

IMPACT OF DROUGHT ON THE FLOW REGIME IN THE ORLJAVA RIVER

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ABSTRACT

Aim of the study

The aim of the study is to analyze droughts in Požega, their temporal evolution, and their influence on the daily discharge of the Orłjava River, which flows through the city. Additionally, the study discusses the possible implications for hydropower potential.

Materials and methods

In this paper, the analysis of droughts in the period from 1961 to 2024 is based on the Standardized Precipitation Evapotranspiration Index (SPEI), which was calculated for Požega, a city located in the continental part of Croatia. Results obtained with SPEI were compared with those from another drought index, the New Drought Index (NDI). Further analysis of both indices across all time scales was provided using the RAPS (rescaled adjusted partial sums) method, and the daily discharge of the Orłjava River were analyzed based on the obtained subperiods. An index representing hydrological drought – Standardized Streamflow Index (SSI) – was also calculated for the Orłjava River (station Požega).

Results and conclusions

The results showed that there are two statistically different subperiods regarding drought occurrence: from 1961 to 1999 and from 2000 to 2024. The second subperiod is characterized by lower SPEI and NDI values, indicating more severe drought conditions. Based on daily discharges from the Orłjava River, discharges are calculated for the entire period and for two subperiods identified through drought analysis, corresponding to 50% and 70% probability of occurrence. The lowest discharges are observed during the second subperiod, which was also characterized by more intense drought conditions. These results underscore the impact drought has, indicating constraints for hydropower development.

Keywords: drought, Standardized Precipitation Evapotranspiration Index (SPEI), New Drought Index (NDI), Požega, Orłjava River

INTRODUCTION

The increase in the frequency of extreme hydrological events, such as droughts and floods, is characteristic of climate change. Droughts, unlike floods, have a distinctly global character, and their increased duration and intensity have been confirmed across

almost all regions of the world (Cheng et al., 2023; Lloyd-Hughes et al., 2012). According to IPCC reports, a +2°C of global warming could raise drought risk by 50%. Over the past century, major drought events have claimed more than 10 million lives and caused economic losses of several hundred billion USD (UNCCD, 2022).

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Drought is defined as a sufficiently long period of dry weather to cause a disturbance of the hydrological balance. Related phenomena include high air temperatures, low air humidity, and prolonged periods of solar radiation (Škvareninová et al., 2018). Drought manifests itself through meteorological, hydrological, and agricultural parameters. In addition to being global, droughts are extremely complex phenomena, difficult to predict and often only noticeable after weeks or months, with hard to avoid far-reaching consequences. Drought is one of the most destructive and challenging hydroclimatic hazards globally, posing severe threats to ecosystems, society, and the economy (Rahman et al., 2025). Given the complexity and frequency of drought worldwide, several methods, known as indices, have been developed to measure them. These indices are primarily based on meteorological (precipitation and temperature) and hydrological (discharges and water levels) parameters. However, indices can also be based on soil moisture content, groundwater levels, and remote sensing data (WMO, 2016). The most commonly used indices are based on meteorological data, such as the Standardized Precipitation Index (SPI), Rainfall Anomaly Index (RAI), Standardized Precipitation Evapotranspiration Index (SPEI), and Palmer Z Index. In recent years, due to climate

change and rising air temperatures, new indices have been developed, such as the New Drought Index (NDI) (Bonacci et al., 2023).

Drought is most evident when there is no precipitation, which is a crucial component of the hydrological cycle. If precipitation deficit persists over an extended period, it leads to a decline in the water levels of rivers, reservoirs, lakes, and aquifers. Each of those water-lowering measures has far-reaching consequences. This paper analyzes the impact of meteorological drought on the flow regime of the Orłjava River. The Orłjava River flows through Croatia's hilly region and has significant hydropower potential. It is well established that droughts pose the greatest threat to the stability and prosperity in the Balkans, particularly due to their effects on the hydroelectric sector and agriculture (Barron and van Manen, 2022). This paper analyzed the impact of meteorological drought on the Orłjava River's flow regime and the potential constraints on hydropower development.

MATERIALS AND METHODS

The study area is located in the continental part of Croatia, within the catchment areas of the Orłjava and Londa rivers (Figure 1). The area is characterized by

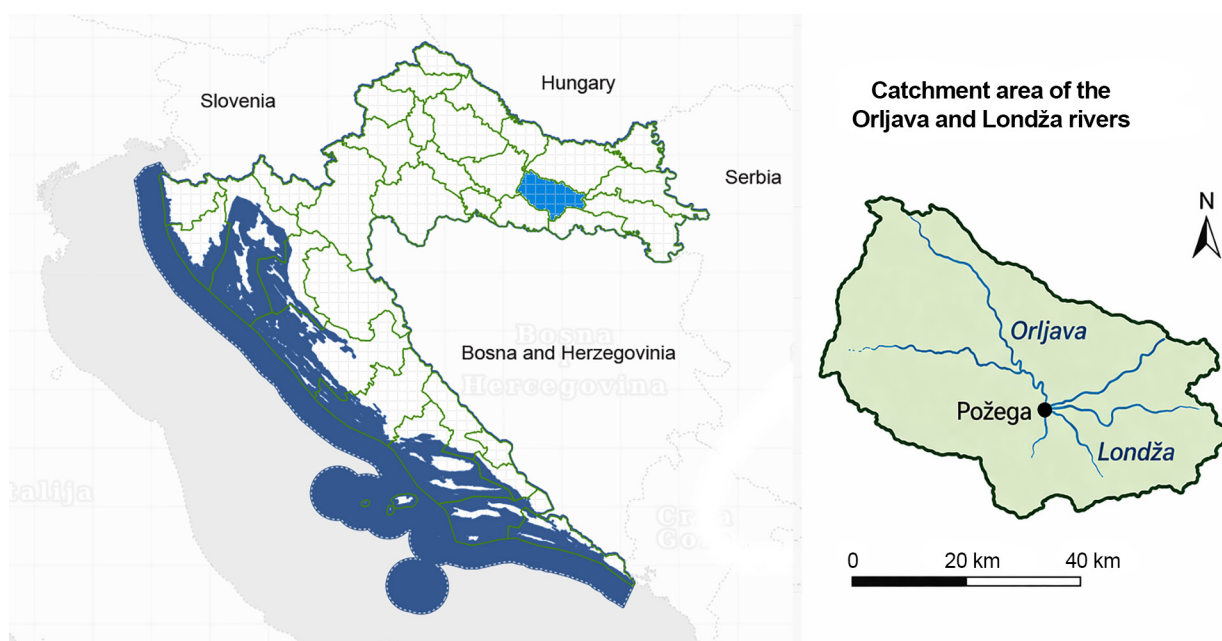


Fig. 1. Location of the catchment area of the Orłjava and Londa rivers (Source: Authors' own elaboration)

a pronounced altitudinal range. The lowest elevation is approximately 83 m a.s.l., situated in the lowland part of the Sava River plain, close to the confluence of the Orljava with the Sava River. In contrast, the highest elevation reaches 985 m a.s.l. on Psunj Mountain.

