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Maximum rainfall probability distributions pattern in Haryana –A case study

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Abstract: The present study has been undertaken to fit best probability distribution of rainfall in Ambala District of Haryana State. The analysis showed that the maximum daily rainfall among the years ranged between 41mm (1980) to 307.9mm (2009) indicating a very large variation during the period of study. The mean of maximum daily rainfall of all years annually is 112.13mm. The means of monthly and weekly values ranged from 33.10-88.92mm and 8.77-46.28 mm, respectively. The maximum daily rainfall in a year/monsoon season was307.9 mm and monthly maximum daily rainfall in monsoon season ranged from 105 -307.9mm. The weekly maximum daily rainfall ranged from48 mm-307.9 mm. It was also observed that the minimum among the maximum daily rainfall was 41mm for annual, 34mm for season and 0 in all the months and weeks. The maximum value of coefficient of variation was observed in the first week which indicated a large fluctuation in the rainfall data set and minimum value of coefficient of variation 0.464 was observed for the whole year which shows that fluctuation was minimum for the whole year. Generalized extreme value distribution was found to be best fit probability distribution for most of the periods.

Keywords: Goodness-of-fit tests, Maximum rainfall, Probability distributions

INTRODUCTION

It has long been a topic of interest in the fields of climatology to find a probability distribution that provides a good fit to daily rainfall. Several studies have been conducted in India and abroad on rainfall analysis and best fit probability distribution function such as normal, log-normal, gumbel, weibull and Pearson type distribution were identified (Mayooran, and laheetharan, 2014).

Rama Rao *et al.* (1975) analyzed the daily rainfall data collected at Bijapur for the year 1921 to 1970 at Bihapur. K N Krishnamurthy *et al.* (2015) studied the distribution of rainfall in the Bengaluru Urban District and observed that normal distribution was found to be the best for annual and seasonal months whereas gamma (2P),Weibull (3P) and general extreme distributions were found to be the best fit probability distributions for most of the weekly periods. Duan *et al.* (1995) suggested that for modeling daily rainfall data, the weibull and to a lesser extent the exponential distribution is suitable. Upadhaya and Singh (1998) stated that it is possible to predict rainfall more accurately using various probability distributions for certain returns period although the rainfall varies with space, time and have erratic nature. Sen and Eljadid (1999) reported that for monthly rainfall in arid regions, Gamma probability distribution is the best fit.

Ogunlela (2001) observed that log-Pearson type III distribution is best to describe the stochastic analysis of peak daily rainfall. Tao *et al.* (2002) recommended generalized extreme value model as the most suitable distribution after a systematic assessment procedure for representing extreme-value process and its relatively simple parameter estimation. Salami (2004) studied the meteorological data for Texas and found that Gumbel distribution fits adequately for both evaporation and temperature data, while for precipitation data log-Pearson type III distribution confirms to be more accurate. Takara *et al.* (2013) analyzed the extreme events and revealed that hydrological extremes sometimes do not fit well to the theoretical extreme-value distribution such as the Bumbel and generalized extreme value distributions. Lee (2005) indicated that log-Pearson type III distribution fits for 50% of total station number for the rainfall distribution characteristics of Chia-Nan plain area.

Bhakar *et al.* (2006) observed the frequency analysis of consecutive days peaked rainfall at Banswara, Rajasthan, India, and found gamma distribution as the best fit distribution. Kwaku *et al.* (2007) revealed that the log-normal distribution was the best fit probability distribution for one to five consecutive days' maximum rainfall for Accra, Ghana. Hanson *et al.* (2008) indicated that Pearson type III distribution fits the full record of daily precipitation data and Kappa distribution describes best the observed distribution of wet-day daily rainfall. Olofintoye *et al.* (2009) examined that

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50% of the total station number in Nigeria follows log-Pearson type III distribution for peak daily rainfall, while 40% and 10% of the total station follows Pearson type III and log-Gumbel distribution, respectively.
It is the distribution of rainfall during a season rather than its total amount which influence the crop yield. Water management of a country also depends on the pattern and distribution of rainfall.In view of this, the present study has been planned to establish the methodology for identifying the best fit probability distribution on the basis of three types goodness of fit tests. The maximum rainfall data of a single site (Ambala District, Haryana) was used to select a best fit probability distribution for rainfall.

