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ESTIMATION OF T-YEAR FLOOD AT A.P GHAT STATION IN BARAK RIVER, ASSAM, INDIA

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Abstract—*This paper presents a frequency distribution study on maximum annual flood data in Barak River at A.P ghat station using widely used frequency distributions for periods from 1996 to 2010. The Normal, Lognormal, Log pearson type III and Gumbell extreme value type I are proposed and tested together with their single distributions to identify the optimal model for maximum annual flood analysis. The selected model will be determined based on the minimum error produced by some criteria of goodness of-fit (GOF) tests. The results indicated that Normal distribution is better than the other distributions in modeling maximum annual flood magnitude at A.P Ghat station in Barak River. Hence frequency curve at A.P Ghat station is derived using Normal distribution method. However these results can vary between the flow gauge stations which are strongly influenced by their geographical, topographical and climatic factors. The following study can be used by planning and designing engineers for deciding the dimension of hydraulic structures such as bridges, dams, canals ,levees , and spillways etc. This study can be further extended into preparation of flood forecasting techniques and flood inundation maps for Barak river..*

1. INTRODUCTION

A flood is an unusually high stage in a river, normally the level at which the river overflows its banks and inundates the adjoining area. The damages caused by flood in terms of loss of life, properties and economic loss due to disruption of economic activity are all too well known. So a large sum of money has been invested by most of the countries every year in the flood control measures and flood forecasting systems. For this purpose the knowledge of probable magnitude of flood in the years to come is very necessary. This can be achieved by the knowledge of T-year flood. At a given location in a stream, flood peaks vary from year to year and their magnitude constitutes a hydrological series which enable one to assign a frequency to a given flood peak value. Using the annual series and by the application of statistical probability functions, one can estimate the magnitude of such probable flood peaks that is likely to be occur at least once during T-year. Again this T-year flood can be used in the design of many hydraulic structures, flood plain mapping and flood risk assessment of structures. However, the magnitude of flood to be adopted for the structures should neither be very large nor very low. Because, a very high value will invest a very high amount of money while in case of a low value result in the failure of the structure causing much damage than the absence of the structure.

1.1 Return Period

Return period or recurrence interval is the average interval of time within which any extreme event of given magnitude will be equalled or exceeded at least once (Patra, 2001). Return period was calculated by Weibull's plotting position formula (Chow, 1964) by arranging annual maximum flood in descending order giving their respective rank as:

$$T = \frac{N + 1}{R} \qquad (1)$$

Where, N - the total number of years of record and R- the rank of observed flood values arranged in descending order.

1.2 Frequency analysis using frequency factors

Frequency or probability distribution helps to relate the magnitude of extreme hydrologic events like floods, droughts and severe storms with their number of occurrences such that their chance of occurrence with time can be predicted successfully. Observed values of maximum annual flood can be obtained statistically through the use of the Chow's general frequency formula. The formula expresses the frequency of occurrence of an event in terms of a frequency factor, K_r , which depends upon the distribution of particular event investigated. Chow (1951) has shown that many frequency analyses can be reduced to the form

$$X_T = \bar{X}(1 + C_V K_T) \qquad (2)$$

Where, X_r is maximum value of event corresponding

to return period T; $\bar{X}$ is mean of the annual maximum series of the data of length N years, C_v is the coefficient of variation and K_r is the frequency factor which depends upon the return period T and the assumed frequency distribution. The expected value of annual maximum flood for the same return periods were computed for determining the best probability distributions.

2. METHODOLOGY

Several methods can be used to estimate design flood at sub basins of a region. To estimate T-year design flood sample data is used to fit frequency distribution which in turn is used to extrapolate from recorded events to design events either graphically or by estimating the parameters of the frequency distribution.

Graphical method is simple but, subjective.

Following continuous distributions are used to fit the annual peak discharge series

1. Normal Distribution
2. Log normal Distribution
3. Log Pearson Type-III Distribution
4. Gumbel distribution

2.2 Normal Distribution

The probability density function f(x) for this distribution function is given by $f(x) = [1/\sigma(\sqrt{2\pi})].\exp[-(x-\mu)^2/2\sigma^2]$

from which the standard normal variable

$z = (x-\mu)/\sigma$ and $X_T = \mu + \sigma.z$ where μ= mean of x, σ = standard deviation.

