

Characteristic Features of Rainfall and Meteorological Droughts in Jhunjhunu District of Arid Rajasthan

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Received: December 2012

Abstract: The rainfall characteristics and meteorological drought conditions in Jhunjhunu district of arid Rajasthan were studied using six tehsil-wise rainfall data (1901-2011). The district experiences 405 to 560 mm of annual rainfall in 26 to 34 rainy days with a coefficient of variation of 37 to 44%. The seasonal rainfall (June-September) varied from 343 to 477 mm in 18 to 24 rainy days. The highest annual rainfall recorded in the district was between 828 mm at Jhunjhunu and 1252 mm at Khetri. Similarly, the lowest rainfall record varied between 89 mm at Khetri and 187 mm at Udaipurwati. The extreme rainfall events recorded in the Jhunjhunu district showed that 1-day highest rainfall varied from 158 mm at Jhunjhunu to 281 mm at Khetri. The 1-day rainfall was lowest at Jhunjhunu (82.8 mm, 98.1 mm, 117.2 mm, 131.5 mm and 146.0 mm) and highest at Buhana (116.5 mm, 143.0 mm, 176.0 mm, 200.7 mm and 225.8 mm) for all return periods (5, 10, 25, 50 and 100 years). The long-term annual rainfall trends showed that there was a marginal increase at a rate 0.43 mm year⁻¹ at Jhunjhunu, 0.48 mm year⁻¹ at Khetri, 0.74 mm year⁻¹ at Chirawa. The meteorological droughts prevailed in 36 years out of 111 years (1901-2011) with lowest frequency of 32 years with drought at Jhunjhunu and Chirawa to a highest frequency of 35 years drought at Khetri. The decade 1981-90 experienced highest (6 out of 10 years) number of moderate to severe droughts, whereas the 1941-50 recorded least frequency (2 out of 10 years) of droughts.

Key words: Rainfall characteristics, meteorological drought, Jhunjhunu district.

Jhunjhunu district located in the arid western Rajasthan is highly vulnerable to extreme climatic conditions and drought compared to other arid regions of the country. It is characterized by very hot summers and very cold winters with poor rainfall during south-west monsoon. In May and June, the maximum temperature may sometimes goes up to 48°C. The potential evapotranspiration rates are quite high, especially during May and June. The average annual potential evapotranspiration of the area is 1819 mm compared to average rainfall of 480 mm received. During major cropping season of monsoon period (July to September) the normal daily PET at Jhunjhunu varied from 4.9 to 8.0 mm day⁻¹ and in winter (December to February) the normal daily PET varied from 2.1 to 3.7 mm day⁻¹ (Rao and Poonia, 2011). Out of 6463.2 sq. km of cropped area, only 2267.9 sq. km (35.1%) area has irrigation facility aggregating drought impact on crop production in the district (CGWB, 2008). Agriculture activity is spread over both

kharif and rabi cultivation. Kharif cultivation is rainfed and rabi cultivation is mostly based on ground water. The main kharif crops grown in the area are pearl millet, clusterbean, cowpea, mung bean and moth bean whereas, principal rabi crops are wheat, gram and mustard etc. (DES, 2008). An attempt is made in this paper, to analyze the rainfall characteristics for identifying the meteorological droughts.

Materials and Methods

Jhunjhunu district is located in the extreme north eastern part (bordering Haryana state) of Rajasthan State (Fig. 1) which lies between 27°38' and 28°31' N latitudes and 75°02' and 76°06' E longitudes. For the present meteorological drought study, tehsil-wise rainfall data for six stations for the period 1901 to 2011 was collected.

The frequency of different categories of meteorological drought are made according to a classification given below (Table 1) by the India Meteorological Department (Koteswaram, 1976; Subrahmanyam, 1967; Rao *et al.*, 2007 and 2012).

