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Research Article

COMPARISON OF RECONNAISSANCE DROUGHT INDEX (RDI) AND STANDARDIZED PRECIPITATION INDEX (SPI) FOR DROUGHT MONITORING IN ARID AND SEMIARID REGIONS

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ABSTRACT
Drought is one of the most common natural events that have a great negative impact on agriculture and water resources. Recently, a new index for drought assessment and monitoring is presented called Reconnaissance Drought Index (RDI). RDI is calculated based on precipitation and potential evapotranspiration. In this study, indices of SPI (Standardized Precipitation Index) and RDI were calculated using 29 years meteorological data (1981-82 to 2009-2010) for five regions. The Results showed that dry and wet periods on short time scales, in addition to precipitation depend on the evapotraspiration and the other weather parameters. It is recommended, in short time scales (1, 3 and 6 months) to be used the RDI index for drought assessment.

Keywords: *Drought, Standardized Precipitation Index (SPI), Reconnaissance Drought Index (RDI)*

INTRODUCTION
Drought as an environmental disaster is associated with a deficit of water resources over a large geographical area, which extends for a significant period of time (Rossi, 2000). It occurs in areas with high and low rainfall and all climate conditions. The different drought indices are presented for drought monitoring. They are useful tools for decision makers to identify weather abnormal conditions for a region (Wilhite *et al.,* 2000).
There are many literatures on the drought evaluation by using different indices, models and water balance simulations (Palmer, 1965; Alley, 1985; Stahl and Demuth, 1999; Jain *et al.,* 2010). There are different indices for drought monitoring, such as: Palmer Drought Severity Index (PDSI), Crop Moisture Index (CMI), Surface Water Supply Index (SWSI), Percent of Normal Index (PN), Standardized Precipitation Index (SPI) (Hayes, 2003; Mishra and Singh, 2010).
Along the various indices for meteorological drought monitoring, SPI were widely accepted and used (Hayes and Svoboda, 1999; Tsakiris and Vangelis, 2004; Shamsnia and Pirmoradian, 2009).The SPI was presented by McKee and his colleagues at Colorado State University (McKee *et al.,* 1993). SPI is completely related to probability. This Index use precipitation as the most effective parameter in the calculation of the drought severity. The SPI is normally distributed so it can be applied to monitor wet as well as dry periods. During the last decade the SPI has become very popular due to its low data requirements. This index can be useful for drought monitoring and forecasting (Cancelliere *et al.,* 2007; Shamsnia *et al.,* 2009). Recently, a new index for drought assessment and monitoring is presented called Reconnaissance Drought Index (Tsakiris and Vangelis, 2005; Tsakiris *et al.,* 2007). RDI is calculated based on precipitation and potential evapotranspiration. Precipitation alone cannot show the impact of drought on agricultural production and vegetation. Applying both of the P and PET in drought severity calculation and monitoring, increases the validity of the results (Tsakiris *et al.,* 2007). The main aim of this study is to determine the relationship between two meteorological indices, namely RDI and SPI and identify the differences.
The Study Area
Iran is exposing drought with different severities (Badripour, 2007; Raziei *et al.,* 2009; Asadi Zarch *et al.,* 2011). To evaluate drought, five regions in Fars Province in the south of Iran were selected. Fars Province with semi-arid and arid climates is one of the most important agricultural parts of the country. This province is located in the southern part of Iran, at 50° 30' to 55° 38' E longitude and 27° 3' to 31° 42' N latitude, with

an arable land area of 1.32 million Km^2. The annual mean of precipitation for the province ranges from 50 to 1000mm (Sadeghi *et al.*, 2002). The Location of study areas, is shown in Figures 1. The geographic characteristics, rainfall, PET values (based on the PM equation) and climate of each region for the 9 years (2000 - 2009) are presented in Table 1 & 2. UNESCO (1979) used a system based on average annual precipitation (P) and potential evapotranspiration (PET) for aridity/humidity classification. According to UNESCO, the potential evapotranspiration was calculated using Penman formula. Table 2 indicates the climatic condition of each area.

Data Used

Meteorological data were collected from the Fars Regional Water Authority in a period of 29 years (1981-82 to 2009-2010) for SPI and RDI calculation.

