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Determination of the dry periods using standard precipitation index in eskişehir porsuk basin and drought management

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ABSTRACT

Standardized Precipitation Index (SPI) is the most widely used drought index which provides good estimates on the drought intensity based on the size of the temporal and spatial dimensions. The main advantage of the SPI in comparison with other indices is the fact that the SPI enables both determination of drought conditions at different time scales and monitoring of different drought types.

In this study, drought analysis of the western region of Türkiye, Eskişehir, specifically, the local and regional Porsuk Basin was performed using standardized precipitation index, and drought management strategies have been studied.

Keywords: *Drought, Standard Precipitation Index (SPI), Drought management, Porsuk Basin*

INTRODUCTION

Drought is a natural disaster that affects the environment and could have serious harmful effects on the water resources. Droughts occur slowly, its duration and magnitude cannot be predicted; therefore, it could have serious adverse effects on the large spatial dimension of socio-economic stability in the region.

Characterization of drought detection and monitoring is of great important for the planning and management of water resources. Drought management and planning of water resources provides an essential collection of planning and management tools for minimizing the negative impacts of droughts. It is not possible to avoid droughts. But drought preparedness can be developed and the impacts of the drought can be managed.

Defining drought is therefore difficult; it depends on differences in regions, needs, and disciplinary perspectives (NDMC, 2007). In general there are tree different types of drought: (1) meteorological drought, (2) hydrological drought; and (3) agriculturaldrought (e.g. Livada and Assimakopoulos 2007). This study focuses on the meteorological drought which is defined as a lack of precipitation over a region for a period of time. The standardized precipitation index (SPI) (McKee et al. 1993, 1995; Hayes et al. 1999) was widely used to reveal meteorological drought (e.g. Silva et al. 2007; Bordi et al. 2004a; Moreira et al. 2006) and was proven to be a useful tool in the estimation of the intensity and duration of drought events (Bordi et al. 2004a). Livada and Assimakopoulos (2007) used the SPI to analyze drought events in Greece. Wilhite and Glantz (1985) applied the SPI in Nebraska on time scales of 3, 6, 12, 24 and 48 months.

In this study, the SPI is calculated based on 12 month precipitation time series. Specifically, the local and regional Porsuk Basin in Eskişehir.was performed using standardized precipitation index, and drought management strategies have been studied.

STUDY AREA

Catchment area of the Porsuk River, which is a tributary of the Sakarya River, covers an area of 11188 km^2 in the Northwest Anadolu in Turkey. Study area is situated between east longitudes 29°38' and 31°59' and between north longitudes 28°44' and 39°99' (Figure 1). Porsuk River catchment area accommodates Eskisehir and Kutahya provincial centers and seven county seats of these provinces. Annual total rainfall as calculated by isohyetal method gives the value 451 mm. Snowfall occurs in the period from November to April. January is the coldest month whereas July is the hottest. Annual average temperature varies from 8.8 °C to 12.3°C. Evaporation gaugings by round-pen Meteorological Gauging Station in Kutahya (State Meteorological Work's Station) and Porsuk dam (State Hydraulics Work's Station) are used in calculations of net evaporations in all dams which are in operation scheduled to implementation and planning stage.

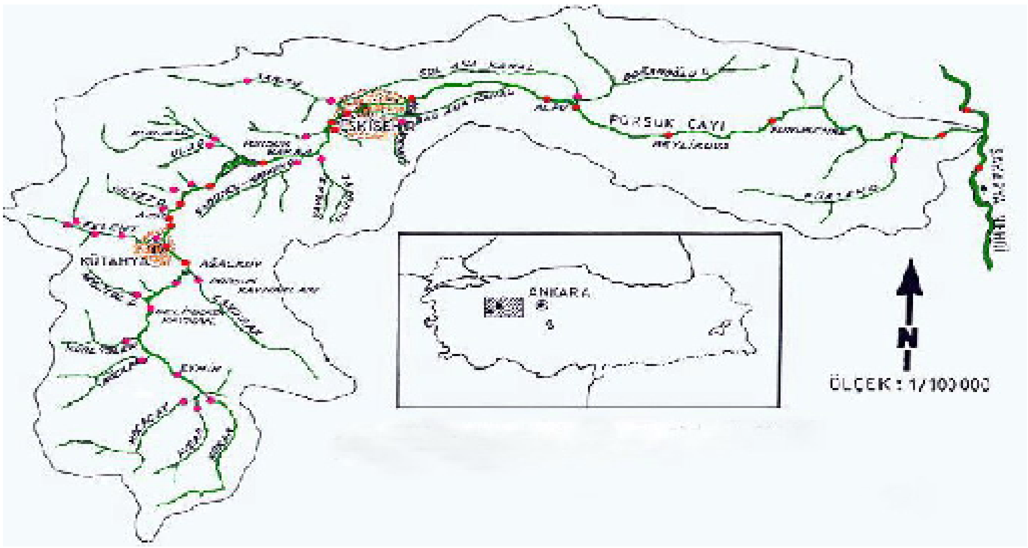

Figure 1 Study area

STANDARDISED PRECIPITATION INDEX

The Standardized Precipitation Index (SPI), which is one of the most widely used drought indices, was developed by McKee *et al.* (1993). The SPI has the following favourable characteristics:
(a) Simplicity (only rainfall data required for calculation)
(b) Standardization (frequency of extreme drought events at any location and time scale are consistent)
(c) The SPI is normally distributed so it can be used to monitor wet as well as dry periods.