MATERIALS AND METHODS

The present study is based on time series data of maximum daily rainfall in a year, season, month and week. The maximum daily, weekly, monthly, seasonal and annual rainfall data of 47 years (1966 to 2013) were collected from the India Meteorological Department. Various probability distributions namely normal, lognormal (2P, 3P), gamma (2P, 3P), generalized gamma (3P, 4P), log-gamma, weibull (2P, 3P), Pearson 5 (2P, 3P), Pearson 6 (3P, 4P), log-Pearson 3, generalized extreme value were fitted and evaluated by using the Komogorov-Smirnov, Anderson Darling and Chi-square tests. Different steps/ methods were used to find out the results

Step I: Fitting the probability distribution: The probability distributions viz. normal, lognormal, gamma, weibull, Pearson, generalized extreme value were identified to evaluate the best fit probability distribution for rainfall pattern. In addition to these different forms of distributions some other distribution were also tried and thus total 16 probability distributions viz. normal, lognormal (2P, 3P), gamma (2P, 3P), generalized gamma (3P, 4P), log-gamma, weibull (2P, 3P), Pearson 5 (2P, 3P), Pearson 6 (3P, 4P), log-Pearson 3, generalized extreme value were applied to find out the best fit probability distribution. The description of various probability distribution functions viz. density function, range and the parameters involved are presented in Table 1.

Step II: Testing the goodness of fit: The goodness of fit test measures the compatibility of random sample with the theoretical probability distribution. The goodness of fit tests was applied for testing the following null hypothesis:

H_0: The maximum daily rainfall data follow the specified distribution

H_A: The maximum daily rainfall data does not follow the specified distribution.

The following goodness of fit tests viz. Kolmogorov-Smirnov test and Anderson-Darling test were used along with the chi-square test at α(0.01) level of significance for the selection of the best fit Probability distribution.

(i) Kolmogorov-smirnov Test: The Kolmogorov-Smirnov statistic (D) is defined as the largest vertical difference between the theoretical and the empirical cumulative distribution function (ECDF):

$$D = \max \left[F(x_i) - \frac{i-1}{n}, \frac{i}{n} - F(x_i) \right] \quad (1)$$

Where x_i = random sample, i =1, 2… n.

$$CDF = F_n(x) = \frac{1}{n} \text{[Number of observations} \leq x] \quad (2)$$

This test is used to decide if a sample comes from a hypothesized continuous distribution.

(ii) Anderson-darling test: The Anderson-Darling statistic (A^2) is defined as

$$A^2 = -n - \frac{1}{n}\sum_{i=1}^{n}(2i-1).[InF(x_i) + InF(x_{n-i+1})] \quad (3)$$

It is a test to compare the fit of an observed cumulative distribution function to an expected cumulative distribution function. This test gives more weight to the tails then the Kolmogorov-Smirnov test.

(iii) Chi-squared test: χ 2The Chi-Squared statistic is defined as

$$\chi 2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i} \quad (4)$$

Where

O_i = observed frequency E_i = expected frequency

'i'= number of observations (1, 2, …….k)

This test is for continuous sample data only and is used to determine if a sample comes from a population with a specific distribution.

Step III: Identification of best fit probability distribution: The three goodness of fit tests mentioned above were computed to the maximum rainfall data treating different data set. The test statistic of each test were computed and tested at (α=0.01) level of significance. Accordingly, the ranking of different probability distributions were marked from 1 to 16 based on minimum test statistic value. The distribution holding the first rank was selected for all the three tests independently. The assessments of all the probability distribution were made on the basis of total test score obtained by combining the entire three tests. Maximum score 16 was awarded to rank first probability distribution based on the test statistic and further less scores were awarded to the distribution having rank more than 1, i.e. 2 to 16. Thus the total score of the entire three tests were summarized to identify the best fit distribution on the bases of highest score obtained.
The probability distribution having the maximum score was included as a fourth probability distribution in addition to three probability distributions which were previously identified.

RESULTS AND DISCUSSION

The methodology presented above was applied to the 47 years weather data in which maximum rainfall

Table 1. Description of various probability distribution functions((Mayooran, and laheetharan, 2014).

