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L E T T E R S

551.577.38 (540.25)

RAINFALL CHARACTERISTICS AND METEOROLOGICAL DROUGHT IN HANUMANGARH DISTRICT OF ARID RAJASTHAN

The rainfall characteristics and meteorological drought conditions in Hanumangarh district of arid Rajasthan (28°46′ & 29°57′ north latitudes and 73°49′ & 75°31′ east longitudes) were studied using seven *tehsil*-wise rainfall data (1960-2012). It is characterized by very hot summers and very cold winters with poor rainfall during south-west monsoon period. The extreme air temperatures recorded in the region were as high as 49.4 °C during summer and as low as -2.8 °C during winter. The potential evapotranspiration rates are quite high, especially during May and June. The estimated annual potential evapotranspiration of the area is 1736 mm compared to average rainfall of 295 mm received. During major cropping season of monsoon period (July to September) the normal daily PET at Hanumangarh varied from 5.4 to 7.6 mm/day and in winter (December to February) the normal daily PET varied from 1.6 to 3.2 mm/day (Rao and Poonia, 2011). Out of the total (1.18 million ha) cropped area in the district during 1997-98 about 58% goes to *rabi* crops and rest 42% to *kharif* crops. Of the total cropped area 47 percent is irrigated while 53% goes rain fed.

The district experiences 225 to 371 mm of annual rainfall in 12 to 19 rainy days. The resultant standard deviation of annual rainfall was 104 to 171 with a coefficient of variation of 39 to 48 per cent. The seasonal rainfall (June-September) varied from 170 to 309 mm in 10 to 15 rainy days. The highest annual rainfall recorded in the district was between 460 mm at Pilibanga and 887 mm at Bhadra. Similarly, the lowest rainfall record varied between 22 mm at Hanumangarh and 111 mm at Bhadara (Table 1).

A study of the intensity of rainfall and its variability would be of extreme importance both for the purpose of assessing the water harvesting potential of a district as well as for planning soil conservation measures. From the daily rainfall data (1960-2012), the highest rainfall intensities in a day during each year at all stations were taken to calculate probable maximum precipitation (PMP) values using Hershfield (1961, 1965) technique as adopted by Samra *et al.* (1975) of extreme values.

The extreme rainfall events recorded in Hanumangarh district showed that 1-day highest was between 122.0 mm at Bhadara during 2 July 1990 to 163.0 mm at Rawatsar during 13 September, 2007. The probable maxiumum 1-day rainfall was between 128 mm at Bhadara to 402 mm at Pillibanga (Table 2).

The one day rainfall indicates that even though the district receives less annual rainfall, occasional cloud bursts associated with monsoon depression and trough movements occur over the district. Such intensive short period rainfall causes excessive runoff and damages to agricultural crops. Knowledge on probable maximum

TABLE 1

***Tehsil*-wise rainfall characteristics of Hanumangarh district**

Station	Annual rainfall (mm)	Annual rainy days	SD (mm)	CV (%)	Seasonal rainfall (mm)	Seasonal rainy days	Highest rainfall (mm)	Lowest rainfall (mm)
Hanumangarh	239	14	115	48	193	12	547 (2010)	22 (1994)
Tibi	288	14	124	43	224	11	625 (1997)	37 (1965)
Sangaria	314	16	146	47	249	13	688 (1960)	54 (1969)
Nohar	354	18	137	39	297	14	679 (1975)	106 (2000)
Bhadara	371	19	171	46	309	15	887 (1978)	111 (1961)
Rawatsar	277	12	111	41	195	10	497 (1997)	109 (2002)
Pillibanga	225	13	104	46	170	11	460 (1997)	55 (1972)

TABLE 2

Maximum 1-day rainfall at different stations in Hanumangarh district

Station	Maximum one day rainfall (mm)	Date	Probable maximum precipitation values (PMP)
Hanumangarh	160.0	10th July, 1968	177
Tibi	125.0	15th June, 1989	132
Sangaria	147.0	18th July, 2001	170
Nohar	130.3	3rd October, 1955	134
Bhadara	122.0	2nd July, 1990	128
Rawatsar	163.0	13th September, 2007	180
Pillibanga	175.0	21st July, 1999	402

TABLE 3

Estimated 1-day rainfall (mm) for different return periods in Hanumangarh district

Station	Return period (Years)				
	5	10	25	50	100
Hanumangarh	81.7	100.3	123.4	140.7	158.2
Tibi	85.4	103.0	124.8	141.0	157.6
Sangaria	72.7	88.3	107.8	122.3	136.41
Nohar	90.6	107.9	129.4	145.4	161.8
Bhadara	85.8	100.4	118.5	132.1	145.9
Rawatsar	79.1	93.0	110.3	123.2	137.1
Pillibanga	115.9	144.9	180.9	207.9	235.3

TABLE 4

Minimum, maximum and frequency of SPI values for different intensity of meteorological drought in two time scale during 1960-2012

