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Research Paper

Assessment of Probability Distribution of Rainfall of North East Region (NER) of India

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ABSTRACT : *Monthly rainfall data for 40 years (1971-2010) were collected from 27stations of NER. Four of the commonly used hydrological time series probability distribution were selected viz. Normal, Log Normal, Log Pearson Type III and Extreme Value Type I (Gumbel distribution) to find the best probability distribution of rainfall of NER India using Chi-square test. EasyFit software developed by Mathwave was employed for finding the goodness of fit. While assessing of all the event i.e. monthly and annual for each station, 124 event have been fitted with Extreme Value Type I occupying 35.33 % of the all the event which was also found to be dominating distribution of NER. It is followed by Log Pearson Type III, Log Normal and Normal with 85, 72 and 70 number of station occupying 24.23 %, 20.52% and 19.94 % respectively.*

Keywords *- Probability distribution, Chi-square test, EasyFit, North East India*

I. INTRODUCTION

North East Region (NER) of India received very high rainfall and also known for world most heaviest rainfall zone where Cherrapunji-Mawsynram lies in it, which is also one of the wettest places on earth. The rich in water resources potential makes tremendous opportunity to explore different water resource development programmes and projects. Rainfall is one of the main basic source of all the available water resources. The characteristics of rainfall are its amount, frequency and intensity, the values of which vary from place to place, day to day, month to month and year to year. Precise knowledge of these three main characteristics is essential for planning its full utilization (Dastane, 1978). The general impacts of climate change on water resources have been brought out by the Third Assessment report of the Intergovernmental Panel on Climate. It indicates an intensification of the global hydrological cycle affecting both ground and surface water availability. Changes in the amount, frequency, and intensity of precipitation have also been predicted. Such changes when on the surplus side may affect the magnitude and timing of runoff but shall create drought-like situations when these are on the deficit side, (Dhar, 2010). One of the important problem in hydrology deals with the interpreting past records of hydrological event for future probabilities of occurrence (Singh *et al.* 2012). The selection of an appropriate model depends mainly on the characteristics of available rainfall data at the particular site (Tao *et al.* (2002). Therefore, this study was aimed to determine the best fit probability distribution or model for the monthly and annual rainfall data in 27 station stations of NER India.

Some significant contribution in the field of probability distribution for different hydrological parameter, best fit and use of EasyFit software etc. are presented here. Ogunlela (2001) studied the stochastic analysis of rainfall event in Ilorin, Nigeria, using five probability distribution namely the Normal, Log Normal, Log Pearson Type III, Exponential and Extreme value Type I distributions and found that, Log Pearson Type III distribution best suited the maximum daily rainfall data while the Normal distribution best described the maximum monthly rainfall. Lee (2005) showed that Log Pearson Type III distribution perform the best in probability distribution of rainfall distribution characteristic of China-Nan plain. Bhakar *et al*. (2006) employed Chi-square test for studied the frequency analysis of consecutive day's maximum rainfall using Normal, Log Normal and Gamma distributions. Kwaku and Duke (2007) also used Chi-square test to determine the best fit probability distribution for three commonly used distribution i.e. Normal, Log Normal and Gamma distribution and found that Log Normal distribution was the best fit probability distribution for one day annual maximum as well as two to five consecutive days maximum rainfall for the region. Hanson *et al.* (2008) indicated that Pearson Type III distribution fits the full record of daily precipitation data. Olifintoye *et al.* (2009) performed the best fit probability distribution model for peak daily rainfall of selected cities of Nigeria, by using Gumbel,

Log Gumbel, Normal, Log Normal, Pearson and Log Pearson distributions which showed that the Log Pearson Type III distribution performed the best by occupying 50% of the total station number. Sharma and Singh (2010) studied the daily rainfall data of 37 years for GB Pant University of Agriculture and Technology, Pantnagar, India, to identify the best fit probability distribution for each period. The Log Normal and Gamma distribution were found as the best fit probability distribution for the annual and monsoon season period of study, respectively. Generalized extreme value distribution was observed in most of the weekly period as best fit probability distribution. Singh *et al.* (2012) analyzed the annual one day maximum rainfall of Jhalarapatan area of Rajasthan, India using four well known probability distribution functions viz. Normal, Log Normal, Log Pearson Type III and Gumbel and goodness of fit was determined by Chi-square test. The results showed that the Log Pearson Type III distribution was the best fit probability distribution to forecast annual one day maximum rainfall for different return periods. Mehrannia and Pakgohar, (2014) showed the advantage of using software to fit the data and interpreting probability data is that they are able to automatically fit data with a variety of known distribution patterns simultaneously. These methods are preferred especially in cases there is little or no information about the base distribution pattern in data, and desire to find the best distribution type. EasyFit is a data analyzer and simulation software which allows us to fit probabilistic distributions to given data samples, simulate them, choose the best fitting sample, and implement the results of analysis to take better decisions.