According to McKee et al. (1993), the SPI was defined on each of the time scales as the difference between precipitation on the time series (x_i) and the mean value ($\bar{x}$), divided by the standard deviation (s_x), i.e.

$$SPI = \frac{x_i - \bar{x}}{s_x} \quad (1)$$

In fact, the index calculation of periods of precipitation less than 12 months and normally distributed primarily because of failure to comply with complicated and therefore the normal distribution of precipitation series is made available. The resulting SPI values linearly with rainfall deficiency shows a increasing and decreasing trend. Normalized values as a result of SPI within the selected time period as well as both dry and wet periods are represented in the same way. That the SPI values negative values, the periods is defined as the dry period . When the SPI index falls under zero, the first months is considered as the beginning of drought. The SPI index rise positive value is considered to be the end of the drought.

McKee *et al.* (1993) used a classification system which is normalized so that wetter and drier climates can be represented in the same way. SPI is a normalised index in time and space. This feature allows comparisons of SPI values between different locations. The values of SPI can be classified according to Table 1. Here, the near normal class results from the aggregation of two classes: $-1<SPI<0$, equivalent to mild drought and $0\leq SPI\leq 1$, equivalent to slightly wet.

Table 1 Wet and drought period classification according to the SPI index

SPI Index value	**Classification**	**Probability**	***Cumulative Probabilty %***
SPI ≥2.00	Extremely wet	0.977 - 1.000	2.3
1.50 ≤SPI < 2.00	Very wet	0.933 - 0.977	4.4
1.00 ≤SPI < 1.50	Moderately wet	0.841 - 0.933	9.2
0 ≤SPI < 1.00	Slightly wet	0.500 - 0.841	34.1
-1.00 ≤SPI < 0	Mild drought	0.159- 0.500	34.1
−1.50 ≤SPI < −1.00	Moderate drought	0.067 - 0.159	9.2
−2.00 ≤SPI < −1.50	Severe drought	0.023 - 0.067	4.4
SPI < −2.00	Extreme drought	0.000 - 0.023	2.3

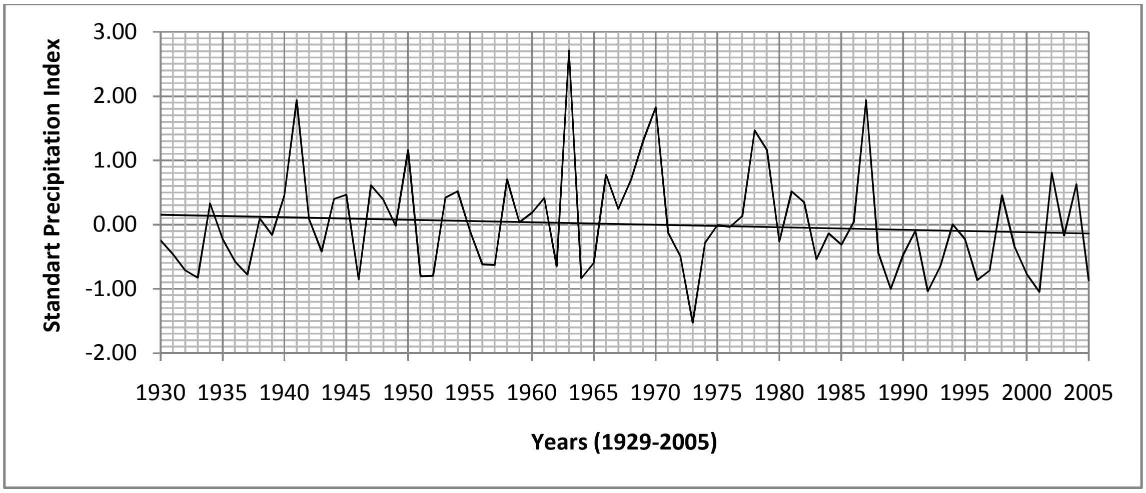

Figure 2.SPI values change according to the years (1929-2005) in Eskisehir

Dry periods are considered in the past 40 years, moderate drought consecutive dry periods were observed. However, in 1973 was the most severe drought (Fig.2).

DROUGHT MANAGEMENT

Effective drought management emphasizes three components: monitoring and early warning; risk and impact assessment and mitigation and response.

Drought monitoring, data and information related indicators (eg, precipitation, temperature, evapotranspiration, seasonal weather forecasts, soil moisture, stream, groundwater, reservoir and lake levels, and snow cover) should be taken into account the evaluation of the country water resources. There should be a monitoring committee comprising of representatives from agencies with responsibility for monitoring climate and water supply, traditionally meteorological, hydrological and agricultural services.

Wilhite (1997) completed an assessment of drought mitigation technologies implemented by U.S. states in response to drought conditions. These actions were clustered into nine primary areas:

- monitoring and assessment
- legislation and public policy
- water supply augmentation
- public education programs
- technical assistance
- demand reduction
- emergency response
- water use conflict resolution
- drought planning.

CONCLUSION

The SPI is commonly used for the identification of various drought characteristics such as the duration of dry and wet period. The Eskisehir Porsuk basin in years of research (1929-2005) in mild, moderate, severe and very severe levels of drought occurred.

According to Fig.2. the first of two times to the present day in the city are severe and moderate drought in 1973 (SPI = 1.6), in the present and the other in 2001 (SPI = -1.1).

Implemented effective strategies for drought management and drought preparedness and risk reduction associated with the effect. Drought preparedness and management are effective strategies to reduce risks and therefore the impacts associated with droughts. Preparedness for drought necessitates greater institutional capacity at all levels of government and more efficient coordination between different levels of government.

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