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Short Communication

Standardized precipitation index (SPI) for drought severity assessment of Almora, Uttarakhand, India

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Drought is the period of water shortage due to extended unusual dry weather in a certain regions resulted in crop damage and other losses. Drought can be classified into three categories i.e. meteorological drought, hydrological drought and agricultural drought. Agricultural drought is deficit in soil moisture requirement to grow the plant leading to low crop production. Because of slow transition, it is difficult to determine the beginning of the drought event and sometimes the duration may vary from months to years and the core area or epicenter get changed over time.

The Irrigation Commission of India defines that where rainfall is less than 75 per cent of normal rainfall as drought area. Therefore, in order to acquire the information about drought occurrence and get better understanding and knowledge about the fluctuations in recent climate, it is worthwhile to study long-term series of precipitation in the region. In this study, the Standardized Precipitation Index (SPI) was followed which is based on drought index proposed by McKee *et al.*(1993) and adopted widely because of its applicability in different regions of climatology such as Mexico (Giddings, 2005), Greece (Loukas and Vasiliades, 2004), Iran (Morid *et al.,* 2006), European Alps (Bartolini *et al.,* 2009), Portugal (Paulo *et al.,* 2005), Europe (Lloyd-Hughes and Saunders,2002), Poland (Labedzki *et al.,* 2005), mountainous Mediterranean basin (Vicente-Serrano *et al.,* 2004), Slovenia (Ceglar *et al.,* 2008), Colorado, North Dakota, Iowa, Kansas, Nebraska, South Dakota, and Wyoming (Wu *et al.,* 2006), Eastern China (Bordi *et al.,* 2004), Northeast of Thailand (Wattanakij *et al.,* 2006), South Africa (Rouaultand Richard, 2003), India (Chaudhari and Dadhwal, 2004).The main objective of this study is to analyze monthly, seasonally and annually rainfall data to detect the wet and dry period on the basis of SPI values.

This research work was carried out for the area, Almora, Uttarakhand, India which is located at 29°35' N latitude, 79°39' E longitude and MSL of 1250 m. Monthly rainfall data of 53 years (from 1964 to 2016) was collected from the ICAR-VPKAS,Experimental Farm, Hawalbagh, Almora. The data was grouped in three time scales i.e. monthly, seasonally and annually. During the study, the average temperature was 23.5°C and warmest month was June with an average temperature 31.1°C. The coolest month was January with an average temperature 13.3°C and rainfall of 1132.5 mm and August month got its maximum precipitation. Seasonal atmospheric circulation indices were defined as the average values for spring (March, April, May), summer (June, July, August), autumn (September, October, November), and winter (December, January, and February). The SPI computation is based on the long term precipitation data for the desired time step.

$$SPI = \frac{(X_i - X_m)}{\sigma}$$

Where, X_i= Monthly/seasonally/annually rainfall record of the station, X_m = Average rainfall and σ =Standard deviation.

Since there is spatial and temporal variation reported in the rainfall which varies from 200-400cm in Assam and North east India to 10cm in Western desserts of Rajasthan, the analysis of precipitation on various time scales are required to obtain ideas about temporal and spatial variation like drought and floods. Rice is the principal food grain for most of the regions of Indian subcontinent mainly grown during June to November and has a water requirement of 1500-2500 mm. Therefore for this period rainfall nature has utmost importance and it can be analyzed by using monsoon period data (Table 1 and 2).

Graphical results showed that for the January data set, the moderate drought occurred in 1964, 1966, 1967, 1990, 2007, 2009, 2011, 2016, for the February data set the

Table1: SPI Values for different drought category (McKee *et al.,* 1993)

SPI values	Drought Category
2.00 and more	Extremely wet
1.50 to 1.99	Very wet
1.00 to 1.49	Moderately wet
-0.99 to 0.99	Near normal
-1.00 to -1.49	Moderate drought
-1.50 to -1.99	Severe drought
-2.00 and less	Extreme drought

moderate drought occurred in 1964, 1967, 1969, 1977, 1997, 1999, 2004, 2006, 2008, 2012, 2016, for the March data set the moderate drought occurred in 1977, 1985, 1994, 1999, 2004, 2008, 2010, for the April data set the moderate drought occurred in 1966, 1970, 1973, 1975, 1992, 1999, 2005, 2016 for the May data set the moderate drought occurred in 1967, 1968, 1972, 1975, 1984, 1996, 2003, 2012, 2013, 2015.Data set of June showed that the moderate drought occurred in 1964, 1965, 1972, 1991, 2003, 2005 and severe drought occurred in 2009, 2012, for the July data set the moderate drought occurred in 1970, 1999, 2004, 2009, 2011, 2015 and severe drought occurred in 1997. In case of August data set the moderate drought occurred in 1981, 1983, 1986, 2001 and severe drought occurred in 1964, 1999, 2005, 2014, 2015, for the September data set the moderate drought occurred in 1965, 1979, 1982, 1984, 1987, 2001, 2006, 2015, in case of monthly data analysis (Fig. 1 and 2).

