Research Article

Statistical Analysis of Rainfall data in Tiruchirappalli District

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Abstract
Agro-climatic characters play an important role in deciding the cropping pattern of a region. The distribution of rainfall is one such climatic character essential to plan farm activities in a given region. The present study was conducted to know the climatic characterization of Tiruchirappalli rain gauge station. The Secondary data of rainfall for 34 years (1980-2014) was obtained from Department of Economics and Statistics, Chennai. Among the weather parameters, amount of maximum daily rainfall (mm) was considered to fit appropriate probability distributions. The probability distributions viz., Normal, Log- normal, Gamma (1P, 2P, 3P), Generalized Extreme Value (GEV), Weibull (1P, 2P, 3P), Gumbel and Pareto were used to evaluate the best fit for maximum daily rainfall (mm). Kolmogorov-Smirnov test for the goodness of fit of the probability distributions showed that for majority of the data sets on rainfall at different study periods, Log- normal distribution was found to be the best fit. However, all the data sets were shape dominated which indicated that there was not much large variation in the distribution of rainfall.

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Introduction

Climate is one of the main determinants of agricultural production. Since climatic factors serve as direct inputs to agriculture, any change in climatic factors is bound to have a significant impact on crop yields and production. Rainfall is one of the most important natural input resources to crop production and its occurrence and distribution is erratic. In order to describe behavior of the rainfall at a particular area, it is necessary to identify the distributions which fit the data well.

India has an extraordinary variety of climatic regions ranging from tropical in the south temperate and alpine in the Himalaya north. There is a large variation in the amounts of rainfall received at different locations.

The normal annual rainfall of the Tamilnadu state is about 945 mm (37.2 in) of which 48% is through the North East monsoon and 32% through the South West monsoon. Based on soil characteristics, rainfall distribution, irrigation pattern, cropping pattern and other ecological and social characteristics, the State Tamil Nadu has been classified into seven agro-climatic zones. The following are the seven agro-climatic zones of the State of Tamil Nadu Cauvery Delta zone, North Eastern zone, Western zone, North Western zone, High Altitude zone, Southern zone and High Rainfall zone

Rainfall is one of the most important natural input resources to crop production and its occurrence and distribution is erratic. In order to describe behavior of the rainfall at a particular area, it is necessary to identify the distributions which fit the data well.

Material and Methods

Secondary data of rainfall for 34 years (1980-2014) was obtained from Department of Economics and Statistics, Chennai. This study includes 20 data sets of maximum daily rainfall such as, Trichy Airport, Trichy Town, Golden Rock, Trichy Junction, Upper Anicut, Thathaiangarpet, Thuraiyur, Lalgudi, Nandhiyar Head, Pullambadi, Musiri, Samayapuram, Ponnaiyar Dam, Kovilpatti, Manaparai, Chettikulam, Kallakudi, Siruganur, Kuttapattu and Poongudi. The probability distributions viz., Normal, Log-Normal, Gamma (1P,2P,3P), GEV, Weibull (1P,2P,3P), Gumbel and Pareto were used to evaluate the best fit for maximum daily rainfall (mm).
Kolmogorov–Smirnov test was used to test the goodness of fit of the probability distributions.
The goodness of fit test was applied for testing the following null and alternative hypothesis.

H_0- Maximum daily rainfall data follow the specified distributions.
H_1- Maximum daily rainfall data does not follow the specified distributions.

Kolmogorov-Smirnov test

The Kolmogorov-Smirnov (K-S) test is defined as the largest vertical difference between the empirical cumulative distribution function (edf) $F_n(x)$ to and the theoretical cumulative distribution function (cdf) $F(x)$. It is used for testing the null hypothesis that a sample of size comes from a population with a specified distribution. That is, if $x_{(1)}, x_{(2)}, ..., x_{(n)}$ denote an ordered sample of independent observations from a population with distribution function $F(x)$, the K-S test statistic is given by Equation (1).

$$D = \frac{\max}{1 \le i \le n} \left(\frac{i}{n} - u_i, u_i - \frac{1}{n+1} \right)$$

(1)

Where $u_i = F(x_i)$, the cdf evaluated at the ith ordered observation of the ordered sample, $i = 1, 2, 3, ..., n$, and n is the number of observations. The null hypothesis of the test is rejected in favour of the alternative if the calculated value of D is improbably large.

Results and Discussion

The present study was conducted to know the climatic characterization of Tiruchirappalli rain gauge stations which belongs to Cauvery delta zone. The probability distributions used to evaluate the best fit for maximum rainfall were Normal, Log Normal, Gamma (1P, 2P, 3P), Generalized Extreme Value (GEV), Weibull (1P, 2P, 3P), Gumbel and Pareto. The best fit probability distribution for each data set was found out based on the Kolmogorov Smirnov test statistic and the p- value. The test statistic D along with the p-values for each data set was computed for 11 probability distributions.

Among all the fitted probability distributions for maximum daily rainfall, the distribution with lowest test statistic value and highest p-value was considered as the best fit. The best fit probability distribution for each data set along with the parameters is presented in the **Table 1**.

