Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.5, No.11, 2015

Study On Rainfall Probability Analysis At Allahabad District Of Uttar Pradesh

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ABSTRACT

The present investigation included rainfall probability analysis of previous 34 years rainfall data (1980-2013) with the prime objective for prediction of annual rainfall of Allahabad district. The observed values were computed by weibulls formula (1939). The annual rainfall values were estimated by proposed prediction models Viz. Gumbel and Log Normal (Chow 1964). The rainfall data in the above distribution and their corresponding rainfall events were estimated at 2.9, 11.4, 20.0, 40.0, 51.4, 60.0, 80.0 and 97.1 percent probabilities level. The goodness of fit was tested by Chi-square test. It clearly indicates that the Gumbel distribution was found to be best model for predicting the annual rainfall (mm). While Log Normal distribution is fairly close to the observed annual rainfall (mm).

Keywords: Probability analysis, rainfall variability, rainfall, prediction, distribution.

INTRODUCTION

Rainfall is one of the important hydrological events, which plays an important role in many of the agricultural and non-agricultural operations. The average rainfall of our country is 1190 mm per annum; it ranges from 350 to 2,000 mm. Most part of our country receives 80 percent of the total annual rainfall during four months June to September of a year (**Bara and Lal, 2008**). Rainfall is the unique phenomenon varying both in space and time, the rainfall distribution is very uneven and it not only varied considerably from place to place but also fluctuates from year to year. The rainfall is an important and governing factor in the planning and operation strategies of any agricultural programme for any given area. As such, proper and specific information about the rainfall distribution pattern over a period for a particular place is quintessential for proper and optimal planning of requisite irrigation system and cropping pattern. The major share of conjunctive water-need of the country during entire calendar year is met by the rainfall, which occurs in the monsoon period. There is large variation in distribution of rainfall from year to year. In our country swallowing floods and thirstily droughts are the results of spectacular extremities of the rainfall distribution (**Asati S.R. 2012**).

Analysis of rainfall and determination of annual maximum daily rainfall would enhance the management of water resources applications as well as the effective utilization of water resources (**Subudhi, 2007**). Probability and frequency analysis of rainfall data enables us to determine the expected rainfall at various chances (**Bhakar *et al.*, 2008**). Such information

can also be used to prevent floods and droughts, and applied to planning and designing of water resources related to engineering such as reservoir design, flood control work and soil and water conservation planning.

MATERIAL AND METHODS

Study Area and Collection of Data

The study area Allahabad is located in the southern part of the state at 25°27′N 81°50′E/ 25.45°N 81.84°E and stands at the confluence of the Ganga and Yamuna rivers.

The rainfall data (1980-2013) was collected from IMD (Indian meteorological department, New Delhi) and Meteorological station of SHIATS, Allahabad. Present study was focused on variation of rainfall data for last three decades and a transformed distribution Log Normal distribution and an extreme distribution Gumbel distribution were used for probability analysis and prediction of annual maximum rainfall of Allahabad.

Statistical Analysis of Data

The mean, standard deviation, coefficient of variation and coefficient of skewness which describe the variability of rainfall were computed.
The mean rainfall was computed by the following formula:

$$\overline{X} = \frac{\Sigma x}{N}$$

Where, = mean, Σx = Sum of rainfall, N = total number of observations.
The standards deviation (σ_n) which measures the variability of rainfall was estimated by the following formula:

$$\sigma_n = \frac{\sum (X - X)^2}{N - 1}$$

The Coefficient of Variation (C_V) was calculated by the following formula:

$$C_V = \sigma_n / X$$

The Coefficient of skewness (C_S) was calculated by the following formula:

$$C_S = N \Sigma (Z - \overline{Z})^3 / (N- 1) (N - 2) (\sigma_n)$$

Where,

Z = Log value of rainfall data.

$\overline{Z}$ = Mean value of the rainfall data.

N = Sample size.

σ_n= Standard deviation.

Annual maximum rainfall data were fitted to various probability distribution functions.

Frequency Analysis using Frequency Factors

Gumbel Distribution

$X_T = X + K \times \sigma_n$

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

Where, X_T = Predicted rainfall amount for return period of T years, K = Frequency factor of Gumbel distribution.