In case of seasonal and annual data analysis, the moderate drought occurred in 2008, 2009, 2010, 2011, 2012, 2013 in winter season, in 1968, 1972, 1974, 1975, 1984, 1992, 2012, 2013 in summer season, in 1970, 1974, 1982, 1987, 1991, 1999, 2001, 2004, 2006, 2009 in monsoon season, in 1970, 1984, 1992, 1999, 2004, 2006 for annual data, and severe drought occurred in 1964, 2014, 2015, 2016 in winter season, in 2015 in monsoon season, in 1974, 2001, 2015 for annual data.It was also observed that extreme wet conditions occurred in some periods. Results showed that extreme wet conditions occurred during January in 1975 (with SPI value 2.28), during February in 1989 (2.67), 2007 (2.49), 2013 (2.24), during March in 1978 (2.96) and 1982 (4.02), during April in 1983 (4.36) and 1997 (2.21), during May in 1971 (2.63), 1979 (2.03) and 1983 (2.48), during June in 1973 (2.34) and 2000 (2.21), during July in 1986 (2.69), during August in 2011 (2.29), during September in 1969 (2.41), 1993 (2.28) and 2010 (3.33),

Table 2: Year wise distribution of moderate and severe drought years

Data period	Moderate Drought years	Severe drought years
January	1964, 1966, 1967, 1990, 2007, 2009, 2011, 2016	-
February	1964, 1967, 1969, 1977, 1997, 1999, 2004, 2006, 2008, 2012, 2016	-
March	1977, 1985, 1994, 1999, 2004, 2008, 2010	-
April	1966, 1970, 1973, 1975, 1992, 1999, 2005, 2016	-
May	1967, 1968, 1972, 1975, 1984, 1996, 2003, 2012, 2013, 2015	-
June	1964, 1965, 1972, 1991, 2003, 2005	2009, 2012
July	1970, 1999, 2004, 2009, 2011, 2015	1997
August	1981, 1983, 1986, 2001	1964, 1999, 2005, 2014, 2015
September	1965, 1979, 1982, 1984, 1987, 2001, 2006, 2015	-
October	-	-
November	-	-
December	-	-
Winter	2008, 2009, 2010, 2011, 2012, 2013	1964, 2014, 2015, 2016
Summer	1968, 1972, 1974, 1975, 1984, 1992, 2012, 2013	-
Monsoon	1970, 1974, 1982, 1987, 1991, 1999, 2001, 2004, 2006, 2009	2015
Post-monsoon	-	-
Annual	1970, 1984, 1992, 1999,2004, 2006	1974, 2001, 2015

