Pak. J. Agri. Sci., Vol. 31, *No.* 3, 1994

FREQUENCY PREDICTION ANALYSIS OF FLOOD DATA OF JHELUM RIVER AT RASUL BY GENERALISED EXTREME VALUE DISTRIBUTION

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Gumbel and GEV flood frequency curves for river Jhelum at Rasul are developed using 67 years flood 1922-88 Annual Maximum flood series. The GEV distribution is estimated by method of probability weighted moments. Its goodness of fit is seen by KS test. This distribution appears to be appropriate for modelling the flood data. The flood estimates at various return periods i.e. 4, 5, 7, 10, 20, 50 and 100 are worked out using GEV distribution. The estimated 100 years flood by this distribution is seen to be 1.24 millions cusecs while the barrage was designed to pass a maximum flood discharge of 0.85 million cusecs.

INTRODUCTION

Under Indus Basin works programme, the new rasul Barrage is constructed 45 miles downstream of Mangla Dam and 3 miles downstream of old Rasul weir. The barrage is 3209 feet long having 2800 feet clear water way. It consists of 42 bays each 60 feet wide.

The barrage is designed to pass a maximum flood discharge of 0.85 million cusecs. The barrage come under maximum pressure to pass flood discharge of 0.88 million cusecs which was 0.03 million cusecs above its design capacity. On the left bank of the barrage two channels regulators are constructed, having each bay 40 feet wide. Provision has also been made on the right bank for Jalalpur canal regulators. No slit excluder is provided on this barrage. Radial gates having 12 feet height, are electrically operated (Rasul, 1988).

Safety requirements need remodelling of barrage and thus it is necessary to estimate with precision the highest possible flood likely to arrive at Rasul for the next 100 years. So, we find the quantile magnitude of 100 years flood at Rasul. Frequency analysis of flood data is a powerful source of providing planes of hydraulic structures e.g. darns, bridges, etc.

We have taken Annual maximum series for u/s Rasul Barrage from Directorate of Hydrology, Lahore for flood frequency analysis from the year, 1922 to 1988. The basic statistic are calculated and results are presented in Table 1.

Method of frequency analysis: In order to model the flood frequency data, Gumbel and GEV (Jenkinson, 1955) distribution were considered and their parameters were estimated by the method of moments and method of probability Weighted moments, respectively.

Table 1. Summery of Basic Satistic of the data.

N	Mean	Median	STDEV
67	231779	150000	223335
MIN	MAX	Ql	Q3
24336	1124211	105500	254848
C.V.	KURTOSIS	Coefficient of SK	
96.3568	7.7614956	0.40465	

Gumbel distribution: The Gumbel distribution has probability density function, cumulative distribution function and inverse cumulative distribution function as follows:

$$F(X) = l/a\ [-(x-u)/a \quad e-(x-u)/a, \qquad (1)$$

$$F(x) = \exp[-e^{-(x-u)/a}] \qquad (2)$$

$$x(F) = u + aY \qquad (3)$$

where

u is location and a is scale parameter and

$$Y = -\ln(-\ln F)$$

is the reduced form which does not depend on parameters.

GEV distribution: The generalized extreme-value (GEV) distribution, introduced by Jenkinson (1955) combines into a single form the three possible types of limiting distribution for extreme values as derived by Fisher and Tippett (1928). The distribution function is:

$$F(x) = \exp[-\{1-k(x-u)/a\}^{1/k}] \qquad k \neq 0$$

$$= \exp[-\exp\{-(x-u)/a\}] \qquad k = 0 \quad (4)$$

with x bounded by u + a/k from above if k > 0 and from below if k < O. Here, u and a Oare location and scale parameters, respectively and the shape parameter k determines which extreme value distribution is represented. Fisher-Tippetl Types I, 11 and 111 corresponde to k = 0, k < 0 and k > 0, respectively. When k = 0, the GEV distribution reduces to the Gumble distribution. The inverse distribution function is:

$$x(F) = u + a\{1-(-\log F)^K\}/K \qquad k \neq 0$$

$$= u - a\log(-\log F) \qquad k = 0 \quad (5)$$

The probability-weighted moments of the GEV distribution for k = 0 as derived by Hosking *et al.* (1985) are given by:

$$B_r=(r+1)^{-1}[u + a\{1 + \Gamma(1+k)\}/k) \qquad k>-1 \quad (6)$$

When k~-l B_0 (the mean of the distribution) and the rest of the B, do not exist. From (6), we have:

$$B_0 = u + a\{1-\Gamma(1 + k)\}/k \qquad (7)$$

$$2B_1 - B_0 = a\,\Gamma(1 + k)(1-2^{-k})/k \qquad (8)$$

and

$$(3B_2 - B_0)/(2B_1-B_0) = (1-3^{-k})/(1-2^{-k}) \qquad (9)$$

The PWM estimators $\hat{u}, \hat{a}, \hat{k}$ of the parameters are the solution of (7) - (9) for u, a, k when the Br are replaced by their estimators br or B, [Pin).

