Journal of Agrometeorology 13 (1): 68-71 (June 2011)

Short Communication

Analysis of meteorological drought at New Delhi using SPI

S. PRADHAN, V.K. SEHGAL, D.K. DAS and R. SINGH
Division of Agricultural physics, Indian Agricultural Research Institute, New Delhi – 110 012
(Email: sanatan28@gmail.com)

Drought is a natural phenomenon that has significant adverse effect on the socioeconomic, agricultural, and environmental conditions. No single definition of drought exists that applies to all circumstances, but most definitions of drought are based on an expression of deficiency of precipitation resulting in water shortage for some activity related to use of water (Wilhite and Glantz, 1985, Dracup *et al.,* 1980). Among the several proposed indices for meteorological drought monitoring, the Standardized Precipitation Index (SPI) developed by McKee *et al.* (1993, 1995) to quantify precipitation deficit at different time scales has found widespread application Heim, 2000; Rossi and Cancelliere, 2002). This index compares very favorably against several other drought indices and has been adopted by US National Drought Mitigation Centre for operational use. Keyanatash and Dracup (2002) reviewed fourteen indices of precipitation anomaly for their robustness, tractability, transparency, sophistication, extendibility and dimensionality and concluded that SPI substantially outranked twelve other indices in all respects.

SPI assigns a single numeric value to the precipitation anomaly that can be compared across regions with markedly different climates. Technically, SPI is the number of standard deviations that the observed value would deviate from the long term mean, for a normally distributed random variable, i.e. it is Z-variate. Mathematically, SPI for period *i* is calculated based on equation:

$$SPI_i = (X_i - X_{mean})/\sigma$$

Where, X_i is rainfall of station for period *i*; X_{mean} and σ are long-term mean and standard deviation of rainfall for the same period.

Since precipitation is not normally distributed, a transformation is first applied so that the transformed precipitation values follow a normal distribution. The SPI calculation for any location is based on the long-term precipitation record that is fitted to an incomplete-gamma probability distribution, which is then transformed into a normal distribution so that the mean SPI for the location and desired period is zero (Edwards and McKee, 1997). The SPI is a dimensionless index where negative values indicate drought; positive values wet conditions. A drought event occurs any time the SPI is continuously negative and reaches intensity of -1.0 or less. The classification of SPI is given in Table 1.

In this study an attempt has been made to analyze frequency and temporal trend of SPI at IARI, New Delhi station during early *kharif* (June, July and August), mid *kharif* (August and September), late *kharif* (September and October) and whole *kharif* (June, July, August, September and October) seasons for 1951-2009 period. For this SPI was calculated and analyzed at four time scales, namely, trimonthly SPI_JJA, bimonthly SPI_AS, bimonthly SPI_SO and pentamonthly SPI_JJASO corresponding to early, mid, late and whole *kharif* seasons, respectively.

The SPI values for all the four seasons (early, mid, late and whole *kharif*) are summarized in Table 2 and graphically shown in Fig 1. In the 59 years of study, there were five year with moderate drought (1979, 1986, 1987, 1997, 2009) and three year with extremely drought (1951, 1989, 2002) during early *kharif* season. During mid *kharif* season, seven years experienced moderate drought (1951, 1953, 1954, 1986, 1989, 1999, 2006), two years severe drought (1974, 1981) and one year (1979) experienced extreme drought. During late *kharif* season, four years experienced moderate drought (1974, 1979, 1982, 2000), three years severe drought (1953, 1987, 1994) and two years extreme drought (1952, 1968). The whole *kharif* season experienced three moderate drought years (1952, 1979, 1997), three severe drought years (1986, 1987, 2002) and two extreme drought years (1951, 1989). Table 2 shows that though all the four season showed more or less same number of drought years, the number of extreme

Table 1: Classification of SPI values (MacKee *et al.,* 1993)

SPI value	Category
2.00 and above	Extremely wet
1.50 to 1.99	Very wet
1.00 to 1.49	Moderately wet
-0.99 to 0.99	Normal
-1.00 to -1.49	Moderately dry
-1.50 to -1.99	Severely dry
-2.00 and less	Extremely dry

Table 2: Minimum, maximum and frequency of SPI values for different intensity of meteorological drought in four seasons during 1951-2009.

