Journal of Water Resources and Ocean Science
2013; 2(2): 25-28
Published online June 30, 2013 (http://www.sciencepublishinggroup.com/j/wros)
doi: 10.11648/j.wros.20130202.13

Flood frequency Modeling using Gumbel's and Powell's method for Dudhkumar river

Md. Abdullah Asad[*1], Mohammad Ahmeduzzaman[1], Shantanu Kar[1], Md. Ashrafuzzaman Khan[1], Md. Nobinur Rahman[2], Samiul Islam[3]

[1]Dept. of Civil Engineering, Stamford University Bangladesh, Dhaka 1217, Bangladesh
[2]Dept. of Civil Engineering, Rajshahi University of Engineering & Technology, Rajshahi 6204, Bangladesh
[3]Office Engineer, BETS Consulting Services Ltd., Dhaka, Bangladesh

Email address:
abdullah.asad03@gmail.com(M. A. Asad), maz060086@gmail.com(M. Ahmeduzzaman)

To cite this article:
Md. Abdullah Asad, Mohammad Ahmeduzzaman, Shantanu Kar, Md.Ashrafuzzaman Khan, Md. Nobinur Rahman, Samiul Islam, Flood Frequency Modeling Using Gumbel's and Powell's Method for Dudhkumar River. *Journal of Water Resources and Ocean Science,* Vol. 2, No. 2, 2013, pp. 25-28. doi: 10.11648/j.wros.20130202.13

Abstract: The results of a study on an international river Dudhkumar (shared by Bhutan, India and Bangladesh) analyzing flood frequency of 14 years using Gumbel and Powell distribution have been presented in this paper. Flash flood occurrence over recent years had washed away fields making vulnerable life safety. It was assumed that, Dudhkmar flood flows obey the Gumbel and Powell distribution. The scale and shape parameters of the distribution were estimated using method of moments. . A Chi-square test results (p =1.000) between observed and predicted flood flows which is considered to be not statistically significant by the conventional criteria. Due to goodness of fit of the Gumbel and Powell distribution, it was assumed to be appropriate for modeling frequency of Dudhkumar River floods. However, the magnitudes of the 100, 200 and 1000 year floods were significantly differed in the two mentioned methods.

Keywords: Dudhkumar River, Flood Frequency Gumbel and Powell Distribution, Recurrence Interval

1. Introduction

Dudhkumar River the Raidak or the Sankosh river of WEST BENGAL (India) enters Bangladesh near Pateshwary and is renamed as the Dudhkumar. The river receives the Gadadhar and the Gangadhar as tributaries at Pateshwary and travels along a 52 km long meander course and joins the BRAHMAPUTRA at KURIGRAM SADAR upazila. Most of the main course of the Dudhkumar lies in India. The river is free from tidal influence, but often overflows. The average slope of the river is about 10 cm/km. This high slope makes Dudhkumar a flashy type river during rainy season when onrush of surface runoff due to monsoon rain cause flooding to the flood plain of the river causing bank erosion and destruction of houses and settlement of the people living on both banks. Destruction caused by this flashy river has increased in recent years. This paper aims at estimating return period associated with flood peaks of varying magnitudes from recorded floods using statistical methods.

2. Literature Review

Flood frequency analysis (FFA) is the estimation of how often a specified event will occur. Before the estimation can be done, analyzing the stream flows data are important in order to obtain the probability distribution of flood (Ahmad et. al., 2010). One of the greatest challenges facing the Hydrology is to gain a better understanding of flood regimes. To do this, flood frequency analysis (FFA) is most commonly used by engineers and hydrologists worldwide and basically consists of estimating flood peak quantities for a set of non-exceedance probabilities. The validity of the results in the application of FFA is theoretically subject to the hypothesis that the series are independent and identically distributed (Stedinger et al., 1993; Khaliq et al., 2006). Nevertheless, to determine flood flows at different recurrence intervals for a site or group of sites is a common challenge in hydrology. Although studies have employed several statistical distributions to quantify the likelihood and intensity of floods, none had gained worldwide acceptance and is specific to any country (Law and Tasker, 2003). Ferdows et. al. analyzed (1964-2000) discharge data for four specific river location in Bangladesh. Design flow and stage computation for Teesta River was done by Rahman et. al. using frequency analysis and MIKE 11modeling. However, this study involves the flood frequency analysis of Dudhkumar river for its flashy nature in the recent years (1996-2010) using two methods Gumbel's and Powell's respectively. To the best of author's knowledge, no previous study was done to model dudhkumar's flashy nature. It was assumed that, Dudhkumar River flood flows fit Gumbel and Powell distribution model. Location of Dudhkumar River in Bangladesh map is shown in Fig. 1.