$$k = 7.8590c + 2.9554c^2, \quad c = \frac{2b_1 - b_0}{3b_2 - b_0} - \frac{\log 2}{\log 3} \qquad (10)$$

$$\hat{a} = \frac{(2b_1-b_0)k}{\Gamma(1 + k)(1 - 2^{-k})}, \qquad \hat{u} = b_0 + \hat{a}\{\Gamma(1+k)-1\}/k \qquad (11)$$

Goodness of fit: After the fitting of distribution our next step is to test the goodness of fit. In addition to theoretical justification, it is desirable to assess how well a distribution fits the observed flood series.

Goodness of fit tests are of several types and we have used the test based on empirical distribution function (edl) statistics. We have selected Kolmogrov-Smirnov (KS) test out of various tests based on edf statistics. It is a non-parametric test based on the difference between the empirical distribution function and the fitted distribution function.

edf=ijN & cdf=F(x)
0+ = sup (i/N - F(x»)
0- = sup (f(x) - (i-I)/N]
D = max (0+ ,0-)

Three test statistics are made by above O's.

Nl/2 (0+)
Nl/2 (0-)
Nl/2 (Om.,.)

If our calculated value is greater than tabulated value (Stephen, 1986), then we reject the hypothesis of good fit.

RESULTS AND DISCUSSION

The preliminary analysis of the annual maximum series is presented in Table (I). Various statistics presented in Table (I) reveal that there is a substantial difference between mean and median moreover the coefficient of skewness is 0.404565 which indicate that the distribution is skewed. Thus, the first candidcate distribution was Gumbel distribution. The estimated parameters of this distribution were presented in Table (2) along with KS statistic. The KS statistic rejected the hypothesis of Gumbel distribution suggesting that this distribution was not appropriate to model the flood series of rive Jhelum at Rasul. Consequently, the GEV distribution was considered. Its parameters were estimated by the method of probability weighted moments as derived in section 2 and presented in Table 2.

Table 2. Parameters estimating of Gumble and GEV distribution fitted to 67 annual maximum flood river Jhelum.at Rasul

GUMBLE			GEV		
et"	=	0.7516	et"	=	0,36327
Jl."	=	0,5663	Jl."	=	0,55487
0+	=	0.1713	K	=	-0,39921
0-	=	0,1829	0+	=	0.08164
0	=	0,1829	0-	=	0.05765
Deal	=	1,49710	D	=	0.08164
D1ab	=	0.9570	Deal	=	0.66825
			O.,,	=	0.9570

The goodness of fit was tested by KS test and the value of which is given in the same Table. The KS test suggests that the GEV distribution fits the data well and hence can be used to predict the frequency of floods using the inverse distribution function:

X(F) = Jl + (a/k) [l-(-lnF)] k1O

The quantities at various return periods i.e. 4, 5, 7, 10, 20, 50 and lOO years were worked out and are presented in Table 3.

CONCLUSION

Gumbel and GEV distribution are compared for modelling annual maximum

Table 3. Flood estimates at various return periods by GEV

Row	Excedence probability	Return period	Quantile magnitude		
1	0.25	4	1,1413 $\bar{X}$	=	264548.10
2	0.20	5	1,3010 $\bar{X}$	=	301567.47
3	0.15	7	1,5245 $\bar{X}$	=	353354.52
4	0.10	10	1,8795 $\bar{X}$	=	435641.88
5	0.05	20	2.6234 $\bar{X}$	=	608062.37
6	0.02	50	3.9654 $\bar{X}$	=	919115.34
7	0.01	100	5,3543 $\bar{X}$	=	1241018.38

series of river Jhelum at rasul on the basis of KS test. GEV distribution is recommended for modelling flood frequency data. Estimates of floods at return periods 4, 5, 7, 10, 20, 50, 100 have been derived and the growth curves to predict flood at any return period both by Gumble and GEV were established.

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