Table 1 Parameters of the best fit probability distributions for Maximum daily rainfall

Study areas	Best fit	Parameters		
		Shape parameter (k)	Scale parameter (β)	Location parameter (μ)
Trichy Airport	Gamma (2P)	5.652	20.709	-
Trichy Town	Log- Normal	4.637	0.600	-
Golden Rock	Log- Normal	4.661	0.511	-
Trichy Junction	Gamma (2P)	4.987	21.266	-
Upper Anicut	Pareto	31.5	16.03	-
Thathaiangarpet	Gamma (2P)	2.864	21.702	-
Thuraiyur	Log- Normal	4.458	0.329	-
Lalgudi	Gamma (2P)	6.954	14.813	-
Nandhiyar Head	Log- Normal	4.400	0.568	-
Pullambadi	Log- Normal	4.468	0.528	-
Musiri	Log- Normal	4.89	0.431	-
Samayapuram	Log- Normal	4.424	0.472	-
Ponnaiyar Dam	Log- Normal	4.424	0.354	-
Kovilpatti	Pareto	2.461	25.717	-
Manaparai	Log- Normal	4.483	0.495	-
Chettikulam	Pareto	708	228	-
Kallakudi	Pareto	2.201	6.966	-
Kuttapattu	GEV	0.165	29.749	72.254
Poongudi	GEV	-0.167	40.510	72.767
Siruganur	Log- Normal	4.428	0.382	

Figure 1 shows the year wise variation in Trichy Airport station maximum daily rainfall from 1980-2014. It ranged from 48.8 mm (in 2014) to 310.5 mm (in 1999). The minimum of the maximum daily rainfall, i.e., 48.8 mm and the maximum of the maximum daily rainfall of 310.5 mm. **Figure 2** represents the year wise variation in Thuraiyur maximum daily rainfall from 1980-2014 and it ranged from 52 mm (in 2010) to 193 mm (in 2006).The minimum of the maximum daily rainfall was 52 mm and the maximum daily rainfall was 193 mm. From both the figures it reveals that the variation in rainfall is stationary over the years.
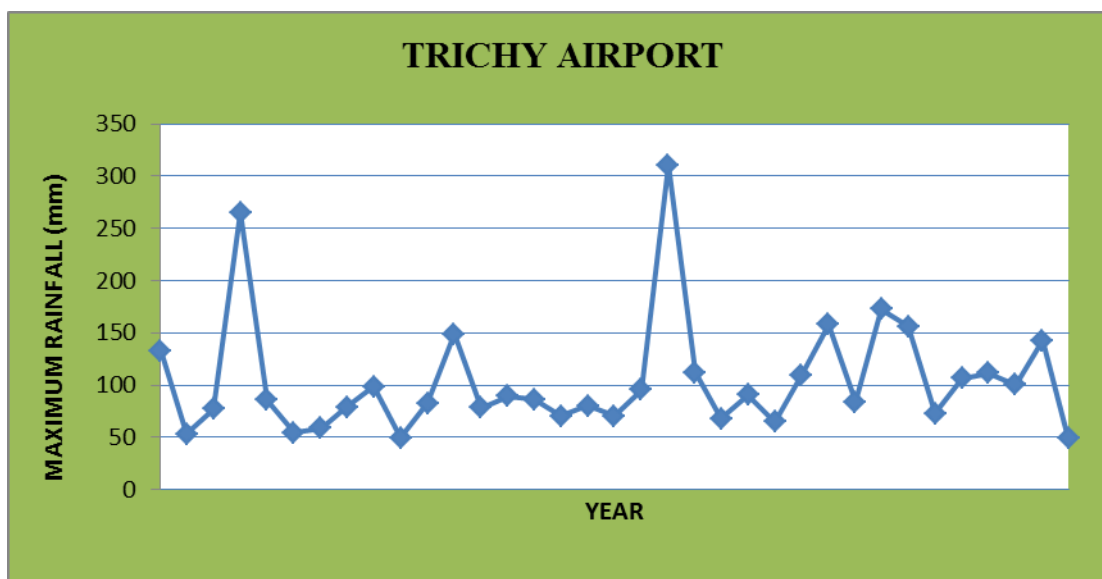
Figure 1 Variation in Trichy Airport station maximum daily rainfall (mm)
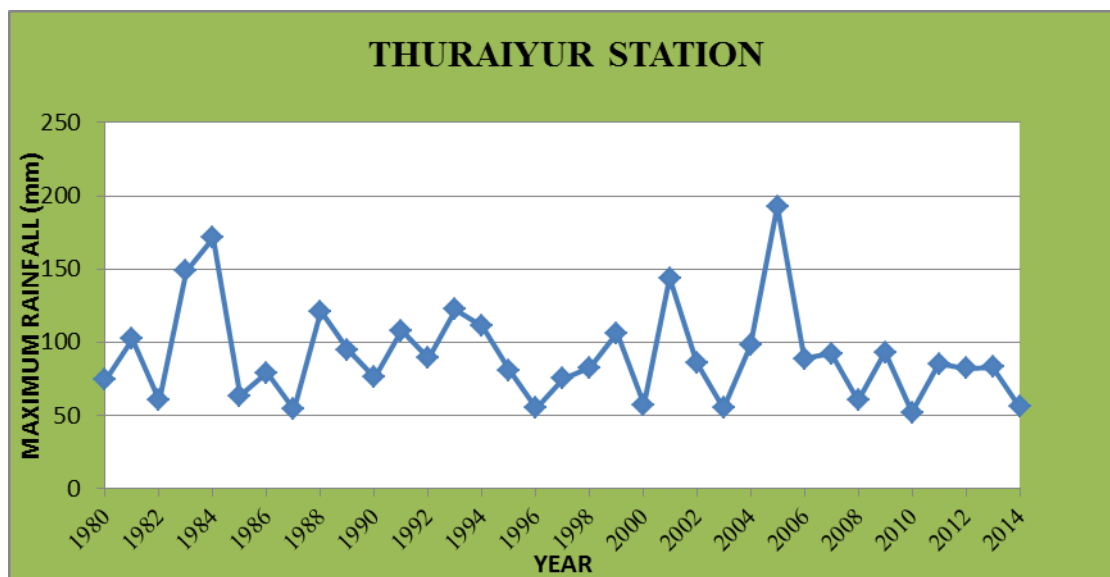
Figure 2 Variation in Thuraiyur station maximum daily rainfall (mm)

Trichy Airport

For the data sets on Trichy Airport rain gauge station maximum daily rainfall, Gamma (2P) and Weibull (2P, 3P) distributions were found to be the best fits. Among these distributions, Gamma (2P) had the lowest test statistic value and the highest p-value. This distribution was found to be shape-dominated which indicated that consistent rainfall was seen for the study period of trichy airport.

