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RAINFALL PATTERN AT MID HILLS OF SIKKIM

R.K. Singh, A.K. Mishra and K.K. Satapathy
Division of Agricultural Engineering
ICAR Research Complex for NEH Region
Umroi Road, Umiam – 793 103

ABSTRACT

Daily ranifall data of 18 years (1979-96) and annual maximum daily rainfall data of 19 years (1979-97) recorded at ICAR Research farm were statistically anaiysed. Total rainfall in a week, month and year, and annual maximum daily rainfall at different probability levels were predicted. Comparison of estimated values of annual maximum daily rainfall by Chi-square test indicated that Longnormal distribution fitted the observed data more closely. Regression model for estimation of annual maximum daily rainfall for each distribution was also computed. Lognormal distribution can be used to forecast annual maximum daily rainfall for different recurrence intervals (RI) for the study area. The knowledge of weekly and annual maximum daily rainfall expected at different probability levels will help in planning and scheduling of agricultural activities, and in hydrological design of hydraulic structures recommended for conveyance, control and conservation of runoff.

INTRODUCTION

The place of study, Tadong is located 5 km south of Gangtok in Sikkim state at 1350 m above meen sea level. It falls under high rainfall zone of Eastern Himalaya region. Climate of the place is representative of subtropical mid hills. Average annual rainfall is more than 3000 mm. Characteristics of rainfall is erratic and intense. Agricultural in the area is practised in rainfed condition on subsistence basis. Safe disposal of runoff is of great concern in kharif season whereas rabi crops suffer from moisture stress. Thus production and productivity of both *kharif* and *rabi* crops are adversely affected. In this situation, judicious utilization of available soil moisture assumes great importance to enhance productivity of rabi crops. Therefore, knowledge of rainfall expected at different probabilities will be helpful to farmers in planning their various agricultural activities. Slopy land topography coupled with high rainfall poses serious threat to production base. So annual maximum daily rainfall assumes an important role in design of various soil conservation structures. Its estimation for desired recurrence interval is essential for safe and economic hydrological design of bund, terrace, waterways, small bridge, culvert, check dam and spillway etc.

Rainfall can be stochastically predicted by frequency analysis. Many workers (Sharda and Bushan, 1985; agrawal et.al., 1988; and Bhatt et.al., 1996) attempted frequency analysis of one day maximum rainfall for different places. Gupta et.al. (1975), Sharma et.al. (1979) and Satapathy (1991) carried out the probability analysis of rainfall for different places. In this paper an attempt to forecast annual maximum daily rainfall, weekly, monthly and annual rainfall of Tadong for different recurrence interval is made using Lognormal, Log Pearson type III and Gumbel probability distribution functions.

MATERIALS AND MEHODS

Daily rainfall data of Tadong for 18 years (1979-96) and annual maximum rainfall data for 19 years (1979-1997) were collected from Meteorological Observatory, ICAR Research Complex for NEH Region, Sikkim Centre Tadong.

A) **Daily rainfall data :** Weelky rainfall was calculated by adding the daily rainfall data of a week. Week days were considered as suggested by Gupta et al. (1975 from 1st to 7st, 8st to 15th, 16th to 23th and 24th to 30th or 31st (as the case may be) for all months except February for which 1st to 7th, 8th to 14th, 15th to 21st and 22nd to 28th or 29th. Log Pearson Type III distribution was selected for frequency analysis carried out through the use of frequency factor. Weekly, monthly and annual rainfalls were utilized to predict the corresponding rainfalls at different levels of probability. Trend analysis was done by moving average method by taking the mean of consecutive three years. Estimation of normal, and brough conditions were made as per the definitions suggested by Sharma et al. (1979). According to these definitions any month receiving less than 50% and more than 200% of average rainfall are termed as drought and abnormal months respectively. Months receiving rainfall in-between above limits is called normal months. Similarly, any year receiving raifall less than X–SD, more than X+SD and in-between these limits are called drought, abnormal and normal year, respectively.

B) **Annual maximum daily rainfall :** Frequency analysis of the data was carred out using general equation of bydrologic frequency analysis as proposed by Chow (1964)

$X = \overline{X} + sK$

Where,

X = variate, $\overline{X}$ = mean of variate, s = standard deviation and K = Frequency factor.

Frequency factor, K is a function of the recurrence interval and the type of probability distribition to be used in the analysis. Three probability distribution functions- Lognormal, Log Pearson Type III and Gumbel were used. The K values for first two distributions for a given recurrence interval were determined from tables available whereas, K values or Gumbel distribition were computed from the following formula.

$K = -6/(3.14)^{0.5} (v + \ln \ln (T/(T-1))$

Where

V = Euler's constant (0.5772)

T = Recurrence interval in years

Statistical parameters required in a particular distribution were computed from the hydrologic data series. Recurrence interval of observed values was determined by Weibull's formula as m/(N+1) were m is order of record arranged in descending order and N is the total number of records. Chi-Square (X^2) test was applied to test the goodness of fit to the observed values for all three probability distribution functions.

