, and Italian. His atlases in Croatian began to appear in the late 1880s (Bratec Mrvar 2007; Bratec Mrvar et al. 2011). With its thirty-seven maps, it is the richest source of adapted names from that period. Although Dobrilović and Matković, like other authors, had to come up with »correct« ways of writing a large number of exonyms, many characteristics of exonyms of that time, which have been confirmed in other sources, can be detected from this atlas.

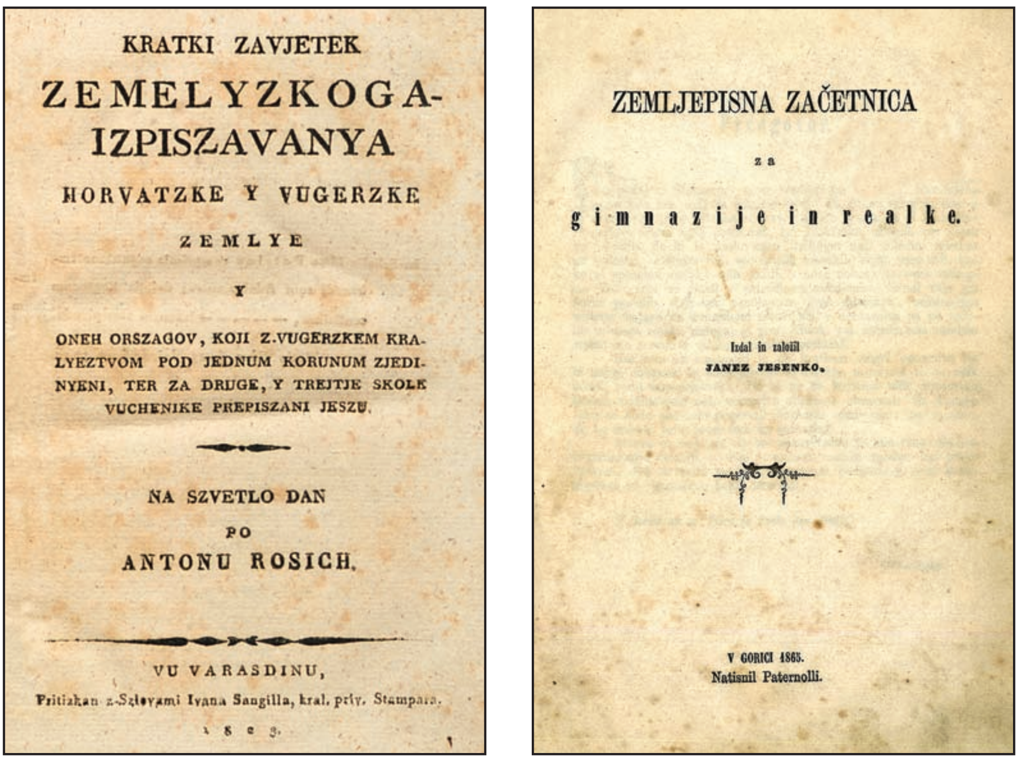
Compared to some later periods, the second half of the nineteenth century was very inclined toward Croatian exonyms, which means that exonyms enjoyed good reception and rather frequent use. This is also reflected in the fact that in most sources endonyms do not stand next to exonyms, not even in parentheses.

In Slovenia, exonym standardization can be more systematically observed with the appearance of the first newspapers in Slovenian. The first one was published on April 1st, 1797, and was called *Lublanske novize od vſih Krajov zeliga ſvejta* (Ljubljana News from All Parts of the Whole World). The title itself promises the appearance of foreign geographical names, and indeed many appear in the first issue, including *Dunej* 'Vienna', *Shpania* 'Spain', *Madrit* 'Madrid', *Franzoſka deshela* 'France', *Paris*, and *Sdrushene holendorſke deshele* 'United Provinces of the Netherlands'. At that time, the Bohorič alphabet (hence *Lublanske novize*, 1797) was still established as the orthography for writing Slovenian. The next Slovenian newspaper was *Kmetijske in rokodelske novice*, which was launched in 1843. An increase in the use of exonyms began, similarly to Croatian, with the Slovenian national movement and its spread in the late eighteenth and early nineteenth centuries.

An important change that took place in the nineteenth century and also affected the writing of geographical names was the change of Slovenian orthography in 1848, when people began using the Gaj alphabet instead of the Bohorič alphabet.

Illyrianism, which was strongly present in Croatia, did not experience such strong sympathies in Slovenia. The key factor in this resistance was the idea or demand to abandon Slovenian as a language and adopt a South Slavic language, which would be based on Štokavian dialect. Even Stanko Vraz, the main proponent of Illyrianism in Slovenia, primarily saw cultural integration in a broader sense in the movement, and somehow he was not ready to give up Slovenian. There were more sympathizers mainly on the northeastern edge of Slovenian ethnic territory, where the pressure of Germanization was strongest and Illyrianism represented a kind of defense against Germanization (Cvirn 2000).

The first geography textbook in Slovenian that systematically contains a large number of foreign geographical names is *Zemljepisna začetnica za gimnazije in realke* (Figure 2; left). It was written by Janez Jesenko and was self-published in 1865 (Kladnik 2005; Kladnik and Bratec Mrvar 2008). The work already uses



KRATKI ZAVJETEK

ZEMELYZKOGA-
IZPISZAVANYA

HORVATZKE Y VUGERZKE

ZEMLYE

Y

ONEH ORSZAGOV, KOJI Z.VUGERZKEM KRALYEZTVOM POD JEDNUM KORUNUM ZJEDINYENI, TER ZA DRUGE, Y TREJTJE SKOLE VUCHENIKE PREPISZANI JESZU.

NA SZVETLO DAN
PO
ANTONU ROSICH.

VU VARASDINU,
Pritiszkan z-Szlovami Ivana Sangilla, kral. priv. Stampara.
1 8 0 5.

ZEMLJEPISNA ZAČETNICA
za
gimnazije in realke.

Izdal in založil
JANEZ JESENKO.

V GORICI 1865.
Natisnil Paternolli.

Figure 2: Title pages of the oldest geography textbooks in Croatian (left) and Slovenian (right).

Table 1: Comparison of milestones in exonym standardization in Croatian and Slovenian.

	Croatia	Slovenia
First orthographic manual	1892 (*Hrvatski pravopis*)	1899 (*Slovenski pravopis*)
First geography textbook	1823 (*Kratki zavjetek zemelyzkoga-izpiszavanya Horvatzke y Vugerzke zemlye*)	1865 (*Zemljepisna začetnica za gimnazije in realke*)
First world atlas	1887 (*Kozennov geografijski atlas za srednje škole*)	1869–1877 (*Atlant*)
First newspaper	1806 (*Il Regio Dalmata = Kraglski Dalmatin*)	1797 (*Lublanske novize od vſih Krajov zeliga ſvejta*)
Official language status	1847	1849

many Slovenianized names in its text, and at the end the author added several tables containing names of towns. The first table lists towns »in Austria« (i.e., Austro-Hungarian territory), followed by European towns and finally towns on other continents. The author does not present the issue of Slovenianizing geographical names, but he adds Slovenian names to some names of towns in Austria-Hungary (e.g., *Gjur* = *Raab* 'Győr') whereas he writes names elsewhere in Europe and the world with a single name, using either the endonym (e.g., *Birmingham*) or a Slovenianized name (e.g., *Kodanj* 'Copenhagen'). The only exception is the name *Konstantinopel* 'Constantinople', to which he adds the Slovenianized form *Carjigrad*.

4 Results

The comparison of the beginnings of exonym standardization is based on the name corpus, which contains a total of 482 names, of which 232 are from Croatian sources and 250 from Slovenian ones (Table 1). The collected names designate 161 different topographic features (Figure 3).

Table 2: List of geographical names used in the analysis. List contains Croatian and Slovenian exonyms, as well as exonyms and endonyms of other languages when used interchangeably with the corresponding Croatian or Slovenian exonyms, rarely without them. If different name forms appear for a certain geographical feature, they are separated by a comma. Toponyms are listed in the same way they appear in the sources – sometimes with a small initial letter. The names are listed in alphabetical order in the left column.

Names identified in Croatian sources	Names identified in Slovenian sources	Current endonyms
Abruzi	Abruzzo	Abruzzo
Adiža, Eča, Ečava	Adiža	Adige
Adžmir	Adžmir	Ajmer
aegejsko more, Egejsko more	Egejsko morje	Egeo pélagos/Ege Denizi
Afrika	Afrika	Africa/Afrique*
Akaba	Akaba	Al-'Aqabah
Amerika	Amerika	America/Amérique*
arabski zalěv, cèrveno more, perzijski zalěv, Perzijski zaljev	Arabski zaliv, Persijski zaliv, Perzijski zaliv, Rdeče Morje	al-Bahr al-Ahmar/Badda Cas/QeyH baHri/ Yam Suf/Red Sea
Arapsko more	Arabsko morje	Bahr al-'Arab
Asia, Azija	Asia, Azija, Azia	Asia/Asie*
Astrakan	Astrahan	Astrahan'/Ästerxan
Atena, Atina	Atene, Atine	Athína
atlantički ocean, Atlantski ocean	Atlanško morje, Atlantsko morje	Atlantic Ocean/Océan Atlantique
Attersko jezero	Attersko jezero	Kammersee
Australija, Nova Holandija	Avstralija, Nova Holandija	Australia
Austrija	Avstrija, Estrajh	Österreich

Names identified in Croatian sources	Names identified in Slovenian sources	Current endonyms
azovsko more	Azovsko morje	Azovskoe more/Azovs'ke more/Azaq deñizi
Balaton, Blatno jezero	Blatno jezero	Balaton
Beč, Beç	Beč, Dunaj, Dunej	Wien
Bečko Novo Mjesto	Dunajsko novo mesto	Wiener Neustadt
Bělak, Beliak, Beljak	Belak	Villach
bělo more, bielo more, Bielo more, Bijelo more	Belo morje, Marmarsko morje	Marmara Denizi/Propontis
Benares	Benares	Vārānasi
Bengalski zalěv	Bengalski zaliv	Bay of Bengal
Bitolj	Bitelj, Bitolja, Monastir	Bitola
Bodansko jezero	Bodensko jezero	Bodensee
Bolonja	Bolonja	Bologna
Brašov	Braševo	Braşov
Brazilija	Brazilija	Brasil
Bruselj	Bruselj	Brussel/Bruxelles
Bukarešt, Bukurešt	Bukreš	Bucureşti
Carigrad, Czarrigrad	Carjigrad, Konstantinopel, Zargrad	İstanbul
Cělovac, Celovac, Cjelovac	Celovec, Zelovez	Klagenfurt am Wörthersee
Cernagora, Cherna Gora, Czerna gora, Czerna Gora, Černa Gora	Črna gora	Crna Gora
Cerno more, Cerno morje, crno more, Crno more	Črno morje	Čërnoe more/Chorne more/Marea Neagră/ Černo more/Karadeniz/Shavi zghva
Dnjestar, Dnyeztar	Dnester, Dnestr	Dnister/Nistru
Draždjani, Dražđani	Draždane	Dresden
Drinopolje	Adrianopel, Drenopolje	Edirne
Dunav	Donava, Dunaj, Dunava	Donau/Dunaj/Duna/Dunav/Dunărea/Dunay
Englezka	Angleško, Angležko, Anglia, Britania, England	England
Erdelj, Sedmogradska	Erdelj, Erdeljsko	Transilvania/Ardeal/Erdély/Siebenbürgen
Eufrat	Evfrat, Furat	al-Furāt/Firat
Europa, Evropa	Evropa, Europa	Europe*
Falačka	Palatinat	Pfalz
Filippini	Filipinski otoci	Pilipinas/Philippines
Fiorencija, Firenca, Florenc, Florencija	Fiorenza, Florenca, Florensa, Florenz	Firenze
Francezka, Francuska, Franczuzko Kralyeztvo	Francija, Francosko, Franzoſſka deshela, Franzosko	France
Gadames	Ghadames	Ghadāmis/ghdams
Galicija	Galicia, Galicija	Halychyna/Galicja
Gardsko jezero	Gardsko Jezero	Lago di Garda/Benàco
Gerčka	Grško	Elláda/Hellás
Gjur	Gjur	Győr
glavina Dobre nade	Nos dobre nade, Nos Dobre Nade	Kaap die Goeie Hoop/Cape of Good Hope
Gradac	Gradec	Graz
Habeš	Abisinija, Habeš	Ītyōṗṗyā
Irska	Irland, Irlandija, Irrland	Éire/Ireland
Islandija	Izlandija	Ísland
Italia, Italija, Talijanska	Italia, Italija, Laſhko, Laška, Laško	Italia

Names identified in Croatian sources	Names identified in Slovenian sources	Current endonyms
Iztočno kitjasko more	Vzhodno-kitajsko Morje	Zhōngguó Dōng Hăi/Higashi-Shina-Kai/Dongjungguk-hae
Jakin	Jakin	Ancona
Jaš	Jaš	Iaşi
Jedrene	Jadrene	Edirne
Jenizaj	Jenisej	Enisej
jonsko more	Jonsko morje	Iónio pélagos/Mar Ionio/Deti Jon
Južna Karolina	Južna Karolina	South Carolina
Južni Sporadi	Južne Sporade	Nóties Sporádes
južno kitajsko more	južno Kitajsko morje	Nán Zhōngguó Hăi/Nán Hăi/Dagat Timog Tsina/Biên Đông/Laut Cina Selatan
Kadiz	Kadix	Cádiz
Kairo	Kairo	al-Qāhira
Kalifornija	Kalifornija	California
Kališ	Kališ	Kalisz
Kitajska	China, Kina, Kitaj	Zhōngguó
Kološvar	Kološvar	Kolozsvár
Kolumbija	Kolumbija	Colombia
Kopenhagen	Kodanj	København
Krf	Krf	Kérkyra
Lavov	Levov	L'viv
Linac	Linc	Linz
Lipsko	Lipsko	Leipzig
Majna	Men	Main
Marijanska kupelj	Marijanske toplice	Mariánské Lázně
Mekhong	Majkoung, Mekhong	Láncāng Jiāng/Mae Khaung/Mae Nam Khong/Mènam Khong/Tonle Mékôngk/Sông Mê Kông
Mexički zaljev, mexikanski zalěv, zaljev Meksički, Zaton Mejički, Zaton Mexički	Mehikanski zaliv, Mexikanski zaliv	Gulf of Mexico/Golfo de México
Mexika, Mexiko	Mehikanska, Mexico, Mexiko	México
Mleci, Mletci, Mljetci, Venecija	Benedke, Benetke	Venezia
Moldavska	Moldavija, Moldavska, Moldavski, Multanija	Moldova
Monakov	Mnihov	München
Moriš	Moriš	Mureş/Maros
Moriški Novi Tèrg	Moriški Novi trg	Târgu Mureș
Moza	Maza, Moza	Meuse/Maas
Mozela	Mozela	Moselle/Mosel
Muhač	Muhač	Mohács
Napolj, Napuli, Napulj	Napoli, Neapol, Neapolj, Neapel, Neapoli	Napoli
Nemachka, Nemačka, Němačka, nimaçka zemglia, Njemačka, Njemadija, Njemčadija	Nemčija, nemſhki Rajh, nemſhko, Nemške države, Nemško	Deutschland
Nil	Nil	an-Nīl/Nile/Phiaro/iteru
Nizza	Nizza	Nice
Norveška, Norvežka	Norvegija	Norge/Noreg

Names identified in Croatian sources	Names identified in Slovenian sources	Current endonyms
Nova Foundlandija	Nova Fundlandija	Newfoundland
Nova Kaledonija	Nova Kaledonija	Nouvelle-Calédonie
Nova Seelandija	Nova Zelandija	New Zealand/Aotearoa
Novi Hebridi	Nove Hebride	New Hebrides/Nouvélles-Hebrides*
Novi Jork	Novi Jork, Novi York	New York
Odra	Odra	Odra/Oder
Olomuc	Olomouc	Olomouc
Oporto	Oporto	Porto
Orijaško gorje	Krkonoši	Krkonoše/Karkonosze
Pad	Pad	Po
Parigi, Pariz	Paris, Pariz	Paris
Pasov	Pasov	Passau
Pećuh, Pećuj	Pečuh	Pécs
Persia, Perzia	Iran, Persia, Persija, Perzija	Īrān
Petrograd	Petrograd, Petrovburg	Sankt-Peterburg
Pirej	Pirej	Peiraiás
Piza	Pisa	Pisa
Plzanj	Pelzenj	Plzeň
Poljsko Kraljevstvo, Polyzko Kralyeztvo	Poljsko	Polska
Požun	Požunj	Požun
Prag, Pragha	Prag, Praga	Praha
Pruska	Prajſoviko, Prusko	Preußen
Rajna	Rajna	Rhein/Rhin/Rijn
retičke Alpe, Rhaetske Alpe	Retiske Alpe, Retiske Planine, Retiške Planine	Alpi Retiche/Rätische Alpen
Rim	Rim	Roma
Robsko jezero	Sužniško Jezero, Veliko Sužniško Jezero	Great Slave Lake
Rodos	Otok Rod, Otok Rodos, Rod, Rodos	Ródos/Rhódos
Ruska	Rusija, Rusko, Rusko cesarstvo, Ruſsia	Rossija
Sala	Salla	Saale
Saska	Sasko	Sachsen/Sakska
Siget	Siget	Szigetvár
Sileska, Szlezia	Sleško	Śląsk/Slezsko/Schlesien
Smirna	Smirna	İzmir
Solnograd	Solnimgrad	Salzburg
Spanyolzko Kralyeztvo, Španjolsko Kraljevstvo	Shpanija, Španija	España
sredozemno more, Sredozemno more	Srednje morje, Sredozemsko morje	Mediterranean Sea/Mer Méditerranée/ Mar Mediterráneo/Mar Mediterrània/ Mar Mediterraneo/Sredozemno more/ Deti Mesdhe/Mesogeios Thalassa/Akdeniz/ ha-Yam ha-Tikhon/al-Baḥr al-Abyaḍ al-Mutawassiṭ/Ilel Agrakal
Stajerzka, Štajerska	Štajersko	Steiermark
Stokholm, Štockholm, Štokholm	Stockholm	Stockholm
Stolni Biograd	Stolni Belgrad	Székesfehérvár

Names identified in Croatian sources	Names identified in Slovenian sources	Current endonyms
Syrija	Sirija, Sirsko	Sūriyya/Sūryā
Šopronj	Šopronj	Sopron
Štrasburg	Strassburg	Strasbourg
Švedska	Švedija	Sverige
Tamiš	Tamiš	Timiş/Tamiš
Temišvar	Temišvar	Timişoara
Tèrst, Trst	Terst, Terſt, Trst	Trieste
Thirrensko more, Tirensko more, Tirrensko more, Tirrhensko more	Tirensko morje, Toskansko Morje	Mar Tirreno/Mer Tyrrhénienne
Tiber	Tibera	Tevere
Tibet	Tibet	Xīzàng zìzhìqū/Xīzàng/ Bod-rang-skyong-ljongs/Bod
Tiflis	Tiflis	T'bilisi
Tirolska	Tirolska, Tirolsko	Tirol
Turska, Turzko Czeszarztvo	Turčia, Turčija, Turške dežele, Turzhija	Türkiye
Varsciovia, Varšava	Varšava	Warszawa
Velika Britania, velika Britanija, Velika Brittania	Velika Britanija	Great Britain/Breatainn Mhòr/Prydain Fawr
Velika Kaniža	Velika Kaniža	Nagykanizsa
Veliki Varadin	Veliki Varad, Veliki Varadin, Veliki Vardin	Oradea
Veliko medvedje jezero	Medvedje Jezero	Great Bear Lake
Vezera	Vezera, Vezra, Wezra	Weser
visoke Ture	Visoke Ture	Hohe Tauern
Volinj	Volinj	Volyn'
Vorarlberžka	Predarelsko	Vorarlberg
Zalĕv sv. Lovrinca	Svetega Lovrencija zaliv	Gulf of Saint Lawrence/Golfe du Saint Laurent
zelena glavina	Zeleni Nos	Cap Vert
Žuto more	Rumeno morje	Huáng Hǎi/Hwang-Hae

*English and French name

4.1 Comparison

In comparing the oldest exonyms in Croatian and Slovenian, the use of an identical exonym in both languages was found for forty-five topographic features. These are cases in which only one exonym form was identified for a single language (the exception is 'Europe', for which two identical ones were identified in both languages). Such examples are *Jakin* 'Ancona', *Krf* 'Corfu', and *Nizza* 'Nice'. A match was also found in at least one exonym form in twenty-two named topographic features, where the use is not uniform in either Croatian or Slovenian. Such examples are *Beč* 'Vienna', *Habeš* 'Abyssinia, Ethiopia', *Persija* 'Persia, Iran', and *Varšava* 'Warsaw'. Six cases involved differences only in the generic part of the name. These are mostly the names of bays and seas, such as Cro. *Azovsko more* and Sln. *Azovsko morje* 'Sea of Azov', Cro. *Bengalski zalĕv* and Sln. *Bengalski zaliv* 'Bay of Bengal', and Cro. *Jonsko more* and Sln. *Jonsko morje* 'Ionian Sea'. However, only three examples of names have a single Croatian or Slovenian exonym form and these forms are obviously different from each other. These are Cro. *Kopenhagen* and Sln. *Kodanj* 'Copenhagen', Cro. *Mleci*, *Mletci* and Sln. *Benetke*, *Benedke* 'Venice', and Cro. *Bečko Novo Mjesto* and Sln. *Dunajsko Novo mesto* 'Wiener Neustadt'.

When comparing exonyms in the two languages, some characteristic differences were also found. In some cases, there is a difference between exonyms in the languages examined regarding the letters *e* and *a* (e.g., Cro. *Bodansko jezero* and Sln. *Bodensko jezero* 'Lake Constance') and when using the diphthongs *au* and *av* (e.g., Cro. *Austria* and Sln. Avstrija 'Austria'). There is also a characteristic difference in the suffixes of some modern or historical countries and administrative units, with the Croatian suffix *-ska* and the Slovenian suffix *-sko* (e.g., Cro. *Pruska* and Sln. *Prusko* 'Prussia'). Two more examples of the use of the Slovenian exonyms instead of German endonyms in Croatian for modern Austria are noteworthy: for Villach (Sln. *Beljak*) the Croatian exonym variants *Bělak*, *Beliak*, and *Beljak* were used, and for Klagenfurt (Sln. *Celovec*) the Croatian exonym variants *Celovac*, *Čělovac*, and *Cjelovac*.

Some principles of exonym standardization were also seen in individual semantic types of geographical names. The exonyms for seas and lakes in both languages are usually formed with the adjective endings *-sko* and *-ško* plus a common noun; for example, Cro. *Arapsko more* and Sln. *Arabsko morje* 'Arabian Sea', Cro. *Bodansko jezero* and Sln. *Bodensko jezero* 'Lake Constance', and Sln. *Atlanško morje* 'Atlantic Ocean'.

For adapting the names of European rivers from the German-speaking area, adding the suffix *-a* prevailed; that is, converting the name into a feminine noun (which agrees with the gender of Cro. *rijeka* 'river' or Sln. *reka* 'river'; for example, Cro./Sln. *Rajna* 'Rhine'. The use of the name form *Ren* later dominated in Slovenian.

The names of continents, many countries, and important or large towns gained exonyms in Croatian and Slovenian early on. Names of continents were adapted to facilitate pronunciation. An interesting example is Cro. *Europa* 'Europe', which is cited in the oldest sources in this form (only Klaić uses the form *Evropa*, but he also sometimes replaces it with the form *Europa*). A similar situation is found in Slovenian, in which the use is inconsistent in the oldest newspaper sources (both *Europa* and *Evropa* 'Europe'), but the form *Evropa* later became established. Names of countries were most often nativized by the addition of the suffixes *-s(z)ka* in Croatian and *-s(z)ko* in Slovenian, and *-ija* in both languages; for example, Cro. *Australija* and Sln. *Avstralia*

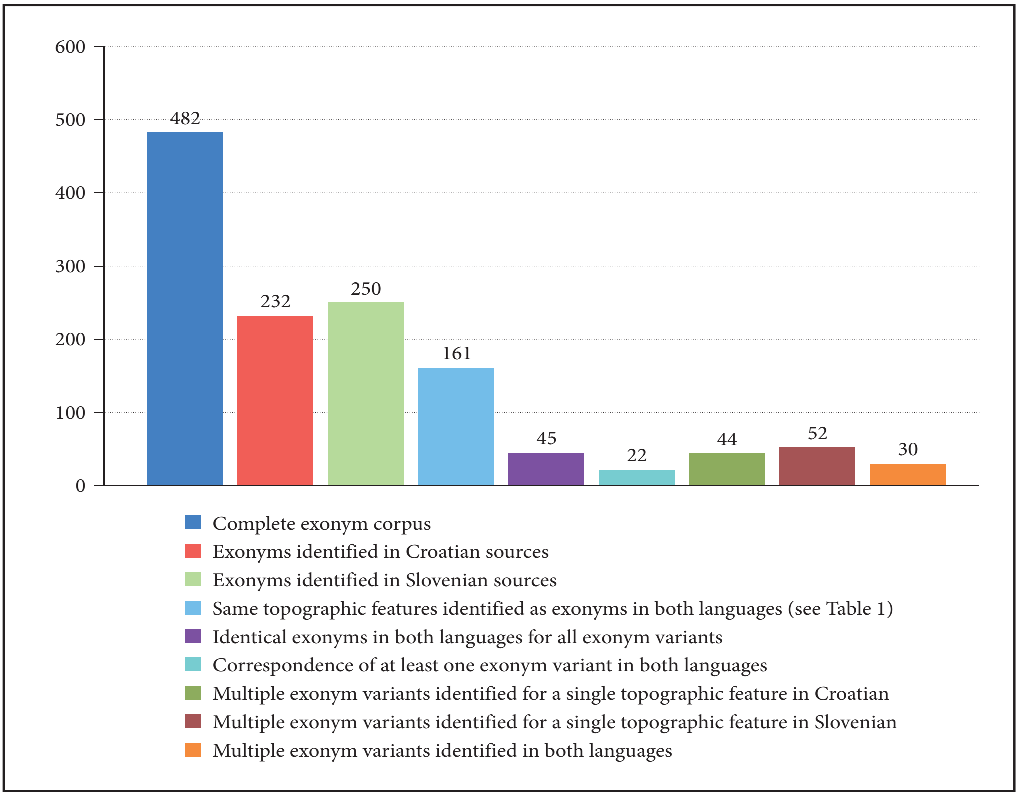


Figure 3: Number of exonyms analyzed by individual sources and types.

'Australia', Cro. *Francezka* (later *Francuska*) and Sln. *Francija* 'France', and Cro./Sln. *Pers(z)ija* 'Persia, Iran'. For the Croats and Slovenians, prominent towns often already had traditional Croatian or Slovenian names.

A comparison of the number of different exonyms for individual topographic features showed that there are fifteen such cases only in Croatian, nineteen only in Slovenian, and twenty-two in both languages. This indicates rather inconsistent use of exonyms in the oldest sources.

Unsystematic use can also be found within an individual issue of a newspaper, when different exonym forms appear for the same geographical feature. A good example is found in the Croatian literary supplement *Danicza horvatzka, slavonzka y dalmatinzka* from 1835, where the following forms are found for 'Montenegro': *Cherna Gora*, *Czerna Gora,* and *Czerna gora* (issue 19), *Černa Gora* (issue 32), and *Cernagora* (issue 50). Comparing the exonyms identified in both languages, there are forty-four that appear in different forms in Croatian, and fifty-two in Slovenian.

4.2 Typology

When comparing Croatian and Slovenian exonyms in the oldest sources, it was found that roughly four most frequent patterns of adapting a toponym (i.e., type of exonymization) appear:

The first pattern is the translation of all or part of the endonym. For example, Cro. *Bělo/Bijelo more* and Sln. *Belo morje* 'White Sea', Cro. *Cerno/Crno more* and Sln. *Črno morje* 'Black Sea', Cro./Sln. *Nova Holandija* 'New Holland', and Cro. *Bečko Novo Mjesto* and Sln. *Dunajsko Novo mesto* 'Wiener Neustadt'.

The second pattern is the addition of Slavic suffixes: Cro./Sln. *-ija*, Cro. *-ska*, *-ška*, *-čka* (in oldest sources *-zka*), and Sln. *-sko*, *-ško*, *-žko*; for example, Cro. *Australija* and Sln. *Avstralija* 'Australia', Cro. *Austrija* and Sln. *Avstrija* 'Austria', Cro. *Moldavska* 'Moldova', Cro. *Norveška* 'Norway', Cro. *Gerčka* and Sln. *Grško* 'Greece', Cro. *Francezka* and Sln. *Francosko* 'France', and Cro. *Englezka* and Sln. *Angležko* 'England'.

The third pattern is the simplification of pronunciation and the omission of special characters and letters that do not exist in either Croatian or Slovenian; for example, Cro. *Atina/Atena* and Sln. *Atene/Atine* 'Athens', Cro. *Bukarešt/Bukurešt* and Sln. *Bukreš* 'Bucharest', Cro. *Eufrat* and Sln. *Evfrat/Furat* 'Euphrates', Cro./Sln. *Gjur* 'Győr', Cro./Sln. *Olomuc* 'Olomouc', Cro./Sln. *Pasov* 'Passau', and Cro./Sln. *Varšava* 'Warsaw'.

The fourth pattern is the use of old Croatian and Slovenian names, which can be described as »typical« exonyms; for example, Cro. *Beč/Beç* and Sln. *Dunaj/Dunej/Beč* 'Vienna', Cro./Sln. *Bruselj* 'Brussels', Cro. *Carigrad/Czarrigrad* and Sln. *Carjigrad/Konstantinopel/Zargrad* 'Istanbul', Cro. *Draždjani/Draždđani* and Sln. *Draždane* 'Dresden', Cro. *Erdelj* and Sln. *Erdelj/Erdeljsko* 'Transylvania', Cro./Sln. *Jakin* 'Ancona', Cro. *Jedrene* and Sln. *Jadrene/Adrianopel/Drenopolje* 'Edirne', Cro./Sln. *Krf* 'Corfu', Cro./Sln. *Lipsko* 'Leipzig', Cro. *Mleci/Mletci* and Sln. *Benetke/Benedke* 'Venice', Cro. *Napulj/Napolj* and Sln. *Neapolj/Neapel* 'Naples', Cro./Sln. *Pad* 'Po', Cro. *Pećuh/Pećuj* and Sln. *Pečuh* 'Pécs', Cro. *Prag* and Sln. *Praga* 'Prague', Cro./Sln. *Rim* 'Rome', Cro. *Tiber* and Sln. *Tibera* 'Tiber', and Cro./Sln. *Trst* 'Trieste'.

4.3 Discussion

Exonyms have been relatively well studied in central Europe (Hajčiková and Kováčová 1997; Horňanský 2000; Jordan 2000), but there are differences between languages. Some languages (e.g., Finnish and Polish) have a decades-long tradition of gazetteers with exonyms (e.g., Hakulinen and Paikkala 2012; Wolnicz-Pawłowska 2013), whereas others have only individual partial studies. Slovenian does not have such a long tradition, but it has a dictionary or list of exonyms in both digital and book form (Kladnik et al. 2013; Kladnik and Perko 2013). In addition, Slovenian exonyms are also considered from some other points of view. Two separate gazetteers of exonyms have also been published in Croatian in recent years (Crljenko 2016; 2018), but some aspects have not yet been addressed. All these works mostly focus on the current situation, and in neither language has there yet been a fundamental discussion of the beginnings of exonym standardization. This gap has been addressed with the bilateral project A Comparative Analysis of Croatian and Slovenian Exonyms, based on which several studies have been published (e.g., Kladnik et al. 2017).

A comparison of the beginnings of exonym standardization in Croatian and Slovenian confirms some basic assumptions about this process in both languages; however, some differences between the two languages are also apparent. Although some exonyms appear very early, in both languages their number increased considerably in the second half of the nineteenth century. Namely, this was the time of national movements, which were initially also (or mainly) asserted with a national language. This was also the time of the large-scale press, especially newspapers, which also carried news from areas where foreign languages were spoken. A key characteristic of the use of exonyms in this period is especially their lack of systematicity.

There are several reasons for the unsystematic use of exonyms. The most important of these, which applies to both languages, is the absence of orthographic manuals in the languages, which began to appear in the last decade of the nineteenth century (in 1892 in Croatian and 1899 in Slovenian). The difference between the Slovenian and Croatian orthographic manuals is that the Slovenian one contained rules for writing foreign geographical names as soon as it was published in 1899, and the Croatian one only in its edition published in 1904. An additional circumstance in Croatian is the existence of multiple standards at the same time. Up until the Illyrian movement in the first half of the nineteenth century, the northern Croats wrote using an adapted Hungarian Latin script, and the southern Croats used an adapted Italian script. In addition, some writers often changed their Latin script orthography from one occasion to another. The Croatian linguist Ljudevit Gaj, following the example of the Czech alphabet, created a Roman-alphabet system (known as *gajica* 'the Gaj alphabet'), using a distinct set of letters. The Gaj alphabet also replaced the Bohorič alphabet in Slovenian. However, the Slovenian Gaj alphabet is somewhat modified and, in contrast to the Croatian version, has only twenty-five letters. Another difference between the two languages or their scripts is associated with Ljudevit Gaj – that is, Illyrianism, which did not win as much sympathy among the Slovenians as among the Croats. For the Slovenians, this meant, above all, a departure from the German political framework, but in no way did they accept Štokavian dialect as the standard norm for all South Slavs.

An interesting difference in the use of geographical names in both languages is also reflected in some Slovenian names in territory that lies outside Slovenia. For settlements near today's Slovenian–Austrian border, the Croats used Slovenian-(based) forms (e.g., *Beljak, Celovac*) while they were in common countries with the Slovenes – and, as distance to the north increases, this kind of shared use decreases. For example, for the highest Austrian peak, Mount Großglockner, the Croats use the German name (and in older usage also the form *Gros Glokner*), whereas in Slovenian the name *Veliki Klek* has become established.

A shared characteristic is also the fact that some exonyms in both languages were taken from other languages, especially Slavic ones.

The lack of uniformity in both languages was also contributed to by the fact that some basic geographical and cartographic works were published before the first orthographic manuals, for example, textbooks (in 1823 in Croatian and 1865 in Slovenian) and atlases (in 1887 in Croatian and between 1869 and 1877 in Slovenian); among all publications, these certainly contain the most adapted foreign geographical names. Because the spelling norm on writing names was not established before this, the lack of uniformity is really not surprising.

Comparing the findings of this study with some other related studies in European languages (Pokoly 2006; Gînsac and Ungureanu 2018; Moscal 2018) reveals some similarities. The time when exonyms arose is similar in Romanian, around 1800, and in Hungarian the oldest systematic sources are from the beginning of the eighteenth century (the name *Bees* 'Vienna' appears as early as 1356). In classifying these names by their manner of adaptation, three types are roughly shown in related research: complete translation, partial translation, and addition of suffixes. Interestingly, at least in the Romanian case, this does not involve exonyms, but translated names. The use of exonyms was also inconsistent because in the same source an individual name may appear in different forms. The role of individual languages, which acted as mediators in the adaption of some foreign geographical names, is also evident.

This discussion, which is based on a limited amount of material, partially fills the research gap regarding the beginnings of the appearance of exonyms in two related languages, Croatian and Slovenian. An updated corpus of names would clearly contribute to even better results. In the case of Croatian, the appearance of exonyms in the first atlases should be treated more systematically, and in Slovenian especially their use in newspapers. In this way, individual types of material could be compared, not only the material as a whole.

5 Conclusion

The first exonyms in Croatian and Slovenian appeared in large numbers at the end of the eighteenth century with the first newspapers. Their number increased in the nineteenth century because the first orthographic manuals, atlases, and geographical textbooks containing foreign geographical names also appeared in the second half of the century.

A comparison of the beginnings of exonym standardization in Croatian and Slovenian shows that the emergence of exonyms in both languages was mainly influenced by historical and political circumstances and the language policy of the time. A similar language, immediate proximity, and a partly common past fostered many similar and identical exonyms in both languages, and some differences are mainly due to spelling differences and some differences in grammatical rules. In the analysis of exonyms, four groups were highlighted: partly or entirely translated names, names with a Slavic suffix added, names with simplified writing based on pronunciation, and old or »typical« exonyms.

ACKNOWLEDGEMENTS: The authors acknowledge financial support from the Croatian Ministry of Science, Education, and Sports and from the Slovenian Research Agency for funding the bilateral project A Comparative Analysis of Croatian and Slovenian Exonyms, and from the Slovenian Research Agency core funding Geography of Slovenia (P6-0101). Special thanks to Irena Orel for sharing data about Slovenian exonyms from old newspapers.

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Acta geographica Slovenica, 61-2, 2021, 91–107

COVID-19 IMPACT ON DAILY MOBILITY IN SLOVENIA

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Bus stop Dovje-Mojstrana.

DOI: https://doi.org/10.3986/AGS.9390
UDC: 913:331.556:616-036.22(497.4)
COBISS: 1.01

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COVID-19 impact on daily mobility in Slovenia

The Slovenian subsample (n=415) of an international online survey about changes in daily mobility during the COVID-19 outbreak in the spring of 2020 was analysed from a geographical perspective. The dataset was split into three spatial classes (urban, transitional and rural) according to the respondents' place of residence. People's behaviour before and during the COVID-19 lockdown was compared and analysed in terms of commuting frequency, changes in mode choice for commuting and style of grocery shopping. The results show that commuting was reduced drastically during the lockdown while the car remained the main transport mode both for commuting and shopping, especially in rural areas. The study provides an unprecedented insight in travel behaviour changes due to the pandemic and congruously argues for improved transport policies to meet climate change and public health challenges.

KEY WORDS: travel behaviour, modal share, level of urbanization, lockdown, pandemic, Slovenia

Vpliv epidemije covida-19 na dnevno mobilnost v Sloveniji

POVZETEK: Z geografskega vidika smo analizirali slovenski podvzorec (n = 415) mednarodne anketne raziskave o spremembah dnevne mobilnosti, ki je bila izvedena med prvim valom epidemije covida-19 spomladi 2020. Podatkovno bazo smo najprej razdelili v tri skupine glede na kraj bivanja anketirancev (urbani, prehodni in ruralni), nato pa primerjali mobilnost ljudi pred in med zaprtjem države ter jo analizirali z vidika pogostnosti poti na delo, izbora načina potovanja in nakupovalnih navad. Ugotovili smo, da so bila potovanja na delo med zaprtjem države izrazito okrnjena, pri tem pa je osebni avtomobil tako za pot na delo kot nakupovanje ostal prevladujoč potovalni način, zlasti na podeželju. Raziskava nudi edinstven vpogled v spremembe potovalnih navad med epidemijo in podkrepljuje potrebo po bolj trajnostnih prometnih politikah za omilitev podnebne krize in izboljšanje javnega zdravja.

KLJUČNE BESEDE: potovalne navade, modalni delež, stopnja urbanizacije, zaprtje države, pandemija, Slovenija

The article was submitted for publication on January 6th, 2021.
Uredništvo je prejelo prispevek 6. januarja 2021.

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1 Introduction

The COVID-19 pandemic has been affecting the World in an unprecedented manner. When the SARS-CoV-2 virus spread in Europe in early spring of 2020, a diversity of reactions – from pharmaceutical to non-pharmaceutical – ensued. Among the non-pharmaceutical interventions (NPI) enacted by national and/or regional authorities were measures to reduce virus transmission by restricting socializing and public life and limiting human movement (Flaxman et al. 2020) – also called lockdown.

The SARS-CoV-2 virus was also detected in Slovenia. In the first half of March 2020, the spread of infections accelerated and on March 12th, the Government of the Republic of Slovenia declared an epidemic (Odredba o razglasitvi … 2020). Interventions followed quickly: on March 16th, gathering of people in educational institutions was prohibited and the prohibition of public transport was issued as well. In addition, all restaurants and many shops were closed. On March 30th, any movement outside municipalities of residence was also prohibited (with certain exceptions). The total lockdown of public life and many activities lasted about a month, as the first measures to lift the lockdown took effect on April 17th (Odlok o začasni prepovedi in omejitvah … 2020; Odlok o spremembi … 2020; Odlok o začasni prepovedi, omejitvah … 2020). While many EU countries introduced restrictions on public transport (Internet 1; Internet 2; Internet 3), Slovenia was one of the very few countries that decided to shut-down public transport completely. International road and rail-bound public transport was reinstated on June 13th (Odlok o načinu izvajanja … 2020). With such an approach to fighting the epidemic, some sources cite Slovenia ranked high among countries on the stringency index in the first wave (Hale et al. 2020), while others (Hans et al. 2020) cite in general less stringent measures. The same study (Hans et al. 2020) argues that around April 1st 2020 Slovenia's measures during lockdown were among the most stringent in EU, however this phase lasted less than a month. Therefore, the general assessment is that Slovenia faced medium exposure to potential negative impact of COVID-19 lockdown, a medium sensitivity in the eastern and central parts and a low sensitivity in the western part of the country (Hans et al. 2020). This makes Slovenia interesting for research on potential consequences of COVID-19 on human behaviour such as mobility.

After the first COVID-19 wave, many scholars evaluated the worldwide effect of lockdown on human mobility. While some research collectives fathomed the global impact by interviewing transport scholars and professionals (Zhang and Hayashi 2020), other scholars conducted surveys of mobility changes due to COVID-19 for different countries.

A team of researchers from TU Wien – with the aid of international colleagues – designed, translated, launched and distributed an online questionnaire in 21 languages to study the impact of the various intensities of NPI measures on people's daily mobility patterns. An analysis of the obtained international data focuses on the commonalities and discrepancies in commuting behaviour for a subsample of fourteen countries (Shibayama et al. 2021). As Austrians were the most represented participants in this survey, country-specific results were highlighted particularly by Brezina et al. (2020b). Their findings show substantial changes in transport demand and in general a drastic decrease of transport volumes during lockdown.

A major branch of research focused on analysing traffic flows and all reported significant decrease. One such analysis (Internet 4) shows that congestion levels in many cities dropped to 10% during the lockdown, whereas they normally reach around 30–60%. In China, during the Spring Festival rush from January 10th to February 13th, commercial passenger traffic fell by 46.6% and rail, road, waterway and civil air traffic fell by 50.3% compared to the same period of the previous year (Zhou, Wang and Huscroft 2020). In Japan, for example the major Tokaido Shinkansen line reported a 59% drop in passenger numbers in March. A study by Zhang (2020) estimates that between January and March 2020, Japanese domestic intercity rail travel declined by 30%. In India, after the nationwide lockdown on March 25th, a similar decrease of daily mobility was detected with only a slow recovery (Dandapat et al. 2020). In Sweden, for three regions (Stockholm, Västra Götaland and Skane) the number of daily trips from March 1st to April 1st decreased by about 40–60% relative to the same period in 2019 (Jenelius and Cebecauer 2020). In the city of Santander, Spain, Aloi et al. (2020) report significant decrease in public transport and reduction of transport related emissions of pollutants, with emissions of NO_2 reduced by 60%. Arellana, Márquez and Cantillo (2020) made an analysis of official and secondary data of transport systems in seven urban areas within Colombia. In the first three months of the pandemic, freight transport was the most resilient transport component. A German survey studied the effects on the travel behaviour by means of an online survey while distinguishing areas with different levels of lockdown intensity. Results reveal a shift away from public transport and increases in car usage, walking and cycling (Anke et al. 2021).

From the geographical perspective, also studies on modelling the influence of mobility on the spread of SARS-CoV-2 should be noted, for example by Chang et al. (2021). While many studies focused on COVID-19 impact during the pandemic, some are already trying to foresee how cities will change in order to live with a permanent COVID-19 threat (Florida, Rodriguez-Pose and Storper 2020).

Slovenia represents a good example of polycentric urban development (Nared et al. 2017) and is one of the European countries with the most dispersed settlement system. According to the degree of urbanization (DEGURBA) classification, 44.5% of people are living in thinly populated areas, also classified as »rural« (Local Administrative Units 2021). Trends in daily mobility in recent decades have been associated with an increase in inter-regional traffic flows towards major centres, a weakening of public transport and an increase in car-dependent mobility patterns (Bole 2004; 2011). Travel behaviour changes among the youth show a similar trend: between 1991 and 2016 in primary schools in Novo mesto, the share of pupils who come to school by car increased from 4 to 53% (Plevnik, Balant and Mladenovič 2017).

However, only few studies have been conducted on the impact of the COVID-19 pandemic on travel behaviour in Slovenia so far. A survey by the Slovenian Car Association (AMZS) questioned almost 500 people about the change of their mobility habits, indicating some substantial changes (Poženel 2020). While the survey of the European Consumer Organization shows that occasional work at home in Slovenia increased from 27 to 63% of the population during the lockdown compared to before lockdown, 56% of respondents were still occasionally working from home in October 2020 (Okorn 2020).

Some »pre-COVID-19« mobility studies took spatial differences in transport behaviour into consideration, such as between rural and urban areas. In general, the mobility of the urban-rural continuum is characterized by the fact that as rurality increases, the private car gains in value and public transport loses (Pucher and Renne 2005; Bouwman and Voogd 2005). Studies from the Netherlands have also shown that the number of short distance trips in rural areas decreases and the number of medium distance trips increases (Bouwman and Voogd 2005). Connections between mobility pattern and lifestyle across the urban-rural continuum were also studied in Slovenia by Drozg (2012). Inhabitants of towns and suburbs were found to be more mobile than rural dwellers, while the latter usually travel over longer distances. His study confirms the gap between urbanization of inhabitants (urban way of life) and urbanization of space (accessibility of urban activities).

Our review of existing research and literature shows that a geographic approach to studying the impact of the COVID-19 epidemic on daily mobility has not been used yet. Thus this paper examines the Slovenian subsample of the openly available dataset »International survey on COVID-19 lockdowns and mobility behaviour« (Brezina et al. 2020a) from a geographically differentiated viewpoint. Previous analysis of this available dataset has examined differences and commonalities between 14 countries, Slovenia included, but did not specify geographic differences (Shibayama et al. 2021). Their research also indicates that the Slovenian subsample appears well suited for a detailed geographical analysis, as it shows the best balanced distribution between urban and rural locations. Apart from Slovenia, countries show predominantly urban respondent locations. In this paper, we analyse the replies of respondents from Slovenia, distinguishing by their residential location along the urban-rural continuum. Here we study the changes in daily travel behaviour of the subsample for work commuters and for grocery shopping due to NPIs during the first wave of the COVID-19 pandemic compared to the pre-pandemic period. These types of trips were the only ones allowed during the lockdown, except for emergency trips.

2 Methods and data

2.1 Questionnaire

We utilise the openly accessible dataset of an international online survey in 21 languages on changes in everyday mobility, carried out during the COVID-19 outbreak in spring of 2020 (Brezina et al. 2020a). The online questionnaire was available with its first language versions from March 24th until May 12th, 2020. The Slovene version was available from March 25th on. In total, the dataset contains more than 11,000 responses from over 100 countries. The questionnaire is reported (Shibayama et al. 2021) to have been distributed with the snowball method using email and social media and comprised of 33 total questions with predominantly closed-ended questions. Replies included the option »other« to specify a divergent answer.

