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Recent insights into spatial and temporal changes of aridity in the region of southern and eastern Serbia

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Abstract— This study investigated the spatial and temporal distribution of aridity indices to determine climatic conditions in regions of southern and eastern Serbia in the period 1961-2022. We used the mean monthly and annual air temperature and precipitation data obtained from nine meteorological stations in the study area. Three indices were used to quantify aridity: the de Martonne aridity index, the Emberger index and the Pinna combinative index. Calculations are carried out on an annual scale for all the indices mentioned. The results show large territorial differences in the de Martonne aridity index, which distinguishes between two climate types on an annual basis. The Emberger index is characterized by humid climate types for all meteorological stations in the area. The Pinna combinative index also indicates humid conditions in the entire area, although the annual values of the index vary considerably. There was no change in the trend of aridity in the study area during the period of investigation. The spatial distribution was determined via the inverse distance weighting interpolated method. The Mann-Kendall test indicated that the aridity trends at all the meteorological stations were not statistically significant.

Key-words: aridity indices, trends, spatial analysis, region of Serbia

1. Introduction

Climate change is not only a concern for future generations, but its impacts are also already evident. This change can lead to significant damage to natural and socioeconomic systems. According to the *IPCC* (2021) report, extreme heat events have increased in almost all regions of the world since the 1950s. Extreme precipitation and droughts have become more frequent and severe in most land areas worldwide. The absence of precipitation can have significant impacts on sectors such as agriculture and forestry, making its analysis crucial for adaptation strategies in a changing climate.

Aridity presents a lack of moisture and a temporary decrease in precipitation in an area (*Maliva* and *Missimer,* 2012) or water availability (*Moral et al*., 2015). According to the *American Meteorological Society* (2019), "aridity is the degree to which the climate lacks effective moisture to support life". Increasing aridity is a physical hazard that negatively affects many ecosystems and economic sectors, including water management, agriculture, forestry, and tourism. This is because it can be a limiting factor for the growth and spread of plants (*Moral et al.,* 2015). A regional study of aridity, therefore, requires appropriate aridity indices, which can be defined as numerical indicators of the degree of aridity of the climate in a given location. Aridity indices have been applied at continental and subcontinental scales and are mostly related to the distributions of natural vegetation and crops. The critical values of the indices were derived from the observed vegetation boundaries. The parameters for which there is a mathematical relationship between precipitation (and/or humidity) and air temperature are referred as aridity indices. These indices are highly valuable for tracking the impacts of climate change on local water resources (*Maliva* and *Missimer*, 2012). The higher the aridity index values in a region are, the greater the variability in water resources (*Deniz et al.,* 2011; *Arora,* 2002). To quantify aridity, numerous climatic and aridity indices have been developed (*Stephen,* 2005). Indices can be calculated as the ratio between precipitation and potential evaporation, i.e., the aridity index (AI) (*Shoshany* and *Mozhaeva,* 2023; *Zomer et al.,* 2022), the Thornthwaite aridity index (*Thornthwaite,* 1948), or the ratio of precipitation to temperature, i.e., the De Martonne aridity index (I_{DM}) (*De Martonne,* 1926), Lang rain factor (*Lang,* 1915), Pinna combinative aridity index (I_P) (*Zambakas,* 1992), Emberger aridity index (I_E) (*Emberger,* 1930), Lobova aridity index (*Burić et al.,* 2018), etc. The aforementioned indices are based on different variables, which is why they provide different results in the assessment of aridity.

Beštáková et al. (2023) investigated the spatial distribution of arid and humid regions in Europe through the aridity index for the period 1950–2019, concluded that the area of the Balkan Peninsula was identified as arid. *Paniagua et al.* (2019) examined variations in aridity in the Iberian Peninsula from 1960–2017 via the De Martonne aridity index, Pinna combinative aridity index, and Erinç aridity indices. Despite the large spatial variability, they reported that the entire area is dominated by arid conditions, with aridity increasing significantly in future projections on the basis of trends in air temperature and precipitation projections. In Calabria, Italy, researchers used the de Martonne aridity index to identify areas susceptible to aridity (*Pellicone et al*., 2019). The findings indicated that coastal regions were arid, whereas the highest mountains were classified as humid. This study highlights a significant correlation between the de Martonne aridity index results and the region's orography.

Numerous studies have investigated aridity and drought in various Balkan countries, including Croatia (*Ugarković* and *Ugarković,* 2013), Bosnia and Herzegovina (*Trbić et al.,* 2022), Montenegro (*Luković et al*., 2024), North Macedonia (*Aksoy et al.,* 2020), Greece (*Baltas,* 2007), Bulgaria (*Nikolova* and *Yanakiev,* 2020), and Serbia (*Djurdjević et al.,* 2024; *Amiri* and *Gocić,* 2023; *Gocić et al.,* 2025; *Milentijević et al.,* 2025). *Şarlak* and *Mahmood Agha* (2018) used the aridity indices of Lang rain factor, De Martonne, UNEP, and Erinç to estimate the spatiotemporal variation in aridity in Iraq. *Gebremedhin et al*. (2018) and *Moral et al.* (2016) used De Martonne, the combined Pinna, and FAO aridity index, to assess the spatial distributions of aridity in Ethiopia and Spain, respectively. Similarly, *Nikolova* and *Yanakiev* (2020) used the De Martonne and Emberger indices to investigate the spatial pattern of aridity in southern Bulgaria. All the above studies have used aridity indices for specific regions worldwide. Therefore, there is a need for a more comprehensive study to estimate, compare, and interpret the spatiotemporal trends of multiple aridity indices in the study area.

