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Rainfall probability modeling for Neelambur areas of Coimbatore, Tamil Nadu

B. MAHESHWARA BABU and D. C.SAHOO
Dept. of Soil & Water Engineering, College of Agricultural Engineering
University of Agricultural Sciences, Raichur-584 102
Email: babubandamahesh@yahoo.co.in

ABSTRACT

Daily rainfall data obtained from the rain gauge station, Sulur (11^0 N and 77^0 E) were analyzed for fitting one day maximum rainfall, average weekly, monthly and seasonal rainfall data, using different distributions like Normal, Log-normal, Gumbel and Log-Pearson III to determine the best fit distribution. Over the study area, the Gumbel and Normal distribution distributions are identified for the estimation of one day maximum rainfall, the average weekly and monthly rainfall with minimum D-index. However for seasonal rainfall, all four distribution *viz.,* Gumbel, Log-normal, Log-Pearson III and Normal distributions gave relatively low D-index values with minimum in Gumbel distribution.

Key words: Probability density function, D-Index

Rainfall is a random hydrological event, which is unevenly distributed in both space and time. Being the primary source of water in any area, its estimation at different probabilities is important for efficient planning of soil and water conservation programmes and the optimum utilization of water resources in various production systems. Hence the analysis of rainfall at different time intervals is important for better crop planning, safe disposal of excess runoff. Rainfall at 80 per cent probability can be safely taken as assured rainfall while 50 per cent can be taken as maximum limit for taking any risks (Gupta *et. al.*, 1975). A number of studies have been conducted for location speciûc (Sharda and Bhushan, 1985; Bhatt *et.al*., 1996; Anil Kumar 1999; Mohanty *et.al.*, 2001) agricultural planning in general and crop planning in particular by analyzing rainfall data. An attempt has been made for analysis of monthly, seasonal and annual total rainfall at different probability levels, annual maximum daily rainfall for different return periods. Based on theoretical probability distributions, it would be possible to forecast the rainfall of various magnitudes with different return periods.

MATERIALS AND METHODS

The study area is located at 11^0 N latitude and 77^0 E longitude, 437 m above mean sea level. The daily rainfall data for a period of 30 years (1976-2005) were collected from the rain gauge station, Sulur of Coimbatore district. From this, one day maximum rainfall, annual maximum rainfall, average weekly rainfall, average monthly rainfall were determined for the same period. For average weekly and monthly rainfall, South West Monsoon (June to September) period is considered for analysis. Similarly for North East Monsoon period, the cumulative seasonal values were worked out from October to December. Using the average monthly rainfall, probability of getting normal, abnormal and drought months were determined. The rainfall amounts associated with 20, 40, 60 and 80 per cent probability of exceedence were estimated. The rainfall analysis was done by fitting different theoretical distributions like Normal, Log-normal, Gumbel and Log-Pearson type III distributions.

D –Index

For comparison of relative fitness of different distributions, D-Index (Verma *et al*., 1989) was calculated and distribution with minimum index value was considered as best fit distribution.

$$D-index=\sum_{i}^{4}\frac{\left|x_i\ observed-x_i\ Estimated\right|}{\bar{x}}$$

Where,

X = Mean of the observed rainfall, mm

i = Series of rainfall amounts at 20, 40, 60, 80% probabilities of exceedence

Maximum and minimum rainfall

Prediction of maximum and minimum rainfall magnitude within specified time period is done by using the Weibull's formula (Subramanya, 1997).

Table 1: Annual one day maximum daily rainfall

Probability of excedence (per cent)	Observed rainfall (mm)	Estimated rainfall (mm)			
		Normal distribution	Log normal distribution	Gumbel distribution	Log Pearson Type III distribution
20	37.90	36.65	55.78	31.11	42.54
		(1.25)	(-17.88)	(6.79)	(-4.64)
40	57.04	54.86	59.68	52.42	56.44
		(2.18)	(-2.64)	(4.62)	(0.60)
60	76.18	70.92	67.18	73.73	69.56
		(5.26)	(9.00)	(2.45)	(6.62)
80	95.32	89.13	85.12	95.03	85.94
		(6.19)	(10.20)	(0.23)	(9.38)
Mean	66.61	62.89	66.94	63.07	63.62
D-Index		0.24	0.59	0.22	0.33

Note: *The parenthesis values indicates the deviation of observed rainfall from estimated rainfall.*

Table 2: Average weekly rainfall (South West Monsoon)

Probability of excedence (per cent)	Observed rainfall (mm)	Estimated Rainfall (mm)			
		Normal distribution	Log normal distribution	Gumbel distribution	Log Pearson Type III distribution
20	5.66	6.26	8.89	5.63	11.87
		(-0.60)	(-3.23)	(0.03)	(-6.21)
40	8.12	8.77	9.72	8.11	10.91
		(-0.65)	(-1.60)	(0.01)	(-2.79)
60	10.58	9.93	11.36	10.59	9.25
		(0.65)	(-0.78)	(-0.01)	(1.33)
80	13.04	12.43	15.50	13.07	15.66
		(0.61)	(-2.46)	(-0.03)	(-2.62)
Mean	9.35	9.35	11.37	9.35	11.92
D-Index		0.27	0.71	0.01	1.09

Note: *The parenthesis values indicates the deviation of observed rainfall from estimated rainfall.*

$$P = \frac{m}{(N+1)}$$

Where P=Probability of rainfall magnitude being equal to or exceeding to a set value.

m=Rank of the rainfall magnitude when arranged in descending order.