The survey gathered information from respondents on:
- the specifics of workplace;
- the specifics of place of education;
- the specifics of grocery shopping;
- the transport means, duration and frequency of trips for these purposes before and during the COVID-19 triggered lockdown;
- the way of and motivation for changing one's behaviour;
- and the COVID-19 triggered changes in child-care.

In addition to age class, gender, education and occupation, household type and country of living, the postcode was also asked to identify the location of the respondents. We use the postcode for spatial classification of responses. The metadata of the dataset gives details on questions and answering options (Brezina et al. 2020a).

2.2 Sample

The Slovenian subsample encompasses 415 total replies of which 244 stated to be female, 167 to be male and 4 people chose diverse or left it unanswered. As for the gender and age class of the respondents, Table 1 shows the age distribution of the sample.

Table 1: Age distribution of the survey participants.

	Sample (n = 411)	
Age class	Male [%]	Female [%]
0–18	0.5	0.5
19–29	4.1	11.2
30–39	11.7	18.0
40–49	11.9	18.0
50–59	6.1	8.3
60–69	5.1	2.4
70 or older	1.2	1.0
Total	40.5	59.2

Out of 415 total participants, 337 (307 + 20 + 10 in Figure 1) stated to be of working occupation. Table 2 gives the number of participants answering to questions being relevant in the course of this analysis.

Table 2: Subsample sizes.

Subsample	n	Reference to
Working occupation	337	Figure 1
Commuting before lockdown	290	Figure 2
Commuting under lockdown	310	Figure 3
Work commute	289	Figure 4
Grocery shopping	351	Figure 5
Workplace type	313	Figure 6
Grocery shopping style before lockdown	387	Figure 7
Grocery shopping style under lockdown	384	Figure 8

As for the respondents' occupational status, 74% were employees, 7.5% were retired, 6.8% were students (working and non-working) and 4.8% were self-employed (see Figure 1). Therefore, occupational status deviates from the national distribution as persons in employment, which account for around 43% of the national population, are overrepresented in the sample on the account of other population groups (Čuk 2020; Razpotnik 2020).

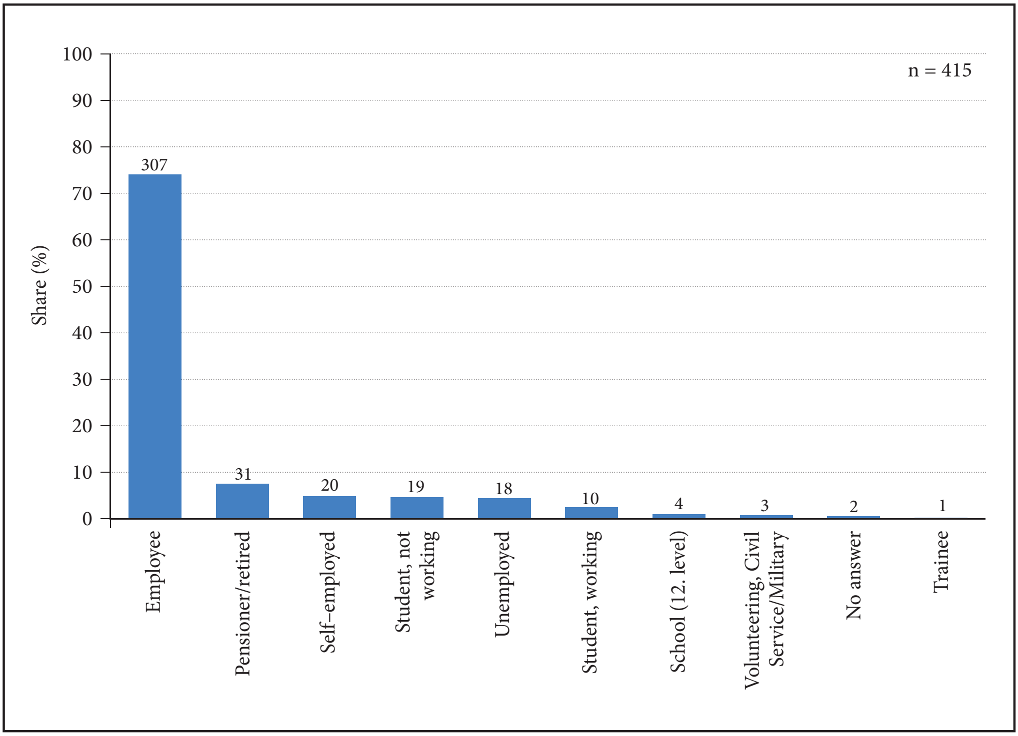

Figure 1: Share of survey respondents by occupation with absolute respondent number over each column.

2.3 Spatial classification

The geographic classification for Slovenia regarding the level of urbanization is also available at the settlement level (n = 5,994) and consists of six types: S1 = city/town, S2 = suburbanized settlement, S3 = urbanized settlement, S4 = strongly urbanized rural settlement, S5 = urbanized rural settlement and S6 = rural settlement (Ravbar 1997; Cigale 2005). As individual survey data records were available on the national postal district level, the data from the survey (available with much smaller granularity) needed to be aggregated to a higher level. For this task we applied the following criteria for determining three postcode types along the urban-rural continuum:

1. Urban area – predominant share (minimum 50%) of urban population (type S1) AND 75% of population together with suburbs (types S1+S2) AND maximum 10% of rural population (types S5+S6).
2. Transitional area – mixed, urban-rural area; does not meet the criteria either for urban or rural areas.
3. Rural area – a minimum of 50% of the population lives in rural or urbanized rural settlements (type S5+S6).

As the type S1 in the original classification of settlements was based on the outdated list of towns from 1981, we slightly revised it and identified cities and towns according to the classification of the Slovenian statistical office's (SURS) criteria numbers one (≥ 3,000 inhabitants) and four (suburban settlements, gradually spatially and functionally integrated with an urban settlement with 5,000 inhabitants or more) (Pavlin et al. 2004).

The results show that 268 respondents are located in districts defined as urban (64.6%), 92 in transitional (22.2%) and 35 in rural (8.4%), while 20 participants (4.8%) provided non-assignable postcode data (Table 3). Participants from a total of 110 postal districts (out of 466) have been recorded. The distribution along the rural-urban continuum is therefore slightly biased with overrepresented urban dwellers (around 50% of the Slovene population lives in urban areas) and underrepresented rural dwellers (their actual share in the national population is around 25%). The share of respondents in transitional areas is comparable to the national average (Cigale 2005). Figure 2 shows the distribution of participants by postcode types over Slovenia.

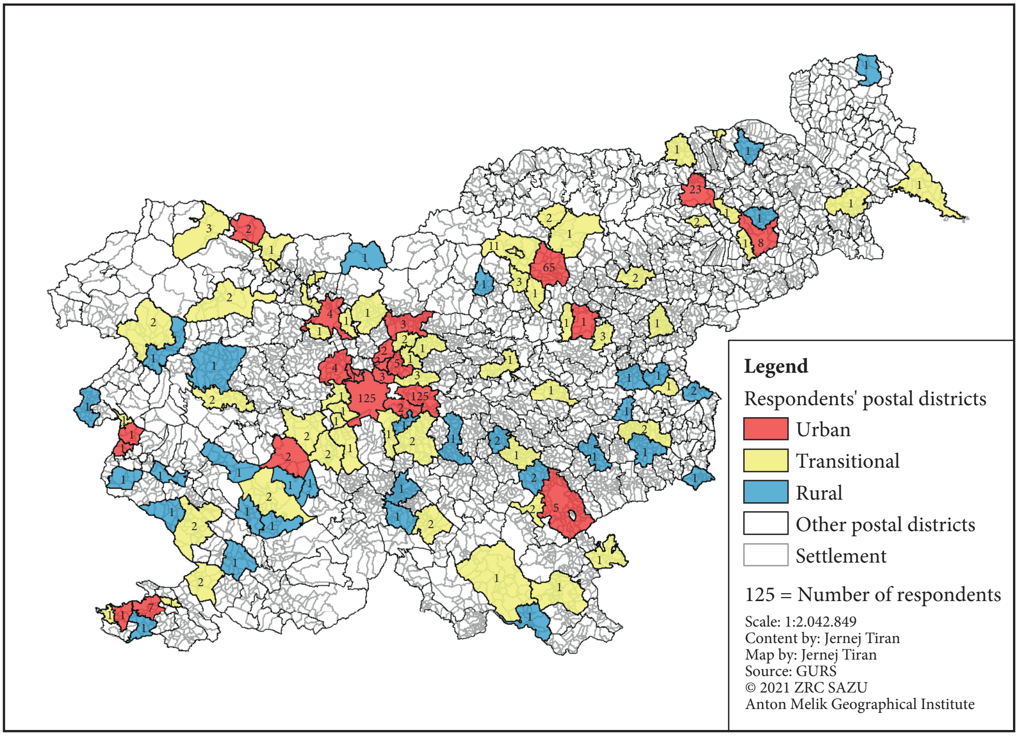

Figure 2: Map of Slovene postcode districts with their level of urbanization and inscribed number of survey participants.

Table 3: Sample sizes and shares of respondents by geographical classification.

Postcode types	Sample size	Sample share [%]
Urban	268	64.6
Transitional	92	22.2
Rural	35	8.4
None	20	4.8
Total	415	100.0

3 Results

The geographical distinction of commuting frequency before COVID-19 lockdown (Figure 3) shows a clear picture, as 81% (transitional) to 92% (rural) of the respondents were commuting five days a week. Under COVID-19 lockdown, the situation changed drastically (Figure 4): around half report that they were not commuting, but were under a mandatory home office regime. When adding those persons whose work was closed (rural 3.4% to urban 10.0%) and those who worked at home voluntarily (rural 6.9% to urban 13.9%), no actual commuting was taking place for a portion of between 62.1% (rural) and 72.2% (urban) of the sample. Only around 10% of respondents commuted the same number of times.

Figure 5 shows the mode choice for work commute (left column) and for grocery shopping (right column) in Sankey (flow) diagrams. The left hand side of each diagram shows the mode choice before COVID-19 lockdown and the right hand side during lockdown.

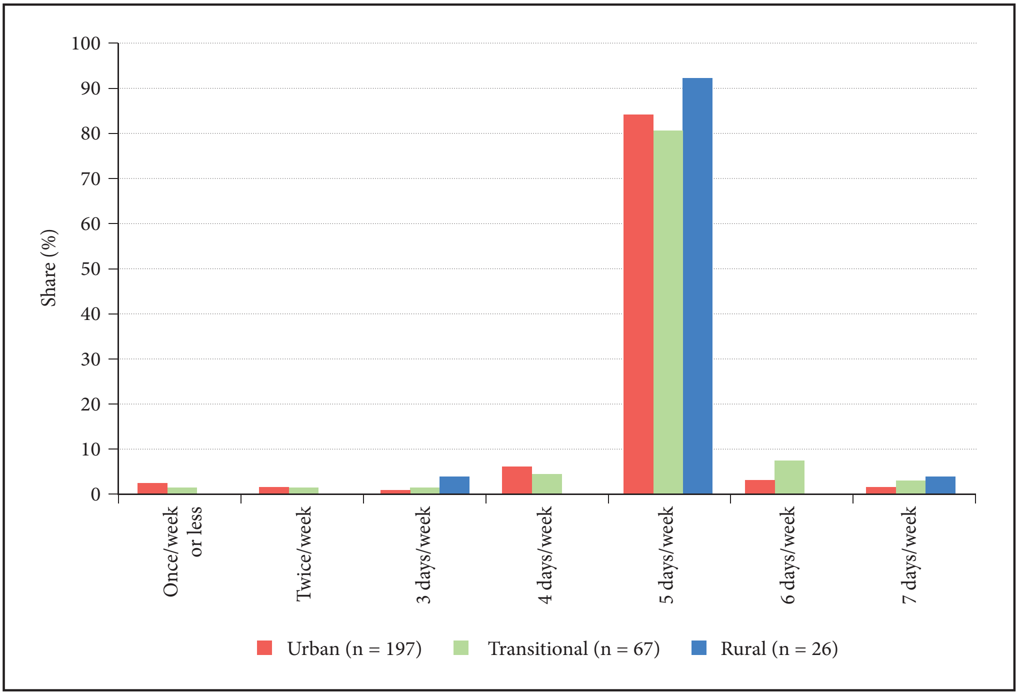

Figure 3: Commuting frequency distribution before COVID-19 lockdown.

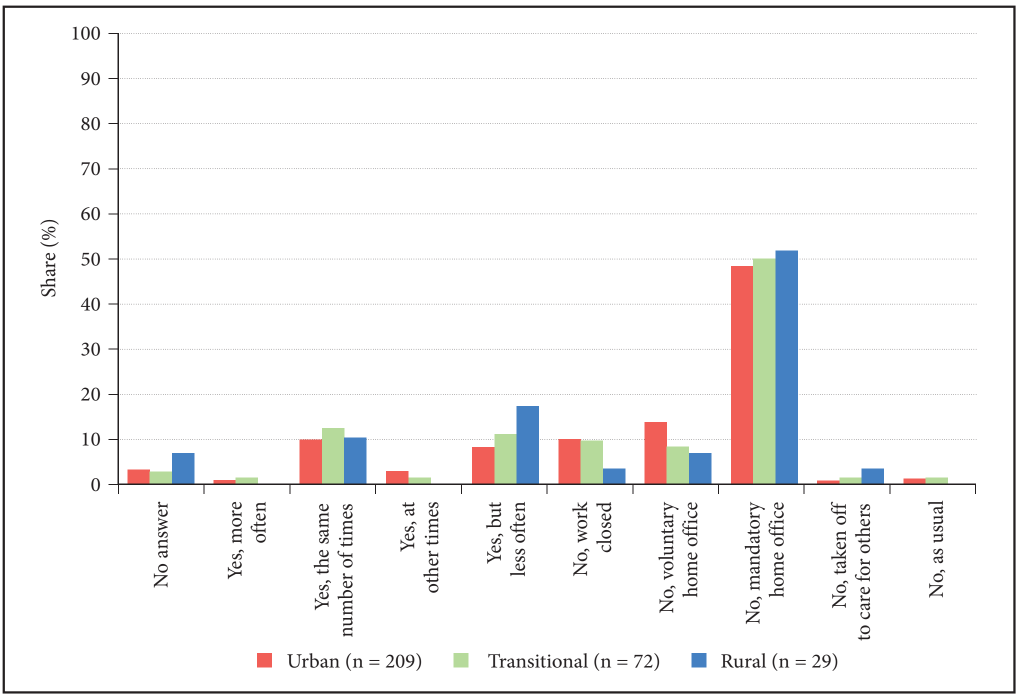

Figure 4: How commuting behaviour changed under COVID-19 lockdown in comparison to before.

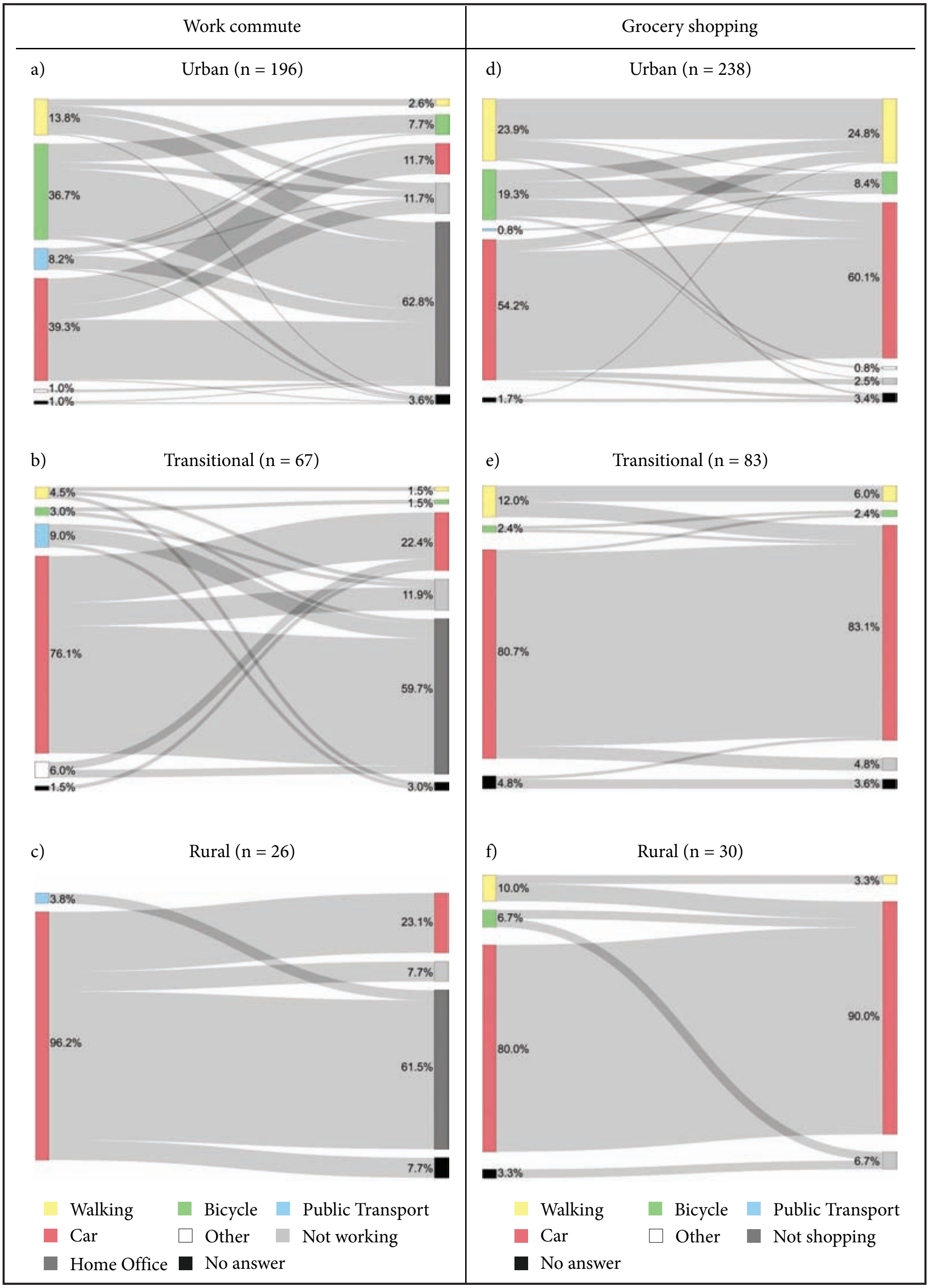

Figure 5: Sankey diagram matrix of changes in commuting mode choice before (left hand side) and during lockdown (right hand side) for workers (left column) and changes in mode choice for grocery shopping (right column) according to the spatial classification urban (top row), transitional (centre row) and rural (bottom row).

There are obvious differences in the mode choice results of the survey for commuting between the spatial classes before the COVID-19 lockdown. In urban areas, we see higher shares in active modes (walking and cycling) and lower levels of private car use than in transitional ones. Especially in rural areas with no share of active modes at all, a very high car share of 96.2% is evident. With 9.0%, the share of public transport was higher in transitional and urban areas (8.2%) than in rural areas (3.8%).

During the COVID-19 lockdown, the percentage of people who were not commuting for work was quite similar in all three areas. Between 59.7% (transitional areas) and 62.8% (urban areas) were in home office and 7.7% (rural areas) to 11.9% (transitional areas) were not working. As public transport was ceased nationwide, its share dropped to zero in all areas. The total shut-down of public transport did not significantly increase car traffic as the share of public transport users was already low before, while its users mostly worked from home. In urban areas there was still a considerable share of active modes in commuting during lockdown with 2.6% of walking and 7.7% of cycling, while in transitional areas only 1.5% walked or cycled to work and even nobody in rural areas. There, cars were the only transport mode used by the commuters.

A similar pattern can be seen for the grocery shopping mode choice. However, before the COVID-19 lockdown, car use was more prevalent in urban areas for shopping than for commuting compared to transitional and rural areas, where it was high for both purposes. During lockdown, the modal share of cars for shopping increased in all three spatial classes. The cessation of public transport did not affect the modal share as public transport use for shopping before the lockdown was extremely rare. In contrast to work commuting, the dominance of the car for shopping purposes persisted, while for work commuting the car's share shrunk in urban areas. For rural areas one can easily state that the car is basically the only commuting mode.

The questionnaire also surveyed a wide variety of main workplace types before COVID-19 (Figure 6). In our sample, a clear trend is visible with the changing perspective from urban to rural settings: 'Office' workplaces decrease from almost 55% to almost 38%, while simultaneously 'Classrooms / lecture hall / stage' increase from 11% to almost 35%.

Workplace types differ in their suitability for switching to working from home. We differentiate between 'home office possible', 'presence essential' and 'undetermined'. For this categorization, we define workplace types 'Home', 'Office' and 'Classroom / lecture hall / stage' to be 'home office possible' and workplace types 'Mobile (customer visits)', 'Customer traffic', 'Hospital, nursing home' and 'At customer site (e.g. construction site)' to be 'presence essential'. 'Customer traffic' denotes working places with stationary customer contact, while service-oriented visits to customers are named 'At customer site'. Results are shown in Table 5. Two trends surface: 'home office possible' increases by a good 10 percent-points when switching from urban (72.6%) to rural (82.8%) settings, while 'presence essential' decreases from 17.5% (urban) to 13.8% (rural). The workplace types that we consider as 'undetermined' decrease from 9.9% to 3.4% with reduced spatial density.

When it comes to the style of grocery shopping before COVID-19 lockdown (Figure 7), the distinction that urban people tend to shop for groceries more often than rural dwellers is notable, as 38.5% of urban respondents do it many times per week, which is 5.5 percentage-points more than for transitional and 9.1 percentage-points more than for rural respondents. Interestingly, twice as many people let others do the shopping in rural areas than they do in urban or transitional ones.

COVID-19 related mobility changes could be explained by changed grocery shopping behaviour during lockdown, depicted in Figure 8. Irrespective of spatial classification, a combined share of 50 to 60% of responses report buying 'larger quantities at once' (18.6 to 21.8%), buying 'long-lasting products' (8.1 to 11.5%) and 'shopping less often' (29.3 to 30.8%). In urban settings 12% of respondents report to 'eat out less often', while in rural settings 10.3% go to 'stores nearby'.

Table 4: Share of workplace types in subsample by spatial classification and distinction between 'home office possible' and 'presence essential'.

Shares [%]	Home office possible	Presence essential	Undetermined
Urban	72.6	17.5	9.9
Transitional	80.6	15.3	4.2
Rural	82.8	13.8	3.4

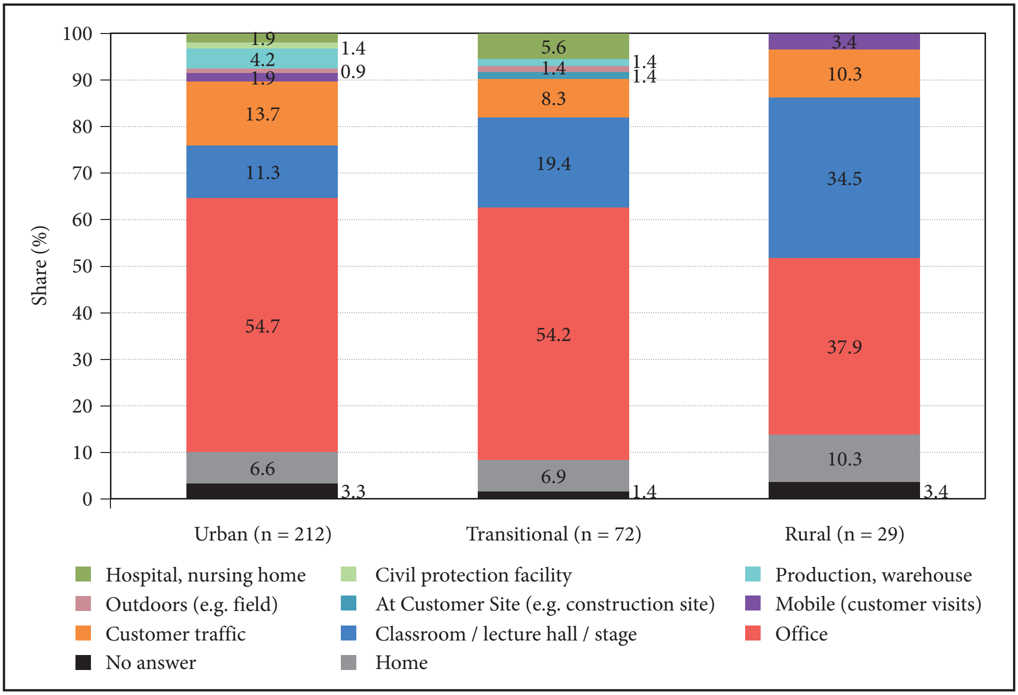

Figure 6: Workplace type before COVID-19 lockdown by spatial classification.

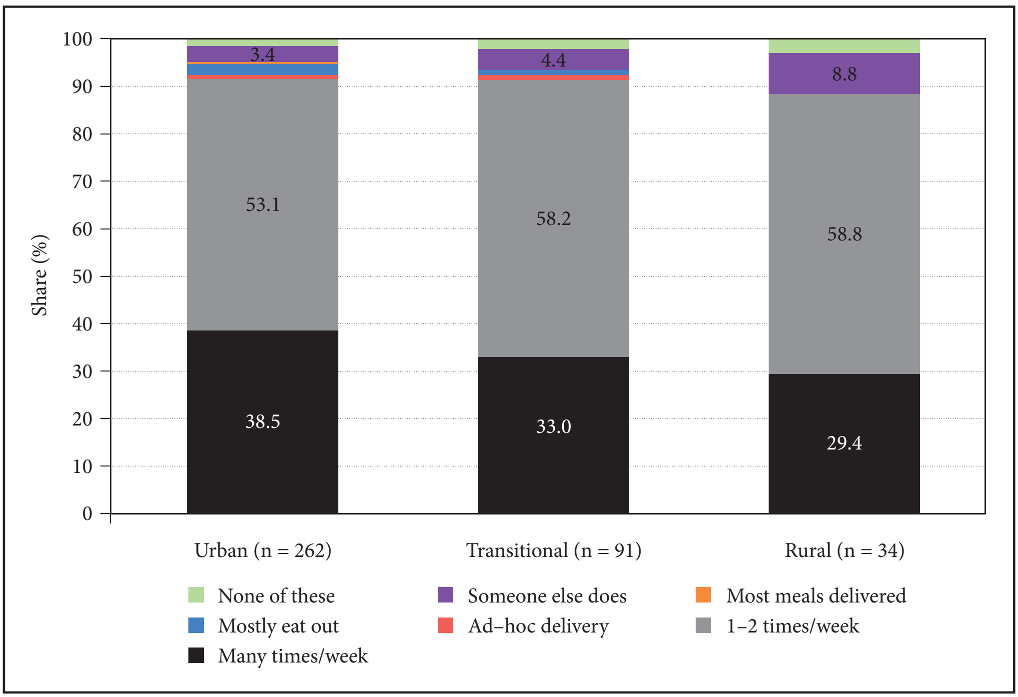

Figure 7: Style of grocery shopping before COVID-19 lockdown by spatial classification.

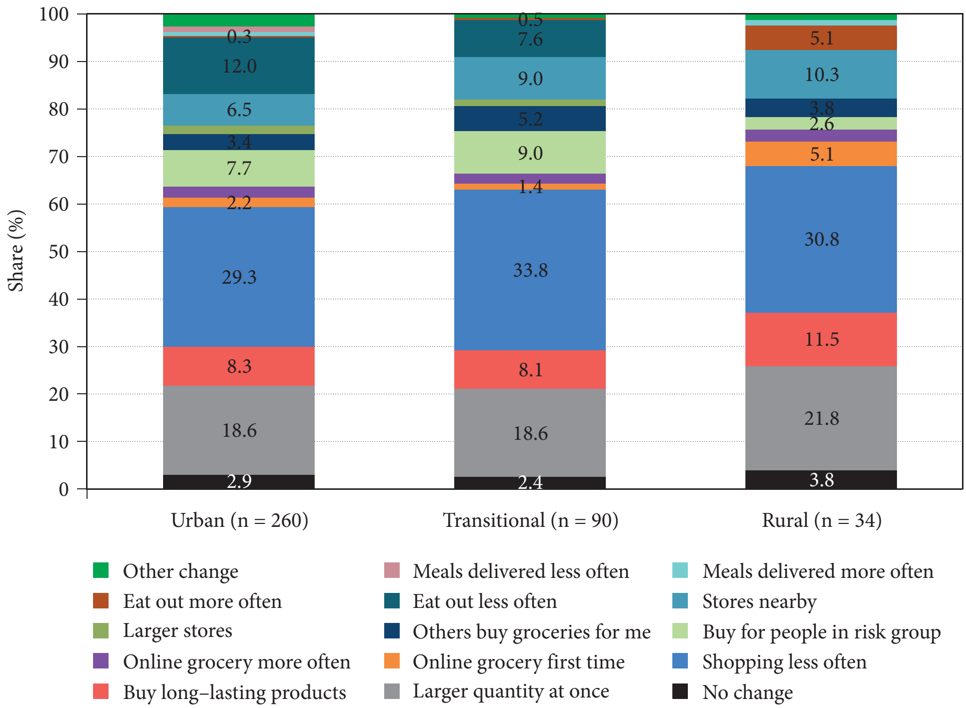

Figure 8: Change in grocery shopping under COVID-19 lockdown by spatial classification. Multiple choices per participant were possible.

4 Discussion

The changes in travel behaviour during the COVID-19 lockdown (comprising of limitations for travelling, closed services and workplaces etc.) can be viewed as a social response to the threat of virus transmission. On one hand, the mobility in Slovenia was reduced due to quite stringent measures, and a large proportion of people working from home and going shopping less often, which is similar to other parts of the world (Aloi et al. 2020; Jenelius and Cebecauer 2020; Dandapat et al. 2020). On the other hand, the private car even reinforced its status as the major transport mode. However, there are some important differences along the urban-rural nexus. Slovenian rural areas are very dependent on car mobility and in the last decades, car dependency has even reinforced (Bole and Gabrovec 2012). While work commuters show a very strong affinity with private cars in transitional and rural areas pre-lockdown as well as during lockdown, the picture looks more diverse in urban settings. There, car-dependency is not as pronounced and is balanced by walking, cycling and the use of public transport. The higher share of non-car users in urban areas in pre-lockdown can be explained with better service of public transport, especially in bigger urban areas (Ogrin and Dovečar 2014) and with shorter distances of daily trips. While more than 30% of urban dwellers still use alternatives to cars for grocery shopping, in transitional and rural areas, the travel behaviour for shopping, as well as for commuting is distinctively dominated by car use. Very few alternatives are used and the situation did not improve during the lockdown. These findings confirm a notion that built environment influences the travel behaviour and frequency through promoting sustainable travel modes (Jiao, Vernez Moudon and Drewnowski 2011; 2016).

The survey of AMZS (Poženel 2020) on travel behaviour changes in Slovenia due to the lockdown shows somehow different results: only 24% used the car about the same, while about 69% of respondents used the car less, and 3% used the car more than prior to the pandemic. The share of bicycle and walking increased: 18% used the bicycle more often, 31% used it the same and 15% used it less, while 31% walked more, 53% walked the same and only 8% walked less. Their findings are not strictly in line with ours, as trips were not separated by trip purpose and Brezina et al. (2020a) did not explicitly ask for frequency changes. AMZS' survey as well as our inquiry suggest that shopping behaviour changed by shifting from higher frequencies and smaller quantities to lower frequencies and higher quantities – and did so by increasingly using cars for this purpose.

In contrast to previous recent (Shibayama et al. 2021) research, based on the survey's complete dataset, we also studied the spatial distribution of workplace types. The respondents who can work from home have a high share in our sample irrespective of the spatial setting. Regarding changes in lockdown-induced commuting, the scene is set with 82.8% of jobs in rural areas being 'home office possible' and 62.1% of respondents reporting no commute. On the urban end of the spectrum, 72.6% reported to have 'home office possible' jobs and 72.2% had no commute. While in the urban surrounding possibilities and actual behaviour almost coincided, the rural settings saw a discrepancy of about 20 percentage-points. The location of 'presence essential' workplaces in relation to dwelling areas appears to be a crucial perspective in terms of crisis resilient and environmentally friendly transport supplies. With 17.5% the share of such workplaces was highest in urban settings in our case. In general, we suggest that the closer 'presence essential' workplaces are located to dwellings (preferably of their workers), the more attractive it will appear to workers to choose walking and/or cycling as a transport mode for commuting. However, this cannot be always the case due to recent trends of decentralized spatial development (Rebernik 2010), current model of the reimbursement of travel expenses, which favours long-distance commuting by car (Gabrovec et al. 2021), and the lack of infrastructure for sustainable mobility due to allocating funds mostly to road infrastructure in the past (Bole and Gabrovec 2012).

In both cases, safe and attractive infrastructures for public transport and active mobility need to be provided. Consequentially, from a planning perspective, the provision of such infrastructures thus not only asks to be appraised from an ecological perspective but also from the viewpoint of providing resilience in a major health crisis – as was shown by research on pop-up infrastructures (Kraus and Koch 2021).

The lack of public transport use due to measures taken by the government is apparent in all settings and was reflected also in its lower usage after the first wave was over (Čampa et al. 2020). As suggested before, this sector had a remarkable position: Even though its services were cut down by the government, no noteworthy protests from the public opposed this move. The reasons for that appear to be rooted in the ongoing declining relevance of public transport and its low usage (Gabrovec and Bole 2009; Halilović et al. 2020). On first sight, additional reduction of passengers in public transport may lead to an increase in the level of service (ceteris paribus): less crowded vehicles offer more comfort, are more COVID-safe and are expected to run more punctually. But on a systemic level, this passenger reduction has led (and may also do so in the future) to a decrease in cost-recovery rates for un-/tendered public transport services on state and city levels. Other research suggests that urban transport as one of the crucial urban systems will need to introduce pandemic-proof infrastructure and transport management (touchless solutions, capacity monitoring, floor markings, …) (Florida, Rodriguez-Pose and Storper 2020).

Replacement of public transport for individual motorised mobility to avoid COVID-19 disease is not an option. Not only would air quality deteriorate in many urban areas and have a negative impact on public health, the growth of traffic in urban areas would increase the traffic loads on road infrastructures, leading to a rapid increase in congestion and a deterioration in accessibility. Studies from Slovenia's capital Ljubljana confirmed poor air quality in major city roads within the period 2005 to 2013 (Ogrin and Vintar Mally 2013; Vintar Mally and Ogrin 2015). Since then, some streets in the centre of Ljubljana have been closed to motorized individual traffic and remained open to public transport, and air quality in these areas has improved. A return of individual traffic in the city centre would do much more harm than good. But the regional challenges for substantial shifts from non-sustainable to sustainable modes remain persistent in a policy culture that on the one hand eases all matters car and on the other highlights alleged difficulties in providing better public transport (Brezina and Lokar 2020).

The study also has certain methodological limitations. As the data was collected with an online survey, non-probability sampling was used. Even though the sample is not representative of the total population, we insinuate that the snowball method of survey engagement proved functional for quickly harvesting social reactions under a rapidly evolving situation at least among employees, which were the most represented population group in the sample. We also found the sample to be not too spatially biased, although the rural dwellers were a bit underrepresented. One might also question the accuracy of determining the location of the respondents as it was only available at the postal district level and not at a lower spatial scale, which may be more appropriate for a country with such a disperse settlement system. We are aware that classifying respondents along the urban-rural spectrum may lead to certain generalizations and errors.

On matters of shortcomings, we need to admit that similar to changes in modes and commuting duration, an inquiry of commuting distances would have deemed promising. Commuting distance was asked in the survey, but unfortunately the subsample of valid responses was too small (n = 8 altogether for all three spatial classes) for useful evaluation.

5 Conclusion

In our research we address the COVID-19 pandemic and the corresponding mobility responses in Slovenia from a geographic perspective. Emanating from a worldwide survey, we study the changes in everyday travel behaviour with focus on working commuters and grocery shopping of the Slovene subsample, for which we differentiate responses by three spatial classes: urban, transitional and rural. Depicting the changes in travel behaviour from regular to lockdown shows the persisting and even increasing dominance of the car for shopping purposes, while for work commuting the car's share shrunk due to a high portion of people working from home. Taking into account the spatial perspective, our study confirmed the notion that rural areas remain very car-oriented, while modal share of the urban dwellers is more diverse.

Our results pose a challenging picture for the long-term future which requests transport policy to switch shares of trips from non-sustainable to sustainable modes. Such transport policy does not only need to implement measures which are effective from a sustainability perspective, but – as we may have learned from the COVID-19 pandemic – needs to meet these demands under public health requirements.

Congruously, this also opens avenues for future research on the design and implementation of transport policies that will enable people to move sustainably and in a pandemic dampening way in less densely populated areas – not only in Slovenia but in all European countries.

ACKNOWLEDGMENTS: We thank the reviewers for their valuable comments that helped to finalize the paper. We thank Takeru Shibayama, Fabian Sandholzer, Melissa Kapfenberger, Ulrich Leth, Helmut Lemmerer and Günter Emberger who co-designed and co-implemented the survey. We thank Miha Lokar for the translation of the initial survey into Slovene language. We thank many colleagues who helped in distributing the survey among their peers. The authors also acknowledge receiving financial support from the Slovenian Research Agency, research core funding Geography of Slovenia (P6-0101).

CONTRIBUTIONS: Conceptualization of research: T. B., J. T., M. O.; geographical analysis: J. T.; data analysis: T. B., B. L.; literature review: M. O.; paper writing: T. B., J.T., M. O., B. L.

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Acta geographica Slovenica, 61-2, 2021, 109–121

HOW THE STATE LEGITIMIZES NATIONAL DEVELOPMENT PROJECTS: THE THIRD DEVELOPMENT AXIS CASE STUDY, SLOVENIA

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PRIMOŽ GAŠPERIČ

Public participation in a decision-making processes.

DOI: https://doi.org/10.3986/AGS.9572
UDC: 711.122:711.7(497.4)
COBISS: 1.01

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How the state legitimizes national development projects: The Third Development Axis case study, Slovenia

ABSTRACT: We analyzed planning mechanisms and evaluated their performance in achieving legitimacy in infrastructure planning in Slovenia. Planning mechanisms were divided according to the concept of input, throughput and output legitimacy. We conducted a document analysis and interviews to assess their effectiveness in achieving legitimate decisions. Although the analyzed decision-making process declaratively promoted democratic principles, the mechanisms failed to satisfactorily enhance the legitimacy of decisions. The study revealed inadequate communication approaches, both in the decision-makers' relationship with the public and within the expert discourse. Accordingly, the study argues for more genuine communication with the public and within academia to address legitimacy challenges in increasingly conflictual decision-making processes.

KEY WORDS: deliberative governance, post-political spatial planning, qualitative research, citizen participation, transportation planning

Kako država legitimira nacionalne razvojne projekte: primer tretje razvojne osi, Slovenija

POVZETEK: V prispevku smo analizirali postopek načrtovanja infrastrukturnega projekta v Sloveniji in ocenili uspešnost uporabljenih pristopov za doseganje legitimnosti odločitev. Pristopi k načrtovanju so bili razdeljeni v tri sklope, glede na uveljavljen koncept vhodne, postopkovne in izhodne legitimnosti. Legitimnost uporabljenih prostorsko-načrtovalskih pristopov smo ugotavljali s pomočjo kvalitativnih metod, natančneje z analizo dokumentov in intervjuji. Raziskava je pokazala, da je največji legitimacijski primanjkljaj na področju komunikacije, ne le med odločevalci in javnostjo temveč tudi med posameznimi strokami. Iz tega sledi, da bi morali za večjo družbeno sprejemljivost v bodočih, čedalje bolj konfliktnih postopkih odločanja, prostorski načrtovalci nameniti več pozornosti kakovosti komunikacije in sporazumevanju med akterji.

KLJUČNE BESEDE: deliberativno upravljanje, post-politično prostorsko načrtovanje, kvalitativne metode, participacija civilne družbe, prometno načrtovanje

The article was submitted for publication on February 9th, 2021.
Uredništvo je prejelo prispevek 9. februarja 2021.

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1 Introduction: The necessary legitimacy of national spatial planning system

Modern societies increasingly face a crisis of legitimacy in spatial planning and other public policies due to conflicts, the emergence of citizens' initiatives and an overall decline in social acceptance of public policies (Sager 1999; Kos 2002; Inch 2015). Decision-making is often value-based and requires trade-offs and long-term solutions (Rittel and Webber 1973; Innes and Booher 2010). Differentiated sectoral policies, science, and the division of labour between different levels tires of government often overlap spatially and substantively. Policy decisions are therefore increasingly difficult to make and justify (Healey 1997; Kos 2002). As a result of the legitimacy crisis, the core question of modern nation-states today is how the state is supposed to justify and maintain its position of control and responsibility for the implementation of public policies in front of the public – the people who are directly affected by these policies. Habermas addressed this issue as early as the 1970s, claiming that the state must intervene to limit adverse effects of the liberal market economy while allowing the economy to function (Plant 1982). The need for trustworthy planning is particularly relevant in the formulation of long-term development plans where outcomes cannot be expected immediately. In this context, Tyler (2001) argues that legitimate government institutions and their public policies are more efficient and less likely to generate public opposition. Public policies that are perceived as illegitimate are generally more conflictual, less feasible and also more expensive for the state. Legitimacy has therefore always been one of the central concerns of planning theorists and practitioners.

The concept of legitimacy in spatial planning theory is closely related to the balance between individual and public interests. It reflects the extent to which national policies and spatial plans (that are supposed to be in the public interest) are consistent with individual interests and opinions (Alexander 2002). Legitimacy is thus a powerful means of achieving efficiency in the implementation of national policies and development plans (Tyler 2001). It refers to substantive and procedural dimensions of decision-making processes. Substantively, it depends on the legitimacy and conformity to established norms, rules and processes relevant to the matter at hand. In procedural terms, legitimacy depends on whether and how the decision-making process enables relevant actors to participate. Legitimacy thus signifies shared beliefs about how a country should be governed as a political community. It concerns the rights of citizens as well as the rights and duties of the state (or those who govern). Legitimacy in this sense is closely related to the notion of justification. Decisions of the state are legitimate insofar as they are properly justified. In other words, policies and decisions of the state are legitimate if the decision-makers can demonstrate that the powers they have and use are just, right and reasonable (Bekkers, Dijkstra and Fenger 2007).

Despite various critiques that participatory processes cannot live up to their theoretical ideals in practice (e.g., Flyvbjerg 1998; Forester 1999; 2009; Flyvbjerg, Bruzelius, and Rothengatter 2003; Flyvbjerg and Richardson 2003; Hillier 2003; Innes and Booher 2010; Sager 2013), there remains a general consensus among theorists and practitioners that participatory planning approaches are crucial for legitimizing development projects (e.g.., Forester 1993; Healey 1996; 1997; 2003; Innes 1996; Marega and Kos 2002). However, empirical studies have shown that in practice it is often carried out superficially (Nared et al. 2015) and perceived as a hindrance in decision-making processes. Tokenistic participation is particularly characteristic of post-socialist countries (Hafner Fink 2012; Pop-Eleches and Tucker 2013; Poljak Istenič and Kozina 2020). Stable power relations and the strategic functioning of actors in decision-making processes also prevent genuine collaboration and consensus-building (Flyvbjerg 1998; Flyvbjerg and Richardson 2003).

Nevertheless, little is known about the actual performance of spatial planning and its mechanisms for legitimizing national development projects in Slovenia (e.g. Nared et al. 2015; Goluža 2020). Several conflictual and protracted decision-making processes, especially in the field of transport and energy infrastructures in the past decades, have shown that legitimation processes in Slovenia have obviously failed. In addition, Slovenian spatial planning legislation has been amended several times after independence, with clear attempts to optimize the preparation of national spatial plans, also by limiting public participation. We therefore hypothesize that the Slovenian attitude towards public participation in spatial planning is a legacy of the former Yugoslav socialist economic and political system of self-government. The system, which was democratic in theory and granted considerable decision-making powers to the working population, proved to be inefficient in practice. Decision-making processes were still heavily influenced by politics and market relations and were also very time-consuming and unproductive (Centrih 2014). Thus, the self-governance system did not contribute to more democratic decision-making processes. On the contrary, the experience with the self-government system probably left traces of distrust in participatory decision-making that persisted even after Slovenia declared independence in 1991 and transitioned to liberal democracy. Although Slovenia has adopted the Aarhus Convention (Zakon o ratifikaciji … 2004) and, as an EU member state, declares the idea of participation as necessary for the legitimacy of public decision-making, its planning laws require only a minimum of public participation. The purpose of this study is to examine how the Slovenian spatial planning system relates to legitimacy and how the adoption of democratic norms affects legitimacy processes in practice. There are two main objectives of this study. The first is to outline the planning mechanisms used in the decision-making process to legitimize the national development project (the northern part of the Third Development Axis, hereafter Third Development Axis) and the national spatial plan as the basis for its implementation. Secondly, the legitimacy of the applied mechanisms will be assessed through a qualitative analysis. The research will contribute to a better understanding of the planning mechanisms and their contribution to the legitimacy of national development projects. With a specific focus on the Slovenian case study, the research will in particular deepen the understanding of key legitimacy problems in spatial planning that Slovenia as a young democracy is facing today.

2 Conceptual framework for assessing legitimacy of decision-making process: Input, throughput and output legitimacy

Spatial planning is increasingly facing a crisis of legitimacy due to conflicting scientific viewpoints, uncertainties, time and financial constraints, and many other value-based, institutional, and worldview differences among actors that are difficult to bridge (Forester 1984; Wheeler 2020). Legitimacy, then, is an elusive and context-dependent concept that cannot easily be guaranteed by a universal approach to planning. Since there is no absolutely correct planning approach that would ensure intrinsically legitimate decisions, researchers have no choice but to analyse and learn from individual case studies. In order to evaluate planning approaches in terms of legitimacy, some authors propose to decompose the concept of legitimacy into three pillars: Input, Throughput and Output Legitimacy (e.g. Bekkers, Dijkstra and Fenger 2007; Schmidt 2012; Lieberherr and Thomann 2020), which are summarised in Table 1. The concept of input, throughput and output legitimacy is also used in this paper as it provides a systematic analytical means to evaluate decision-making processes.

Table 1: Norms for assessing democratic legitimacy in decision-making processes (adapted from Bekkers, Dijkstra and Fenger 2007).

Input legitimacy	Throughput legitimacy	Output legitimacy
• Equal opportunities for participation in decision-making process and influencing the decisions; • Representation of relevant interests; • Openness of the governance practices to respond to specific needs in society.	• Realization of collective decision-making (e.g., voting, deliberation, etc.); • Who participate in decision-making (e.g., public, experts, representatives of public sector); • Transparency; • Balanced power relations.	• How decisions taken tackle collective problems; • Effectiveness and efficiency of decision-making process; • Accountability of decisions.

Input legitimacy refers to a quality of policymaking (Lieberherr and Thomann 2020). It concerns political equality, active citizenship and popular sovereignty in shaping spatial policies or plans. It depends on the opportunities given to citizens to participate, express their interests, engage and influence the decision-making process. When citizen participation is only indirect, input legitimacy depends on the quality of representation of interests and preferences by political intermediaries. Input legitimacy also refers to the openness of the agenda-setting process to citizens' demands and concerns. In this sense, it means the openness of governance practices to respond to (locally) specific needs in society (Bekkers, Dijkstra and Fenger 2007).