$z=w-(2.515517+0.80285w+0.001308w^2)/(1+1.432788w+0.189269w^2+0.001308\,w^3)$

where $w = \sqrt{[\ln(1/p^2)]}$ is an intermediate value & P is the probability.

2.2 Log-Normal Distribution

The probability density function f(x) for this distribution function is given by

$f(x) = [1/x\sigma(\sqrt{2\pi})].\exp[-(y-\mu)^2/2\sigma^2]$

where y= Log x, σ =standard deviation of y and μ = mean of y.z = standard normal variable same as in Normal distribution.

$Y_T = \mu + \sigma.z$ and X_T = anti log of Y_T

2.3 Log-Pearson Type III

The probability density function f(x) for this distribution function is given by-

$f(x) = [1/\beta^\gamma\Gamma\gamma].(y-\mu)^{\gamma-1}.\exp[-(y-\mu)/\beta]$

where $\mu = x+\beta.\gamma$, $\sigma^2 = \beta^2.\gamma$, $c_s = 2/\sqrt{\gamma}$ and x, β, γ are location, scale and shape parameters. $\Gamma\gamma = (\gamma-1)!$ & Γ is gamma function, y = Log x.

$Y_T = \mu + K_T\,\sigma$, where K_T is the frequency factor.

Using Kite's approximation formula,

$K_T = z + (z^2 -1)\,k + 1/3(z^3 -6z)\,k^2 - (z^2 - 1)\,k^3 + z\,k^4 + 1/3\,k^5$,

where z = standard normal variable as already explained and $k= C_s/6$, C_s is the co- efficient of skewness or K_T from table corresponding to return period T and co-efficient of skewness C_s , X_T = antilog of Y_T **.**

2.4 Gumbel Distribution

The probability density function f(x) for this distribution function is given by-

$f(x) = [1/\alpha].\exp[-(x-u)/\alpha - \exp\{-(x-u)/\alpha\}]$; where u and α are parameters. $u=\mu-0.5772\,\alpha$ and $\alpha = \sqrt{6}.\sigma/\pi$

$X_T = \mu + K_T\,\sigma$ where, K_T = frequency factor

$= -\sqrt{6}/\pi[0.5772+ \ln\{\ln(T/T-1)\}$

$= -\sqrt{6}/\pi[0.5772+ \ln\{-\ln(1- P)\}]$

In the above studies the flood magnitudes are estimated by extracting the values of standard normal variable z or frequency factor K_T from table. A lot of interpolation will be done to compute these values. It is also found that the estimated flood magnitudes obtained using different statistical distribution methods have got in different values. Hence, the best fit method suitable for a river basin is to be selected. Chi-Square test will be conducted for Goodness of fit in these studies. In this context, the values of z or $\mathbf{K_T}$ will be computed from approximation formula using SPSS software. All the statistical parameters like mean (μ), standard deviation (σ) & coefficient of skewness (C_s) will be computed by using SPSS software. The probability distribution function f(x) for the flood data corresponding to each distribution methods will be drawn using SPSS software to see how well the data are distributed to the analytical distributions. The probability P corresponding to each flood peak will be computed using Cunnane recommended plotting position formula suitable to the different distribution methods The flood Peaks(X) will be plotted against their corresponding values of z or $\mathbf{K_T}$ and a line is fitted to the plotted data by regression using SPSS software in order to check whether the data fit the distribution. Chi-Square Test will be conducted for Goodness of fit.

3. STUDY AREA AND DATA COLLECTION

The Barak River is one of the major rivers of South Assam and is a part of the Surma-Meghna River System. It rises in the hill country of Manipur State, where it is the biggest and the most important of the hill country rivers. After Manipur it flows through Mizoram State and into Assam, ending just after it enters Bangladesh where the Surma and Kushiyara rivers begin. From its source in the Manipur Hills of India, Liyai Village of Poumai Naga tribe, the river is known as the Barak River. Near its source, the river receives a lot of little hill streams, including the Gumti, Howrah, Kagni, Senai Buri, Hari Mangal, Kakrai, Kurulia, Balujhuri, Shonaichhari and Durduria. It flows west through Manipur State, then southwest leaving Manipur and entering Mizoram State.