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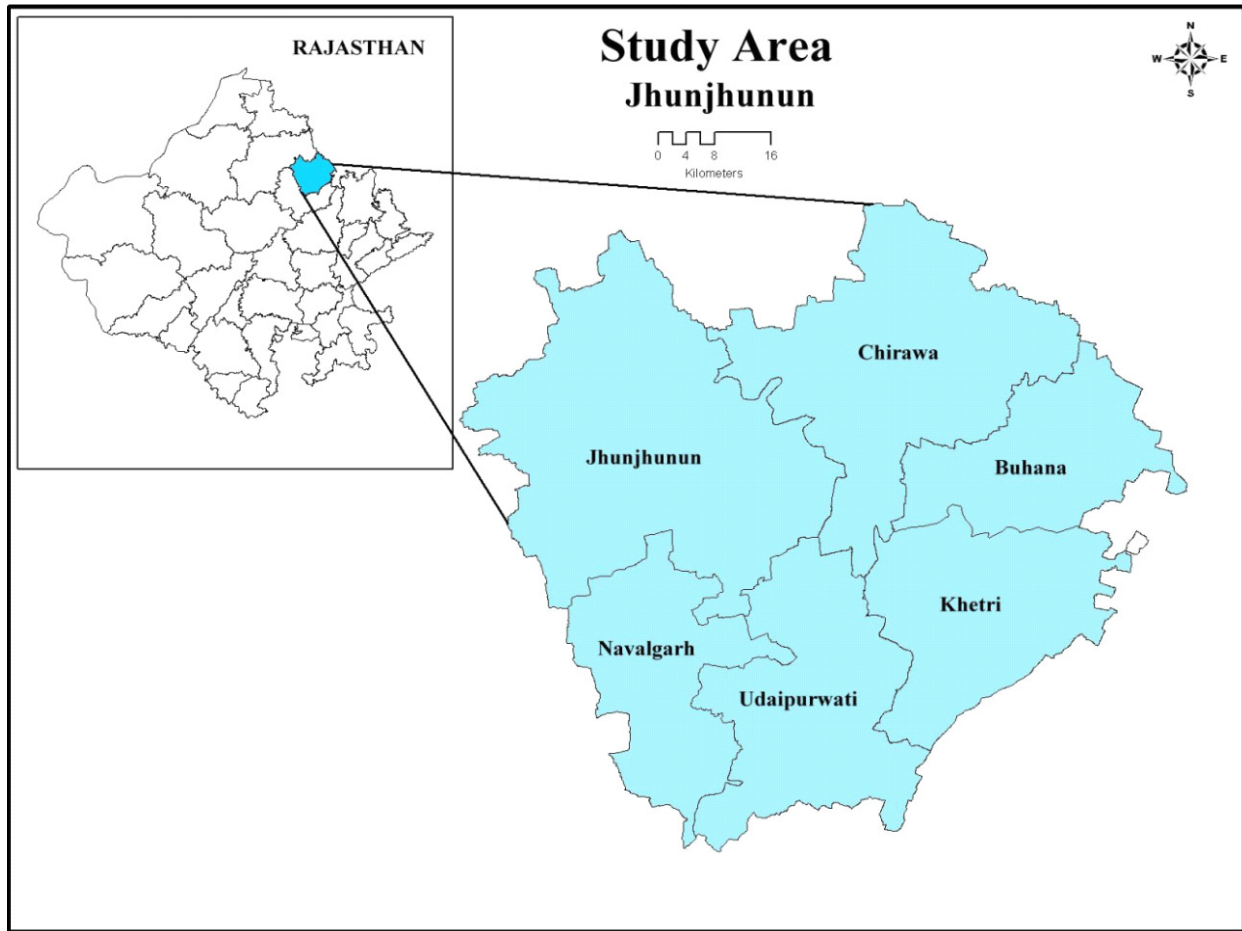


Fig. 1. Tehsil-wise map of Jhunjhunu district of arid Rajasthan.

The Hershfield (1961 and 1965) technique suggested by Chow (1964) was used to find out the 1-day maximum rainfall for different return periods based on daily rainfall events at six tehsil locations of Jhunjhunu district. Such technique was earlier used by Samra *et al.* (1975) to calculate probable maximum precipitation (PMP) over coastal Andhra Pradesh for 93 stations and by Rao *et al.* (2007 and 2012) to calculate 1-day maximum rainfall for different return periods for locations in Churu and Sirohi districts of arid Rajasthan. The following equation was used to estimate the probable maximum precipitation;

$$X_m = X_{\text{mean}} + S K_m$$

where, X_m = estimate of PMP;

X_{mean} = mean of rainfall;

S = standard deviation of rainfall; and

K_m = frequency factor

where, $K_m = X_L - (X_{\text{mean}N-1}) / \sigma_{N-1}$; X_L is the largest value of the rainfall series; $X_{\text{mean}N-1}$ = Mean of the rainfall excluding X_L value

σ_{N-1} = Standard deviation of rainfall excluding X_L value

The annual rainfall trends were obtained by using linear regression technique based on the annual rainfall totals for Chirawa, Jhunjhunu and Khetri tehsils.

