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Research Article

The role of TCI and TCCI indexes in regional tourism planning

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Abstract

Podunavlje region in Serbia comprises 16.6% of the territory and 38.9% of the total population of the country. Due to its attractive natural values, cultural-historical monuments, ethnographic features, etc., Serbian Podunavlje has favorable conditions for the development of excursion, nautical, stationary, event, youth, rural, hunting, transit, and other kinds of tourism. Since the climate as a tourism resource and the factor of tourist migrations in the observed area has not been analyzed yet, the aim of this paper is the tourism valorization of the significance of climate using the two tourism climatic indexes: tourism climate index (TCI) and tourism climate comfort index (TCCI). To achieve it, the climate elements were first analyzed at five meteorological stations in Serbian Podunavlje: Sombor, Novi Sad, Belgrade, Veliko Gradište, and Negotin for the period 1990–2010. Then the periods favorable for tourism activities were determined according to the mentioned indexes at the given stations. The research results show that summer is certainly the most favorable season for tourism activities in the observed area since the maximum TCI values were recorded during summer, and the minimum ones during winter at all the stations. Regarding the TCCI, the most optimal values of this index were recorded in September and May. These results can further serve the tourism organizations in the municipalities in Serbian Podunavlje when considering the construction of the tourism infrastructure, marketing activities, and further affirmation of the resources for the purpose of sustainable development of tourism.

Highlights:

- Cohesion between climatic conditions and tourism in the regional planning

- TCI and TCCI climatic indexes as useful tools for the tourism valorization

- Podunavlje region in Serbia – the area of the most frequent tourism flows in the country

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1. INTRODUCTION

Climate is a very important factor which affects numerous tourism activities, from swimming and sunbathing, ski-sports, water sports and nautics to extreme sports and rehabilitation. Also, it has an impact on the directions of tourism development, potential investments in tourism, the duration and quality of a tourism season, as well as on the quantitative and qualitative space transformation in terms of sustainable development. Climate is an important tourism resource in sun-and-beach tourism, even though it has an indirect impact on other forms of tourism as well (Jahić & Mezetović, 2014; Joksimović, Gajić & Golić, 2013; Pecelj et al., 2019). Numerous studies have shown that the climate changes will affect the tourists' choice of destination (Amelung, Nicholls & Viner, 2007; Dogru et al., 2019; Matzarakis, 2007; Scott et al., 2008) because some destinations will not meet all the tourists' needs, and they will not be willing to spend money to visit them. Also, the natural surroundings represent a crucial resource for the development of tourism, and the changes in nature caused by the climate changes will certainly affect tourism destinations.

When proper planning of the accommodation capacities and accompanying amenities of a tourist destination is implemented, a more precise interpretation of the climatic conditions can help. In that way, visitors are provided with appropriate comfort, and a tourist entrepreneur will invest optimally in the infrastructure. Studies on climatic conditions can go in the direction of determining positive or negative climate conditions in resorts or similar locations. The goal is to obtain relevant data and conclusions on the length of the period in which the facilities can operate profitably during the year. Also, the way of placing and publishing tourist information with an alternative offer of the destination in case of unfavorable climatic conditions may depend on this (de Freitas, 2003).

The location of hotels, tourism offer, events organization, usage of infrastructure, etc. will all depend on climate conditions (Matzarakis, 2006). The papers where climate is considered in the context of tourism are numerous (Berritella et al., 2006; Callaway et al., 2010; Koenig & Abegg, 1997; Martín, 2005; Moreno, 2010; Pecelj et al., 2018; Perch-Nielsen, Amelung & Knutti, 2010; Scott et al., 2004). Developed tourism regions, such as the Mediterranean and the Alps, and the climate changes that occur there are in the focus of the works by Amelung & Viner (2006), Cengiz et al. (2008), Koenig & Abegg (1997), and many others. Climate indexes and coefficients (comfort indexes), which define the impact of the climatic elements on people are represented in the form of complex equations of the balance of human body energy in the works by Anđelković et al. (2016), de Freitas (1990), Matzarakis et al. (2008), Matzarakis (2009), and Mieczkowski (1985).

