

## Probability Analysis of Annual Daily Maximum Rainfall at Ahmednagar Tahsil

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### Abstract

A detailed statistical analysis of annual daily maximum rainfall for Ahmednagar tahsil was carried out using 33 years (1982–2012) daily rainfall data, collected from State Data Storage Centre, Hydrology Project (Surface Water) Jal Vidnyan Bhavan, Nashik. For forecasting the annual rainfall Log Pearson type-III, Log-normal and Gumbel probability distribution functions were fitted. Calculated values were compared with tabular values at 5 percent level of significance. As the variation between actual rainfall values and predicted rainfall values is less in Log Pearson Type III distribution as compared to Log Normal and Gumbel distribution, the Log Pearson Type III distribution found the best suitable for probability analysis of annual daily maximum rainfall.

### Keywords

Gumbel probability distribution; Log Pearson Type III distribution; Rainfall; Hydrology.

post monsoon (September and October). During monsoon (June-September) rainfall varies between 77.9 mm and 690 mm (excluding extreme events) while the normal rainfall during monsoon for Ahmednagar is 423.26 mm.

Rainfall analysis for any region is essential in planning and design of irrigation and drainage systems and overall programme of command area development. Several applications in water resources engineering require appropriate estimate of rainfall depth and its return period from available historic data. Estimation of flood in watersheds, water balance studies, water management studies, rainwater harvesting, detention and retention pond design, evapotranspiration estimation, irrigation planning, etc. are some of the examples where rainfall provides a vital input to design and modeling. Planning and development of water resources at the local or regional level require comprehensive and reliable information of hydrological data of the area under investigation.

### Introduction

Ahmednagar is a Tahsil in Ahmednagar District of Maharashtra State, India. With average annual rainfall of 560.69 mm, mean minimum temperature 19.2°C and mean maximum temperature of 32.9°C. A secondary rise in temperature occurs

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Proper database is needed to assess the water availability of a region, the absence of which can lead to erroneous planning and design. Long period data can provide reliable water resource assessment. The degree of uncertainty increases if the data length is short.

Probability and frequency analysis of rainfall data enables us to determine the probability of drought, normal and surplus months and weeks. Saha and Mishra (2005) have suggested use of weekly and monthly rainfall to predict the occurrence of drought period for Meghalaya. Sharda and Bhushan (1985) analysed annual maximum daily total rainfall data for 22 years for Agra. The probability analysis was done using three probability distribution functions,

i.e. Gumbel distribution, Log Normal distribution and Log-Pearson Type-III distribution. It was concluded from the frequency distribution curves that the log-normal probability distribution gives the closest fit to the observed data.

### Materials and Methods

The required daily rainfall data of 31 years, of Nagar tehsil was obtained from the State Data Storage Centre, Hydrology Project (Surface Water) JalVidnyanBhavan, Nashik and downloaded from [www.maharain.gov.in](http://www.maharain.gov.in) for the period of 1982–2012. The study area, 1605.74 km<sup>2</sup>, is situated at 19.095°N latitude, 74.749°E longitude.