Based on various aridity indices, southern and eastern Serbia are characterized as humid according to the global aridity index (AI) distribution (*Zomer et al.,* 2022), semiarid according to the I_{DM} index, and semidry based on the I_P index (*Radaković et al.,* 2017).

This study employs three aridity indices: the De Martonne aridity index (I_{DM}), the Emberger index (I_E), and the Pinna combinative index (I_P). These indices were calculated via monthly and annual temperature and precipitation data from nine meteorological stations in southern and eastern Serbia, covering the period from 1961–2022.

The main objectives of this study include a detailed analysis of the spatial and temporal distributions of the abovementioned indices. The study provides a detailed analysis of selected aridity indices, examines trends in these indices, and assesses their statistical significance via the nonparametric Mann-Kendall test and Sen's slope analysis. Geographic information systems (GIS) are utilized for spatial modeling of precipitation, temperature, and aridity indices at various time scales through the inverse distance weighted (IDW) interpolation method. Understanding the spatiotemporal patterns of the aridity index is crucial for effective agricultural and water management in the region.

2. Data and methods

2.1. Study area

This research focuses on the NUT 2 unit of southern and eastern Serbia (*Fig. 1*), which covers 26,248 km², or 29.7% of Serbia's total area (*Miletić et al.,* 2017).

The region extends from the Danube in the north to the North Macedonian border in the south, and from the Velika Morava and Južna Morava valleys in the west to the Bulgarian border in the east. The investigated area includes the Dacian Basin (the extreme northeastern part of the research area) toward Romania, and farther south are the mountains of the Carpathian-Balkan massif with valleys between the mountains, where larger settlements are located. South of the river Nišava are the mountains of the Rhodope Serbian-Macedonian massif. The terrain is mountainous with various small-scale features. The area under investigation is located in the central part of Balkan Peninsula, so the continentality of the region is pronounced (*Fig. 1*). The territory of Serbia has a warm temperate–humid climate with warm summers of the Cfb type according to the Köppen climate classification. The maximum precipitation occurs at the beginning of summer and at the end of spring (*Milovanović et al.,* 2017a).

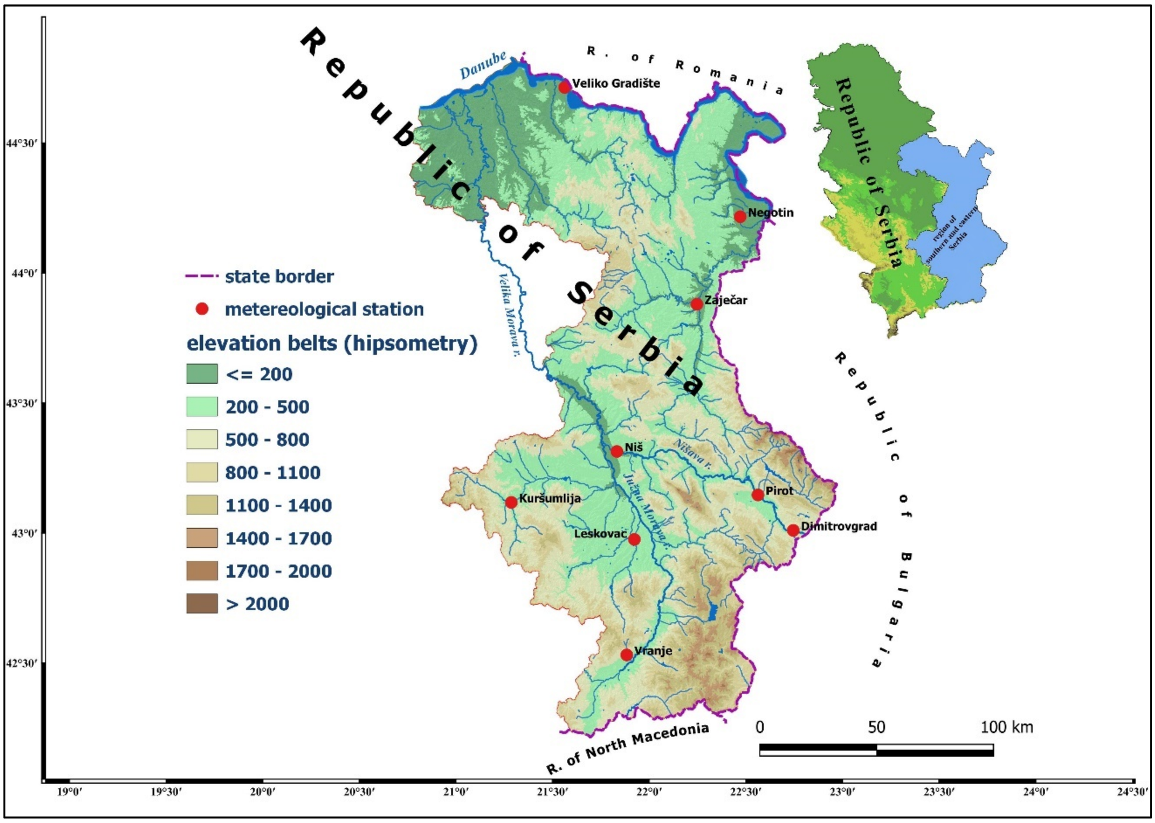

Fig. 1. The regions of southern and eastern Serbia with the locations of the meteorological stations.

To consider the climatic characteristics of the study area, we used the average monthly and annual values of air temperature and precipitation from nine meteorological stations (MS) for the period of 1961–2022 (*Table 1*). The data were retrieved from the Hydrometeorological Service of the Republic of Serbia and can be found in meteorological yearbooks (*RHSS*, 2024). We have only analyzed meteorological stations that have data for the entire period.