Particulars	Tri-monthly (June-August)	Four monthly (June-September)
Minimum SPI Value	-1.80	-1.71
Maximum SPI Value	3.00	3.04
Frequency of –ve SPI value	26	29
Frequency of +ve SPI value	27	24
Severe drought years	1979, 1986, 1987, 1994	1979, 1986, 1987, 1994
Moderate drought years	1967, 1969, 1971, 1974, 1988, 1989, 1991, 2002	1967, 1969, 1974, 1989, 1990, 1991, 2000, 2002
Total drought years	12	12

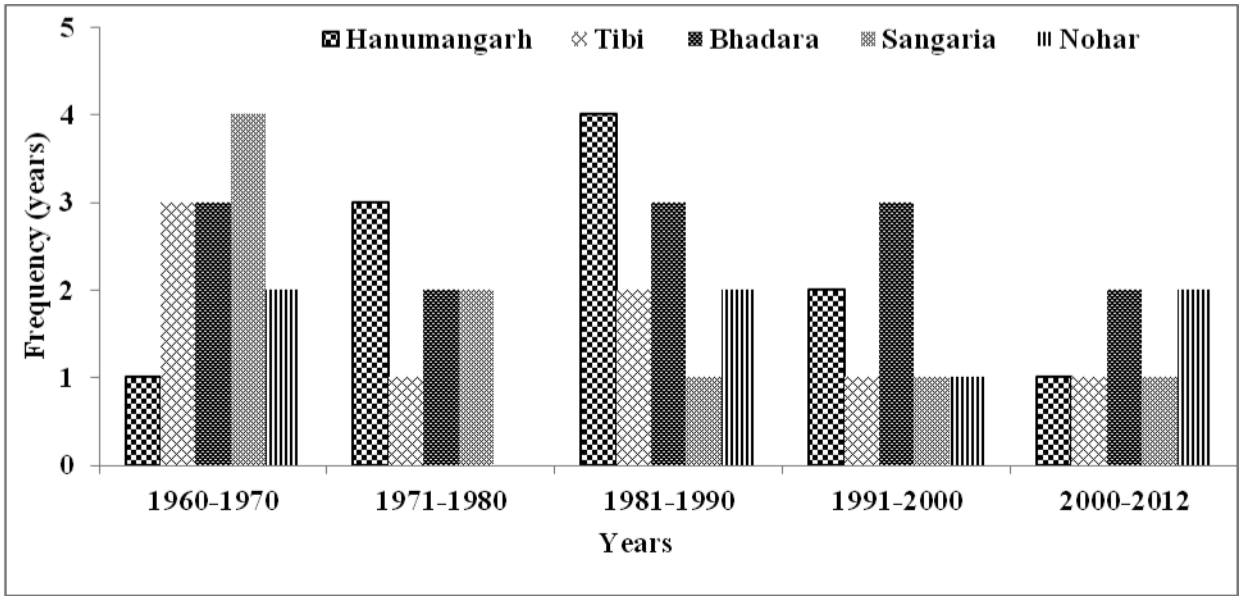

Fig. 1. Decadal-wise drought situation in Hanumangarh district

precipitation (PMP) values is very useful for planning in constructional works like roads, bridges, buildings and dams etc.

The probability of occurrence of intense falls is reflected on the length of the return period of the fall considered. In order to work out the 1-day rainfall values for different return periods from 5-100 years were estimated using the formula given by Chow (1964) based on daily rainfall events at these seven locations of Hanumangarh district. Such technique was earlier used by Samra *et al.* (1975) to calculate probable maximum precipitation (PMP) over coastal Andhra Pradesh for 93 stations, Singh *et al.* (1991) for Kutch region of India and Rao *et al.* (2007 and 2013) to calculate 1-day maximum rainfall for different return periods for locations in Churu and Jhunjhunu districts of arid Rajasthan. The 1-day rainfall in Hanumangarh district for different return periods of 5, 10, 25, 50 and 100 years are presented in Table 3.

These return period rainfall values also showed that there is plenty of scope for water harvesting and re-use for cultivation of crops. These values show a substantial increase on the 100 year return period values and must therefore have a very low probability of occurrence. It is very difficult to judge how realistic these values are, but they are of course the estimated upper limits to the likely samples of rainfalls.

The long-term trends in the annual rainfall (1960-2012) of six *tehsil* locations of Hanumangarh district have showed that there is an increase in the annual rainfall of the district. The rate of increase in the annual rainfall was 1.21 mm year^{-1}at Hanumangarh, 2.24 mm year^{-1}at Tibi, 1.00 mm year^{-1}at Bhadara, 2.42 mm year^{-1}at Sangaria, 0.60 mm year^{-1}at Nohar and 1.41mm year^{-1}at Pillibanga. The decadal wise (1960-2012) meteorological drought situation of Hanumangarh, Tibi, Bhadara, Sangaria and Nohar *tehsils* of Hanumangarh district are presented in Fig. 1.