From a geomorphological perspective, the catchment area comprises both lowland alluvial plains in its downstream section and a surrounding hilly to mountainous relief formed by the slopes of Psunj and adjacent uplands. This considerable elevation difference influences hydrological processes, runoff dynamics, and the spatial variability of climatic conditions within the area.

This catchment area is divided into two subcatchments: the Orljava River subcatchment (area 1616 km²) and the Londa River subcatchment (486 km²). Both rivers are tributaries of the Sava River. The Sava River is a major tributary of the Danube River.

The Orljava River is the biggest river in that catchment, and it flows through Požega, the biggest city in the area. The analysis covers both.

The studied area is characterized by relatively steep terrain and significant elevation differences, which provide generally favorable conditions for the development of small hydropower plants. In fact, several small (run-of-river) hydropower installations already exist in the Orljava River catchment. Given that small hydropower plants depend heavily on available streamflow, changes in discharge regimes caused by droughts may have important implications for their operation and efficiency.

Dry periods were identified in Požega from 1961 to 2024 using the Standardized Precipitation Evapotranspiration Index (SPEI) and New Drought Index (NDI). The input data for the SPEI budget and NDI calculations, as well as monthly precipitation values and air temperatures obtained from the Croatian Meteorological and Hydrological Service, contain gaps for some months between 1985 and 1997 due to the war in Croatia. These 82 missing months (of the 768 total) were supplemented with data from a meteorological E-OBS gridded dataset (ensemble mean, spatial resolution 0.25°). Previous analyses (Santos et al., 2023) showed a high correlation between the E-OBS data and the measured data in Croatia, which is why this particular dataset was also used in this analysis.

E-OBS provides spatially interpolated daily climate data based on quality-controlled station observations

across Europe (Cornes et al., 2018) that is available at the Copernicus website (Copernicus Climate Change Service, 2020). The grid cell corresponding to the station's geographic coordinates was identified within the E-OBS dataset in a GIS environment. Daily values from the ensemble mean field at 0.25° spatial resolution were extracted from the grid cell corresponding to the location of Požega and used to replace missing station observations. Daily precipitation and temperature values were then transformed to a monthly scale as needed for drought indices calculations.

Using gridded data introduces certain uncertainty because E-OBS values represent spatially interpolated grid-cell averages rather than point measurements at the exact station location. This uncertainty mainly arises from the interpolation procedure, the spatial density of the underlying station network, and potential differences between grid-cell averages and local station conditions. Such differences may be more pronounced in areas with complex topography or where station coverage was lower in the early 1990s. However, E-OBS is widely used in European climate studies and has been shown to provide reliable representations of daily temperature variability (Cornes et al., 2018). Furthermore, missing data is replaced for a relatively short period, 10% of the total time, and therefore, the potential influence of this procedure on the overall results is expected to be limited.

The multiparameter Standardized Precipitation and Evapotranspiration Index (SPEI) was developed to improve the Standardized Precipitation Index (SPI) by incorporating air temperature into its calculation. This has been used worldwide (WMO, 2016). The calculation is very simple and follows the original method: instead of monthly precipitation, the difference between monthly precipitation and monthly potential evapotranspiration is used as input (Telesca et al., 2012):

$$ISO_n = \frac{1}{\sigma_n} \sum (P_i - PET_i) \quad (1)$$

where:

- n – number of months,
- P_i – normal transformed monthly precipitation,
- PET_i – normal transformed monthly potential evapotranspiration,
- σ_n – standard deviation.

The SPEI can be determined over periods of 1, 3, 6, 12, or 24 months. The time-scale of SPEI can be divided into three groups: short (2–4 months), medium (6–10 months), and long (10–20 months) (López-Moreno et al., 2013). For the calculation of SPEI values on all time scales, the R Software (RStudio Team, 2023), namely the “SPEI” package, was used. Evapotranspiration was calculated using the Thornthwaite method, also in the R Software. The SPEI index categories, according to Telesca et al. (2012), are shown in Table 1.

Table 1. Classification of SPEI values (Li et al., 2015)

Category	SPEI
Extremely wet	≥ 2.00
Severely wet	from 1.50 to 1.99
Moderately wet	from 1.00 to 1.49
Normal	from 0.99 to -0.99
Moderate drought	from -1.00 to -1.49
Severe drought	from -1.50 to -1.99
Extreme drought	≤ -2.00

The SPEI accounts for precipitation and temperature, but only indirectly through evapotranspiration. As shown in Figure 2, the average annual air temperature at the Požega station has increased. To ensure this change in air temperatures was captured, another index was used to check the results obtained with SPEI. NDI assumes that drought severity is driven by precipitation deficits (below average at a given area) and by rising air temperatures (above average at a given area). Thus, the equation for calculating NDI is (Tadić et al., 2025; Bonacci et al., 2023):

$$NDI_i = [(P_i - P_{av})/\sigma_P] - [(T_i - T_{av})/\sigma_{PT}] \quad (2)$$

where:

- P_i – precipitation in the year or month i ,
- P_{av} – the average value of the analyzed series of precipitation in the obtained period,
- σ_P – the standard deviation of the analyzed series of precipitation in the analysis period,
- T_i – the mean temperature in the year or month i ,
- T_{av} – the average value of the analyzed series of air temperature data in the analysis period,
- σ_{PT} – the standard deviation of the series of air temperature in the analysis period.

The proposed classification of NDI values is based on SPEI ranges, as shown in Table 1 (Bonacci et al., 2024).