The prevailing models for the climate assessment for the purposes of tourism development are mainly focused on climate indices which consider only elementary climate elements (e.g. precipitation, humidity, air temperature, etc.) and mean monthly values (Mieczkowski, 1985; Matzarakis & de Freitas, 2001; Matzarakis et al., 2004). The climate indices do not have physiological or thermal importance nor do they offer enough evidence about frequencies of extreme events. Furthermore, they do not provide high temporal resolution (Petrović et al., 2021). According to de Freitas (2003), the current indices do not obtain all imperative factors and facets, so new methods should comprise various and innovative facets of climate for contemporary tourism development (Weir, 2017; Hoogendoorn & Fitchett, 2018; Scott, Hall & Gössling, 2019).

Considering that there are not many works that deal with this issue in Serbia, this paper will focus on Podunavlje region (area along the Danube river), which stands out as a separate tourism entity in Serbia due to its natural and anthropogenic tourism values. With a length of about 2,850 km, the Danube represents the second largest river in Europe (after the Volga) and the largest river in Central and South-Eastern Europe. Today, the Danube flows through 10 countries, more than any other river in the world, before draining into the Black Sea (Lukić & Petrović, 2019). Its drainage basin extends into nine more countries. In Serbia, Podunavlje region covers an area of 15,755 km^2, and according to the latest 2011 census, nearly three million inhabitants live in its nine administrative units and 499 settlements (Statistical Office of the Republic of Serbia, 2014), which is about 38.9% of the total population of Serbia. The

Serbian section of the Danube is 588 km long and, with one part of the flow, it represents a natural border with Croatia and Romania. The interesting natural landscapes are connected with certain ethnographic specific features with the corresponding forms of economy (e.g. fishing, animal husbandry) and folklore characteristics. All this provides favorable conditions for the development of numerous kinds of continental tourism forms throughout the year, such as short visits, nautical, stationary, event, youth, rural, hunting, and transit tourism. Most of these kinds of tourism complement each other and affect a higher level of use of accommodation capacities and the accomplishment of better economic effects. Since climate is becoming an important factor in the choice of tourism destination (Hu & Ritchie, 1993; Lohmann & Kaim, 1999), for the valorization of the climate in the observed region, in this study, we will analyze tourism climate index (TCI) developed by Mieczkowski (1985) and tourism climate comfort index (TCCI) developed by Anđelković et al. (2016). The research goal is to explore the relationship between TCI and TCCI on tourism development in the observed region and to identify the differences and similarities. Considering that valorization of the climate represents an important factor of estimation and future initiatives in tourism progress, the research aims to investigate the effects of these analyses on further tourism policy and regional perspectives.

2. DATA & METHODS

For the needs of this paper, we first analyzed the values of the climatic elements for the 20-year period 1991–2010, followed at the meteorological stations in the Serbian Podunavlje region: Sombor, Novi Sad (Rimski Šančevi), Belgrade, Veliko Gradište, and Negotin (Figure 1). This period was chosen for the analysis since there are continuous data for it which regard all the climatic elements necessary for the analysis of the climate indexes at the abovementioned stations in the observed area.

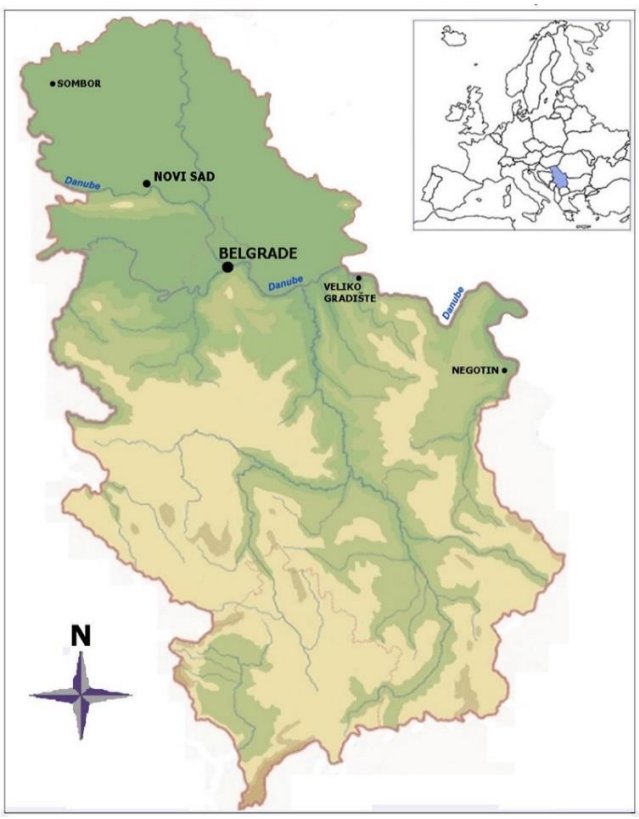
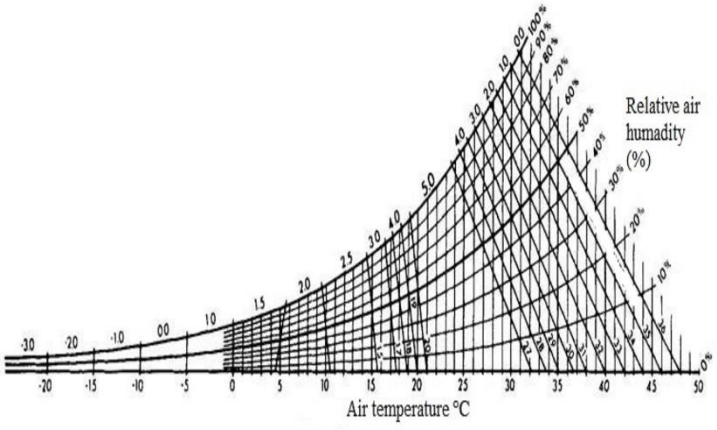


