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Drought Risks Assessment Using Standardized Precipitation Index †

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Abstract: The paper explores the occurrence of minimal precipitation extremes at specific meteorological stations in the southeastern region of Serbia. With climate change leading to increased instances of droughts, these natural phenomena have garnered heightened interest due to their negative impacts on society, environment, and the economy. Employing the SPI-12 index in the southeastern part of Serbia from 1946 to 2021, the study sheds light on the vulnerability of this natural phenomenon in the observed stations. Understanding historical manifestation of these events helps water resource managers, farmers and policymakers manage these risks in the southeastern region of Serbia.

Keywords: drought; Serbia; vulnerability of drought

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1. Introduction

Drought is a natural hazard whose likelihood increases with changing weather conditions [1]. The hydrologic cycle's parameters have been affected by climate, which led to changes in temperature and precipitation patterns that may increase the probability of floods and droughts [2,3]. The analysis of drought is a well-known topic in the scientific field. Starting from defining the main parameters of drought, to defining how to quantify it using different drought indices [4], the researchers have been occupied with how to describe drought risk assessment [5,6]. The SPI is used for drought analysis in different areas of the world [7]. This study aims to assess drought in Serbia from 1946 to 2021 using the Standardized Precipitation Index (SPI), which is based on measured monthly precipitation data at five synoptic stations located in the south-east of the country.

2. Materials and Methods

The Standardized Precipitation Index is a versatile and powerful tool for drought analysis [8]. It was developed to determine the precipitation change over a period of time. The SPI is calculated every n months at a different time scale, from 1 to 48 months depending on the time of interest. It can assist in diagnosing, defining, and monitoring drought that impacts a variety of human activities as well as ecosystems [9]. The SPI is used in this study to analyze drought at five meteorological stations (Nis, Leskovac, Dimitrovgrad, Vranje, Zajecar) located in the south-east part of Serbia. The monthly precipitation data were collected for the period from 1946 to 2021 and used for calculating the SPI for a 12-month time scale. The SPI is based on the cumulative probability of precipitation occurring at the

observation station and the application of the Gamma function [8]. The analyzed region is characterized by a moderate precipitation regime with the average annual precipitation of 650 mm. The precipitation values are below average in Serbia.

3. Results and Concluding Remarks

The results of SPI for drought are presented and analyzed. The results of SPI-12 for five stations are shown in Figure 1 and extreme droughts are marked in green. Drought analysis using the SPI was done on a 12-month time scale for all selected stations for 75 years. The results of the SPI were used to identify the intensity of drought. The results for the selected five stations in south-east Serbia are presented in Table 1. The Nis station has the highest drought intensity (−3.809) and the Zajecar station has the highest wet intensity (3.231). According to results, the driest years for this region are 1993, 1949 and 1985, while the wettest years are 2010, 1955 and 2018, respectively. Based on the terrain topography and local hydro-climatic conditions, it is clear that drought periods and intensity are not the same at all stations. The Leskovac station stands out, from all stations, as the driest station with 142 dry months in observed period, while Vranje is the wettest station with 149 months. The analysis showed that extremely dry states are presented at Nis in 1947 (12 months) and in 1949 (4 months), Leskovac in 1959 and 1972 (5 months) and in 1964 (4 months), Dimitrovgrad in 1950 (6 months), in 1949 and 1993 (5 months) and in 2001 (4 months), Vranje in 1992 (5 months) and in 1990 and 2001 (4 months) and Zajecar in 2001 (4 months). It is clear that the driest stations are Zajecar and Dimitrovgrad (especially in the period 1946–1952) and the wettest is the Vranje station.