To these obtained values of the SPEI and NDI indices, the rescaled adjusted partial sums (RAPS) method was applied. This is a statistical method for analyzing time series data. The graphical representation of RAPS indicates subperiods with similar characteristics, a greater number of trends, sudden jumps or falls in values, irregular fluctuations, and periodicity in the analyzed time series, among other features. The equation for calculating RAPS is (Garbrecht and Fernandez, 1994; Bonacci, 2010):

$$RAPS_k = \sum_{t=1}^k \frac{Y_t - \bar{Y}}{S_y} \quad (3)$$

where:

- t – 1, 2, ..., k the counter during the summation process,
- $\bar{Y}$ – the average value of all members in the analyzed time series,
- Y_t – the individual value of the analyzed member,
- S_y – standard deviation.

Within the RAPS framework, both the F -test and the t -test were applied to assess the statistical properties of the analyzed datasets at the 0.05 significance level. The F -test was used to evaluate the equality of variances between the observed and reference datasets. The null hypothesis assumes that the variances of the two datasets are equal, while the alternative hypothesis states that the variances differ significantly. The t -test was then applied to compare the means of the datasets. Depending on the result of the F -test, either the standard independent samples t -test (assuming equal variances) or Welch’s t -test (assuming unequal variances) was used. The null hypothesis assumes that there is no significant difference between the means of the datasets’, whereas the alternative hypothesis accepts that there is a difference. For each dataset pair analyzed, the corresponding test statistics (F and t values), degrees of freedom, and p -values were calculated. The results with p -values below 0.05 were considered statistically significant, indicating that the differences in variance and/or means were not caused by random variation (Ruxton, 2006; Alemaw and Chakoka, 2002).

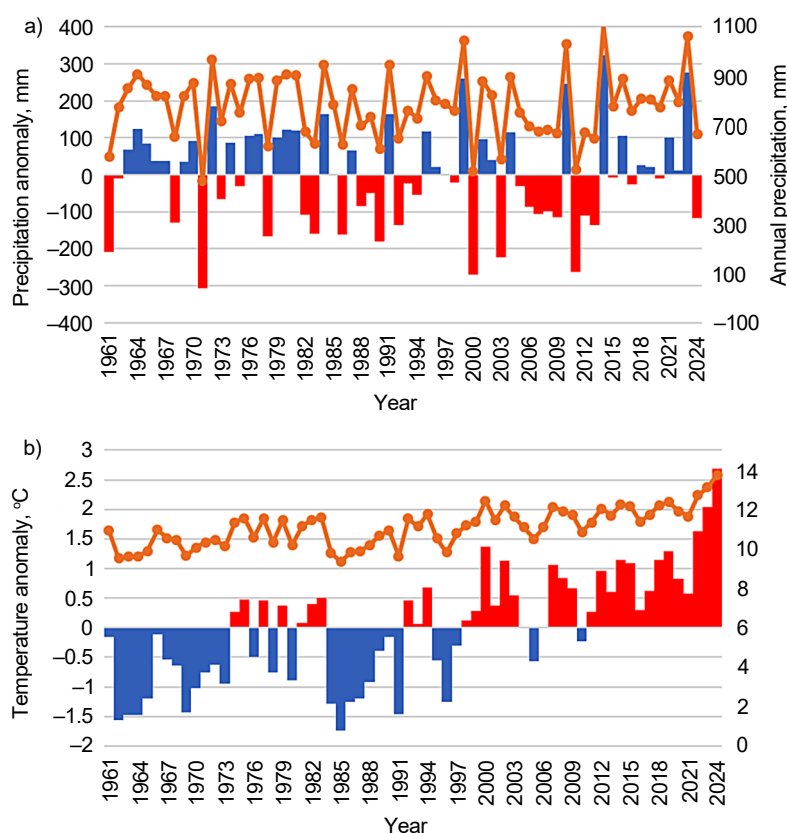


Fig. 2. Annual series of (a) precipitation and (b) mean temperature (lines) for the Požega station, with positive (blue bars) and negative (red bars) anomalies with respect to the mean from 1961 to 2024 (Source: Authors' own elaboration)

After defining the subperiod by applying the RAPS method to the obtained SPEI and NDI values, the daily discharges were divided into the same subperiods. Discharges are calculated at 50% and 70% probability of occurrence for the entire period and for the obtained subperiods. This was done to determine whether drought occurrence influences daily discharges, which are an important hydrological basis relevant for assessing hydropower potential.

In the end, insight into the incidence of hydrological drought is provided by the Standardized Streamflow Index (SSI). A gamma probability distribution was fitted to the monthly streamflow data, as it is widely used for hydrological variables and also for the calculation of the Standardized Precipitation Index (SPI). Based on the fitted distribution, cumulative probabilities were calculated for each observed streamflow value. These probabilities were then transformed into standardized normal scores (z -scores) using the inverse

standard normal distribution, yielding the SSI values (Telesca et al., 2012). The categories for identifying wet and dry periods are the same as for SPEI (Table 1).

RESULTS

An overview of the SPEI index values obtained across all time scales is shown in Figure 3. Values below -1 refer to dry periods, from -1 to 1 indicate a normal state, and values above 1 refer to wet periods. Figure 4 shows the NDI results.

Figure 3 shows the alternation of wet and dry periods with individual extremes within the observed period. In wet periods, extremes occurred in 1969 (SPEI 1, NDI), 1970 (SPEI 1, SPEI 3, SPEI 6, NDI), 1972 (SPEI 1, SPEI 3, SPEI 6, NDI), 1974 (SPEI 1, SPEI 3, NDI), 1999 (SPEI 3, SPEI 12, NDI), 2014 (SPEI 3, SPEI 6, SPEI 12, NDI), and 2023 (SPEI 3, SPEI 6, SPEI 12, NDI) with SPEI values >2 . As for dry periods, the lowest values,