Trichy Town

It was observed that for the station data sets the distributions viz., Gamma (2P), log-normal, and Weibull (2P, 3P) fitted well. The distribution which had the Lowest test statistic value and the highest p-value among all these four

probability distributions was log-normal. This distribution was dominated by the shape parameter which showed consistency in the distribution of seasonal rainfall.
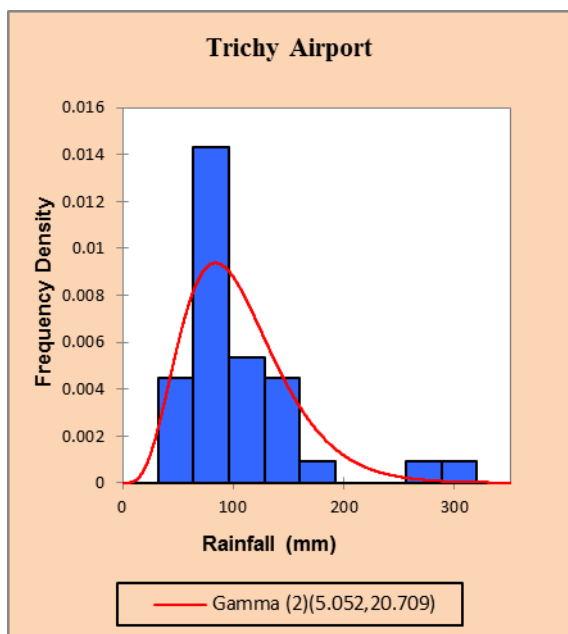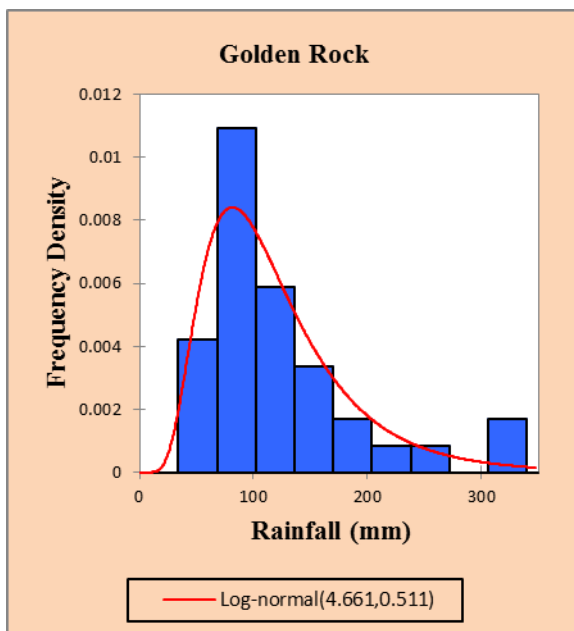

Distribution for Trichy Airport station
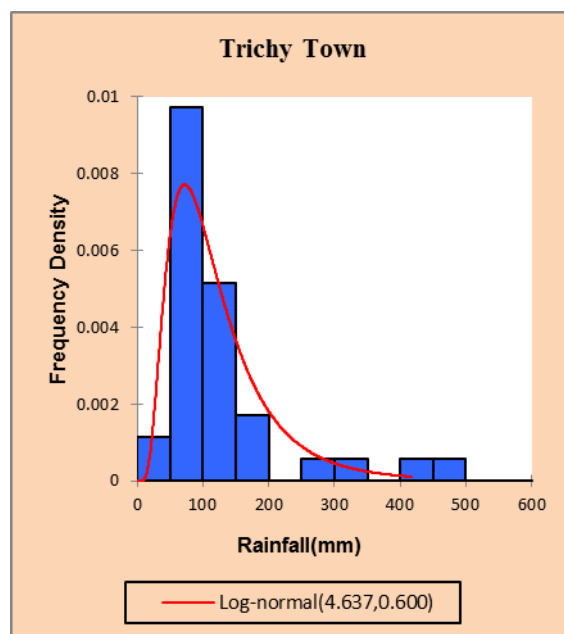
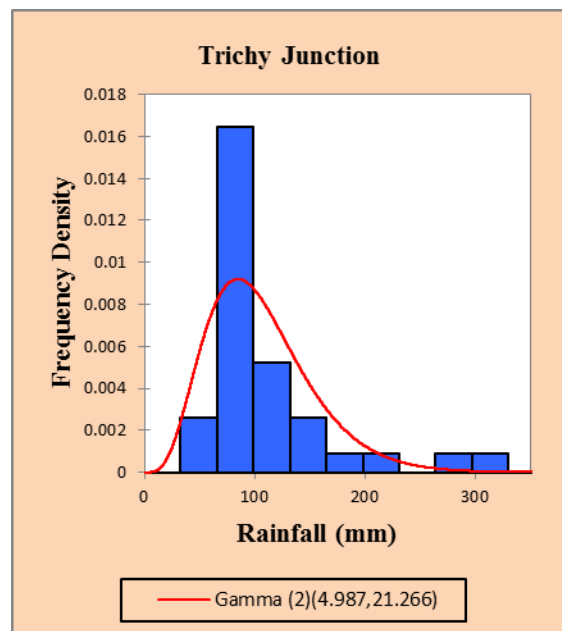Distribution for Trichy Town station

Golden Rock

The distributions which fitted well for Golden Rock rain gauge station were Gamma (2P), log- normal and Weibull (2P, 3P). Among these distributions, log- normal had the lowest test statistic value and the highest p-value. log-normal distribution was shape dominated, there was not much variation in the distribution of rainfall.