Table 1. List of meteorological stations in the investigated area with coordinates, mean annual temperature (T), and precipitation

Meteorological Station (MS)	Latitude	Longitude	Altitude (m)	T (°C)	Precipitation (mm)
Dimitrovgrad	43º01'	22º45'	448	10.2	654.6
Kuršumlija	43º08'	21º16'	384	10.3	666.6
Leskovac	42º59'	21º57'	231	11.2	635.7
Negotin	44º14'	22º32'	42	11.9	637.8
Niš	43º20'	21º54'	202	12.0	602.3
Pirot	43º09'	22º35'	373	11.3	595.8
Veliko Gradište	44º45'	21º30'	80	11.4	666.7
Vranje	42º33'	21º55'	433	11.2	607.6
Zaječar	43º53'	22º17'	144	11.0	617.1

According to data in the yearbooks of RHSS, 2024

2.2. *Methods*

In our study, three aridity indices were used:

– The *de Martonne aridity index* (I_{DM}) is a commonly used climate index for assessing aridity (*De Martonne,* 1926; *Croitoru et al.,* 2013). The index is defined by the following equation for annual (I_{DM}) values:

$$I_{DM} = \frac{P}{T+10} \ , \tag{1}$$

where *P* and *T* are the annual sums of precipitation (mm) and mean annual air temperature (°C), respectively. For monthly and seasonal I_{DM} values monthly and seasonal sums of precipitation and monthly and seasonal means of air temperature are used. The classification according to the I_{DM} is shown in *Table 2*.

Table 2. The De Martonne index (I_{DM}) classification

Climate	**Values of I_{DM}**
arid	I_{DM}<10
semiarid	10≤ I_{DM} <20
mediterranean	20≤ I_{DM} <24
semi humid	24≤ I_{DM} <28
humid	28≤ I_{DM} <35
very humid	35≤ I_{DM} <55
extremely humid	I_{DM} >55

– *The Emberger index (I_E)* is based on data from precipitation totals and average monthly air temperatures of the coldest and warmest months (*Emberger,* 1930). Emberger used this index to classify phytoclimatic regions. For this reason, some scientists have analyzed the distribution of vegetation according to the Emberger index (*Gavilán,* 2005; *Savo et al*., 2012). The Emberger index (I*E*) is calculated via the following formula:

$$I_E = \frac{100*P}{M^2-m^2} \; , \qquad (2)$$

where *P* is the annual sum of precipitation; *M* is the monthly average air temperature of the warmest month; and *m* is the average monthly air temperature of the coldest month. The climate types according to the Emberger index are given in *Table 3*.

Table 3. Climate types according to the Emberger index

Climate	**Values I_E**
arid	I_E < 30
semiarid	30 ≤ I_E ≤ 50
semi humid	51≤ I_E ≤ 90
humid	I_E > 90

– *The Pinna combinative index (I_P)* developed by Pinna (*Baltas,* 2007; *Zambakas,* 1992) defines the combinative or perennial index as:

$$Ip = 0.5 * \left(\frac{P}{Tg+10} + \frac{12*Pdm}{Tgdm}\right), \qquad (3)$$

where *P* represents the annual precipitation (mm); *Tg* represents the annual mean temperature (ºC); *Pdm* represents the precipitation of the driest month (mm); and *Tgdm* represents the temperature of the driest month (ºC). The Pinna combinative index classifications are presented in *Table 4*.

Table 4. Pinna Combinative Index classification (*Baltas*, 2007)

Climate	Values of I_P
dry	$I_P < 10$
semiarid/mediterranean	$10 \leq I_P < 20$
humid	$I_P > 55$

As the index is calculated for a longer period of time, it is successfully used to identify regions threatened by aridity and drought. The dry periods of a year can be distinguished, which is important for agricultural and irrigation activities (*Deniz et al*., 2011).

To determine the magnitude and significance of the trends in the aridity indices and climatic parameters, the nonparametric Mann-Kendall test method and the Sen method were used (*Mann*, 1945; *Helsel* and *Hirsch,* 2002). Trend estimates were made for the period of 1961–2022 on an annual basis.

The geostatistical method of inverse distance weighting (IDW) was used to enable a clear and efficient interpretation of the results. Compared with other interpolation methods (e.g., kriging), this method is easy to apply (*Mei et al.,* 2017) and is preferable to other interpolation methods (*Derdous et al*., 2020). This method was used for the spatial analysis of climate parameters at the annual level. QGIS was used for data processing.

3. Results and discussion

3.1. Temperature and precipitation in the study area

3.1.1. Temperature in the study area

To determine the values of the selected aridity indices, the average longterm air temperature values had to be calculated first. The average air temperature for the period from 1961–2022 was between 10.1 °C at MS Dimitrovgrad and 11.9 °C at MS Nis. Differences in air temperature values at the stations depend on the location of the meteorological station, shelter, or exposure to intrusions of air masses, and altitude, but the differences in values are insignificant (*Table 5*). The lowest monthly average air temperatures at all the stations were recorded in

January. The highest monthly average temperatures were recorded during July and August (MS Vranje). *Fig. 2* shows the spatial distribution of the mean annual temperature in the study area.