Throughput legitimacy refers to the quality of a governance process (Lieberherr and Thomann 2020), to rules and processes that define decision-making processes (Bekkers, Dijkstra and Fenger 2007). Since societal problems and conflicts require collective action, throughput legitimacy is related to the implementation of collective decision-making. Throughput legitimacy is related to the quality of participation of all relevant actors. According to Habermas, communication between all relevant actors should lead to a shared learning process that promotes mutual understanding and confronts and transforms the power of the state and capital (Healey 1996). It should be transparent and informative and balance the power relations between actors. With these prerequisites, throughput legitimacy comes closest to participatory democracy and the goals of the Aarhus Convention (Bekkers, Dijkstra and Fenger 2007).

The third aspect of legitimacy in the decision-making process is output legitimacy, which represents the government's ability to produce outcomes from decision-making processes that solve collective problems (Bekkers, Dijkstra and Fenger 2007). Output legitimacy focuses on whether the outcomes of the decision-making process are legitimate in terms of acceptability, rather than the process itself (Lieberherr and Thomann 2020). Output legitimacy refers to the efficiency and effectiveness of the outputs and outcomes of the implemented policy or plan. It is concerned with how the decisions made meet the originally stated goals of the policy or plan and how they respond to the expressed desires of the population. Output legitimacy also refers to the accountability of decision makers, both for the decisions and for the outcomes of those decisions. Therefore, decisions and their impacts should be based on a fully transparent provision of information (Bekkers, Dijkstra and Fenger 2007).

3 Methodology

3.1 Case study selection

The study is based on a case study approach. For our analysis, we chose the planning process for a motorway along the Third Development Axis that will extend from the Slovenian-Austrian border in the north to the Slovenian-Croatian border in the south. We focused specifically on Section F, which refers to the area between the existing A1 motorway and the town of Velenje (see Figure 1). The selection of the case study was based on information-oriented sampling (Flyvbjerg 2006), which was motivated by several reasons: 1) the Third Development Axis is one of the few major Slovenian infrastructure projects of the last decades and also one of the most notorious ones due to multiple problems of legitimacy and conflicts; 2) the process of preparing the national development plan for Section F was one of the most conflictual and lengthy decision-making processes in Slovenia; and 3) the case involved actors from different social spheres, e. g., from civil society, the public sector and experts.

3.2 Methods

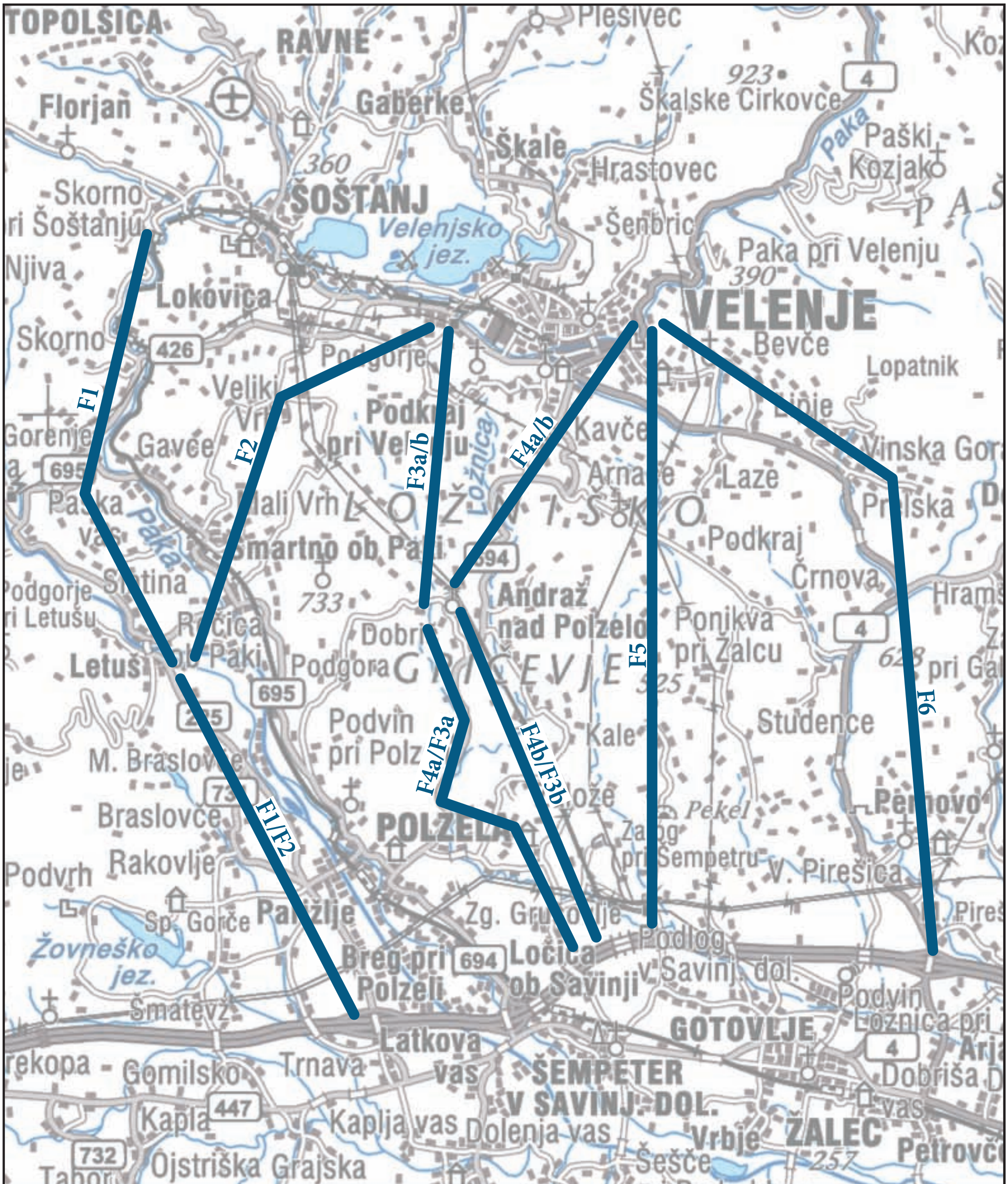
Since legitimacy is a rather ambiguous theoretical concept that cannot be fully measured or quantified objectively, we have adopted a qualitative approach for our study, i.e. a document analysis. Documents related to the preparation of the national spatial plan, such as expert evaluations of alternatives, revisions, reports and minutes, are publicly available upon request from the Ministry of the Environment and Spatial Planning, which is also responsible for the implementation of the decision-making process. These documents were used to identify the applied planning mechanisms used by the State to legitimise the development project under study, the Third Development Axis. We have presented the applied mechanisms according to the concept of input, throughput and output legitimacy discussed in Chapter 2 in Table 2). Finally, we assessed the overall legitimacy of the observed decision-making process.

4 Results: The analysis of decision-making process's legitimacy

4.1 Overview of the planning process and outline of the applied legitimizing planning mechanisms

The motorway along the Third Development Axis is a national infrastructure project defined as one of the development priorities in the national Spatial development strategy of Slovenia (Odlok o strategiji … 2004).

Figure 1: Alternative variants of the Third Development Axis on the Section F. ➤ p. 114



Legend

Alternative routes of third development axis on section F

0 1 2 3 km

Map by: Manca Volk Bahun
Source: GURS, 2021; Študija variant s predlogom najustreznejše variantne rešitve za gradnjo državne ceste med avtocesto A1 Šentilj – Koper in mejo z Republiko Avstrijo FAZA: MAPA I – zvezek 3b, 2012
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The main purpose of the motorway is to increase the economic competitiveness of the regions and cities (such as Slovenj Gradec, Dravograd, Velenje, Novo mesto) along the planned route, improve their accessibility and strengthen the institutional and economic links between them. In short, it is an instrument for strengthening economic, social and territorial cohesion (Projekt … 2007). The motorway link, which would connect five Slovenian regions with the Austrian transport system in the north and the Croatian one in the south, should be implemented by 2013 (Resolucija … 2004). As this is a major national infrastructure project, the state has a key role in legitimizing and implementing the planning process.

Following the launch of the project in 2004, the first spatial planning conference was organized by the Ministry of the Environment and Spatial Planning. This was a formally prescribed mechanism (Spatial Management Act 2002) aimed at soliciting and harmonizing the recommendations, guidelines and legitimate interests of local communities, the business community, interest groups and the organized public with regard to the preparation of the national spatial plan. In accordance with the interests expressed during the spatial planning conference, the preliminary expert analysis of the Third Development Axis was conducted. The analysis took into account various development scenarios, forecasts of traffic flows and various spatial, environmental and economic indicators. Suitable motorway alignment alternatives were identified for further analysis and review (Predhodne … 2008).

The proposed motorway alternatives were further analysed and reviewed based on four groups of indicators: spatial, functional, environmental, and economic. The expert analysis ended in 2007 with the proposal of the most suitable variant for the Third Development Axis. For Section F, two alternatives received the highest score. Finally, the so-called F2 was selected as the most suitable because it was a better fit with the highest scoring alternative on the above-lying section (see Figure 1). However, F2 had two major drawbacks. It was relatively steep and would result in a significant loss of high-quality agricultural land (Študija … 2008).

In 2008, the proposals for the best evaluated sections were presented to the ministries and representatives of the municipalities that would be affected by the new motorway. They were able to comment on the proposed motorway route and suggest optimizations, some of which were later included in the public displays and public hearings. During the public displays and hearings, fierce opposition arose from the local communities in the municipalities that would be affected by Section F, especially in the small rural municipality of Braslovče. They argued that the motorway would unjustifiably damage and cause loss of high-value and other agricultural land in the area typically used for agriculture.

The decision-making process was also reviewed at this stage by experts, as is customary for national development projects. The review revealed several shortcomings, such as that the objective of the whole project and its importance for regional development were not clear enough. They also emphasized that the project neglected anticipated demographic trends and the increasing importance of public transportation, which would reduce automobile use and the need for new motorway. The reviewers also pointed out the ambiguity and inconsistency in the use of various indicators. They claimed that the indicators used in evaluating the alternatives did not include an examination of the social acceptability of each alternative. The lack of clear explanations as to why one alternative is better than others was particularly evident in Section F, where two alternatives received the same score in the expert evaluation.

As the preparation of the national spatial plan as a whole proved to be very challenging due to several conflicts, the Ministry of Infrastructure arranged for the project to be divided into four separate spatial plans. One of these was the spatial plan for Section F. Sectoral ministries were asked to supplement their guidelines for the preparation of new spatial plans.

In 2010, a draft of the national spatial plan for Section F was presented to the ministries and mayors, as well as to the public in the municipalities. The partially optimized version of F2 again provoked opposition from the Ministry of Agriculture, Forestry and Food. It issued three negative opinions in relation with the environmental report. The Ministry of Agriculture, Forestry and Food opposed the construction of the motorway on legally protected, high value agricultural land and pointed out some procedural inconsistencies. They claimed that the chosen alternative was enforced without considering other alternatives.

The preparation of the national spatial plan for Section F continued with the inter-sectoral expert group that the national government had established in 2011 to evaluate the decision-making process. The expert group found similar inconsistencies as the reviewers. They highlighted the lack of justification of the project (in terms of expected traffic scenarios, financial resources, etc.), the vague explanations of the decisions on the alternatives, and the inadequate methodology for assessing impacts on agricultural land. The methodology allowed any type of construction on agricultural land as long as it was planned with mitigation measures.

Thus, in the environmental report, any construction could be assessed as having an insignificant impact on agricultural land (Poročilo … 2011). In 2012, due to conflicts, the national government initiated the study of other possible alternatives for the motorway on Section F, but all of them were discarded due to the crossing of Natura 2000 sites and other protected areas (Študija … 2012).

The preparation of the national spatial plan for Section F was therefore continued for the optimized alternative F2. The proposal for the plan was put on public display in 2015. Three public hearings were held in three municipalities, Velenje, Šmartno ob Paki and Polzela. In Šmartno ob Paki, the public hearing was disrupted by local civic initiatives because they objected to the decision-making process and the selection of the final alternative itself. Despite the objections, the Ministry of the Environment and Spatial Planning continued the preparation of the National Spatial Plan, which was adopted by the national government in 2017. The municipalities of Braslovče, Polzela and Šmartno ob Paki therefore filed a constitutional review of the national spatial plan for the motorway (Decree … 2017). They argued that the procedure for the preparation of the national spatial plan for Section F violated several legally protected rights and legally binding procedures. For example, they relied on the Slovenian Constitution, which grants citizens the right to participate in decision-making processes, the Aarhus Convention (Convention on … 1998), which protects the right to access to information, public participation in decision-making and access to justice in environmental matters, as well as several other directives dealing with the impact of projects, plans and programs on the environment (Directive … 2001; Directive … 2011). In 2019, the Constitutional Court found that the Decree (2017) was not in conflict with the Slovenian Constitution (Odločba … 2019).

4.2 The evaluation of legitimacy of applied planning mechanisms

In the previous subsection, we summarized the process of preparing the national spatial plan for the Third Development Axis, in Section F. Here we will assess the mechanisms that state actors used to legitimize the national development project. They have been presented chronologically and in line with the concept of input, throughput and output legitimacy in Table 2 below.

On paper, in the case of the Third Development Axis, the planning process began with mechanisms that promised high input legitimacy, such as the Spatial Planning Conference, which was a legally binding mechanism and aimed to harmonize the interests of actors, including civil society (Spatial Management Act 2002). A preliminary expert analysis was also carried out to define possible alternative variants and a coordination meeting was held with the mayors of the potentially affected municipalities. Local communities and experts were given the opportunity to influence decision-making by providing guidance, information and expertise (Pravilnik … 2007). However, as the project became more concrete, conflicts between stakeholders increased, while the receptiveness of decision-makers to the plurality of interests and proposals from experts and civil society seemed to diminish. The subsequent process was essentially indifferent to the arguments of the opponents of alternative F2, which came from both experts and the local population in the area concerned. Decision-makers relied exclusively on seemingly rational expert assessments, even though several external experts (including reviewers, an inter-ministerial expert group, and agronomists) argued that these assessments were not entirely appropriate.

Throughput legitimacy refers to the communication aspect of the decision-making process and collective action in responding to problems and conflicts. The case study found that the decision-making process followed legally binding mechanisms, such as informing ministries and municipalities of decisions made and public displays of (propositional) spatial plans with public hearings. The Ministry of the Environment and Spatial Planning, which carried out the preparation of the national spatial plan, organized even more public displays and hearings, as required. This partly contributed to more transparency, and residents were also better informed about the project. However, it did little to improve the legitimacy of the decision-making process. The arguments of the opposing actors remained virtually the same throughout the decision-making process. The relocation of the motorway to an area of high-quality agricultural land was the biggest stumbling block, both for agronomists and for local farmers who depend on hop production and agriculture in general (Študija … 2012). Conflicts between decision-makers and local residents opposed to the F2 variant reached their peak in 2015, when local citizens' groups violently disrupted the public hearing. Public displays and hearings could have facilitated consultation, but in practice they did not improve communication between actors.

Table 2: The timeline of legitimizing planning mechanisms applied in the preparation of national spatial plan for Section F, according to input, throughput and output legitimacy.

Year	Input legitimacy	Throughput legitimacy	Output legitimacy
2006	Spatial conference Preliminary expert analysis of alternatives		
2007	Coordination meeting with mayors of affected municipalities Expert evaluation of alternatives		
2008	Ministries supplement their guidelines for national spatial plan	Display of the proposed route for ministries and municipalities Public display of the proposed variants and public hearing	Revision of the expert evaluation Opposition in local communities National spatial plan divided into four sections
2010		Draft national spatial plan for F2 presented to ministries and municipalities Public display of draft national spatial plan for F2 and public hearing	Negative opinion of the Ministry of Agriculture, Forestry and Food Opposition of civic initiative in Braslovče
2011			Inter-sectoral expert group assessed decision-making process
2012	Expert evaluation of other alternatives on the Section F		National government requires expert analysis of other alternatives on the Section F Ministry of the Environment and Spatial Planning proceeds with optimisation of alternative F2
2015		Public display of draft spatial plan for optimized F2 and public hearing	Ministry of Agriculture, Forestry and Food opposed to the proposed spatial plan
2016		Public display of national spatial plan for optimized F2 and public hearing	
2017			National government adopted spatial plan for Section F Spatial plan for Section F was submitted for constitutional review
2019			The constitutional court rejected alleged irregularities

Output legitimacy refers to the efficiency and accountability of decisions and is thus closely related to the reliability of the expert knowledge that supports the decisions. In the case of the Third Development Axis, the national government reviewed the legitimacy and efficiency of the decision-making process multiple times, for example through independent reviews and the establishment of an inter-sectoral expert group. These mechanisms uncovered multiple problems of legitimacy due to inconsistencies (e.g. in the justification of how the Third Development Axis would improve regional development, why it should be built as a four-lane motorway, or why on agricultural land), ambiguities (e.g. in the use and interpretation of indicators), and shortcomings (e.g. in not assessing the social acceptability of the project) in the decision-making process. There was also opposition from the Ministry of Agriculture, Forestry and Food because the proposed motorway conflicted with sectoral (agricultural) legislation that protects agricultural land.

In an effort to increase the legitimacy of the motorway and facilitate conflict resolution, decision-makers decided to split the Third Development Axis project into four separate spatial plans (Študija … 2012). However, Section F remains controversial and illegitimate even after the government adopted the spatial development plan. The municipalities affected by the planned motorway submitted the Decree (2017) for constitutional review in 2017, but the Constitutional Court rejected the alleged irregularities in 2019 (Odločba … 2019). As the conflicts remained unresolved and the adopted spatial plan did not achieve social acceptance, expert consent or the approval of the Ministry of Agriculture, Forestry and Food, the overall legitimacy in this regard proved weak.

4.3 Discussion: The role of the state in providing legitimate decision-making

The case study showed that the procedural measures used to legitimize the project were not sufficient to increase the legitimacy of the decision-making process as a whole. With the exception of the spatial conference and the preliminary expert analysis, which allowed for deliberation and co-decision-making in the initial phase of the project, the other mechanisms did not contribute to achieving a consensual and legitimate decision. The communication aspect of decision-making was limited to public displays and hearings, which did not allow for argumentation between the actors but for mutual persuasion. Public displays and hearings are commonly known as mechanisms that aim to inform citizens while allowing minimal citizen influence on decisions. According to Arnstein (1969), they fall into the category of tokenistic approach to public participation and give the false impression that decisions are made with public consent (Nared et al. 2015).

The case study revealed an inherently conflictual nature of spatial planning that resulted in a protracted and erratic decision-making process. The state, represented by ministries, the government and municipalities, did not act together and there was a lack of long-term political commitment to the project. The case study showed that there was no genuine communication not only between state actors, but also between experts and civil society. Weak input and throughput pillars of legitimacy also led to eroded legitimacy of the final decision. The constitutional review of the decision-making process, several expert opinions, and opposition from the Ministry of Agriculture, Forestry and Food made it clear that the adopted motorway route was considered illegitimate not only by local communities, but also by experts and politicians. The decision-making process revealed that some of the claims questioned by experts and civil society (especially those related to the environment and sustainable transport planning) were not intended for wider public and expert or scientific discourse. Moreover, government decision-makers did little to increase accountability for the outcomes of decision-making processes. Similar to the findings of Flyvbjerg (1998), the decision-making process analysed demonstrates how power relations and taken-for-granted discourses between certain groups of actors prevent the ideas and demands of others from coming to fruition or at least opening public debate and consideration.

The case study examined in this paper shows a vicious circle of stable power relations that have not fundamentally changed with the transition to liberal democracy, the ratification of the Aarhus Convention or the accession to the EU. Central decision-making power over the motorway project has remained in the hands of narrow circle of decision-makers and experts. On the contrary, there has been little room to reconcile the plurality of interests and opinions among stakeholders, whether from the public sector, wider circle of experts and academia, or civil society. Low level of trust in public institutions and tokenistic participatory approaches, typical of countries in the Central and Eastern Europe (Marinova 2011), are obviously also present in Slovenia. In Slovenia, public trust in the government is markedly low (Public … 2018), which means that the state should make even more efforts to legitimize projects through participatory approaches. The participatory approach to planning was recognized as important in legitimizing national policies. The decision-making process even went beyond the number of formally required public displays and hearings. Nevertheless, these measures did not strengthen mutual trust between actors or bring them closer to a common, accountable and legitimate solution. In this respect, the transition in Slovenia has so far been only partially successful. Awareness of the importance of public participation for legitimate public policies has certainly increased, but there is an apparent lack of will on the part of actors to put this principle into practice and participate in a genuine decision-making process.

The concept of input, throughput, and output legitimacy provides a useful and systematic tool not only for analysis but also for raising awareness of the various aspects of acquiring legitimacy. As such, it is very informative for spatial planners and decision-makers who, in most cases, represent 'the state' in decision-making processes. It argues for more open, transparent and adaptive spatial planning processes to achieve greater legitimacy in future decision-making processes, not only in infrastructure planning but in spatial planning in general. The case study suggests that the mechanisms formally prescribed by the state to legitimize projects facilitate participation (input legitimacy) and shows that the Slovenian national spatial planning system is relatively open to plurality of interests. Nevertheless, communication between actors appeared rather symbolic and remained on the lower rungs of the participation ladder (Arnstein 1969). The adherence to formalistic decision-making processes rather than the promotion of an adaptive and deliberative approach may be the legacy of the earlier system of self-government. Indeed, state decision-makers' fear of losing control if too many decision-making powers are distributed among different actors, even the lay public, is understandable. This may lead to uncritical, unproductive and time-consuming decision-making processes (Centrih 2014), as was the case in the former Yugoslavia's self-government system. Scientific input (not limited to formally selected four domains of expert analyses) should therefore be crucial to justify why one option is better than the other. To increase the legitimacy of throughput, the state should make much more effort to balance power relations and adapt to possible (unexpected) conflicts. Certain concerns of actors, especially in cases where similar criticisms of the project are voiced by both citizens and experts, should be discussed more transparently (e.g., environmental concerns). Any decision or exclusion of a particular option should be publicly deliberated and justified with the broadest possible (expert and public) consensus. Adjusting the formally prescribed decision-making process in such cases should not be seen as an obstacle, but as a moral obligation of the state in changing the environment for present and future generations. Only when the decision-making process allows different voices to be heard, and when collective decisions are based on deliberation and soundly justified (rather than being the result of tokenistic persuasion), can decision-makers make more legitimate and accountable decisions (output legitimacy).

5 Conclusion

The case study analyzed has highlighted several legitimacy problems, which do not depend not only on compliance with formal, procedural mechanisms to facilitate participation, but above all require a change in actors' attitudes towards co-decision. Since legitimacy is a context-dependent and rather ambiguous concept that cannot be easily determined and achieved, the ideal decision-making process cannot be prescribed or formalized. However, being aware of the legitimacy deficits of past decision-making processes is the only way to gradually improve the legitimacy of future processes. The decision-making process analyzed in this paper showed rigidity and adherence to legally binding planning mechanisms that did not significantly enhance the legitimacy of the project. The principles of participatory planning, which encompass the concept of legitimacy, have remained untapped and represent potential that could enhance the legitimacy of national development projects and government agencies themselves. However, the implementation of the principles of participatory planning would inevitably require the allocation of decision-making powers.

ACKNOWLEDGEMENTS: The authors thank the Slovenian Research Agency for funding the core program Geography of Slovenia (P6-0101) and the junior researchers postgraduate research program. Both funds provided support for publishing these findings.

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Acta geographica Slovenica, 61-2, 2021, 123–153

APPLICATION OF ANGOT PRECIPITATION INDEX IN THE ASSESSMENT OF RAINFALL EROSIVITY: VOJVODINA REGION CASE STUDY (NORTH SERBIA)

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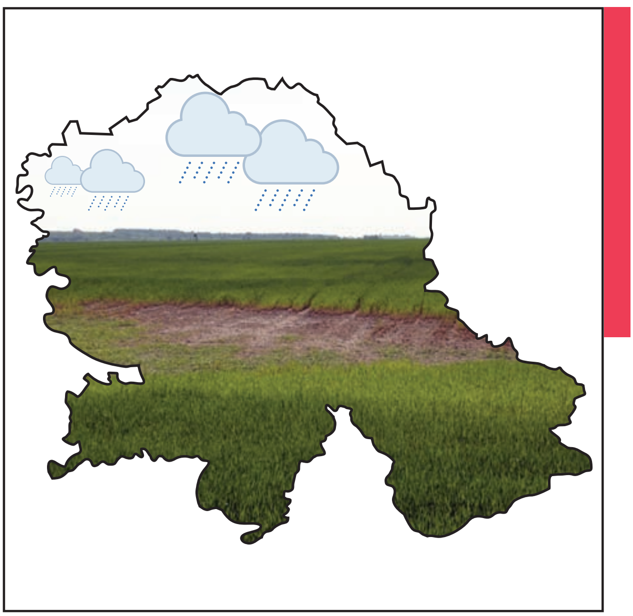

Rainfall erosivity in Vojvodina (North Serbia).

DOI: https://doi.org/10.3986/AGS.8754
UDC: 911.2:556.12:504.121(497.113)
COBISS: 1.01

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Application of Angot precipitation index in the assessment of rainfall erosivity: Vojvodina Region case study (North Serbia)

ABSTRACT: The paper aims to provide an overview of the most important parameters (the occurrence, frequency and magnitude) in Vojvodina Region (North Serbia). Monthly and annual mean precipitation values in the period 1946–2014, for the 12 selected meteorological stations were used. Relevant parameters (precipitation amounts, Angot precipitation index) were used as indicators of rainfall erosivity. Rainfall erosivity index was calculated and classified throughout precipitation susceptibility classes liable of triggering soil erosion. Precipitation trends were obtained and analysed by three different statistical approaches. Results indicate that various susceptibility classes are identified within the observed period, with a higher presence of very severe rainfall erosion in June and July. This study could have implications for mitigation strategies oriented towards reduction of soil erosion by water.

KEY WORDS: climate change, precipitation, rainfall erosivity, soil erosion, Angot precipitation index, Vojvodina, Serbia.

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Uporaba padavinski indeksa Angot za oceno erozivnosti padavin: na primeru Vojvodine (severna Srbija)

POVZETEK: Prispevek podaja pregled najpomembnejših padavinskih parametrov (pojavnost, pogostost in velikost) v Vojvodini (severna Srbija). Za 12 izbranih meteoroloških postaj so bile uporabljene mesečne in letne povprečne vrednosti padavin v obdobju 1946–2014. Kot kazalnike erozivnosti padavin smo uporabili ustrezne padavinske parametre (količina padavin, padavinski indeks Angot). Izračunali smo indeks erozivnosti padavin in ga razvrstili v razrede glede na možnost pojavljanja erozije prsti. Trende smo preučili s tremi različnimi statističnimi pristopi. V preučevanem obdobju smo prepoznali različne razrede indeksa, z zelo močno padavin erozijo junija in julija. Raziskava je dober temelj za oblikovanje strategij, usmerjenih v zmanjšanje vodne erozije prsti.

KLJUČNE BESEDE: podnebne spremembe, padavine, erozivnost padavin, erozija prsti, padavinski indeks Angot, Vojvodina, Srbija

The article was submitted for publication on May 31st, 2020.
Uredništvo je prejelo prispevek 31. maja 2020.

1 Introduction

One of the most prominent causes of land degradation is water erosion (Boardman and Poesen 2006; Bosco et al. 2015). »Erosion is a geomorphic process that detaches and removes material (soil, rock debris, and associated organic matter) from its primary location by some natural erosive agents or through human or animal activity« (Zorn and Komac 2013a, 288). Soil erosion is an important process connected to several erosive agents, such as water, wind, ice, and snow (Morgan 2005; Blinkov 2015a; Blinkov 2015b). Panagos et al. (2015a; 2015b) pointed out that in Europe, soil erosion by water accounts for the greatest soil loss compared to other erosion processes (e.g., Boardman and Poesen 2006). Water erosion may be accelerated by human activity, but human activity may also prevent runoffs and soil removal by building retention ponds (Ferk et al. 2020) or terraces (Šmid Hribar et al. 2017).

Water erosion has many on-site and off-site effects (Santos Telles, de Fátima Guimarães and Falci Dechen 2011), whereby off-site effects may have greater social, economic and environmental concern (Boardman et al. 2019). Soil erosion affects land resources and increases the risk posed by the blockage of rivers and causes degradation of water quality through pesticides, fertilizers and nutrients carried with the sediment (Lukić et al. 2019). Although soils represent a vital resource, research on soil erosion has not gained as much attention as degradation of water and air quality (Blinkov 2015a). The reason can be found in much more complex and extensive natural factors that led to this type of erosion, which are almost impossible to explain with a model that would consist of every variable and factor included in the process. Nevertheless, land degradation is recognized as a major environmental threat in many parts of Europe (e.g., de Luis, González-Hidalgo and Longares 2010; de Luis et al. 2011; Blinkov 2015a; Blinkov 2015b; Lukić et al. 2013, 2016, 2018, 2019; Zorn and Komac 2013b).

Soil erosion may be quantified using field measurement (Stroosnijder 2005) or erosion models (Borrelli et al. 2021). Globally the most widely used erosion models belong to *Universal Soil Loss Equation* family (*USLE/RUSLE* (Wischmeier and Smith 1978; Renard et al. 1997)), whereas on the territory of former Yugoslavia and in some neighbouring countries the Gavrilović equation has predominated (Gavrilović 1972; Hrvatin et al. 2019). Besides these, there are more than 600 other models that can be divided into two basic groups: those extracted from the *USLE* and *RUSLE* equations, while others employ qualitative approaches (Auerswald et al. 2014).

Precipitation is the most important natural agent with regard to water soil erosion, hence representing one of the determining factors in the *USLE* equation (Wischmeier and Smith 1978; Morgan 2005; Mello et al. 2013). The capability of rainfall to cause soil loss is called rainfall erosivity (Nearing et al. 2017; Panagos et al. 2017) and represents a climatological component in the overall erosion processes by water (da Silva 2004; Yu 1998). It is fundamental for the understanding of the climatic vulnerability regarding soil erosion in a given region (Panagos et al. 2015a). Several measures of rainfall erosivity have been proposed (Yu and Neil 2000; Morgan 2005):

- *R*-factor in the *USLE/RUSLE* (Wischmeier and Smith 1978; Renard et al. 1997),
- Fournier's Index (Fournier 1960),
- Modified Fournier Index (Arnoldus 1980),
- Lal's AI_m index (Lal 1976),
- Hudson's $KE > 1$ Index (Hudson 1976), and
- Onchev's Universal Erosivity Index (Onchev 1985).

Rainfall erosivity presents the potential of raindrops to trigger soil erosion and its estimation is fundamental for the understanding of the climatic vulnerability of a given region (Mello et al. 2013). Thereby, respective authors (e.g., Kirkby and Neale 1987; de Luis, González-Hidalgo and Longares 2010; de Luis et al. 2011) investigated the relationship between the intensity of precipitation and its distribution in time, since there is no exact relationship between the total amount of precipitation and soil erosion. Different approaches have been developed when estimating soil erosion, namely indices based on precipitation data, and indices based on kinetic energy and precipitation intensity (e.g., Lukić et al. 2016; 2019). The most recognized indices describing kinetic energy and precipitation intensity are EI_{30} (Weischmeier and Smith, 1978), AI_{m} (Lal 1976), $KE > 1$ (Hudson 1976) and $P/\sqrt{t}$ (Onchev 1985). These parameters require daily precipitation data series over 20 years, and since there is no such data for most parts of the world, it was necessary to create a simpler approach. The most utilized indices based on available rainfall data are the Fournier Index (*FI*) and the Modified Fournier Index (*MFI*) (Morgan 2005; Arnoldus 1980) which are extracted from the *R* – rainfall erosivity factor in the *USLE* equation (Renard and Freimund 1994; Gabriels 2001; Loureiro and Coutinho 2001; Diodato and Bellocchi 2007). They were used in numerous studies with scarce precipitation databases (e.g., Lujan and Gabriels 2005; Boardman and Poesen 2006; de Luis, González-Hidalgo and Longares 2010; Ufoegbune et al. 2011; Costea 2012; Lukić et al. 2016; 2018; 2019). It was also in comparisons of several rainfall erosivity indices (e.g., Oduro-Afriyie 1996; da Silva 2004; Bayramin, Erpul and Erdogan 2006; Angulo-Martínez and Beguería 2009; Alipour et al. 2012; Mello et al. 2013; Sanchez-Moreno, Mannaerts and Jetten 2014). Fournier indices require mean monthly data averages and are based on temporal precipitation distribution obtained through Precipitation Concentration Index (*PCI*) (Arnoldus 1980). Beside articles that were based on *MFI* and *FI* parameters (e.g., Oduro-Afriyie 1996; Lujan and Gabriels 2005; Apaydin et al. 2006; Costea 2012; Yue, Shi and Fang 2014; Hernando and Romana 2015), *PCI* was also used in numerous studies concerning precipitation distribution and concentration (Martínez-Casasnovas, Ramos and Ribes-Dasi 2002; de Luis et al. 2011; Iskander, Rajib and Rahman 2014; Lukić et al. 2019).

According to Dumitrascu et al. (2017), besides soil type, topography, and land use, the amount and intensity of precipitation is an important factor in estimating the rate of soil erosion by water. The climatic factors can lead to the intensification of erosion when they register high intensities and occurrence after a prolonged drought period.

For this purpose, an indicator for the assessment of pluvial aggressiveness (Angot – *K* index) (Dragotă, Micu and Micu 2008) can be applied in assessing rainfall erosivity in Southeastern Europe – a hotspot region with the highest number of severely affected sectors (Dragotă, Micu and Micu 2008; Dragotă et al. 2014; Dumitrascu et al. 2017; Lung and Hilden 2017; Lukić et al. 2019; Milanović et al. 2019). So far, rainfall erosivity assessment in the Vojvodina Region has been carried out in the Bačka and Zemun loess plateaus (Lukić et al. 2016, 2018) and in the Pannonian Basin (Lukić et al. 2019). The study found that the amount and the intensity of precipitation are increasing. According to Marković et al. (2008; 2012; 2015), the largest part of Vojvodina is covered with loess and loess-like sediments (> 60%), which are extremely susceptible to the erosion processes due to high porosity, carbonate and clay content as abounding material (Lukić et al. 2009; Vasiljević et al. 2011; Hrnjak et al. 2014). Therefore, it is very important to point out the most vulnerable areas for mitigation and prevention (Leger 1990; Lukić et al. 2016; 2019).

The publicly available precipitation database of the Vojvodina Region record more than 70 years of continuous observations. However, the data is based on monthly values. Accordingly, the aforementioned Angot – *K* index, which was used in similar studies (in the neighbouring countries), is one of the compatible methodological approaches for assessing the potential vulnerability of the investigated area from the rainfall erosivity (e.g., Dragotă, Micu and Micu 2008; Dragotă et al. 2014; Dumitrascu et al. 2017).

So far, rainfall erosivity assessment in the Vojvodina Region has been carried out for the case study of Kula settlement (southern part of the Bačka loess plateau) and Zemun area in the vicinity of Belgrade (Zemun loess plateau), where Lukić et al. (2016; 2018) studied the relationship between recurring landslides and rainfall erosivity. In a later study, Lukić et al. (2019) showed an increase in the amount and the intensity of precipitation as well as in rainfall erosivity for most parts of the Pannonian Basin, including Vojvodina region.

In this paper climatological parameters from the Vojvodina Region (North Serbia) are processed. We used the Angot precipitation index (Dragotă, Micu and Micu 2008), which is the ratio of the daily average volume of precipitation in a month and the annual daily average precipitation volume (Constantin and Vătămanu 2015) and was previously already used in the wider study region by Dragotă et al. (2014) and Dumitraşcu et al. (2017). In order to assess the erosion vulnerability for the southern part of the Pannonian Basin, the occurrence, frequency and magnitude of some of the most significant precipitation parameters were studied.

2 Study area

The Autonomous Province of Vojvodina (21,533 km^2) is located in the southern part of the Pannonian Basin and the northern part of the Republic of Serbia (Figure 1). It is divided into three regions: Banat, Bačka, and Srem with Novi Sad as the capital (Basarin et al. 2018; Gavrilov et al. 2020).

The largest part of the region is covered with loess and loess-like sediments (> 60%). As the loess material possesses several properties which make it highly susceptible to water erosion, it is very important to point out the most vulnerable areas for mitigation and prevention (Leger 1990; Lukić et al. 2009; 2016; 2019).

The Vojvodina Region is predominantly a lowland area, and the highest parts are Fruška gora Mountain (539 m) in the northern part of the Srem Region, and the Vršačke Mountains (641 m) in the southeastern part of the Banat Region. However, the largest geomorphological structures are formed on loess and loess-like material, and present loess plateaus, terraces and microrelief forms (Marković et al. 2008; 2012; 2015; Lukić et al. 2009; Vasiljević et al. 2011; Gavrilov et al. 2020).

The climate of the Vojvodina Region is controlled by the geographical position in the southern part of the Pannonian Basin. According to the Köppen climate classification it is moderately continental due to the weaker impact of western air currents, and the greater impact of a Eurasian continental climate. Winter seasons are cold (average January temperatures range from < 0.0 °C to 1.0 °C), while summers are hot and humid (average July temperature of between 21.0 °C and 23.0 °C), with a huge temperature range, reaching ~70 °C and very irregular distribution of monthly rainfall (extremely rainy early summer and low precipitation in November and March) (Malinović-Milićević et al. 2018). Climate is influenced by NW cold and humid wind, and the warm and dry SE wind. Hence, the main characteristic of the rainfall regime in Vojvodina is reflected in the pronounced variability in both space and time. The average annual precipitation is 606 mm, with the highest amounts in June, and lowest in February (Gavrilov et al. 2015; 2016). During the summer the total monthly precipitation can fall within a single day. The lowest average annual rainfall of about 540 mm is recorded in the north, while the highest average precipitation values are recorded in the southwest of Vojvodina (Hrnjak et al. 2014; Tošić et al. 2014; Gavrilov et al. 2019).

3 Data and methods

The precipitation data for the rainfall erosivity assessment was obtained from the database of the Hydrometeorological Service of the Republic of Serbia for the period 1946–2014 for 12 meteorological stations (Meteorološki godišnjak 1946–2014) (Table 1), selected based on the completeness of the time series and spatial distribution (Figure 1). Data for the analysed period covers two thirty-year cycles, which is in accordance with the WMO standards.

Datasets for each of the stations were analysed and processed for the calculation of the mean monthly amount of precipitation. Thus, a database was created with a time series of monthly and annual precipitation values. The homogeneity of the precipitation series was confirmed by the Alexandersson (1986) test. Precipitation trends were examined using three different statistical approaches. In the first approach, a simple linear regression was used to determine the existence of a certain tendency in the data series, which gives information on the stagnation, growth or decline of the observed phenomenon (Cohen 1988; Gocić and Trajković 2013). Using

Figure 1: Map of Vojvodina (North Serbia) with meteorological stations used in this study. ➤ p. 128

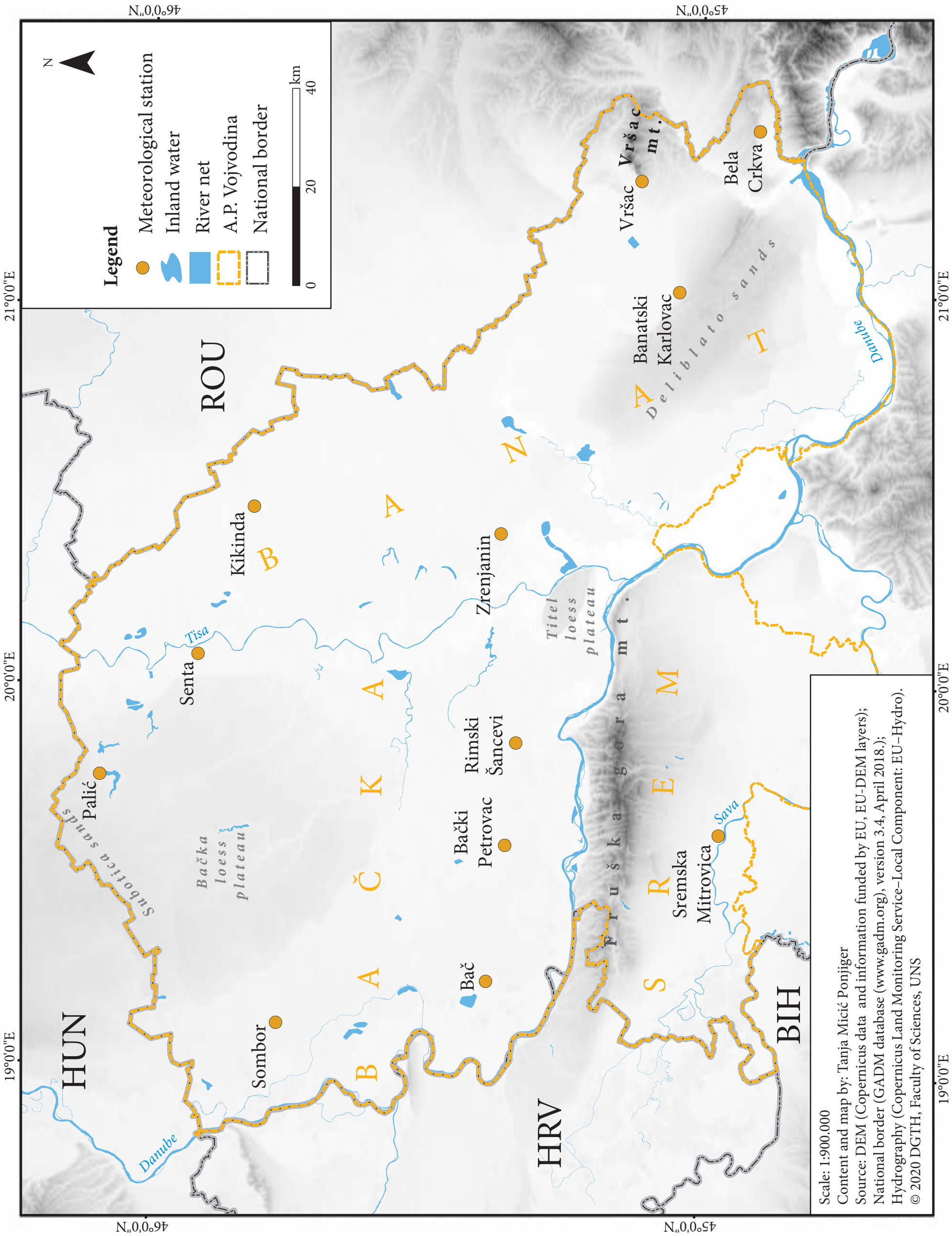
Legend
Meteorological station
Inland water
River net
A.P. Vojvodina
National border
N
0
20
40
km
46°0'0"N
45°0'0"N
19°0'0"E
20°0'0"E
21°0'0"E
HUN
ROU
HRV
BIH
B A Č K A
B A N A T
S R E M
Sombor
Palić
Senta
Kikinda
Zrenjanin
Bač
Bački Petrovac
Rimski Šancevi
Sremska Mitrovica
Banatski Karlovac
Vršac
Bela Crkva
Vršac mt.
Deliblato sands
Subotica sands
Bačka loess plateau
Titel loess plateau
Fruška gora mt.
Danube
Tisa
Sava
Scale: 1:900.000
Content and map by: Tanja Mićić Ponjiger
Source: DEM (Copernicus data and information funded by EU, EU-DEM layers);
National border (GADM database (www.gadm.org), version 3.4, April 2018.);
Hydrography (Copernicus Land Monitoring Service-Local Component: EU-Hydro).
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Table 1: Geographical coordinates and altitudes of selected meteorological stations.

Region	Meteorological stations	Latitude (N)	Longitude (E)	Altitude (m)
Banat	Banatski Karlovac	45°03′00″	21°02′12″	100
	Bela Crkva	44°54′00″	21°25′12″	90
	Vršac	45°09′00″	21°19′12″	83
	Zrenjanin	45°22′00″	20°25′00″	80
	Kikinda	45°51′00″	20°28′12″	81
	Senta	45°55′48″	20°04′48″	80
Bačka	Bač	44°54′00″	21°25′12″	90
	Bački Petrovac	45°22′12″	19°34′12″	85
	Palić	46°06′00″	19°46′12″	102
	Rimski Šančevi	45°19′48″	19°51′00″	86
	Sombor	45°46′12″	19°09′00″	87
Srem	Sremska Mitrovica	45°01′00″	19°33′00″	82

this method, the trend equation for yearly data was obtained for 69 years. The precipitation trend was also investigated using the nonparametric Mann-Kendall test, which is widely applied in environmental sciences for its simplicity and precision (Gilbert 1987; Gavrilov et al. 2011, 2013; Hrnjak et al. 2014; Lukić et al. 2017). Third, Kendall's tau (τ) (Kendall 1938, 1975) was calculated to gain a trend over a fully observed period of 69 years. Then, two hypotheses were tested:

1) Null hypothesis (H_0) – with the assertion that there is no trend in the observed time series for a defined level of significance of 95% ($\alpha = 0.05$);
2) Alternative hypothesis (H_a) – with the assertion that there is a trend in a given time series for a defined level of significance of 95% ($\alpha = 0.05$).

Statistical data processing was performed using the Wolfram Mathematica 11.3 software. Due to the presence of a positive correlation in data sets that can influence the increase in the number of false-positive trend outcomes, the Yue-Pilon method was performed (Yue et al. 2002).

Rainfall erosivity can be assessed using several methods (Costea 2012), of which we choose Angot precipitation index (*K)* (Dragotă, Micu and Micu 2008; Dragotă et al. 2014; Dumitrașcu et al. 2017). According to Dumitrașcu et al. (2017), destructive heavy rainfalls mostly depend on the intensity, duration and water quantity of the precipitation, and particular surface features, such as lithology, vegetation cover, and slope. In such conditions, heavy precipitation can trigger floods, erosion and slope failures (Lukić et al. 2016, 2018). Hence, the main components of the precipitation regime that have the strongest impact on the environment in the Vojvodina Region have been analysed using a specific erodibility *K* index. According to Dumitrașcu et al. (2017), this index has the benefit of relying on easily accessible input data (precipitation), where the quantification and ranking of precipitation aggressiveness is made using already established value classes. The Angot precipitation index (*K)* was initially aimed at determining the characteristic types of monthly and annual variation of precipitation based on regional and local comparisons. The index was quantified according to equations 1 and 2 (Dragotă, Micu and Micu 2008; Dumitrașcu et al. 2017):

$$K = \frac{p}{P} \tag{1}$$

where $p = q/n$, q being the monthly precipitation amounts, and n being the number of days/months, and

$$P = \frac{Q}{365} \tag{2}$$

where Q is the multiannual precipitation amounts.

The resulted index values were used to determine the susceptibility classes of precipitation liable for triggering soil erosion (Table 2).

Table 2: Susceptibility classes of precipitation liable to triggering soil erosion based on Angot precipitation index (K) (Dragotă, Micu and Micu 2008; Dumitraşcu et al. 2017).