Distribution	Probability function	Range	Parameters
Gamma (3P)	f(x)= $\frac{(x-\alpha)^{\alpha-1}}{\beta^{\alpha}\Gamma(\alpha)} exp\left\{-{(x-\gamma)}/{\beta}\right\}$	γ≤x<+∞	σ = Shape parameter>0 β =Scale parameter>0 γ= location parameter yields the two parameter *Γ* = Gamma function
Gamma(2P)	f(x) = $\frac{(x)^{\alpha-1}}{\beta^{\alpha}\Gamma(\alpha)} exp\left\{-{(x)}/{\beta}\right\}$		
Generalized extreme value	f(x) = $\frac{1}{\sigma} exp\left[-(1+kz)^{-1/k}\right](1+kz)^{-1-1/k} k \neq 0$ $\frac{1}{\sigma} exp[-z-\exp(-z)] k=0$	1+ $k\frac{(x-\mu)}{\sigma}>0 \; for \; k\neq 0$ $-\infty$ γ≤x<+∞	σ = scale parameter>0 k =shape parameter>0 μ= location parameter where z = $\frac{x-\mu}{\sigma}$
Generalized Gamma (4P)	f(x) = $\frac{k(x-\gamma)^{k\alpha-1}}{\beta^{k\alpha}\Gamma(\alpha)} exp\left\{-[{(x-\gamma)}/{\beta}]^{k}\right\}$	γ≤x<+∞	k = Shape parameter>0 σ = Shape parameter>0 β =Scale parameter>0 γ= location parameter yields the two parameter *Γ* = Gamma function
Generalized Gamma (3P)	f(x) = $\frac{(kx)^{k\alpha-1}}{\beta^{k\alpha}\Gamma(\alpha)} exp\left\{-({x}/{\beta})^{k}\right\}$		
Log-Gamma	f(x) = $\frac{(In(x))^{\alpha-1}}{x\beta^{\alpha}\Gamma(\alpha)} exp\left\{-{In(x)}/{\beta}\right\}$	0≤x<+∞	σ = Shape parameter>0 β =Scale parameter>0 γ
Lognormal(3P)	f(x) = $\frac{exp\{(-\frac{1}{2}(\frac{In(x-\gamma)-\mu}{\sigma})^{2})}{(x-\gamma)\sigma\sqrt{2\pi}}$	γ≤x<+∞	σ = Scale parameter>0 β = shape parameter>0 γ= location parameter yields the two parameter lognormal distribution
Lognormal(2P)	f(x) = $\frac{exp\{(-\frac{1}{2}(\frac{In(x)-\mu}{\sigma})^{2})}{(x)\sigma\sqrt{2\pi}}$		
Log-Pearson 3	f(x)= $\frac{1}{x\lvert\beta\rvert\Gamma(\alpha)}(\frac{In(x)-\mu}{\beta})^{\alpha-1} exp(\frac{In(x)-\gamma}{\beta})$	0<x≤ e^{γ} β<0 e^{γ} <x≤+ ∞ β<	β = Scale parameter ≠ 0 α= shape parameter>0 γ= location parameter
Normal	f(x) = $\frac{1}{\sigma\sqrt{2\pi}} exp\{(-\frac{1}{2}(\frac{x-\mu}{\sigma})^{2})$	-∞≤x<+∞	σ = standard Deviation >0 μ= Mean
Pearson 5 (3P)	f(x) = $\frac{exp(^{-\beta}/_{(x-\gamma)}}{\beta\Gamma(\alpha)(^{(x-\gamma)}/_{\beta})^{\alpha+1}}$	γ < x< +∞	β = Scale parameter>0 α = shape parameter>0 γ= location parameter yields the two parameter Pearson 5 distribution
Pearson 5 (2P)	f(x) = $\frac{exp(^{-\beta}/_{(x)}}{\beta\Gamma(\alpha)(^{(x)}/_{\beta})^{\alpha+1}}$		
Pearson 6 (4P)	f(x) = $\frac{(^{(x-\gamma)}/_{\beta})^{\alpha_1-1}}{\beta B(\alpha_1,\alpha_2)(1+\frac{x-\gamma}{\beta})^{\alpha_1+\alpha_2}}$	γ≤x<+∞	α_1 = shape parameter α_1 >0 α_2 = shape parameter α_2 >0 β = scale parameter β >0
Pearson 6 (3P)	f(x) = $\frac{(^{(x)}/_{\beta})^{\alpha_1-1}}{\beta B(\alpha_1,\alpha_2)(1+\frac{x}{\beta})^{\alpha_1+\alpha_2}}$		γ= location parameter yields the three parameter Pearson 6 distribution
Weibull (3P)	f(x) = $\frac{\alpha}{\beta}(\frac{x-\gamma}{\beta})^{\alpha-1} exp[-(\frac{x-\gamma}{\beta})^{\alpha}$	γ≤x<+∞	α = shape parameter>0 β = scale parameter>0 γ= location parameter yields the two parameter weibull distribution,
Weibull (2P)	f(x) = $\frac{\alpha}{\beta}(\frac{x}{\beta})^{\alpha-1} exp[-(\frac{x}{\beta})^{\alpha}$		