Table 5. Mean monthly and annual air temperature values at the meteorological stations for the period 1961–2022

MS	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Ann.
Veliko Gradište	0.0	2.0	6.3	11.8	16.7	20.0	21.7	21.4	16.9	11.7	6.5	1.5	11.4
Vranje	-0.3	2.3	6.3	11.2	15.9	19.3	21.3	21.5	17.1	11.8	6.3	1.3	11.2
Dimitrovgrad	-0.9	1.2	5.1	10.2	14.8	18.2	20.1	19.8	15.6	10.6	5.6	0.9	10.1
Leskovac	-0.3	2.2	6.5	11.5	16.3	19.8	21.5	21.2	16.6	11.1	6.2	1.4	11.2
Zaječar	-0.7	1.4	5.6	11.2	16.3	19.8	21.9	21.3	16.5	10.6	5.5	0.9	10.9
Kuršumlija	-0.2	1.7	5.6	10.5	14.8	18.3	19.9	19.6	15.3	10.6	6.0	1.4	10.3
Negotin	-0.2	1.9	6.6	12.3	17.5	21.3	23.2	22.4	17.6	11.6	6.1	1.6	11.8
Niš	0.4	2.8	7.1	12.2	16.9	20.4	22.3	22.2	17.6	12.2	7.0	2.1	11.9
Pirot	-0.1	2.2	6.3	11.4	15.9	19.5	21.4	21.1	16.8	11.6	6.4	1.6	11.2

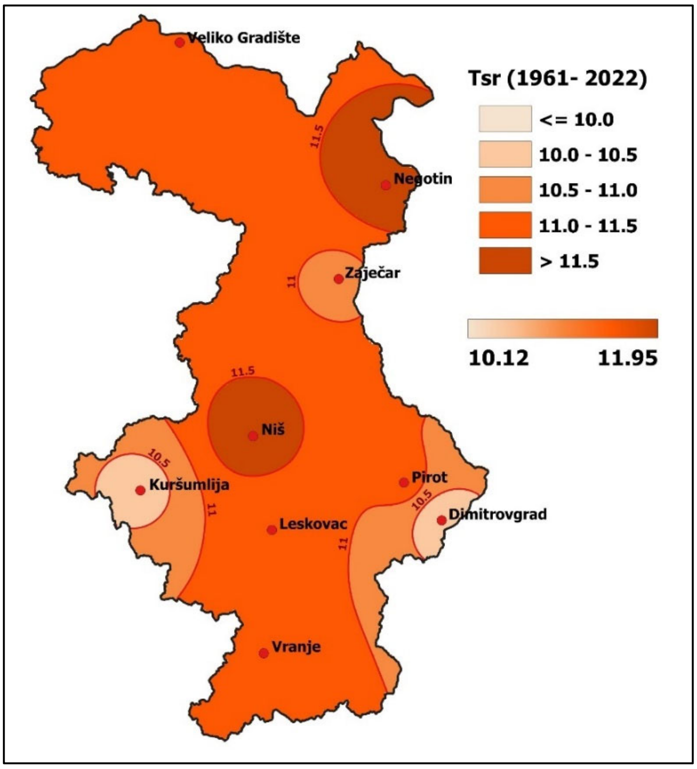

Fig. 2. Spatial distribution of mean annual temperatures in the study area for the period 1961–2022.

3.1.2. Precipitation in the study area

Precipitation was irregularly distributed in time and space in relation to the atmospheric processes and relief features. The mean annual precipitation values for the study period are shown in *Fig. 3*. The mean annual precipitation values for the study period were slightly greater than 600 mm (except for the Pirot MS), which is consistent with previous studies (*Milovanović et al*., 2017b; *Malinovic Milicevic et al*., 2015). The average amount of precipitation in the study area ranges from 595.8 (MS Pirot) to 666.7 mm (MS Veliko Gradište) (*Table 6*, *Fig. 3*). On a monthly basis, the highest precipitation amounts were recorded at the end of spring and the beginning of summer (May, June, July) and the lowest in the summer months (August) and winter (January), which is in line with previous studies (*Živanović et al*., 2024; *Milošević et al*., 2021; *Tošić,* 2004).The differences in the amount of precipitation are not large and depend largely on the location of the station, the orography of the surrounding area (MS Pirot, surrounded by mountains, although located in the basin, therefore receives less precipitation than the surrounding stations, e.g., MS Dimitrovgrad and MS Niš), and the proximity of the moisture source (MS Veliko Gradište near the Danube River). *Fig. 3* shows the spatial distribution of the mean annual precipitation in the study area.

Table 6. Mean monthly and annual precipitation totals at the meteorological stations for the period 1961–2022

MS	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Ann.
Dimitrovgrad	45.4	41.0	48.2	53.8	75.1	78.7	63.2	48.7	47.5	50.1	55.0	48.0	654.6
Kuršumlija	46.3	44.3	51.7	54.6	69.5	66.8	62.0	49.0	50.8	51.7	60.6	59.2	666.6
Leskovac	47.1	43.4	50.6	56.7	63.5	67.4	47.8	44.5	49.2	48.8	59.8	56.8	635.7
Negotin	47.0	48.0	51.4	55.7	61.9	62.9	50.5	39.8	47.0	53.5	60.1	60.0	637.8
Niš	44.0	39.1	46.0	53.5	66.9	62.8	46.6	44.7	46.2	44.4	53.3	54.8	602.3
Pirot	40.7	36.5	42.2	49.3	67.8	77.5	49.9	44.3	44.7	45.0	51.2	46.5	595.8
Veliko Gradište	47.3	43.5	42.1	56.2	72.1	75.3	72.6	54.2	53.9	47.2	46.6	55.8	666.7
Vranje	42.6	41.4	43.5	51.9	61.3	64.3	48.6	40.0	48.1	53.3	59.9	52.7	607.6
Zaječar	43.0	41.2	46.8	52.4	74.6	66.2	57.4	41.5	41.5	46.9	51.8	53.8	617.1

