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Long-Term Statistical Analysis of Meteorological Drought Trends in Isfahan Province

Hadi Zarepour¹, Abbas Ali Vali*², Hamid Ghorbani³, Seyed Javad Sadatinejad⁴, Seyed Hassan Alavinia⁵

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Extended Abstract

Introduction: As one of the greatest natural disasters, meteorological drought has traditionally affected human life. Considering the fact that the consequences of drought and its socio-economic damages increase with increasing population, it is necessary to have an effective monitoring system to analyze the drought process and reduce its adverse effects, thereby taking effective measures to manage the crisis.

Materials and methods

The study area and data: This study was conducted in Isfahan province, located at latitudes of 30° 43' to 34° 27'N and longitudes of 49° 38' to 55° 32' E with an area of 107145 km² (equivalent to 3.6 percent of the total area of Iran), whose annual precipitation rate is 130 mm which is less than half the country's average rainfall rate and one sixth of the average global rate. This study used 30-year precipitation data collected from 10 meteorological stations and neighboring areas with appropriate statistical quality to investigate the drought indices of the Isfahan province.

Case Study Indicators: Trend analysis of precipitation and drought data plays a significant role in the future development and management of water resources. Therefore, this study sought to analyze the trends of meteorological droughts and monthly precipitation rate for the period of 1990-2020 extracted from 10 synoptic stations in Isfahan province, including Ardestan, East Isfahan, Golpaygan, Isfahan, KabootarAbad, Kashan, Khorobianbanak, Naein, Natanz, Shahreza. Moreover, to investigate the variability of the Z-Score Index (ZSI) for different time intervals, the ZSI values of all these stations were calculated at multiple scales of 1, 3, 6, 9, 12, 24 and 48 monthly scales, whose trends were analyzed for all stations by applying the non-parametric Mann-Kendall at 5% significance level. The magnitudes of the trends were also computed and tested using the Sen's

1Ph.D. Student of Faculty of Natural Resources and Earth sciences, University of Kashan

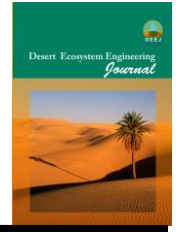
2Associate Professor of Faculty of Natural Resources and Earth sciences, University of Kashan; vali@kashanu.ac.ir

3Assistant Professor of Faculty of Mathematical Sciences, University of Kashan

4Associate Professor of Faculty of New Sciences and Technolgiest, University of Tehran

5Assistant Professor of Faculty of Natural Resources and Earth sciences, University of Kashan

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slope estimator method.

Results and discussion: It should be noted that the purpose of the Mann-Kendall test is to statistically assess the existence of monotonic upward or downward trend of the intended variable over time. A monotonic upward (downward) trend means that while the variable consistently increases (decreases) over time, the trend may be either linear or non-linear.

To identify a linear trend, the slope is usually estimated by computing the least squares estimates using linear regression. However, this is only valid when there is no serial correlation. Moreover, the least squares method is very sensitive to outliers. Therefore, as a robust method against those two least square assumptions, non-parametric Sen's slope estimator was used to analyze ZSI Indices and detect the possible trend.

Further trend analysis was also applied to detect possible single change-point using Pettitt's test, which helped investigate significant abrupt changes in the level of time series at 5% significance level for all stations and different ZSI monthly scales. All statistical analyses were carried out via R statistical software and the facilities of its packages.

Discussion and Conclusion: The results of applying Mann-Kendall and Sen's slope tests based on ZSI Index for 9, 12, 18, 24, and 48-month scales indicated that the drought trend was significantly increasing for all stations out of Esfahan and Shahreza stations. In Isfahan station, the drought trend was significantly decreasing in the 48-month scale, and in Shahreza station, the drought trend was significantly increasing in all time periods. Moreover, the results of Mann-Kendall and Sen's slope tests for a one-month period revealed a significantly increasing trend in terms of ZSI Index in Naein and KabootarAbad stations only. Furthermore, applying Mann-Kendall test on monthly precipitation rates of all stations showed an insignificant downward trend.

Finally, the results of the Pettitt's change point test for 9, 12, 18, 24, and 48-month scales indicated the existence of a significant change point in terms of the ZSI Index. However, no change point was observed for all stations' monthly precipitation rates throughout the same periods.

In short, considering the ZSI drought index, it could be said about 58% of all stations showed significant downward trend according to the results of the Mann-Kendall test, 56% of all stations showed a significant slope trend according to the Sen's slope test, and 81% of all stations showed a significant change point according to the results of the Pettitt's test. In general, it could be argued that drought trends are better analyzed and displayed in terms of the ZSI index for over six-month periods, and that under six-month scale are unable to produce significant results.

Considering what discussed above, it should be reiterated that Isfahan province is facing a water crisis, requiring very urgent water demand management.

Keywords: Drought, Isfahan Province, Mann-Kendall Test, Pettitt's Change Point Test, Sen's Slope Test, Z-Score Index, Trend Analysis.