Results and Discussion

Climatic characteristics

Seasonal variation in air temperature: During winter, mean minimum temperatures in Jhunjhunu district vary between 5.1 and 7.9°C. Air temperatures sharply increase from

Table 1. Classification of meteorological drought

Drought category	Percentage departure from normal
Excess or flood	More than 51%
Above normal	+26% to +50%
Normal	+25 % to -25%
Below normal	-26% to -50%
Drought	Less than -51%

Table 2. Tehsil-wise rainfall characteristics of Jhunjhunu district

Station	Annual rainfall (mm)	Annual rainy days	Coefficient of variation (%)	Seasonal rainfall (mm)	Seasonal rainy days	Highest rainfall (mm)	Lowest rainfall (mm)
Buhana	488	27	44	402	20	915 (1996)	133 (2002)
Chirawa	425	27	41	360	20	932 (1908)	95 (1938)
Jhunjhunu	405	28	37	343	21	828 (2010)	93 (1901)
Khetri	560	34	37	477	25	1252 (1977)	89 (1905)
Navalgarh	442	26	38	376	20	881 (1917)	131 (2002)
Udaipurwati	534	31	39	461	24	1191 (1996)	187 (2009)

April onwards and stands highest during May till pre-monsoon showers sets in the area. Summer air temperatures vary between 33.7°C and 39.6°C with values as high as 49°C in summer and lowest -3.5°C during winter month. Temperatures fall during the monsoon period (June-September), but however, rise after recession of the monsoon by about 3 to 5°C and again start falling from December onwards due to winter conditions.

Rainfall characteristics

The normal annual rainfall of the district varied from 405 mm in 28 rainy days at Jhunjhunu to 560 mm in 34 rainy days at Khetri (Table 2). The southwest monsoon rainfall had contributed for 85-90% to the annual total, whereas the winter rains 4-5% and summer rains 6-7% to the total. The coefficient of variation in annual rainfall for these locations varied from 37% at Jhunjhunu to 44% at Buhana, which indicates high inter-annual variability in the rainfall of the region. The long term rainfall data of the district reveals that the district experienced very poor rainfall between the period 1979 to 1991 with the exception of few years in between. Thereafter, the district was fortunate to have very good spell of rainfall continuously for a period of 7 years from 1992 to 1998. The year 1996 was the best with annual rainfall exceeding mean annual rainfall by 85.4%. The district again experienced drought conditions

from 1999 to 2002. The year 2002 was the worst drought year with rainfall being 62.3% less than mean annual rainfall.

The annual rainfall in the district varied from a lowest of 93 mm in 1901 at Jhunjhunu to a highest of 1252.0 mm in 1977 at Khetri and 1191.0 mm in 1996 at Udaipurwati. The extreme rainfall events recorded in the Jhunjhunu district showed that 1-day highest was between 157.5 mm at Jhunjhunu during 21 July 1920 to 281.4 mm at Khetri during 06 September, 1908 (Table 3).

The 1-day rainfall in Jhunjhunu district for different return periods of 5, 10, 25, 50 and 100 years are presented in Table 4. The 1-day rainfall was lowest at Jhunjhunu and highest at Buhana for all return periods of 5, 10, 25, 50 and 100 years. These return period rainfall values also showed that there is plenty of scope for water harvesting and re-use for cultivation of crops.

The long-term trends in the annual rainfall (1901-2011) of three tehsil locations of Jhunjhunu district (Fig. 2) have showed either normal or marginal increase in rainfall in the district. The rate of increase in the annual rainfall was 0.74 mm year⁻¹ at Chirawa, 0.43 mm year⁻¹ at Jhunjhunu and 0.48 mm year⁻¹ at Khetri. The decadal wise (1901-2011) meteorological drought situation of Chirawa, Jhunjhunu and Khetri tehsils of Jhunjhunu district are presented in Fig. 3.

Table 3. Extreme rainfall events in Jhunjhunu district

Stations	Highest	Date	PMP (K=6)
Buhana	190.0	22 July, 1906	272.9
Chirawa	203.2	22 July, 1908	217.2
Jhunjhunu	157.5	21 July, 1920	164.6
Khetri	281.4	06 September, 1908	313.6
Navalgarh	182.0	23 July, 1996	244.4
Udaipurwati	279.0	09 July, 1968	352.8