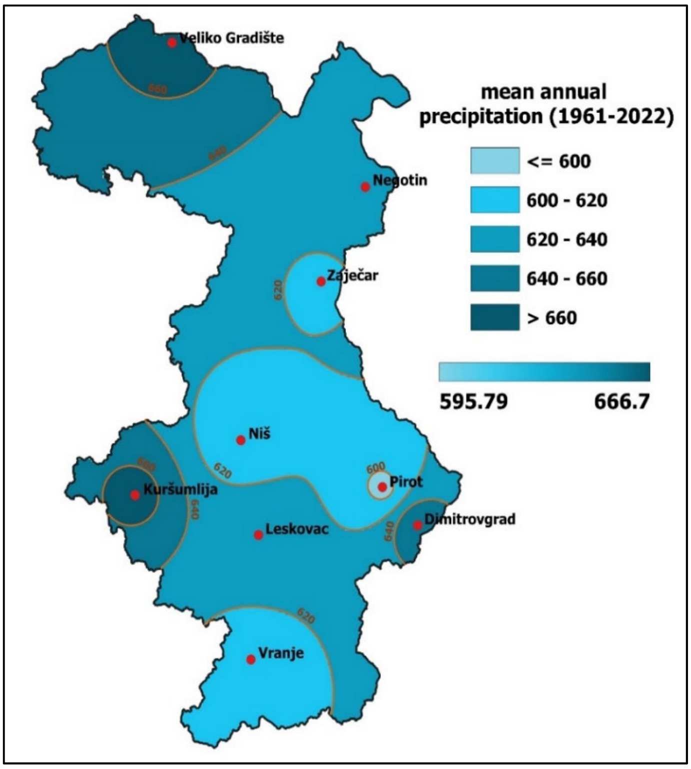

Fig. 3. Spatial distribution of mean annual precipitation in the study area for the period 1961–2022.

3.2. Aridity indices – annual values

The annual values of the three aridity indices were analyzed separately.

3.2.1. De Martonne aridity index

The distribution of the annual I_{DM} values for the period of 1961–2022 is shown in *Fig. 4*. Five out of seven climate types according to the de Martonne classification were found in the analyzed area. The semiarid climate is represented in only one year, 2000, which is characterized as extremely dry by many authors (*Radaković et al*., 2017; *Gocić* and *Trajković,* 2013). Mediterranean climate was represented in 6 years, semihumid climate in 11 years, humid climate in 38 years, and very humid climate in 6 years.

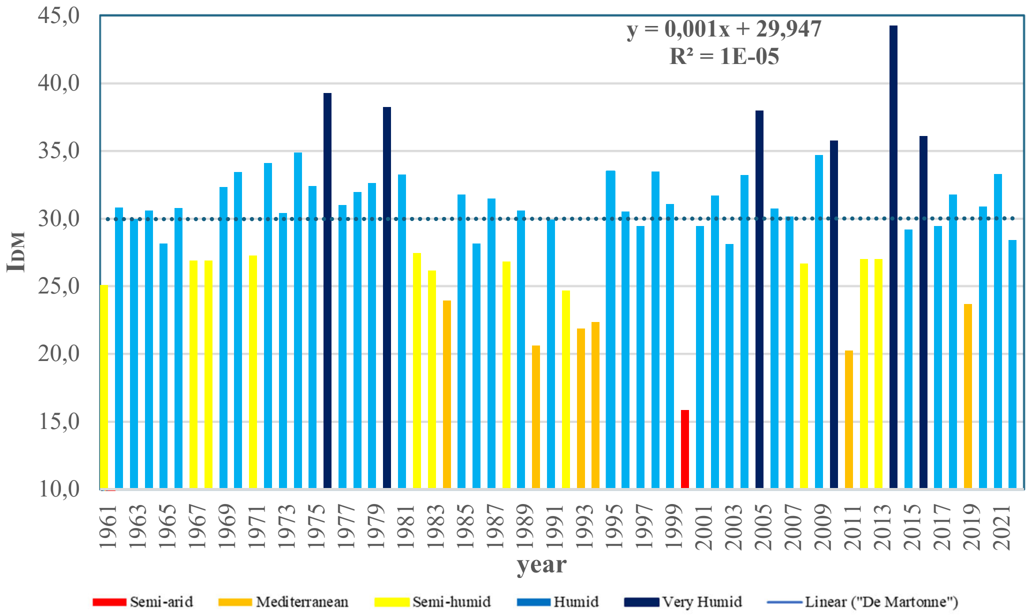

Fig. 4. Annual time series of I_{DM} for all meteorological stations for the period 1961–2022.

The maximum value of this index (44.2) was recorded at all stations in 2014. According to *Tošić et al.* (2017), the maximum value of the I_{DM} in 2014 was confirmed by the extreme annual precipitation, which was the highest for the period of 1961–2014 for all meteorological stations in Serbia. The minimum value of the index was recorded in 2000, with a value of 15.8. During the year 2000, most of Serbia experienced extremely dry conditions (*Tošić* and *Unkašević,* 2014). The spatial pattern of the annual I_{DM} is shown in *Fig. 5*. The average value of the index ranges from 27.4 (MS Niš) to 32.7 (MS Kuršumlija). Humid climate is represented at all the meteorological stations, with the exception of MS Niš, where semihumid climate prevailed during the study period, which was previously established in the work of *Radaković et al.* (2017). The lower I_{DM} values at MS Niš can be attributed to the city's size and higher air temperatures, which indicate the presence of an "urban heat island." This phenomenon has also been observed in other major Serbian cities, such as Belgrade and Novi Sad (*Milovanović et al*., 2020; *Milošević et al.,* 2021).

