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Analysis of One Day and Extended Days Rainfall for Pune

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Abstract

The daily rainfall data of Pune (plain zone) were analyzed for determination of D-days (D=2, 4, 5, and 6 days) rainfall total. Plotting positions were compared using Weibull's and Gringorten's formulae. The relationship between one day and D-days rainfall totals in Plain Zone was developed.

Weibull's formula was found better than Gringorten's formula for plotting positions for the observed data of Pune station. The relationships between one day and D-day annual maximum values of rainfall were found to be exponential in nature for Pune.

Keywords: Extended days rainfall, Gringorten's and Weibull's method; Plotting positions; Rainfall analysis.

INTRODUCTION

The distribution of rainfall in time and space is erratic. It either results in droughts or sometimes occurrence of flood. Hence, there may be limitation on the length of crop growing period. The absence of certain amount of rainfall at critical time can determine the success or failure of crops. Also the intensity, duration and amount of rainfall are important factors responsible for runoff and soil erosion. It is necessary to comprehend the trend changes in the annual daily maximum rainfall (Pandya *et al.* 2022).

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Consecutive days rainfall analysis provides valuable information for planning and management of run off in watershed. Analysis of consecutive days maximum rainfall of different return periods is a basic tool for safe and economical planning and design of structural and non structural measures, small and medium hydraulic structures such as dams, bridges, culverts, spillways, check dams, ponds, irrigation and drainage works in watershed management and command area development (Sethy *et al.*, 2005).

Depending upon the 2, 3, 4, 5 and 6 days (consecutive days) maximum rainfall, period of crop tolerance, storage and drainage of water from the agricultural fields can be planned, thus the knowledge of consecutive days maximum rainfall can lead to successful crop planning.

MATERIAL AND METHODS

Rainfall Data

The daily rainfall data of Pune for 33 years were collected from the respective stations.

Analysis of Rainfall Data

The available rainfall data of Pune station from Plain Zone were analysed using following methodology.

Computation of Extended Day Duration Rainfall

The 2, 3, 4, 5 and 6 days were considered as extended day duration. Cumulative rainfall totals were computed from dailly rainfall data of all the years, for these extended day durations by using moving total rainfall method (Pardhe, 2002). In this method the 2-days rainfall was calculated as addition of rainfall of two consecutive days, 3 days rainfall was calculated as addition of rainfall of three consecutive days. Similarly 4, 5 and 6 days duration rainfall were computed.

Selection of Annual Maximum Values of Rainfall

The daily rainfall data and extended days rainfall data were arranged in descending order of magnitude for each year. The maximum value of rainfall for one day and consecutive days rainfall for each year were selected for analysis.

Plotting Positions Analysis of Rainfall Data

The one day and extended days annual maximum rainfall data were arranged in descending order of magnitude and rank number were assigned to each observation. The probability analysis of one day maximum rainfall and extended days maximum rainfall was carried out by using Weibull's method and Gringorten's method. The probabilities were computed by using the following relations.

Weibull's Formula

$$P = \frac{m}{(n+1)} \quad \text{.... (1)}$$

Gringorten's Formula

$$P = \frac{m - b}{n+1 - 2b} \quad \text{.... (2)}$$

Where,

P = Probability of exceedence

m = Rank number

n = Number of years for which rainfall data were available

b = Constant = 0.44

Comparison of Weibull's and Gringortens Plotting Positions

The plotting positions obtained by Weibull's and Gringorten's methods were compared by using the criteria given by Hann (1977) for plotting position.

Relationship between Annual Maximum Values of 1 Day and D-Day Rainfall

The relationship between 1-day maximum and D-day maximum rainfall (2, 3, 4, 5 and 6 days) were developed. The data pairs of 1-day and D-days duration annual maximum rainfall for same return period were considered for developing the relationships.

Linear, logarithmic, exponential, power and polynomial functions were tried to fit the data. The relationship giving maximum value of R2 was selected as the appropriate relationship.

RESULTS AND DISCUSSION

Computation of Extended Day duration Rainfall and Selection of Annual Maximum Values of Rainfall

Extended day duration rainfall for 2, 3, 4, 5 and 6 days for Pune were computed from the daily rainfall. Single largest values of 1 day and D-day rainfall for each year were identified (Table 1). It is observed form table 1 that maximum values of 1-day rainfall for Pune ranges from 14.7 to 123.3 mm.

Table 1: Maximum values of one day and extended days rainfall (mm) for Pune for different years

Sr no.	Year	1D	2D	3D	4D	5D	6D
1	1970	28.5	49.1	68.4	89	89	89
2	1971	117.2	120.2	120.2	141.5	146.4	146.6
3	1972	44.8	75.5	101.3	110	117.5	118.6

table cont....