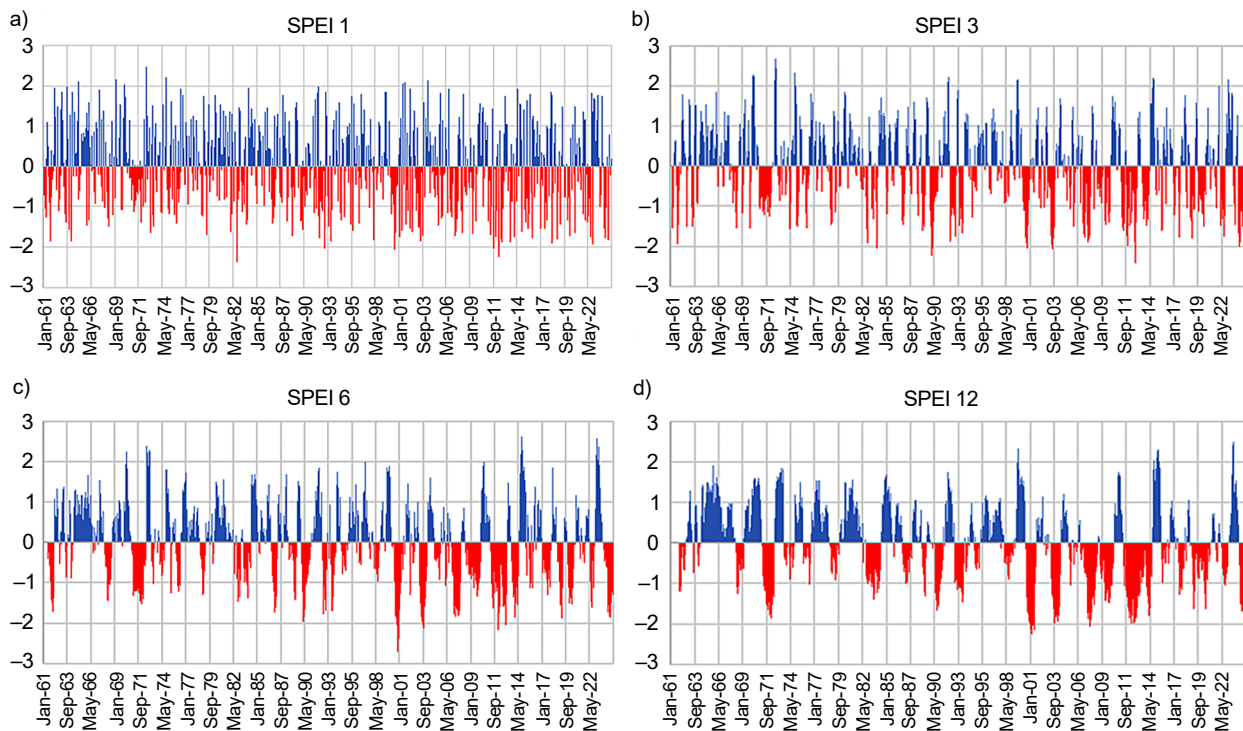


Fig. 3. Results of SPEI calculations for a) 1 month, b) 3 months, c) 6 months, d) 12 months (Source: Authors' own elaboration)

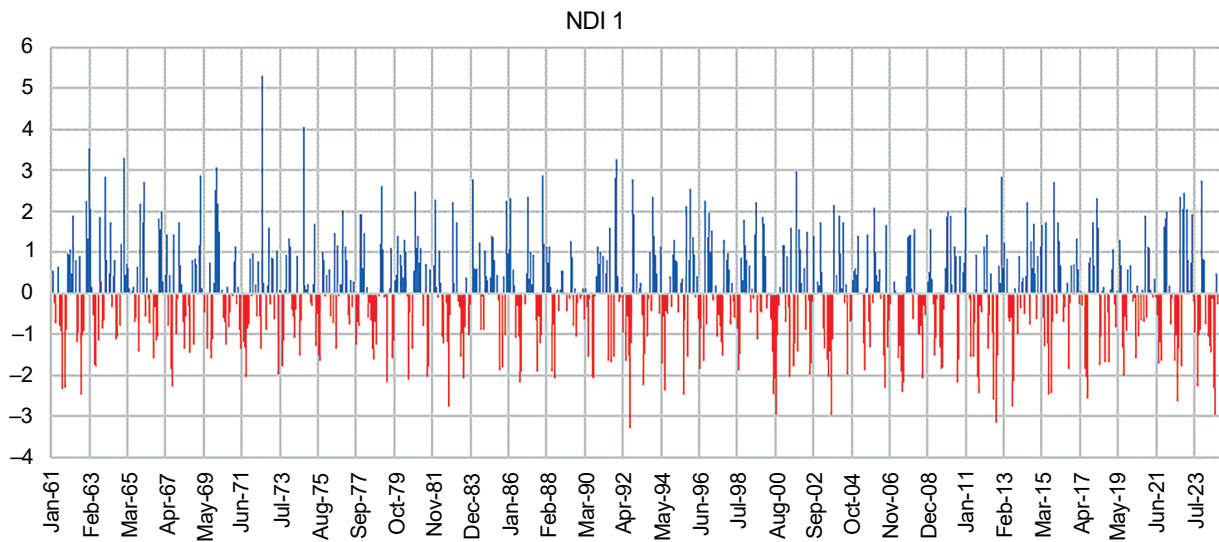


Fig. 4. Results of NDI calculations (Source: Authors' own elaboration)

<-2 , of the SPEI index were in 1982 (SPEI 1, SPEI 3, NDI), 1990 (SPEI 3, NDI), 2000 (SPEI 1, SPEI 3, SPEI 6, NDI), 2003 (SPEI 3, SPEI 6, NDI), 2011 (SPEI 1, NDI), 2012 (SPEI 1, SPEI 3, SPEI 6, NDI), 2021 (SPEI 3), 2022 (NDI) and 2024 (NDI). On the 12-month time scale, SPEI <-2 was recorded only in 2001 and 2007.

Although the grouping of dry years is visible at the end of the analyzed period, this was determined using

the RAPS method applied to the sets of SPEI and NDI indices across all time scales. This method was used to see if there are subperiods within the total observed period. The results (Figures 5 and 6) show two subperiods: the first, from 1961 to 1999, with an upward trend in RAPS values; and the second, from 2000 to 2024, characterized by a decrease in RAPS values. Statistical significance ($p < 0.05$) of the subperiods was confirmed

