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 Bhadara. 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 maximum 1-day rainfall was between 128 mm at Bhadara to 402 mm at Pilibanga (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) |
| Pilibanga | 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                             |
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 1.41 mm 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 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, 1998, 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.

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