3. Data Collection and Interpretation

Discharge data (in m^3/s) for 14 water years of record for SW 81 gauging station on Dudhkumar River were collected from Bangladesh Water Development Board (BWDB). The flow recording station SW 81 was equipped with an automatic recorder. Flow data were expressed in terms of exceedence probabilities and recurrence intervals. Denoting Q_i as the annual maximum flood in year i, the quantile $Q_i(F)$ is the value expected Q_i to exceed with probability F, that is, $P(Q_i \geq Q_i(F)) = F$ during the year of interest. Thus, there is a F% chance that $Q \geq Q(F)$. 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 (Haan, 1977; Shaw, 1983).

4. Gumbel Distribution

This is one of the most widely employed distributions to describe the flood data. As per this distribution, following equations are used to calculate recurrence interval and corresponding flood magnitude.

$$Q_T = Q_{mean} + K\sigma \quad (1)$$

$$K = (y - y_n)/\sigma \quad (2)$$

$$y = -0.834 - 2.303 \log\log (T/T-1) = -0.834 - 2.303 X_T, \quad (3)$$

$$Y_T = \text{Log Log}\ (T/T-1) \quad (4)$$

Where,
y= reduced variate.
T= recurrence interval
Q_T = magnitude of the flood with recurrence interval of T
Q_{mean} = mean of the maximum instantaneous flow
k= frequency factor
σ = standard deviation
Y_T = reduced variate corresponding to a recurrence interval.

5. Powell Distribution

It is also an effective method to describe flood data. As per this method, the magnitude of the flood with recurrence interval of T and frequency factor is given by

Figure 1. *Dudhkumar river location*

$$Q_T = Q_{mean} + K\sigma \quad (5)$$

$$K = \sqrt{6}/\pi\ [\lambda + \ln\ln(T/T-1)] \quad (6)$$

Where,
T= Recurrence Interval, σ= standard deviation, K= frequency factor
λ = Euler's constant = 0.57722

6. Goodness of Fit

It was assumed that, the discharge data fit the Gumbel and Powell distribution. A chi-square test was carried out to find the goodness of fit between the measured and predicted flood. After computing the goodness of fit for the distribution, flood magnitudes were calculated for exceedence probabilities of 0.040, 0.080, 0.120, 0.160, 0.200, 0.240, 0.280, 0.320, 0.360, 0.400, and 0.440, 0.480, 0.520, 0.560, 0.600, 0.640, 0.680, 0.720, 0.760, 0.800, 0.840, 0.880, 0.920, 0.960.

7. Results

The maximum instantaneous flow of 2753.68 m^3/s was recorded at SW 81 in 2005 whereas the lowest flood flow of 800.35 m^3/s occurred in 1997.The mean instantaneous flow is 1506.47504 m^3/s. The values of the flood data for 14 years are presented in table 1.

Table 1. *Observed and predicted floods in corresponding years*

Years	Observed discharge (m^3/s)	Predicted discharge (m^3/s)
1996	1201.61	1181.61
1997	800.35	780.35
1998	821.56	771.56
1999	1120.90	1060.9
2000	1834.02	1754.02
2001	1210.61	1160.52
2002	1020.73	970.73
2003	1603.03	1573.03
2004	1357.29	1347.29
2005	2753.68	2805
2006	1118.03	1200
2008	2519.31	2700
2009	1193.84	1300
2010	2535.63	2535

Observed and predicted flood flows show no significant (p=1.000) differences. Using Gumbel and Powell method the magnitude of flood corresponding to the recurrence interval are calculated.

Sample size= 14

Q_{mean} = 1506.47504

Standard Deviation σ = 654

Y_n= 0.50928

σ_n= 0.86562

A software based chi-square test results chi-square (X^2= 0.685) having two tailed P value of 1.0 with 13 degrees of freedom. The flood magnitudes corresponding to the exceedence probabilities were calculated. The flood magnitude was decreasing with an increase in exceedence probability values. Results have shown that, Dudhkumar River flood flows were variable in 14 mentioned years of study. A chi-square test shows a satisfactory fit between observed and estimated data. Besides, increasing exceedence probability and increasing flood magnitudes indicates the flashy nature of Dudhkumar.1000 year flood will be most violent however extreme care including river dredging, bank protection, channelization and overall river training works should be carried out to have sustainable solution in future.

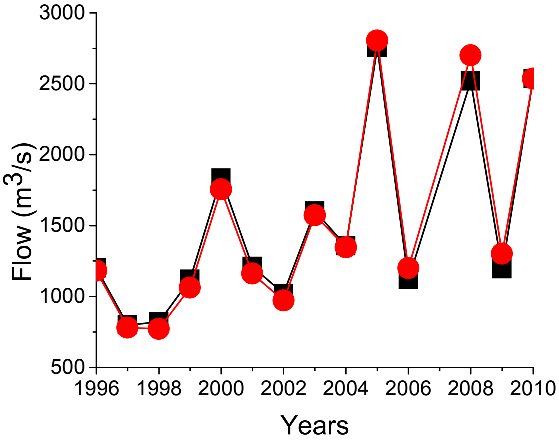

Figure 2. *Observed discharge is shown by black squared symbol and predicted discharge is shown by red circular symbol.*

