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Assessing Temporal Alterations in Drought Status of Kerman Province from 1990 to 2018 Using Mann-Kendall Test and Sen's slope

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Extended Abstract

Introduction: Located in arid and semi-arid climates, most parts of Iran suffer the consequences of drought; the fact that makes the assessment of the trend of changes in the drought a crucially important task. On the other hand, an overview of previous studies indicates the occurrence of severe and long-term droughts in recent years, highlighting the consequences brought about by drought in Iran and other parts of the world. Considering the fact that global warming-induced climate change and severe and prolonged droughts are the major challenges worldwide, especially in the arid and semi-arid regions, it is necessary to examine the drought's trend of changes as a consequence of climate change that may severely limit access to water resources. However, while several studies have been conducted on meteorological drought in different regions of Iran, no comprehensive study has so far been carried out on the changes made in meteorological drought in Kerman province in terms of SPEI. Therefore, this study sought to investigate the trend of such changes in Kerman province over different time scales. In other words, the main goal of the current study was to assess the trend of short-term and long-term changes in the meteorological drought of the province using Mann-Kendall and Sen's slope tests.

Materials and methods: Located in southeastern Iran, the study area of this research comprised Kerman province. To conduct the study, relevant meteorological data, including average monthly precipitation and temperature in seven synoptic stations were obtained from Kerman's Meteorological Organization for the 1990-2018 period. Moreover, Standardized Precipitation Evapotranspiration Index (SPEI) was calculated to identify drought periods within three time scales (3, 9, and 12-month scales). It should be noted that the SPEI is mainly used to estimate the dry and wet periods based on the precipitation and temperature data. To evaluate the trend of time series changes, the existence of autocorrelation between different time series was investigated using the Pre-Whitening method (Von Storch, 1999). After confirming the absence of autocorrelation among the time series data, the Mann-Kendall test was performed to examine the trend of changes in the SPEI values. Furthermore, Sen's slope value was measured to identify the significance of the slope at different confidence levels. In other words, the assessment of the upward and downward trend of the SPEI series was carried out using Mann-Kendall and Sen slope tests.

Results and discussion: Considering the impact of climate change on the precipitation and temperature in Iran and the significant influence of precipitation and its fluctuations on agricultural production, it is important to assess the fluctuations of phenomena such as drought that are directly affected by such climatic parameters. Therefore, this study set out to assess the drought changes in terms of SPEI3, SPEI9, and SPEI12 in Kerman

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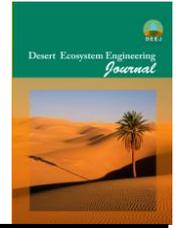
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province which is characterized by an arid and semi-arid climate. The results of the SPEI-based time series analysis showed that the highest number of drought events during the study period (1990-2018) occurred in Shahrabak station with 80% frequency. Moreover, according to the average annual SPEI value, the most severe drought also occurred in Shahrabak station in 2016. Furthermore, the average annual SPEI values indicated that the study area experienced the most severe drought events between 1998 and 2010. On the other hand, the results of the evaluation of the drought's monthly changes performed by Mann-Kendall and Sen's slope tests revealed that in almost all months of the year (except May), increasing and decreasing trends occurred, with the most significant drought changes occurring in January (increasing and decreasing trend) and October (increasing trend). The seasonal changes of drought also suggested that there was an upward slope in some stations during the spring, autumn, and winter, which was significant at 99% and 95% confidence levels, while the summer experienced increasing and decreasing trends of changes during the study period. Similarly, Malekinejad et al. (2012) found an increasing trend of drought changes during the spring, summer, and autumn in Tehran province. In general, the evaluation of annual changes in drought index within the studied stations indicated that the whole area (1990-2018) followed an upward trend throughout the study period. In other words, the severity of drought suggested an increasing trend in the Kerman province, which could be regarded as one of the main reasons for climate change and consequently an increase in the air temperature (Mirakbari and Ebrahimi, 2021; Mesbahzadeh et al., 2020). Moreover, the increasing trend in Iran's drought status has been reported by several researchers, including Ghorbani et al. (2020), Mozaffari et al. (2021), and Amani et al. (2021). The investigation of changes in drought periods suggested that Kerman province experienced three periods with different trend slopes throughout the study's sub-periods. The first period (1990-1996-1990) followed a decreasing slope, while the second (1997-2010) and the third period (2011-2018) showed an increasing slope, which was relatively consistent with the changes in precipitation and average temperature throughout Kerman province. The results of this phase of the study are consistent with the results found by Ebrahimi et al. (2021), who reported the existence of three periods of drought changes with different trend slopes based on the Domarten drought index in the whole parts of Iran. In general, the results of this study indicated that during the previous years, Kerman province had experienced an increasing trend in terms of drought, requiring more attention from water resources experts and planners to proper management of water shortages caused by severe droughts.

Keywords: Drought, SPEI, Mann-Kendall, Sen's slope, Kerman Province.