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Drought analysis of Black Sea Region by standardized precipitation index (SPI) and percent of normal index (PNI)

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Keywords

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ABSTRACT

Drought has become a critical problem for the whole world today. One of the main causes of drought is the decrease in precipitation regimes over time. In this study, the Black Sea Region was based on the annual total precipitation (mm) data between 1961-2019. Annual drought analysis was applied to 16 stations in the Black Sea Region with Standard Precipitation Index (SPI) and Percentage of Normal Index (PNI), which are two of the most used methods in drought analysis. As a result of the study, it was determined that the stations showed normal and above drought levels.

Introduction

Among the natural disasters of meteorological nature, the drought has the most impact. In other words, drought is the decrease of the water level below the normal level as a result of events such as decreases in precipitation, misuse of water resources, and hydrological adverse effects on water resources [1]. We divide drought into three different classes in general, these are meteorological drought, agricultural drought and hydrological drought. Meteorological drought is defined as a decrease in precipitation below the normal level in the long term and is the type of drought that is impossible to avoid [2]. In addition to the environmental damage of drought, it has a great long-term negative impact on the country's economy, agriculture, energy, tourism and forestry activities. The cost of the drought in Europe in 2003 was 11 billion euros, and the drought in Spain in 2006 damaged the agricultural sector more than 2 billion euros. As for our country, the agricultural sector shrank by 7.3% as a result of the drought in 2007 [3]. Today, many methods are used for drought analysis, the most common of which are the standard precipitation index and the percentage of normal index. In their study, Sarış and Gedik [4] analyzed the precipitation data of 11 stations in the Konya Closed Basin between the years 1930-2019 according to the standard precipitation index at different periods (6,12,24 and 36 months). As a result of the study, the temporal and hydrological variability of drought in Konya Closed Basin was statistically demonstrated with SPI analyzes applied at 20 different times [4]. Beden et al. made a two-stage drought analysis between 1960 and 2015 using the precipitation data of Samsun province. In the first stage, standard precipitation index and percent of normal index values were calculated. In the second stage, the index values of Mann Kendall method were applied. In this study, it was determined that the drought in the region was close to normal and above normal as a result of both stages [5]. In another study, Dinç, et al. [6] made standard precipitation index analysis in 3-, 6-, 12- and 24-month periods by using long-term precipitation data of 8 stations in Antalya province. When the results of the study are examined seasonally, it is concluded that the study area can be dry in winter as well as in summer and there is a constant risk of moderate drought in [6].

The Black Sea Region is the region that receives the most precipitation in our country and has diversity in terms of vegetation. It is a developed region of the agricultural sector, mainly tea and hazelnut production, therefore, drought analysis of the Black Sea Region is important and critical for future agricultural activities. In this study, 16 stations in the Black Sea Region investigated according to the precipitation data between 1961-2019 according to the standard precipitation index and the percent of normal index.

Material and Method

Material

In this study, data of 16 stations in the Black Sea region of Turkey were obtained from the Turkish State Meteorological Service (TSMS). In this region, the Black Sea climate varies as western, eastern, and central parts due to landforms. It is the region that receives the most precipitation in Turkey and the Black Sea, in line with the factors such as the elevation of the Eastern Black Sea-type mountains after the coast and the extension form. The climate and vegetation between the coast and the interior are completely different from each other. In the Middle Black Sea type, the amount of precipitation is less due to the decrease in altitude and the mountains being far from the coast. It has a flatter land than the Western and Eastern Black Sea Regions, as a result, it has arable lands [7]. The spatial distribution of the stations is given in Figure 1.
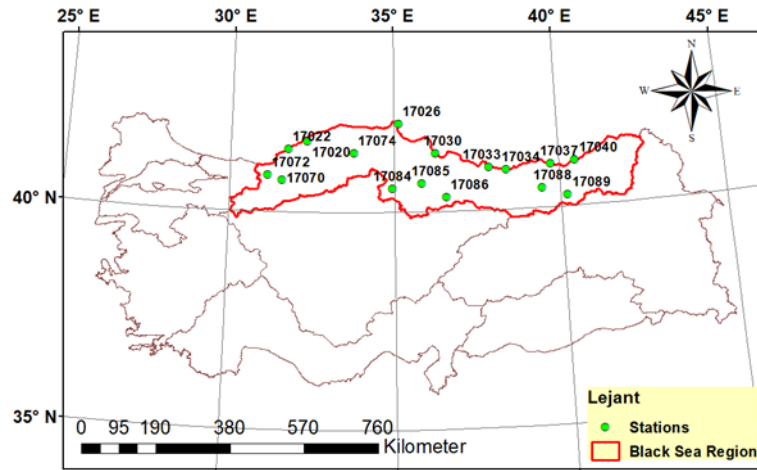

Figure 1. Study area and stations

Method

Standardized Precipitation Index (SPI)

More than one method is used in drought analysis. One of the most common of these methods is the standard precipitation index. The standard precipitation index was first developed by [8]. The standard precipitation index is calculated by dividing the difference from the average of the precipitation in a given period by the standard [8]. The index calculation of the SPI method is performed with Equation 1. The classes as a result of this calculation are given in Table 1 [9].

Percent of Normal Index (PNI)

Another method commonly used in drought analysis is the percentage of the normal index. The percentage index of normal is calculated by dividing the precipitation amount in a certain time by the average precipitation. PNI method is performed with Equation 2. The classes as a result of Equation 2 are given in Table 2 [8].

Table 1. Classifications of the SPI

Index Range	Classification
2.0 and more	Exceptionally Moist
1.60 - 1.99	Extremly Moist
1.30 - 1.59	Very Moist
0.80 - 1.29	Moderately Moist
0.51 - 0.79	Abnormally Moist
0.50 - -0.50	Near Normal
-0.51 - -0.79	Abnormally Dry
-0.80 - -1.29	Moderately Dry
-1.30 - -1.59	Severely Dry
-1.60 - -1.99	Extremly Dry
2.0 and less	Exceptionally Dry

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Table 2. Classifications of the PNI

Period	Normal and Above (%)	Slightly Dry (%)	Moderately Dry (%)	Severely Dry (%)
1	> 75	65-75	55-65	< 55
3	> 75	65-75	55-65	< 55
6	> 80	70-80	60-70	< 60
9	> 83.5	73.5-83.5	63.5-73.5	< 63.5
12	> 85	75-85	65-75	< 65

$$SPI = \frac{\left(X_i - X_i^{avg}\right)}{\sigma} \qquad (1)$$

$$PNI = \frac{X_i}{X_i^{avg}} \times 100 \qquad (2)$$

X_i^{avg} is average amount of precipitation,
σ is standard deviation,
SPI is standardized precipition index,
X_i current amount of precipitation (mm).

PNI is percent of normal index,
X_i current amount of precipitation,
X_i^{avg} is average amount of precipitation.

Results

The index values obtained according to the SPI and PNI methods were examined between 1961 and 2019 and the data of 16 stations were analyzed. As a result of this analysis, normal and above drought symptoms were detected at the rate of 67.4% according to the SPI method and 79.22% according to the PNI method.

Conclusion

In this study, two different drought indices were used to determine the drought of the Black Sea Region. These indexes are SPI and PNI indices. In the study, 16 provincial stations were used to represent the region. The monthly average precipitation data used in the analyzes cover the years 1961-2019. When the results were examined, there are no signs of drought for the region in the near future.

Author contributions:

Bilgehan İnan: Writing-Reviewing, Methodology, Application, **Vahdettin Demir:** Conceptualization, Editing, **Mehmet Faik Sevimli:** Last Editing.

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