II. MATERIAL AND METHODS

2.1 Study Area

The north east region (NER) of India comprises of the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura (Fig. 1). The region stretches between 21° 50' and 9° 34' N latitudes and 85° 34' and 97° 50' E longitudes. The varied physiological features and altitudinal differences give rise to varied types of climate ranging from near tropical to temperate and alpine. The annual rainfall in the region is mainly contributed by south-west monsoon from middle of May to October. On an average, the NER receives about 2450 mm of annual rainfall whereas the Cherrapunji-Mawsynram range receives rainfall as high as 11,500 mm annually (Das *et al.* 2009).

2.2 Meteorological Data

Monthly rainfall data for 40 years (1971-2010) were collected from India Meteorological Department (IMD), State Govt. departments and Central Govt. organizations. The meteorological parameter were collected from 27 stations of NER of India. Table .1 shows the list of meteorological station under study. The data were

Fig. 1 Map of NER India with the location of meteorological stations.

arranged on monthly and yearly basis. The best fit for Probability distribution for various meteorological i.e. hydrological parameters were performed for normal months of each station and normal annual for each station.

2.3 Methododology

2.3.1 Probability Distributions

Four commonly used hydrological time series probability distribution were selected viz. Normal, Log Normal, Log Pearson type III and Extreme value type I (Gumbel distribution). (Singh *et al.* 2012, Ogunlela (2001))

2.3.2 Best Probability Distribution

Chi-square test is one of the most commonly used test to identified the best probability distribution model. The chi-square test statistics is calculated by the equation given below:

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

Where, O_i is the observed rainfall and E_i is the expected rainfall and will have chi-square distribution with (N - k -1) degree of freedom (d.f.), (Singh *et al.* 2012)

Table 1. List of meteorological stations of NER India under study.

Sl.No	Station Name	State	Elevation (m)	Latitude (N) in degree decimal	Longitude (E) in degree decimal
1	Aalo	Arunachal	266	28.1667	94.8000
2	Agartala	Tripura	20	23.883	91.25
3	Barapani	Meghalaya	893	25.7000	91.9667
4	Basar	Arunachal	578	27.9667	94.6833
5	Chaparmukh	Assam	66	26.2000	92.5167
6	Cherrapunji	Meghalaya	1313	25.2500	91.7333
7	Dhubri	Assam	35	26.0167	89.9833
8	Dibrugarh	Assam	268	27.4830	95.0170
9	Dimapur	Nagaland	295	25.8333	93.7500
10	Guwahati	Assam	54	26.1000	91.5833
11	Imphal	Manipur	781	24.7667	93.9000
12	Itanagar	Arunachal	440	27.0013	93.0667
13	Jorhat	Assam	99	26.7333	94.1667
14	Kailashshahar	Tripura	30	24.3170	92.0000
15	Kohima	Nagaland	1390	25.6333	94.1667
16	Kumbhigram	Assam	81	24.9000	92.9667
17	Lengpui	Mizoram	432	23.8333	92.6167
18	Likabali	Arunachal	115	27.6000	94.7167
19	Mohanbari	Assam	111	27.4833	95.0167
20	North Lakhimpur	Assam	99	27.2333	94.1167
21	Passighat	Arunachal	153	28.1000	95.3833
22	Seppa	Arunachal	363	27.3167	93.0000
23	Shillong	Meghalaya	1598	25.5667	91.8833
24	Silchar	Assam	107	24.8167	92.8000
25	Tezpur	Assam	79	26.6500	92.7833
26	Tura	Meghalaya	370	25.5167	90.2300
27	Ziro	Arunachal	1688	27.3167	93.8000

2.3.2 Easyfit Software For Distribution Fitting.

EasyFit is a data analyzer and simulation software which allows us to fit probabilistic distributions to given data samples, simulate them, choose the best fitting sample, and implement the results of analysis to take better decisions. This software can be used as a Windows compatible program, and also as an add-on to Excel spread sheets. (Mehrannia and Pakgohar, 2014). EasyFit trial version 5.5 was used to find the best fit using Chi-square test.