Precipitation attributes	Very dry	Dry	Normal	Rainy	Very rainy
Precipitation erodibility classes	Very low	Low	Moderate	Severe	Very severe
Angot index values (*K*)	< 0.99	1.00–1.49	1.50–1.99	2.00–2.49	> 2.50

In order to examine the relationship between precipitation data, *K* and potential climate drivers, linear correlations were utilized. The selected large-scale phenomenon, North Atlantic Oscillation (*NAO*) and Multivariate ENSO Index (*MEI*) were used following the approach by Malinović-Milićević et al. (2018) and Lukić et al. (2019). *NAO* is characterized as the difference between sea-level pressure observed over Iceland and Portugal. When the values of *NAO* are negative storm tracks shift to the south, inducing more winter precipitation in the regions south of the Pyrenean-Alpine Mountains, including the Pannonian Basin (and the Vojvodina Region). On the other hand, positive values of the *NAO* lead to shifting storm tracks to the north, exposing the area south of the Pyrenean-Alpine Mountains to relatively dry conditions in the winter (Hurrell et al. 2003; Trigo et al. 2004). The station-based *NAO* time series were obtained from the Climatic Research Unit of the University of East Anglia (Internet 1).

Ocean–atmosphere interactions in the Pacific realm El Niño-Southern Oscillation (ENSO) is one of the most important climate drivers whose influence extends across the globe. *MEI* is an appropriate and a rather complex parameter, which integrates complete information of six oceanic and meteorological variables indicating the influence of southern oscillation (Pompa-García and Némiga 2015). The ENSO (*MEI*) record was obtained from the NOAA Physical Sciences Laboratory (Internet 2).

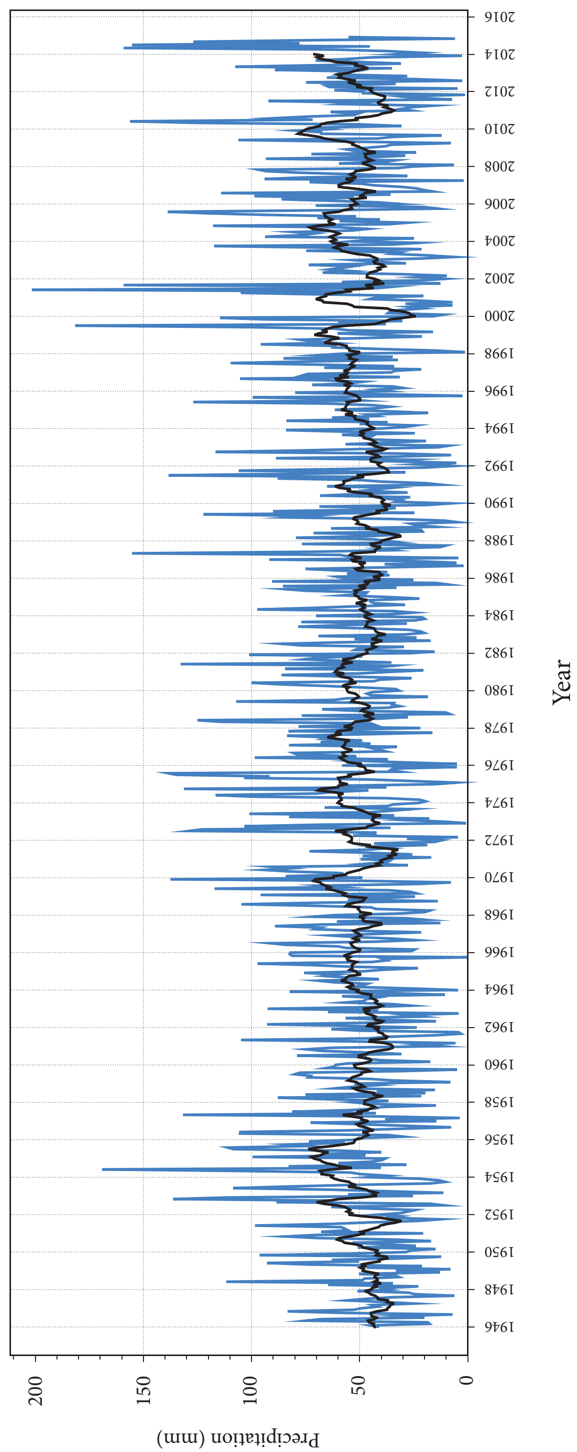
4 Results and discussion

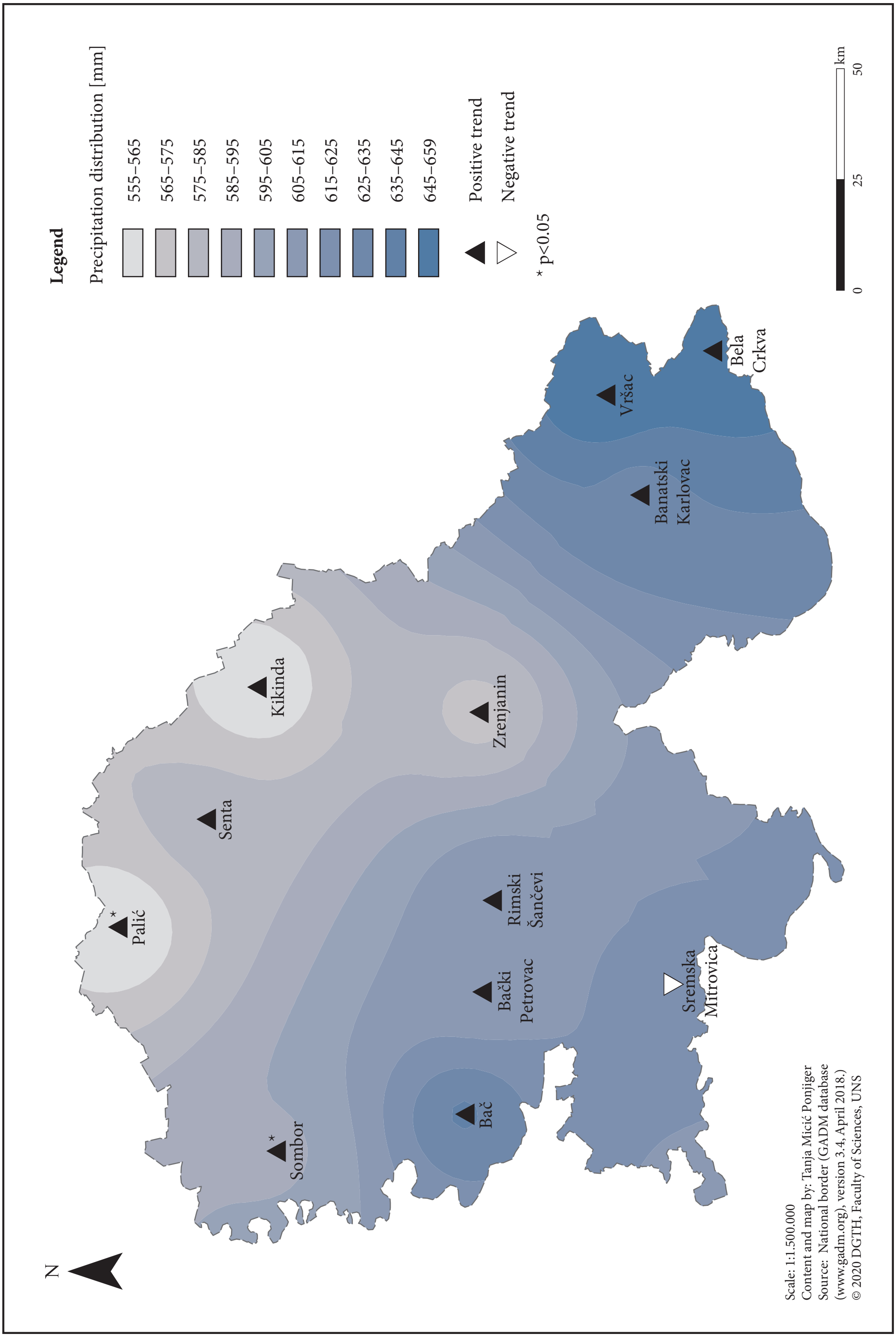
The temporal evolution of the moving average (with a size window equal to 12 months) indicates that there are no significant variations or deviations regarding the precipitation distribution in the study area (Figure 2). This observation corresponds well with the results of Lukić et al. (2019) who pointed out that precipitation concentration values (*PCI*) in northern Serbia belong to the group of moderately distributed precipitation (a statistically significant trend was not observed). According to the authors, seasonal values of precipitation concentration for the Vojvodina Region generally display uniform values, where the winter season exhibits higher values than other seasons for all investigated stations during the period 1961–2014.

As shown by Bjelajac et al. (2016), the average annual precipitation (calculated for a period of 69 years) for 11 out of 12 stations indicate a positive linear trend, of which most pronounced trends are observed for the Bačka Region – Rimski Šančevi meteorological station ($y = 1.8309x + 550.89$). The highest average precipitation amount is recorded for the Bela Crkva meteorological station (659.1 mm) in the southeast, while the lowest values are recorded in the north and northeast (Palić station 555 mm and Kikinda station 555.5 mm) (Figure 3). According to the Mann-Kendall test, based on calculated *p* values, Sombor ($p = 0.020$) and Palić ($p = 0.021$) stations confirm the *Ha* hypothesis, i.e. there is a noticeable positive trend at the significance level $p < 0.05$. Therefore, on the annual basis, Sombor and Palić stations (for the study period) display an increase in the amount of precipitation by 1.46 mm and 1.68 mm, respectively (Figure 3). Other meteorological stations do not show statistically significant trend of precipitation variability for the study period.

The used meteorological database covers the warm period of the year (when positive values of *K* index prevail). The most favourable conditions for the occurrence of water erosion processes are distributed within April and September (when the highest rainfall amounts are recorded for all investigated stations; Figure 4). Table 3 summarizes monthly susceptibility of the Angot precipitation index classes (in%) for the selected stations during the period 1946–2014.

Figure 2: The 12-month moving average of precipitation distribution (for the study period) for the Vojvodina Region. ➤ p. 131
Figure 3: Spatial distribution of the mean annual precipitation for the study period in the study area. ➤ p. 132
Figure 4: Mean monthly multiannual precipitation amounts (mm) for the selected stations and regions. ➤ p. 133–134


Precipitation (mm)
0
50
100
150
200
Year
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016


Legend
Precipitation distribution [mm]
555–565
565–575
575–585
585–595
595–605
605–615
615–625
625–635
635–645
645–659
Positive trend
Negative trend
* p<0.05
0
25
50
km
N
Palić
Senta
Kikinda
Zrenjanin
Sombor
Bač
Bački Petrovac
Rimski Šančevi
Sremska Mitrovica
Banatski Karlovac
Vršac
Bela Crkva
Scale: 1:1.500.000
Content and map by: Tanja Micić Ponjiger
Source: National border (GADM database (www.gadm.org), version 3.4, April 2018.)
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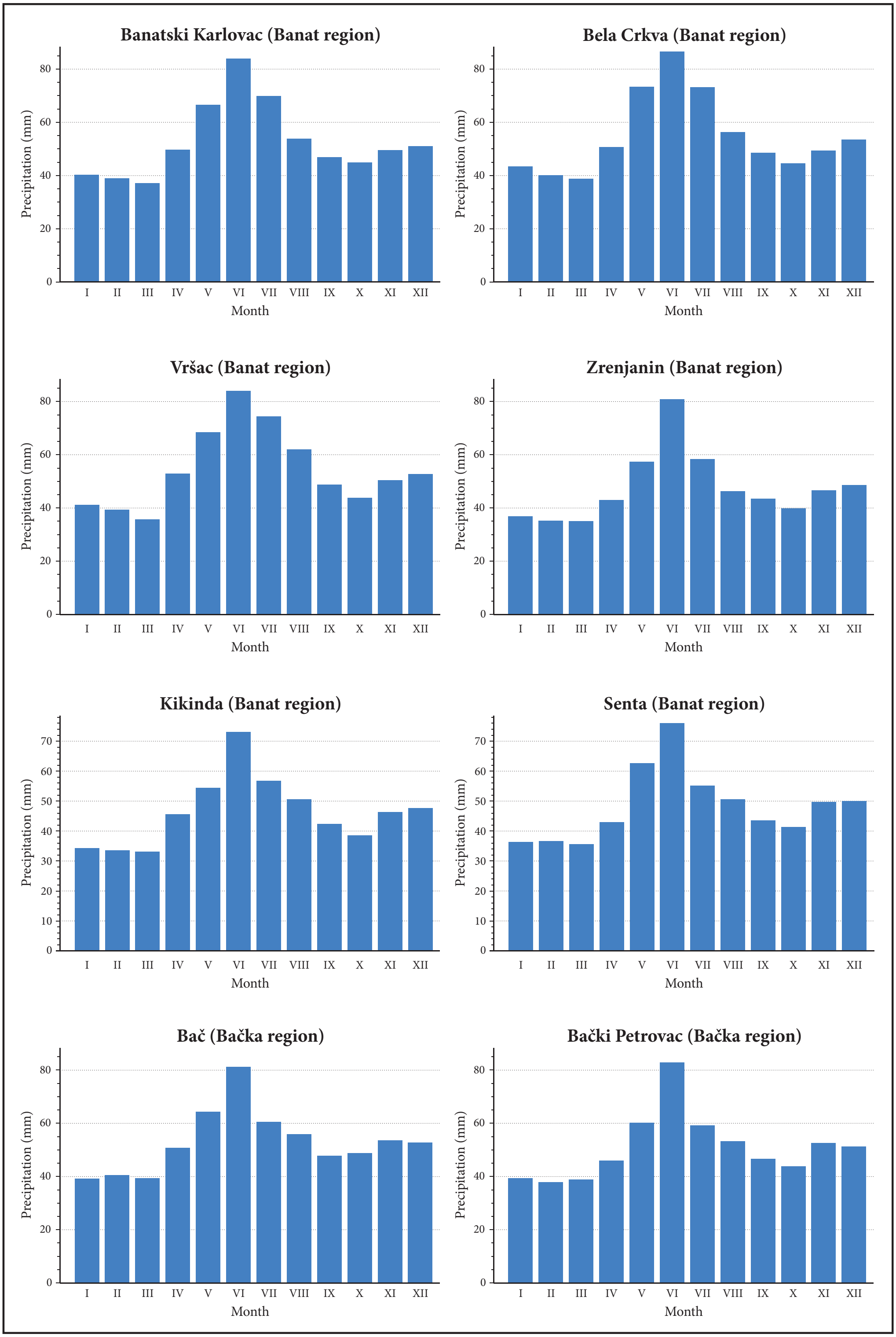

Banatski Karlovac (Banat region)
Precipitation (mm)
0
20
40
60
80
I II III IV V VI VII VIII IX X XI XII
Month
Bela Crkva (Banat region)
Precipitation (mm)
0
20
40
60
80
I II III IV V VI VII VIII IX X XI XII
Month
Vršac (Banat region)
Precipitation (mm)
0
20
40
60
80
I II III IV V VI VII VIII IX X XI XII
Month
Zrenjanin (Banat region)
Precipitation (mm)
0
20
40
60
80
I II III IV V VI VII VIII IX X XI XII
Month
Kikinda (Banat region)
Precipitation (mm)
0
10
20
30
40
50
60
70
I II III IV V VI VII VIII IX X XI XII
Month
Senta (Banat region)
Precipitation (mm)
0
10
20
30
40
50
60
70
I II III IV V VI VII VIII IX X XI XII
Month
Bač (Bačka region)
Precipitation (mm)
0
20
40
60
80
I II III IV V VI VII VIII IX X XI XII
Month
Bački Petrovac (Bačka region)
Precipitation (mm)
0
20
40
60
80
I II III IV V VI VII VIII IX X XI XII
Month

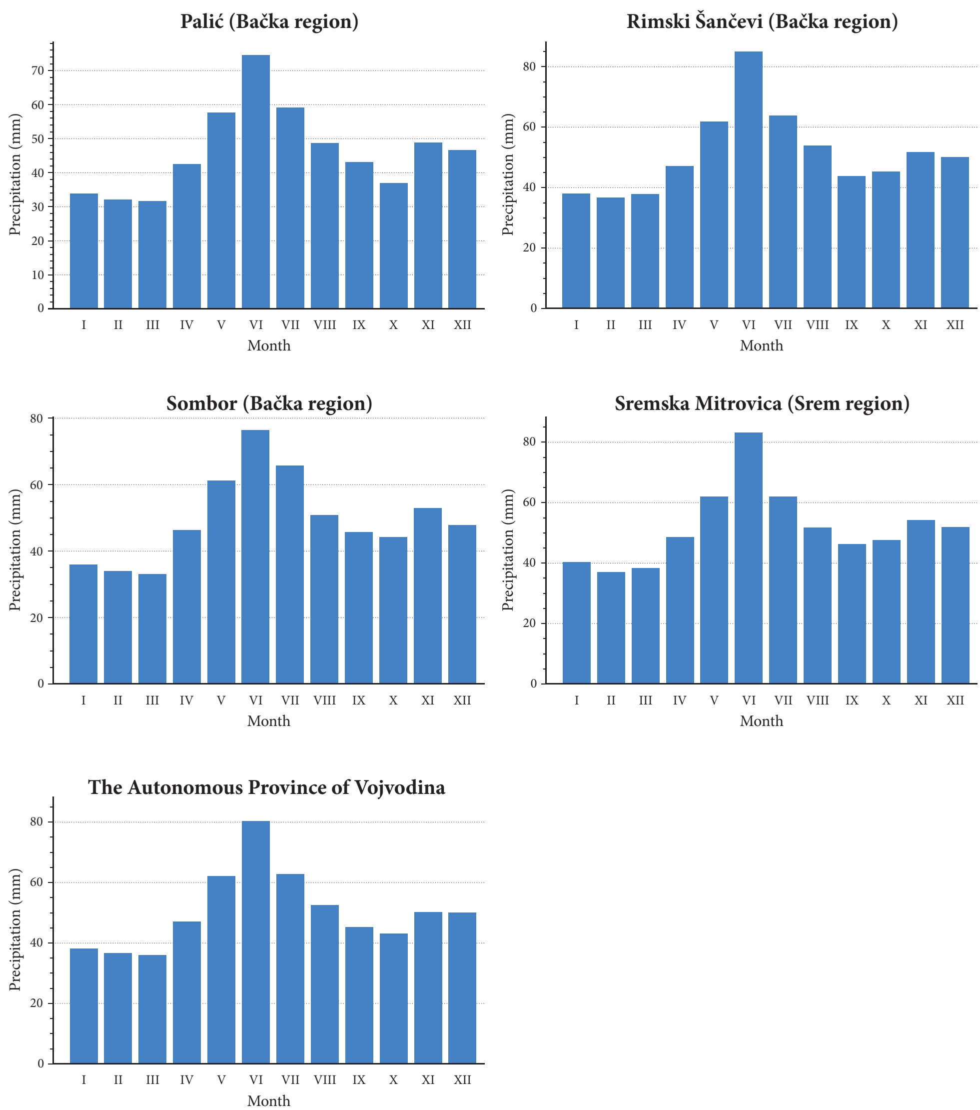

Palić (Bačka region)
Precipitation (mm)
0 10 20 30 40 50 60 70
I II III IV V VI VII VIII IX X XI XII
Month
Rimski Šančevi (Bačka region)
Precipitation (mm)
0 20 40 60 80
I II III IV V VI VII VIII IX X XI XII
Month
Sombor (Bačka region)
Precipitation (mm)
0 20 40 60 80
I II III IV V VI VII VIII IX X XI XII
Month
Sremska Mitrovica (Srem region)
Precipitation (mm)
0 20 40 60 80
I II III IV V VI VII VIII IX X XI XII
Month
The Autonomous Province of Vojvodina
Precipitation (mm)
0 20 40 60 80
I II III IV V VI VII VIII IX X XI XII
Month

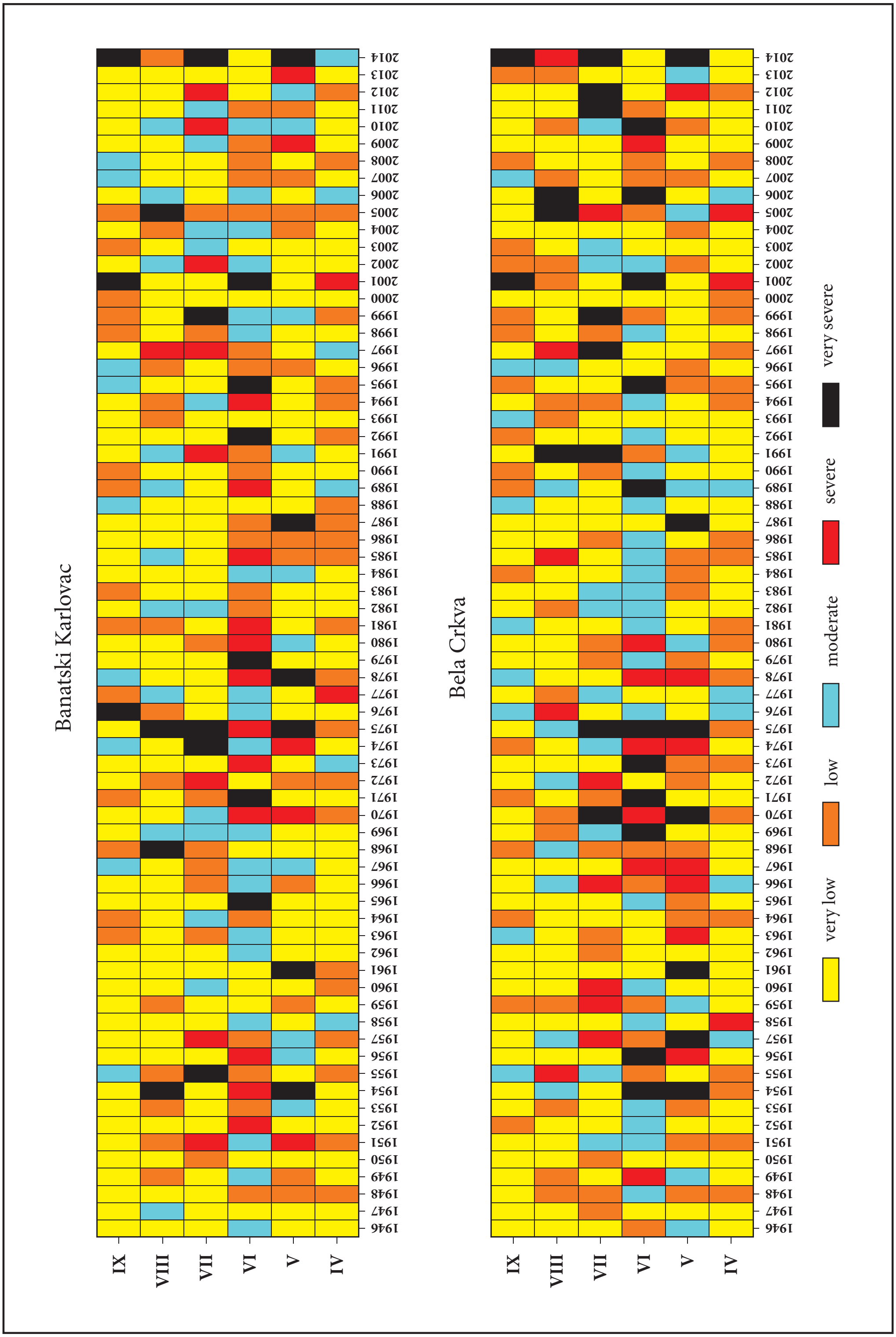
Table 3: Monthly susceptibility of Angot precipitation index classes (1946–2014).

Susceptibility class / Angot index values	Month (%)					
	April	May	June	July	August	September
Banatski Karlovac (Banat Region)						
Very low (< 1.0)	56.5	52.2	20.3	53.6	59.4	62.3
Low (1.0–1.5)	31.9	17.4	26.1	13.4	18.8	20.3
Moderate (1.6–2.0)	8.7	14.5	27.5	14.5	14.5	13.1
Severe (2.1–2.5)	2.9	7.2	17.4	11.6	1.5	0
Very severe (> 2.5)	0.0	8.7	8.7	7.2	5.8	4.4
Bela Crkva (Banat Region)						
Very low (< 1.0)	57.9	42.1	26.1	46.4	55.1	59.4
Low (1.0–1.5)	28.9	26.1	17.4	18.8	21.7	24.6
Moderate (1.6–2.0)	8.7	11.6	30.4	14.5	11.6	13.1
Severe (2.1–2.5)	4.3	10.1	10.1	8.7	7.2	0
Very severe (> 2.5)	0.0	10.1	15.9	11.6	4.3	2.9
Vršac (Banat Region)						
Very low (< 1.0)	53.6	44.9	23.2	47.8	53.6	63.8
Low (1.0–1.5)	31.9	28.9	27.5	18.8	15.9	18.8
Moderate (1.6–2.0)	10.1	14.5	20.3	13.1	14.5	8.7
Severe (2.1–2.5)	4.3	4.3	17.4	8.7	5.8	5.8
Very severe (> 2.5)	0.0	7.2	11.6	11.6	10.1	2.9
Zrenjanin (Banat Region)						
Very low (< 1.0)	59.4	53.6	17.4	53.6	66.6	62.3
Low (1.0–1.5)	28.9	17.4	26.1	18.8	14.5	23.2
Moderate (1.6–2.0)	10.1	15.9	27.5	10.1	10.1	8.7
Severe (2.1–2.5)	1.4	7.2	13.1	7.2	4.3	1.4
Very severe (> 2.5)	0.0	5.8	15.9	10.1	4.3	4.4
Kikinda (Banat Region)						
Very low (< 1.0)	56.5	49.3	30.4	47.8	53.6	56.5
Low (1.0–1.5)	28.9	18.8	23.2	21.7	23.2	28.9
Moderate (1.6–2.0)	5.8	17.4	15.9	14.5	11.6	8.7
Severe (2.1–2.5)	5.8	11.6	15.9	10.1	5.8	2.9
Very severe (> 2.5)	2.9	2.9	14.5	5.8	5.8	2.9
Senta (Banat Region)						
Very low (< 1.0)	69.6	46.4	24.6	59.4	50.7	57.9
Low (1.0–1.5)	18.8	21.7	27.5	20.3	27.5	24.6
Moderate (1.6–2.0)	8.7	15.9	24.6	8.7	13.1	11.6
Severe (2.1–2.5)	1.4	7.2	8.7	7.2	5.8	2.9
Very severe (> 2.5)	1.4	8.7	14.5	4.4	2.9	2.9
Bač (Bačka Region)						
Very low (< 1.0)	57.9	43.5	26.1	47.8	57.9	65.2
Low (1.0–1.5)	30.4	30.4	24.6	28.9	20.3	14.5
Moderate (1.6–2.0)	10.1	13.1	24.6	14.5	11.6	8.7
Severe (2.1–2.5)	0	8.7	14.5	5.8	4.3	8.7
Very severe (> 2.5)	1.4	4.3	10.1	2.9	5.8	2.9
Bački Petrovac (Bačka Region)						
Very low (< 1.0)	65.2	47.8	21.7	53.6	59.4	59.4
Low (1.0–1.5)	23.2	24.6	28.9	21.7	20.3	18.8
Moderate (1.6–2.0)	8.7	17.4	17.4	8.7	10.1	13.1
Severe (2.1–2.5)	2.9	4.3	17.4	8.7	5.8	5.8
Very severe (> 2.5)	0.0	5.8	14.5	7.2	4.4	2.9

Susceptibility class / Angot index values	Month (%)					
	April	May	June	July	August	September
Palić (Bačka Region)						
Very low (< 1.0)	63.8	42.1	26.1	39.1	44.9	57.9
Low (1.0–1.5)	24.6	28.9	26.1	31.9	33.3	24.6
Moderate (1.6–2.0)	5.8	13.1	15.9	15.9	15.9	8.7
Severe (2.1–2.5)	4.4	10.1	20.3	8.7	1.4	4.3
Very severe (> 2.5)	1.4	5.8	11.6	4.3	4.4	4.3
Rimski Šančevi (Bačka Region)						
Very low (< 1.0)	59.4	47.8	23.2	52.2	57.9	66.7
Low (1.0–1.5)	31.9	26.1	23.2	18.8	18.8	15.9
Moderate (1.6–2.0)	5.8	14.5	23.2	10.1	8.7	11.6
Severe (2.1–2.5)	1.4	7.2	14.5	11.6	10.1	4.3
Very severe (> 2.5)	1.4	4.3	15.9	7.2	4.3	1.4
Sombor (Bačka Region)						
Very low (< 1.0)	56.2	49.3	26.1	40.6	59.4	65.2
Low (1.0–1.5)	33.3	23.2	24.6	21.7	23.2	18.8
Moderate (1.6–2.0)	5.8	11.6	27.5	26.1	8.7	5.8
Severe (2.1–2.5)	2.9	7.2	13.1	4.3	2.9	5.8
Very severe (> 2.5)	1.4	8.7	8.7	7.2	5.8	4.3
Sremska Mitrovica (Srem Region)						
Very low (< 1.0)	52.2	49.3	21.7	44.9	60.9	63.8
Low (1.0–1.5)	37.7	23.2	27.5	34.8	18.8	18.8
Moderate (1.6–2.0)	7.2	17.4	24.6	7.2	11.6	11.6
Severe (2.1–2.5)	2.9	4.3	15.9	7.2	4.3	2.9
Very severe (> 2.5)	0.0	5.8	10.1	5.8	4.3	2.9
The Autonomous Province of Vojvodina						
Very low (< 1.0)	56.5	44.9	21.7	46.4	55.1	63.8
Low (1.0–1.5)	34.8	31.9	27.5	27.5	21.7	20.3
Moderate (1.6–2.0)	7.2	10.1	27.5	14.5	14.5	11.6
Severe (2.1–2.5)	1.4	8.7	14.5	5.8	5.8	1.4
Very severe (> 2.5)	0.0	4.3	8.7	5.8	2.9	2.9

According to the *K* index values for the Banat Region, Banatski Karlovac meteorological station records, the presence of very severe rainfall erosivity occurred in 1975 and 2014. On the other hand, the presence of moderate erosion classes is evenly distributed during the two thirty-year cycles in the study period. Bela Crkva station follows a similar pattern. After 1975, an increase of very severe precipitation classes has been observed during the studied six-month interval. The most pronounced very severe precipitation erosion classes have been observed for the Vršac station in 1995. During the study period, this station does not record the presence of severe erosion classes except in 2014 (during May, August and September). This observation corresponds with the results of Lukić et al. (2019), who pointed out that the weather station Vršac (*MFI* – 149.16) and its surroundings have the highest erosivity value for 2014. The Zrenjanin station records very severe rainfall erosivity classes in 2010 and 2014. The number of precipitation months classified as severe and very severe erosion have been increasing since 1999 (Figure 5). The weather station Kikinda does not display extreme rainfall erosivity, during the investigated period. 2001 is highlighted as a year where severe erosion occurred in April, June and September. Extreme precipitation sums (registered in 2014) for the weather station of Senta indicate the presence of very severe erosion during May, July and September. Years with the distinguished presence of very severe erosion classes (33.3% of the studied precipitation interval) are 1974, 1978, 1999, 2001 and 2004. This implies that the area surrounding Senta weather station is somewhat more prone to rainfall erosivity.

Figure 5: Mean multiannual values of *K* Index during the warm part of the year for Banat weather stations. ➤ p. 137–139


Banatski Karlovac
Bela Crkva
IX
VIII
VII
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very low
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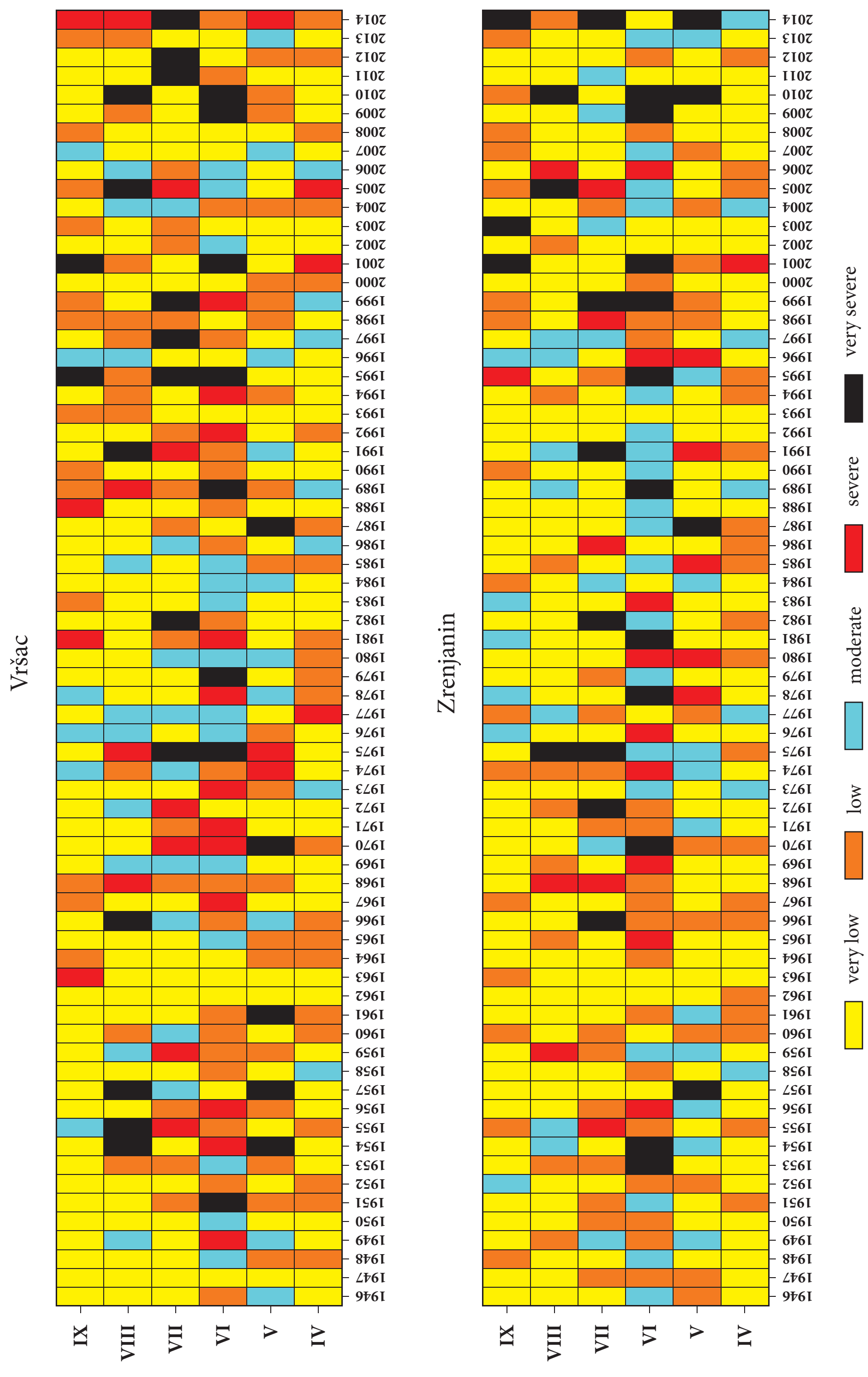
moderate
severe
very severe


Vršac
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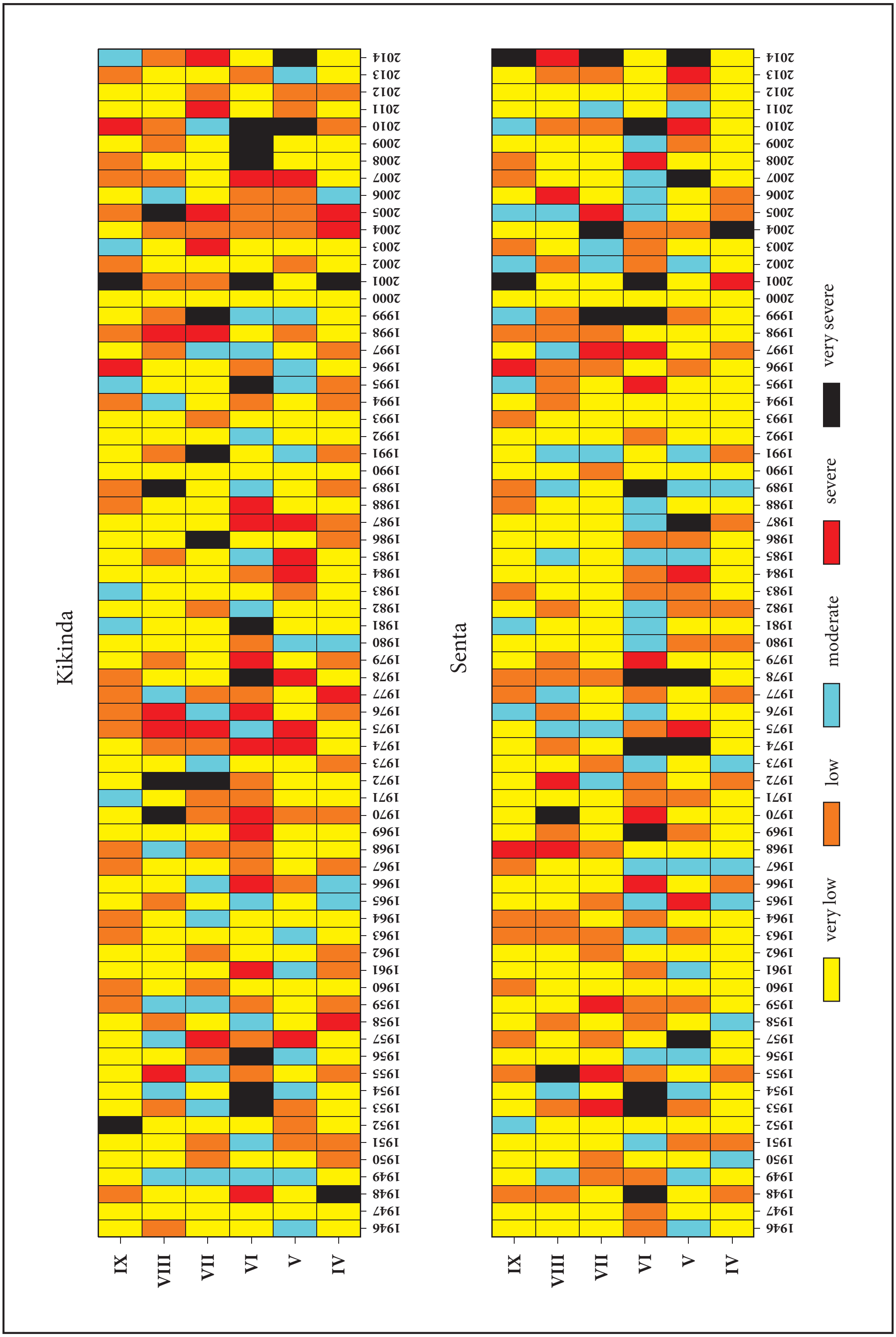
Kikinda
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IV
very low
low
moderate
severe
very severe

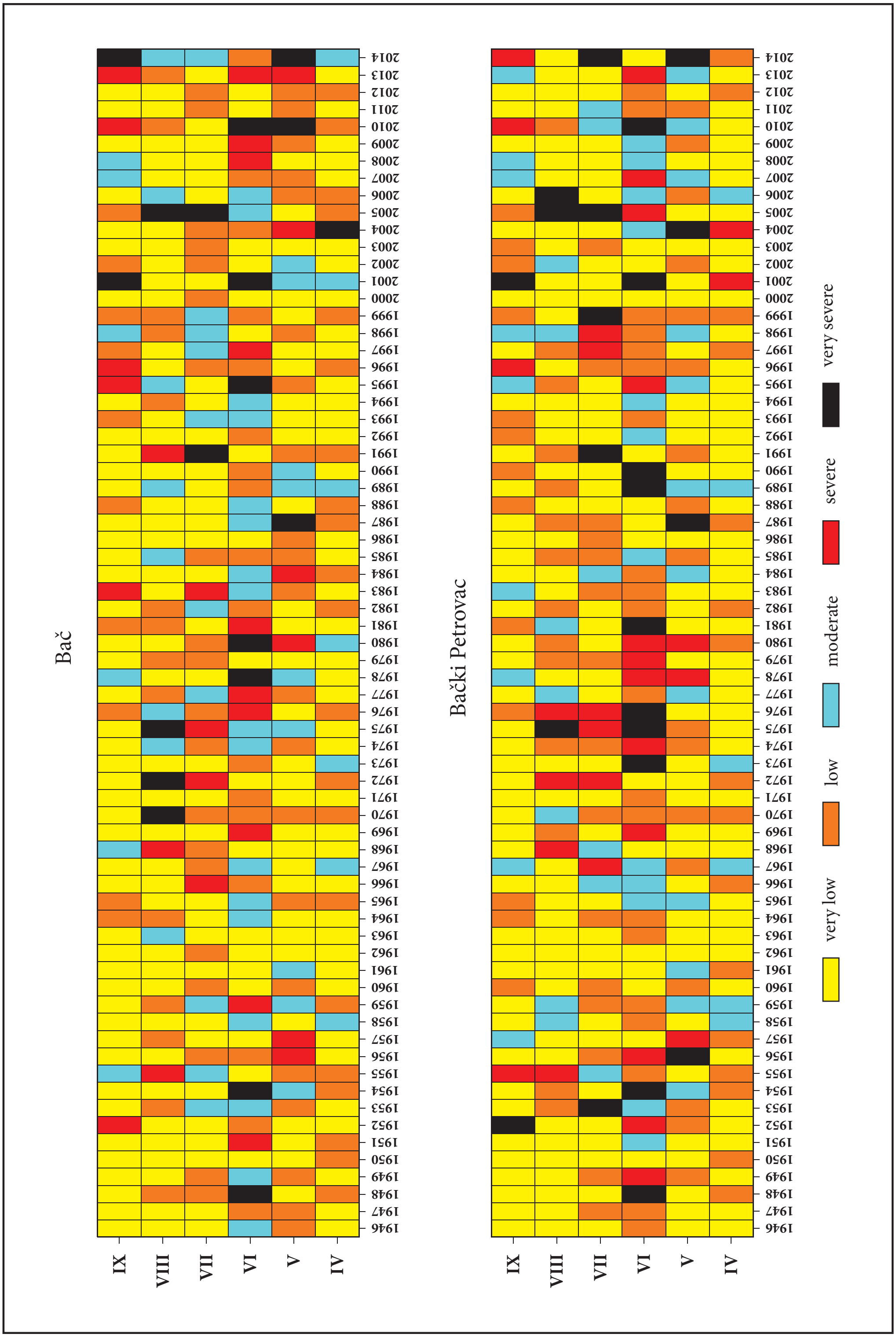
According to the *K* index values for the Bačka Region, the Bač weather station in the western part of Vojvodina Region, registers several years with the two-month precipitation interval presence of very severe erosion classes (2001, 2005 and 2014). The presence of low values of the *K* index corresponds well with the observations provided by Bjelajac et al. (2016). The Bački Petrovac station does not display a higher presence of severe erosion classes during the study period. The years with the presence of severe erosion classes within the 33.3% of the precipitation interval are 1975, 2005 and 2014. On the other hand, the Palić weather station in the north of the Vojvodina province generally displays an absence of periods with intensive rainfall erosivity classes. These observations fit well with the finding of Lukić et al. (2019), that Palić area records the lowest erosivity value in the Vojvodina Region during 1983 (*MFI* – 8.60). Results for the Rimski Šančevi weather station in the southern parts of Bačka Region indicate that an increase of rainfall erosivity can be seen from 1995, with the presence of three-month precipitation intervals of very severe erosion in 2001. Lukić et al. (2019) indicate that this part of the Pannonian Basin is characterized by periods of irregular precipitation concentration and an increase of *MFI* values on an annual basis. These features suggest a rather wetter conditions in this part of Vojvodina Region. The Sombor weather station generally registers weaker rainfall erosivity, with an exception of extreme rainy years (Figure 6).

According to the *K* index values for the Srem Region, the Sremska Mitrovica weather station does not identify higher three-month precipitation intervals of severe and very severe erosion classes. The years 1972, 2001 and 2014 record two-month precipitation intervals of very severe erosion. Three-month precipitation intervals of very severe erosion classes were only present during the extremely rainy 2014. The years of 1975 and 2001 record two-month precipitation intervals of the highest erosion classes. During the period 1946–2014, the highest presence of very low and low rainfall erosivity classes can be observed (Figure 7).

Similar approach related to the hydro-meteorological hazard assessment has been performed by Dumitraşcu et al. (2017) for the south-western part of Romania. Previously, Dragotă et al. (2014) pointed out that the Danube Floodplain displays moderate to excessive rainfall erosivity regime. Authors emphasize that due to relief configuration, reduced declivity and soil types, moderate, low and very low susceptibility classes prevail in the study area. On the other hand, Dumitraşcu et al. (2017) showed that mountainous and hilly areas display the highest susceptibility to rainfall erosivity, as it can be observed for south-eastern parts of the Vojvodina Region (Banat Region with Vršac weather station) (Figure 8). As the altitude drops, severe and very severe class values are approximately equally distributed on a multiannual basis corresponding to the findings in a neighbouring country. As observed for the Romanian plain and the Danube valley, very low and low classes dominate, especially in April, August and September, which is in accordance with the obtained mean *K* values for the Vojvodina Region (Figure 8). On the other hand, Lukić et al. (2019) suggest that both the amount and the intensity of precipitation are increasing and varying in some areas of the Pannonian Basin. The trends generally indicate a progressive increase in the values of the erosion by precipitation at the annual level, which in future may lead to the transition to a higher erosive class and increase the vulnerability to this type of erosion in the Pannonian Basin and Vojvodina Region. Also, the relief properties and the interaction with the general atmospheric circulation in the study area greatly contribute to the spatial pattern of rainfall erodibility potential in terms of intensity, frequency and spatial distribution (Figures 3 and 8). These spatial features correspond with the *RUSLE* soil loss results, presented by Borrelli et al. (2017).

In agricultural areas, evaluation of the vulnerability associated with the high impact of rainfall erosivity is of utmost importance in the context of sustainable agricultural practices and specific local or regional climate conditions (Komac and Zorn 2005; Maracchi, Sirotenko and Bindi 2005). Accordingly, a good understanding of climate variability and main precipitation features is of great importance, especially when dealing with rainfall erosivity in agricultural areas such as Vojvodina Region.