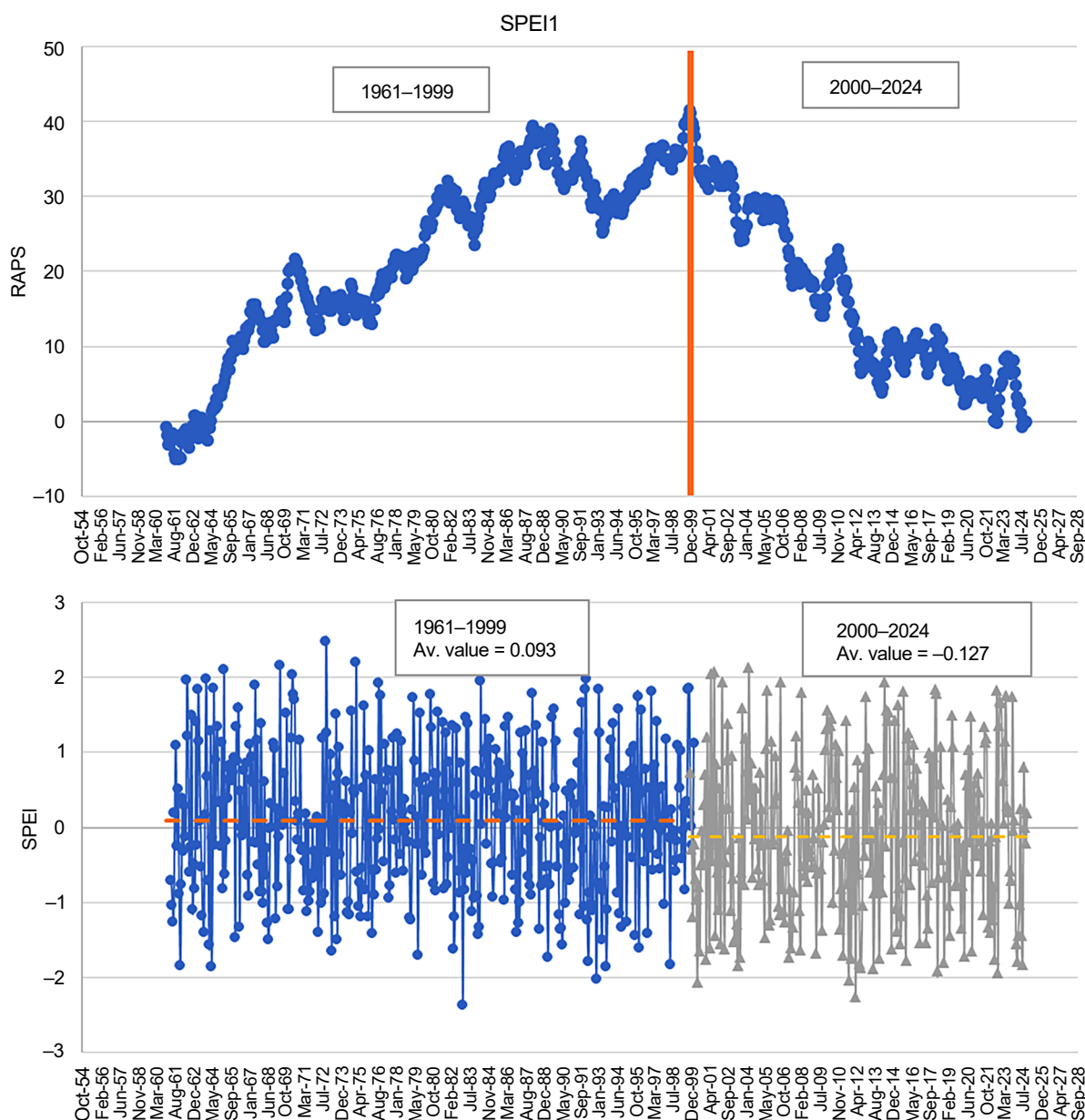


Fig. 5. Results of RAPS analysis for SPEI on the basis of 1 month (Source: Authors' own elaboration)