Log Normal distribution

$X_T = X + K \times {}_n$

Predicted rainfall were calculated as

X_T = antilog (X_T)

Testing the Goodness of Fit

The Chi-square test (Hogg and Tanis 1977) is generally used to test the closeness of the expected values obtained by the fitted theoretical distribution and the observed values for return period T, it is calculated as

$$X^2 = \Sigma \frac{(O - E)^2}{E}$$

Where,

O = Observed values for the return period.

E = Expected valus for the return period.

The least sum of the Chi-square values gave the best fit (Agarwal et al1988).

RESULTS AND DISCUSSION

The predictions of annual maximum rainfall of 34 years were estimated by two most widely used probability distribution method viz. Gumbel and Log Normal Distribution model (Chow 1964).

In lognormal distribution, the number of years of data used for the analysis was given as input and the annual maximum rainfall were arranged in descending order of magnitude. Corresponding to the recurrence interval, C_S and C_V values, the frequency factor values were entered from Chow's table. In Gumbel distribution, the numbers of years of data used were given as input and the annual maximum rainfall were arranged in descending order of

magnitude. Recurrence intervals were computed for Gumbel distribution as shown in table no.2.

The annual maximum rainfall was 1683 mm in the year 2008 and minimum of 493.6 mm in the year 2009 respectively was observed on analysis.

The predicted annual maximum rainfalls at different probabilities level are tabulated in table no.2 for Gumbel and lognormal distribution models. The observed rainfall data points closely lie around the predicted values when plotted in the graph (Fig no.2) for both probability distributions model except at the highest rainfall.

The statistical parameter i.e. Chi-square test for goodness of fit was conducted for all proposed models. The least value of the Chi-square (X^2) value is taken as the best (Bhatt, l996, Aggrawal et al., 1988). The rainfall data were estimated at 2.9, 11.4, 20.0, 40.0, 51.4, 60.0, 80.0 and 97.1percent probabilities levels. The result of annual maximum rainfall is tabulated in table no. 2. It shows that the sum of Chi-square value for Gumbel and Log normal distributions comes out to be is 400.2 mm and 775.2 mm respectively (Table no.3). Since the Gumbel distribution has the smallest value of Chi-square as compared to Log normal distribution. So the Gumbel distribution gave the best fit for annual rainfall data. Thus, it may be concluded that the Gumbel distribution was found to be the best model for predicting the annual maximum rainfall of Allahabad region, which reveals the overall accuracy of the model for predicting rainfall. The graphical representation also shows that the Gumbel distribution is predicting the rainfall very near to the observed rainfall (Fig no.2).

Any predicted value is not an exact representation but only a description of natural process which approximates the underlying phenomena and has proved useful in describing the observed historical data.

Table 2: Annual maximum rainfalls at different return periods in years (1980-2013)

Probability (%)	Recurrence interval (T) in years	Observed rainfall in mm	Predicted rainfall in mm	
			Gumbel	Log Normal
2.9	35.0	1683	1279.5	1154.2
5.7	17.5	1606	1169.7	1132.5
8.6	11.7	1388.3	1062.7	1067.5
11.4	8.8	1276.5	1014.0	1031.8
14.3	7.0	1231.1	991.9	1016.8
17.1	5.8	1178.1	973.3	998.8
20.0	5.0	1124.7	958.8	980.2
22.9	4.4	1074.2	948.0	962.1
25.7	3.9	1017.2	939.0	941.0
28.6	3.5	995.6	935.5	932.9
31.4	3.2	993.6	934.2	932.1
34.3	2.9	987.2	932.8	929.7
37.1	2.7	971.3	931.4	923.6
40.0	2.5	966.7	930.7	921.8
42.9	2.3	960.7	930.1	919.5
45.7	2.2	946.9	929.8	914.1
48.6	2.1	910.1	929.5	899.5
51.4	1.9	895.4	928.8	893.6
54.3	1.8	840.2	925.8	914.4
57.1	1.8	829.3	924.1	919.3
60.0	1.7	818.5	922.1	924.2
62.9	1.6	798.6	919.1	933.4
65.7	1.5	798.1	917.5	933.7
68.6	1.5	794.7	915.6	935.3
71.4	1.4	781.3	912.3	941.8
74.3	1.3	757.1	907.3	953.9
77.1	1.3	746.8	903.6	959.2
80.0	1.3	706	894.7	981.3
82.9	1.2	701.4	890.8	983.9
85.7	1.2	653.9	878.4	1012.3
88.6	1.1	653.4	873.7	1012.6
91.4	1.1	520.6	838.8	1110.3
94.3	1.1	516.6	828.2	1113.8
97.1	1.0	493.6	807.9	1134.6