Trichy Junction

The distributions which fitted well for Trichy Junction rain gauge station maximum daily rainfall, Gamma (2P), GEV and Weibull (2P, 3P) distributions were found to be the best fits. Among these distributions, Gamma (2P) had the lowest test statistic value and the highest p-value. This distribution was found to be shape-dominated which indicated that consistent rainfall was seen for the study period of Trichy Airport.

Distribution for Gold Rock station

Distribution for Trichy Junction station

Upper Anicut

For Upper Anicut station, the distributions such as Gamma (2P), Log- normal, Pareto and Weibull (2P, 3P) fitted well. Pareto distribution was found to have the lowest test statistic value and highest p-value. This distribution was scale-dominated which showed large variation in the distribution of rainfall.

Thathaiangarpet

For Thathaiangarpet rain gauge station, the distributions which were found to be best fits were, Gamma (2P), Pareto, Log- normal and Weibull (2P, 3P), out of which Gamma (2P) distribution had the lowest test statistic value and highest p-value it was dominated by the shape parameter which showed consistency in the distribution of rainfall.
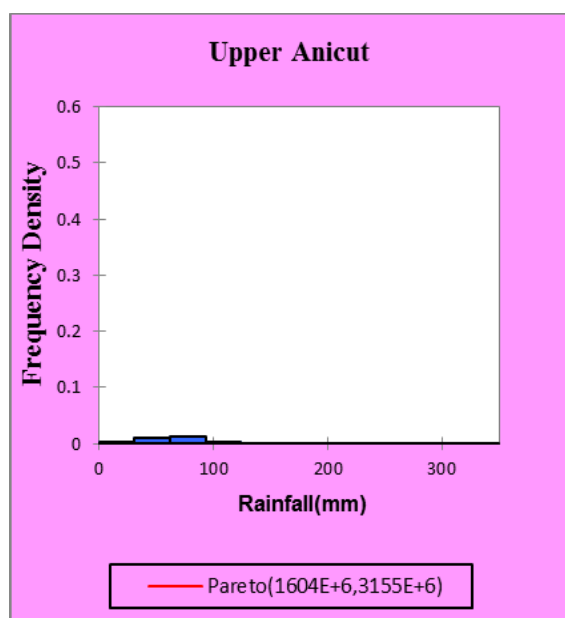
Distribution for Upper Anicut station
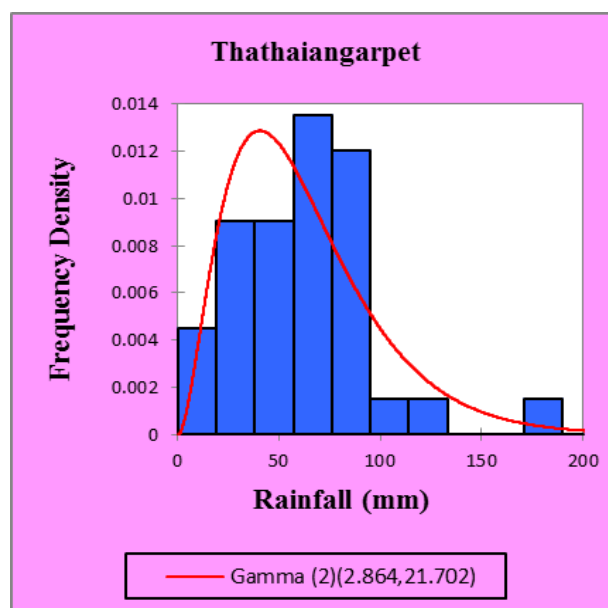
Distribution for Thathaiangarpet station

Thuraiyur

It was observed that the distributions viz., Gamma (2P), GEV, Log- normal and Weibull (2P, 3P) fitted well for September month. Log-normal distribution had the lowest test statistic value and the highest p-value, among these six best fitted distributions. This distribution was found to be shape-dominated which indicated that there was large variation in the distribution of rainfall.
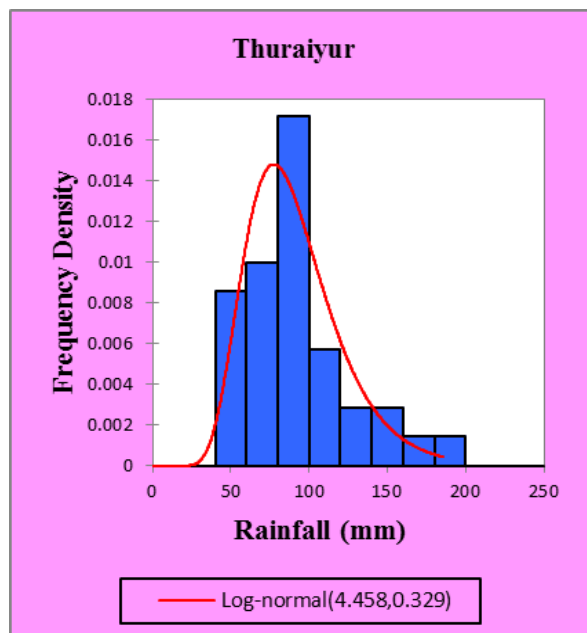
Lalgudi