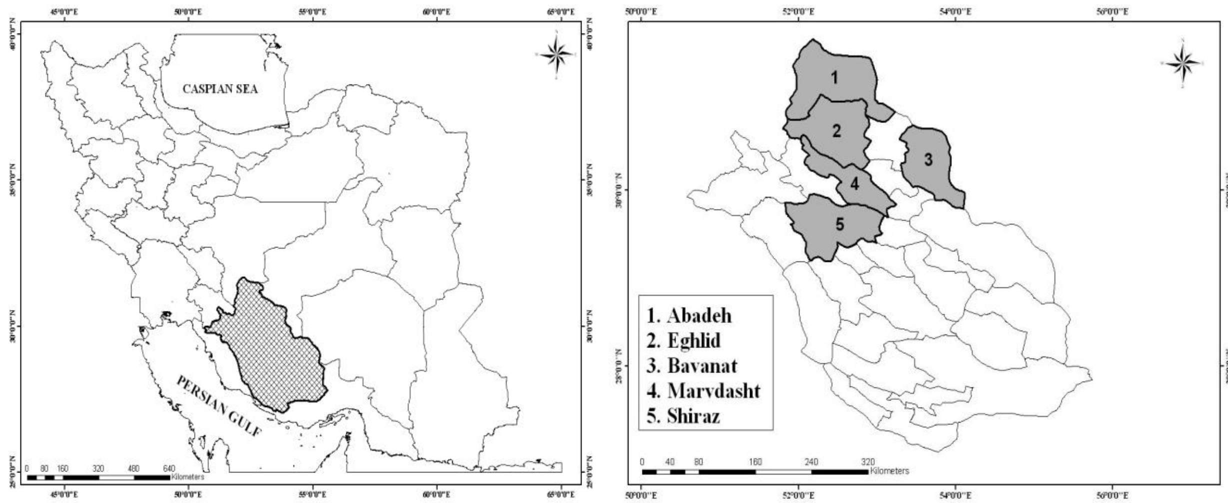

Figure 1: Regional map of Iran, Fars Province and location of study areas for drought evaluation

Table 1: The geographic characteristics for each region

Region	Longitude	Latitude	Elevation(m)
Abadeh	52° 40´ E	31° 11´ N	2030
Eghlid	52° 38´ E	30° 54´ N	2300
Bavanat	53° 40´ E	30° 28´ N	2231
Marvdasht	52° 43´ E	29° 47´ N	1596
Shiraz	52° 36´ E	29° 32´ N	1484

Table 2: Rainfall, PET and climate for each region

Region	P (mm)	PET (mm)	P/PET	Climate
Abadeh	136.7	1457.2	0.094	Arid
Eghlid	319.4	1449.43	0.220	Semi-arid
Bavanat	305	1495.4	0.204	Semi-arid
Marvdasht	309.2	1393.3	0.222	Semi-arid
Shiraz	314.9	1658.5	0.190	Arid

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MATERIALS AND METHOD

Calculation of Meteorological Indices

The Standardized Precipitation Index

The standardized Precipitation Index (SPI) is one of the indices that were presented for drought monitoring. It is calculated in short-term (3, 6 and 9 months) and long-term (12, 24 and 48 months) (McKee *et al.*, 1993) periods. In any time scale, the SPI mean may reach zero in a location and its variance become equal to 1.Using the SPI, quantitative definition of drought can be established for each time scale. A drought event for time scale i is defined here as a period in which the SPI is continuously negative and the SPI reaches a value of -1.0 or less. The drought begins when SPI first falls below zero and ends with positive value (Mckee *et al.*, 1993)

The Reconnaissance Drought Index (RDI)

The Reconnaissance Drought Index (RDI) is calculated in three stages: Initial value of RDI (a_0), normalized RDI (RDIn) and standardized RDI (RDIst). Initial value may be calculated for each month, seasons (3-month, 4-month, etc.) or hydrological year. The a_0 is calculated by using the following equation (Tsakiris *et al.*, 2007; Asadi Zarch *et al.*, 2011)

$$a_0^{(i)} = \frac{\sum_{j=1}^{12} P_{ij}}{\sum_{j=1}^{12} PET_{ij}}, i = 1(1)N \quad \text{and} \quad j = 1(1)12 \tag{1}$$

Where P_{ij} and PET_{ij} are the precipitation and potential evapotranspiration of the jth month of the ith hydrological year. Hydrological year is starting from October in Iran. N is the total number of years of the available data.