III. RESULT AND DISCUSSION

3.1 Best Fit Probability Distribution Of Rainfall For NER India.

In this study four commonly used probability distribution in hydrology were chosen viz. Normal , Log Normal, Extreme Value Type-I (Gumbel) and Log Pearson Type III. The best fit was determined by using chi square method. EasyFit software was employed for best fit. **Table 2** show the fitted distribution for different station under study for different months.

While assessing station wise, at Aalo, Log Pearson Type III is dominating in four of the month i.e. February, June, September and December out of 12 months, Normal and Extreme Value Type I (Gumbel) in three month each whereas Log Normal were found in two of the months. Similarly, in Agartala, Log Normal distribution is

Table 2. Best fit probability distribution of rainfall for different stations of NER India.

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Yearly
Aalo	EVI	LP3	NR	NR	EVI	LP3	LN	NR	LP3	EVI	LN	LP3	LN
Agartala	EVI	LN	EVI	LP3	LP3	LN	LN	LP3	LN	LN	EVI	EVI	NR
Barapani	EVI	EVI	EVI	LN	EVI	NR	EVI	LN	NR	NR	LN	EVI	LP3
Basar	EVI	LP3	NR	LP3	NR	EVI	NR	LN	LP3	EVI	LN	LP3	EVI
Chaparmukh	EVI	NR	EVI	LN	NR	NR	LN	LP3	LN	NR	EVI	EVI	LN
Cherrapunji	EVI	EVI	LN	EVI	LN	NR	LN	LN	LP3	EVI	LN	EVI	LP3
Dibrugargh	LN	LN	LP3	EVI	LP3	LP3	NR	LP3	LP3	EVI	EVI	NR	EVI
Dimapur	EVI	LP3	LP3	LN	LP3	LP3	LP3	LP3	EVI	NR	NR	EVI	NR
Dhubri	EVI	EVI	LN	LN	LN	LP3	LP3	NR	LP3	EVI	EVI	EVI	EVI
Guwahati	EVI	EVI	LP3	EVI	LP3	NR	EVI	LP3	LP3	LP3	EVI	EVI	NR
Imphal	EVI	LN	LN	LN	EVI	NR	LP3	EVI	LN	LP3	LN	EVI	LP3
Itanagar	LP3	LN	EVI	NR	EVI	LP3	LN	EVI	EVI	LP3	LN	EVI	NR
Jorhat	EVI	LN	LP3	LP3	LP3	NR	LN	EVI	LN	EVI	NR	EVI	NR
Kailashshahar	EVI	EVI	EVI	LP3	LN	LN	LN	LN	EVI	LN	LN	EVI	NR
Kohima	EVI	LN	EVI	EVI	EVI	LP3	EVI	LN	EVI	NR	EVI	EVI	EVI
Kumbhigram	EVI	EVI	EVI	NR	EVI	EVI	LN	LP3	LN	LN	EVI	EVI	EVI
Lengpui	EVI	EVI	EVI	NR	NR	NR	LP3	LP3	LP3	LP3	EVI	EVI	NR
Likabali	LN	LP3	LP3	LP3	NR	EVI	LP3	LN	LP3	EVI	NR	EVI	LN
Mohanbari	NR	NR	LN	LP3	EVI	LP3	LP3	NR	LN	LN	EVI	LP3	LP3
North Lakhimpur	NR	EVI	LP3	NR	EVI	LN	NR	LN	LN	LP3	LN	EVI	LP3
Passighat	EVI	EVI	LP3	NR	LP3	LN	EVI	EVI	NR	LP3	LN	EVI	EVI
Seppa	LN	EVI	LN	LP3	NR	LP3	EVI	NR	LP3	LP3	LN	NR	EVI
Shillong	EVI	EVI	EVI	LP3	LP3	LN	NR	EVI	NR	EVI	LN	EVI	NR
Silchar	EVI	EVI	EVI	EVI	EVI	NR	NR	NR	NR	NR	LN	EVI	LN
Tezpur	NR	LN	EVI	EVI	EVI	EVI	NR	LP3	NR	LP3	EVI	EVI	EVI
Tura	NR	LN	LN	LP3	NR	NR	LP3	NR	NR	NR	EVI	EVI	NR
Ziro	EVI	LP3	LP3	LP3	LP3	NR	NR	LP3	LP3	LP3	LP3	LP3	NR