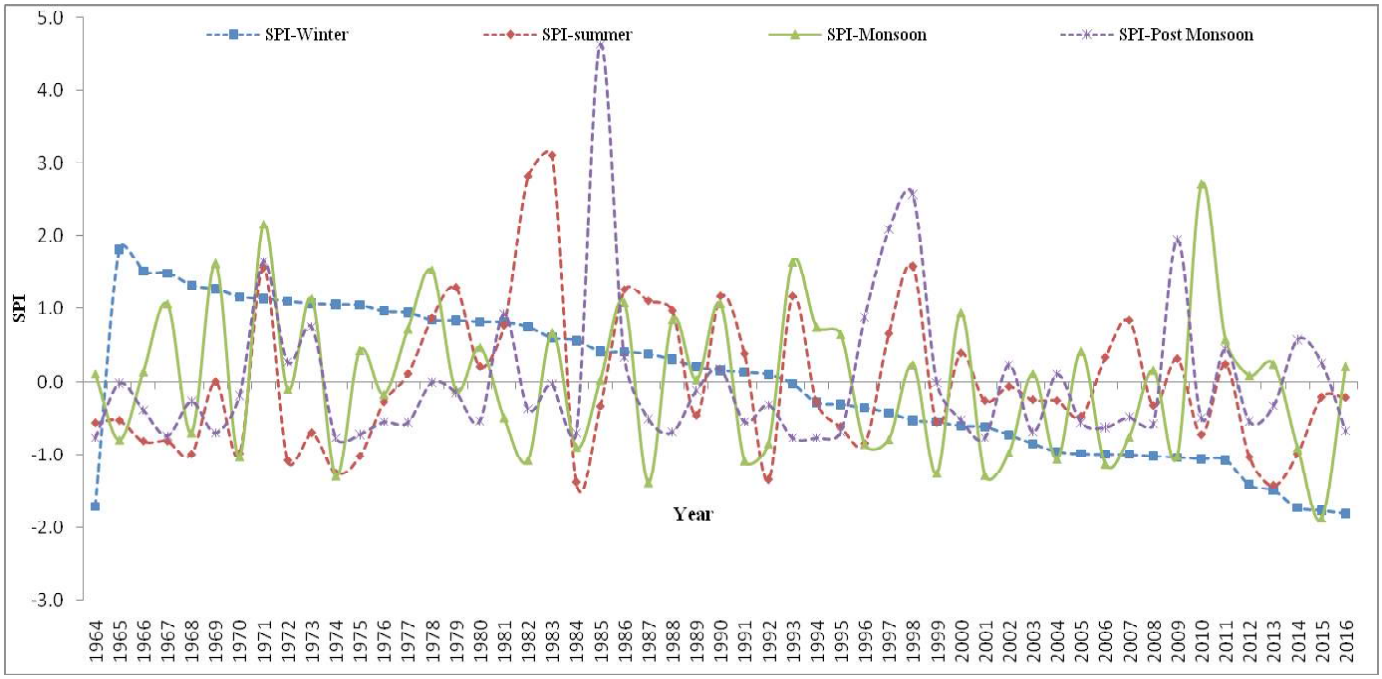

Fig. 1: SPI values for winter, summer, monsoon and post-monsoon seasons during 1964-2016