A second step, the Normalized RDI (RDI_n) is computed using the following equation for each year, in which it is evident that the parameter a_0 is the arithmetic mean of a_0 values (Tsakiris *et al.*, 2007; Asadi Zarch *et al.*, 2011).

$$RDI_n^{(i)} = \frac{a_0^{(i)}}{\bar{a}} - 1 \tag{2}$$

The third step, the Standardized RDI (RDI_s), is computed following a similar procedure to the one that is used for the calculation of the SPI: The equation for the Standardized RDI is:

$$RDI_{st(k)}^{(i)} = \frac{y_k^{(i)} - \bar{y}_k}{\hat{\sigma}_{yk}} \tag{3}$$

Where y_k is the ln(a_0 ; $\bar{y}_k$) is its arithmetic mean of y_k , and $\hat{\sigma}_{yk}$ is its standard deviation.

The RDI is based on the ratio of two aggregated quantities which are precipitation and potential evapotranspiration. It can be estimated for all time scales. However 3, 6, 9 and 12 month are suggested since they are more useful for comparing different locations (Tsakiris and Vangelis, 2005).

Time Scales

In this study, Monthly SPI and RDI were calculated using the monthly precipitation and evapotranspiration data of five stations in Fars Province. SPI and RDI values were calculated in the period of hydrological years from 1981-82 to 2009-2010 for the time scales of 1, 3, 6, 9 and 12 months. Because of data limitations, SPI with time scales longer than 24 months may be unreliable (Guttman, 1999). The RDI_{st} behaves similar to the SPI. Drought classification of these indices is shown in Table 3. The values from -0.5 to -0.99 and +0.5 to +0.99 considered as nominal class of mild drought and slightly wet (Giddings *et al.*, 2005; Shamsnia and Pirmoradian, 2009).

Table 3: Drought classification according to the SPI and RDI_{st} values

SPI and RDI_{st} value	Category
2 or more	Extremely wet
+1.5 to +1.99	Severely wet
+1 to +1.49	Moderately wet
+0.5 to +0.99	Slightly wet
-0.49 to +0.49	Normal
-0.5 to -0.99	Mild drought
-1 to -1.49	Moderate drought
-1.5 to -1.99	severe drought
-2 and less	Extreme drought

Correlation Analysis

For the determination of correlation between SPI and RDI and identifying their differences in different time scales, the correlation coefficient (r) was used.

RESULTS AND DISCUSSION

Correlation Analysis between RDI and SPI

The correlation coefficients (r) between SPI and RDI for each area and each time scales are described in Table 4. Results show the presented correlation coefficients increase in the longer time scales such as (9 and 12 months). The maximum value of r between SPI and RDI was obtained for 12-month time scale and the minimum value for 1-month time scale in all areas (Table 4.). In time Scale 9 and 12 months in all stations, correlation coefficient (r) is more than 0.9. Because SPI index is related to precipitation parameters for drought assessment, the results show that precipitation parameters are more effective in drought with a longer time scale. By contrast, the effect of potential evapotraspiration parameters that were used in the RDI index will be reduced by increasing the time scale. The wet, drought and normal periods have more fluctuation on the short time scales such as 1, 3 and 6 months, because of the low number of effective months and effects of other meteorological parameters on the severity of drought. In other words, changes of dry and wet periods on short time scales, in addition to precipitation, depend on evapotraspiration and the other weather parameters.

Table 4: Correlation coefficient (r) of the SPI and RDI in different time scales

Row	Station	Time Scales (Month)				
		1	3	6	9	12
1	Abadeh	0.838	0.965	0.979	0.990	0.992
2	Eghlid	0.521	0.746	0.899	0.948	0.985
3	Bavanat	0.640	0.831	0.954	0.977	0.991
4	Marvdasht	0.532	0.764	0.842	0.971	0.989
5	Shiraz	0.615	0.856	0.941	0.983	0.997

Conclusion

SPI and RDI were calculated in a period of 29 years data (1981-82 to 2009-2010) for five areas in Fars

Province. Correlation analysis is performed to identify the differences of the standardized precipitation index (SPI) and the reconnaissance drought index (RDI). Dry and wet periods on short time scales, in addition to precipitation depend on the evapotraspiration and the other weather parameters. It is recommended that in short term time scales (1, 3 and 6 months) use the RDI index for drought assessment.