Figure 6: Mean multiannual values of *K* Index during the warm part of the year for Bačka weather stations. ➤ p. 141–143
Figure 7: Mean multiannual values of *K* Index during the warm part of the year for Srem weather station and the Vojvodina Region. ➤ p. 144
Figure 8: Distribution of the mean *K* Index classes for the observed period and comparison with the *RUSLE* soil loss values (adapted after Borrelli et al. 2017). ➤ p. 145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2014
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low
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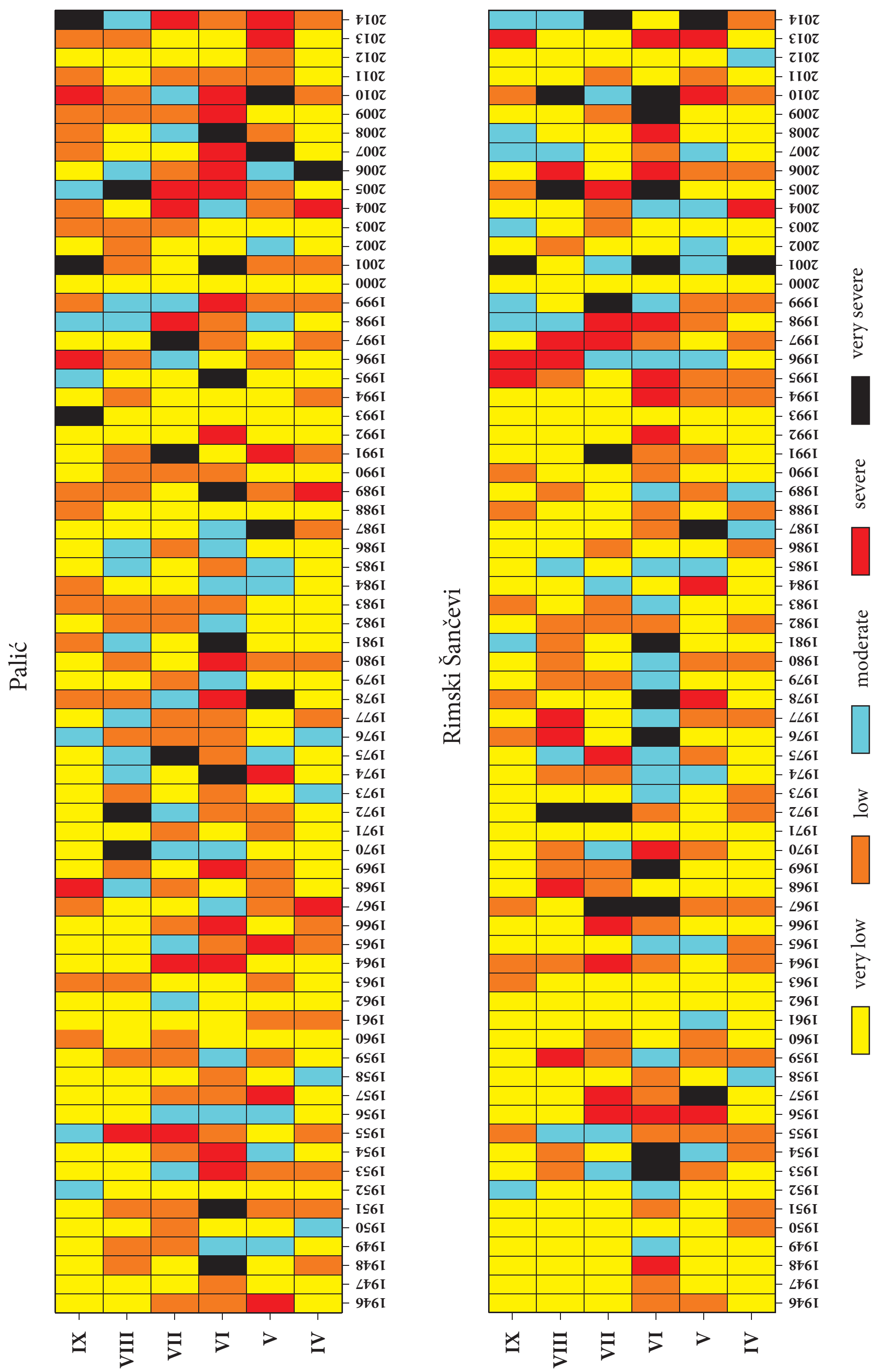
severe
very severe


Palić
Rimski Šančevi
IX
VIII
VII
VI
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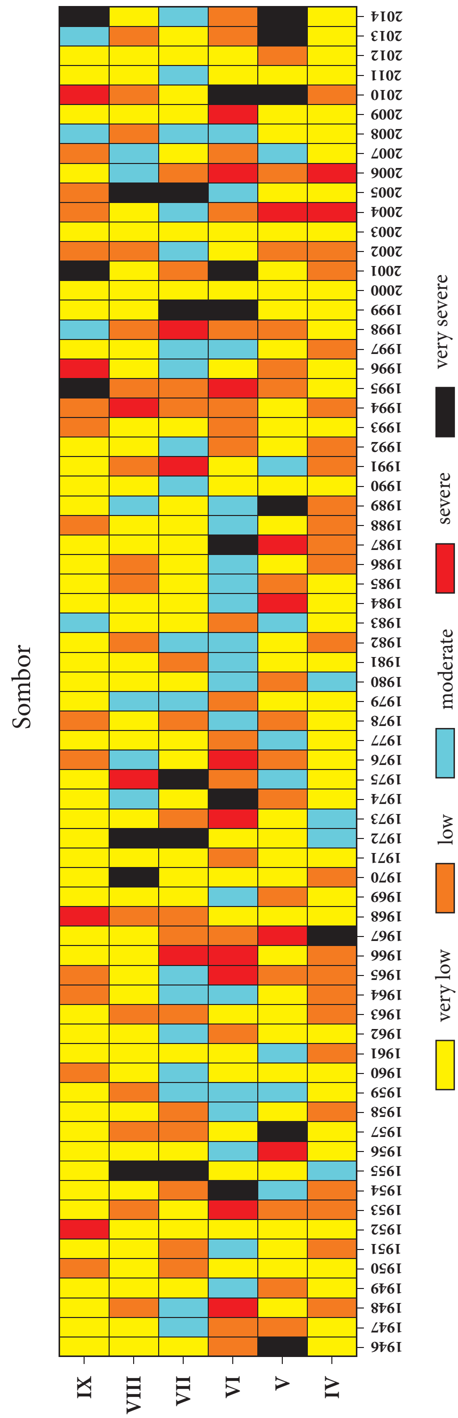
IV
very low
low
moderate
severe
very severe


Sombor
very low
low
moderate
severe
very severe
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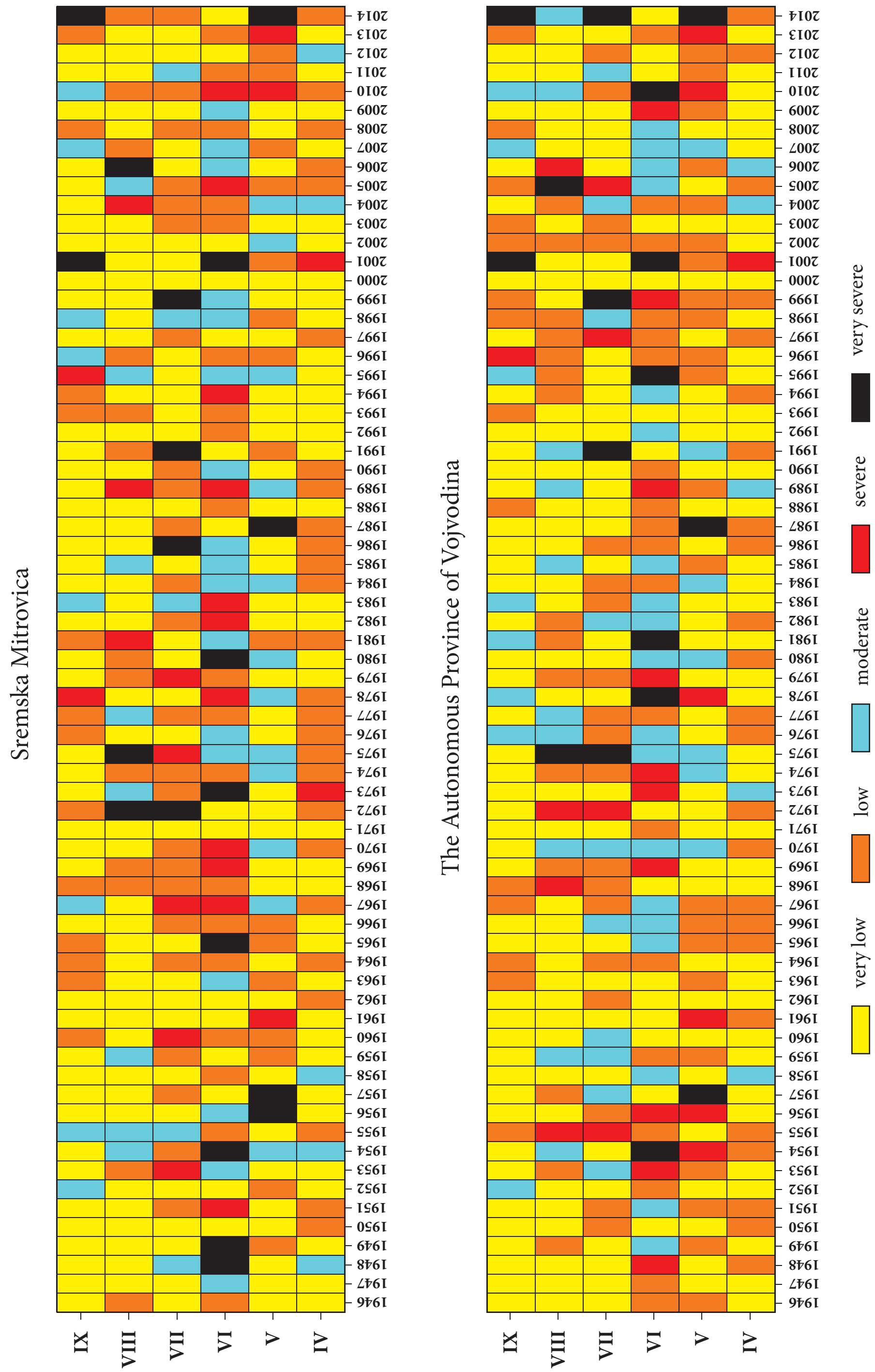
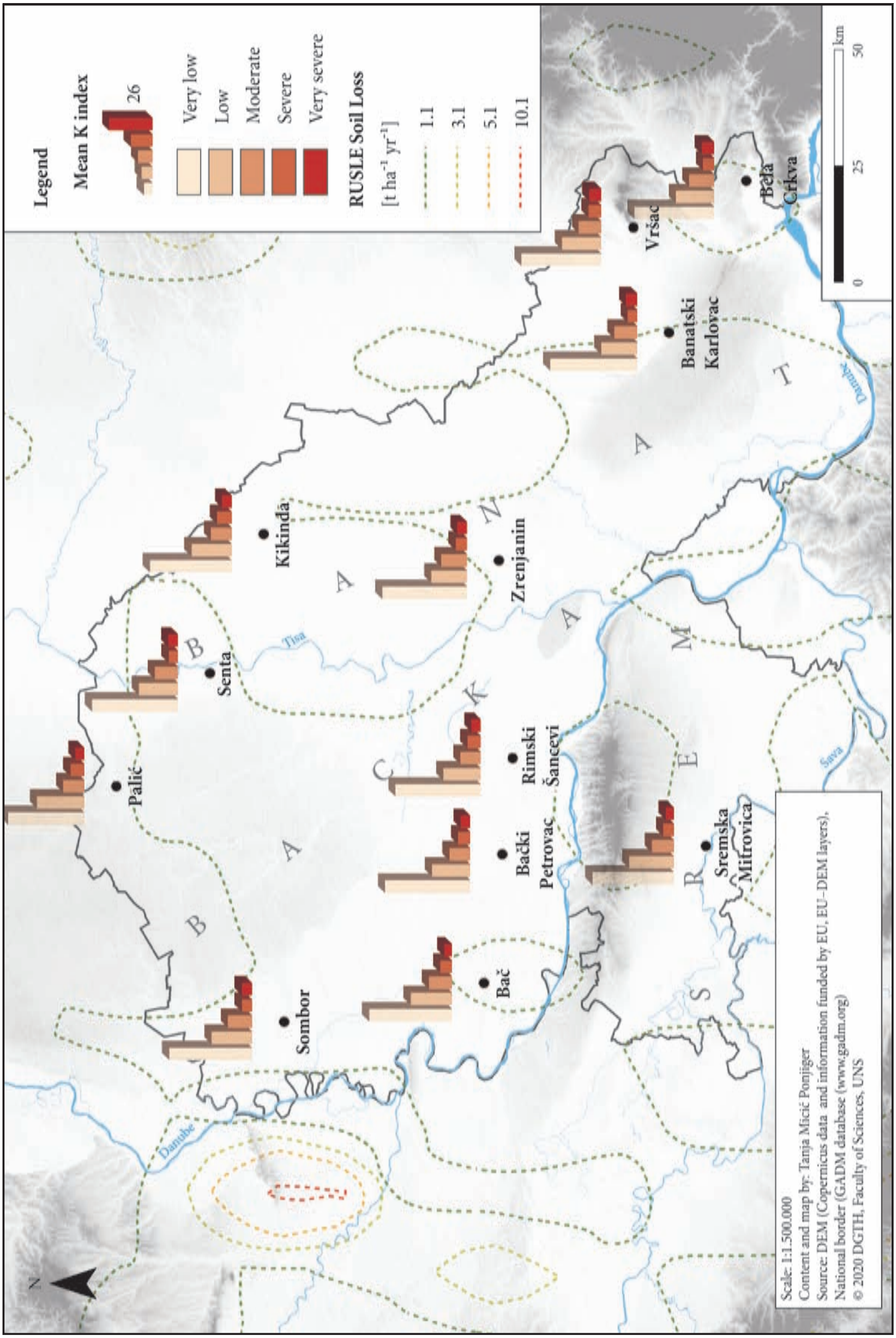

Sremska Mitrovica
The Autonomous Province of Vojvodina
IX
VIII
VII
VI
V
IV
very low
low
moderate
severe
very severe


Legend
Mean K index
26
Very low
Low
Moderate
Severe
Very severe
RUSLE Soil Loss
[t ha⁻¹ yr⁻¹]
1.1
3.1
5.1
10.1
0
25
50
km
N
Danube
Tisa
Sava
Sombor
Palić
Senta
Kikinda
Zrenjanin
Bač
Bački Petrovac
Rimski Šančevi
Sremska Mitrovica
Banatski Karlovac
Vršac
Bela Crkva
B A Č K A
B A N A T
S R E M
Scale: 1:1.500.000
Content and map by: Tanja Mičić Ponjiger
Source: DEM (Copernicus data and information funded by EU, EU-DEM layers),
National border (GADM database (www.gadm.org)
© 2020 DGTH, Faculty of Sciences, UNS

In order to protect areas that are potentially endangered by rainfall erosion, it is necessary to assess the intensity of these processes, and then evaluate the negative impact of social structures. As pointed out by Panagos et al. (2015a), rainfall erosivity in Europe is a key parameter for estimating soil erosion loss and risk in various regions. Authors outline that the European continental climatic zone is characterized by warm summers and cold winters, and thus highly susceptible to the variability of rainfall erosivity. The mean rainfall erosivity factor for the Pannonian zone (central Danubian basin) is 660.1 MJ mm ha^{-1} h^{-1} yr^{-1} and corresponds well with the findings of Mezősi and Bata (2016) and Lukić et al. (2019).

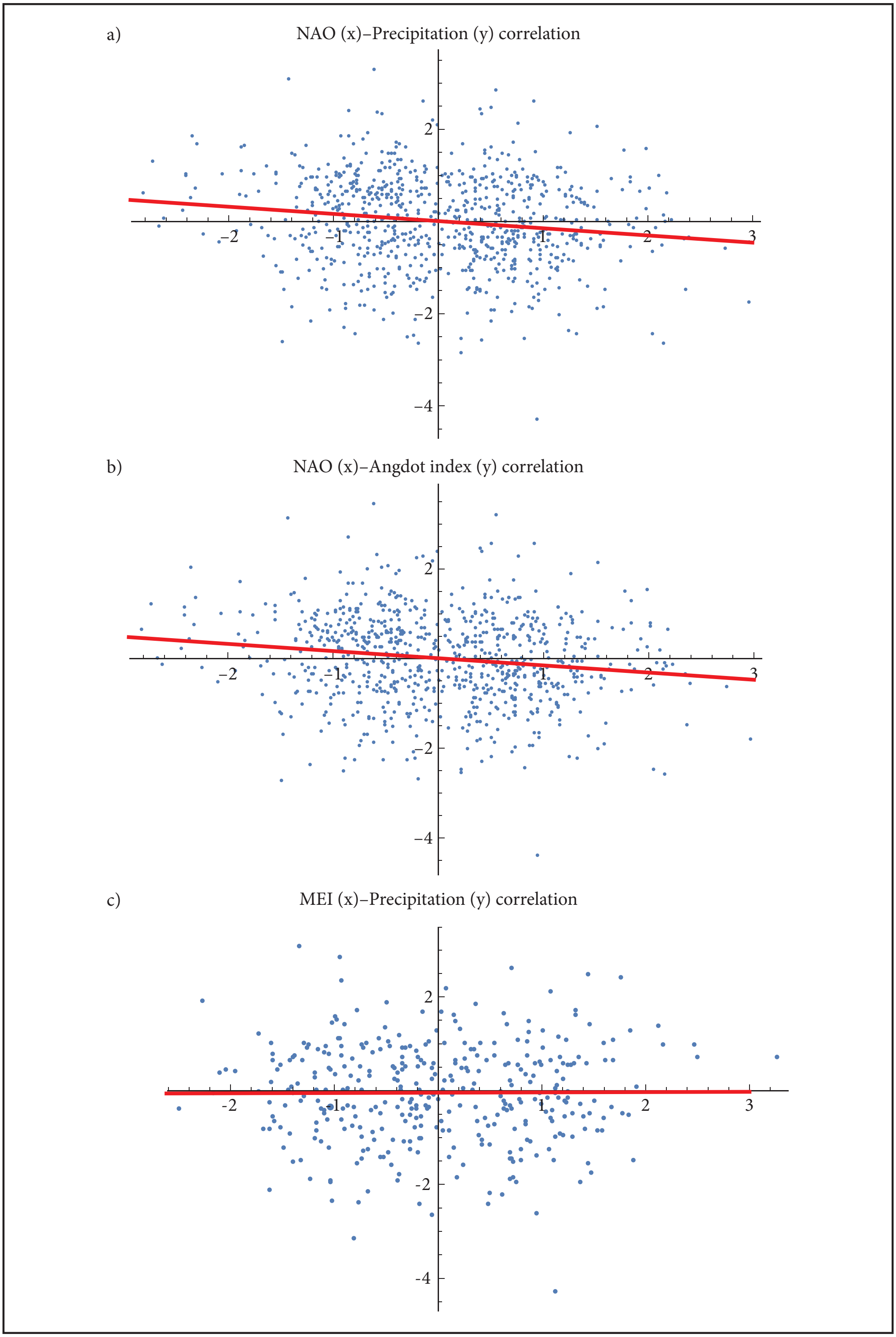
The results of *NAO* and *MEI* indices were correlated with the mean annual precipitation data for the study area and *K* index values. Correlation between the teleconnection patterns and precipitation parameters was estimated in order to investigate the possible relationships between rainfall erosivity and atmospheric variability by applying Pearson's correlation analysis at the 5% ($p < 0.05$) significance level. A correlation between the *NAO* index and precipitation (–0.19), as well as the *K* index (–0.20), is presented in Figure 9. The negative correlation coefficient indicates the wetting effect on the *K* index. Based on contemporary findings it can be pointed out that *NAO* considerably affects rainfall in this part of Europe (e.g., Tošić et al. 2014; Luković et al. 2015; Radaković et al. 2018), and since the *K* index is based on precipitation amounts, *NAO* has a certain influence on it as well. As pointed out by Bice et al. (2012), *NAO* generally has a strong influence on winter precipitation in the Pannonian Basin, with negative *NAO* phases corresponding to periods of high precipitation. Results of Malinović-Milićević et al. (2018) indicate that the amount and intensity of precipitation in Serbia had a statistically significant increase during autumn, and were most pronounced in the northern (Vojvodina) and western parts of the country. The authors showed that »dry« regimes dominate over »wet«, with an increasing trend of »warm« regimes and decreasing trend of »cold« regimes. The correlation between the examined extreme indices and the large-scale circulation patterns showed that East Atlantic (*EA*) and *NAO* patterns had a significant influence on the duration of winter warm periods, while their influence on the duration of cold periods cannot be confirmed with certainty. The East Atlantic/West Russia (*EAWR*) pattern affects statistically significant positive autumn trends of all intensity and frequency indices. In winter, it has an impact on the frequency of »dry« and »wet« conditions and the intensity of the precipitation. On the other hand, the correlation between *MEI* and precipitation (0.006) cannot be confirmed for the given significance level ($p < 0.05$). Hence, no significant correlations were detected between observed precipitation parameters, *NAO* and *MEI*, thus generally indicating the absence of strong linearity between the *K,* and these two large-scale processes of climate variability. As shown by Dehghani et al. (2020), large-scale circulation drivers have a considerable impact on precipitation in different regions, where various climate indices in different phases may decrease the seasonal precipitation (even up to 100%). On the other hand, seasonal precipitation may increase more than 100% in different seasons due to the impact of these indices.

5 Conclusion

Soil erosion by water has often been overlooked (Zorn 2015) as an important land degradation (Zorn and Komac 2013b) and environmental problem. In the Soil Thematic Strategy of the European Commission (Communication … 2006) it is listened among the eight main threats to soil in the EU (Panagos 2015b).

In this study the *K* index was used to determinate the characteristic types of monthly and annual variation of precipitation based on regional and local comparisons. Results of this study indicate that the Vojvodina Region has experienced the presence of various susceptibility classes of precipitation liable for triggering soil erosion from April until September. June and July are the months with higher frequency of very severe erodibility classes, with the distribution of 8.70% and 5.80%, respectively. Most of the distributed erodibility classes observed for the study area belong to moderate, varying from 7.25% (in April) up to 27.54% (in June). On the other hand, a progressive increase in the values of the rainfall erosivity at the annual level (induced by climate variability), in the future can lead to the transition to a higher erosive class and increase the vulnerability to rainfall erosion in the Pannonian continental climatic zone.

Figure 9: Correlation between *NAO* and precipitation (a), *NAO* and *K* Index (b), and *MEI* and precipitation (c). ➤ p. 147


a)
NAO (x)–Precipitation (y) correlation
–2
–1
1
2
3
2
–2
–4
b)
NAO (x)–Angdot index (y) correlation
–2
–1
1
2
3
2
–2
–4
c)
MEI (x)–Precipitation (y) correlation
-2
-1
1
2
3
2
-2
-4

As precipitation is seen as one of the main triggering factors for flash floods, landslides, and soil erosion, future extreme weather events are likely to have seriously damaging effects on crops and pastures, thus changing the land use and land cover.

In the further research it is necessary to look more into the relationship between *NAO* and its impact on changes in seasonal precipitation. For Serbia, these changes should be investigated in detail using a wet season concept between October and March, as previously discussed by Luković et al. (2015). This approach may be suitable since it could investigate the probability of an increase or decrease in precipitation amounts associated with the above-mentioned indices and seasonal rainfall erosivity rates as well.

ACKNOWLEDGEMENTS: The authors acknowledge the financial support of the Ministry of Education, Science and Technological Development of the Republic of Serbia (Grant No. 451-03-68/2020-14/ 200125). A part of the research was supported by the H2020 WIDESPREAD-05-2020 – Twinning: ExtremeClimTwin that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 952384, and the Slovenian Research Agency research programme Geography of Slovenia (grant No. P6-0101). We confirm that all the authors made an equal contribution to the study and its development. Authors are grateful to the anonymous reviewer's whose comments and suggestions greatly improved the manuscript.

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Acta geographica Slovenica, 61-2, 2021, 155–169

THE INFLUENCE OF CLIMATE CHANGE ON DISCHARGE FLUCTUATIONS IN SLOVENIAN RIVERS

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High waters of the Kamniška Bistrica River in 2007.

DOI: https://doi.org/10.3986/AGS.9942
UDC: 556.16:551.583(497.4)
COBISS: 1.01

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The influence of climate change on discharge fluctuations in Slovenian rivers

ABSTRACT: In recent decades, an increase in the number of extreme flood events as well as extreme drought events has been observed in Slovenia. This rise the need for a comprehensive analysis of trends in discharge data series. In the study, statistical trends in seasonal and annual mean, maximum, extreme and low discharge values were investigated using the Mann Kendall test. The results show a temporal and spatial variability of trends in discharge. In general, a decreasing trend in water quantities in the rivers was observed. However, results at some gauging stations indicate statistically significant increasing trends, especially for maximum and extreme discharges. Additional analyses show that the discharge trends depend on the location of the gauging station.

KEY WORDS: hydrology, geography, trend analysis, Mann Kendall test, discharges, Slovenia

Vpliv podnebnih sprememb na nihanja pretokov v slovenskih rekah

POVZETEK: V zadnjih desetletjih v Sloveniji opažamo povečanje števila tako ekstremnih poplavnih kot tudi ekstremnih sušnih dogodkov. To kaže na potrebo po kompleksni analizi trendov v serijah podatkov o pretokih. V raziskavi smo s pomočjo testa Mann Kendall analizirali statistične trende sezonskih in letnih povprečnih, največjih, ekstremnih in nizkih vrednosti pretokov. Rezultati kažejo časovno in prostorsko spremenljivost trendov pretokov. V splošnem smo zaznali trend zmanjševanja količin vode v rekah. Rezultati nekaterih vodomernih postaj pa kažejo na statistično značilno naraščajoče trende, zlasti za največje in ekstremne pretoke. Dodatne analize kažejo, da so trendi pretokov odvisni od lokacije vodomerne postaje.

KLJUČNE BESEDE: hidrologija, geografija, analiza trenda, Mann Kendallov test, pretoki, Slovenija

The article was submitted for publication on May 4th, 2021.
Uredništvo je prejelo prispevek 4. maja 2021.

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1 Introduction

A recent study by Blöschl et al. (2019) demonstrated that no uniform pattern in trends of flood discharge series can be found in Europe in the past five decades. They identified three regional patterns of both increasing and decreasing trends in flood discharges in Europe. Floods are becoming increasingly severe in northwestern Europe, while their intensity is decreasing in southern and eastern Europe. Increasing floods in northwestern Europe are the result of increasing autumn and winter precipitation, while the decreasing trend of flood events in southern Europe is the result of decreasing precipitation and increasing evaporation. However, the decreasing snow cover due to global warming is the reason for the decrease in flooding in Eastern Europe. The average increasing trend of floods in Europe is up to 11% and decreasing by up to 23% per decade (Blöschl et al. 2019). Similarly, Mediero et al. (2015) found a mixed pattern of changes in flood frequency and few significant changes in the flood timing at a pan-European scale by using the longest streamflow records. They identified a stronger field-significant decreasing trends in flood magnitude in the Atlantic region comparing the periods 1920–1999 and 1956–1995 as well as in the Continental region comparing the periods 1900–1999 and 1939–1998. An unclear trend pattern was found in terms of annual number of floods above a threshold, apart from a decreasing trend in the Alpine region for all the periods considered. No clear trend patterns were found with respect to the timing of floods, apart from field-significant increasing trends in the continental region and decreasing trends in the Alpine region in the period 1900–1999 (Mediero et al. 2015). In neighbouring Austria, annual maximum floods for the period 1976–2007 showed increasing trends in 17% of the catchments with a general tendency for increasing trends in the north, decreasing trends in the south, increasing trends in winter floods in the west and decreasing trends in the southeast (Hall et al. 2014). The majority of the stations showed no significant change. For the Alpine region of France, Switzerland, Germany, Italy, Austria and Slovenia, an increasing trend in spring floods associated with snowmelt is found during 1961–2005 (Hall et al. 2014).

In Slovenia, due to high climatic diversity, the magnitude and frequency of flood events is expected to increase at some gauging stations and decrease in others (Bezak, Brilly and Šraj 2016; Kovačič 2016; Šraj et al. 2016; Šraj, Menih and Bezak 2016; Hrvatin and Zorn 2017a; Šraj and Bezak 2020). Furthermore, an increase in torrential flooding is expected due to the increase in local convective precipitation (Blöschl et al. 2019). Indeed, Slovenia has faced an increasing number of flood events causing high damage and even fatalities (Zorn and Komac 2011; Komac and Zorn 2020). Analyses show that extreme flood events have occurred more frequently since 1990 than before (Kobold, Dolinar and Frantar 2012). To name a few, the Železniki flood in 2007 claimed six lives (Kobold 2008), in 2010 part of Ljubljana was flooded (Strojan et al. 2010), and in 2012 Drava River flooded due to increased runoff from neighbouring Austria (Klaneček 2013). Furthermore, in 2014, Slovenia experienced a total of 83 days with high hydrological conditions in at least one river catchment (Golob and Polajnar 2016), flooding karst poljes (Frantar and Ulaga 2015), part of the capital was flooded again (Fazarinc 2014), and the Bolska stream with two fatalities and the Mislinja River with one fatality showed their strength again.

On the other hand, temperature changes and uneven temporal and spatial distribution of precipitation (Hrvatin and Zorn 2017b; Ocena tveganja za sušo 2017; Cunja, Kobold and Šraj 2019) are increasingly causing water scarcity and droughts in Slovenia as well (Kajfež-Bogataj and Bergant 2005; Sušnik et al. 2013; Šebenik, Brilly and Šraj 2017; Cunja, Kobold and Šraj 2020; Jelen, Mikoš and Bezak 2020). After 1990, agricultural drought was declared 11 times in Slovenia, 9 of since 2000 (2000, 2001, 2003, 2006, 2007, 2009, 2012, 2013, 2017). In most of these years, the drought reached the level of a natural disaster, which means that the estimated direct damage exceeded 0.3‰ of the planned state budget revenue (Ocena tveganja za sušo 2017).

Given that an increased number of both extreme flood events (Kobold, Dolinar and Frantar 2012) and extreme drought events (Sušnik et al. 2013; Ocena tveganja za sušo 2017) have been observed in Slovenia in recent decades, the need for comprehensive analyses of trends in different types of discharge data series arose. Therefore, the main objectives of the study were to investigate trends in (i) seasonal and annual mean discharge values (Qs), (ii) seasonal and annual maximum mean daily discharge values Qvp, (iii) extreme seasonal and annual flood discharge values defined by the peak-over-threshold method with an average of one (POT 1) and three (POT3) peaks per year and (iv) seasonal and annual low discharge indices describing the 7- and 30-day duration of low flows (Qmin7 and Qmin30).

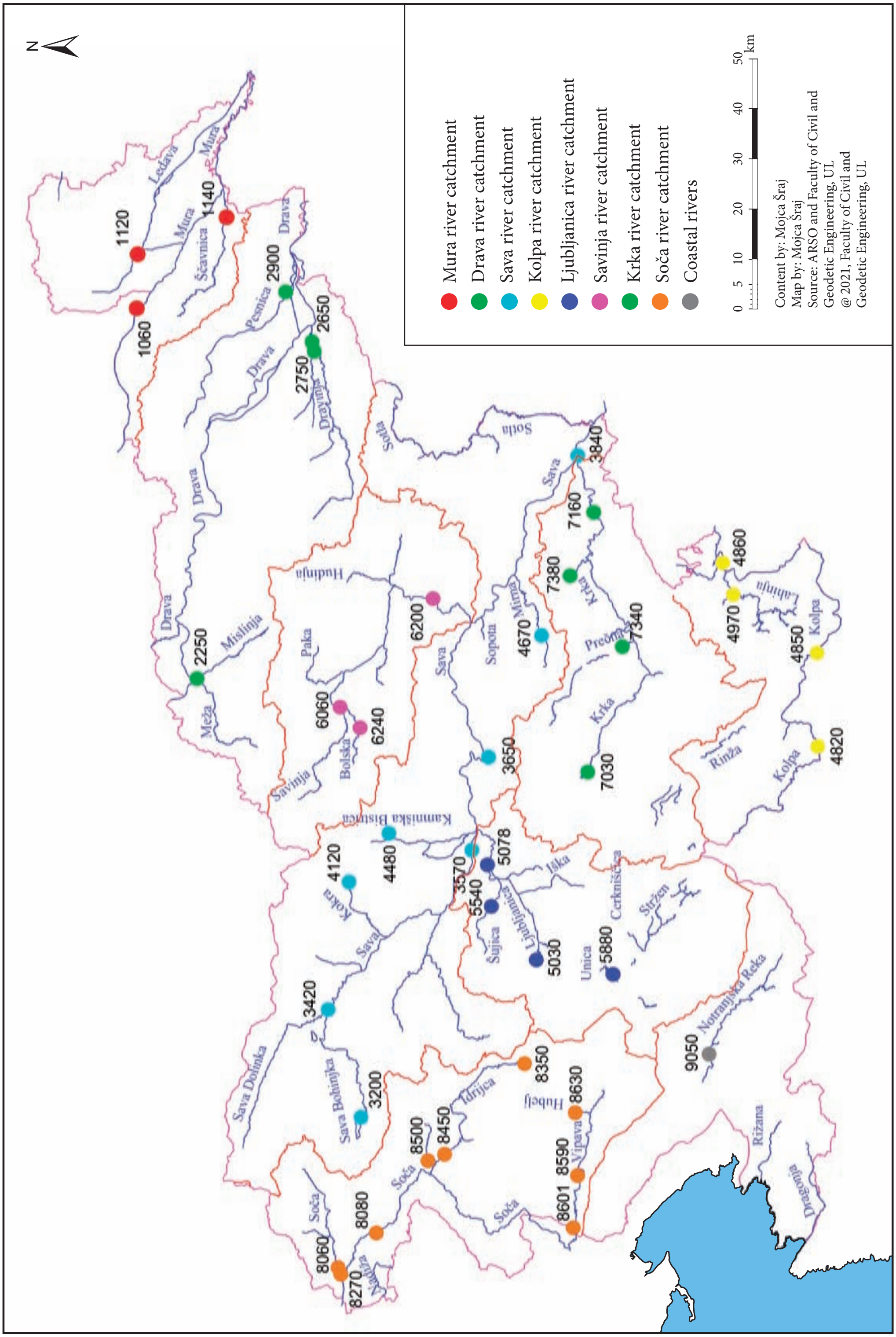
2 Data and methods

Analyses were performed based on daily discharge data series (Arhiv hidroloških podatkov 2017) at 40 gauging stations in Slovenia (Table 1 and Figure 1). The criteria for inclusion of individual gauging station into the study were as follows: (1) at least 52 years of data (1961–2013), (2) no gaps in the data series, (3) uniform

Table 1: List of gauging stations studied with associated catchment area (Arhiv hidroloških podatkov 2017).

Station code	Main catchment	Gauging station	River	Catchment area [km^2]
1060	Mura River	Gornja Radgona	Mura	10,197.2
1140		Pristava	Ščavnica	272.5
1220		Polana	Ledava	208.2
2250	Drava River	Otiški Vrh	Meža	550.9
2650		Videm	Dravinja	763.8
2750		Tržec	Polskava	187.8
2900		Zamušani	Pesnica	477.8
3200	Sava River	Sveti Janez	Sava Bohinjka	94.0
3420		Radovljica	Sava	908.0
3570		Šenjakob	Sava	2,284.8
3650		Litija	Sava	4,821.4
3840		Čatež	Sava	10,185.8
4120		Kokra	Kokra	112.3
4480		Nevlje	Nevljica	82.0
4670		Martinja vas	Mirna	164.6
4820	Kolpa River	Petrina	Kolpa	460.0
4850		Radenci	Kolpa	1,191.0
4860		Metlika	Kolpa	2,002.0
4970		Gradac	Lahinja	221.3
5030		Vrhnika	Ljubljanica	1,135.1
5080		Moste	Ljubljanica	1,762.5
5540		Razori	Šujica	46.9
5880		Hasberg	Unica	Karst
6060	Savinja River	Nazarje	Savinja	457.3
6200		Laško	Savinja	1,663.6
6240		Kraše	Dreta	100.8
7030	Krka River	Podbukovje	Krka	321.4
7160		Podbočje	Krka	2,238.1
7340		Prečna	Prečna	294.2
7380		Škocjan	Radulja	108.0
8060	Soča River	Log Čezsoški	Soča	324.7
8080		Kobarid	Soča	437.0
8270		Žaga	Učja	50.2
8350		Podroteja	Idrijca	112.8
8450		Hotešk	Idrijca	442.8
8500		Bača pri Modreju	Bača	142.3
8590		Dornberk	Vipava	468.5
8600		Miren	Vipava	590.0
8630		Ajdovščina	Hubelj	93.2
9050	Coastal Rivers	Cerkvenikov mlin	Reka	377.9

Figure 1: Location of the considered gauging stations coloured according to the associated river catchment. ➤


Mura river catchment
Drava river catchment
Sava river catchment
Kolpa river catchment
Ljubljanica river catchment
Savinja river catchment
Krka river catchment
Soča river catchment
Coastal rivers
0 5 10 20 30 40 50 km
Content by: Mojca Šraj
Map by: Mojca Šraj
Source: ARSO and Faculty of Civil and Geodetic Engineering, UL
@ 2021, Faculty of Civil and Geodetic Engineering, UL

spatial distribution of stations covering different flow regimes, and (4) data from the catchments with the least possible anthropogenic influence or where the influence of human activities, such as deforestation, urbanization, construction of reservoirs, water abstraction is minimal (Kundzewicz et al. 2005). The choice of the end of the time period under consideration is related to the missing data. Slovenian Environment Agency carried out the renovation of Slovenian gauging stations within the BOBER project (Roškar 2015) in 2014–2016 and there was a data outage (semi-annual and more) at most gauging stations during these years.

Statistical trends were investigated using seasonal and annual mean discharge values (Qs), seasonal and annual maximum mean daily discharge values Qvp, extreme seasonal and annual flood discharge values defined by peak-over-threshold method (POT) with an average of one (POT 1) and three (POT3) peaks per year, and seasonal and annual low discharge indices describing the 7- and 30-days duration of low discharges (Qmin7 and Qmin30).

POT samples were defined using Hydrospect software (Radziejewski 2011). More details about the POT method can be found in (Bezak, Brilly and Šraj 2014). In order to detect trends in aforementioned data samples non-parametric Mann Kendall (MK) test was applied (Kendall 1975) (Equations 1-3), which is one of the most commonly used tests for detecting trends in hydro-meteorological data. Its greatest advantage is that it is robust against missing values and ties in the data and does not require normality of the data (e.g., Douglas, Vogel and Kroll 2000; Strupczewski, Singh and Feluch 2001; Šraj et al. 2016). The null hypothesis of the MK test is that there is no trend in the series and the alternative hypothesis is that there is either positive or negative trend in the tested series (Bezak, Brilly and Šraj 2016). The MK test statistic τ is defined as follows (Douglas, Vogel and Kroll 2000):

$$\tau = S/D \tag{1}$$

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sign(x_i - x_j) \tag{2}$$

$$D = n(n-1)/2 \tag{3}$$

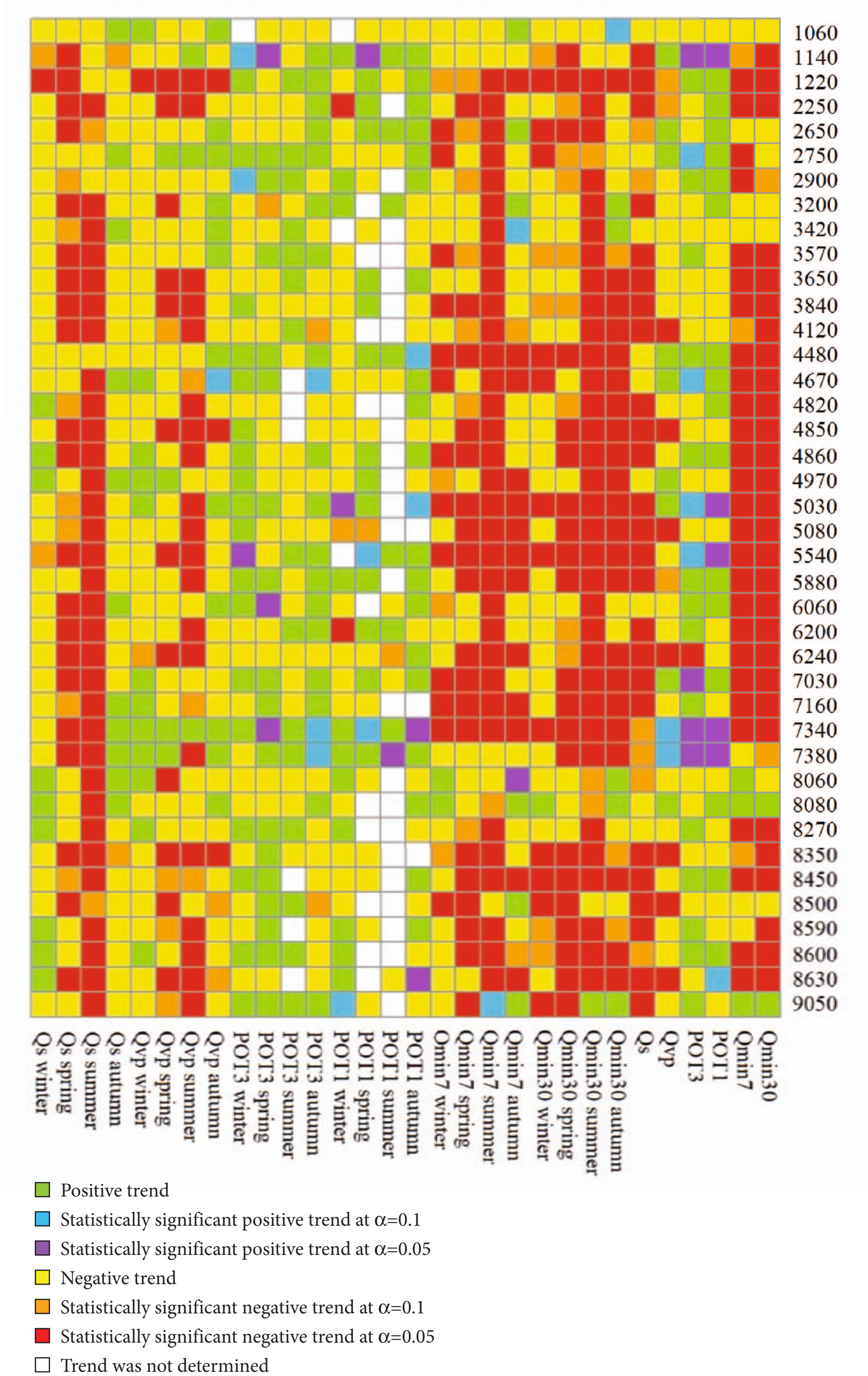
where x is the discharge value at time i and j, and n is the sample length. Kendall package (McLeod 2011) implemented in R software (R Core Team 2013) was used for the trend analyses. The significance levels of 0.05 and 0.1 were applied to identify the statistical significance of the trends in the data series. Additionally, the presence of serial correlation in the data series was investigated in order to avoid incorrectly rejecting the null hypothesis of no trend in the time series (Yue, Pilon and Cavadias 2002; Šraj et al. 2016).

3 Results and discussion

3.1 Trend analysis

The results of the trend analyses for all considered data series are presented in Figure 2. The analysis of the mean discharge values (Qs) shows that the mean annual discharges decreased during the period 1961–2013 at all the considered stations, statistically significant at most of them (25 at the significant level of 0.05 and 6 at the significant level of 0.1). This finding is consistent with the results of Frantar, Kobold and Ulaga (2008), who analysed the trends of mean discharges at the 22 gauging stations in Slovenia using the data for the whole observations period up to and including the year 2005. Obviously, the decreasing trend of mean discharges continues 10 years later. Further analysis by season shows that the decrease in mean discharge in the summer and spring seasons is statistically significant for the majority of the gauging stations considered. In fact, the rivers of the Adriatic catchment have a statistically significant decrease in mean discharge in the summer season and the rivers of the Black Sea catchment in the summer and spring seasons. The mean discharges in winter and autumn mostly do not show statistically significant trends. The decrease in mean discharges is mostly the consequence of the decrease in precipitation and the increase in temperature, which in turn increases evapotranspiration in recent decades (Frantar, Kobold and Ulaga 2008;

Figure 2: Results of trend analyses for the period 1961–2013. ➤


1060
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5880
6060
6200
6240
7030
7160
7340
7380
8060
8080
8270
8350
8450
8500
8590
8600
8630
9050
Qs winter
Qs spring
Qs summer
Qs autumn
Qvp winter
Qvp spring
Qvp summer
Qvp autumn
POT3 winter
POT3 spring
POT3 summer
POT3 autumn
POT1 winter
POT1 spring
POT1 summer
POT1 autumn
Qmin7 winter
Qmin7 spring
Qmin7 summer
Qmin7 autumn
Qmin30 winter
Qmin30 spring
Qmin30 summer
Qmin30 autumn
Qs
Qvp
POT3
POT1
Qmin7
Qmin30
Positive trend
Statistically significant positive trend at α=0.1
Statistically significant positive trend at α=0.05
Negative trend
Statistically significant negative trend at α=0.1
Statistically significant negative trend at α=0.05
Trend was not determined

Ocena tveganja za sušo 2017; Maček et al. 2018; Šraj, Mikoš and Bezak 2019). The results are consistent with those published by Stahl et al. (2010), who came to a regionally coherent picture of annual discharge trends with negative trends identified mainly in the headwater catchments of the larger rivers (e.g. Danube River) of Austria and Germany, Czechia and Slovakia, while positive trends were identified for the main streams of the larger rivers.

The annual maximum mean daily discharges (Qvp) do not show such a uniform trend as the mean annual discharges (Figure 2). Two gauging stations, Prečna (7340) and Škocjan (7380) in the Krka River catchment show a statistically significant increasing trend (at the significant level of 0.1) in the annual maximum discharge series. Previous studies have shown also that some gauging stations in Slovenia have statistically significant trends in the annual maximum flood series (Kobold, Dolinar and Frantar 2012; Bezak, Brilly and Šraj 2016; Šraj, Menih and Bezak 2016). For example, Škocjan gauging station (7380) on the Radulja River with a statistically increasing trend in annual maximum discharges is one of the stations, that have been investigated in detail in some other studies investigating the impact of variable climate on floods in Slovenia (Šraj, Menih and Bezak 2016; Šraj and Bezak 2020). A detailed study of the relationship between annual maximum discharges and annual precipitation have demonstrated a good correlation between high annual precipitation and high discharges for Škocjan at the Radulja River (Šraj, Menih and Bezak 2016). On the other hand, 10 gauging stations show statistically significant decreasing trends in annual maximum discharge series (7 at the significant level of 0.05 and 3 at the significant level of 0.1). Stations with a decreasing trend are located in various river catchments; however, most of them in the Soča River catchment. The rivers of the Adriatic Sea catchment mostly demonstrate a statistically significant decreasing trend in the maximum discharges in the spring and summer seasons, while we cannot give unambiguous conclusions for the rivers of the Black Sea catchment. We can only state that we have quite a few stations in the Ljubljanica and Kolpa river catchments with a statistically significant decrease in the annual maximum discharges in summer. We can make a general statement that the results of the trends of the maximum annual discharges (Qvp) indicate regional diversity with a predominantly decreasing trend, which is in agreement with the results of Frantar, Kobold and Ulaga (2008).

The results of the trend analysis of the extreme annual discharge values defined by the peak-over-threshold method (POT) with an average of one (POT 1) and three (POT3) peaks per year also show no uniform trend. However, compared to the trends in the annual maximum discharges, even more gauging stations demonstrate the statistically increasing trend in the extreme discharge series. 8 gauging stations show statistically significant increasing trends in POT3 data series (4 at the significant level of 0.05 and 4 at the significant level of 0.1) and 6 gauging statins in POT1 data series (5 at the significant level of 0.05 and 1 at the significant level of 0.1). Most of them are located in the Ljubljanica and the Krka River catchments (Figure 2). Among 40 stations considered, only station Kraše (6240) at the Dreta River shows a statistically significant decreasing trend for POT3 data series. Seasonal analysis show that the increasing trend of extreme discharges is statistically significant, especially in the autumn followed by spring. Frantar, Kobold and Ulaga (2008), who analysed trends of discharges at the 22 gauging stations in Slovenia using the data for the whole observation period until 2005, reported an increasing trend for the POT1 data series only for the Ščavnica River. However, they reported that the number of gauging stations with an increasing trend increased in case of the POT3 data series. Thus, it seems that the number of extreme flood events has increased in recent years.