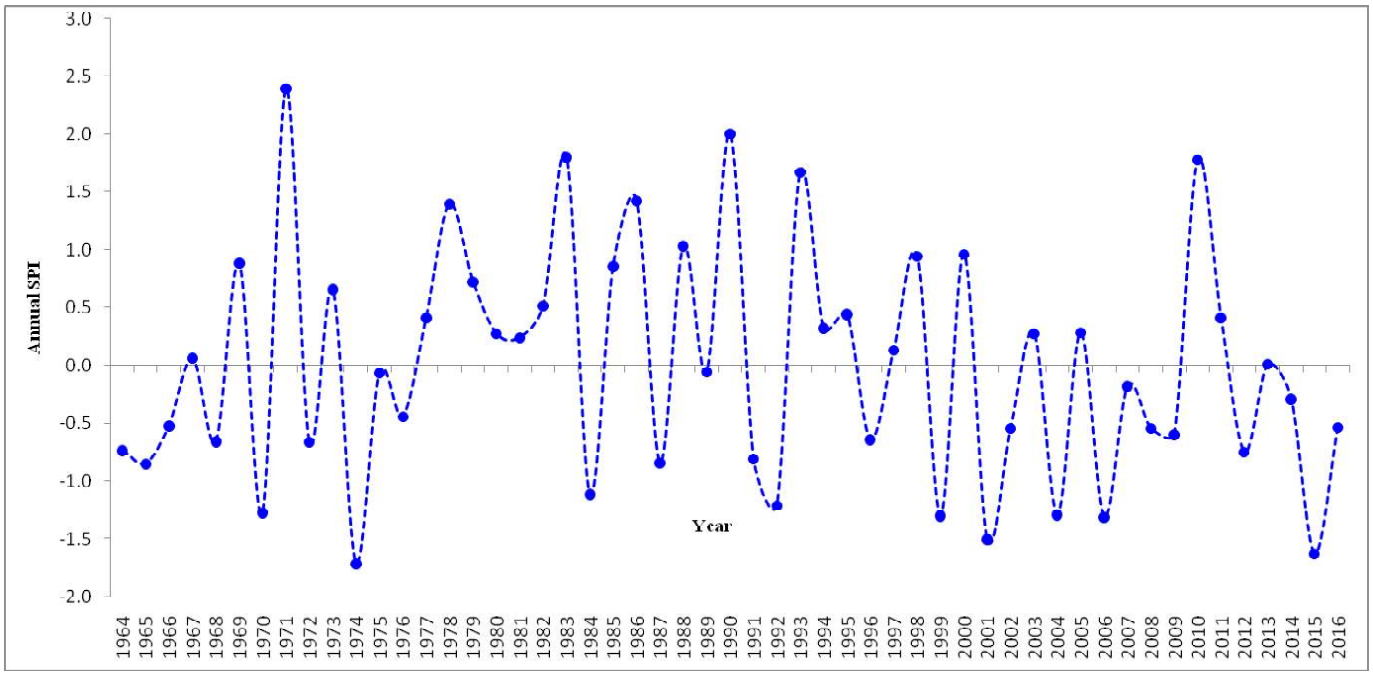

Fig. 2: SPI values for annual data series during 1964-2016

during October in 1985 (5.02) and 1998 (2.73), during November in 1981 (4.76) and 1997 (3.65), during December in 1985 (2.36), 1990 (3.35) and 2014 (2.22), during summer season in 1982 (2.82) and 1983 (3.11), during monsoon season in 1971 (2.16) and 2010 (2.72), during post monsoon season in 1985 (4.63), 1997 (2.10) and 1998 (2.58) and for annual analysis extreme wet occurred in 1971 (2.40) and 1990 (2.03).The other time periodsobserved shown extremely wet, moderately wet, near normal, moderate drought categories and there was no any case of extremely drought. These findings are in conformity with the findings of Sahu *et al.* (2018) and Kamble *et al.* (2019). Hence, success or failure of the rainfed agriculture in any year is always viewed with utmost anxiety as they are closely linked with the behavior of the monthly rainfall.

In conclusion, SPI gives the accurate results by using only monthly rainfallas input even without using other

climatic parameters like minimum and maximum temperature, humidity, evapo-transpiration and sunshine hours. This method gives better results when used for agricultural applications since it is simple and effective. Overall, it was concluded that by using long-term monthly rainfall can model drought severity efficiently and accurately using SPI values for study area.

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REFERENCES

Bartolini, E., Claps, P. and D'Odorico, P. (2009). Inter-annual variability of winter precipitation in the European Alps: relations with the North Atlantic Oscillation. *Hydrol. Earth Syst. Sci.,* 13: 17-25.

Bordi, I., Fraedrich, K., Jiang, M. and Sutera, A. (2004). Spatio-temporal variability of dry and wet periods in eastern China. *Theor. Appl. Climatol.*, 79: 81-91.

Ceglar, A., Zalika, C. and Luèka, (2008). Analysis of meteorological drought in Slovenia with two drought Indices, BALWOIS 2008-Ohrid. *Republic Macedonia,* 27-31.

Chaudhari, K.N. and Dadhwal, V.K. (2004). Assessment of impact of draught on production of major *kharif* and rabi crops using standardized precipitation index. *J.Agrometeorol.,* 6: 10-15.

Giddings, L., Soto, M., Rutherford, B.M. and Maarouf, A. (2005). Standardized precipitation index zones for Mexico, *Atmosphera*, 33-56.

Kamble, D.B., Gautam, S., Bisht, H., Rawat, S. and Kundu, A. (2019). Drought assessment for *kharif* rice using standardized precipitation index (SPI) and vegetation condition index (VCI). *J. Agrometeorol.,* 21(2): 182-187.

£abêdzki, L. and Bogdan, B. (2005). Drought mapping in Poland Using SPI, *ICID 21st European Regional Conf.*, 15-19.

Lloyd-Hughes, B. and Saunders, M.A. (2002). A drought climatology for Europe. *Int. J. Climatol.,* 22(13): 1571-1592.

Loukas, A. and Vasiliades, L. (2004). Probabilistic analysis of drought spatio-temporal characteristics in Thessaly region, Greece. *Nat. Haz. Earth Syst. Sci.,* 4: 719-731.

McKee, B.T., Doesken, J.N. and Kleist, J. (1993). The relationship of drought frequency and duration to time scales, proceedings of ninth conference on applied climatology. *American Meteorol. Soc., Boston*, 17(22): 179-184.

Morid, S., Smakhtin, V. and Moghaddasi, M. (2006). Comparison of seven meteorological indices for drought monitoring in Iran. *Int. J. Climatol.,* 26(7): 971-985.

Paulo, A.A, Ferreira, E., Coelho, C. and Pereira, L.S. (2005). Drought class transition analysis through Markov and Loglinear models, an approach to early warning. *Agric. Water Manage.,* 77(1-3): 59-81.

Rouault, M. and Richard, Y. (2003). Intensity and spatial extension of drought in South Africa at different time scales. *Water SA,* 29: 4.

Sahu, Y.K., Mishra, E.P. and Rawat, S. (2018). Quantification of crop water stress index (CWSI) for maize crop under different microclimatic conditions of Allahabad. *J.Agrometeorol.,* 20: 368-371.

Vicente-Serrano, M.S., Gonzalez-Hidalgo, C.J., Luis de, M. and Raventos, J. (2004). Drought patterns in the Mediterranean area: the Valencia region (eastern Spain). *Climate Res.,* 26: 5-15.

Wattanakij, N. Thavorntam, W. and Mongkolsawat, C. (2006). Analyzing spatial pattern of drought in the northeast of Thailand using multi-temporal standardized precipitation index (SPI), proceedings of ACRS. *Pro. ACRS*, 1: 1221-1226.

Wu, H., Svoboda, D.M., Hayes, J.M., Wilhite, A.D. and Fujiang, W. (2006). Appropriate application of the standardizes precipitation index in arid locations and dry seasons. *Int. J. Climatol.*, 27: 65-79.

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