In Mizoram State the Barak flows southwest then veers abruptly north when joined by a north flowing stream and flows into Assam State where it turns westward again near Lakhipur as it enters the plains. It then flows west past the town of Silchar where it is joined by the Madhura River. After Silchar, it flows for about 30 kilometres (19 mi), and just west of Badarpur it enters Bangladesh and at its mouth divides into the Surma River and the Kushiyara River. The principal tributaries of the Barak are all in India and are the Jiri, the Dhaleshwari (Tlawng), the Singla, the Longai, the Madhura, the Sonai (Tuirial), the Rukni and the Katakhal.Tipaimuk project is on the process on Barak river.

Discharge data (in m^3/s) for 15 water years of record for gauging station Annapurna Ghat on Barak River were collected from Assam State Disaster Management Authority (ASDMA).The flow recording station was equipped with an automatic recorder. Flow data were expressed in terms of exceedence probabilities and recurrence intervals. Denoting *Qi* as the annual maximum flood in year *i*, the quantile *Qi (F)* is the value expected *Qi* to exceed with probability *F,* that is, *P(Qi ≥Qi (F)) = F* during the year of interest. Thus, there is a *F*% chance that *Q ≥Q (F*). Conversely, there is a *(1−F)%* chance that *X<Q(F).* The return period of a flood, *1/(F)* is the reciprocal of the probability of exceedence in one year.

4. RESULTS AND DISCUSSION

The graphical method of estimation can not be able to get a reliable result as the flood peaks are not fitted well to the line of regression. The curves of probability distribution function f(x) vs. peak (X) in Normal distribution shows the data are well fitted to the analytical distribution. From the graph of peak (X) vs. (z) or (kt) for all the distribution methods it is seen that in the Normal distribution the graph of peak (X) vs. (kt) is almost in a straight line which shows that the data fits in the distribution method. Further, the result of the Chi square test for all the distribution method shows that Normal distribution gives better result than others. Hence Normal distribution is selected as the best fit method for estimation of T-year flood in the proposed station.

From the study of the PDF curves and graph of peak vs. z or kt that in the Normal distribution, the samples were well distributed. The values of Chi-square test conducted for Goodness of fit in Normal, Log-normal, Log-pearson type III, and Gumbel are also 160, 2188, 455, 392 respectively. This shows that Normal distribution has better result. Hence, Normal distribution is selected as the best fit method for estimation of T-Year flood for this particular site.

Table 1: Annual maximum flood data series

Year	Maximum Q (in m³/s)	Date	Corres. WL (in m)
1996	1715	15/05/1996	18.638
1997	3750	18/08/1997	20.413
1998	4830	13/07/1998	21.163
1999	3265	06-10-1999	20.673
2000	3084	19/07/2000	19.778
2001	3218	09-09-2001	20.543
2002	3393	06-08-2002	20.613
2003	3114	25/07/2003	19.933
2004	3500	18/04/2004	21.443
2005	4700	22/04/2005	21.693
2006	2500	28/08/2006	18.433
2007	3700	14/06/2007	20.723
2008	4243	09-10-2008	21.743
2009	4447	25/08/2009	19.983
2010	3527	22/08/20010	19.403

Table 2: Computation of statistical parameters of annual maximum flood

Statistical parameter	Computed value	Logarithmic transform
Average c	3532..4	3.53
Standard deviation (σ)	819.39	0.013
Coefficient of variation (C)	0.438	0.092
Coefficient of skewness (Ck)	0.870	0.175

Table 3: Observed and expected annual max. flood

S. no.	Probability (%)	Return Period (years)	Observed Flood (m³/s)	Expected Rainfall (mm) Normal	Log Normal	Log Pearson	Gumbel
1.	99	1.01	1630	1520	1450	1632	1530
2.	95	1.05	1715	1856	1657	1752	1756
3.	90	1.11	2500	2465	1845	2436	2489
4.	80	1.25	3218	3450	2785	3200	2947
5.	50	2	3500	3650	3450	3485	3465
6.	25	4	3750	3667	3665	3650	3650
7.	20	5	4243	4453	3741	4012	4015
8.	10	10	4447	4784	4005	4325	4449
9.	5	20	4700	4790	4412	4689	4698
10.	2.5	40	4830	4865	4862	4756	4798
11.	2	50		4892	4965	4963	4874
12.	1	100		4963	5214	5015	5698
13.	0.5	200		5558	5624	5825	5980

Table 4: Chi-square values at different probability levels for different distributions.

Normal	Log normal	Log pearson type III	Gumbel
160	2188	455	392

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