Particulars	Early *kharif*	Mid *kharif*	Late *kharif*	Whole *kharif*
Minimum SPI value	-2.89	-2.13	-2.12	-2.57
Maximum SPI value	1.83	3.19	2.85	2.76
Frequency of –ve SPI value	29	31	29	27
Frequency of +ve SPI value	28	28	30	32
Moderately dry year	1979,1986,1987, 1997,2009	1951,1953,1954, 1986,1989,1999, 2006	1974,1979,1982, 2000	1952,1979, 1997
Severely dry years	---	1974, 1981	1953,1987,1994	1986,1987,2002
Extremely dry years	1951,1989,2002	1979	1952,1968	1951,1989
Total drought years	8	10	9	8

Table 3: Result of Mann Kendall test

Particulars	Early *kharif*	Mid *kharif*	Late *kharif*	Whole *kharif*
Rank correlation coefficient	-0.0573	-0.0503	-0.1064	-0.1192
Slope	-0.0042	-0.0044	-0.0098	-0.0095
probability	0.5213	0.5731	0.2333	0.1818

drought years are 3, 1, 2 and 2 for early, mid, late and whole *kharif* seasons, respectively. The frequency of +ve and –ve SPI values were nearly equal for early, mid and late *kharif* season but for whole *kharif* season there were more number of positive SPI than negative showing higher chance of rainfall excess during this period. All the years of early season drought except one (2002) appeared in the whole season drought. Year 2002 was extreme drought during early season and was severe drought during whole *kharif* season. Correlation analysis of whole season SPI vs early, mid and late season SPI values showed correlation coefficient values of values of 0.89, 0.76 and 0.58 ($N=59$), respectively. Though all the three correlation coefficients values were significant at 99% confidence level ($p<0.01$), highest value for early season indicate that it mainly determines the whole season drought. It also indicates that the moderate to extreme deficiency in rainfall during early season is not getting compensated with rainfall during mid and late seasons.

The temporal trend of SPI values was determined using Mann-Kendall trend test and the results for different season are given in Table 3. No significant trend was observed in any season as shown by low correlation values and high probability (p) values. It indicates that there is no temporal trend in rainfall amount or its distribution in last 59 years at IARI New Delhi station.

It could be concluded that meteorological drought has nearly same frequency for early, mid, late and whole *kharif* seasons at Delhi and on an average it is experiencing one drought year in 10 – 12 years. It is the early season rainfall deficit which is mainly determining whole season drought at Delhi. There are nearly equal numbers of deficit and excess rainfall years in past 59 years and no temporal trend is seen in the magnitude of rainfall deficit in any of the season. It has important implications from climate change and climate variability point of view, suggesting that rainfall variability and magnitude has not changed significantly at Delhi in recent past though Delhi has seen significant land-use/cover changes during this period.

REFERENCES

Dracup, J.A., Lee, K.S. and Paulson, E.G. (1980). On the definition of droughts. *Water Resources Res.,* 16:297–302.

Edwards, D.C. and McKee, T.B. (1997). Characteristics of 20th century drought in the United States at multiple time scales. Climatology Rep. 97–2, Department of Atmospheric Science, Colorado State University, Fort Collins, Colorado.

Heim, Jr., R.R., (2000) Drought indices: A review. Chapter 11 in Drought, Volume 1: A Global Assessment (D.A. Wilhite, ed.), London: Routledge, 159-167.

Keyantash, J. and Dracup, J.A. (2002). The quantification of drought: an evaluation of drought indices. *Bulletin*