REFERENCES

Alley WM (1985). The Palmer Drought Severity Index as a measure of hydrological drought. *Water Resources Bulletin* **21** 105–114.

Asadi Zarch MA, Malekinezhad H, Mobin MH, Taghi Dastorani M and Kousari MR (2011). Drought Monitoring by Reconnaissance Drought Index (RDI) in Iran. *Water Resources Management* **25**(13) 3485-3504.

Badripour H (2007). Role of drought monitoring and management in NAP implementation. In: *Climate and Land Degradation* edited by Mannava *et al.,* (Springer, The Netherlands).

Cancelliere A, Mauro GD, Bonaccorso B and Rossi G (2007). Drought forecasting using the Standardized Precipitation Index. *Water Resources Management* **21** 801-819.

Giddings L, Soto M, Rutherford NM and Maarouf A (2005). Standardized precipitation index zones for Mexico. *Atmosfera* **18**(1) 33-56.

Guttman NB (1999). Accepting the standardized precipitation index: A calculation algorithm. *Journal of American Water Resources Association* **35**(2) 311-322.

Hayes M (2003). Drought Indexes. National Drought Mitigation Center, University of Nebraska–Lincoln, (available from University of Nebraska–Lincoln, 239 LW Chase Hall, Lincoln, NE 68583).

Hayes MJ and Svoboda MD (1999). Monitoring the 1996 drought using SPI. *Bulletin of the American Meteorological Society* **80** 429–438.

Jain SK, Keshri R, Goswami A and Sarkar A (2010). Application of meteorological and vegetation indices for evaluation of drought impact: a case study for Rajasthan, India. *Natural Hazards* **54** 643-656.

McKee TB, Doesken NJ and Kleist J (1933). The relationship of drought frequency and duration to time scales. Preprints, *8th Conference on Applied Climatology*, Anaheim, California 179–148

Mishra AK and Singh VP (2010). A review of drought concepts. *Journal of Hydrology* **391** 202-216.

Palmer WG (1965). Meteorological drought. US department of commerce, Weather bureau research paper. No. 45, US Weather, Washington, DC, USA.

Raziei T, Saghafian B, Paulo AA, Pereira LS and Bordi I (2009). Spatial patterns and temporal variability of drought in western Iran. *Water Resources Management* **23** 439–455

Rossi G (2000). Drought mitigation measures: a comprehensive frame work. In *Drought and Drought Mitigation in Europe* edited by J Voght and F Somma (Kluwer Academic Publishers, Dordrecht).

Sadeghi AR, Kamgar-Haghighi AA, Sepaskhah AR, Khaliliand D and Sh. Zand-Parsa (2002). Regional classification for dryland agriculture in southern Iran. *Journal of Arid Environments* **50** 333–341.

Shamsnia SA, Amiri SN and Pirmoradian N (2009). Drought simulation in Fars province using standardized precipitation index and time series analysis (ARIMA model). *International Journal of Applied Mathematics* **22**(6) 869-878.

Stahl K and Demuth S (1999). Linking stream flow drought to occurrence of atmospheric circulation pattern. *Hydrological Sciences Journal* **44**(5) 665–680.

Tsakiris G and Vangelis H (2004). Towards a Drought Watch System based on Spatial SPI. *Water Resources Management* **18** 1-12.

Tsakiris G and Vangelis H (2005). Establishing a drought index incorporating evapotranspiration. *European Water* **9**(10) 3-11.

Tsakiris G, Pangalou D and H Vangelis (2007). Regional drought assessment based on the reconnaissance drought index (RDI). *Water Resources Management* **21** 821-833.

UNESCO (1979). Map of the world distribution of arid regions. Explanatory note. Man and Biosphere (MAB).

Wilhite D, Sivakumar M and Wood D (2000). Early Warning Systems for Drought Preparedness and Drought Management. *Proceedings of an Expert Group Meeting*, 5-7 Sep, Lisbon, Portugal.WMO TD No. 1037.