For Lalgudi station, Gamma (2P) and Weibull (2P, 3P) distributions fitted well among which the Gamma (2P) distribution had the Lowest test statistic value and the highest p-value and it was dominated by the scale parameter which showed large variation in the distribution of rainfall.
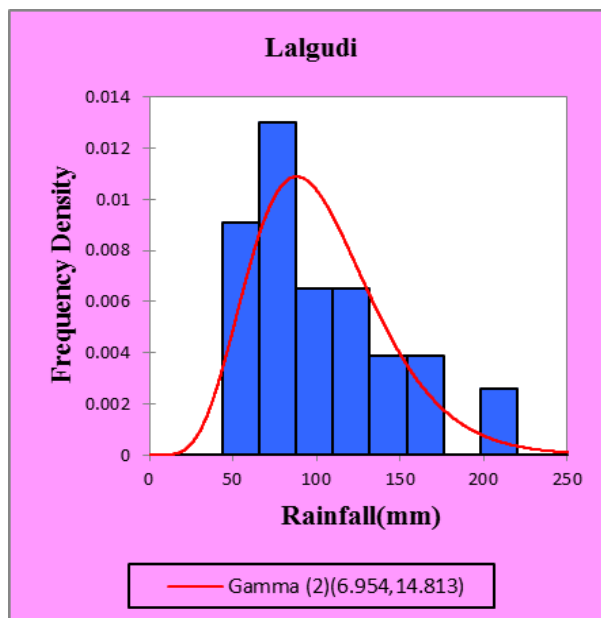
Nandhiya Head

The distributions which fitted well for Nandhiyar Head rain gauge station were Gamma (2P), Log-normal and Weibull (2P). Among these distributions, Log- normal had the lowest test statistic value and the highest p-value. Log-normal distribution was shape dominated; there was not much variation in the distribution of rainfall.
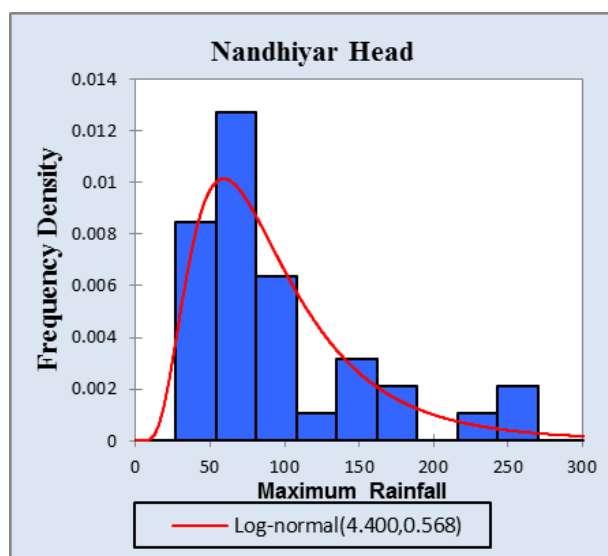
Pullambadi

For Pullambadi rain gauge station, Gamma (2P), Log- normal and Weibull (2P,3P) distributions were found to be the best fits. Log- normal was observed to have the lowest test statistic value and the highest p-value and it showed not much large variation in the distribution of rainfall since it was shape-dominated.
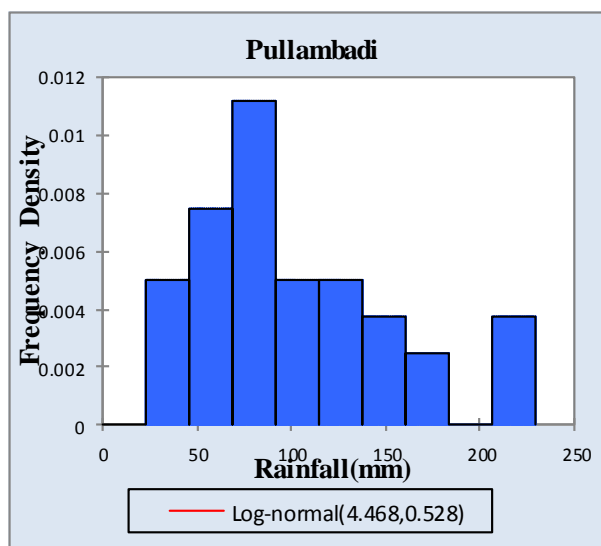
Distribution for Thuraiyur station

Distribution for Lalgudi station

Distribution for Nandhiyar Head station

Distribution for pullambadi station

Musiri

Gamma (2P), Log- normal and Weibull (2P) distributions were found to be the best fits for the musiri station. Among the two best fitted distributions, Log- normal distribution had the lowest test statistic value and the highest p-value. Since this distribution was shape-dominated, there was not much large variation in the distribution of rainfall.