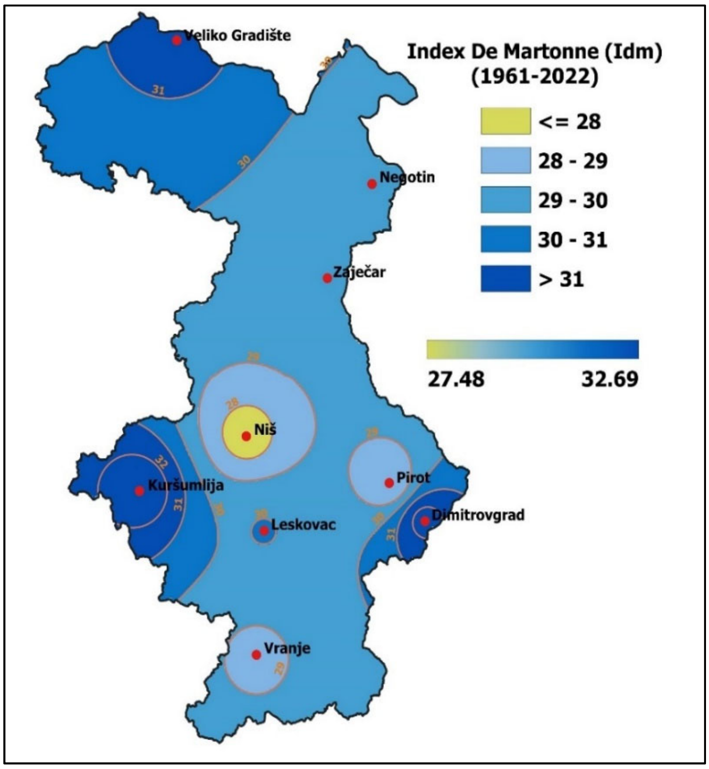

Fig. 5. Spatial distribution of I_{DM} for the period 1961–2022.

3.2.2. Emberger index (I_E)

The annual time series of I_E for all the meteorological stations for the period of 1961–2022 shows that humid climate was recorded in 58 years and semihumid climate was recorded in 4 years (*Fig. 6*). The highest values of I_E were measured in 1976 and 2014, with values of 208.3 and 201.2, respectively (which were described as extremely humid years in other studies due to extreme precipitation) (*Anđelković et al.*, 2018; *Tošić et al.*, 2017). The lowest value of I_E was measured in 2000 and was 58.9. The years with extremely high temperatures are 2007 (*Bajat et al.*, 2015) and 2011 (*Živanović et al.*, 2024), and the most extreme year is 2000, which is confirmed by the values of this index (the years belong to the semihumid climate), which is calculated on the basis of the values of temperature and precipitation.

The I_E value fluctuates between 113.8 (MS Negotin) and 167.1 (MS Kuršumlija) (*Fig. 7*). However, all the values are in the humid climate range (i.e., greater than 90).

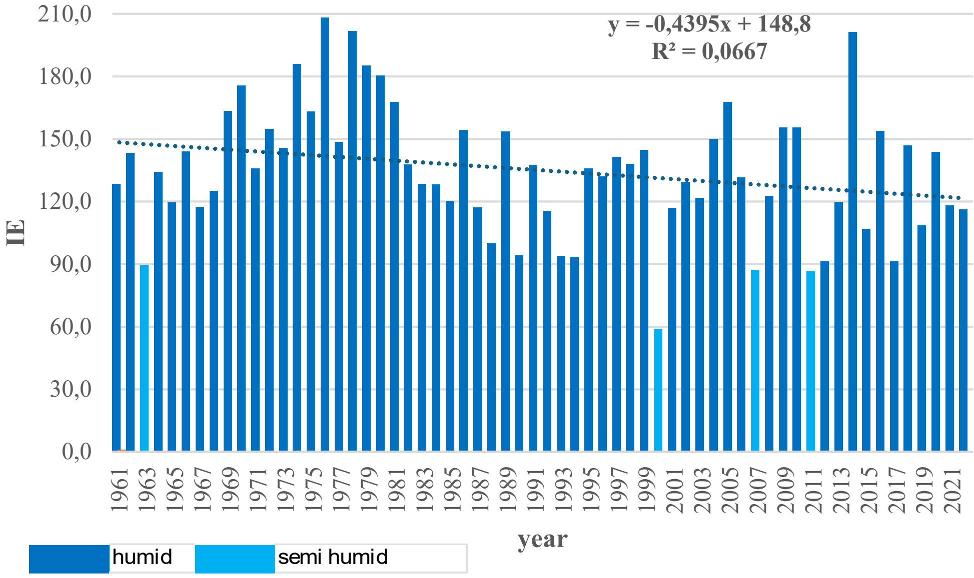

Fig. 6. Annual time series of I_E for all meteorological stations for the period 1961–2022.

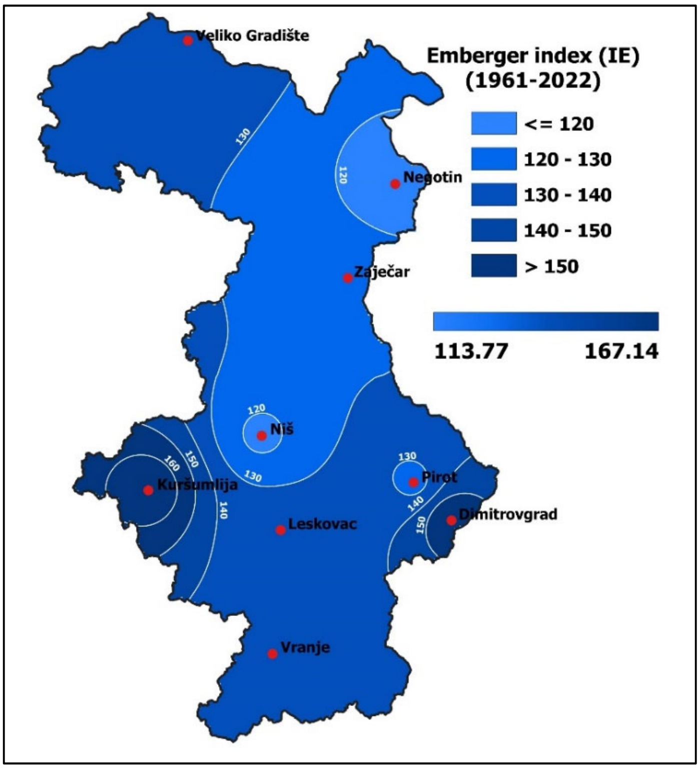

Fig. 7. Spatial distribution of I_E for the period 1961–2022.