Figure 1. The map of Serbia with the locations of the observed meteorological stations.

Then, the periods suitable for tourism throughout the year were determined on the basis of tourism climate index (TCI) and tourism climate comfort index (TCCI). Tourism climate index (TCI) valorizes climate as a resource for the development of tourism on the basis of two bioclimatic and three individual climatic elements. The bioclimatic elements that are valorized are: daylight comfort index (tk – the relation between the maximum daily air temperature and the minimum daily relative air humidity) and the daily comfort index (tk_{24h}– the relation between the average daily air temperature and the average daily relative air humidity). The individual climatic elements that are valorized are insolation (S), precipitation (R) and wind speed (W) (Figure 2). Tourism climate index (TCI) is calculated using the following formula:

$$TCI = 8 \cdot tk + 2 \cdot tk_{24h} + 4 \cdot R + 4 \cdot S + 2 \cdot W$$

The maximum value of TCI can be 100. According to the TCI range, the weather for tourism can be: *ideal* (90–100), *excellent* (80–89), *very good* (70–79), *good* (60–69), *acceptable* (50–59), *possible* (40–49), *undesirable* (30–39), *very undesirable* (20–29), *extremely undesirable* (10–19) *and impossible* (-30–9) (Mieczkowski, 1985).



Points	R (mm)	S (h)	W (m/s)
5.0	≤14.9	>10	< 0.8
4.5	15.0–29.9	9-10	0.8-1.5
4.0	30.0-49.9	8-9	1.6-2.5
3.5	50.0-59.9	7-8	2.6-3.3
3.0	60.0-74.9	6-7	3.4-5.4
2.5	75.0-89.9	5-6	5.5-6.7
2.0	90.0-104.9	4-5	6.8-7.9
1.5	105.0-119.9	3-4	-
1.0	120.0-134.9	2-3	8.0 – 10.7
0.5	135.0-149.9	1-2	-
0	150.0-209.0	0-1	> 10.7
-0.5	-	-	-
-1.0	210.0-269.9	-	-
-1.5	-	-	-
-2.0	270.0-329.9	-	-

Figure 2. The diagram for the valorization of the thermal comfort (tk, tk_{24h}) and the table for the valorization of average monthly precipitation sums (R), average daily insolation (S), and the average monthly wind speed (W).
Note: ^{0}C – air temperature in degrees Celsius and % – relative air humidity.
Source: *Adapted from Mieczkowski (1985)*.

On the other hand, TCCI points to the climate comfort for tourist flows, i.e. it provides information on when the climate is most probably favorable in a destination for indoor and outdoor activities. It is calculated using the following formula:

$$TCCI = Tm + 0.5ATm + 0.1(Sm – Um) – nrd$$

where Tm is the average monthly air temperature (ºC), ATm – average monthly air temperature amplitude (ºC), Sm – monthly insulation (h), Um – average monthly air humidity (%), nrd – the number of rainy days in the given month (Anđelković et al., 2016). According to the tourism comfort values, a scale of climate comfort is made (Table 1). The negative index shows that that month is not favorable for tourism activities. Its positive values up to 30 points to the climate favorability, but the higher they are, the less attractive they are for tourist flow.