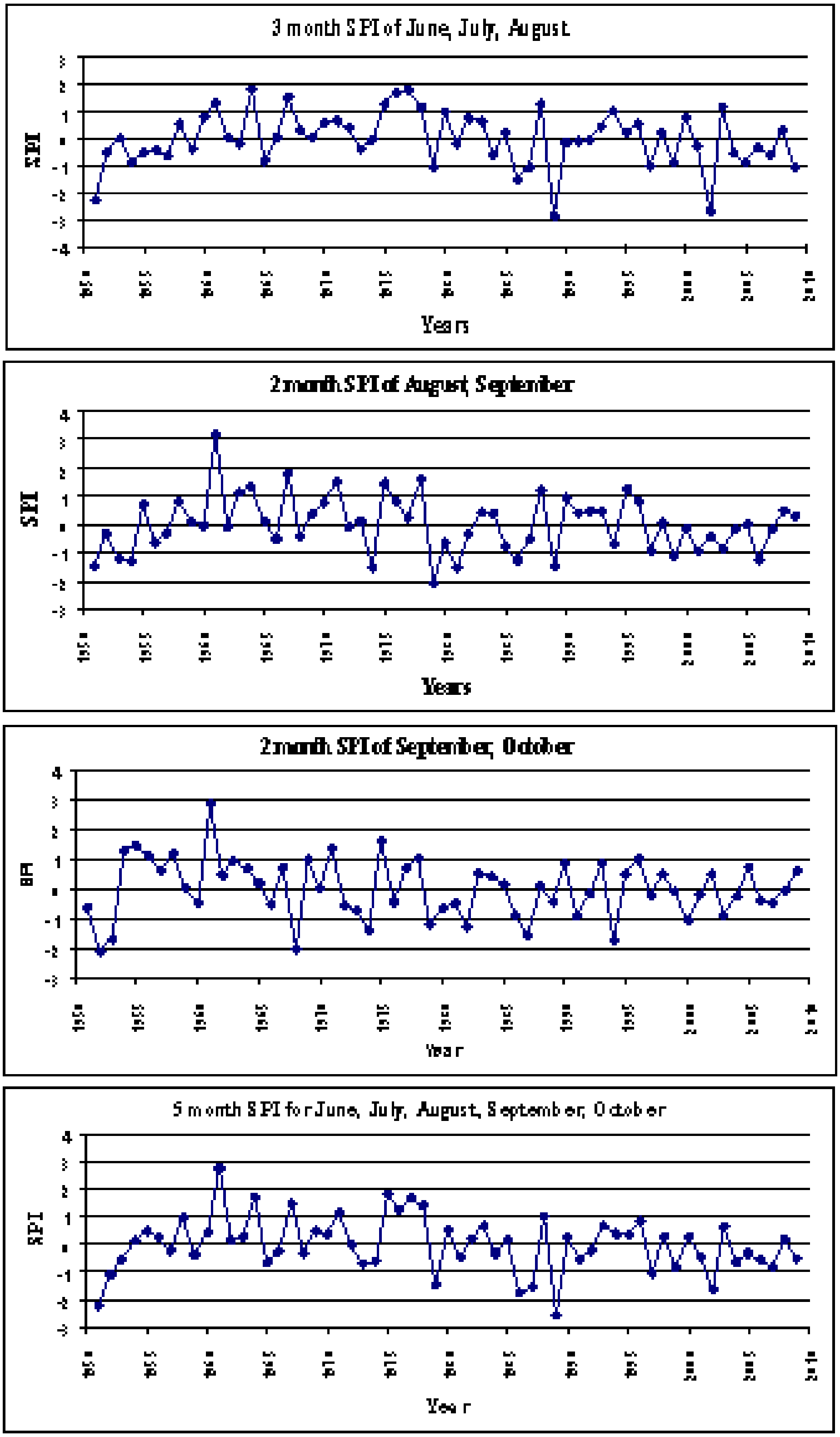

Fig. 1: SPI values for IARI during early, mid, late and whole *kharif* seasons.

American Meteorol Soc., 83(8): 1167-1180.

McKee, T.B., Doesken, N.J. and Kleist, J. (1993). The relation of drought frequency and duration to time scales. Proceedings of the Eighth Conference on Applied Climatology; pp. 179–84. American Meteorological Society, Boston.

McKee, T.B., Doesken, N.J. and Kleist, J. (1995). Drought monitoring with multiple time scales. Proceedings of the Ninth Conference on Applied Climatology; pp. 233–236. American Meteorological Society, Boston.

Rossi, G. and Cancelliere, A. (2002). Early warning of drought: development of a drought bulletin for Sicily. Proc. 2nd international conference "New trends in water and environmental engineering for safety and life: ecocompatible solutions for aquatic environments". Capri, Italy, June 24-28, 2002, pp1-12.

Wilhite, D.A. and Glantz, M.H. (1985). "Understanding the

Received : Nov. 2010; Accepted: April 2011