Samayapuram

For Samayapuram rain gauge station, Gamma (2P), Log- normal and Weibull (2P,3P) distributions were found to be the best fits. Log- normal was observed to have the lowest test statistic value and the highest p-value and it showed not much large variation in the distribution of rainfall since it was shape-dominated.
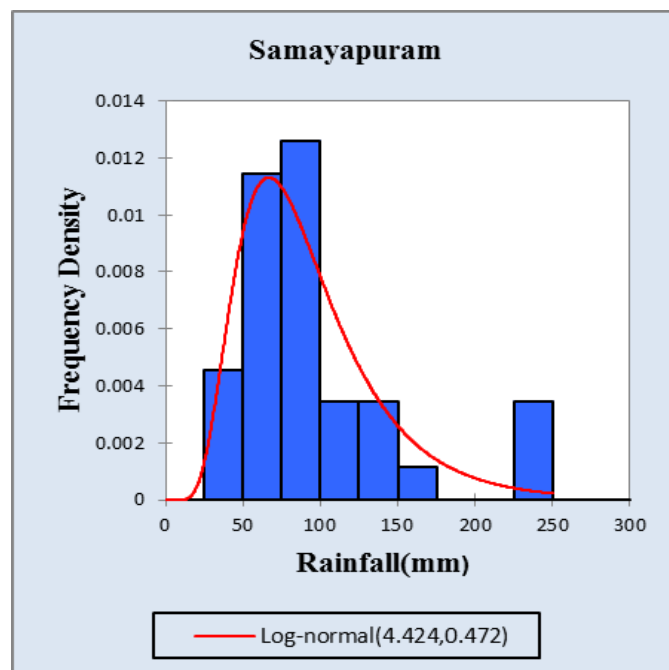
Ponnaiyar Dam

The distributions which fitted well for ponnaiyar Dam rain gauge station were Gamma (2P), Log- normal and Weibull (2P). Among these distributions, Log- normal had the lowest test statistic value and the highest p-value. Log- normal distribution was shape dominated; there was not much variation in the distribution of rainfall.
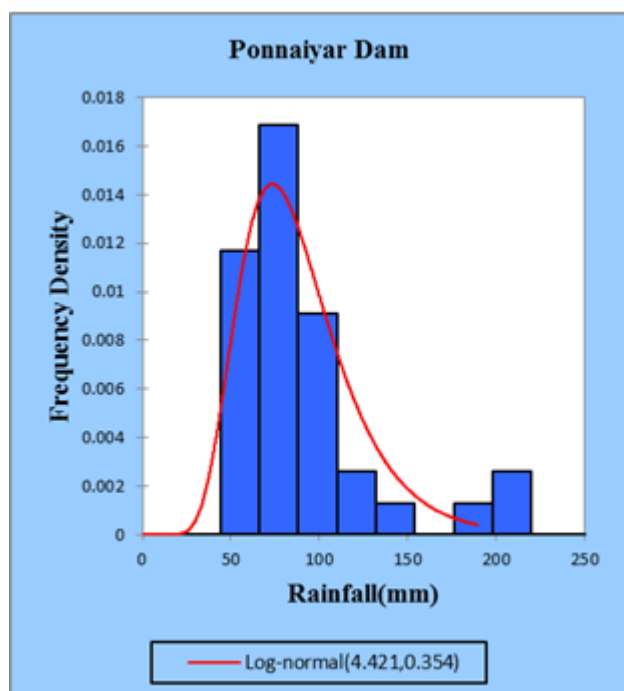
Manaparai station

Gamma (2P), GEV, Log- normal, and Weibull (2P, 3P) distributions were found to be the best fits for the manaparai station. Among these distributions, Log- normal distribution had the lowest test statistic value and the highest p-value. Since this distribution was shape-dominated, there was not much large variation in the distribution of rainfall.
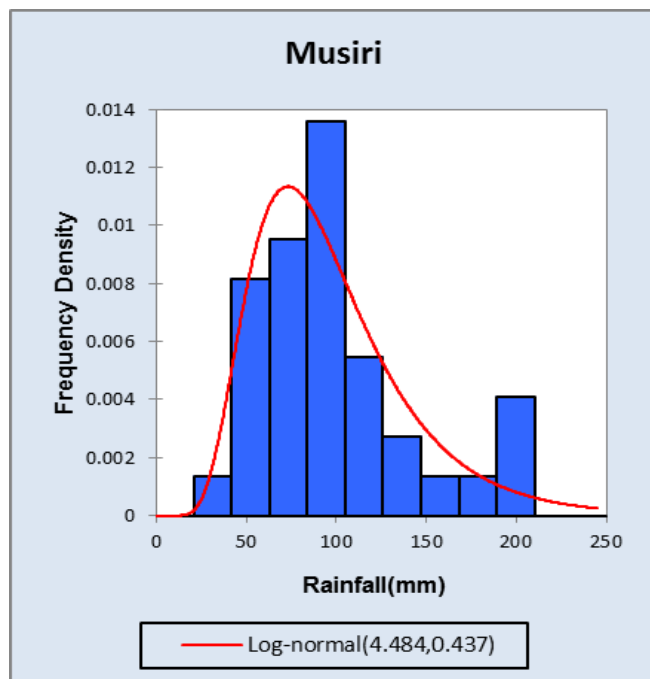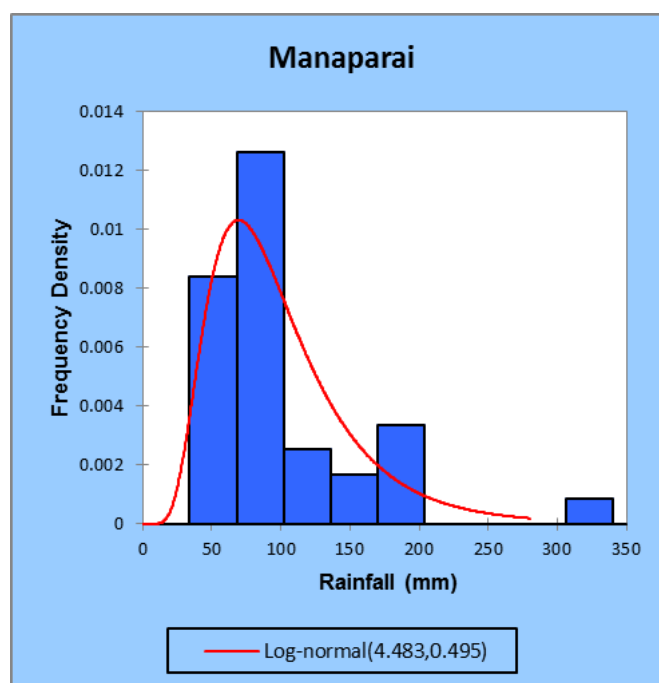