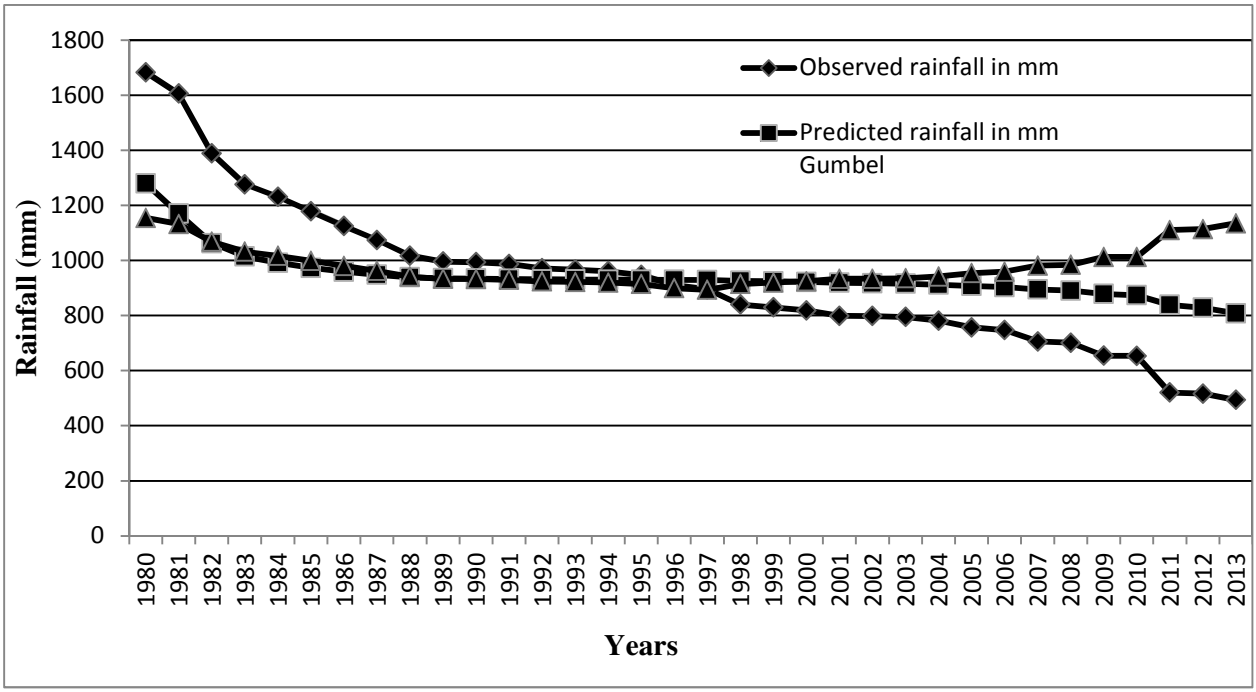

Fig 1: Comparison of observed and predicted annual rainfall from years (1980-2013)