4	1973	90.8	153	181.4	196.3	206.4	212.4
5	1974	58	86.7	88.6	91.1	103.6	103.6
6	1975	43.6	53.4	61.5	76.4	101.2	108.1
7	1976	101.5	171.1	233.4	244.4	259.3	270.3
8	1977	73.6	74.6	89.3	92.7	93.7	98.8
9	1978	29.4	48.7	48.7	48.7	49.1	52.5
10	1979	83.4	102	110	126.5	129.3	180.3
11	1980	71.6	106.6	162.3	168.6	168.6	178.2
12	1982	52.6	76.2	102.3	112.7	112.7	113.1
13	1983	110.7	121.8	130.7	144.7	167.1	191.1
14	1984	97.8	106.2	122.4	166.7	167	179.1
15	1985	64.6	117.3	132	134	137.8	145.6
16	1986	46	59.2	71	79.9	84.8	98
17	1987	14.7	24	33.9	43.9	51.6	58.6
18	1988	63.5	126.3	126.5	162.8	172.6	173.5
19	1989	86.9	127.5	137.7	150.8	156.7	158.4
20	1990	68.9	94.8	108.7	109.7	123.6	133.4
21	1991	123.3	228.2	298	357.5	385.5	404.9
22	1992	50.7	73.7	94.2	101	126.4	144.7
23	1993	49.7	60.9	85.1	99.8	119.4	126.7
24	1994	81.7	97.8	111.7	126.6	142.7	151.6
25	1995	67.3	70.7	83	92.1	105.7	111.5
26	1996	55.9	116.6	140.8	144.3	144.3	153.2
27	1997	71.2	140.4	171.9	185.3	205	205
28	1998	67.9	85.3	94.6	100.5	101.4	104.2
29	1999	52.5	68.5	84.4	98.6	119.2	148.4
30	2000	45.1	66.9	89.2	105.3	113.5	120.9
31	2001	37.5	66.1	90.9	106.7	106.7	109.8
32	2003	57.8	60.4	67.7	68.5	68.5	70.1
33	2004	76.2	113.4	127.9	150	166.8	183

Plotting Position Analysis of Rainfall Data

Plotting position analysis of annual maximum values of 1 day and D-days rainfall were carried out by Weibull's and Gringorten's formulae. The return period was obtained by the inverse of probability of exceedence. The probabilities and return periods of annual maximum 1-day and consecutive days for Pune are given in Table 2.

Comparison of Weibull's and Gringorten's Plotting Positions

It is revealed from Table 2 that:

1. All the observations can be plotted, as the plotting positions are greater than zero by both the methods.
2. The plotting position lies between (m-1)/n and m/n for all values of m and n by both the methods.
3. The return periods obtained by Weibull's formula show that for largest value of rainfall it approaches n and for smallest value of rainfall it approaches 1. However, the return period obtained by Gringorten's formula for largest value of rainfall, becomes very large as compared to n and for smallest value of rainfall it approaches 1.
4. The difference between the plotting position of the (m + 1) th and mth value is same for all values of m and n by both the methods.
5. Both the methods are simple and easy to use.

From above discussion, the Weibull's formula satisfies all five criteria for plotting position. The Gringorten's formula satisfies all criteria except the third criteria for plotting position formulae. Hence,

Table 2: Observed values of one day maximum rainfall with probability and return period by Weibull's method and Gringorten's method for Pune

Rank No.	1-day maximum rainfall (mm)	Weibull's method		Gringorten's method	
		Probability	Return period (years)	Probability	Return period (years)
1	123.3	0.0294	34	0.0169	59.143
2	117.2	0.0588	17	0.0471	21.231
3	110.7	0.0882	11.333	0.0773	12.938
4	101.5	0.1176	8.5	0.1075	9.303
5	97.8	0.1471	6.8	0.1377	7.263
6	90 .8	0.1765	5.667	0.1679	5.957
7	86.9	0.2059	4.857	0.1981	5.049
8	83.4	0.2353	4.25	0.2283	4.381
9	81.7	0.2647	3.778	0.2585	3.869
10	76.2	0.2941	3.4	0.2886	3.464
11	73.6	0.3235	3.091	0.3188	3.136
12	71.6	0.3529	2.833	0.349	2.865
13	71.2	0.3824	2.615	0.3792	2.637
14	68.9	0.4118	2.429	0.4094	2.442
15	67.9	0.4412	2.267	0.4396	2.275
16	67.3	0.4706	2.125	0.4698	2.129
17	64.6	0.5	2	0.5	2
18	63.5	0.5294	1.889	0.5302	1.886
19	58	0.5588	1.789	0.5604	1.784
20	57.8	0.5882	1.7	0.5906	1.693
21	55.9	0.6176	1.619	0.6208	1.611
22	52.6	0.6471	1.545	0.651	1.536
23	52.5	0.6765	1.478	0.6812	1.468
24	50 .7	0.7059	1.417	0.7114	1.406
25	49.7	0.7353	1.36	0.7415	1.349
26	46	0.7647	1.308	0.7717	1.296
27	45.1	0.7941	1.259	0.8019	1.247
28	44.8	0.8235	1.214	0.8321	1.202
29	43.6	0.8529	1.172	0.8623	1.16
30	37.5	0.8824	1.133	0.8925	1.12
31	29.4	0.9118	1.097	0.9227	1.084
32	28.5	0.9412	1.063	0.9529	1.049
33	14.7	0.9706	1.03	0.9831	1.017

only the values obtained by Weibull's method are used for further analysis.

Relationship between Annual Maximum Values of 1-Day and D-Day Rainfall

The relationships were established by using the observed maximum rainfall of 1-day and computed D-days maximum rainfall values for same return period which are given in Table 3. All the relationships were found to be exponential

Table 3:. Relationship between 1-day and D-days annual maximum rainfall for Pune

D-days	Relationship	R2
2	Y = 29.286 e0.0165 x	0.9371
3	Y = 35.752 e0.0162 x	0.9562
4	Y = 40.891 e0.0159 x	0.9483
5	Y = 45.174 e0.0156 x	0.9395
6	Y = 48.295 e0.0155x	0.9445

Y = Extended day maximum rainfall, mm
x = One-day maximum rainfall, mm (14.7 < x < 123.3)

in nature with R2 values ranging from 0.9371 to 0.9562.

CONCLUSION

1. Weibull's method of plotting position was found to be better than Gringorten's method of plotting positions for observed rainfall data of Pune (plain zone).
2. The relationships between one day and D-days annual maximum rainfall were found to be exponential in nature for Pune (plain zone).

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