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Short Comminucation

Long-term changes in monsoon rainfall patterns over arid region of India

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Arid region covers a major area of the world, which is very dry for usual rain fed agriculture. In India, areas of west Rajasthan and Saurashtra & Kutch fall under arid region wherein more than 90 per cent of its annual rainfall occurs during monsoon season. Any changes in monsoon rainfall have strong impact on agriculture of this region. Therefore, quantification of long term trends in monsoon rainfall is very important to find out temporal changes in rainfall over the region. IPCC (2013) has also reported increased variability in arid regions. There are many studies in the literature related to long term trends over India as a whole and for some specific regions of India viz. Dash *et al.* (2007), Rajeevan *et al*. (2008), Attri *et al.* (2011), Lunagaria *et al.* (2015) and Rathore *et al*. (2013). But, comprehensive studies on long term trend in precipitation over arid region of India are lacking. Therefore, an effort has been made to analyse monsoon and annual rainfall for the period 1871–2011 over arid region of India.

Monthly rainfall data of west Rajasthan (WR) and Saurashtra, Kutch & Diu (SK & D) sub-divisions for the period from 1871-2011 was collected from Indian Institute of Tropical Meteorology (IITM), Pune (http://www.tropmet.res.in/) site. Rainfall data of seven meteorological surface observatories namely, Bhavnagar, Wadhawan, Bhuj, Dwaraka, Rajkot, Porbandar and Amerli have been used for preparing sub-division series for Saurashtra & Kutch. For West Rajasthan sub-division, data of nine meteorological surface observatories namely, Pali, Jodhpur, Nagaur, Rajgarh, Anupgarh, Bikaner, Jaisalmer, Barmer and Jalore have been used. The monthly sub-divisional series were prepared by assigning the district area as the weight for each rain-gauge station in that subdivision. From monthly data of above sub-divisions, data series for arid region of India was developed by taking the mean of both series. From monthly rainfall data series, standard deviation (SD), coefficient of variation (CV) for monsoon (June - September) and annual (January-December) have been computed. In order to make uniformity, Standard Precipitation Index (SPI) has been calculated for each value

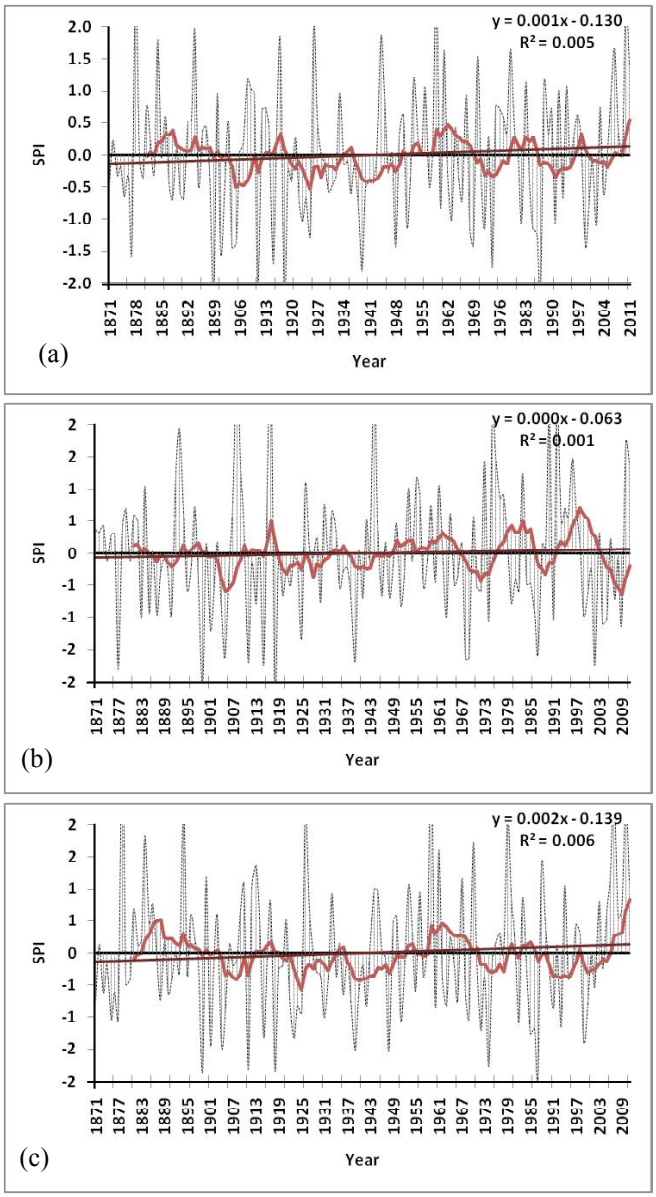

Fig. 1: Monsoon rainfall trends over (a) arid region, (b) WR and (c) SK & D during 1871 to 2011

by subtracting the mean from it and dividing by SD. Finally to calculate the trends in rainfall, linear regression analysis (Krishnakumar *et al.* 2009) and Mann Kendall test (Kendall, 1976) has been used.

Annual LPA rainfall of arid region is 38.6 cm, of which

Table 1: Decadal mean annual and monsoon season rainfall and percent departure from the normal

Year	Annual rainfall		Monsoon season	
	Mean (in cm)	% Dep from LPA	Mean (in cm)	% Dep from LPA
1871-1880	37.1	-3.9	33.7	-3.6
1881-1890	40.1	3.8	36.9	5.7
1891-1900	39.8	3.1	36.4	4.1
1901-1910	36.2	-6.4	33.7	-3.4
1911-1920	36.9	-4.5	31.5	-9.7
1921-1930	35.6	-7.8	32.9	-5.7
1931-1940	33.6	-13.0	29.8	-14.6
1941-1950	38.9	0.8	36.4	4.3
1951-1960	42.7	10.4	38.3	9.7
1961-1970	37.5	-3.0	34.4	-1.4
1971-1980	41.1	6.2	36.8	5.4
1981-1990	36.6	-5.4	31.5	-9.8
1991-2000	39.1	1.2	33.9	-2.9
2001-2010	44.0	14.0	40.8	16.8

90 per cent occurs during monsoon season, and 4 per cent occurs each in pre-monsoon and post-monsoon season.

The monsoon rainfall trends over arid region, WR and SK & D are shown in Fig. 1. The monsoon rainfall shows non-significant increasing trends in rainfall over arid region as a whole as well as over WR and SK & D.

Decadal mean and its per cent rainfall departure from LPA for annual as well as monsoon rainfall per decade during 1871- 2010 is presented in Table 1. It is observed that decadal annual mean rainfall is above normal in 7 decades and below normal in 7 decades. During the period 1901- 40, all the decades of annual as well as monsoon seasons received below normal rainfall. Maximum annual as well as monsoon rainfall occurred during the decade 2001-2010 with 14 per cent and 16.8 per cent excess rainfall from respective LPA.

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