Chi-Square (X^2) = Sum $(O-E)^2/E$
Where O is observed and E is estimated value.

Based on general equation for hydrologic frequency analysis, regression models for each distribution were computed using least square method to predict annual maximum daily rainfall for desired recurrence interval.

RESULTS AND DISCUSSION

Average anual rainfall of the area was found to be 3089.26 mm with standard deviation of 330.25 mm. No definite trend was found as its observed values oscillate around annual mean value. About 93% of total rainfall occurs during the period from April to October. Winter season (October to March) rainfall is only 12.3% only but it is very much beneficial to rabi crops. Every week received rainfall but average weekly total rainfall ranges from lowest of 3.6 mm in 4th week of January to a highest of 139.12 mm in 2nd week of June. One time highest weekly rainfall of 475.1 mm was also observed in the same week. Dry weather prevails from 3rd week of October to mid March. During this period weekly rainfall was less than 20 mm. Though every week receives some amount of raifall even then moisture stress in rabi crops is inevitable because rainfall in particular week may occur on 1st day of the week and on last day in subsequent week. Thus a gap of 13 days may occur in-between two storms. Almost 55% day in a year was observed as rainy days. More than four days in a week was observed as rainy days during the period from 2nd week of April to end September including the period rom mid June to mid Spetember in which on an average more than six days per week were observed as rainy days. Period ranging from 3rd week of October to 1st week of February experienced rainy days ranging from 0.63 to 1.29 in a week. About 96.3% of total months from March to October were normal and remaining 3.7% were drought months. 100 and 90.7% of total abnormal and drought months, respectively fall between October to March. July and August months of every year were found to be normal. A 66.6% of total years were normal and 16.7% each of total years were abnormal and drought years. Weekly, monthly and yearly rainfall at different levels of probability are shown in Table 1. Farmers may take 50% risk in showing rabi crops in anticipation of rainfall amount at 50% probability. They may schedule their agricultural activities like land preparation, selection of drought resistant crop variety, weeding, spraying of plant protection chemicals etc. Soil conservation measures such as bund, terrace and waterways may be designed taking into consideration rainfall expected at 75-90% probability levels.

The expected annual maximum daily rainfall by Lognormal, Log Pearson Type III and Gumbel distribution for different recurrence interval, observed valued with their recurrence interval and respective Chi-Square value have been presented in Table 2. The best

distribution was selected that gave the smallest Chi-Square value (Agrawal et. al, 1988). The best probability function to represent the observed data amont the three distribition studied was found to be Lognormal as it gave least Chi-Square value. This fact is also confirmed by the frequency distribution curve (Fig 1) in which the observed data points lie more closely around Lognormal distribution. Hence, Lognormal distribution can be suggested for prediction of annual maximum daily rainfall of the study place.

A linear relationship between annual maximum daily rainfall, X in mm and frequency factor, K for each distribution was computed as

1. Lognormal distribution	X=138.47+45.66K	(r=0.998)
2. Log Pearson Type III	X=142.78+48.15K	(r=0.986)
3. Gumbel	X=138.95+49.98K	(r=0.991)

As coefficient of correlation (r) is maximum for regression model for Lognormal distribution, it is further confirmed that Lognormal probability distribution function is most suitable fo prediction of annual maximum daily rainfall for the study place. Jeevrathnam and Jakumar, (1979); Agrwal et. al (1988) and Bhatt et. al (1996 found the Log Pearson Type II and Senapati et. al (1979) found the Lognormal distrubution to be the best for prediction of annual maximum daily rainfall for their locations of studies. The most suitable probability distribution function to repesent the observed data may depend on rainfall pattern of the place. As rainfall pattern varies from place to place, the most suitable distribution may also vary from place to place. Annual maximum daily rainfall can be predicted directly from regression model of Lognormal distribution by putting the value of K for particular recurrence interval.

Table 1. Weekly, mothly and annual predicted rainfall (mm) at different probability levels at Tadong.

Month	Period	Predicted rainfall at probability levels			
		80%	50%	20%	10%
January	Week 1st	0.7	1.2	3.6	8.8
	2nd	0.7	1.9	5.7	10.8
	3rd	0.7	1.9	7.5	18.8
	4th	0.8	1.9	5.6	11.0
	Monthly	6.5	15.7	34.9	51.3
February	Week 1st	1.9	3.6	9.1	17.0
	2nd	1.5	4.5	15.9	33.6
	3rd	1.9	7.1	25.0	46.7
	4th	3.6	7.4	20.3	38.8
	Monthly	20.6	65.8	99.0	104.8