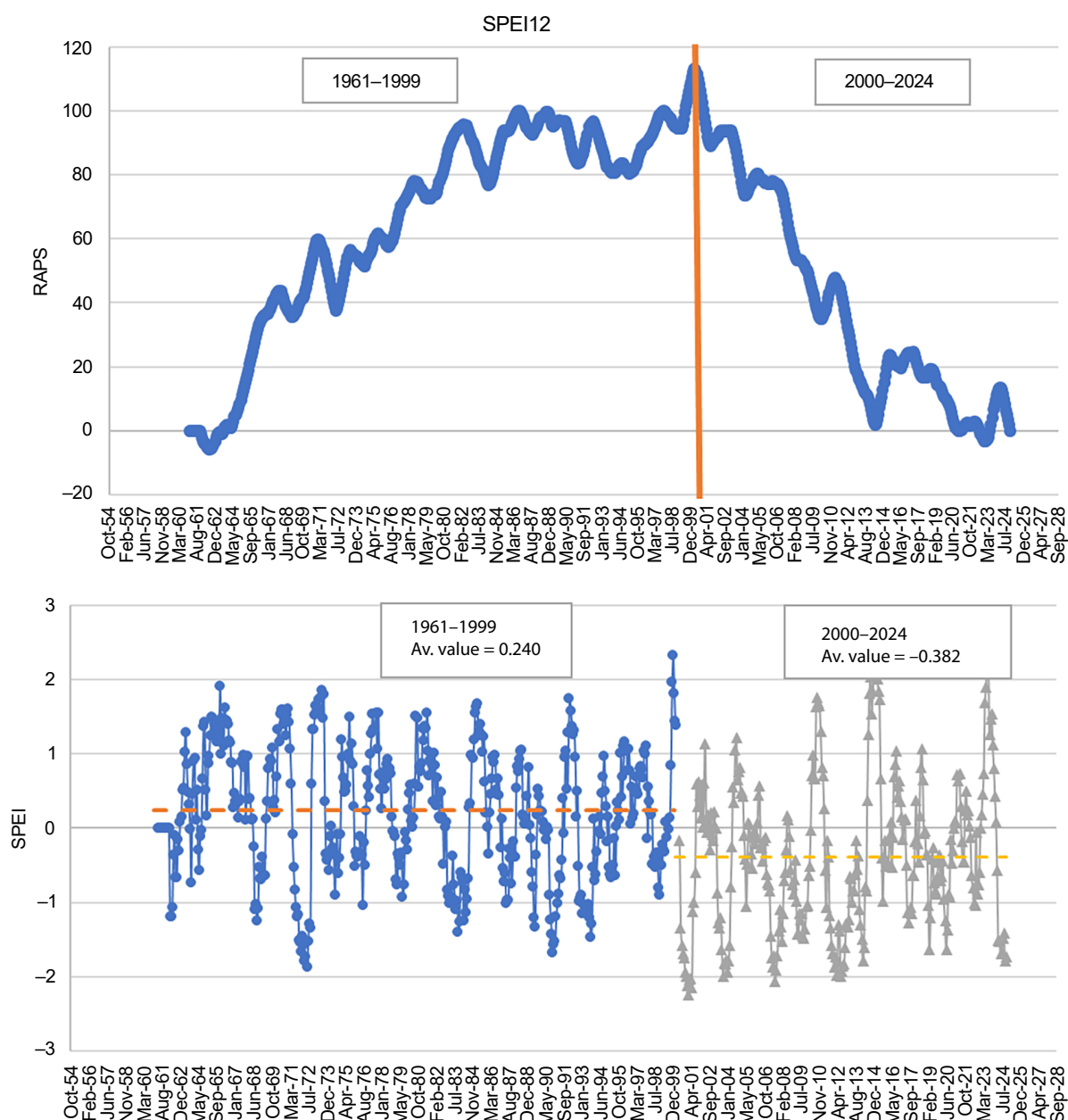


Fig. 6. Results of RAPS analysis for SPEI on the basis of 12 months (Source: Authors' own elaboration)

by both the F -test and the t -test on the original series (SPEI and NDI indices) at all time scales. Figures 5 and 6 show the results of the RAPS method at the smallest and largest time scales (the results are the same at all time scales). In the first subperiod, the mean value of the SPEI index for all results is higher than in the second subperiod. Given that negative values indicate drought

conditions, it has been proven that, since 2000, droughts have become more frequent in the city of Požega.

To check the SPEI results and the obtained subperiods, the RAPS method was also applied to the NDI values, and the results are shown in Figure 7.

The same results and subperiods were also obtained with the NDI. The first subperiod, from 1961 to 1999,

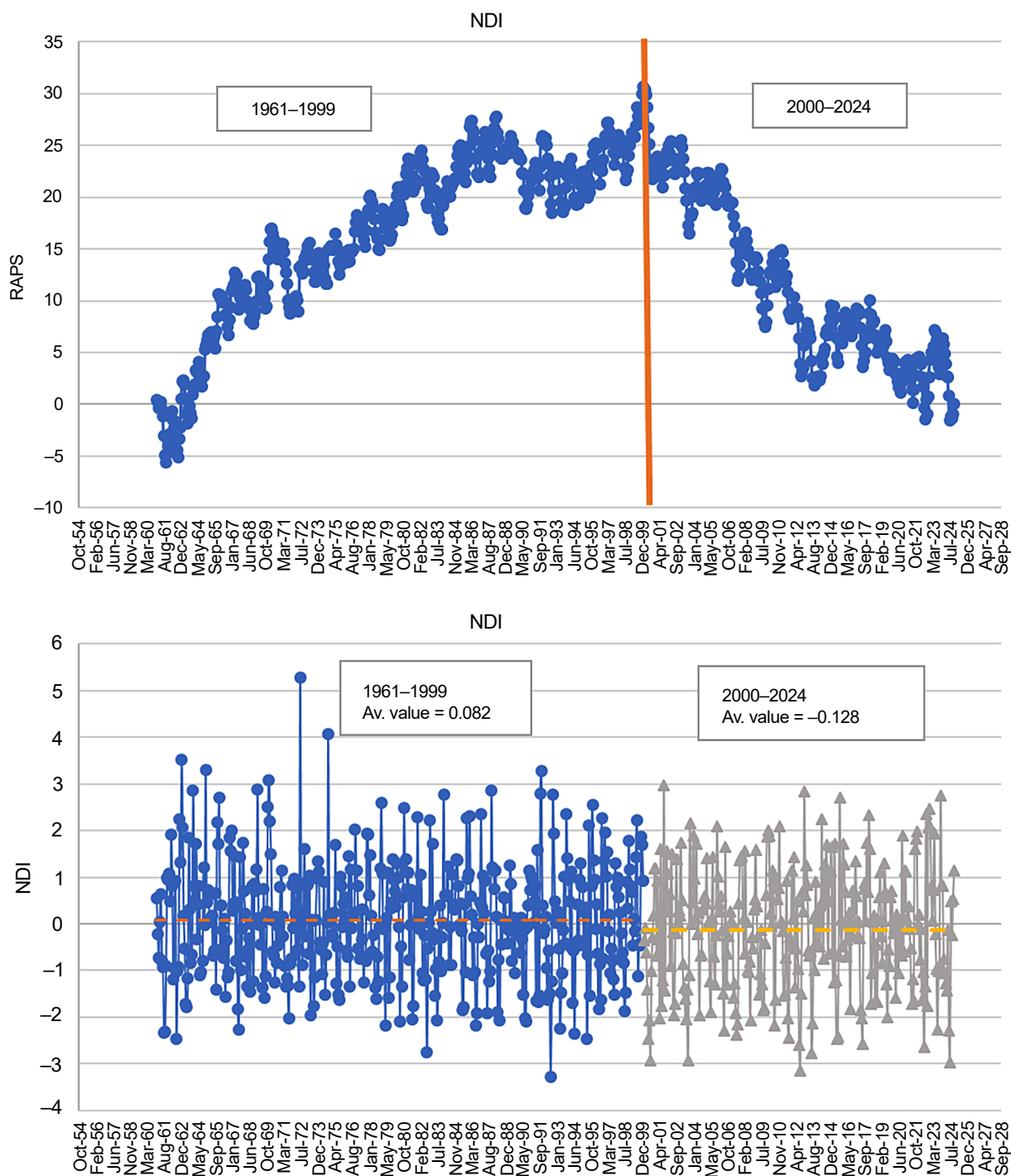


Fig. 7. Results of RAPS analysis by NDI (Source: Authors' own elaboration)

shows an upward trend in RAPS values, while the second, from 2000 to 2024, shows a downward trend. The results are also confirmed by both the F -test and the t -test applied to the original series of NDI values. The average NDI value for the first subperiod is 0.082, and for the second, -0.128 , are very similar to the average values obtained for SPEI 1 (0.093 and -0.127 , respectively).

Since the paper's aim was to assess the impact of meteorological drought on the discharge in the Orłjava River, the same subperiods, with a breakpoint at 2000, confirmed by two different indices, were applied to daily discharge data. Even though a longer time series was used for drought analysis, the breaking year obtained with the RAPS method was 2000, which falls within both time spans, allowing further analysis and comparisons.

The discharges are calculated at 50% and 70% probability of occurrence for the entire period and for the two obtained subperiods. The calculated discharge values are presented in Table 2.