3.2.3. Pinna combinative index (I_P)

The distribution of annual I_P values during the study period revealed that a humid climate predominated in the study area (48 years) (*Fig. 8*). The semiarid Mediterranean climate (13 years) is representative of arid climates only (2000). The data of this index are similar to those of the I_{DM} index, although they are calculated differently. The driest year according to this index is 2000 at all meteorological stations, with an average value of 9.4. The wettest year according to the Ip index was 2005, with an average value of 42.9 (*Fig. 8*), which was also demonstrated in the paper of *Radaković et al*. (2017). The results of the I_P index are consistent with the conclusions of *Nikolova* and *Yanakiev* (2020) for southwestern Bulgaria, which is territorially close to our study area.

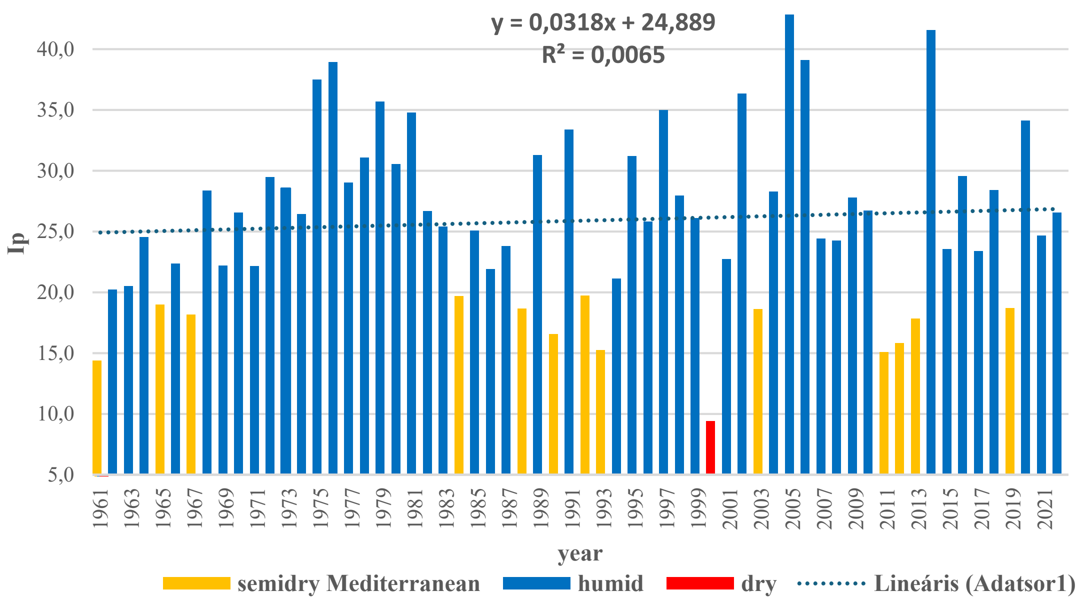

Fig. 8. Annual time series of I_P for all meteorological stations for the period 1961–2022.

Although the value of the I_P index indicates that the humid climate dominated the entire research area, slight differences were detected (*Fig. 9*). The average annual index values range from 22.2 (MS Vranje) to 30.2 (MS Kuršumlija).

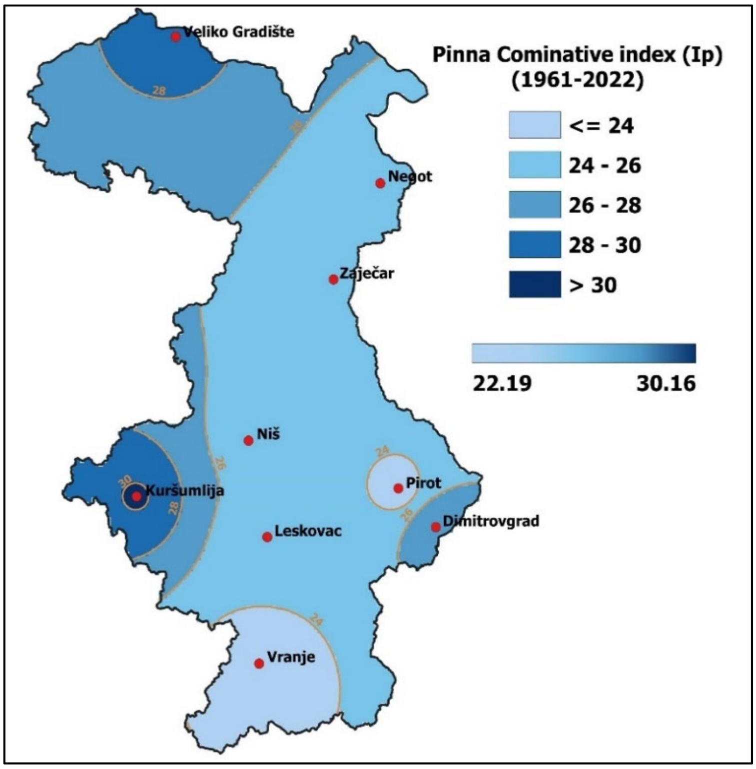

Fig. 9. Spatial distribution of I_P for the period 1961–2022.