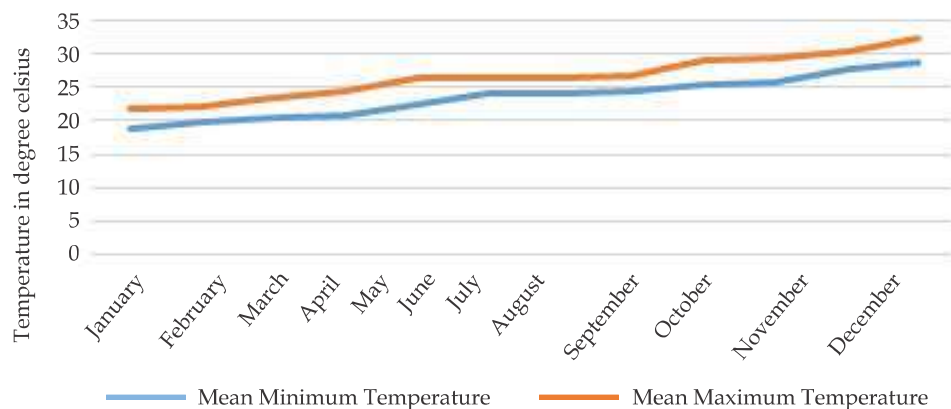


Fig. 1: Mean maximum and mean minimum temperature of Ahmednagar

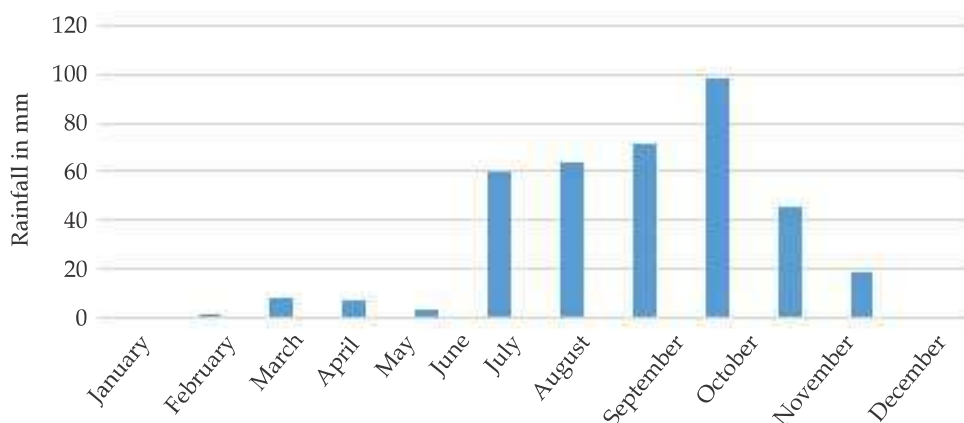


Fig. 2: Mean monthly rainfall distribution of Ahmednagar

### Theoretical Consideration of Probability Distributions

The theory of different probability distributions is given as under.

### Probability Distributions

One of the important problems in hydrology deals with interpreting a past record of rainfall events, in terms of future probabilities of occurrences.

There are many probability distributions that have been found to be useful for hydrologic frequency analysis. These can be summarized as below.

**(a) Log Pearson Type III distribution**

In general the basic equation to define the probability density of a Pearson distribution is

$$P(x) = \int_{-\infty}^{\infty} \frac{(a+x)}{b_0 + b_1x + b_2x^2} dx$$

**(b) Gumbel distributions**

This distribution results from any initial distribution of exponential type, which converts to an exponential function, as  $x$  increases. The examples of such initial distributions are normal, chi-square and log normal distributions. The probability density function of type I distribution is

$$P(x) = e^{-e^{-y}}$$

Where,

$$y = \frac{a + x}{c}$$

$$a = \gamma c - \bar{x}$$

$$c = \frac{\sqrt{6}}{\pi}$$

$$\gamma = 0.5772$$

**(c) Log normal distribution**

This is a transformed normal distribution in which the variable is replaced by its logarithmic value. Its probability density function

$$P(x) = \frac{1}{\sigma_y e^y \sqrt{2\pi}} e^{-\frac{(y/\mu_y)^2}{2\sigma_y^2}}$$

where,

- $y = \ln x;$
- $x = \text{a variable};$
- $\mu_y = \text{mean of } y; \text{ and}$
- $\sigma_y = \text{standard deviation of } y.$

This is a skewed distribution of unlimited range in both directions.

**Results and Discussion**

The daily rainfall data for Ahmednagar tahsil was analysed and annual daily maximum rainfall for Ahmednagar station was determined from 1982-2012. The most widely used probability distributions for extern events, viz. Log Pearson Type III, Log Normal and Gumbel were used.

**Log Pearson Type III distribution**

The data of rainfall were analysed and the parameters like mean, standard deviation and coefficient of skewness of transformed data were determined, which found to be 52.9747 and 0.2103 respectively. The frequency factor,  $K$ , values were determined for different probabilities corresponding to the value of coefficient of skewness. The theoretical values of annual maximum rainfall for different return periods are presented in Table 1

**Table. 1:** Theoretical values of annual daily maximum rainfall using Log Pearson Type III distribution for Ahmednagar station.