Table 2 shows that the lowest values correspond to the second subperiod. That subperiod is characterized by the lowest SPEI values, which indicates drought conditions. Minimum values of $0 \text{ m}^3/\text{s}$ reflect actual observations when there was no flow in the River Orłjava. Discharge values are usually reduced during

late summer and early autumn. During the summer of 2007, values of $0 \text{ m}^3/\text{s}$ were recorded for a period of 15 days.

Table 2. Results of daily discharges analysis for different periods for the Orłjava River

Period	1977–2023	1977–1999	2000–2023
Min	$0 \text{ m}^3/\text{s}$	$0.098 \text{ m}^3/\text{s}$	$0 \text{ m}^3/\text{s}$
Max	$155 \text{ m}^3/\text{s}$	$63.7 \text{ m}^3/\text{s}$	$155 \text{ m}^3/\text{s}$
50% duration	$1.72 \text{ m}^3/\text{s}$	$2 \text{ m}^3/\text{s}$	$1.53 \text{ m}^3/\text{s}$
70% duration	$0.772 \text{ m}^3/\text{s}$	$0.868 \text{ m}^3/\text{s}$	$0.736 \text{ m}^3/\text{s}$
Average value	$3.11 \text{ m}^3/\text{s}$	$3.066 \text{ m}^3/\text{s}$	$3.151 \text{ m}^3/\text{s}$

Based on this analysis, which showed that meteorological drought impacts discharges from the Orłjava River, a hydrological drought analysis was conducted using the Standardized Streamflow Index (SSI). Results are presented in Figures 8 and 9.

According to the SSI analysis, the hydrological drought was most pronounced in 1990, 2000, 2003, 2009, 2011, and 2012. This pattern is similar to that of the meteorological drought, as well as the SPEI and NDI values on time scales of 1, 3, and 6 months.

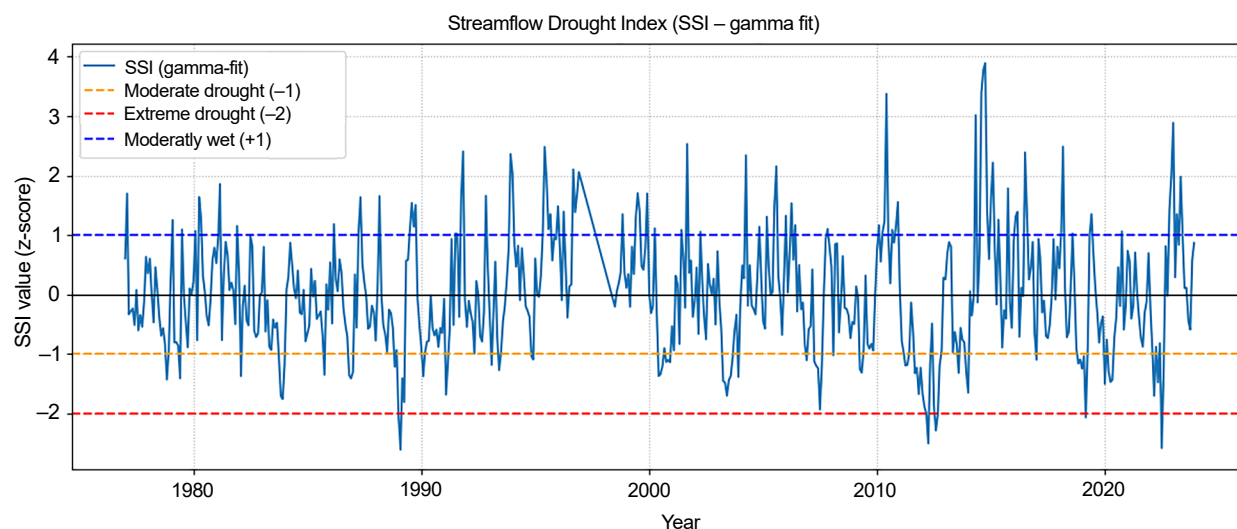


Fig. 8. Results of the SSI analysis (Source: Authors' own elaboration)

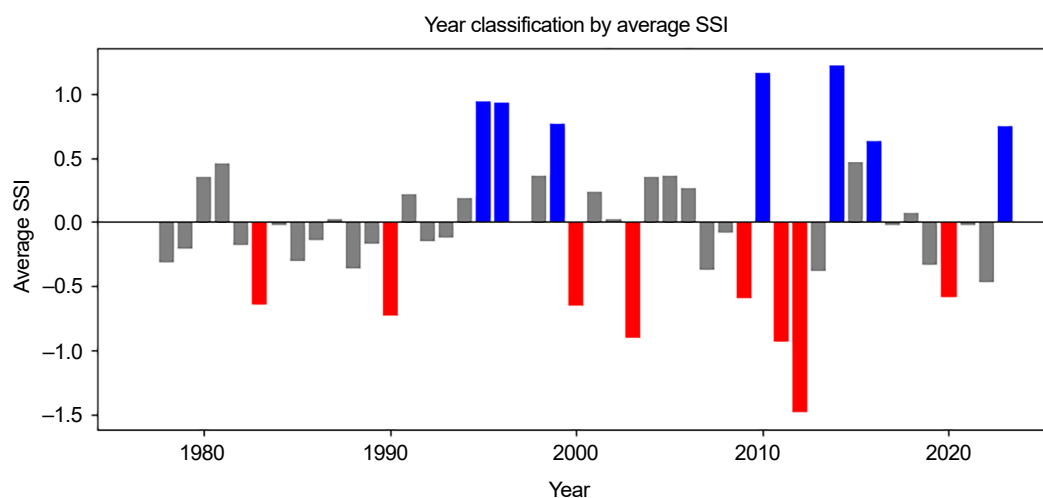


Fig. 9. Year classification based on average SSI values (Source: Authors' own elaboration)

DISCUSSION

In a study on European drought climatologies and trends between 1950–2012 (Spinoni et al., 2015), it was found that the increase of precipitation was not significant in Central Europe and the Balkans. However, the increase in temperature, and hence the potential evapotranspiration (PET), exacerbated the severity of droughts. For this reason, the SPEI was chosen for this analysis to capture the effect of the temperature increase. To capture both the effects of precipitation and temperature, otherwise two different indices need to be used, as in the papers by Bai et al. (2026) and Kubicz (2019). For this reason, a new index, such as NDI, which directly accounts for precipitation and temperature, was recently developed and also used in this study to assess the SPEI results, given the increase in air temperature in the analyzed area. Short-to-medium SPEI time-scales could be used to analyze the response of crops and natural vegetation to drought. With longer time-scales, the index could capture water resource availability and thus be used to evaluate hydrological variations. Based on the results, both indices capture the same extreme wet and dry years.