Distribution for Musiri station

Distribution for Samayapuram station

Distribution for Ponnaiyar dam station

Distribution for Manaparai station

Kovilpatti

For kovilpatti rain gauge station, Gamma (2P), Pareto and Weibull (3P) distributions were found to be the best fits. Pareto distribution was found to have the lowest test statistic value and highest p-value. This distribution was scale-dominated which showed large variation in the distribution of rainfall.
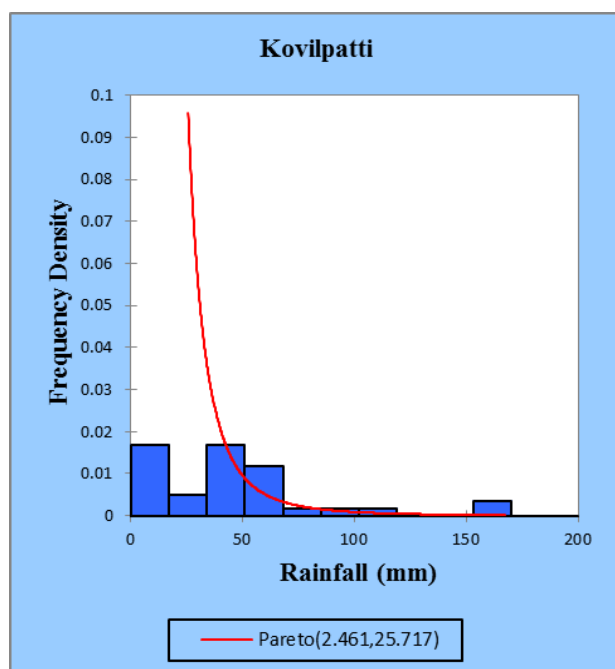
Chettikulam

The distributions which fitted well for this chettikulam rain gauge station were Pareto and Weibull (2P). Pareto distribution had the lowest test statistic value and the lowest p-value which was found to be shape-dominated.
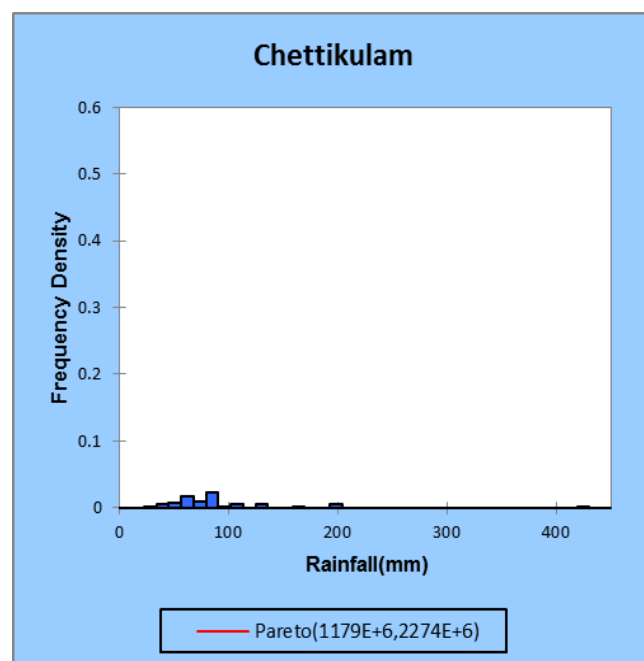
Kallakudi

Gamma (2P) and Pareto distributions were found to be the best fits for this station. Among the two best fitted distributions, Pareto distribution had the lowest test statistic value and the highest p-value. Since this distribution was found to be shape–dominated.
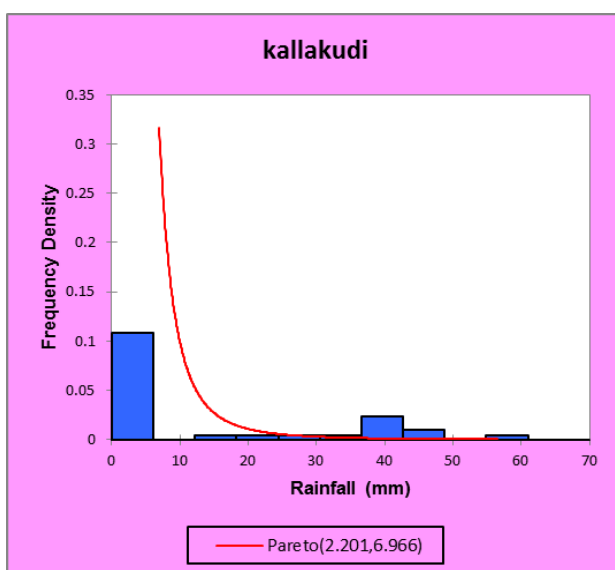
Kuttapattu