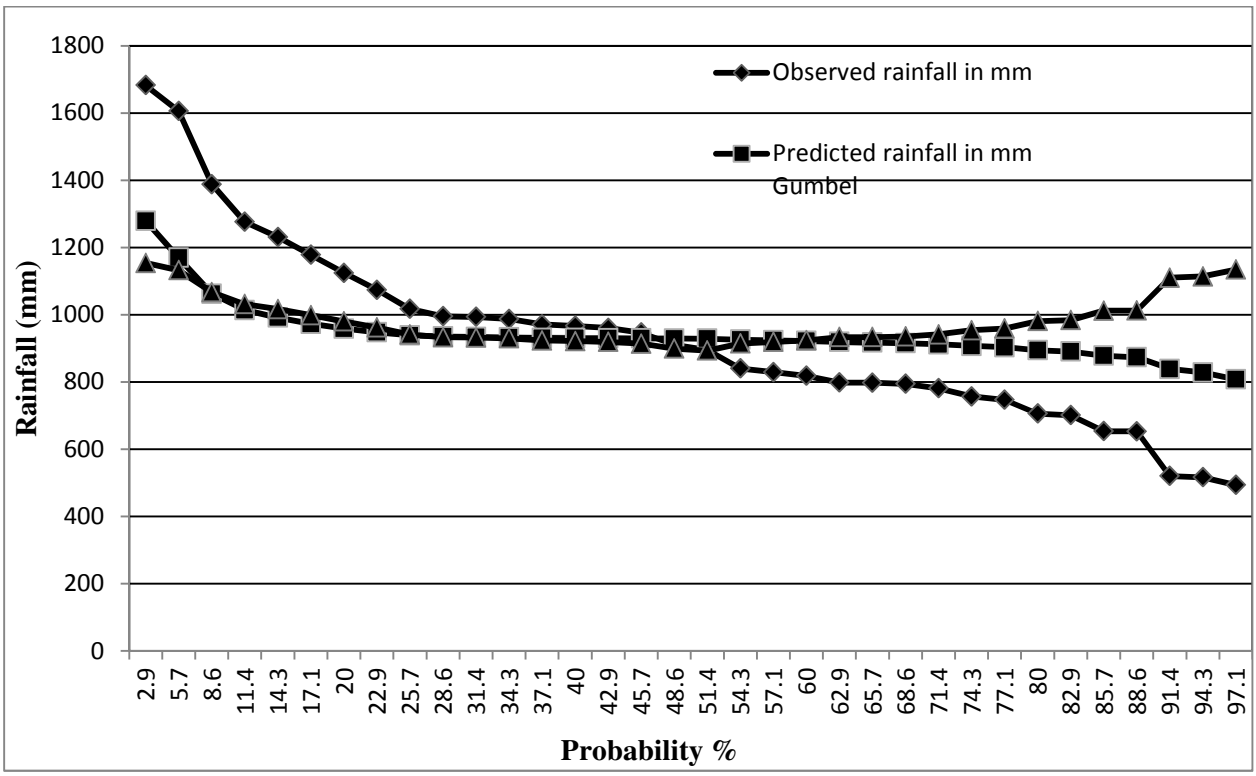

Fig 2: Comparison of observed and predicted rainfall at various distribution levels

Table 3: Chi-square test of goodness of fit for various distributions for annual rainfall in years (1980-2013)

P (%)	Return period (T)	Observed rainfall in mm (O)	Predicted rainfall in mm (E)		Chi- square $X^2 = \Sigma (O - E)^2/E$	
			GUMBEL	LOGNORMAL	GUMBEL	LOGNORMAL
2.9	35.0	1683	1279.5	1154.2	127.3	242.2
11.4	8.8	1276.5	1014.0	1031.8	67.9	58.0
20.0	5.0	1124.7	958.8	980.2	28.7	21.3
40.0	2.5	966.7	930.7	921.8	1.4	2.2
51.4	1.9	895.4	928.8	893.6	1.2	0.0
60.0	1.7	818.5	922.1	924.2	11.6	12.1
80.0	1.3	706	894.7	981.3	39.8	77.2
97.1	1.0	493.6	807.9	1134.6	122.3	362.1
			TOTAL		400.2	775.2

CONCLUSION

The present study concluded that the data of thirty four years (1980-2013) is sufficient to obtain annual maximum rainfall (mm) distribution of Allahabad region. The most suitable probability distribution function to represent the observed data may depend on rainfall pattern of the place. As rainfall pattern varies from place to place. The statistical comparison at 2.9, 11.4, 20.0, 40.0, 51.4, 60.0, 80.0 and 97.1percentage probabilities were done by Chi-square test (Hogg and Tannis, 1977) for goodness of fit. The predicted rainfalls are fairly close to the observed rainfall. It shows that the Gumbel distribution has the least value as compared to Log Normal distribution method. Therefore prediction by Gumbel distribution method was found to be best model for Allahabad region.

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