N=Number of years of records.

For finding the maximum rainfall, the rainfall data is arranged in descending order and rank number is assigned. Using this formula, the expected maximum rainfall amount against any desired recurrence interval is predicted. The same procedure is followed for minimum rainfall by arranging the data in ascending order.

RESULTS AND DISCUSSION

Annual one day maximum rainfall

The observed and estimated annual one day maximum rainfall at different probabilities is presented in Table 1. It is observed from the table that the percentage deviations from the observed rainfall data in Log-Normal distribution is maximum in numerical value at 20 per cent probability of exceedence. The percentage deviation value ranged from 1.25 to 17.88 at 20 per cent probability with a minimum in Normal distribution. Similarly the percentage numerical deviation is minimum in Gumbel distribution for 60 and 80 per cent probability of exceedence as compared to Normal, Log-Pearson type III distribution and Log-Normal distribution. But for 40 per cent probability of exceedence, the deviation is minimum for Normal distribution. Also, D-Index value is observed to be minimum for Gumbel (0.22) followed by

Table 3: Average monthly rainfall (South West Monsoon)

Probability of excedence (per cent)	Observed rainfall (mm)	Estimated rainfall (mm)			
		Normal distribution	Log normal distribution	Gumbel distribution	Log Pearson Type III distribution
20	28.89	31.94	35.67	27.92	32.16
		(-3.05)	(-6.78)	(0.97)	(-3.27)
40	40.97	42.47	48.58	41.05	39.79
		(-1.50)	(-7.61)	(-0.08)	(1.18)
60	53.05	51.75	54.10	53.19	49.20
		(1.30)	(-1.05)	(-0.14)	(3.85)
80	65.13	62.28	67.11	65.37	60.86
		(2.85)	(-1.98)	(-0.24)	(4.27)
Mean	47.01	47.11	51.36	46.88	45.50
D-Index		0.18	0.34	0.03	0.28

Note: *The parenthesis values indicates the deviation of observed rainfall from estimated rainfall.*

Table 4: Average seasonal rainfall (North East Monsoon)

Probability of excedence (per cent)	Observed rainfall (mm)	Estimated rainfall (mm)			
		Normal distribution	Log normal distribution	Gumbel distribution	Log Pearson Type III distribution
20	177.92	198.42	175.63	181.26	189.34
		(-20.5)	(2.29)	(-3.34)	(-11.42)
40	279.55	289.55	276.85	278.10	296.63
		(-10.0)	(2.70)	(1.45)	(-17.08)
60	381.17	370.63	388.25	389.56	381.18
		(10.54)	(-7.08)	(-8.39)	(-0.01)
80	482.80	462.16	491.34	485.61	455.62
		(20.64)	(-8.36)	(-2.81)	(27.18)
Mean	330.36	330.19	333.02	333.63	330.69
D-Index		0.19	0.06	0.05	0.17

Note: *The parenthesis values indicates the deviation of observed rainfall from estimated rainfall.*

Normal (0.24) distribution and Log-Pearson type III (0.33) distribution. Hence, Gumbel and Normal distribution fitted better with the one day maximum rainfall and give the reliable estimates in the selected study regions.

Average weekly and monthly rainfall for South West monsoon

Results in Table 2 indicate that the percentage deviations from the observed rainfall data in Log-Pearson type III is maximum in numerical value at 20 per cent probability of exceedence with a minimum in Gumbel distribution. Moreover, the numerical deviations are minimum in Gumbel distribution (0.01 to 0.03 %) in all ranges of probability of exceedence when compared to Normal, Log-normal and Log-Pearson III distribution. The D-Index is minimum for Gumbel (0.01) followed by Normal (0.27) distribution. It is inferred from the above that Gumbel and Normal distributions fitted better for the weekly rainfall for the study region compared to other distributions.

Similarly the observed and estimated monthly rainfall (Table 3) indicates that the percentage numerical deviations from the observed rainfall data is minimum in Gumbel distribution (0.08 to 0.97 %) for all ranges of probability of excedence. Also D-Index is observed to be minimum for Gumbel (0.03) followed by Normal (0.18) distributions. Hence, Gumbel and Normal distributions are well-fitted with the average monthly rainfall and provide reliable results for the region.

Average seasonal rainfall for North East monsoon

The estimated cumulative seasonal rainfall at different probabilities (Table 4) shows that the per cent deviations from the observed rainfall data in Log-Pearson type III distribution are more in numerical value at both 40 & 80 per cent probability of excedence. The numerical deviations are relatively higher in Normal & Log-Pearson III distributions when compared to other distributions. Also, the D-Index is minimum in Gumbel (0.05) followed by Log-normal (0.06).

Therefore, it can be concluded that all the four distributions fitted well with cumulative seasonal rainfall for North east monsoon period in the selected study region with comparatively better result expecting from Gumbel distribution.

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