The results showed that, since 2000, droughts in the analyzed area have occurred more often than in the previous period – with statistical significance. This was recorded at different time scales, and each corresponds to a different type of drought condition. Similar re-

sults can be found for other parts of Croatia. Usually, drought analysis in Croatia focuses on one location, one catchment, at one regional scale, or for the entire country. Generally, the results showed that Croatia has been exposed to growing incidence of droughts, especially since the 1990s, when the frequency of extreme hydrological phenomena intensified, not only droughts, but also floods (Lončar-Petrinjak et al., 2024). Regarding the temporal occurrence of drought, results showed that Croatia experienced an extreme drought in 2011 and 2012 (Cindrić et al., 2016), which was also noticeable in Požega at almost all time-scales for both analyzed indices.

In the paper by Santos et al. (2023) that analyzed the temporal and spatial evolution of drought in Croatia it was concluded that from the year 2000 onwards the frequency of extreme droughts, with an evidently affected cumulative area, increased comparatively to the rest of the period at SPEI 6 and 12 time-scales. Although in this paper the occurrence of drought was analyzed across the entire Croatia, the SPEI was used at only two scales. In this paper, the SPEI was adopted to capture variations in meteorological and hydrological drought across all time scales. The results are verified using the developed New Drought Index (NDI), which directly incorporates temperature data, offering a novel approach compared to other published scientific papers. In the paper by Tadić et al. (2015), which analyzed drought occurrence using

different indices, Požega was excluded due to missing data. This issue was addressed in this paper by using the E-OBS gridded dataset. The new approach also involves correlating the resulting indices with discharge analysis of the surrounding river.

Regarding discharge analysis across two subperiods obtained from drought analysis with the RAPS method, it is evident that discharge values corresponding to 50% and 70% probability of occurrence are the lowest in the second subperiod, the driest one. Discharges with a 50% probability of occurrence are in the second subperiod are lower by 11% compared to the entire analyzed period and by 24% compared to the first subperiod. Discharges with a 70% probability of occurrence are lower by 5% and 15% compared to the entire period and the first subperiod, respectively. Although this study does not include direct calculations of hydropower production or technical parameters (e.g., head, efficiency, or installed capacity), the observed decrease in discharges at 50% and 70% exceedance probabilities in the recent period (2000–2024) suggests reduced water availability under typical operating conditions. Given that small hydropower plants depend on available streamflow, reductions in discharge can significantly affect the performance of existing facilities and the region's overall hydropower potential.

CONCLUSION

This study analyzed drought conditions in the city of Požega using the Standardized Precipitation Evapotranspiration Index (SPEI) and the recently developed New Drought Index (NDI). The results allowed us to identify dry and wet periods and assess their intensity and duration throughout the observed period. The SPEI and NDI values indicate pronounced interannual variability, with moderate to severe drought episodes occurring in specific years. Detected trends suggest an increased frequency of negative SPEI and NDI values in the more recent part of the analyzed period, potentially due to rising air temperatures and enhanced evapotranspiration.

These results provide a solid foundation for further research, including the application of climate models to assess future drought scenarios in the Požega area. The integration of regional and global climate models

would enable more precise projections of changes in precipitation and temperature patterns and their potential impact on water resources.

Drought analysis and prediction hold great importance for Požega, particularly considering their significant influence on agriculture, water resource management, and hydropower potential, all of which were analyzed in this paper. Early detection of trends and the development of reliable predictive models enable better planning and implementation of adaptation measures to mitigate potential negative impacts. Therefore, continuous monitoring and modeling of drought conditions are crucial steps toward sustainable environmental management and climate change adaptation.

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WPLYW SUSZY NA PRZEPLYW RZEKI ORŁJAVA

ABSTRAKT

Cel badania

Celem badania jest analiza okresów suszy w Pożedze, ich ewolucji w czasie oraz ich wpływu na dobowe przepływy rzeki Orłjava, przepływającej przez miasto. Ponadto, w badaniu omówiono możliwe konsekwencje dla potencjału hydroenergetycznego.

Materiały i metody

W tej pracy analiza suszy w okresie od 1961 do 2024 roku opiera się na znormalizowanym wskaźniku opadów i ewapotranspiracji (SPEI), który obliczono dla miasta Požega, położonego w kontynentalnej części Chorwacji. Wyniki uzyskane za pomocą wskaźnika SPEI porównano z wynikami uzyskanymi przy użyciu innego wskaźnika suszy – nowego wskaźnika suszy (NDI). Dalszą analizę obu wskaźników we wszystkich skalach czasowych przeprowadzono przy użyciu metody RAPS (rescaled adjusted partial sums), a dzienny przepływ rzeki Orłjava przeanalizowano w oparciu o uzyskane podokresy. Dla rzeki Orłjava (stacja Požega) obliczono również wskaźnik reprezentujący suszę hydrologiczną – Standaryzowany Wskaźnik Przepływu (SSI).

Wyniki i wnioski

Wyniki wykazały, że istnieją dwa statystycznie różne podokresy pod względem występowania suszy: od 1961 do 1999 roku oraz od 2000 do 2024 roku. Drugi podokres charakteryzuje się niższymi wartościami wskaźników SPEI i NDI, co oznacza bardziej dotkliwe warunki suszy. Na podstawie dobowych przepływów rzeki Orłjava obliczono wartości przepływu dla całego badanego okresu oraz dwóch podokresów wyodrębnionych na podstawie analizy suszy, odpowiadających prawdopodobieństwom jej wystąpienia wynoszącym 50% i 70%. Najniższe przepływy odnotowano w drugim podokresie, który charakteryzował się również bardziej intensywnymi suszami. Wyniki te potwierdzają wpływ suszy, wskazując na potencjalne ograniczenia dla rozwoju energetyki wodnej.

Słowa kluczowe: susza, znormalizowany wskaźnik opadów i ewapotranspiracji (SPEI), nowy wskaźnik suszy (NDI), Požega, rzeka Orłjava