Annual low discharges with a duration of 7 days (Qmin7) decrease statistically significantly for the rivers of the Black Sea catchment (Figure 2). The Kolpa, Ljubljanica and Savinja rivers show statistically significant decreasing trend for all analysed gauging stations, while the Mura, Drava, Sava, and Krka rivers show a statistically significant decreasing trend for most of the considered stations. The rivers of the Adriatic Sea catchment show no uniform trends as 5 gauging stations in the Soča River catchment demonstrate statistically significant decreasing trend and 4 stations do not show any statistically significant trend. All together 30 out of 40 gauging stations show a statistically significant decreasing trend (27 at the significant level of 0.05 and 3 at the significant level of 0.1). Qmin7 discharges decrease at most of the stations in the summer, while in the Kolpa, Ljubljanica and Krka catchments also in the autumn season and in the Drava, Sava, Kolpa, Ljubljanica, Krka and Soča catchments also in the spring season. Frantar, Kobold and Ulaga (2008) reported an increasing trend of low discharges in the karstic and eastern areas of Slovenia using the data for the whole observation period up to 2005. However, they argued that the number of gauging stations with an increasing trend is getting smaller, while the number of those with a decreasing trend increase. The results of this study demonstrate that for the period 1961–2013 none of the considered stations has a statistically significant increasing trend in data series of annual low discharges with a duration of 7 days (Qmin7) anymore. In comparison with other European countries, the study by Stahl et al. (2010) showed that low discharges have decreased in most regions, where the lowest mean monthly discharge occurs in summer, but vary for catchments, which have discharge minima in the winter season and secondary low discharge in summer. In most of western and central Europe, the lowest discharge occurs in late summer, between July and September. In the Alps and northern Europe, the annual minima occur in January and February (Stahl et al. 2010).

Very similar results are observed in the trend analysis of annual low discharges with a duration of 30 days (Qmin30). Overall, together 31 out of 40 gauging stations demonstrate statistically significant decreasing trend (28 at the significant level of 0.05 and 2 at the significant level of 0.1) (Figure 2). Additionally, seasonal trend analysis indicates that summer low discharges (Qmin30) show a statistically significant decreasing trend for 36 stations considered.

3.2 Analysis of station location influence

Since precipitation in Slovenia typically decreases in the direction from west to east, we performed additional analyses of the influence of the water gauging station location on the results of the calculated discharge trends. The analysis was performed using annual and seasonal values for all selected data series, namely Qs, Qvp, POT3, POT1, Qmin7 and Qmin30.

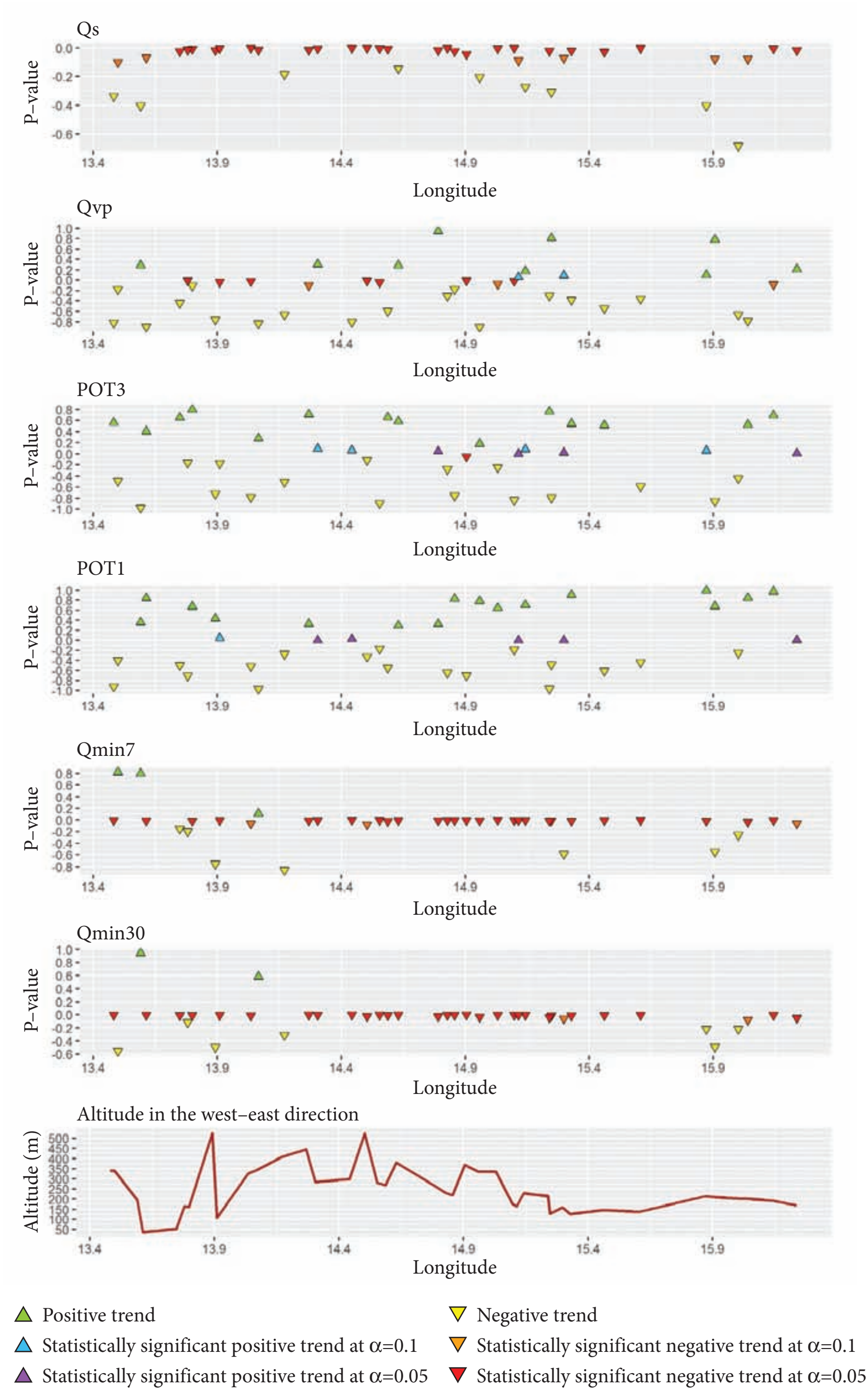
The analysis shows that the mean annual discharges (Qs) are decreasing across the country regardless of the location, most of them statistically significantly (Figure 3). As we noted earlier, the annual maximum mean daily discharges (Qvp) do not show as consistent trends as the mean annual discharges. Statistically significant decreasing trends of Qvp mostly occur in the western and central part of Slovenia, while statistically significant increasing trends mostly occur in the eastern and central part of the country (Figure 3). Furthermore, the extreme annual flood discharge values (POT1 and POT3) do not show statistically significant decreasing trends, with the exception of the POT3 data series at Kraše gauging station at Dreta River. Statistically significant increasing trends of the POT3 data series were found mainly in the east of the country, while in case of POT1 data series statistically significant increasing trends occur regardless of the location. Annual low discharges with a duration of 7 days (Qmin7) and 30 days (Qmin30) have a statistically significant decreasing trend at most of the considered stations regardless of the location (Figure 3).

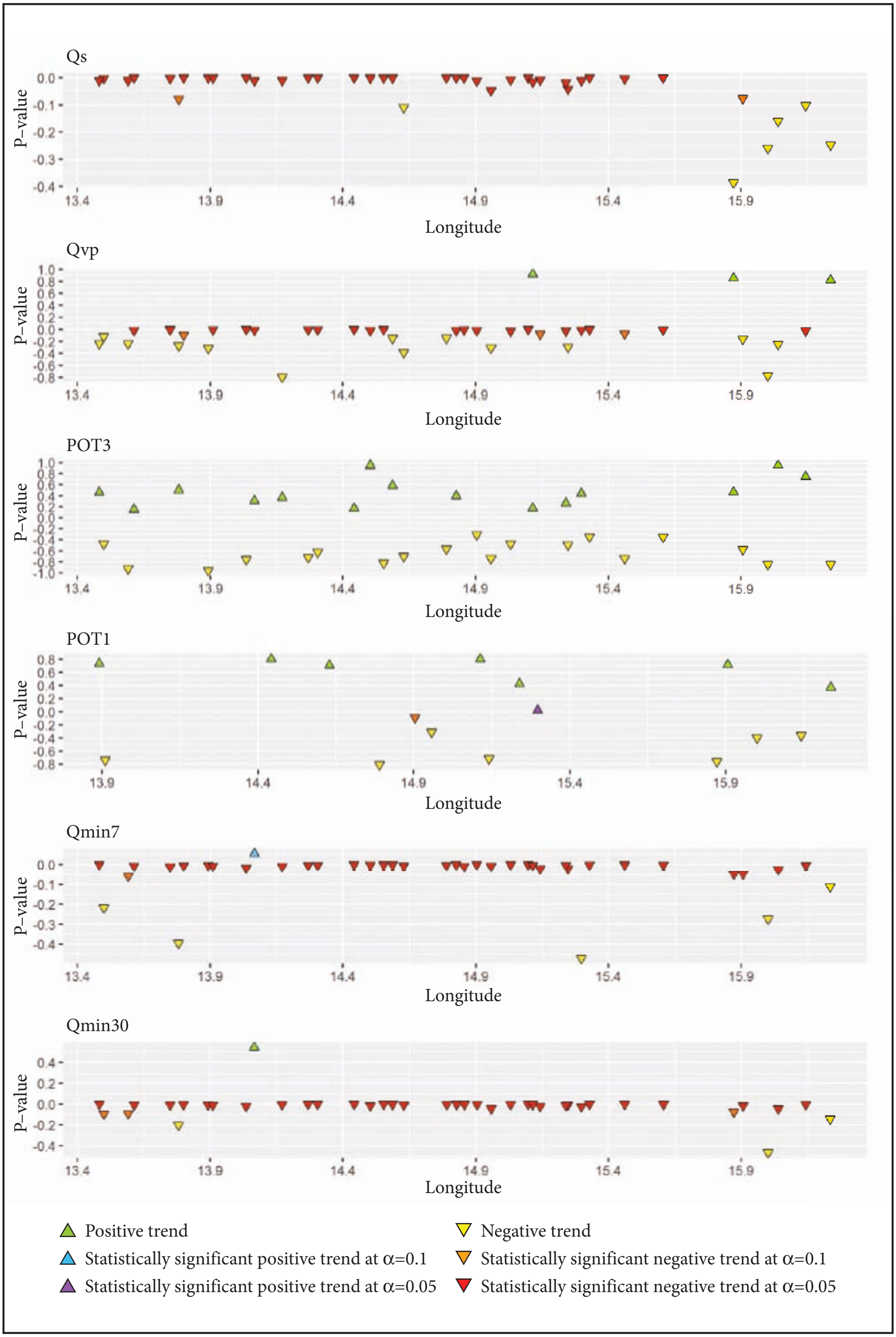
Analysis by season shows that mean summer discharges (Qs) have a statistically significant decreasing trend throughout the country with the exception of the eastern part, where decreasing trends are mostly not statistically significant (Figure 4). In addition, the largest summer discharges (Qvp) in Slovenia are mostly statistically significantly decreasing, with the exception of some stations in the eastern part of the country, where the trends are increasing, but not statistically significant. The same is true for the summer low discharges (Qmin7 and Qmin30), which mostly show statistically significant decreasing trends across the country regardless of the location (Figure 4).

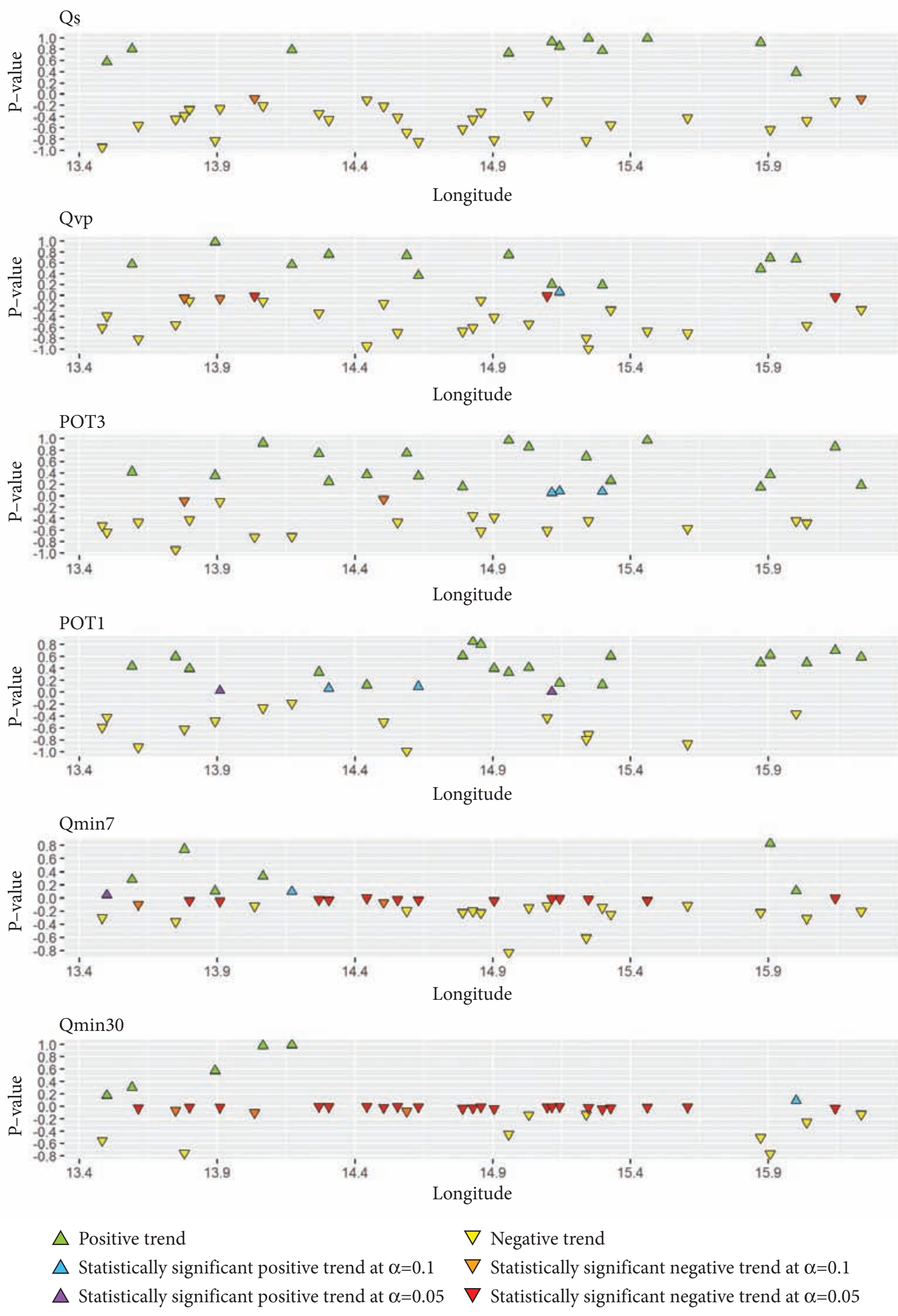
Mean autumn discharges (Qs) are mostly decreasing; however, the trend is statistically significant for two stations. Location does not appear to affect these results (Figure 5). The same can be concluded for the largest autumn discharges (Qvp). Stations with statistically significant decreasing trends are found in the eastern, western and central parts of the country. On the other hand, the extreme autumn flood discharges are mostly increasing, especially the POT1 data series. Stations with the statistically significant increasing trend in the POT1 and POT3 values are mainly located in the central part of Slovenia. Autumn low discharges (Qmin7 and Qmin30) mostly show decreasing trends (Figure 5). However, they are not as pronounced as for the summer low discharges, especially in the eastern and western part of Slovenia.

Statistically significant decreasing trends in mean winter discharges (Qs) are characteristic mainly for the eastern part of the country. The same is true for the largest winter discharges (Qvp). The extreme winter discharges show decreasing and increasing trends. Stations with statistically significant increasing trends

Figure 3: Trends in annual values of discharge data series for the period 1961–2013, plotted in west-east direction. ➤ p. 164
Figure 4: Trends in summer values of discharge data series for the period 1961–2013, plotted in west-east direction. ➤ p. 165
Figure 5: Trends in autumn values of discharge data series for the period 1961–2013, plotted in west-east direction. ➤ p. 166


Qs
P–value
Longitude
Qvp
P–value
Longitude
POT3
P–value
Longitude
POT1
P–value
Longitude
Qmin7
P–value
Longitude
Qmin30
P–value
Longitude
Altitude in the west–east direction
Altitude (m)
Longitude
13.4
13.9
14.4
14.9
15.4
15.9
Positive trend
Negative trend
Statistically significant positive trend at α=0.1
Statistically significant negative trend at α=0.1
Statistically significant positive trend at α=0.05
Statistically significant negative trend at α=0.05


Qs
P–value
Longitude
Qvp
P–value
Longitude
POT3
P–value
Longitude
POT1
P–value
Longitude
Qmin7
P–value
Longitude
Qmin30
P–value
Longitude
Positive trend
Negative trend
Statistically significant positive trend at α=0.1
Statistically significant negative trend at α=0.1
Statistically significant positive trend at α=0.05
Statistically significant negative trend at α=0.05



Qs
P–value
Longitude
Qvp
POT3
POT1
Qmin7
Qmin30
13.4
13.9
14.4
14.9
15.4
15.9
Positive trend
Negative trend
Statistically significant positive trend at α=0.1
Statistically significant negative trend at α=0.1
Statistically significant positive trend at α=0.05
Statistically significant negative trend at α=0.05

in POT3 values are located in the eastern and central parts of the country, while stations with statistically significant increasing trends in POT1 values are located in the western part of the country. Furthermore, three stations showing statistically significant decreasing trends in POT1 data series are located in the central part of the country. Winter low discharges (Qmin7 and Qmin30) show mostly decreasing trends, which are less pronounced in the western part of the country.

The results for the spring discharge data series are very similar to the summer results, but less pronounced. Mean spring discharges (Qs) are decreasing throughout the country. Most of them are statistically significant, except in the western part where the trend is not statistically significant. Furthermore, the largest spring discharges (Qvp) have mostly statistically significant decreasing trend, except for some stations in the eastern part of the country, where the trends are increasing, but not statistically significant. Extreme spring discharge values (POT1 and POT3) do not show consistent trends as they increase at some stations and decrease at others. Statistically significant decreasing trends in extreme discharges were found at some stations in the western and central parts of the country, whereas statistically significant increasing trends were found in the eastern and central parts of the country. Location does not appear to have the influence on trends of the spring low discharges.

4 Conclusion

The results of the study show that climate variability during the considered period (1961–2013) influences the temporal and spatial variability of discharges and associated floods and droughts in Slovenia. In general, a decrease in water quantities in the rivers was observed. Similar conclusions were drawn also by Frantar, Kobold and Ulaga (2008) using the data for the whole observation period until 2005. Thus, it seems that similar trends continue also a decade later.

Mean annual discharges are decreasing at all stations considered, statistically significant at most of them. Furthermore, the rivers of the Adriatic catchment demonstrate a statistically significant decrease in mean discharges in the summer season and the rivers of the Black Sea catchment in the summer and spring seasons. On the other hand, the maximum mean daily discharges do not show such uniform trends as the mean discharges as some gauging stations exhibit statistically significant trends in annual maximum discharge series. However, despite the fact that the results of the trends of the maximum annual discharges indicate regional differences, a predominantly decreasing trend was observed. The rivers of the Adriatic Sea catchment mostly demonstrate a statistically significant decreasing trend in the maximum discharges in the spring and summer seasons, while the rivers of the Black Sea catchment do not show uniform trends. The extreme annual discharge values also do not show a uniform trend; however, even more gauging stations show a statistically increasing trend compared to the trends in maximum discharges. Most of them are located in the Ljubljanica and the Krka River catchments. Furthermore, the results of the trend analysis of low discharges demonstrate statistically significant decrease for the rivers of the Black Sea catchment, while for the rivers of the Adriatic Sea catchment some stations do not show statistically significant changes. Low discharges decrease in summer at most stations, while in some catchments they also decrease in autumn and spring.

The results show that the discharge trends depend to some extent on the location of the gauging station. This was to be expected due to the great climatic and landscape diversity in Slovenia. The findings of the study related to the trends of different types of discharge data series should be taken into account in practice, e.g. for effective water management, flood protection, granting permits for water abstraction, designing of irrigation systems.

ACKNOWLEDGMENTS: The work was partially supported by the Slovenian Research Agency (ARRS) through the research program »Water Science and Technology, and Geotechnical Engineering: Tools and Methods for Process Analyses and Simulations, and Development of Technologies« (P2-0180).

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Acta geographica Slovenica, 61-2, 2021, 171–186

THE ROLE OF ECOTOURISM IN COMMUNITY DEVELOPMENT: THE CASE OF THE ZASAVICA SPECIAL NATURE RESERVE, SERBIA

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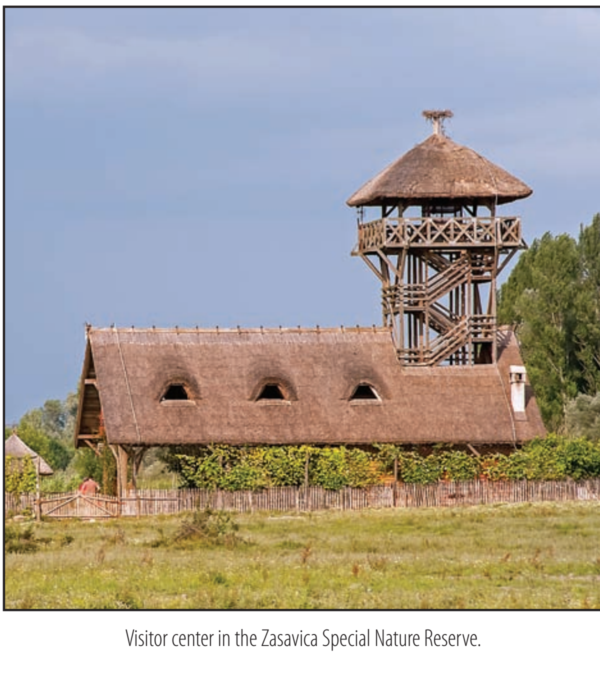

Visitor center in the Zasavica Special Nature Reserve.

DOI: https://doi.org/10.3986/AGS.9411
UDC: 91:338.48-6:502/504(497.11)
COBISS: 1.01

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The role of ecotourism in community development: The case of the Zasavica Special Nature Reserve, Serbia

ABSTRACT: This study explores local community attitudes toward ecotourism as a form of sustainable tourism in the Zasavica Special Nature Reserve in Serbia using the Sustainable Tourism Attitude Scale (SUS-TAS). Residents of the Zasavica Special Nature Reserve acknowledge the sociocultural and economic benefits of ecotourism development while recognizing the negative impacts of development on the natural environment. Low awareness of non-charismatic species among residents contrasts with strong awareness of them among large communities of scientists and naturalists in Serbia. This study shows the importance of local community support for ecotourism and conservation development. Moreover, the study revealed that the SUS-TAS scale can be successfully applied in ecotourism research.

KEY WORDS: ecotourism, sustainable development, local community, local residents, attitude, protected areas, Sustainable Tourism Attitude Scale

Vloga ekoturizma pri razvoju skupnosti: Primer posebnega naravnega rezervata Zasavica, Srbija

POVZETEK: V članku raziskujemo odnos lokalne skupnosti do ekoturizma kot oblike trajnostnega turizma v posebnem naravnem rezervatu Zasavica v Srbiji z lestvico odnosa trajnostnega turizma. Prebivalci posebnega naravnega rezervata Zasavica priznavajo družbeno-kulturne in gospodarske koristi razvoja ekoturizma, hkrati pa prepoznavajo negativne vplive razvoja na naravno okolje. Med prebivalci zaznavamo nizko ozaveščenost o pomenu nekarizmatičnih rastlinskih vrst, kar je v nasprotju s stališči velike skupnosti znanstvenikov in naravoslovcev v Srbiji. Članek kaže na pomen podpore lokalne skupnosti za razvoj ekoturizma in ohranjanja narave. Poleg tega je študija pokazala, da je mogoče lestvico SUS-TAS uspešno uporabiti pri raziskavah ekoturizma.

KLJUČNE BESEDE: ekoturizem, trajnostni razvoj, lokalna skupnost, lokalni prebivalci, odnos, zaščitena območja, Lestvica odnosa do trajnostnega turizma

The article was submitted for publication on March 17th, 2021.
Uredništvo je prejelo prispevek 17. marca 2021.

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1 Introduction

Sustainable development and sustainable tourism are complementary (Stojanović et al. 2014; Espiner, Orchiston and Higham 2017). Sustainable development is a development concept that emphasizes the balance of economic, environmental, and social approaches. The main assumption is that preserving the environment will lead to an increase in tourist visits. Accordingly, it can be argued that a protected nature resort can prove to be a popular tourist destination and eventually develop toward ecotourism (Diamantis 1999; Hermon 2016; Putra et al. 2018). Ecotourism is growing rapidly worldwide and is predicted to be one of the main growth areas in the coming years (Arlym and Hermon 2019). Using the Zasavica Special Nature Reserve (SNR) in Serbia as an example, this article identifies local residents' attitudes toward sustainable tourism development. We applied the Sustainable Tourism Attitude Scale (SUS-TAS) developed by Choi and Sirakaya (2005) to assess local perceptions of conservation. It is important to emphasize that ecotourism differs from other forms of tourism by its objectives. It aims to form close links between natural and cultural environments, which makes it the most valuable form of sustainable tourism (Stefanica and Vlavian-Gurmeza 2010; Burgoyne and Mearns 2020).

Education and awareness raising among residents about the importance of ecosystems is crucial and can help local communities better appreciate the importance of protected areas. One way in which protected areas can have a positive social impact is by ensuring that the costs and benefits of conservation are shared equitably. If this is achieved, local communities can more readily recognize protected areas as important resources that can improve their livelihoods and contribute to the development of their communities – for example, through the development of ecotourism (Abukari and Mwalyosi 2020).

This article analyzes 1) local residents' attitudes about the importance of involving residents in ecotourism development, 2) whether respondents' socio-demographic characteristics influence their attitudes toward ecotourism as a form of sustainable tourism development, and 3) the extent to which the community has a positive attitude toward ecotourism development and residents' willingness to be involved in tourism planning and decision-making processes.

2 Theoretical background

Many researchers claim that ecotourism seems to meet most of the objectives set out in the definition of sustainable tourism because it is a tool for both social empowerment and long-term economic development of local communities (Weaver and Lawton 2007; Carić 2018; Ramón-Hidalgo et al. 2018; Graci et al. 2019). The involvement of local communities in ecotourism is one of its core rules (Senko et al. 2011; Kihima and Musila 2019; Albu 2020). There is an ethical dimension to the collaboration of these communities in ecotourism projects because local communities should benefit from such a relationship (Abdullah, Weng and Som 2011; Eshun and Tichaawa 2020). Local residents need to be involved in the planning and development of ecotourism projects from the early stages to maximize the positive effects of ecotourism. To fully participate in the planning process, they need to be aware of the impacts and supportive of the development. It is also important that the local community have »a basic level of awareness of the potential benefits and costs of tourism« to successfully participate in the planning process (Khoalenyane and Ezeuduji 2016; Thetsane 2019). Assessment of ecotourism awareness can be measured by understanding the host community's attitudes toward the positive and negative environmental, economic, and social impacts of ecotourism (Adetola and Adediran 2014; Milheiras 2019).

Community involvement is a process of working together (McCloskey et al. 2013). It has been found that the involvement and active participation of local residents plays a vital role in implementing conservation programs and helps conserve national heritage and take good care of protected areas (Jaafar, Noor and Rasoolimanesh 2015). Moreover, lack of resident participation reduces the value of heritage sites and protected areas (Buta, Holland and Kaplanidou 2014; Majid et al. 2019).

During the last decade, studies on residents' attitudes toward tourism development have increased (McGehee and Andereck 2004; Diedrich and García-Buades 2009; Soldić Frleta and Smolčić Jurdana 2020), and conceptual models and theories have sought to explain the relationship between residents' attitudes toward tourism development (Mohammadi and Khalifah 2014; Hsu, Chen and Yang 2019; Biju and Biju 2020). Protected areas managed as ecotourism sites play an important role in generating much-needed revenue to finance biodiversity conservation and improve the income of local communities (Belete and Assefa 2005; Abeli 2017). When it comes to ecotourism planning and management, because local residents that interact directly with tourists are indirectly the most important stakeholders, it is essential to ensure their positive perceptions and attitudes toward tourism (Lee 2013; Bhat and Mishra 2020).

Previous studies on this topic have suggested that ecotourism and other types of sustainable tourism development initiatives would not succeed without the cooperation, support, goodwill, and participation of local residents (Chen, Li and Li 2017; Eusébio, Vieira and Lima 2018; McCaughey, Mao and Dowling 2018). In light of this, the involvement of local residents in decision-making and their positive attitude toward tourism is essential for tourism sustainability (Canalejo et al. 2015; Panyik 2015). Empowered communities are able to benefit more from tourism development opportunities and use these opportunities more constructively (Chen, Li and Li 2017; Bittar Rodrigues and Prideaux 2018).

3 Methods

3.1 Case study area

The Zasavica Special Nature Reserve (SNR) is located in the southern part of the province of Vojvodina, Serbia. It extends across the territories of the municipalities of Sremska Mitrovica and Bogatić and covers an area of 671 hectares, and the protected zone covers an area of 1,150 hectares (Decree … 1997). The Zasavica area is a remnant of a once large wetland area in the Sava and Drina basins (Stanković 2014). In 2012, wider boundaries of the reserve were proposed, toward a total area of 1,128 hectares, with a protected zone of 3,462 hectares (Dobretić et al. 2012).

The Zasavica SNR is also an area of international importance, considering that it has the following listings: a Ramsar site (wetland of international importance), an IBA (Important Bird Area) as a patchwork and the best-preserved habitat of marsh birds in northwestern Serbia, an IPA (Important Plant Area) due to its floristic and vegetation value and its inclusion in the botanically important areas of central and eastern Europe (Stevanović 2005), a PBA (Prime Butterfly Area) as one of four in Vojvodina (Jakšić and Nahiranić 2011), an Emerald Network Area of Special Conservation Importance (ASCI) due to the presence of wetland, forest, and meadow habitats of the Pannonian landscape that are a priority for conservation, and a proposed NATURA 2000 area with twenty-three types of habitat priority for conservation recorded (Lazić et al. 2008). The Zasavica SNR is also part of the international networks Sava Parks and Dinarides Parks (Puzović et al. 2015). Finally, due to its good conservation and accessibility, it offers excellent conditions for the development of ecotourism.

3.2 Research design, instrument, and data collection

To achieve the objectives of the research, a survey in a form of a questionnaire was developed. It explores local residents' attitudes toward sustainable tourism development. The questionnaire consists of three parts.

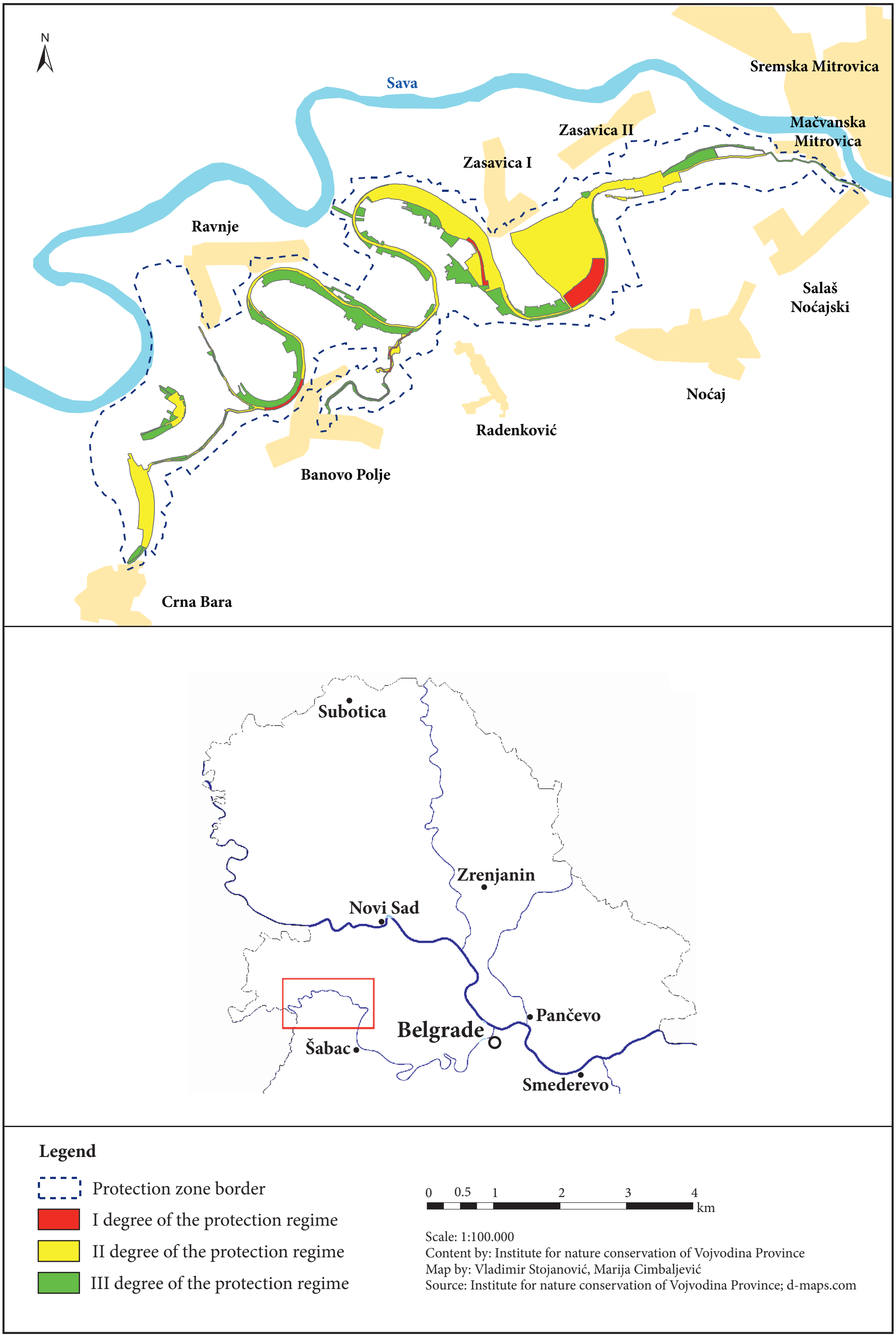
The first part contains demographic data about the participants.

In the second part, participants were asked to respond to 42 statements about sustainable tourism development using the SUS-TAS scale (Choi and Sirakaya 2005). Choi and Sirakaya (2005) developed the Sustainable Tourism Development Scale (SUS-TAS) to measure residents' attitudes toward the current sustainability status of tourism development and the expected level of sustainability. This study adopts the SUS-TAS with only minor modification in wording. For the questionnaire, the SUS-TAS scale was translated into Serbian. Responses in the second part were measured using a five-point Likert scale (1 = absolutely disagree, 2 = partially disagree, 3 = neutral, 4 = partially agree, and 5 = absolutely agree) as in several previous studies on sustainable tourism development (Choi and Sirakaya 2005; Gidebo 2019; Rathnayake and Darshi 2020).

In the third part, participants were asked about nature conservation in the area studied. We asked participants the following questions:

- Do you know any plant species in the Zasavica SNR?
- Do you know any animal species in the Zasavica SNR?

Figure 1: Map of the Zasavica SNR. ➤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Sava
Sremska Mitrovica
Mačvanska Mitrovica
Zasavica II
Zasavica I
Ravnje
Salaš Noćajski
Noćaj
Radenković
Banovo Polje
Crna Bara
Subotica
Zrenjanin
Novi Sad
Pančevo
Belgrade
Šabac
Smederevo
Legend
Protection zone border
I degree of the protection regime
II degree of the protection regime
III degree of the protection regime
0 0.5 1 2 3 4 km
Scale: 1:100.000
Content by: Institute for nature conservation of Vojvodina Province
Map by: Vladimir Stojanović, Marija Cimbaljević
Source: Institute for nature conservation of Vojvodina Province; d-maps.com

- In your opinion, are there any problems related to nature protection in the Zasavica SNR?
- Are you involved in any programs connected with nature protection in the Zasavica SNR?
- Would you like to contribute as a volunteer to nature protection in the Zasavica SNR?

The data were collected in August 2020. The study sample consisted of 399 respondents. Part of the respondents (seventy-six participants) were surveyed through an online questionnaire (at Google Forms), which was distributed through social media (Facebook). The rest of the responses were collected through a face-to-face interview. For this portion, a pen-and-paper questionnaire was conducted by giving paper questionnaires to individuals in person and asking them to complete them by hand and return them to the researcher. Respondents were informed that the survey was anonymous, that participation was voluntary, and that the results of the survey would be used for research purposes only.

3.3 Sampling procedure

The sample includes residents from towns and villages surrounding the Zasavica SNR. Data were collected in eight cadastral municipalities (total population 14,437). A representative targeted sampling was used to select respondents in each cadastral municipality: Ravnje (population 1,142), Radenković (946), Zasavica Ravnje (1,142), Radenković (946), Zasavica (1,330), Noćaj (1,866), Salaš Noćajski (1,751), Mačvanska Mitrovica (4,116), Crna Bara (1,924), and Banovo Polje (1,362). The total sample numbered 399, which is 2.76% of the total population.

3.4 Data analysis techniques

For data analyses, IBM SPSS 25.0. Statistics was used. The statistical methods used in this research include descriptive statistical analysis to determine the sociodemographic profiles of the respondents, principal component analysis (PCA) to determine the dimensions of the SUS-TAS, Cronbach's alpha to test the internal consistency of the items measuring each factor, and correlation to determine associations between the responses of respondents belonging to different age groups based on the SUS-TAS factors. An ANOVA test was conducted to determine the differences in the respondents' answers in terms of their employment, education, type of settlement, and nationality, and a *t*-test was performed to compare the data reported by respondents of different sexes in terms of sustainable tourism development factors.

4 Results

4.1 Respondents' sociodemographic profiles

A total of 399 questionnaires were submitted. A descriptive summary of the respondents (Table 1) shows that females (55.39%) slightly outnumbered males (44.61%). The majority of the respondents were under 30 (age ≤ 19: 26.06%; 20–29 years: 29.57%) and had a high-school education (55.39%) or above (university education: 37.09%). The household size in the area studied is above the Serbian average, 2.88 (according to the 2019 census). About half of the respondents (49.37%) earn more than the average monthly income in Serbia (€450). In terms of duration of residence, the majority of respondents had lived locally between 10 and 19 years (38.34%) and between 20 and 29 years (20.81%).

4.2 Factor analysis of local communities' attitudes toward sustainable tourism development

Fist, a principal component analysis (PCA) was conducted with a varimax rotation on forty-two items to delineate the dimensions of the SUS-TAS, and it loaded within seven domains. Almost all communalities were above 0.300, further confirming that each item shares some common variance with other items. Only the statements »Sometimes it is acceptable to exclude a residents of a community from tourism development« and »Residents of a community should have an opportunity to participate in tourism development and management« were 0.120 and 0.285, respectively, and they were not included in further analysis. Given these overall indicators, the factor analysis was considered appropriate for 40 out of the 42 items.

Table 1: Socio-demographic characteristics of respondents (n = 399).

Category		*n*	%
Sex:	Male	178	44.61
	Female	221	55.39
Age (years):	≤ 19	104	26.06
	20–29	118	29.57
	30–39	79	19.80
	40–49	57	14.29
	50–59	22	5.52
	≥ 60	19	4.76
Education:	Elementary school	30	7.52
	High school	221	55.39
	University and above	148	37.09
Household size:	< 3	78	19.55
	3–5	258	64.66
	> 5	61	15.29
Monthly income (€):	< 250	67	16.80
	250–450	132	33.08
	> 450	197	49.37
	No response	3	0.75
Residence (years):	≤ 9	40	10.02
	10–19	153	38.34
	20–29	83	20.81
	30–39	49	12.28
	40–49	26	6.52
	≥ 50	48	12.03

The Kaiser–Meyer–Olkin measure of sampling adequacy was 0.87, above the generally recommended value of 0.6 required for valid factor analysis (Kaiser 1970; 1974; Tabachnick and Fidell 1989; 2007), and Bartlett's test of sphericity was significant (χ^2 (780) = 10,582.367, p = 0.000). Using the eigenvalue criterion (greater than 1), we confirmed seven significant factors totaling 65.68% of the explained variance (Table 2).

In this study, Cronbach's alpha coefficients for each SUS-TAS domain ranged from 0.603 to 0.884 with an overall scale reliability of 0.871, indicating that the variables had strong to moderate correlation with their factor grouping and were internally consistent.

The highest level of agreement was for environmental sustainability (90%), followed by visitor satisfaction (85.8%) and community-centered economy (85.2%), and the lowest level of agreement was for perceived social cost (42.2%).

4.3 ANOVA test: respondents' age, education status, and correlation analysis

Respondents over 19 (Table 4) are more likely to consider environmental sustainability than the youngest respondents (F = 5.813; p = 0.000), whereas the youngest respondents are more concerned about perceived social costs than other groups (F = 4.956; p = 0.000). Significant differences were found based on the educational status of the respondents regarding six factors of sustainable tourism development, except in the case of community participation.

Educational status correlated significantly (mostly positively) with almost all SUS-TAS factors except community participation (Table 5). Residents' age and length of residence also showed a significant positive correlation with environmental sustainability as well as community-oriented management. Furthermore, a significantly negative correlation was found between perceived social costs and age, educational status, and length of residence.

Table 2: Factor analysis for host community attitudes toward sustainable tourism development.

Factors and statements	Value
Environmental sustainability (α = 0.869)	
1. The community's environment should be protected now and for the future	0.825
2. The diversity of nature must be valued and protected	0.819
3. The development of tourism should increase efforts to protect the environment	0.744
4. Tourism must protect the community environment	0.732
5. Tourism must be developed in harmony with the natural and cultural environment	0.709
6. Appropriate tourism development requires wildlife and natural habitat protection at all times	0.642
7. Tourism development must promote positive environmental ethics for all tourism stakeholders	0.562
8. Regulatory environmental standards are needed to reduce impacts of tourism development	0.301
9. Tourism must improve the environment for future generations	0.312
Perceived social costs (α = 0.884)	
10. Tourists in my community are disrupting my quality of life	0.831
11. My quality of life has deteriorated because of tourism	0.820
12. I often feel irritated because of tourism in the community	0.818
13. The community's recreational resources are overused by tourists	0.739
14. My community is overcrowded because of tourism development	0.734
15. I do not feel comfortable or welcome in local tourism businesses	0.664
16. Tourism is growing too fast	0.651
17. The quality of social interaction in my community has deteriorated because of tourism	0.551
Perceived economic benefits (α = 0.884)	
18. I like tourism because it brings new income into our community	0.760
19. Tourism makes a strong economic contribution to the community	0.721
20. Tourism generates significant tax revenue for local government	0.681
21. Tourism is good for our economy	0.666
22. Tourism creates new markets for local products	0.626
23. Tourism diversifies the local economy	0.554
24. Tourism is beneficial to other industries in the community	0.512
Community participation (α = 0.603)	
25. Tourism decisions need to be made by everyone in my community regardless of background	0.864
26. The whole community must participate in decisions for successful tourism development	0.837
Long-term planning (α = 0.703)	
29. The tourism industry must plan for the future	0.616
30. Successful management of tourism requires an advanced planning strategy	0.839
31. We need to take a long-term perspective when planning tourism development	0.811
32. Residents must be encouraged to take a leadership role on tourism planning committees	0.686
33. Tourism development needs well-coordinated planning	0.641
34. Tourism development plans should be continuously improved	0.601
Visitor satisfaction (α = 0.782)	
35. Tourism businesses have a responsibility to provide for visitors' needs	0.777
36. Community attractiveness is the core element of environmental attractiveness to visitors	0.750
37. Tourism enterprises need to monitor visitor satisfaction	0.614
38. The tourism industry must ensure high-quality tourism experiences for future visitors	0.604
Community-centered economy (α = 0.837)	
39. The tourism industry should obtain at least half its goods and services locally	0.749
40. Tourism should hire at least half its employees from the local community	0.687
41. Local community residents should receive a fair share of the benefits from tourism	0.686
42. The tourism industry must contribute to community improvement funds	0.467

Table 3: Respondents' attitudes to sustainable tourism development.

Sustainable tourism development factors	Mean	*SD*	Agreement level (%)
Environmental sustainability	4.50	0.54	90
Perceived social cost	2.11	0.84	42.2
Perceived economic benefits	3.97	0.74	79.6
Community participation	3.77	0.66	75.4
Long-term planning	4.07	0.72	81.4
Visitor satisfaction	4.29	0.65	85.8
Community-centered economy	4.26	0.68	85.2

Table 4: ANOVA test: Factors of sustainable tourism development by respondents' age and education.

	Factors	F-value	LSD post-hoc test
By age	Environmental sustainability	5.813*	2, 3, 4, 5, 6 > 1
	Perceived social cost	4.956*	1 > 2, 3, 4, 5, 6
	Perceived economic benefits	3.042	/
	Community participation	0.241	/
	Long-term planning	2.675	/
	Visitor satisfaction	1.691	/
	Community-centered economy	4.225*	3 > 1, 2, 5; 4 > 1
By education	Environmental sustainability	12.295*	3 > 1, 2; 2 > 1
	Perceived social cost	3.955*	1 > 3
	Perceived economic benefits	10.400*	3 > 1, 2; 2 > 1
	Community participation	0.105	/
	Long-term planning	10.403*	3 > 1, 2; 2 > 1
	Visitor satisfaction	5.274*	3 > 1, 2;
	Community-centered economy	4.000*	

*$p < 0.01$; $F > 3.32$

Table 5. Correlation analysis: age of respondents, educational status, household size, and sustainable tourism development factors.

	Pearson correlation coefficient (*r*)		
Factors	Age	Education status	Length of residence
Environmental sustainability	0.202**	0.240**	0.163**
Perceived social costs	−1.810**	−0.126*	−0.147**
Perceived economic benefits	0.048	0.218**	0.006
Community participation	−0.013	−0.009	−0.062
Long-term planning	0.046	0.219**	−0.070
Visitor satisfaction	0.052	0.150**	0.015
Community-centered economy	0.101**	0.140**	0.023

*Correlation significant at $p = 0.05$, **Correlation significant at $p = 0.01$

4.4 Respondents' attitudes toward nature protection

In general, respondents expressed a very positive attitude toward nature protection in the study area. Two-thirds of the respondents (68%) stated that they knew some plant species, and similar responses were found for respondents' knowledge of animal species. Although managers of the nature reserves informed the public about the importance of the presence of endangered plant species, locals mainly recognized yellow and white water lilies and reeds. Unfortunately, 91% of the respondents indicated that the most popular animal species in the study area was the domestic donkey, and only 0.5% of the respondents knew about the European mudminnow (*Umbra krameri*), an endangered fish species.