The distributions which fitted well for this station were GEV and Gamma (2P) where GEV distribution had the lowest test statistic value and the highest p-value. This distribution was found to be scale-dominated which showed large variation in the distribution of rainfall.
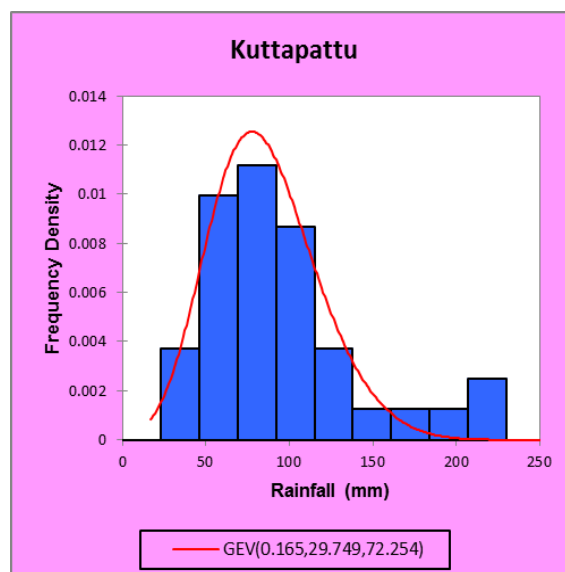

Distribution for Kovilpatti station

Distribution for chettikulam station

Distribution for Kallakudi station



Distribution for Kuttapattu station

Pongudi

Gamma (2P) and GEV distributions were found to be the best fits for this station. Among the two best fitted distributions, GEV had the lowest test statistic value and the highest p-value and it was found to be scale-dominated which showed large variation in the distribution of rainfall.

Siruganur

The distributions which fitted well for these stations were Log- normal and Gamma (2P) where log-normal distribution had the lowest test statistic value and the highest p-value. This distribution was found to be shape dominated which showed large variation in the distribution of rainfall.
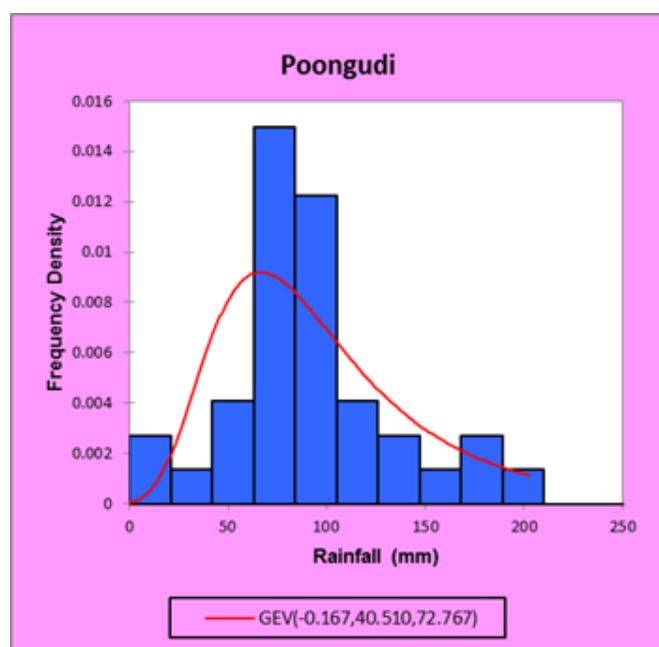
Distribution for Poongudi station
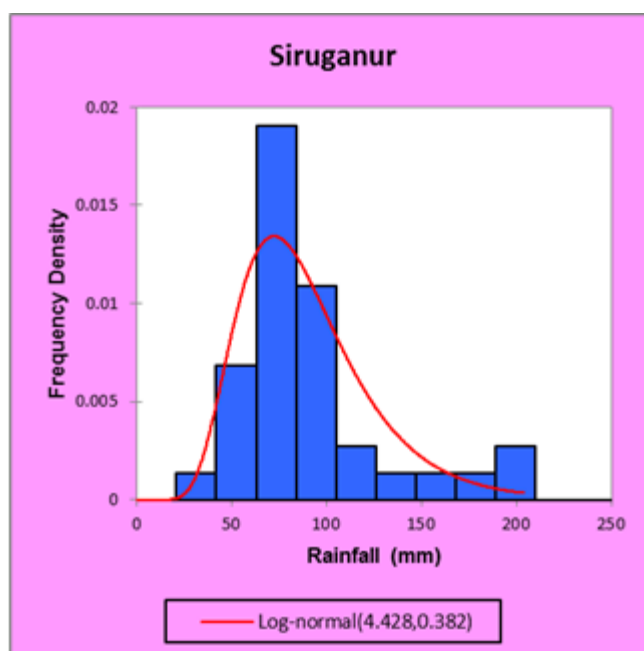
Distribution for Siruganur station

Conclusion

The above results showed that, the distributions such as Log-Normal, Gamma (1P,2P,3P), GEV, Weibull (1P,2P,3P), Gumbel and Pareto distributions fitted well. Gamma (2P) distribution fitted well for the following rain gauge stations, Trichy Airport, Trichy Junction, Thathaiangarpet and Lalgudi. For Majority of the rain gauge stations, Log-normal distribution was considered as the best fit with the lowest test statistics value and with highest p- value. Pareto was found to be best fit distributions for Upper Anicut, Kovil Patti, Chetti Kulam, Kallakudi stations.

The distribution provides a flexible representation of a variety of shapes. Majority of the study periods were shape-dominated which indicated that there is no large variation in the distribution of rainfall which means rainfall was consistent during the study period.

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