The frequencies of different categories of meteorological drought are made according to a classification by the India Meteorological Department (Koteswaram, 1976 and 1978; Subrahmanyam, 1967, Singh *et al.*, 1991; Rao *et al.*, 2007 and 2013). The meteorological droughts prevailed in 17 years out of 53 years (1960-2012) with lowest frequency of 16 years with drought at Bhadara, Sangaria and Nohar to a highest frequency of 18 years drought at Hanumangarh. The decade 1960-69 experienced highest (5 out of 10 years) number of moderate to severe droughts, whereas the 2001-2012 recorded least frequency (2 out of 10 years) of droughts.

The frequency and temporal trend of drought occurred in Hanumangarh district of arid Rajasthan during 53 years period (1960-2012) was carried out using the

Standardized Precipitation Index (SPI) developed by McKee *et al.* (1993 and 1995). This index compares very favorably against several other indices and has been adopted by US National Drought Mitigation Centre for operational use. Although SPI is a comparatively new index, it has been used in Turkey, Argentina, Canada, Spain, Korea, Hungary, China and India for real time monitoring or retrospective analysis of droughts (Patel *et al.,* 2007).

For this SPI was calculated and analyzed at two time scales, namely tri-monthly (June-August) and four monthly (June-September). The SPI values for both time scales are summarized in Table 4. Positive SPI values indicate greater than median precipitation, and negative values indicate less than median precipitation. In the 53 years of study, there were four year with severe drought (1979, 1986, 1987, 1994) during tri-monthly and four monthly time scale. During tri-monthly, eight years experienced moderate drought (1967, 1969, 1971, 1974, 1988, 1898, 1991, 2002) and in four monthly time scale also experience different moderate drought years (1967, 1969, 1974, 1989, 1990, 1991, 2000, 2002). The decade 1960-1969 (7 out of 10 years) and 1980-1989 (5 out of 10 years) experienced highest number of moderate and severe droughts. It could be concluded that meteorological drought has nearly same frequency for tri and four monthly time scale at Hanumangarh and on an average it is experiencing one drought year in every four years.

References

Chow, V. T., 1964, "Hand Book of Applied Hydrology", McGraw Hill Book Company, New York, U.S.A.

Hershfield, D. M., 1961, "Estimating the probable maximum precipitation", Proceedings American Society of Civil Engineers, *Journal Hydraulics Division*, **87**(HY5), 99-106.

Hershfield, D. M., 1965, "Method for estimating probable maximum precipitation", *Journal American Waterworks Association*, **57**, 965-972.

Koteswaram, P., 1976, "Climatic studies of droughts in Asiatic monsoon", particularly India. *Proceedings of National Science Academy*, New Delhi, **54**, 1-14.

Koteswaram, P., 1978, "Meteorology and Climatology of the Rajasthan desert", *Proceedings of Indian National Science Academy,* **44**, 401-410.

McKee, T. B., Doesken, N. J. and Kliest, J., 1993, "The relationship of drought frequency and duration to time scales", In Proceeding of the Eighth conference on Applied Climatology, Anaheim, California, American meteorological Society, Washington DC, 179-184.

McKee, T. B., Doesken, N. J. and Kleist, J., 1995, "Drought monitoring with multiple time scales", In Proceedings of the Ninth Conference on Applied Climatology, American Meteorological Society, Boston, 233-236.

Patel, N. R., Chopra, P. and Dadhwal, V. K., 2007, "Analyzing the spatial patterns of meteorological drought using SPI", *Meteorological Application*, **14**, 329-337.

Rao, A. S. and Poonia, S., 2011, "Sensitivity of crop water requirements to elevated temperatures in Arid Rajasthan", *Annals of Arid Zone*, **50**, 131-138.

Rao, A. S. and Poonia, S., 2013, "Characteristics features of rainfall and meteorological droughts in Jhunjhunu district of arid Rajasthan", *Annals of Arid Zone*, **52**, 1, 1-6.

Rao, A. S., Purohit, R. S. and Mertia, R. S., 2007, "Rainfall characteristics and crop production in Churu district of western Rajasthan", *Annals of Arid Zone*, **46**, 151-156.

Samra, P. B. S., Kailasanathan, K. and Rao, G. G. S. N., 1975, "Analysis of maximum precipitation over coastal Andhra Pradesh", Proceedings of the Second World Congress, *International Water Resources Association*, New Delhi, **3**, 4, 471-487.

Singh, R. S., Ramakrishna, Y. S. and Purohit, R. S., 1991, "Rainfall characteristics analysis of Kutch (Gujarat) region of India", *Annals of Arid Zone*, **30**, 2, 93-100.

Subrahmanyam, V. P., 1967, "Incidence and Spread of Continental drought", WMO/IHD Rep. No.2, WMO, Geneva, Switzerland.

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