A significant number (75%) of the respondents are aware that there are problems related to nature protection, but no one named them. Also, only 8.5% of the respondents answered that they have been involved in some programs related to nature protection – but, again, without specific answers regarding the capacity to which they are involved in such programs. Fortunately, half of the people surveyed (55%) would be happy to contribute to nature protection and tourism development in the Zasavica SNR without receiving any compensation.

5 Discussion

The results obtained show that inhabitants of the Zasavica SNR have a positive attitude toward sustainable tourism development, ecotourism, sociocultural and economic impacts of ecotourism, and nature conservation in the area studied. Furthermore, our findings reinforce previous research and support the position that SUS-TAS is also a reliable and valid instrument for measuring residents' attitudes toward sustainable tourism development in ecotourism research (Nunnally and Bernstein 1994; Gidebo 2019). In this study, the SUS-TAS scale was applied in the Zasavica SNR, where tourism is underdeveloped, whereas previous studies were conducted in tourist destinations and in countries where tourism is one of the most important economic sectors; for example, in Izmir, Turkey (Sirakaya-Turk, Ekinci and Kaya 2007; Sirakaya-Turk, Ingram and Harill 2008), Cyprus (Kvasova 2011), and the United States (Hawaii, Indiana, South Carolina, Texas, and rural counties in the Midwest; Choi and Sirakaya 2005; Yu et al. 2011; Assante, Wen and Lottig 2012; Sirakaya-Turk and Gursoy 2013; Zhang, Cole and Chancellor 2015).

SUS-TAS has also been applied to hotels (Prayag, Dookhony-Ramphul and Maryeven 2010), and some studies have been conducted in national parks (Gidebo 2019) and outstanding natural landscapes (Obradović and Stojanović 2021), which are also protected natural areas. In the study by Obradović and Stojanović (2021), it was confirmed that this scale can be used in different cross-cultural settings (confirmatory factor analysis, or CFA, was used) and in municipalities and protected areas where tourism has not yet emerged as a significant economic area of activity.

This study seeks to promote the development of ecotourism in communities and raise awareness of the need to create programs that engage local communities. So far, educational programs have mostly been periodic and related to specific projects, but there is a need to ensure their continuity. Their goal should be continuous education and promotion of awareness of the potential of the Zasavica SNR to protect and preserve it through ecotourism as a form of sustainable tourism development. The development of such a form of tourism requires the participation of three groups of stakeholders: the local community, the management of the protected area, and the tourism industry. If the local community is informed and educated, this will lead to increased investment in the tourism industry. This approach can increase the involvement of local residents as entrepreneurs and employees in tourism development and encourage young people to remain in the area. This can in turn lead to the creation of employment opportunities for local people, reduce unemployment, and improve living standards, making the residents much more supportive of tourism development.

In general, community members show agreement with seven factors of sustainable tourism development, with the exception of perceived social costs, which is consistent with previous studies (Gidebo 2019; Rathnayake and Darshi 2020). Our presumption is that the community in the study area has experienced lower social costs associated with tourism development at this time, which mitigates the negative impacts on the local community. This would explain the lowest level of agreement in the case of perceived social costs. Furthermore, the results obtained show a predominantly positive correlation between residents' educational status and almost all SUS-TAS factors. The positive correlation of high education level with support for tourism development is consistent with the literature consulted (Teye, Sirakaya and Sönmez 2002; Chen and Qui 2017). The group of respondents with completed high school education is more likely to consider environmental sustainability, perceived economic benefits, and long-term planning than the group with only primary school education. Perceived social costs as a factor of sustainable tourism development are more thoroughly considered by locals with completed primary school. Older respondents with higher levels of education were found to have more positive attitudes toward environmental sustainability and a community-based economy. The results of this study are consistent with previous research (Teye, Sirakaya and Sönmez 2002; Chen and Qui 2017), which suggests that people with higher levels of education are more aware of the potential benefits of tourism than people with lower levels of education. Furthermore, the survey results show that respondents with higher levels of education strongly believe that tourism development needs well-coordinated planning, similar to a study conducted in Sri Lanka (Rathnayake and Darshi 2020). On the other hand, younger respondents with lower educational status were more likely to perceive social costs than older ones, which is associated with a critical attitude toward the negative environmental impact caused by tourism development, which was confirmed in a study conducted by Kuvan and Akan (2005).

According to a number of researchers, length of residence in a geographic location may be a better predictor of residents' attitudes toward tourism impacts (Walpole and Goodwin 2001; Gu and Ryan 2008). In this study, length of residence was positively correlated with attitudes toward environmental sustainability, which is consistent with similar research (Khoshkam, Marzuki and Al-Mulal 2016). Furthermore, some previous studies confirmed that length of residency was positively correlated with attitudes toward the economic impacts of tourism development (Liu and Var 1986; Haralambopoulos and Pizam1996; Khoshkam, Marzuki and Al-Mulal 2016).

General public awareness about nature and environmental protection is still insufficient in Serbia (Tomićević, Shannon and Milovanović 2010). To our knowledge, this is the first time that this type of survey has been used in nature protection to investigate the level of knowledge of the local population. Although respondents expressed a very positive attitude toward nature protection, key species for conservation of the Zasavica SNR are poorly recognized by the local population. For the globally threatened aquatic waterwheel plant (*Aldrovanda vesiculosa*), Zasavica is the only remaining habitat in Serbia (Tomović et al. 2009). This species has the status of a globally threatened species (EN; Cross and Adamec 2020), and in Serbia it is designated as critically endangered (IUCN 2001). Extant populations of *A. vesiculosa* are rare in Europe, and only a few sites remain in the Balkans. *A. vesiculosa* was promoted as one of the »flagship species« of the reserve (Stanković 2014). However, only the staff of the Zasavica SNR knew about the existence of this species. The low level of knowledge about non-charismatic plant species among residents contrasts with the awareness of large communities of scientists and naturalists from Serbia, who recognize *A. vesiculosa* as one of the most important species in the reserve. Moreover, only 0.5% of respondents knew about the endangered European mudminnow (*Umbra krameri*). This species is a relict, and it is the only native species in the genus *Umbra* in Europe. In particular, the Zasavica SNR is one of two remaining habitats in Serbia (Sekulić et al. 2013).

Previous studies show that the most attractive and secure species receive the highest public support compared to less attractive and more threatening ones (de Pinho et al. 2014; Liordos et al. 2017). Furthermore, physical size (Metrick and Weitzman 1998) and phylogenetic similarity to humans (Tisdell, Wilson and Swarna Nantha 2006) also increase support in efforts to save threatened species. In our study, *A. vesiculosa* and *U. krameri* do not meet these parameters, and this is probably why they are not recognized by the locals. One of the solutions could be found, for example, in Greece, where campaigns to increase public interest in the less charismatic species, conducted by the WWF and NGOs have so far promoted successful management and conservation of the black vulture for more than twenty-five years (Liordos et al. 2017).

Moreover, in the area studied, one of the famous attractions is donkeys, together with liqueur and soap made from donkey milk. This is the only place in the region where people can see and buy such products. This is probably why the respondents said that the most popular animal in the reserve is the domestic donkey. The Zasavica SNR is involved in a genetic resources conservation program, and the donkeys are part of the breeding stock of a special native Balkan breed. The Zasavica SNR hosts a population of a few hundred Balkan donkeys, Podolian cattle, and Mangalitsa pigs, which roam freely in large pastures in the central part of the reserve, and they contribute to the management of grasslands and wetlands. Although kept as domestic animals, these are perceived as valuable representatives of local biodiversity and part of native ecosystems.

On the other hand, the examples of *U. krameri* and *A. vesiculosa* show that, despite intensive promotion and education campaigns (e.g., the tourist boat on the Zasavica River is named *Umbra* after the endangered fish), managers have not succeeded in raising awareness of non-charismatic wildlife among local people, most of whom recognize the Zasavica SNR as a preserved natural habitat with traditional livestock management. Similar results on local perception toward conservation have been found in other parts of the world (de Albuquerque and de Albuquerque 2005; Abukari and Mwalyosi 2020). Therefore, it would be good to investigate how locals learn about biodiversity and conservation in other protected areas. The results of the survey suggest that long-term educational programs on conservation should be devised for locals. Over time, their knowledge will accumulate, multiply, and spread to eventually achieve a better balance with nature.

The large number of respondents that want to contribute to nature protection and sustainable development is important because of the scope of tourism development in the Zasavica SNR. This protected area is one of the most frequently visited in northern Serbia. The Zasavica SNR stands out for its level of tourism development and tourist services (a visitors' center, educational and eco-trails, restaurants, and a camp), and it has strategies and plans according to which it is developing as a destination (Stojanović, Lazić and Dunjić 2018). Revenue from tourist visits from tickets alone is about €21,000 a year. The profit from catering services is also significant, and from the sale of souvenirs and ethnic food: goat milk, cheeses, and processed meat from Mangalitsa pigs (Jovanović et al. 2019).

On the whole, the residents are aware of the importance of nature and protecting it even if they differ in material status or education level. Interestingly, Tomićević, Shannon and Milovanović (2010) came to a similar conclusion in Tara National Park in Serbia. Moreover, our results show that a significant number of respondents would like to contribute to nature conservation and tourism development in the Zasavica SNR. In conclusion, as indicated in a study conducted by Tomićević, Shannon, and Milovanović (2010), a comprehensive, participatory management program is undoubtedly necessary to reach people that already feel connected to a protected area to develop tailored plans and increase community participation in management of the protected area.

6 Conclusion

According to the literature in this area, sustainable tourism relies heavily on stakeholder participation, and efforts must be made to improve the links between conservation, local community development, and the tourism industry (Wearing and Neil 2009). This study emphasized the importance of local community support and participation. The results of this case study reinforce the findings of similar previous studies (Lundberg 2017; Wang 2019) and show that SUS-TAS can be used to measure residents' attitudes toward sustainable tourism development in communities and protected areas where tourism has not yet emerged as a significant economic activity.

According to the study by Jaafar, Noor, and Rasoolimanesh (2015), local residents' involvement and active participation plays a vital role in implementing conservation programs that contribute to preserving heritage sites and protected areas. This study shows that half of those surveyed would like to contribute to nature conservation and tourism development in the Zasavica SNR. Lack of local participation diminishes the value of heritage sites and protected areas (Buta, Holland and Kaplanidou 2014; Majid et al. 2019), but this research has confirmed that community participation and active involvement are necessary for nature protection and tourism development. Attitudes toward tourism development and protecting nature vary among individuals in the Zasavica SNR. Moreover, the results of this study have a practical application for the local authorities in designing and planning future tourism development and nature protection in the Zasavica SNR as well as in other protected areas in Serbia and the wider region. Finally, it is important to emphasize that the residents of the area studied recognize the benefits of sociocultural and economic impacts of development, while acknowledging the negative impacts of development on the natural environment.

ACKNOWLEDGEMENTS: We would like to thank dr. Marija Cimbaljević from University of Novi Sad for her helpful advice. This research was supported by the Serbian Ministry of Education, Science, and Technological Development (grant number 451-03-9/2021-14/ 200125 and project III 43005).

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Acta geographica Slovenica, 61-2, 2021, 187–206

DETECTION OF EARTHFLOW DYNAMICS USING MEDIUM-RESOLUTION DIGITAL TERRAIN MODELS: DIACHRONIC PERSPECTIVE OF THE JOVAC EARTHFLOW, SOUTHERN SERBIA

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Jovac earthflow, head scarp zone.

DOI: https://doi.org/10.3986/AGS.9818
UDC: 911.2:551.435.62(497.11-13)
COBISS: 1.01

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Detection of earthflow dynamics using medium-resolution digital terrain models: Diachronic perspective of the Jovac earthflow, Southern Serbia

ABSTRACT: The paper presents and discusses the landslide research procedure related to the topography before and after its occurrence, using the comparative analysis of two medium-resolution digital terrain models. The case study is the Jovac mega-landslide – the largest landslide to occur in Serbia in the last 100 years, active for three days in February 1977. The indicators used to determine the volume and movement mechanism were the spatial distribution of elevation differences within the two digital terrain models (DTM), and the analysis of geomorphological features before the landslide. The obtained elevation differences allowed the definition of the approximate landslide volume: 11.6×10^6 m^3. All the data obtained indicate that the movement mechanism falls into the category of earthflow.

KEY WORDS: landslide, earthflow, GIS analysis, Jovac, Serbia

Zaznavanje dinamike premikanja zemeljskih gmot z uporabo digitalnih modelov višin srednje ločljivosti: Diakronična perspektiva plazu Jovac, južna Srbija

POVZETEK: Prispevek predstavlja in obravnava postopek raziskovanja zemeljskih plazov, ki se nanaša na topografijo pred nastankom procesa in po njem, s primerjalno analizo dveh digitalnih modelov terena srednje ločljivosti. Študija primera je mega zemeljski plaz Jovac, ki je največji plaz v Srbiji zgodil v zadnjem stoletju in je bil aktiven tri dni februarja 1977. Kazalniki, ki določajo prostornino in mehanizem gibanja, so prostorska porazdelitev višinskih razlik v obeh digitalni modeli terena (DTM), pa tudi analiza predhodnih geomorfoloških značilnosti. Dobljene višinske razlike so omogočile določitev približne prostornine plazu: $11{,}6 \times 10^6$ m^3. Vsi pridobljeni podatki kažejo, da mehanizem gibanja spada v kategorijo zemljinskih tokov.

KLJUČNE BESEDE: zemeljski plaz, drobirski tok, analiza DMR, Jovac, Srbija

The article was submitted for publication on March 22nd, 2021.
Uredništvo je prejelo prispevek 22. marca 2021.

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1 Introduction

The article deals with earthflow as a specific form/process of landslides from the perspective of changing topography, within a case study of the Jovac earthflow in south-eastern Serbia. Landslides, as one of the most dynamic processes, have been thoroughly studied in the last decades, especially with the rapid development of geomorphometric tools. Among the most cited and important references are the works of Varnes (1978; 1984) on landslide hazard zonation, Cruden (1991), Cruden and Varnes (1996) on landslide types, and Hungr, Leroueil and Picarelli (2014) on landslide typification. Cruden's (1991) definition is accepted by the institutions which defined the international standards in landslide research, such as The international geotechnical societies' UNESCO working party for world landslide Inventory (1993), and the International Association for Engineering Geology and the Environment (IAEG) (UNESCO working… 1993). Furthermore, the above-mentioned references indicate a high degree of diversification of landslides depending on the type of movement and the type of material. Within this typology, the combination of relatively high water content within the small-grained material indicates the landslide category of earthflow, as a subgroup in the landslide classification system. Hungr, Leroueil and Picarelli (2014) define earthflow material as a cohesive, plastic, clayey soil material, often mixed and remoulded with the Liquidity Index below 0.5. Keefer and Johnson (1983) state that many earthflows contain fragments of material in various stages of remoulding and may carry granular clasts. The IGS Multilingual Landslide Glossary (1993) recognizes the term »flow« (not earthflow) and explains that the distribution of velocities in the displacing mass is similar to that in a viscous fluid. Valuable theoretical background for earthflows is provided by Urciuoli et al. (2016), who explain the relationship between morphological aspects, kinematic behaviour and slope stability conditions.

Digital terrain models (DTMs) are a resource of high importance within landslide detection and research. (Mahalingam and Olsen 2016). Jaboyedoff et al. (2012) see the role of DTM in:
- mass movement detection and characterization,
- hazard assessment and susceptibility mapping,
- modelling, and
- monitoring.

The resolution of a DTM is one of the crucial properties affecting the quality of research results (Lee et al. 2004; Hrvatin and Perko 2005; Santini et al. 2009). In the early period of DTM development, it was assumed that higher resolution would automatically lead to better results (Dietrich and Montgomery 1998). However, recent studies show that resolutions of 2 m, 5 m and 10 m do not necessarily provide more accurate results (Mahalingam and Olsen 2016; Chen et al. 2020). In some cases with quite high resolution, the DTM may also contain irrelevant data (Tarolli and Tarboton 2006). These can blur the key influencing factors related to sliding during further processing. Examples of this are microtopographic details created by subsequent denudation of the landslide body or small-scale rockfalls in the scarp zone. Therefore, the selection of the optimal DTM resolution must consider the dimensions of the landslide, as well as the context of the analysis (McKean and Roering 2004; Claessens et al. 2005).

Landslide detection using DTM was one of the main aims of our research which was conducted in several time frames. A time frame refers to a state of the topographic surface at the time of the analysis. Performing two or more analyses (assuming that the intervening period included an observable change) provided the insight into the temporal dynamics of the process (Table 1).

Table 1: Landslide detection methods using a Digital Terrain Models (DTM).

	Time frame	Detection method	Detected features
DTM	One time frame	Visual interpretation of DTM Automated interpretation of DTM	Landslide outlines and morphometric features of the landslide topographic surface
	More time frames	Detection of elevation differences before and after the landslide (two DTMs)	Landslide outlines, dimensions, morphometric features of the landslide topographic surface, depletion zone, accumulation zone, movement mechanism, monitoring

Within a time frame, the detection process can be done by two methods: visual interpretation and/or automated recognition. In our case, the visual method combined with fieldwork was the starting point for determining landslide outline (Ardizzone et al. 2007; Amundsen et al. 2010; Guzzetti et al. 2012). Visual interpretation of DTMs relies on hillshade, the generated contours, and the slope of the topographic surface (Van Den Eeckhaut et al. 2007; Schulz 2007; Đomlija 2018). This method of landslide determination is very subjective. In contrast, an objective landslide identification method is based on statistical analyses of DTM-generated morphometric parameters (curvature, surface roughness), which can be used to automatically determine landslide contours (Tarolli, Sofia and Dalla Fontana 2012).

Two or more time-frames recorded within the DTMs allow the application of quantitative methods in defining the outline (boundaries), approximate volume estimation, identification of depletion and accumulation zones, and monitoring of landslide dynamics. The spatial distribution of colluvium can indicate the mechanism of movement (Corsini et al. 2009; Fernández et al. 2011; 2017; Giordan et al. 2013). The work of Conoscenti et al. (2015) is an example of the use of multiple time-frames in DTM analyses. A potential drawback of DTM as a method of landslide detection in general is that the DTM resolution in the analysis phase is usually limited by the pre-sliding input data. In our case, lower data resolution can be expected because the topographic data acquisition took place about 10 years before the landslide event, when mapping methods were not sophisticated as today.

The aim of this article is to determine whether a medium-resolution DTM (*sensu*, Gigović 2010; Table 2) can be a reliable data source for landslide studies, given the current era of LiDAR dominance. Our hypothesis is that a medium-resolution DTM can prove to be sensitive enough to determine landslide outlines, areas and volumes, as well as reconstruct their movement mechanisms. In this study, two DTMs of the same area are analysed – one is before and one after a landslide, created by applying two different methods. The article describes the details of the superposition procedure applied in order to avoid the systematic errors in determining the elevation differences. In the subsequent analysis, it is possible to define the movement mechanism based on the comparison of the paleo-topography and the present topography of the Jovac landslide.

Table 2: DTM resolutions (after Gigović 2010).

Resolution	Horizontal distance of elevation points	
	In meters	In arc seconds
Low	900–90	30–3
Medium	90–30	30–1
High	30–10	1–0.3
Very high	10–1	0.3–0.03

2 Study area and basic geological setting

The Jovac landslide is located in the villages of Jovac and Ostrovica (Vladičin Han municipality) in southeastern Serbia (N 44.64°, E 22.003°). The mountainous area within the altitude range 400–800 m hosts the catchment area of the Jovačka Reka River, the left tributary of the Južna Morava River (Figure 1). The current average precipitation average is about 740 mm, with the peaks in June and May.

Geologically, the study area is located on the southwestern edge of the Eurasian Plate. According to Prelević et al. (2005), the closure of the Neotethys basin and the collision of the Eurasian Plate with the African Plate triggered large-scale volcanism in early Cenozoic (Cvetković, Šarić and Mladenović 2019). One of the eruption points was located in the zone of the Grot and Oblik peaks (Vukanović et al. 1970), 7 km west of the present landslide (Figure 1). Pyroclastic material was deposited in the area within the dacite lava eruption. During the Miocene, the lower parts of the drainage area were part of a lacustrine basin where terrigenous sediments were deposited (Vukanović et al. 1970; Babović et al. 1977; Jovanović and Novković 1988). The combination of these lithological components created a landslide-prone setting in the area. Landslide activation occurred in February 1977 and destroyed 70 households in the villages of Jovac and Ostrovica (Petrović and Stanković 1981).

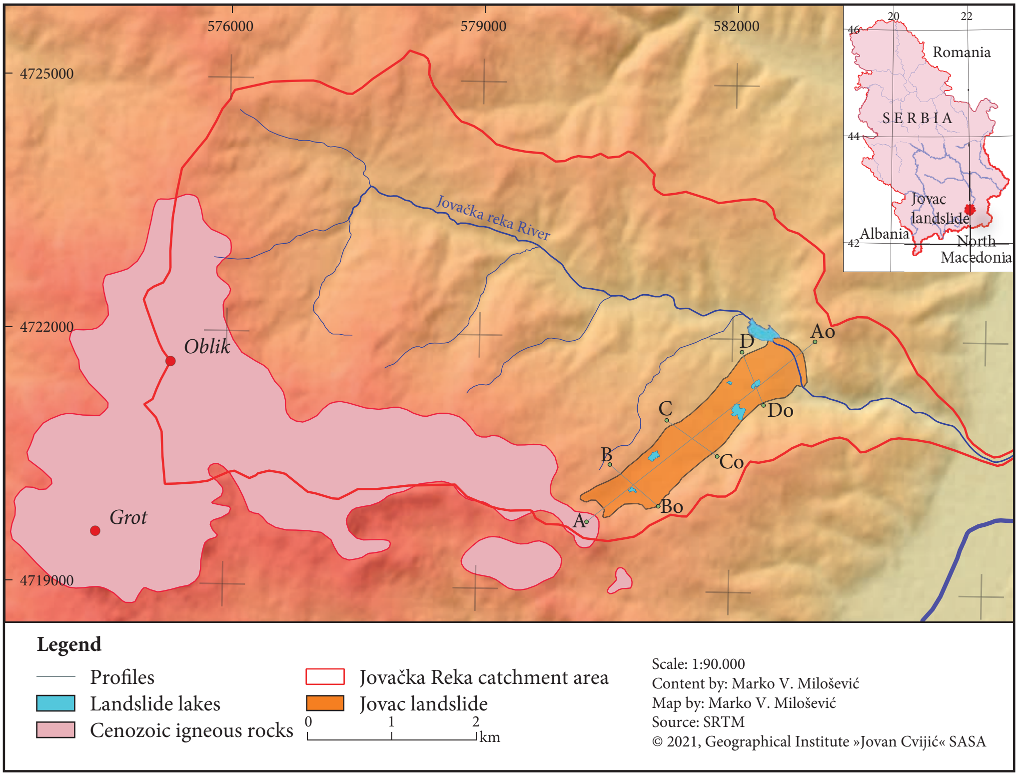


Figure 1: Situation map of the study area (profiles refer to figures 10 and 11).

2.1 Previous research

Two papers have already been published on the genesis and morphometry of this landslide (Lazarević 1977; Petrović and Stanković 1981), giving dimensions of 3 km^2 area, 50 m average width and 150×10^6 m^3 volume. Both described the movement mechanism as a typical landslide, using the visual observation and field mapping. Review papers mentioning the Jovac landslide mostly refer to the primary references mentioned (Jevremović, Sunarić and Kostić 2011; Pavlović et al. 2012). Lazarević (1977) defined the Jovac landslide as translational and determined its area to be 1.52 km^2. Interestingly he found that there was no synchronized movement of the entire landslide body, but rather that the upper part moved first, while the middle and lower parts moved subsequently. Petrović and Stanković (1981) estimate the average depth of 50 m and the volume of 150×10^6 m^3. They do not explicitly mention the mechanism of movement but their figure shows a translational landslide character (see Figure 11A).

3 Data sources and methods

The aim of the research was to determine the precise outline (boundaries), area, volume and movement type of the Jovac landslide by analysing the topographic data from both, the pre-activation period and the resulting landform after the landslide process was complete. The most accurate data source available for the period before the landslide are the classical topographical maps at 1 : 25,000 published in 1971. The contour lines of the 1 : 25K maps were digitized in detail (contour interval 10 m, additional 5 m and 2.5 m) to subsequently create a 30×30 m DTM referring to the year 1971, in UTM 34N. The accuracy of the obtained DTM based on digital contour lines from the cartographic records is 2.2 m for TIN interpolation method

(Govedarica and Borisov 2011). According to the 1971 map, forest vegetation covered only 12% of the studied area (in total), in 13 separate fragments; therefore, we do not consider that it affected the accuracy of the data obtained by the photogrammetric method.

For the post-slide period, we used an SRTM DTM 30 × 30 m raster referring to the year 2000. To allow the comparison between the two datasets, the final resolution of 30 × 30 m raster cell (pixel) resolution was accepted for the analysis

3.1 Calculation and analysis of elevation differences

Raster arithmetic was used to calculate the elevation differences. In the first overlap of two DTMs, the 1971 elevations were subtracted from the 2000 elevations. The analysis of the elevation differences allowed the

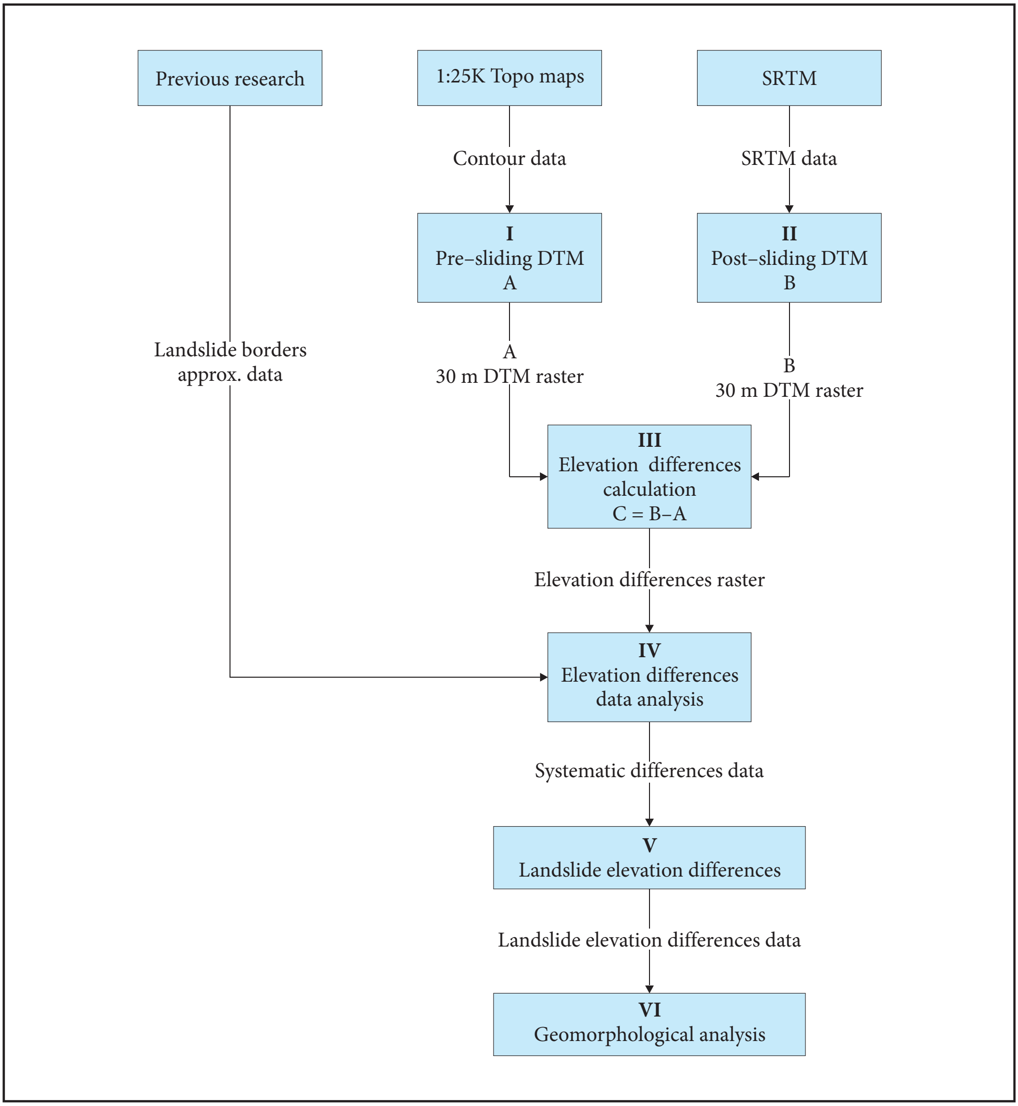


Figure 2: Workflow.

distinction between the sliding and non-sliding (stable) parts of the studied area, which led to the determination of the exact boundary of the landslide.

The non-sliding area was subjected only to statistical analysis of elevation differences, while the sliding area was subjected to geomorphological analysis. The preliminary delineation between these two units was based on cartographic sources, literature, and fieldwork. The size ratio between the units is approximately 1 : 3 (sliding area 1770 pixels; non-sliding area 4878 pixels). The objective of the statistical analysis of the elevation differences of the non-sliding area was to determine the quality of the overlap of two DTMs used, while the task of the geomorphological analysis was to determine the characteristics and consequences of the sliding process.

3.2 Test of the overlap quality of DTMs

It is assumed that the non-sliding area was not subject to any influences that would significantly change its elevation. Consequently, the comparison of pre- and post- elevation values should be possible. The characteristics and spatial distribution of the differences would indicate whether there are systematic errors in the overlap of two DTMs obtained using the different data sources.

The total number of pixels (in the non-sliding area) for which the elevation differences were analysed is 4878, i.e. 146,340 m^2. The distribution of the obtained elevation differences is shown in Figure 3.

The arithmetic mean of the elevation differences between the two DTMs is $\bar{x} = 3.940$ m, while the standard deviation is $\sigma = 4.331$ m. The standard deviation is a measure of the quality of the overlap (i.e. agreement of the data).

Two tests of overlap of two DTMs were performed in the following way: One of the models was shifted by one pixel (30 m) with respect to the other model. The displacement had four directions – N, E, S, W. The data on the mean ($\bar{x}$) and standard deviation (σ) of the elevation differences for each movement are given in Table 3. Comparison of the standard deviation values of vertical differences shows that the deviation for the initial model is the smallest, which means that the overlap was correct.

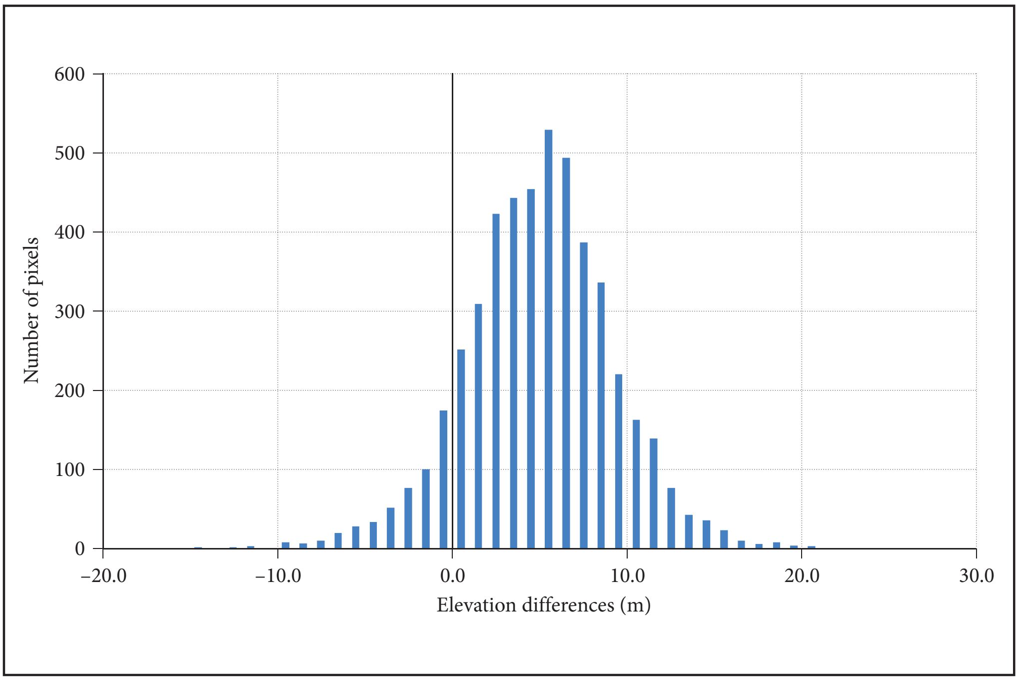


Figure 3: Distribution of elevation differences for the non-sliding (stable) area.

Table 3: Arithmetic means and standard deviations of the elevation differences during the overlap test.

Pixel movement direction	$\overline{x}$	σ
North	8.356	5.734
East	0.748	5.082
South	–0.490	6.454
West	7.091	6.567
Initial value	3.940	4.331

Definite values of elevation differences were obtained by subtracting the value of 4 m in the post-sliding DTM in relation to the pre-sliding DTM. As mentioned above, the value of 4 m ($\overline{x}$ = 3.940) was taken as the value of the systematic error.

4 Results

4.1 Paleotopography

Analysis of the pre-slide topographic surface (1971 topographic map) revealed colluvial (slope) and fluvial morphogenetic relief types, determined by lithological composition. The indicator for the recognition of colluvial forms are the contour distances which at some places do not regularly follow the contour intervals. Rogers and Chung (2016) suggest that the heterogeneous contour intervals on narrow and elongate surfaces may indicate earthflows. In the case of Jovac, the colluvial traces were present only in the zone of volcanoclastic sediments, mainly in the middle and upper part of the slope (Figure 4). Lazarević (1977) pointed out the signs of former sliding by noting that the pond at the Jezero locality (meaning »lake« in Serbian language) is located in a depression formed during an earlier sliding phase.

This former hydrological feature with a size of 2345 m^2 (45 × 50 m in SW–NE direction), is visible on the 1971 topographic map. Our field research results show that there was another pond in the hamlet Deda Dorinci, called Cekino Jezero or Cekina Bara (pond / swamp). Petrović and Stanković (1981) indirectly confirm this by listing the morphological elements of the slope that were present before the activation of the Jovac landslide. They note that the »middle part of the present landslide was subject to dynamic changes, inversely inclined, with microdepressions, rounded hillocks and steep sides,« – features typical for landslides. In the central part of the slope there were hillocks of up to 10 m relative height, depressions and landslide terraces of different heights.

Fluvial landforms were present only in the catchment area of Manastirski Potok, which extended from the mouth to the Jovačka River (at 400 km^2. The lower course of the Manastirski Potok, carved a 40 m deep gorge in pyroclastics. The valleys of the upstream tributaries are carved in volcanoclastic material with morphological traces of sliding processes.

The longitudinal profile of a stream is one of the indicators of its morphological stage of development. In the case of Manastirski Potok, the profile is not parabolic (as it would be in a balanced state), but uniformly sloping (Figure 5), indicating an early morphogenetic phase and a possible imprinting by a paleo-(colluvial)-relief. The lateral tributary valleys were relatively shallow, with maximum depths up to 10 m, with inherited colluvial landforms – hillocks, depressions, sliding terraces. The hydrographic network consisted only of occasional streams, with a total length of 2910 m.

4.2 Predispositions for the development of landslides

There were three main predispositions for the landslide process on the right valley side of the Jovačka Reka River:

- lithological composition,
- morpho-hydrographic conditions: a) surface runoff areas and b) endorheic areas, and
- human impact.

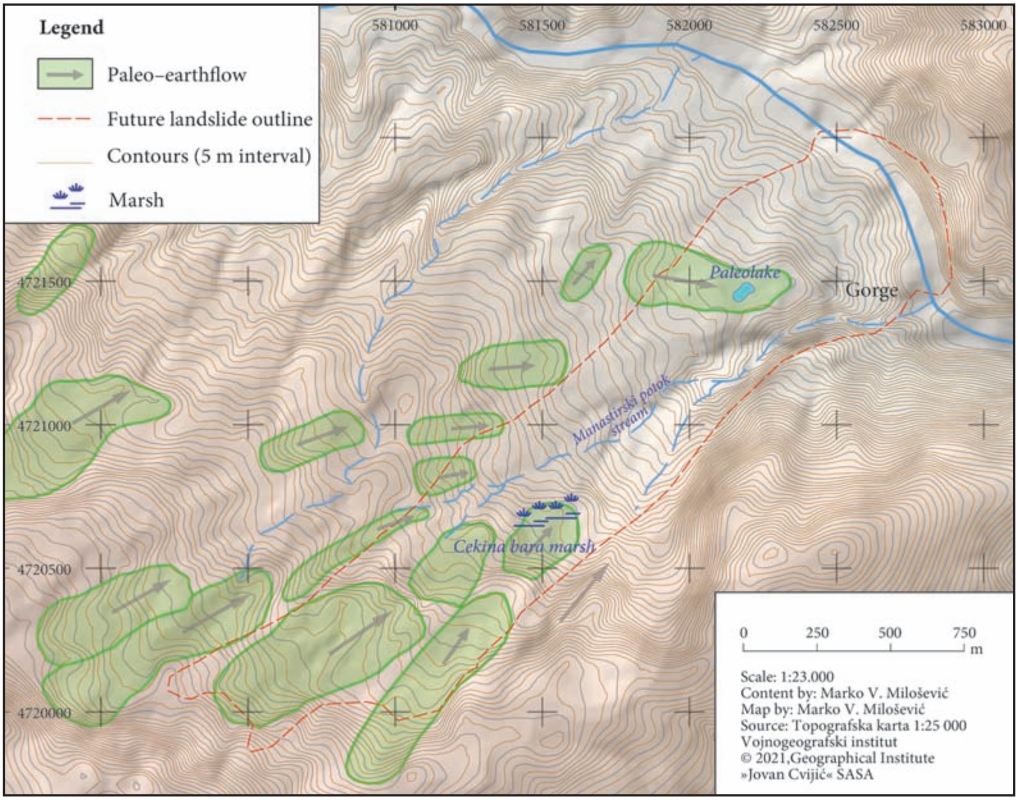


Figure 4: Paleo-earthflows on the right side of the valley of the Jovačka River (1971 situation), where the 1977 landslide was later formed.

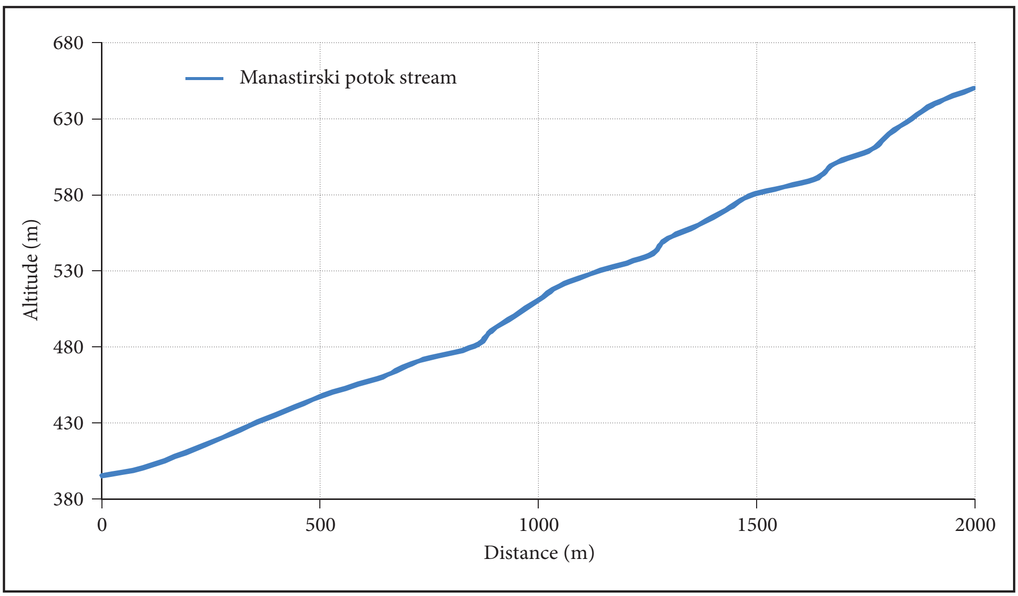


Figure 5: Longitudinal profile of the stream Manastirski Potok.

Through the palaeogeographic evolution of the area during the Tertiary, it is possible to identify some of the lithological predispositions for the formation of the Jovac landslide. As mentioned above, synchronous deposition of terrigenous and volcanoclastic sediments took place during the Middle Miocene (Jovanović and Novković 1988). This sedimentary-volcanogenic unit represented by clays, sands, pebbles, volcanic ash, lapilli, tuff, volcanic agglomerates and volcanic blocks subsequently becomes an ideal environment for the formation of the Jovac landslide. Lithologically, the southwestern hinterland of the landslide consists of dacites (the Gradište and Ostrovica peaks) (Vukanović et al. 1970), while pyroclastites such as volcanic breccias and agglomerates, as well as tuff sandstones and tuffs (Kremen Ridge) are located to the east and southeast (Babović et al. 1977). The contact of these lithological units with the sedimentary-volcanogenic unit determined the boundaries of the subsequent Jovac landslide.

The hydrogeological characteristics of pyroclastites, which topographically gravitate towards the landslide, are different than those of the dacites. Their permeability is extremely low and the regolith is rather thin. Considering the morpho-hydrological criteria, there are two significant topographic units. The first is the surface catchment area of the Jovac landslide and the second is the endorheic area within it. The landslide catchment area includes not only the landslide body and hinterland of the scar, but also the lateral areas that morphologically gravitate towards the main landslide body (Figure 6).

Regarding the hydrogeological characteristics of the lithological units, two zones can be distinguished: feeding zone and collection zone. The feeding zone is the landslide body (Miocene sedimentary-volcanogenic

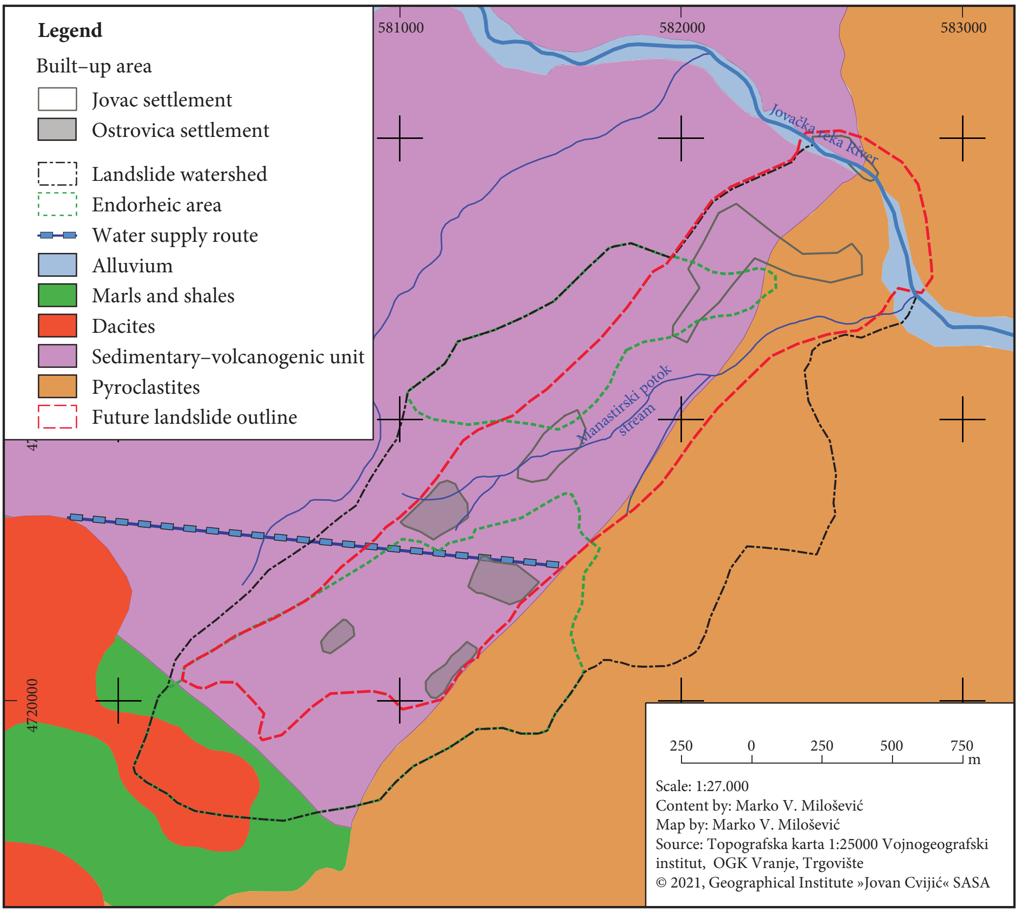


Figure 6: Predispositions for the development of the Jovac landslide.

unit), which has the role of hydrocollector (reservoir) and is fed by infiltration of atmospheric and surface water. Water flowed from the impermeable areas of the dacites and pyroclastites towards the landslide body. This was an additional factor in increasing the amount of water received by the topographic surface. The total catchment area of the Jovac landslide was 3.06 km^2, of which 52% was the area of landslide itself.

Another morpho-hydrographic feature is the occurrence of endorheic areas, which were detected on 48% of the catchment area (Table 4). This means that the water of 1.47 km^2 did not drain superficially but infiltrated into the ground. The endorheic areas were divided into two areas. The first (1.07 km^2; of which 0.519 km^2 on the landslide) included the upper part of the slope, immediately below the Ostrovica peak, while another of 0.4 km^2 (of which 0.107 km^2 on the landslide) included the area around a palaeolake, to the northwest from the Manastirski Potok Gorge.

Table 4: Hydrographic characteristics of the catchment area.

Hydrography	Catchment area		Jovac landslide	
	km^2	%	km^2	%
Exorheic	1.59	52	0.96	60
Endorheic	1.47	48	0.62	40
SUM	2.84	100	1.58	100

In the case of the Jovac landslide, human impact is associated with the increase of the slope catchment area. In other words, the total amount of water that a given area receives comes not only from its topographic catchment, but also from other catchments. The inhabitants of the village of Ostrovica built a water-supply system that directed the water from below the Oštra Čuka (1040 m) (Figure 6). Despite the fact that this area is not morphologically directed to the future landslide body, the human activity additionally increased the water balance of the slope. The water supply system was of gravitational and flow-through type, which resulted in water consumption exceeding the actual needs of the population (Lazarević 2000). This was certainly not the main, but only an additional factor in triggering the landslide. The main anthropogenic factor was the permanent humidification of the ground in the built area zone, due to the water supply system which transferred the water from the neighboring catchment, area thus increasing the water input.