According to the yearly index changes, the same authors distinguish four types of the yearly distribution of the comfort zone in Serbia have been distinguished:

1. spring-autumn type (SpAut): maximum comfort in May and September;
2. expanded spring-autumn type (ESpAut): maximum comfort in June and September;
3. summer type (Sut): maximum comfort in July and August; and
4. spring type (Spt) maximum comfort only in May or in June (Anđelković et al., 2016).

Table 1. Tourism climate comfort index scale

Index value	Rate	Description	Purpose
less than 0	very unfavorable	unfavorable and unpleasant	snow activities
0-20	unfavorable	partially pleasant and favorable	excursions
20-30	favorable	pleasant and favorable	all tourism activities except extreme and snow activities
30-40	unfavorable	partially pleasant and favorable	recreational water activities (sunbathing, swimming, lake, spa)
over 40	very unfavorable	unfavorable and unpleasant	sunbathing, swimming

Source: Adapted from Anđelković et al., 2016.

3. RESULTS AND DISCUSSION

Since the Serbian Podunavlje region is situated in the humid continental and continental zones, it is characterized by the insolation of over 2,100 hours a year. The greatest insolation in the period 1991–2010 was recorded at Novi Sad station with 2,198.8 hours, and the smallest was at Veliko Gradište station with 2,089.9 hours of sunshine. In Podunavlje region, for the observed stations, the average annual air temperatures were in the range from 11.5ºC in Veliko Gradište and Novi Sad to 12.5ºC in Belgrade. The highest average monthly air temperatures were in July, up to 23.8ºC and in August 23.8ºC in Negotin, whereas the lowest ones were in winter, especially in January, when the temperatures went below zero. In January, the average air temperature values ranged from 0.4ºC in Sombor, Novi Sad and Veliko Gradište to 1.7ºC in Belgrade.

When the average maximum air temperatures are concerned, they were the highest in July and August, and in Novi Sad they went up to 31.6ºC and 31.2ºC respectively. In May, the average maximum air temperatures were above 22ºC, and they were high during September and October. The average total number of summer days (days with maximum temperatures ≥ 25°C) for the observed period ranged from 98 in Novi Sad to 110 in Negotin, and the largest was in July and August with about 25 on average, during June from 19 to 23 and in September from 11 to 14, which can have a favorable impact on sun-and-beach, sport and recreational, and nautical tourism.

In Podunavlje region, the most frequent wind is from the south-east quadrant, so-called *košava*, and northwesterly and westerly winds. These winds had the highest frequency at the meteorological stations in Veliko Gradište (250‰) and Belgrade (213‰) (*košava*), and the westerly ones at the stations in Novi Sad (221‰) and Belgrade (201‰). Besides the high frequency of the winds, their speed is also specific. The average wind speed was the highest in Veliko Gradište (2.4 m/s) and Novi Sad (2.6 m/s). The longest silent periods were recorded in Negotin (331‰), and the shortest ones in Novi Sad (40‰) and Belgrade (44‰). For the observed period, the lowest average yearly relative air humidity was recorded in Belgrade (68%), and the highest in Novi Sad (75%). The highest average monthly values of over 80% occurred during November, December and January and the lowest ones were in spring and summer. The cloud cover was the smallest in June, July and August and it ranged from 3.1 to 4.8 tenths of the sky. The smallest average yearly cloud cover was recorded in Negotin (5.1 tenths), and the largest in Veliko Gradište (5.5 tenths). The largest average monthly cloud cover occurred in December and it ranged from 6.8 tenths in Negotin to 7.3 tenths in Novi Sad and Veliko Gradište. The average number of foggy days for the period 1991–2010 ranged from 26 in Negotin and Novi Sad to 36 in Sombor. Monthly, the largest number of foggy days was in winter months and late fall, more precisely, in November, December and January. Fog rarely happens during summer months. The total annual quantity of precipitation in the Serbian Podunavlje region ranges from 570 mm to 686 mm, which is in accordance with the continental

climate and the development of steppe vegetation. Maximum precipitations occur in spring, the secondary maximum is in fall, and the minimum precipitation is during winter months (Lukić, 2015).