Sr. No.	Recurrence Interval (Years)	Frequency factor	$K.\sigma_y$	$Y = \log R$ $Y = M + K.\sigma_y$	Rainfall (mm)
1	2	-0.1320	-0.0264	1.7336	54.1502
2	5	0.7800	0.1560	1.9160	82.4138
3	10	1.3360	0.2672	2.0272	106.4633
4	25	1.9980	0.3996	2.1596	144.4109
5	50	2.4530	0.4906	2.2506	178.0738
6	100	2.8910	0.5782	2.3382	217.8713
7	200	3.3120	0.6624	2.4224	264.4844

**Gumbel distribution**

In Gumbel distribution only two parameters, mean and standard deviation of original data were determined. The analysis was carried out as per the procedure given in methodology. The mean and

standard deviation data were determined, which found to be 66.315 and 40.98, respectively. The frequency factor,  $K$ , values were determined by using given formula for different return periods. The theoretical values of annual maximum rainfall for different return periods are presented in Table 2

**Table 2:** Theoretical values of annual daily maximum rainfall using Gumbel distribution for Ahmednagar station.

Sr. No.	Recurrence Interval (Years)	Frequency factor, $K$	$K \cdot \sigma_y$	Rainfall (mm) $Y = \bar{x} + K$
1	2	-0.164	-0.6294	40.5182
2	5	0.735	0.1786	73.6375
3	10	1.300	0.6870	94.4703
4	25	2.043	1.3552	121.8517
5	50	2.590	1.8471	142.0100
6	100	3.135	2.3372	162.0946
7	200	3.677	2.8246	182.0687

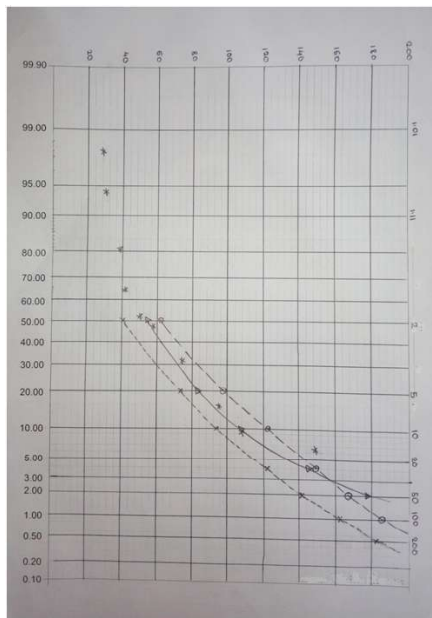
**Log normal distribution**

The statistical parameters mean, standard deviation and coefficient of skewness of transformed data were determined, which are found to be 66.315 are 0.2067 and 0.619, respectively. The frequency

factor,  $K$ , values were determined for different probabilities corresponding to the value of coefficient of skewness. The theoretical values of annual maximum rainfall for different return periods are presented in Table 3

**Table 3:** Theoretical values of annual daily maximum rainfall using Log Pearson Type III distribution for Ahmednagar station

Sr. No.	Recurrence Interval (Years)	Frequency factor, $K$	$\frac{x}{\bar{y}} = 1 + C_v K$	$X$ , Rainfall (mm)
1	2	-0.132	0.9182	60.8965
2	5	0.78	1.4828	98.3332
3	10	1.336	1.8269	120.8275
4	25	1.998	2.2367	148.3308
5	50	2.453	2.5184	167.0081
6	100	2.891	2.7895	184.9876
7	200	3.312	3.0501	202.2692



**Fig. 4:** Analytical frequency curves for annual daily maximum rainfall at Ahmednagar Tahsil

- $\Delta$  ———  $\Delta$  Log Pearson Type III Distribution
- $\circ$  - - -  $\circ$  Log Normal Distribution
- \* - - - - \* Gumbel Distribution

From the graph 1, it is observed that Log Pearson Type III Distribution gives the closest fit.

**Summary and conclusion**

The daily rainfall data for Ahmednagar Tahsil was from obtained from the State Data Storage Centre, Hydrology Project (Surface Water) JalVidnyanBhavan, Nashik. The Gumbel, Log Pearson Type III distribution and Log Normal distribution were used to determine the probabilities of the different amounts. As the variation between actual rainfall values and predicted rainfall values is less in Log Pearson Type III distribution as compared to Log Normal and Gumbel distribution, the Log Pearson Type III distribution found the best suitable for probability analysis of annual daily maximum rainfall..

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