Month	Period	Predicted rainfall at probability levels			
		80%	50%	20%	10%
March	Week 1st	2.7	5.5	14.1	25.0
	2nd	1.6	10.8	49.9	95.2
	3rd	1.9	12.7	57.8	111.9
	4th	3.9	9.9	30.4	59.0
	Monthly	45.1	110.9	154.7	162.6
April	Week 1st	4.8	18.1	44.7	62.5
	2nd	19.1	35.5	71.1	105.2
	3rd	31.2	72.5	116.2	132.9
	4th	37.9	79.3	137.9	172.3
	Monthly	175.9	260.2	325.3	347.1
May	Week 1st	39.0	87.7	196.5	299.3
	2nd	57.0	93.8	155.9	204.2
	3rd	54.8	129.9	238.1	300.0
	4th	50.1	115.5	193.4	228.3
	Monthly	352.5	486.6	660.0	768.5
June	Week 1st	62.7	109.6	182.9	234.7
	2nd	61.8	100.3	158.5	199.1
	3rd	77.9	111.0	169.4	217.4
	4th	59.1	93.9	146.9	184.3
July	Week 1st	87.9	128.9	174.2	197.9
	2nd	84.1	130.8	186.3	217.0
	3rd	86.6	134.8	188.8	216.7
	4th	93.3	128.3	175.9	207.2
	Monthly	446.3	532.8	633.9	692.3
August	Week 1st	55.8	85.9	131.1	163.0
	2nd	95.1	130.1	174.5	201.9
	3rd	74.0	124.8	189.7	227.3
	4th	84.1	118.6	160.4	184.8
	Monthly	394.8	496.1	586.3	626.2
September	Week 1st	67.4	112.5	179.7	225.7
	2nd	62.1	97.2	142.9	170.7
	3rd	55.6	106.9	167.2	197.2
	4th	25.4	45.9	97.1	153.6
	Monthly	299.3	408.2	541.3	620.7

Month	Period	Predicted rainfall at probability levels			
		80%	50%	20%	10%
October	Week 1st	8.4	23.2	63.2	106.1
	2nd	3.4	19.7	70.2	115.0
	3rd	1.5	6.8	38.7	105.6
	4th	1.5	2.8	8.7	20.4
	Monthly	52.5	107.8	215.5	306.2
November	Week 1st	0.7	1.8	7.3	17.7
	2nd	1.3	2.4	8.5	20.7
	3rd	0.9	1.1	2.8	6.3
	4th	0.5	1.5	5.0	10.4
	Monthly	2.1	11.7	49.0	93.2
December	Week 1st	0.4	0.9	3.0	7.1
	2nd	0.5	1.4	3.9	6.7
	3rd	0.8	2.0	5.7	10.5
	4th	0.8	4.0	15.4	29.0
	Monthly	4.1	18.1	38.3	46.1
	Annual	2784.4	3077.1	3367.1	3515.8

Table 2. Probability distribution and Chi-Square test

Sl No.	Recourrence Interval	Observed Value (O)	Estimated Value (E) (mm)			Chi-Square Value		
	(Year)	(mm)	Lognormal	L.P.Type III	Gumbel	Lognormal	L.P.TypeIII	Gumbel
1	1.05	76	76.1	63.9	73.7	0.00013	2.291	0.0721
2	1.25	97.3	100.1	102.2	97.9	0.078	0.235	0.0036
3	2	134.4	132	142.2	130.7	0.044	0.428	0.105
4	5	176	173.1	183.2	174.9	0.048	0.283	0.0069
5	20	220.2	222.5	223.7	232.2	0.124	0.055	0.62
6	100		274.5	255.7	295.7			
					Total	0.194	3.292	0.808

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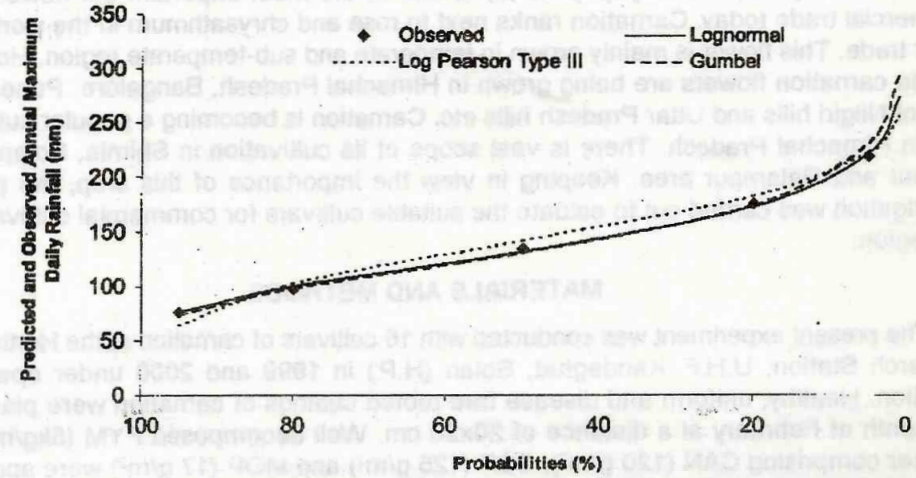

Fig. 1 Frequency distribution curves