4.3 Morphometric characteristics of the Jovac landslide

The landslide boundary was determined based on the spatial distribution of elevations of the topographic surface, as explained in the Chapter 3. The topographic surface with no or with minimal differences was declared as the landslide boundary. Thus, a polygon similar to the one defined by Petrović and Stanković (1981) was formed. The boundaries outline the elongated area with an area of 1.58×10^6 m^2. The maximum length of the landslide is 3,000 m, while the widthe varies from 490 m to 670 m. Two distinct continuous areas are visible, representing the values of the elevation change differences. The smaller area (0.62×10^6 m^2) is located in the highest part of the landslide. It is characterised by the lowering of the previous topographic surface in the interval from –1 to –45 m. In the middle and hypsometrically lowest part of the slope (0.96×10^6 m^2) (Figure 8A), the changes indicate the increased elevation of the topographic surface. The values are in the interval from +1 to +51 m. The boundary between these two areas is a narrow belt where the elevation change was not detected or is negligible (Figure 7).

In the area of lowering of the previous topographic surface, the differences are positioned concentrically, and increase towards the interior. In the central part the highest extent of the topographic surface lowering was –45 m. The distribution of the differences in elevation is very uneven. The greatest change is recorded at the former gorge of the Manastirski Potok Stream. The values of topographic elevations increase fall in the interval from +31 to +51 m. Outside this zone, the accumulation reaches +30 m only in some places. Other values of topographic increase are distributed in various locations.

By analysing the topographic elevation difference for each DTM cell (30 × 30 m), the volume of landslide was determined. The estimated volume of the depleted ground, where the surface was lowered is 12.45×10^6 m^3. The volume of colluvium in the zone of topographic surface elevation increase is 11.6×10^6 m^3, which is 4% less than the volume of depleted ground (Figure 8B).

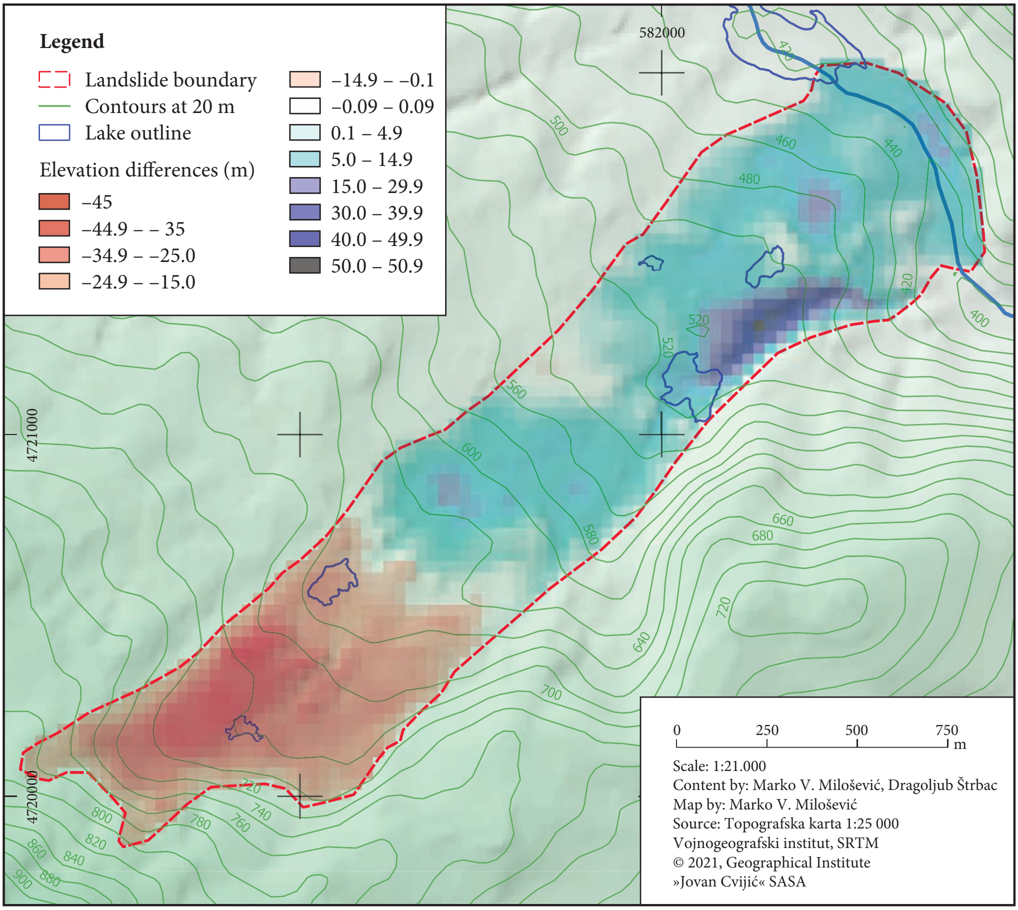


Figure 7: Elevation differences of the topographic surface of the Jovac landslide (contours refer to the present topographical surface).

As a result of large denivelation of the topographic surface on the landslide body, several small lake basins have formed. They are permanently filled with water. Of the six lakes, five are located on the landslide body – two in the depletion zone and three in the accumulation zone (Figure 7). The sixth and largest lake is the Jovac Lake, formed by the landslide dam of the Jovačka Reka River.

Table 5: Extreme and average morphometric characteristics of pre-sliding and post-sliding topographic surfaces.

		Elevation (m)	Slope (°)	Curvature	Aspect (°)
Pre-sliding	Min	380	0.0	–5.046	
	Max	807	87.0	5.046	
	Average	568	11.0	0.015	110
Post-sliding	Min	390	0.0	–0.342	
	Max	793	43.0	0.361	
	Average	567	9.6	0.014	101

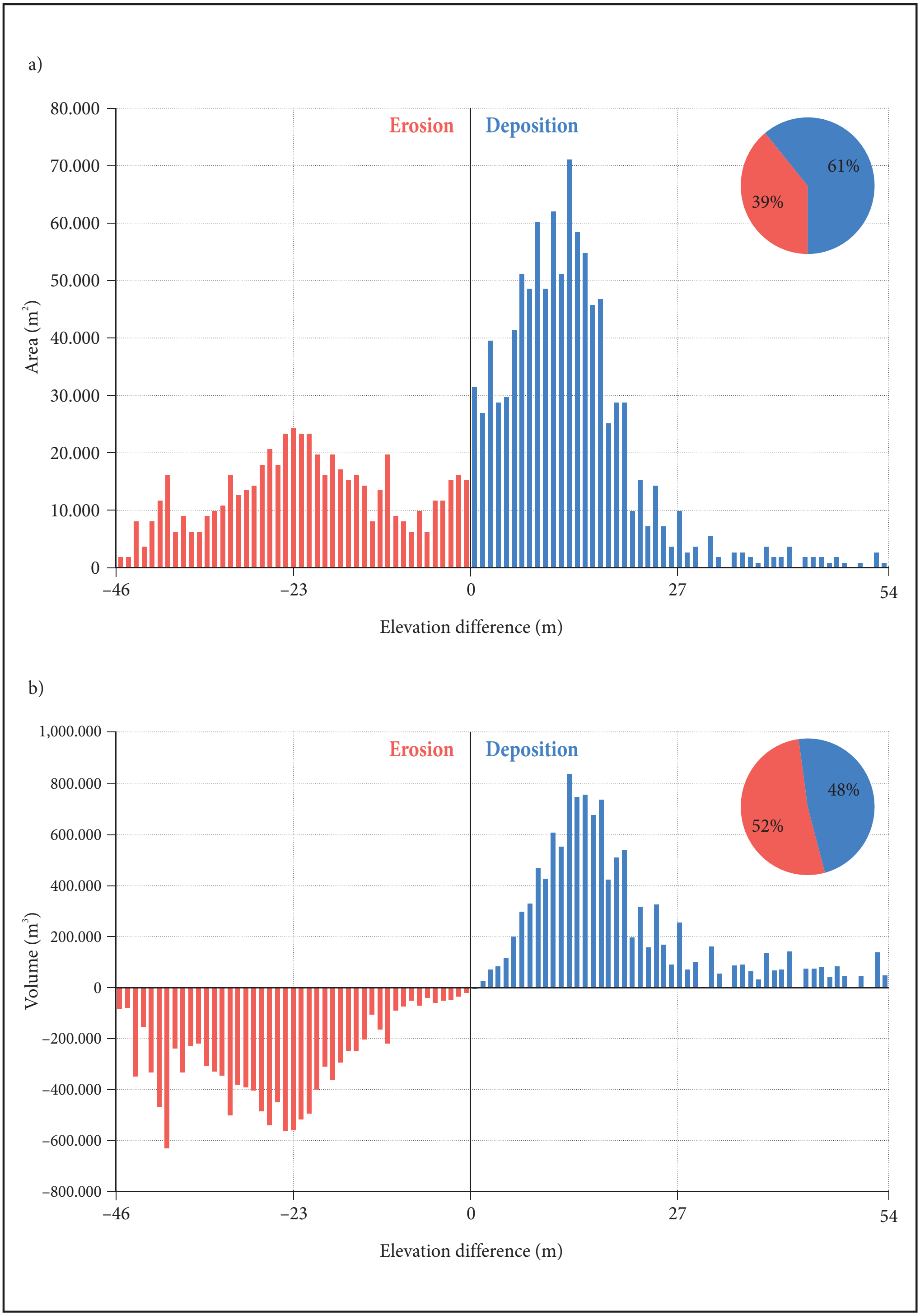


Figure 8: Distribution of elevation differences on the topographic surface (A) and distribution of volumes (B).

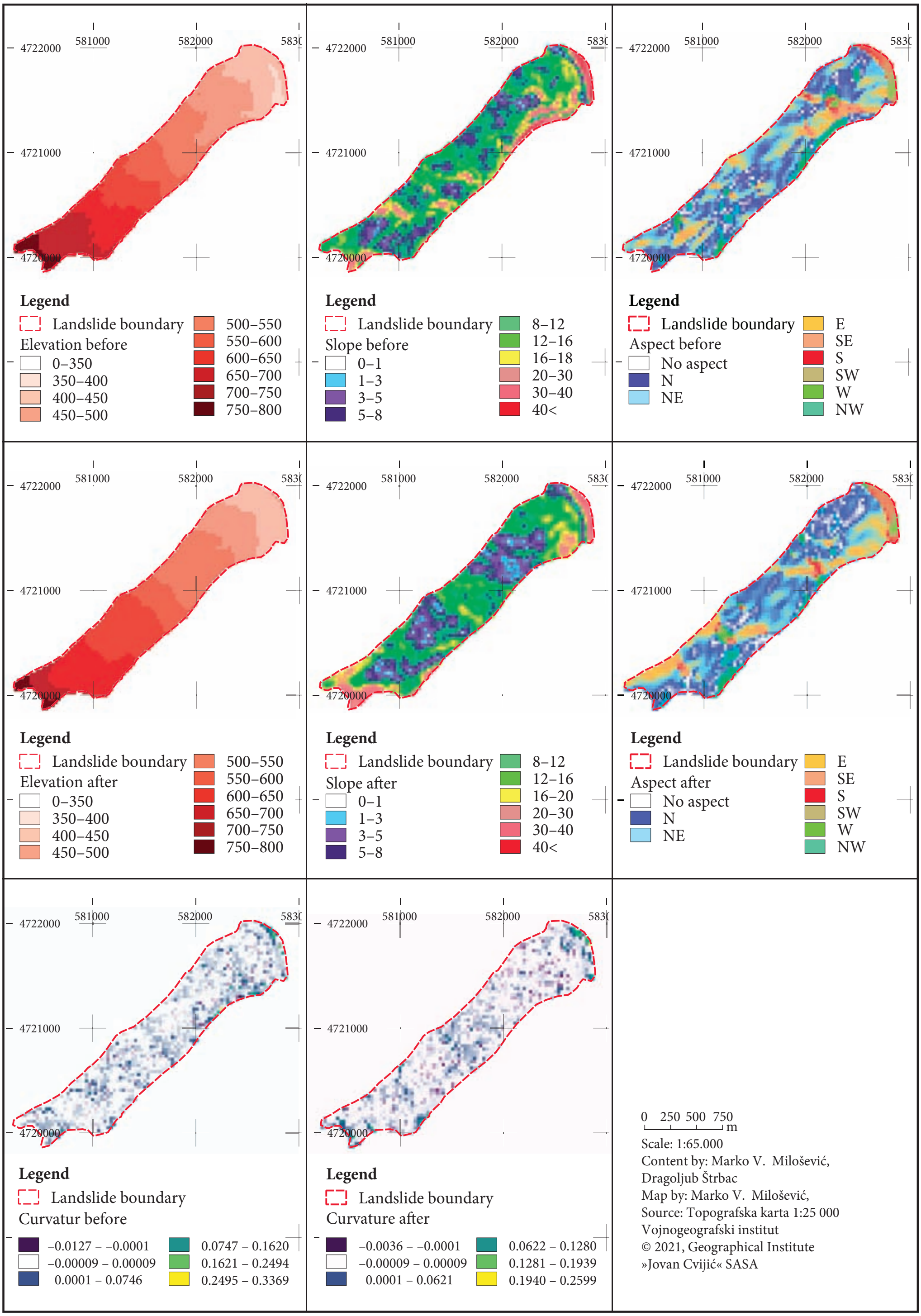


Figure 9: Morphometric characteristics before and after the sliding process.

5 Discussion

Although the descriptions of Jovac the mechanisms of movement of the Jovac landslide by Lazarević (1977) and Petrović and Stanković (1981) fit into the category of »flow«, the authors explicitly referred to the movement as sliding. The analysis of the planar form of the Jovac landslide, where the length is much greater than the width, according to the nomenclature of Varnes, modified by Hungr et al. (2014) and the international classification of landslides according to the movement mechanism IAEG (1991–1992), indicate that the flow-associated elements are also present.

This statement can be analysed by three indicators based on the analysis of two DTMs, and related to the elevation differences of the situations before and after the slide.

The first indicator is runoff. It shows how many cells (30 × 30 m pixels) gravitate to an observed cell, i.e. how large is the »catchment area« of each cell. For this analysis, only the values obtained from the pre-sliding DTM were considered. The second indicator is the elevation difference of two DTMs for each selected cell (negative or positive, indicating depletion or accumulation). The third indicator is the current elevation of a cell, the elevation after the sliding process.

Comparative analysis of these indicators was a valuable tool in geomorphological reconstruction of the area. The cross-section in the depletion zone (with lowering of the topographic surface) showed that the depletion peaks do not follow the peaks of the runoff capacity. The runoff peaks are directly proportional to the drainage lines. This indicates that the sliding process in the upper part of the landslide was independent of the morphology of the topographical surface (profile B–Bo in the Figure 10A). The depletion zone almost completely overlaps with the endorheic area and conditions for water saturation of soil and rock are favourable (Lollino, Giordan and Allasia 2014).

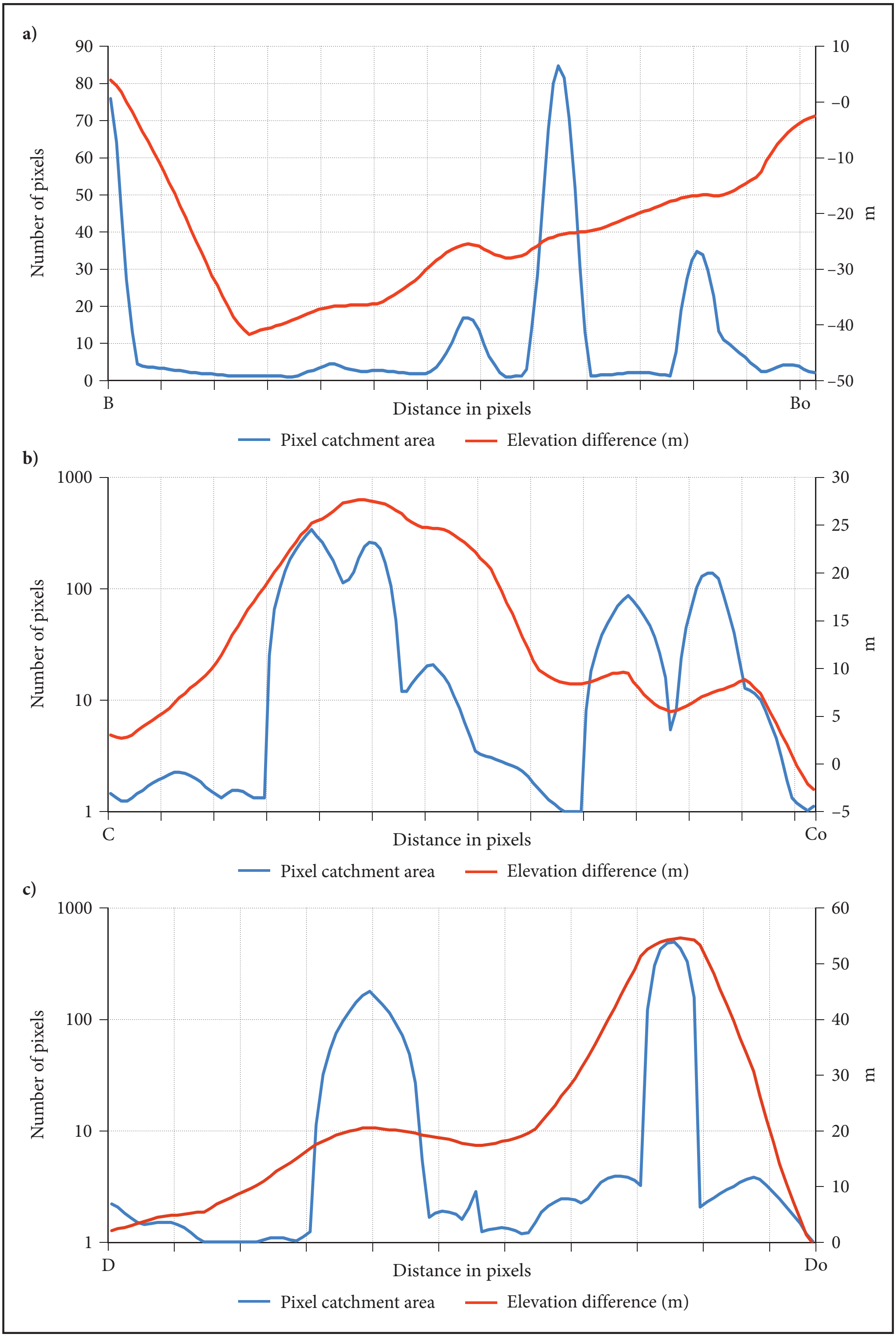
The cross sections in the accumulation zone show a clearly different situation. Profile C–Co shows a matching of the runoff peaks, but not so many conspicuous peaks in the increase of the topographic values (Figure 10B). The same is seen on the D–Do profile, with slightly better visible peaks compared to C–Co, thanks to its lower position on the slope (Figure 10C). This feature may indicate that the highest accumulation of the material occurred along the drainage lines. In other words, the morphology of the pre-sliding surface determined the movement of colluvial material from the depletion zone (upper slope) through the accumulation zone (middle and lower zones).

To prove the assumption that in the lower part of the landslide the flow followed the stable palaeotopographic surface, it was necessary to include the third indicator, the elevation of the cells after the slide (Figure 11D). Figure 11D shows that the convex portions of the current topographic surface overlap with the peaks of runoff and accumulation. A convex profile of the topographic surface in the earthflow accumulation zones was also pointed by Soeters and van Westen (1996). This undoubtedly proves that the colluvial material from the depletion zone continued to move downwards following the pre-existing morphology of the middle and lower parts of the slope. The underlying rock was certainly stable, thanks to the pyroclastite zone on the northeast side. This type of movement was a consequence of supersaturation by water, which decreased the viscosity of the colluvium and allowed it to follow the slope morphology. This also explains the asymmetry in the colluvium thickness, which is greatest in the zone of the former gorge of Manastirski Potok.

Based on the presented relationships between the colluvium and topographic surface we conclude that the Jovac landslide has elements of earthflow movement. According to the ICL classification (Internet 1), the Jovac earthflow is in the category of large landslides ($\geq 10^6$ m^3). In Serbia, landslides with similar volume and lithology usually occur along the banks of large rivers and their movement mechanisms are rotational and planar. The right bank of the Danube River hosts the Bocke landslide, Krčedin landslide (Mészáros 2013), Ciagansko Brdo (Janjić 1996), Rujište (Lazarević 1957; Janjić 1996), Provalija (Luković 1951), while the Umka and Duboko landslides are located on the right bank of the Sava River (Abolmasov et al. 2014).

Figure 10: Relationship between discharge and elevation differences along cross sections (see also Figure 1). ➤ p. 202

Figure 11: Model of the Jovac landslide adapted from Petrović and Stanković (1981) (A); longitudinal profile of the Jovac landslide (B); cross section in the topographic decrease zone (C); cross section in the increase zone of Manastirski Potok Gorge (D) (see also Figure 1). ➤ p. 203


a)
90
80
70
60
50
40
30
20
10
0
Number of pixels
10
−0
−10
−20
−30
−40
−50
m
B
Distance in pixels
Bo
Pixel catchment area
Elevation difference (m)
b)
1000
100
10
1
Number of pixels
30
25
20
15
10
5
0
−5
m
C
Distance in pixels
Co
Pixel catchment area
Elevation difference (m)
c)
1000
100
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m
D
Distance in pixels
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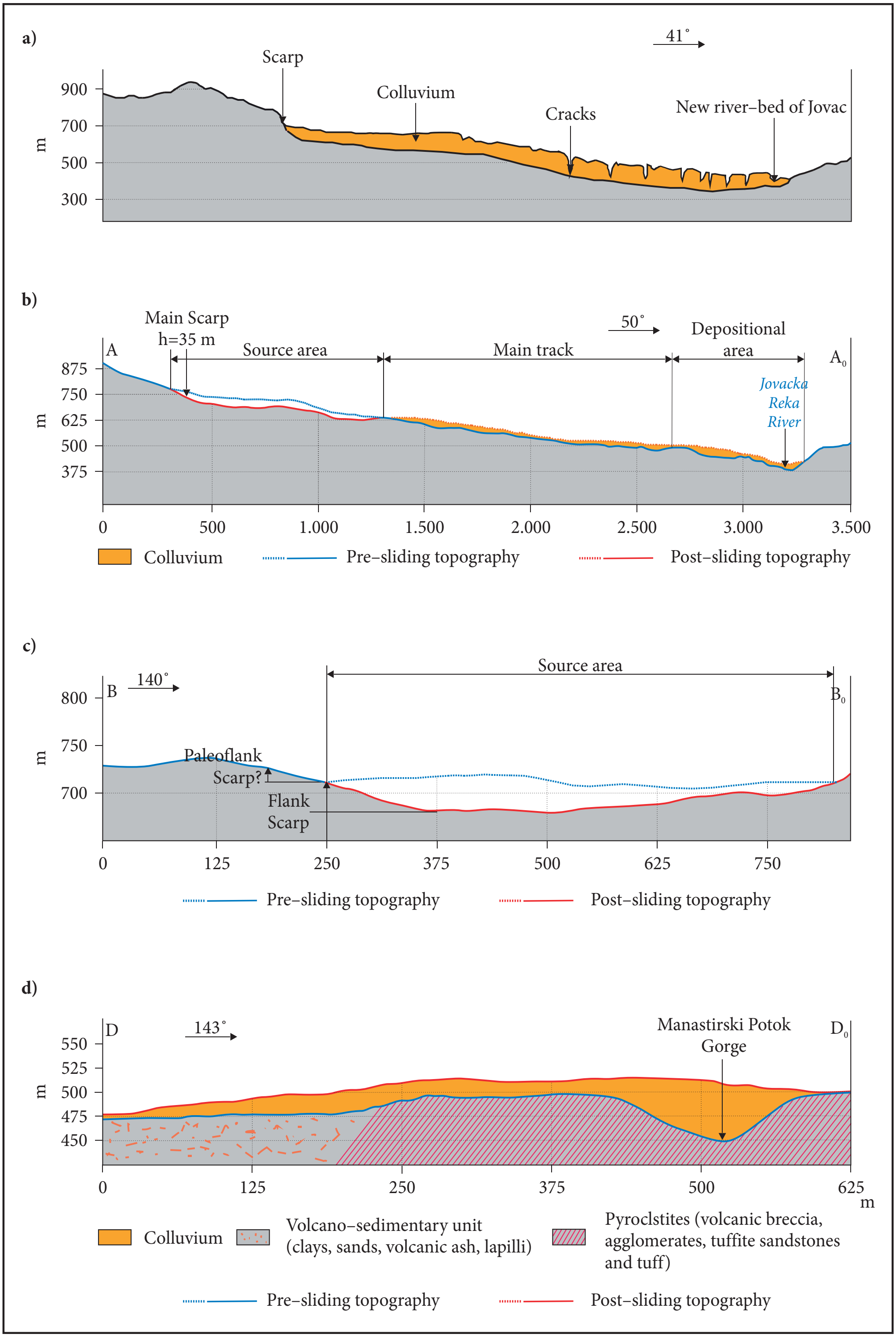
Pixel catchment area
Elevation difference (m)


a)
41°
Scarp
Colluvium
Cracks
New river–bed of Jovac
900
700
500
300
m
b)
Main Scarp
h=35 m
50°
Depositional
area
A
Source area
Main track
A0
875
750
625
500
375
m
Jovacka
Reka
River
0
500
1.000
1.500
2.000
2.500
3.000
3.500
Colluvium
Pre–sliding topography
Post–sliding topography
c)
140°
B
Source area
B0
800
750
700
m
Paleoflank
Scarp?
Flank
Scarp
0
125
250
375
500
625
750
Pre–sliding topography
Post–sliding topography
d)
D
143°
Manastirski Potok
Gorge
D0
550
525
500
475
450
m
0
125
250
375
500
625
m
Colluvium
Volcano–sedimentary unit
(clays, sands, volcanic ash, lapilli)
Pyroclstites (volcanic breccia,
agglomerates, tuffite sandstones
and tuff)
Pre–sliding topography
Post–sliding topography

6 Conclusion

According to the systematization of Varnes (1978) and Cruden and Varnes (1996), the mechanism of the Jovac landslide colluvium movement can be determined as flowing. In terms of material (criteria of Varnes 1978), it belongs to the category of earth, containing high proportion of particles about 2 mm in size. Using the modified Varnes (1978) classification of landslides (Hungr, Leroueil and Picarelli 2014), the Jovac landslide belongs to the category of earthflow. Its estimated volume is 11.6×10^6 m^3, which is a significant difference compared to the earlier estimates of 150×10^6 m^3 (Lazarević 1977; Petrović and Stanković 1981). The reason for such a difference lies is that the earlier researchers had rather poor spatial data, mostly collected by fieldwork observations. We believe that the exceptional size of the landslide and the degree of damage may have influenced the earlier researchers to somewhat subjective conclusions.

In determining the landslide contour, two DTMs were used, one with the situation before the landslide and one with the situation after the landslide. In order to explain that the elevation differences between them are the consequences of the sliding process, it was necessary to define the procedure to avoid technical errors. Possible errors could be related to the incorrect overlapping of two DTMs and to the possible presence of systematic errors due to different types of elevation data acquisition. After completing the testing, we obtained the exact elevation differences between two DTMs caused by the sliding process.

The use of small- and medium-resolution DTMs, in this case 30×30 m (Corsini et al. 2009; Hu et al. 2019), can be a relevant data source for landslide studies, provided that the dimensions of the landslide are large enough to be visible in a DTM. The DTM resolution used makes the study comparable worldwide, as both EU and global DTMs use this resolution. In the case of the Jovac landslide, the pre-slide data were obtained from the topographic map 1 : 25,000. The input data determined the resolution of 30×30 m. Judging by the area of the Jovac earthflow (1.58 km^2) and the volume (11.6×10^6 m^3), we conclude that the DTM at this resolution contains the information relevant to the earthflow formation process. We also conclude that the analysis of the elevation differences of the topographic surface before and after the landslide is an appropriate method to study earthflows (Fernández et al. 2011; Giordan et al. 2013). The endorheic character of the paleotopographic surface, determined by the previous earthflow process, was one of the conditions that strongly contributed to the reactivation of the Jovac earthflow in 1977.

ACKNOWLEDGMENTS: The authors would like to sincerely thank an anonymous reviewer for his valuable comments on the manuscript, which demonstrate the very responsible way in which the review process was handled.

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- **Conclusion:** present the main implications of the findings, your interpretations, and unresolved questions, offering a short take-home message.

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Enter all necessary information into the OJS. Any addition, deletion, or rearrangement of names of the author(s) in the authorship list should be made and confirmed by all coauthors before the manuscript has been accepted, and is only possible if approved by the journal editor.

To make anonymous peer review possible, the article text and figures should not include names of author(s).

Do not use contractions or excessive abbreviations. Use plain text, with sparing use of **bold** and *italics* (e.g. for non-English words). Do not use auto-formatting, such as section or list numbering and bullets.

If a text is unsatisfactory, the editorial board may return it to the author(s) for professional copyediting or reject the article. See the section on the peer-review process (available at https//ags.zrc-sazu.si) for details. Author(s) may suggest reviewers when submitting an article.

4.2 Language

Articles are published in English.

Articles can be submitted in English or Slovenian.

Authors must take care of high-quality English text. In the case of poor language, the article is copyedited/translated after acceptance by a professional chosen by the editorial board. In such a case, the translation or copyediting costs are borne by the author(s) and must be paid before layout editing.

All articles should have English and Slovenian abstracts.

4.3 Supplementary file submission

Supplementary files (figures) can be submitted to the OJS packed in one zip file not exceeding 50 MB.

4.4 Submission date

The journal publishes the submission date of articles. Please contact the editorial board (ags@zrc-sazu.si) with any questions.

5 Citations

Examples for citing publications are given below. **Citing »grey literature« is strongly discouraged**.

5.1 Citing articles

- Bole, D. 2004: Daily mobility of workers in Slovenia. Acta geographica Slovenica 44-1. DOI: https://doi.org/10.3986/AGS44102
- Fridl, J., Urbanc, M., Pipan, P. 2009: The importance of teachers' perception of space in education. Acta geographica Slovenica 49-2. DOI: https://doi.org/10.3986/AGS49205
- Gams, I. 1994a: Types of contact karst. Geografia Fisica e Dinamica Quaternaria 17.
- Gams, I. 1994b: Changes of the Triglav glacier in the 1955-94 period in the light of climatic indicators. Geografski zbornik 34.
- Van Hall, R. L., Cammeraat, L. H., Keesstra, S. D., Zorn, M. 2016: Impact of secondary vegetation succession on soil quality in a humid Mediterranean landscape. Catena, In press. DOI: https://doi.org/10.1016/j.catena.2016.05.021 (25. 11. 2016).
- De Kerk, G. V., Manuel, A. R. 2008: a comprehensive index for a sustainable society: The SSI – The Sustainable Society Index. Ecological Economics 66-2,3. DOI: https://doi.org/10.1016/j.ecolecon.2008.01.029
- Perko, D. 1998: The regionalization of Slovenia. Geografski zbornik 38.
- Urry, J. 2004: The 'system' of automobility. Theory, Culture and Society 21-4,5. DOI: https://doi.org/10.1177%2F0263276404046059
- Yang, D. H., Goerge, R., Mullner, R. 2006: Comparing GIS-based methods of measuring spatial accessibility to health services. Journal of Medical Systems 30-1. DOI: https://doi.org/10.1007/s10916-006-7400-5

5.2 Citing books

- Cohen, J. 1988: Statistical power analysis for the behavioral sciences. New York.
- Fridl, J., Kladnik, D., Perko, D., Orožen Adamič, M. (eds.) 1998: Geografski atlas Slovenije. Ljubljana.
- Hall, T., Barrett, H. 2018: Urban geography. London. DOI: https://doi.org/10.4324/9781315652597
- Hall, C. M., Page, S. J. 2014: The geography of tourism and recreation: Environment, place and space. New York. DOI: https://doi.org/10.4324/9780203796092
- Luc, M., Somorowska, U., Szmańda, J. B. (eds.) 2015: Landscape analysis and planning, Springer Geography. Heidelberg. DOI: https://doi.org/10.1007/978-3-319-13527-4
- Nared, J., Razpotnik Visković, N. (eds.) 2014: Managing cultural heritage sites in southeastern Europe. Ljubljana. DOI: https://doi.org/10.3986/9789610503675

5.3 Citing chapters of books or proceedings

- Gams, I. 1987: A contribution to the knowledge of the pattern of walls in the Mediterranean karst: A case study on the N. island Hvar, Yugoslavia. Karst and Man, Proceedings of the International Symposium on Human Influence in Karst. Ljubljana.
- Hrvatin, M., Perko, D., Komac, B., Zorn, M. 2006: Slovenia. Soil Erosion in Europe. Chichester. DOI: https://doi.org/10.1002/0470859202.ch25
- Komac, B., Zorn, M. 2010: Statistično modeliranje plazovitosti v državnem merilu. Od razumevanja do upravljanja. Naravne nesreče 1. Ljubljana.
- Zorn, M., Komac, B. 2013: Land degradation. Encyclopedia of Natural Hazards. Dordrecht. DOI: https://doi.org/10.1007/978-1-4020-4399-4_207

5.4 Citing expert reports, theses, dissertations and institutional reports

- Breg Valjavec, M. 2012: Geoinformatic methods for the detection of former waste disposal sites in karstic and nonkarstic regions (case study of dolines and gravel pits). Ph.D. thesis, University of Nova Gorica. Nova Gorica.

- Holmes, R. L., Adams, R. K., Fritts, H. C. 1986: Tree-ring chronologies of North America: California, Eastern Oregon and Northern Great Basin with procedures used in the chronology development work including user manual for computer program COFECHA and ARSTAN. Chronology Series 6. University of Arizona, Laboratory of tree-ring research. Tucson.
- Hrvatin, M. 2016: Morfometrične značilnosti površja na različnih kamninah v Sloveniji. Ph.D. thesis, Univerza na Primorskem. Koper.
- Šifrer, M. 1997: Površje v Sloveniji. Elaborat, Geografski inštitut Antona Melika ZRC SAZU. Ljubljana.
- World commission on environmental and development 1987: Our common future: Brundtland report. Oxford.

5.5 Citing online materials with authors

- Tiran, J. 2021: Slovenija se je v celoti odela v modro. Metina lista. Internet: https://metinalista.si/slovenija-se-je-v-celoti-odela-v-modro/ (3. 11. 2021).
- Davies, G. 2017: The place of data papers: Producing data for geography and the geography of data production. Geo: Geography and Environment. Internet: https://blog.geographyandenvironment.com/2017/09/27/the-place-of-data-papers-producing-data-for-geography-and-the-geography-of-data-production/ (8. 11. 2021).

5.6 Citing websites without authors (e.g. websites of projects and institutions)

Use in-text citations only. It is not necessary to include a citation in the reference list. The in-text citation should include the URL.

5.7 Citing publicly archived data (e.g. statistical data)

Use in-text citations only. It is not necessary to include publicly archived datasets in the reference list. The in-text citation should include the name of the dataset, the institution providing the data and the time frame of the data used.

When the data you cited were published as a report, add it to the reference list and use the following format:

- Popis prebivalstva, gospodinjstev, stanovanj in kmečkih gospodarstev v Republiki Sloveniji, 1991 – končni podatki. Zavod Republike Slovenije za statistiko. Ljubljana, 1993.
- Agriculture, forestry and fishery statistics. 2020 edition. Publications Office of the European Union. Luxembourg, 2020.

5.8 Citing geospatial data and cartographic materials

Geospatial data used in maps should be cited in the colophon on the map (see the Table and Figures section of the Authors' Guidelines). It is not necessary to include geospatial data in the reference list.

When cartographic materials are published as an independent monograph, add it to the reference list and use the following format:

- Buser, S. 1986: Osnovna geološka karta SFRJ 1 : 100.000, list Tolmin in Videm (Udine). Savezni geološki zavod. Beograd.
- Državna topografska karta Republike Slovenije 1 : 25.000, list Brežice. Geodetska uprava Republike Slovenije. Ljubljana, 1998.
- Franciscejski kataster za Kranjsko, k. o. Sv. Agata, list A02. Arhiv Republike Slovenije. Ljubljana, 1823–1869.
- The vegetation map of forest communities of Slovenia 1:400,000. Biološki inštitut Jovana Hadžija ZRC SAZU. Ljubljana, 2002.

5.9 Citing legal sources

Use in-text citation. It is not necessary to include a citation in the reference list. The in-text citation should include the title of legal document and the year.

5.10 In-text citation examples

All references in the reference list are cited in the text. In-text citations should include the last name of the author(s) or the name of the institution, and the year of publication. Separate individual citations by semicolons, arrange citations by year of publication, and separate the page information from author(s)' names and years by a comma; for example: (Melik 1955), (Melik, Ilešič and Vrišer 1963; Gams 1982a; Gams 1982b; World Commission on Environment and Development 1987). For references with more than three authors, cite only the first, followed by et al.: (Melik et al. 1956). Give page numbers only for direct quotations. Narrative citations: Perko (2016, 25) states: »Hotspots are …« or parenthetical citation (Kokole 1974, 7–8).

When citing online materials without authors, such as project or institutional websites, the URL should be included, for example: »The aim of the LABELSCAPE project is to develop mechanisms for integrating sustainability labels into tourism policy (https://labelscape.interreg-med.eu).«

When citing publicly archived data, such as statistical data, inform the reader in the text with the name of dataset, the time frame, and the institution that provides the data: »The 2000–2020 population data used in the analysis were provided by the Eurostat«. If the statistical data were published as a report, cite the document, e.g. (Popis prebivalstva … 1993).

When citing legal sources such as legislative acts, white papers, etc., you should provide (short formal) title and the year, for example: »… The European Commission's White paper on transport (2011) sets out ten strategic goals for a competitive and resource-efficient transport system: …«

5.11 Reference list

Arrange references alphabetically and then chronologically if necessary. Identify more than one reference by the same author(s) in the same year with the letters *a*, *b*, *c*, etc., after the year of publication: (1999a; 1999b). Use this format for indirect citations: (Gunn 2002, cited in Matei et al. 2014).

Include the Digital Object Identifier (DOI) in the reference if available. Format the DOI as follows: https://doi.org/… (for example: https://doi.org/10.3986/AGS.1812).

6 Tables and figures

Number all tables in the article uniformly with their own titles. The number and the text are separated by a colon, and the caption ends with a period. Example:

Table 1: Number of inhabitants of Ljubljana.

Table 2: Changes in average air temperature in Ljubljana (Velkavrh 2009).

Tables should contain no formatting and should not be too large; it is recommended that tables not exceed one page.

Upload figures to the OJS as separate supplementary files in digital form. If the graphic supplements prepared cannot be uploaded using these programs, consult the editorial board (ags@zrc-sazu.si) in advance.

Number all figures (maps, graphs, photographs) in the article uniformly with their own titles. Example:
Figure 1: Location of measurement points along the glacier.

All graphic materials must be adapted to the journal's format. Illustrations should be exactly 134 mm wide (one page) or 64 mm wide (half page, one column), and the height limit is 200 mm.

To make anonymous peer review possible, include the name of the author(s) with the title of the illustration in the supplementary file metadata, but not in the article text.

Maps should be made in digital vector form with Corel Draw, Adobe Illustrator, or a similar program, especially if they contain text. They can exceptionally be produced in digital raster form with at least 300 dpi resolution, preferably in TIFF or JPG format. For maps made with *CorelDraw* or *Adobe Illustrator*, two separate files should be prepared; the original file (.cdr or .ai format) and an image file (.jpg format).

For maps made with ArcGIS with raster layers used next to vector layers (e.g., .tif of relief, airborne or satellite image), three files should be submitted: the first with a vector image without transparency together with a legend and colophon (export in .ai format), the second with a raster background (export in .tif format), and the third with all of the content (vector and raster elements) together showing the final version of the map (export in .jpg format).

Do not print titles on maps; they should appear in a caption.

Save colors in CMYK, not in RGB or other formats.

Use Times New Roman for the legend (size 8) and colophon (size 6). List the author(s), scale, source, and copyright in the colophon. Write the colophon in English (and Slovenian, if applicable). Example:

Scale: 1:1,000,000
Content by: Drago Perko
Map by: Jerneja Fridl
Source: Statistical Office of the Republic of Slovenia 2002
© 2005, ZRC SAZU Anton Melik Geographical Institute

Graphs should be made in digital form using *Excel* on separate sheets and accompanied by data.
Photos must be in raster format with a resolution of 240 dots per cm or 600 dpi, preferably in .tif or .jpg formats; that is, about 3,200 dots per page width of the journal.

Figures containing a screenshot should be prepared at the highest possible screen resolution (Control Panel\All Control Panel Items\Display\Screen Resolution). The figure is made using Print Screen, and the captured screen is pasted to the selected graphic program (e.g., *Paint*) and saved as .tif. The size of the image or its resolution must not be changed.
Examples of appropriate graphic data formats: see the templates of maps in cdr and mxd files (available at https://ags.zrc.sazu.si) for a full-page map in landscape layout and an example of the correct file structure (available at https://ags.zrc.sazu.si) for submitting a map created with *ESRI ArcGIS*.

SUBMISSION PREPARATION CHECKLIST

As part of the submission process, authors are required to check off their submission's compliance with all of the following items, and submissions may be returned to authors that do not adhere to these guidelines.

- I, the corresponding author, declare that this manuscript is original, and is therefore based on original research, done exclusively by the authors. All information and data used in the manuscript were prepared by the authors or the authors have properly acknowledged other sources of ideas, materials, methods, and results.
- Authors confirm that they are the authors of the submitting article, which is under consideration to be published (print and online) in the journal *Acta geographica Slovenica* by Založba ZRC, ZRC SAZU.
- All authors have seen and approved the article being submitted.
- The submission has not been previously published, nor it is under consideration in another journal (or an explanation has been provided in Comments to the Editor). Authors have disclosed any prior posting, publication or distribution of all or part of the manuscript to the Editor.
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- The journal policies and guidelines have been reviewed and followed.

- The metadata (title, abstract, key words, authors, affiliation, ORCiD, etc.) are provided in English (Slovenian authors must provide the metadata also in Slovenian language).
- The list of authors is complete. Failure to do so may result in co-authors not being listed on the article at publication.
- The submission is in Microsoft Word format and the document template was used (single-spaced text, 12-point font, no formatting except italics and bold).
- The article has been checked for spelling and grammar.
- Figures are not embedded in the Word file and are provided as a supplementary file: editable vector format (e.g., cdr, ai) for maps and illustrations; tif for photographs; xlsx for graphs. The Word file includes only figure captions.
- Tables are placed in the Word file with text at the appropriate place.
- The reference list was prepared following the guidelines.
- All references in the reference list are cited in the text.
- Where available, URLs and DOI numbers for references are provided.
- Supplementary files are in one .zip file.
- Authors agree that any costs of English proofreading are borne by the author(s). No additional costs are associated with the submission.
- The instructions for ensuring a double-blind review have been followed.

ACTA GEOGRAPHICA SLOVENICA EDITORIAL REVIEW FORM

This is a review form for editorial review (version 14) of an article submitted to the AGS journal.

This is an original scientific article.
(The article is original and the first presentation of research results with the focus on methods, theoretical aspects or a case study.)

- Yes
- No

The article follows the standard IMRAD/ILRAD scheme.

- Yes
- No

The article's content is suitable for reviewing in the AGS journal.
(The article is from the field of geography or related fields of interest, the presented topic is interesting for the readers of *Acta geographica Slovenica* and well presented. In case of negative answer add comments below.)

- Yes
- No

Editorial notes regarding the article's content.

The reference list is suitable (the author cites previously published articles with similar topics from other relevant geographic scientific journals).

- Yes, the author cited previously published articles on a similar topic.
- No, the author did not cite previously published articles on a similar topic.

Notes to editor-in-chief regarding previously published scientific work.

Is the language of the article appropriate and understandable?

RECOMMENDATION OF THE EDITOR
- The article is accepted and can be sent to the review process.
- Reconsider after a major revision (see notes).
- The article is rejected.

ACTA GEOGRAPHICA SLOVENICA REVIEW FORM

This is *Acta geographica Slovenica* review form (version 7).

1 RELEVANCE

Are the findings original and the article is therefore a significant one?
- yes
- no
- partly

Is the article suitable for the subject focus of the AGS journal?
- yes
- no

2 SIGNIFICANCE

Does the article discuss an important problem in geography or related fields?
- yes
- no
- partly

Does it bring relevant results for contemporary geography?
- yes
- no
- partly

What is the level of the novelty of research presented in the article?
- high
- middle
- low

3 ORIGINALITY

Has the article been already published or is too similar to work already published?
- yes
- no

Does the article discuss a new issue?
- yes
- no

Are the methods presented sound and adequate?

- yes
- no
- partly

Do the presented data support the conclusions?

- yes
- no
- partly

4 CLARITY

Is the article clear, logical and understandable?

- yes
- no

If necessary, add comments and recommendations to improve the clarity of the title, abstract, keywords, introduction, methods or conclusion:

5 QUALITY

Is the article technically sound? (If not, the author should discuss with the Editorial Board [ags@zrc-sazu.si] for assistance.)

- yes
- no

Does the article take into account relevant current and past research on the topic?

- yes
- no

Propose amendments, if no is selected:

Is the references list at the end of the article adequate?

- yes
- no

Propose amendments, if no is selected:

Is the quoting in the text appropriate?

- yes
- no
- partly

Propose amendments, if no is selected:
Which tables are not necessary?
Which figures are not necessary?

COMMENTS OF THE REVIEWER

Comments of the reviewer on the contents of the article:
Comments of the reviewer on the methods used in the article:

RECOMMENDATION OF THE REVIEWER TO THE EDITOR-IN-CHIEF

Please rate the article from 1 [low] to 100 [high] (this will NOT be presented to the author):
Personal notes of the reviewer to the editor-in-chief (this will NOT be presented to the authors):

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The first author of the article shall receive one free copy of the publication.

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PUBLISHER

Anton Melik Geographical Institute
Research Center of the Slovenian Academy of Sciences and Arts
PO Box 306
SI–1001 Ljubljana
Slovenia

SOURCES OF SUPPORT

The journal is subsidized by the Slovenian Research Agency and is issued in the framework of the Geography of Slovenia long-term core research programme (P6-0101). The journal is also supported by the Slovenian Academy of Sciences and Arts.

JOURNAL HISTORY

Acta geographica Slovenica (print version: ISSN: 1581-6613, digital version: ISSN: 1581-8314) was founded in 1952. It was originally named *Geografski zbornik / Acta geographica* (print ISSN 0373-4498, digital ISSN: 1408-8711). Altogether 42 volumes were published. In 2002 *Geographica Slovenica* (ISSN 0351-1731, founded in 1971, 35 volumes) was merged with the journal.

Since 2003 (from volume 43 onward) the name of the joint journal has been *Acta geographica Slovenica*. The journal continues the numbering system of the journal *Geografski zbornik / Acta geographica*.

Until 1976, the journal was published periodically, then once a year, from 2003 twice a year and from 2019 three times a year.

The online version of the journal has been available since 1995. In 2013, all volumes of the magazine were digitized from the beginning of its publication to 1994 inclusive.

All articles of the journal are available free of charge in digital form on the journal website http://ags.zrc-sazu.si.

Those interested in the history of the journal are invited to read the article »The History of *Acta geographica Slovenica*« in volume 50-1.

ISSN: 1581-6613
UDC – UDK: 91
ACTA GEOGRAPHICA SLOVENICA
GEOGRAFSKI ZBORNIK

61-2
2021

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Print/tisk: Present, d. o. o.

Ljubljana 2021

ACTA GEOGRAPHICA SLOVENICA
GEOGRAFSKI ZBORNIK
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ISSN 1581-6613
9 771581 661010