EVI- Extreme value Type-I (Gumbel) distribution.
NR – Normal Distribution
LN – Log Normal Distribution
LP3 – Log Pearson Type-III distribution

fitted and dominating with five of the months i.e. February, June, July, September and October, four month with Extreme Value Type I (Gumbel) and three month each with Log Pearson III and Log Normal distributions. Extreme Value Type I (Gumbel) was best fitted in six of the months i.e. January, February, March, May, July December and witness most dominating distribution as whole at Barapani, whereas, Normal and Log normal was found to be best fit in three of the months each. Log Pearson III was found to be best fit in four of the months i.e. February, April, September and December and was dominating distribution at Basar, whereas, three months are found fitting with Normal and Extreme Value Type I (Gumbel) but two month are shown with Log Normal. In Chaparmukh station, Normal and Extreme Value Type I (Gumbel) distribution was found to be the best probability distribution in four of the months each and Log normal was found to be best in three months whereas only one month fitted with Log Pearson Type III distribution. In Cherrapunji station, five month each were found to be fitted with Extreme Value Type I (Gumbel) and Log normal whereas only one month each was fitted with Normal and Log Pearson III distributions.

In Dibrugargh, five of the months were found to be best fitted with Log Pearson Type III distribution whereas three station with Extreme Value Type I (Gumbel) and two stations each with Normal and Log normal distributions. In Dimapur, Log Pearson III was found to be best fitted in six of the months which was most dominating distribution, whereas, three months with Extreme Value Type I (Gumbel), two months with Normal and one month with Log Normal were also seen. In Dhubri station, Extreme Value Type I (Gumbel) was found

to be best probability distribution in five of the months whereas, three month each were found fitted with Log Pearson Type III and Log Normal respectively. Only one month was fitted with normal distribution. In Guwahati station, Extreme Value Type I (Gumbel) was found to be best probability distribution in six of the months. Whereas, Log Pearson Type III was found to be fitted in five of the months and one month with Normal distribution. In Imphal station, Log Normal was found to be best fitted in five of the months whereas, Extreme Value Type I (Gumbel) in four of the months, two month with Log Pearson Type III and only one month with Normal distributions. In Itanagar station, Extreme Value Type I (Gumbel) was found to be best probability distribution in five of the months whereas three month each were found fitted with Log Pearson Type III and Log Normal distribution respectively but only one month was fitted with Normal distribution. In Jorhat station, four of the months were found to be best fitted with Extreme Value Type I (Gumbel) distribution whereas, three month each were found fitted with Log Pearson Type III and Log Normal respectively and two month with Normal distribution.

In Kailashshahar station, six month was found to be fitted with Log normal distribution whereas Extreme Value Type I (Gumbel) was found to be best fit in five of the months and only one month with Log Pearson Type III. In Kohima station**,** Extreme Value Type I (Gumbel) was found to be best probability distribution in eight of the months whereas, Log normal was found to be best fit in two months and one month each were seen fitted with Log Pearson Type III and Normal distributions. In Kumbhigram station, Extreme Value Type I (Gumbel)was found to be best probability distribution in seven of the months whereas, Log Normal was fitted in two months and one month each were seen fitted with Normal and Log Pearson Type -III distributions. In Lengpui station**,** five of the months i.e. January, February, March, November and December were found to be best fitted with Extreme Value Type I (Gumbel) distribution, whereas, Log Pearson Type III was found to be fitted in four of the months and Normal distribution in three of the months. In Likabali station, five of the months were best fitted with Log Pearson Type III distribution whereas, Extreme Value Type I (Gumbel)was found to be fitted in three of the months and two month each were seen fitted with Normal and Log Normal distributions. In Mohanbari station**,** Log Pearson Type III was found to be best suitable probability distribution in four of the months whereas, three month each have been fitted with Normal and Log normal distributions and Extreme Value Type I (Gumbel)was found to be best fit in two of the months.