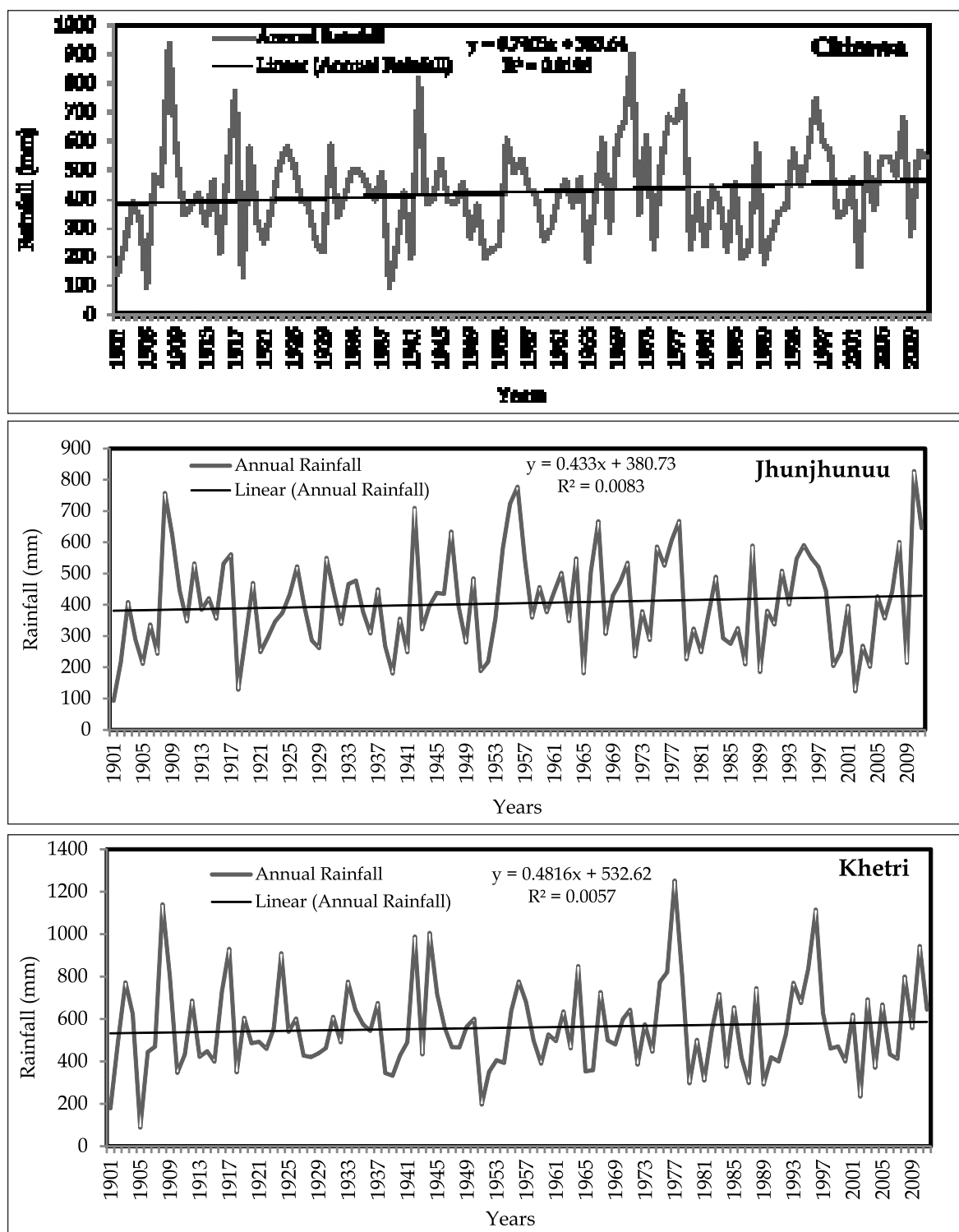


Fig. 2. Annual rainfall trend at different locations in Jhunjhunu district.

Meteorological Droughts

The frequency of meteorological droughts occurred in Jhunjhunu district are given Table 5. Jhunjhunu tehsil experienced highest number

of normal to above normal rainfall years of 80 out of 111 years with minimum number of 30 years with below normal conditions. Khetri experienced highest number of years with below or severe drought conditions in

Table 4. Return period of 1-day rainfall (mm) in Jhunjhunu district

Station	Return period (years)				
	5	10	25	50	100
Buhana	116.5	143.0	176.0	200.7	225.8
Chirawa	91.8	109.9	132.6	149.5	166.7
Jhunjhunu	82.8	98.1	117.2	131.5	146.0
Khetri	110.7	133.1	161.0	181.8	203.0
Navalgarh	112.7	138.2	169.9	193.6	217.8
Udaipurwati	113.0	137.3	167.6	190.3	213.3

35 out of 111 years. Thus, the frequency of occurrence of drought in the Jhunjhunu district varied from once in 3.6 years at Jhunjhunu to 3.0 years at Khetri. The other locations in the district experienced in 30 years at Chirawa, 21 years out of 58 years at Navalgarh and 20 years out of 55 years at Udaipurwati. The drought frequency was highest during the decade 1981-90 with 6 out of 10 years recording moderate to severe drought and least frequency recording during 1941-50 with 2 out of 10 years as drought years (Fig. 3).