Using TCI, it is possible to determine favorable climate periods for tourism activities in the Serbian Podunavlje region (Table 2). The TCI values at the analyzed stations ranged from 33 (undesirable weather) to 93 (ideal weather). There were no values in the scope of very undesirable, extremely undesirable, and impossible weather for tourism, which points to the potential for the development of the all-year-round tourism without seasons. At all the stations, the maximum TCI values occurred in summer months, and the minimum values were in winter months. It indicates that the most favorable season for tourism in the observed region is summer. The ideal weather was in August at the stations in Sombor (TCI – 90), Veliko Gradište (TCI – 90), and Negotin (TCI – 93). Excellent weather (TCI – 80–89) from May to September was recorded at the stations in Belgrade, Veliko Gradište, and Negotin. At the station in Novi Sad that period was prolonged and comprised April as well, whereas in Sombor that period was shorter and lasted from May to July. In December, the conditions were unfavorable for the tourists' stay and outdoor activities in Sombor, Veliko Gradište, and Negotin (TCI – 30–39), whereas the conditions for the same month were more acceptable for tourism activities in Belgrade (TCI – 41) and Novi Sad (TCI – 51).

Table 2. TCI values in the Serbian Podunavlje region for the period 1991–2010

Station	J	F	M	A	M	J	J	A	S	O	N	D
Sombor	43	51	57	72	84	84	86	90	78	55	54	33
Novi Sad	46	53	61	80	81	81	80	82	82	74	53	51
Belgrade	43	49	57	63	84	82	88	76	80	70	51	41
Veliko Gradište	42	48	57	68	84	92	88	90	80	66	53	39
Negotin	43	49	58	73	89	88	85	93	80	68	47	38

Negative values of the tourism climate comfort index at all the stations in the Serbian Podunavlje region were recorded during December and January. In Sombor and Negotin, these values occurred in November as well. Such an index value only conditions the possibility of tourism snow activities, but since it is the case of lowland stations, such an index negatively affects tourism activities. The most optimal index values (TCCI - 20–30) were recorded in September at all the stations except in Negotin, and in May at the stations in Belgrade and Veliko Gradište. Such a favorable index is good for all the tourism activities except for extreme sports and snow activities. The index values of 30–40 during May were recorded at the stations in Sombor, Novi Sad, Negotin, and in June at all the stations except in Negotin. Such an index points to the favorable conditions for recreation water activities, i.e. sunbathing, swimming, as well as to the possibility of the development of lake and spa tourism. Tourism climate comfort index with the values over 40 was recorded in July and August at the stations in Sombor, Novi Sad, Veliko Gradište, and Negotin. Since it is very unfavorable and unpleasant, this index only indicates to the possibility for sunbathing and swimming. The last two values (classes 30-40 and over 40) of the index indicate a high possibility for the development of sun-and-beach tourism in the Serbian Podunavlje region in summer months (Table 3).

Table 4 presents the data from the Statistical Office of the Republic of Serbia regarding the number of tourists for the year 2010 at the analyzed stations in the studied area. From the Table it can be concluded that the largest number of visitors, in terms of seasons, was recorded during summer at all the stations, which is in accordance with the maximum values of TCI. The largest number of tourists, in terms of months, was recorded in May, September, and October, which mostly match the most favorable period for tourism activities obtained according to the values of TCCI for the given stations.

Table 3 TCCI values in the Serbian Podunavlje region for the period 1991-2010

Station	J	F	M	A	M	J	J	A	S	O	N	D
Sombor	-6.44	3.94	12.39	19.85	30.81	35.56	41.35	41.16	23.84	14.44	-0.6	-9.59
Novi Sad	-6.21	2.07	11.61	18.36	30.48	34.49	42.84	40.85	24.57	15.23	0.74	-9.58
Belgrade	-5.67	3.15	10.02	16.01	26.44	32.72	38.74	36.87	24.34	13.78	0.88	-9.65
Veliko Gradište	-6.46	1.6	10.01	15.83	26.37	33.59	40.5	40.23	24.27	13.44	0.83	-9.32
Negotin	-1.72	5.25	13.02	19.48	31.66	41.72	49.11	44.47	15.3	12.8	-1.18	-6.77

Table 4 The total number of visitors in the Serbian Podunavlje region in 2010 (Statistical Office of the Republic of Serbia, 2014)