Table 2. Summary of statistics for maximum daily rainfall from the year 1966 to 2013.

Study Period		Mean	SD	Skewness	C.V.	Max	Min	Quartile Q1	Quartile Q3
Annual	1 Jan-31 Dec	112.13	52.056	1.7433	0.46425	307.9	41	81	125
Seasonal	1 June-30 Sep	111.17	53.164	1.6179	0.47823	307.9	34	81	
June	1 June-30 June	33.096	23.654	0.88517	0.71472	105	0	15.25	46.52
July	1July-31 July	88.919	56.083	1.3757	0.63072	307.9	0	52.75	113.75
August	1 Aug-31 Aug	68.7	48.154	1.6524	0.70093	239	0	40	91.25
Sept	1 Sep-30 Sep	49.879	38.037	0.49101	0.76258	131.7	0	21.25	80.75
1 week	4 June-10 June	8.775	18.598	3.0801	2.1195	84.7	0	0	10
2 week	11 June-17 June	10.871	14.623	1.2571	1.3452	48	0	0	21
3 week	18 June-24 June	16.338	22.953	1.791	1.4049	105	0	0	27.25
4 week	25 June-1 July	18.929	19.869	1.614	1.0497	90	0	1.25	26.75
5 week	2 July-8 July	37.394	45.211	1.6641	1.209	196.7	0	3	59.725
6 week	9 July-15 July	32.304	25.53	0.76314	0.79031	102	0	12	49.5
7 week	16 July-22 July	38.744	44.877	1.5457	1.1583	206.7	0	2.25	66.8
8 week	23 July-29 July	46.277	57.471	2.408	1.2419	307.9	0	7.075	63.25
9 week	30 July-5 Aug	40.904	43.713	2.2876	1.0687	239	0	14.2	49.3
10 week	6 Aug-12 Aug	28.971	27.137	1.1734	0.9367	119	0	5.25	42.1
11 week	13 Aug-19 Aug	30.756	29.809	1.2474	0.96919	121	0	7.25	42.225
12 week	20 Aug-26 Aug	24.565	33.775	1.9586	1.3749	158	0	0	39.225
13 week	27 Aug-2 Sep	26.11	38.842	3.3275	1.4876	225	0	0	36.5
14 week	3 Sep-9 Sep	23.721	31.659	1.7436	1.3346	131.7	0	0	14.5
15 week	10 Sep-16 Sep	19.613	31.195	1.7663	1.5906	112.1	0	0	23.25
16 week	17 Sep-23 Sep	10.838	19.033	2.2753	1.7562	81	0	0	12.675
17 week	24 Sep-30 Sep	15.785	32.009	2.3677	2.0277	125	0	0	20.5

Table 3. Study period wise first ranked probability distribution using goodness of fit tests.

