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Prediction of Degree of Dryness and Wetness at Various Return Periods among Different Rain Gauge Stations of Raichur Taluk

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Abstract

The identification, monitoring and characterization of drought are of great importance in water resources planning and management. Standardized precipitation index (SPI) was calculated from the probability distribution of precipitation, using a two-parameter gamma function. The methods were applied for daily rainfall data for the period from 1976 to 2003 for 8 rain gauge stations in Raichur taluk. An attempt was also made to predict the degree of dryness/wetness for all the rain gauge stations using daily maximum SPI values for 5, 10, 20, 30, 40, 50, 80 and 100 years by employing Gumbel's extreme value distribution in which degree of dryness ranged from -0.6 to -2.9 whereas degree of wetness ranged from 0.25 to 3.28.

Key words : Drought, SPI, Prediction, Dryness, Wetness.

Drought has been grouped as meteorological, hydrological, agricultural and socio-economic. Precipitation is the best indicator of drought over an area and this has been commonly used for meteorological drought analysis. Meteorological drought is defined usually on the basis of the degree of dryness of atmosphere and the duration of dry period. Numerous types of drought indices have been proposed to quantify different types of drought events (1). Among these indices standardized precipitation index (SPI) was used to measure degree of wetness and dryness. This method is designed to act as an indicator of drought that recognized the importance of time scales in the analysis of water availability and water use (2). Drought which is a stochastic variable that is time dependent, probability natural parameter, having considerable spatial and temporal variability with high uncertainty and hence the prediction of rainfall becomes crucial in the overall planning process. The SPI values were predicted for 5, 10, 20, 30, 40, 50, 80 and 100 years using gumbel distribution. The gumbel distribution is one of the most widely used probability-distribution functions for extreme values in hydrologic and meteorological studies for prediction of hydrological parameters. Gumbel distribution fitted well to the observed data and the expected and observed frequencies were found to be fair in agreement with each other (3).

Methods

Raichur taluk is a part of north-eastern dry zone of Karnataka which is situated between $15^0 55'$ to $16^0 20'$ N latitude and $77^0 10'$ to $77^0 35'$ E longitude at an elevation of 400 above msl. The taluk has a semi-arid and sub-tropical climate with moderate to severe summer, moderate winter and low but erratic rainfall. The average annual rainfall of taluk is 601.6 mm, during the south-west monsoon the taluk receives about 71% of the annual rainfall, with September as the month with the highest rainfall. During the past 103 years (1901 to 2003), the taluk experienced the highest rainfall amounting to 207% of the normal in 1916. The years 1941 and 2002 were the years with the lowest annual rainfall, during this period which was only 82% below the normal. Historical rainfall data for 28 years (1976—2003) of 8 rain gauge stations (Chandrabanda, Devsugur, Hospet, Raichur, Yermarus, Yergera, Jegarkal and Raichur RARS) were procured form the India Meteorological Department, Bangalore. The daily rainfall data were analyzed by using MS Excel worksheet by arranging the data on chronological order and this data was transformed into yearly series (Table 1). The analysis of yearly rainfall done for estimation of standard deviation, coefficient of variation and mean value to fit into the SPI.

A drought event is said to occur any time, the

Table 1. Details pertaining to average rainfall records of the rain gauge for 28 years.

Raingauge stations	No. of years rainfall data used	Average annual rainfall (mm)
Chandrabanda	28	611.94
Devasugur	28	661.43
Hospet	28	630.11
Raichur	28	656.93
Yermarus	28	713.70
Yergera	28	688.39
Jegarkal	28	664.22
Raichur, RARS	28	655.74

standardized precipitation index (SPI) is continuously negative and reaches a value of -1.0 or less. The drought classification based on SPI is shown in Table 2. The event would end when the SPI becomes positive (4).

After finding annual maximum SPI values for all rain gauge stations, these values are fitted to Gumbel's extreme values distribution to predict the degree of wetness and degree of dryness for 5, 10, 20, 30, 40, 50, 80 and 100 years return period. This statistical tool was used for this study to determine the drought magnitude for a specific return period (5).

Reduced mean (y_n) and reduced standard deviation (S_n) were determined using constants.

Reduced variate was found for 5, 10, 20, 30, 40, 50, 80 and 100 years by using the equation.

$$Y_t = \left(- \text{In. In.} \frac{T}{T-1} \right)$$

where, Y_t = Reduced variate, T = Return period (years). Frequency factor (K) was found out by using equation

$$K = \frac{Y_t - Y_n}{S_n}$$

where, Y_t = Reduced variate, Y_n = Reduced mean, S_n = Reduced standard deviation,

Values of variate 'X' was found out by using equation

$$X_T = \bar{x} + K \sigma_{n-1}$$

Table 2. Classification of drought using SPI.

SPI values	Class
> 2	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
-0.99 to 0.99	Near normal
-1 to – 1.49	Moderately dry
-1.5 to – 1.99	Severely dry
< -2	Extremely dry

where, X_T = value of variate X of a random hydrologic series with a return period of T, $\bar{x}$ = Mean of the sample size, σ_{n-1} = Standard deviation of the sample of size, K = Frequency factor.