Station	J	F	M	A	M	J	J	A	S	O	N	D
Sombor	353	389	401	730	904	770	755	716	717	971	571	515
Novi Sad	3,50	4,12	5,17	7,47	12,45	7,42	11,26	6,44	9,23	14,79	7,56	6,54
Belgrade	28,81	36,49	42,10	49,10	56,08	55,88	61,24	66,05	68,744	60,06	46,37	47,48
Veliko Gradište	0	0	393	602	2,601	985	970	886	1,38	1,79	9	12
Negotin	94	202	316	382	367	619	313	319	1077	410	267	160

4. CONCLUSIONS

The outdoor tourism planning is particularly climate-sensitive. Climate affects the appropriateness of destinations for a broad range of activities and could significantly influence the estimation of visitors' flows and the organization of outdoor tourism events of any kind. It should be highlighted that the nature and the magnitude of climate fluctuation impacts differ among destinations worldwide. Global climatological changes are increasingly the subjects to extensive debates within the scientific community. Without knowledge of nature and its characteristics, there is no good economic and social development, nor development in terms of contemporary tourism. This has also affected the tourism market, so modern trends are embodied in the sustainability of tourism trends, including weather-induced impacts. The applied methodology of calculating TCI and TCCI indexes provides a helpful overview of the climate as a tourism resource of the observed region in Serbia. Together with this, it could be a useful tool for similar research in the whole Danube basin in other European countries.

Namely, the TCCI index, as a key climatic element for the tourists' feeling of comfort, emphasizes the air temperature and excludes the wind speed. Since the frequency of winds in the observed region exceeds the value of 200‰ a year and wind speeds are 2.6 m/s, the analysis of winds is very important for tourism activities and for the tourists' comfort. By using the TCI index, which valorizes this climatic element as well, the negative sides of TCCI index are eliminated. Certainly, we should bear in mind that the estimations of tourist flows in the tourism sector by using climate tourism indexes do not provide the complete overview of the problem, since there are a lot of other factors of tourist flows that are impossible to comprise only by climatic indicators.

The results of our research have pointed to several important questions: tourism climate index and tourism climate comfort index may be beneficial tools in empirical analysis in tourism; climate creates various conveniences for the tourists' activities in various seasons; and the Serbian Podunavlje region has favorable climatic characteristics for the development of various types of tourism, except winter/ski tourism. Even though tourism organizations and local authorities in the observed region do not focus on the analysis of the climate as a tourism resource, the knowledge related to it can be helpful both for marketing purposes and for the construction of tourism infrastructure and the development of tourism resources in general. With good organization, the investigated climatic indexes and proper weather forecasting can have a positive effect on the state of the elements of regional tourism planning, contribute to

the promotion of climatic studies in tourism literature and the popularization of scientific knowledge about the connection between tourism and climatology studies.

This study is important because it is one of the first research projects on a combination of climatic indexes, along with their role in tourism knowledge in Serbia and this part of Europe. Moreover, Serbian society is currently going through an intensive period of adjusting to the new social and economic (tourism) changes in rural areas, including the observed region, so these outcomes play a significant role in understanding the impacts of external determinates. This could be connected with the global trend of the conditionality of outdoor events (such as tourism) on weather-induced impacts, especially in developing destinations. The evident gap in this type of research should be upgraded and put forward in similar tourism studies that should be further developed.

The main limitation in the research and our suggestion for future studies is to introduce new modifications in the current indexes, so examination of the climate determinants and their impact on tourism perspectives might reach higher significance. The second issue that we would like to point out is the evident national character of the study (although large enough on the national scale, it involved only one region in Serbia), so future research should involve other regions in the country and the whole Danube basin with similar tourism prospect. In that way, the entire research would have greater importance and data would be more relevant and comprehensive for the chosen geographic area and perhaps for the entire country and similar developing societies.

Although there are limitations within this study that demand further research, certain benefits arise from our findings. The most important practical implications of this paper are twofold: a) the results of the research have shown that the applied methodology of calculating TCI and TCCI indexes offer a supportive outline of the climate as a tourism resource in Serbia and it could be a valuable instrument for comparative studies in other settings; b) the larger number of visitors, in terms of seasons, in the Serbian Podunavlje region mainly occurs in those periods of the year which are favorable for tourism activities, according to the tourism indexes. This research can affect future studies to investigate the relationship between climate and tourism from a regional perspective, on one side, and also alternative opportunities for local development in less-advantaged communities, on the other side. In addition, this supports the research goal to identify the differences and similarities of the relationship between TCI and TCCI indexes and the benefit in similar, future tourism studies.

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