		Kolmogorov Smirnov		Anderson Darling		Chi-Square	
Study Period		**Distribution**	**Statistics**	**Distribution**	**Statistics**	**Distribution**	**Statistics**
Annual	1 Jan-31 Dec	Gen. Extreme	.07378	Gen. Extreme	.02035	Lognormal (3P)	0.312888
Seasonal	1 June-30 Sep	Gen. Extreme	.08439	Gen. Extreme	.32114	Pearson 6	.85293
June	1 June-30 June	Gen. Extreme	.07294	Gen. Extreme	.19153	Gamma	0.82822
July	1July-31 July	Gen. Gamma	.08462	Gen. Extreme	.39106	Gen. Extreme	0.79631
August	1 Aug-31 Aug	Gen. Extreme	.09279	Gen. Extreme	.6191	Pearson 6	4.7585
Sept	1 Sep-30 Sep	Gen. Extreme	.11961	Gen. Extreme	.78035	Lognormal (2P)	0.93463
1 week	4 June-10 June	Normal	.31853	Weibull	-5.5831	Normal	14.073
2 week	11 June-17 June	Normal	.24847	Weibull	-1.6365	Normal	8.7168
3 week	18 June-24 June	Normal	.2383	Gamma	1.7723	Normal	8.8549
4 week	25 June-1 July	Gen. Extreme	.12316	Gen. Extreme	0.9657	Gen. Extreme	2.1798
5 week	2 July-8 July	Gen. Extreme	.12583	Gen. Extreme	0.9947	Gen. Extreme	1.0918
6 week	9 July-15 July	Gen. Extreme	.0828	Gen. Extreme	0.4454	Normal	1.6877
7 week	16 July-22 July	Gen. Extreme	.13271	Gen. Extreme	1.3722	Pearson 5	5.0899
8 week	23 July-29 July	Gen. Extreme	.10819	Gen. Extreme	0.6685	Pearson 5	1.9855
9 week	30 July-5 Aug	Gen. Extreme	.08376	Gen. Extreme	0.4512	Gamma (3P)	1.3943
10 week	6 Aug-12 Aug	Gen. Extreme	.09081	Gen. Extreme	.56004	Gen. Extreme	2.4656
11 week	13 Aug-19 Aug	Gen. Extreme	.08791	Gen. Extreme	.40648	Gamma(3P)	1.3868
12 week	20 Aug-26 Aug	Gen. Extreme	.1665	Gen. Extreme	2.2935	Gen. Extreme	8.9913
13 week	27 Aug-2 Sep	Gen. Extreme	.13938	Gen. Extreme	1.1948	Gen. Extreme	3.1964
14 week	3 Sep-9 Sep	Gen. Extreme	.1765	Gen. Extreme	1.8772	Gen. Extreme	5.7725
15 week	10 Sep-16 Sep	Gen. Extreme	.21102	Gen. Extreme	3.1495	Gen. Extreme	8.8568
16 week	17 Sep-23 Sep	Normal	.28454	Weibull (3P)	-8.7009	Gen. Extreme	8.8169
17 week	24 Sep-30 Sep	Normal	.34026	Weibull(3P)	-4.4725	Normal	15.704

(mm) were taken from daily rainfall. The various probability distribution functions are described in Table 1. The annual maximum daily rainfall ranged from 41 to 307.9 mm during the study period and is presented in Fig.1. The data was classified into 23 data sets. These 23 data sets were classified as 1 annual (Jan to Dec.), 1 seasonal (June to Sept), 4 months of rainy season and 17 weeks (from Standard Meteorological (week no.23 to 39) to study the distribution pattern at different levels. The summary statistics (mean, standard deviation, skewness coefficient, coefficient of variation, maximum and minimum values of daily maximum rainfall) are presented in Table 2. It is observed that mean of maximum daily rainfall of all years annually is 112.13 mm, seasonal mean value is 111.17 mm. The means of monthly and weekly values ranged from 33.10-88.92mm and 8.77- 46.28 mm, respectively. The maximum daily rainfall in a year/monsoon season was 307.9 mm. During different months (i.e. June, July, August & September) of monsoon period ,the maximum daily rainfall ranged from 105 -307.9mm. The weekly maximum daily rainfall ranged from48 mm-

Table 4. Parameters of the best fitted distribution.