Results and Discussion

Daily rainfall data of 1976 to 2003 were summed up to obtain the yearly series to fit into statistical properties to know the erratic behavior. The probability analysis of rainfall data was done by using gumbel distribution. The following are the results obtained for different rain gauge stations of Raichur taluk.

Chandrabanda Rain Gauge Station

In Chandrabanda rain gauge station of Raichur taluk the degree of dryness ranged from -1.05 to -2.9, while the degree of wetness ranged from 0.25 to 0.75 (Table 3 and 4).

Devasugur Rain Gauge Station

In Devasugur rain gauge station of Raichur taluk the degree of dryness for various return periods ranged from -0.80 to -2.82, while the degree of wetness ranged from 0.45 to 1.31 (Table 3 and 4).

Hospet Rain Gauge Station

In Hospet rain gauge station of Raichur taluk the degree of dryness for various return periods ranged from -0.61 to 01.71, while the degree of wetness ranged from 0.70 to 2.00 (Table 3 and 4).

Raichur Rain Gauge Station

In Raichur rain gauge station of Raichur taluk

Table 3. Degree of dryness for different rain gauge stations of Raichur taluk at various return period.

	Return period, T (years)	Chandrabanda	Devasugur	Hospet	Raichur	Yergera	Yermarus	Jagarkal	RARS, Raichur
1	5	-1.05	-0.80	-0.61	-0.60	-0.6	-1.00	-0.90	-0.80
2	10	-1.50	-1.20	-0.90	-0.78	-0.8	-1.40	-1.38	-1.05
3	20	-1.90	-1.50	-0.15	-0.90	-1.1	-1.72	-1.80	-1.30
4	30	-2.15	-1.71	-1.3	-1.00	-1.20	-2.00	-2.13	-1.40
5	40	-2.35	-1.87	-1.4	-1.05	-1.40	-2.20	-2.20	-1.55
6	50	-2.98	-2.00	-1.5	-1.11	-1.50	-2.30	-2.30	-1.65
7	80	-2.70	-2.20	-1.69	-1.22	-1.60	-2.60	-2.62	-1.80
8	100	-2.90	-2.82	-1.71	-1.80	-1.70	-2.70	-2.75	-1.90

the degree of dryness for various return periods ranged from -0.60 to -1.80, while the degree of wetness ranged from 0.70 to 1.40 (Table 3 and 4).

Yergera Rain Gauge Station

In Yergera rain gauge station of Raichur taluk the degree of dryness for various return periods ranged from -0.6 to -1.7, while the degree of wetness ranged from 0.95 to 3.24 (Table 3 and 4).

Yermarus Rain Gauge Station

In Yermarus rain gauge station of Raichur taluk the degree of dryness for various return periods ranged from -1 to -2.7, while the degree of wetness ranged from 1.1 to 3.28 (Table 3 and 4).

Jegarkal Rain Gauge Station

In Jegarkal rain gauge station of Raichur taluk the degree of dryness for various return periods ranged from -0.9 to -2.7, while the degree of wetness ranged from 0.95 to 2.85 (Table 3 and 4).

Raichur RARS Rain Gauge Station

In Raichur RARS rain gauge station of Raichur taluk the degree of dryness for various return periods ranged from -0.8 to -1.9, while the degree of wetness ranged from 0.8 to 2.68 (Table 3 and 4).

It was observed that the probability of degree of wetness was rather linear compared to degree of dryness. The extent of increase in dryness with increase in return period was logarithmic from the lower return period to higher return period as compared to linear relationship in case of degree of wetness. The dryness figure (-0.6 to -2.9) indicates the larger variations from lower return period to highest return period for all the rain gauge stations of Raichur taluk, while wetness figure (0.25 to 3.28) indicates the constant variation from lower return period to higher return period in 6 rain gauge stations. For Chandrabanda and Devasugur rain gauge stations degree of wetness is almost normal even for higher return periods (6). The gumbel distribution was extremely useful in

Table 4. Degree of wetness for different rain gauge stations of Raichur taluk at various return period.

	Return period, T (years)	Chandrabanda	Devasugur	Hospet	Raichur	Yergera	Yermarus	Jagarkal	RARS, Raichur
1	5	0.25	0.45	0.70	0.70	0.95	1.1	0.95	0.80
2	10	0.35	0.65	1.00	0.85	1.87	1.55	1.40	1.22
3	20	0.50	0.85	1.28	1.15	2.15	2.05	1.82	1.65
4	30	0.55	0.95	1.48	1.50	2.35	2.35	2.10	1.90
5	40	0.60	1.05	1.60	1.90	2.50	2.65	2.28	2.10
6	50	0.65	1.12	1.70	1.98	2.85	2.70	2.40	2.20
7	80	0.70	1.25	1.90	2.10	3.00	3.10	2.70	2.51
8	100	0.75	1.31	2.00	2.35	3.24	3.28	2.85	2.68

analysis and prediction. Gumbel distribution can be used in prediction of drought occurrence in the condition where the moderate amount of rainfall is available with high skewness and variability.

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