Conclusion

The present study showed that the Jhunjhunu district of arid Rajasthan experiences 405 to 560 mm of annual rainfall in 26 to 34 rainy days with a coefficient of variation of 37 to 44%. The seasonal rainfall (June-September) varied from 343 to 477 mm in 18 to 24 rainy days. The

highest annual rainfall recorded in the district was between 828 mm at Jhunjhunu and 1252 mm at Khetri. Similarly, the lowest rainfall record varied between 89 mm at Khetri and 187 mm at Udaipurwati. The extreme rainfall events recorded in the Jhunjhunu district showed that 1-day highest rainfall varied from 158 mm at Jhunjhunu to 281 mm at Khetri. The 1-day rainfall was lowest at Jhunjhunu and highest at Buhana for all return periods of 5, 10, 25, 50 and 100 years. These return period rainfall values also showed that there is plenty of scope for water harvesting and re-use for cultivation of crops. The long-term annual rainfall trends showed that there was a marginal increase at a rate $0.43 \text{ mm year}^{-1}$ at Jhunjhunu, $0.48 \text{ mm year}^{-1}$ at Khetri, $0.74 \text{ mm year}^{-1}$ at Chirawa. The meteorological droughts prevailed in 36 years out of 111 years (1901-2011) with lowest frequency of 32 years with

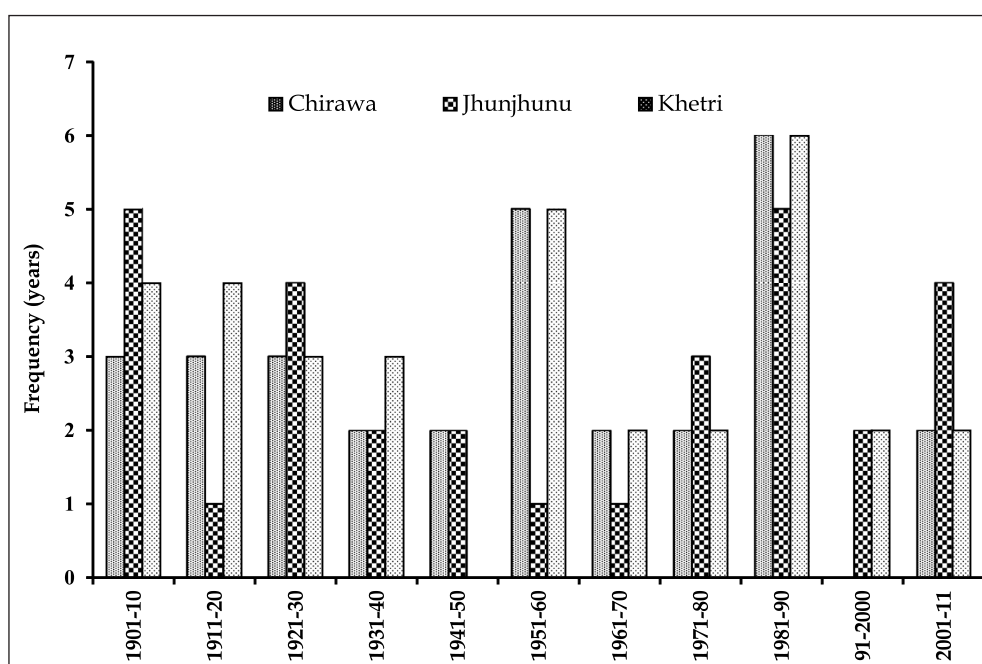


Fig. 3. Decadal-wise drought situation in Jhunjhunu district.

Table 5. Frequency of meteorological droughts occurred in Jhunjhunu district (1901-2011)

Category	Buhana (1996-2011)	Chirawa (1901-2011)	Jhunjhunu (1901-2011)	Khetri (1901-2011)	Navalgarh (1915-2011)	Udaipurwati (1957-2011)
Excess	1	10	11	10	05	07
Above normal	2	21	20	20	04	06
Normal	9	50	50	46	28	22
Below normal	2	20	24	31	17	18
Severe	2	10	06	04	04	02
Total	16	111	111	111	58	55

drought at Jhunjhunu and Chirawa to a highest frequency of 35 years drought at Khetri. The decade 1981-90 experienced highest (6 out of 10 years) number of moderate to severe droughts, whereas the decade 1941-50 recorded least frequency (2 out of 10 years) of droughts.

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