Study Period		Distribution	Parameters
Annual	**1 Jan-31 Dec**	**Gen. Extreme Value**	**k=0.18315 =31.421 =87.11**
		Lognormal (3P)	σ=0.5113 μ=4.3917 γ=19.897
seasonal	1 June-30 Sep	Gen. Extreme Value	k=0.13518 σ=34.398 μ=86.048
		Pearson 6 (4P)	α_1=60.716 α_2=9.173 β=17.62 γ=-19.817
June	1 June-30 June	Gen. Extreme Value	k=-0.0119 =19.164 =22.257
		Gamma	α=1.9576 β=16.906
July	1July-31 July	Gen. Gamma	k=1.0441 β= 35.373 α=2.7505
		Gen. Extreme Value	k=-0.03467 σ=44.12 μ=64.918
August	1 Aug-31 Aug	Gen. Extreme Value	k=0.09353 σ=32.454 μ=46.678
		Pearson 6	α_1=2.203 α_2=8.2807E+7 β=2.6904E+9
Sept	1 Sep-30 Sep	Gen. Extreme Value	k=-0.03777 σ=32.379 μ=32.359
		Lognormal	σ=0.99988 μ=3.6612
1 week	4 June-10 June	Normal	σ=18.598 μ=8.775
		Weibull	α=0.24843 β=1.1293
2 week	11 June-17 June	Normal	σ=14.623 μ=10.871
		Weibull	α=0.19133 β=1.569
3 week	18 June-24 June	Normal	σ=22.953 μ=16.338
		Gamma	α=0.50664 β=32.246
4 week	25 June-1 July	Gen. Extreme Value	k=0.17691 σ=12.288 μ=9.2559
5 week	2 July-8 July	Gen. Extreme Value	k=0.32213 σ=22.151 μ=14.391
6 week	9 July-15 July	Gen. Extreme Value	k=-0.02839 σ=21.199 μ=20.648
		Normal	σ=25.53 μ=32.304
7 week	16 July-22 July	Gen. Extreme Value	k=0.2572 σ=24.881 μ=15.999
		Pearson 5	α=0.61085 β=6.2787
8 week	23 July-29 July	Gen. Extreme Value	k=0.33074 σ=26.308 μ=18.477
9 week	30 July-5 Aug	Gen. Extreme Value	k=0.2447 σ=23.375 μ=20.039
		Gamma	α=0.87562 β=46.714
10 week	6 Aug-12 Aug	Gen. Extreme Value	k=0.13107 σ=18.559 μ=15.516
11 week	13 Aug-19 Aug	Gen. Extreme Value	k=0.17418 σ=19.145 μ=15.759
		Gamma	α=1.0646 β=28.89
12 week	20 Aug-26 Aug	Gen. Extreme Value	k=0.38348 σ=14.332 μ=7.6545
13 week	27 Aug-2 Sep	Gen. Extreme Value	k=0.40048 σ=14.187 μ=8.7415
14 week	3 Sep-9 Sep	Gen. Extreme Value	k=0.37874 σ=13.692 μ=7.7287
15 week	10 Sep-16 Sep	Gen. Extreme Value	k=0.50757 σ=9.7111 μ=4.3207
16 week	17 Sep-23 Sep	Gen. Extreme Value	k=0.57128 σ=4.7674 μ=1.9351
		Normal	σ=19.033 μ=10.838
		Weibull	α=0.22523 β=1.4678
17 week	24 Sep-30 Sep	Normal	σ=32.009 μ=15.785
		Weibull	α=0.20662 β=1.0945

307.9 mm.

It was also observed that the minimum among the maximum daily rainfall was 41mm for annual, 34mm- for season and 0 in all the months and weeks. The maximum value of coefficient of variation was observed in the first week which indicates a large fluctuation in the rainfall data set and minimum value of coefficient of variation 0.464 was observed for the whole year which shows that fluctuation was minimum for the whole year.

The test statistics D, $A^2$and χ^2 for each data set were computed for sixteen probability distribution and the probability distribution having the first rank along with their test statistic is presented in Table 3. It was observed that Generalized extreme value distribution using Kolmogorov Smirnov test, Generalized Extreme value using Anderson Darling test and Pearson(6) using Chi-square test obtained the first rank for maximum daily monsoon rainfall. Thus the two probability distributions were identified as the best fit based on these three tests independently. The months of July and August on which the monsoon period remained centered are best expressed by generalized extreme value followed by Pearson 6. The other two months i.e. June and September are best explained by Generalized extreme value, Gamma and Lognormal (2P).

The sum of total test score were obtained for each data set for all 16 probability distribution. This was done to

Table 5. Score wise best fit probability distribution.