All the three indices used show that some stations have relatively high humidity, namely, MS Kuršumlija, MS Dimitrovgrad, and MS Veliko Gradište. The reason for this is primarily the location of the stations in relation to the source of humidity (humid air masses coming to Serbia from the northwest and west) as well as the altitude of the stations (MS Dimitrovgrad and MS Kuršumlija). In the case of MS Veliko Gradište, the proximity of the Danube is the reason for the relatively high humidity. Therefore, lower air temperatures and greater amounts of precipitation were recorded. Although the values of all indices result from the relationship between temperature and precipitation, there are differences in the calculations.

3.3. Trend of aridity indices

The MK test revealed that when all the given values of the indices were considered, there was no significant change in the aridity trends over the last 62 years in the regions of southern and eastern Serbia.

The Mann-Kendall test was used to determine the statistical significance of the trend in the analyzed data for temperature, precipitation, and aridity indices. The Mann-Kendall test revealed a statistically significant positive trend for temperature (α=0.001) at all the meteorological stations in the study area (*Table 7*). Precipitation only shows a positive statistically significant trend for MS

Dimitrovgrad. A positive statistically significant trend was recorded for the I_{DM} at MS Kuršumlija and MS Leskovac at the α=0.05 significance level. The values of the Emberger index indicate a significant downward trend at the level of significance α=0.05 at the meteorological stations Negotin, Niš, Pirot, and Vranje.

The assessment of a statistically significant positive trend in temperature in southern and eastern Serbia is in line with the results at the global, European and local levels (*Twardosz et al*., 2021; *Mohorji et al*., 2017; *Rosmann et al.,* 2016). The positive/negative trends of the aridity indices depend on the choice of aridity index and the location of the area. An increase in aridity has been observed in Serbia and surrounding countries (*Radaković et al.,* 2017; *Gocić* and *Trajković,* 2014; *Vlădut* and *Licurici,* 2020; *Nikolova* and *Yanakiev,* 2020). Future scenarios predict an increase in the intensity of aridity in the central and eastern parts of the Balkan Peninsula (*Beštakova et al*., 2023; *Cheval et al.,* 2017; *Gao* and *Giorgi,* 2008), where the study area is located.

Table 7. Statistical summary of the mean annual temperature (T), mean annual precipitation (P), De Martonne aridity index (I_{DM}), Emberger index (I_E), Pinna combinative index (I_P) based on Mann–Kendall statistics and the magnitude of trends (β) calculated via Sen's slope estimator

MS	**T**			**P**			**I_{DM}**			**I_E**			**I_P**
	Z_{MK}	**Ann Mean**	**β**	**Z_{MK}**	**Ann Mean**	**β**	**Z_{MK}**	**Ann Mean**	**β**	**Z_{MK}**	**Ann Mean**	**β**	
Dimitrovgrad	**5.7*** **	11.4	9.09	**2.27**	654.6	609.18	1.06	32.36	32.61	-0.92	158.9	170.70	27.8
Kuršumlija	**6.5*** **	11.2	9.02	1.63	666.6	627.59	**1.93**	33.50	29.97	-0.51	167.1	172.40	30.2
Leskovac	**6.7*** **	10.1	10.13	1.51	635.7	628.70	**2.25**	30.10	27.66	-0.26	132.6	134.40	24.9
Negotin	**6.8*** **	11.2	10.32	-0.40	637.8	656.07	-1.38	29.24	31.95	**-2.25**	113.8	131.60	25.4
Niš	**5.9*** **	10.9	10.80	0.81	602.3	588.69	0.15	27.60	27.10	**-1.94**	117.7	126.30	25.5
Pirot	**6.2*** **	10.3	10.01	0.43	595.8	586.25	-1.03	27.93	29.77	**-3.10**	127.6	149.90	23.1
Veliko Gradište	**5.4*** **	11.8	10.31	0.17	666.7	669.86	0.03	31.44	30.67	-1.53	137.7	150.40	28.6
Vranje	**5.9*** **	11.9	10.09	0.99	607.6	562.86	-0.46	28.58	28.40	**-1.98**	134.7	144.00	22.2
Zaječar	**6.3*** **	11.2	9.84	0.37	617.1	588.75	-0.78	29.59	30.21	-1.56	124.6	129.60	25.4

Note: *** level of significance=0.001; bold values - level of significance=0.05

4. Conclusion

Based on the results of the spatial and temporal distribution of the aridity index in the analyzed area, we can conclude that there was no statistically significant trend of change. An increase in aridity and temperature is expected in the future, which will have a negative impact on agriculture, soil, and water resources. Climate change, increasingly characterized by long periods of drought combined with heavy rainfall and global warming, will make it increasingly difficult for humanity to adapt to natural and environmental conditions to ensure sufficient food and agricultural yields and the availability of clean and safe drinking water. The annual values of the De Martonne Index (I_{DM}) indicate humid climate, except for MS Niš, where the semihumid climate is dominant. The annual values of the I_{DM} index show a statistically significant positive trend at only two stations. The Emberger index and the Pinna Combinative index revealed that humid climate dominated throughout the entire research area. A comparison of the results of the I_{DM}, I_E and I_P indices revealed that the I_{DM} gives better results and more precisely defines the climate of the selected area. It can be concluded that the climate of the analyzed area shows a weak tendency to increase aridity (no significant trend) but may entail certain risks for the development of the agricultural sector and water supply.

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