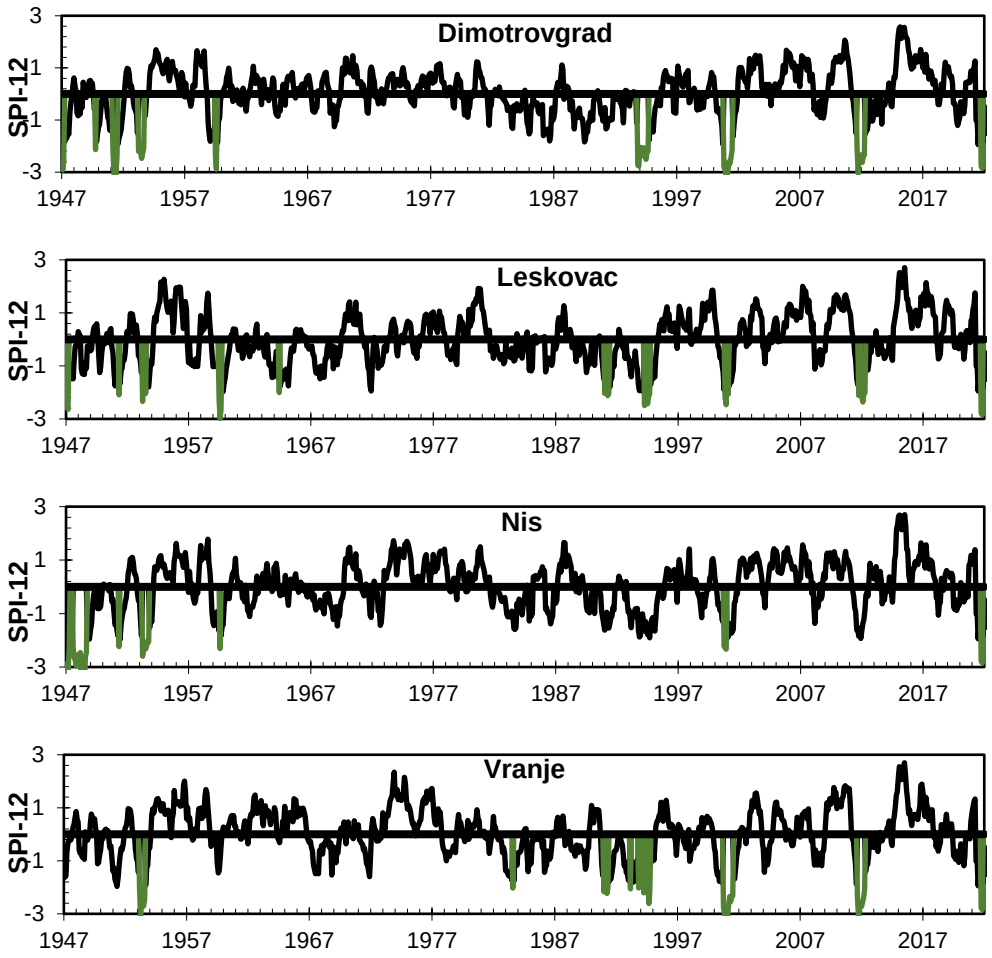

Figure 1. *Cont.*

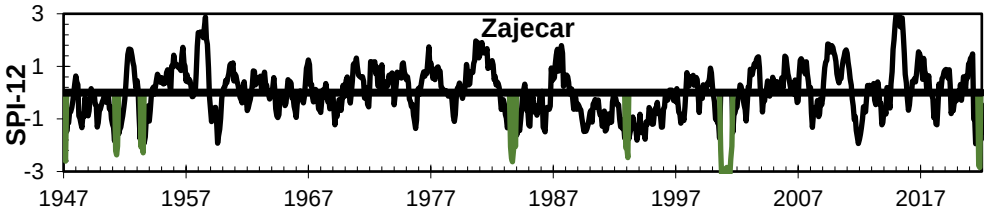

Figure 1. SPI-12—hydrographs for south- east part of Serbia during the period 1946–2021. Black are the SPI values; green are the extreme values of drought that occurred at this station.

Table 1. Identification of drought by SPI-12 for selected five stations.

Station	Maximum Drought Intensity	Driest Year	Maximum Wet Intensity	Wettest Year
Dimitrovgrad	−3.358	1950	2.771	2015, 2021
Leskovac	−3.177	1959, 1964	3.004	1955
Nis	−3.809	1947	3.110	2005
Vranje	−3.227	1993	2.814	2010
Zajecar	−3.337	1993	3.231	2010

The most frequent long-term minimum precipitation totals appear in the winter months. In the period from 1965 to 1983, no extremely long-term meteorological drought was recorded in the monitored stations. The Leskovac station is the most sensitive to the occurrence of extreme long-term precipitation deficits.

4. Conclusions

The analysis of drought using the SPI was calculated on a 12-month time scale for five stations in the south-east of Serbia for 75 years from 1946 to 2021. From the results, it is possible to see how extreme droughts often occurred during the period 1946–2021. Drought analysis could help decision-makers in water resources management. The results approved that SPI is a useful tool that could help decision-makers make efficient plans for drought risk management that could mitigate the impacts of such disasters. This analysis, on a local scale, can be easily applied in different locations around the world.

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