In North Lakhimpur station, Log normal was found to be best fit in four of the months whereas, three months each were seen fitted with Normal and Extreme Value Type I (Gumbel) distributions and two of the months were found to be best fitted with Log Pearson Type III distribution In Passighat station, five of the months were found to be fitted with Extreme Value Type I (Gumbel) distribution whereas, Log Pearson Type III was found to be best suitable probability distribution in three of the months and two month each were seen fitted with Normal and Log Normal distributions. two of the months were found to be fitted with Extreme Value Type I (Gumbel) distribution. In Shillong station, Six of the months i.e. January, February, March, August, October and December were found to be best fitted with Extreme Value Type I (Gumbel), whereas, other distributions were found fitted in two months each. In Silchar station, Extreme Value Type I (Gumbel) was found to be best probability distribution in six of the months whereas, five of the stations were found to be best fitted with Normal distribution. and Log normal was found to be fitted in one month only. In Tezpur station, Extreme Value Type I (Gumbel) was found to be best probability distribution in six of the months whereas, three months were found to be best fitted with Normal distribution, two months with Log Pearson Type III and one month with Log Normal distributions. In Tura station**,** Normal distribution was found to be the best probability distribution in six of the month whereas two months each were found to be fitted with Extreme Value Type I (Gumbel), Log Normal and Log Pearson Type III distributions. At Ziro station, nine of the Stations were found to be the best fitted with Log Pearson Type III, whereas, normal distribution was fitted in two of the months and one month was seen fitted with Extreme Value Type I (Gumbel).

While assessing of all the event i.e. monthly and annual for each station, 124 event have been fitted with Extreme Value Type I occupying 35.33 % of the all the event which was also found to be dominating distribution of NER.. It is followed by Log Pearson Type III, Log Normal and Normal with 85, 72 and 70 number of station occupying 24.23 %, 20.52% and 19.94 % respectively

While assessing on monthly basis, out of the 27 stations under study, Extreme Value Type I was found to be fitted and dominating in the month of January, February, March, May, November and December with 19, 12, 11, 10, 11 and 21 number of stations respectively, whereas, in the month of April, June, July, August, September and October,6, 4, 5,5, 4 and 8 number of station are found to be best fitted with Extreme Value Type I. Normal distribution was found to be dominating only in the month of June with 10 number of stations. Normal distribution are also seen fitting in 4, 2, 2, 6, 6, 7, 6, 6, 6, 3 and 2 number of stations in the month of January, February, March, April, May, July, August, September, October, November and December respectively. Log Normal distribution was found dominating in the month of July and November with 8 and 12 number of stations respectively, whereas, in 3, 8, 6, 5, 3, 5, 7, 7, 4 number of stations were also found to be fitted with Log Normal distribution in the month of January, February, March, April, May, June, August, September, October and October. However, none of the station was seen fitted with Log Normal in the month of December. Log Pearson Type III distribution was found to be dominating in the month of April, August, September and October with 10, 9, 10 and 9 numbers of stations respectively, whereas, in the month of January, February, March, May, June, July, November and December were also found to be fitted with Log Pearson Type III in 1, 5, 8, 8, 8, 7, 1 and 4 number of stations respective. While assessing for annual, Normal distribution was found to be dominating with 10 number of stations followed by Extreme Value Type I with 8 numbers of stations, Log Pearson Type III with 5 number of stations and Log Normal with 4 number of station respectively.

It was also observed that the particular probability distribution was not in absolute dominating the other and different probability distribution have mixed result at different location and time..

IV. CONCLUSION

While assessing of all the event i.e. monthly and annual for each station, 124 event have been fitted with Extreme Value Type I occupying 35.33 % of the all the event which was also found to be dominating distribution of NER.. It is followed by Log Pearson Type III, Log Normal and Normal with 85, 72 and 70 number of station occupying 24.23 %, 20.52% and 19.94 % respectively. Different probability distribution have mixed result at different location and time.

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