Study Period	Distribution with highest Score	
	Distribution	Score
Annual	Gen.Extreme Value	41
	Pearson 5	43
Seasonal	Gen.Exteme Value	45
June	Gen. Extreme Value	46
	Gamma	45
July	Gen. Extreme Value	43
August	Gen. Extreme Value	46
Sept	Gen. Extreme Value	40
1 week	Normal	45
2 week	Normal	45
3 week	Normal	46
4 week	Gen. Extreme Value	48
5 week	Gen. Extreme Value	48
6 week	Gen. Extreme Value	46
	Normal	46
7 week	Gen. Extreme Value	44
8 week	Gen. Extreme Value	48
9 week	Gen. Extreme Value	47
10 week	Gen. Extreme Value	48
11 week	Gen. Extreme Value	47
12 week	Gen. Extreme Value	48
13 week	Gen. Extreme Value	48
14 week	Gen. Extreme Value	48
15 week	Gen. Extreme Value	48
16 week	Gen. Extreme Value	45
17 week	Normal	45

identify the one more probability distribution in addition to distribution identified earlier for obtaining the best fit probability distribution. This distribution was identified using maximum overall score based on sum of individual point score obtained from three selected goodness of fit tests. The distributions identified which were having highest score are presented in Table 4. The distributions with same highest score were also included in the selected probability distribution. For annual data set Pearson 5 (3P) having highest score of43 was selected. It was also observed that some of the probability distributions already having the first rank in Table 3 were also having the highest scores and hence three or less distributions were identified. The distributions so identified are listed in Table 5 where the parameters of these identified distributions for each data set are mentioned in Table 4. Weibull (3P) distribution was found to be the best fit among the 11 fitted distributions by the Krishnamurhy *et al.* (2015). As reported by the Bhim *et al.* (2012) log-Pearson distribution was found to be the best fit probability distribution. In our study the General extreme value distribution was found to be the best fit probability distribution. The results show that both annual and seasonal maximum daily rainfall was observed to be 307.9 in the current study whereas in case of Krishnamurthy *et al.* (2015) and Bhim *et al.* (2015), it was found to be 200 mm and 252.98mm respectively.

Conclusion

Probability distribution of rainfall analysis has always attracted much attention due to erratic behavior over space and time. Thus the identifying the best distribution is of vital importance for better planning and management of the water especially for agrarian state like Haryana where agriculture pattern is intensive. Since India is facing the problem of drought in the year 2002,2004,2009,2014 and 2015. So by studying the distribution of rainfall in the district or village level the water management can be done. In overall General extreme value distribution was found to be the best for annual, seasonal, weekly and monthly followed by

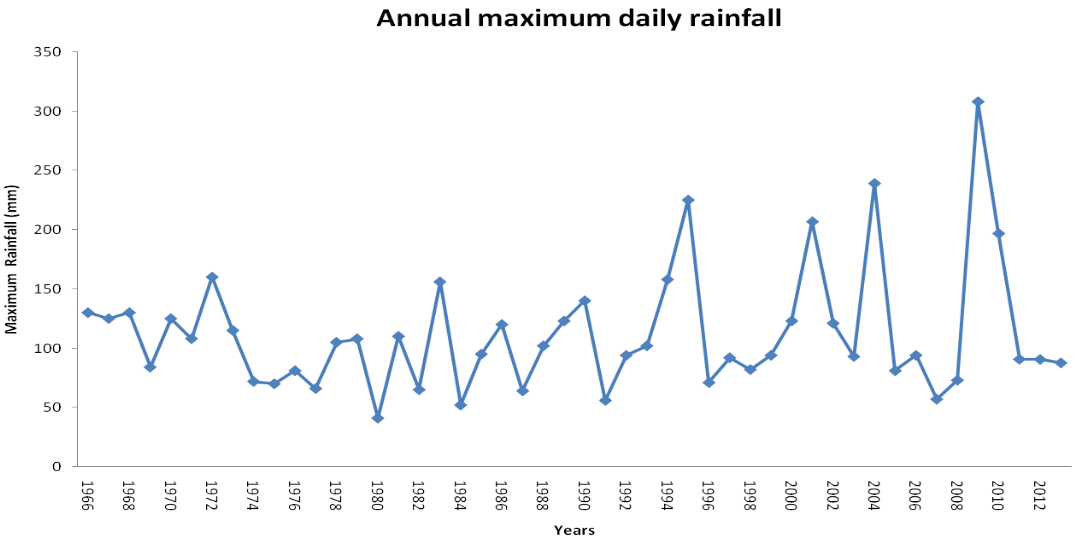

Fig. 1. *Annual maximum rainfall (mm) at Ambala during 1966-2013 (Source: Indian Meteorological Department)* .

Lognormal (3P), Gamma and normal distribution.

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