Table 2. *Floods corresponding to recurrence interval*

Recurrence interval (T)	Magnitude of flood (m^3/s) (Gumbel)	Magnitude of flood (m^3/s) (Powell)
2	1399	1399
2.33	1559	1507
5	2255	1977
10	2822	2360
20	3366	2727
25	3539	2843
50	4071	3202
100	4598	3558
200	5124	3913
1000	6342	4734

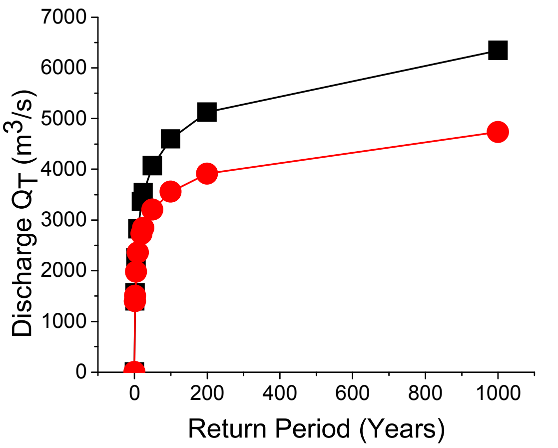

Figure 3. *Discharge data versus return period, black squared symbol represents Gumbel's flood frequency and red circular symbol shows Powell's flood frequency.*

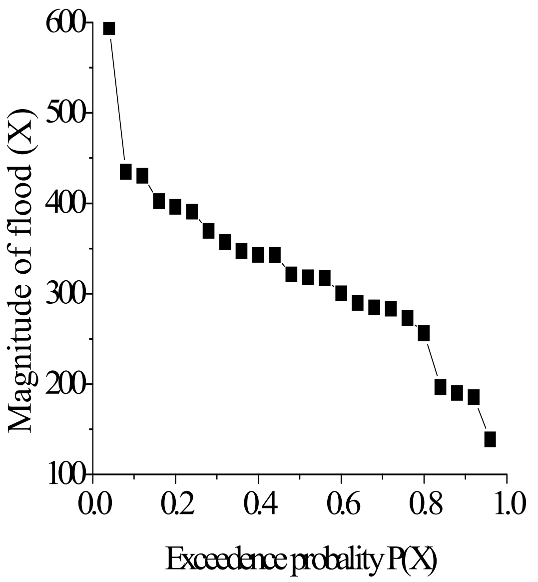

Figure 4. *Magnitude of flood versus exceedence probability, black squared symbol represents flood magnitude corresponding to exceedence probabilities.*

All these works could be implemented after being judged by the flood modeling methods like Gumbel and Powell.

8. Conclusion

Flood Frequency Analysis (FFA) has been done for Dudhkumar River for 14 years discharge data.The results tells that, Gumbel and Powel distribution clearly describes the flood magnitude while a chi square test derives no significant differences (P=1) between the predicted and observed floods. Probability distribution function also fit with the flood data. Due to goodness of fit and probable fitted value of the flood, the distribution should be used in calculating design flood magnitude. Hence the distribution models can be used to predict the occurrence of flood event for Dudhkumar River.

References

[1] U. N. Ahmad, A. Shabri, and Z. A. Zakaria, "Flood frequency analysis of annual maximum stream flows using L-Moments and TL-Moments." Applied Mathematical Sciences, vol. 5, pp. 243– 253, 2011.

[2] J. R. Stedinger and R. M. Vogel, "Frequency analysis of extreme events." Handbook of Hydrology, chapter 18, McGraw-Hill, New York, 1993.

[3] D. S. Reis and J. R. Stedinger, "Bayesian MCMC flood frequency analysis with historical information." Journal of Hydrology, vol. 313, pp. 97–116, 2005.

[4] M. Khaliq, T. Ouarda, J. Ondo, P. Gachon, and B. Bobée, "Frequency analysis of a sequence of dependent and/or non-stationary hydro-meteorological observations: A review." Journal of Hydrology, vol. 329(3-4), pp. 534–552, 2006.

[5] G. S. Law, and G. D Tasker, "Flood-Frequency prediction methods for unregulated streams of Tennessee." Water Resources Investigations Report 03-4176, Nashville, Tennessee, 2003.

[6] M. Ferdows, M. OTA, R. Jahan , M. Bhuiyan and M. Hossain, "Determination of probability distribution for data on rainfall and flood levels in Bangladesh." , Journal - The Institution of Engineers, Malaysia, vol. 66, pp. 61–72, March 2005

[7] M. Rahman, D. Arya, N. Goel and A. Dhamy, "Design flow and stage computations in the Teesta River, Bangladesh, using frequency analysis and MIKE 11 modeling." Journal of Hydrologic. Engineering.", vol. 16(2), pp. 176–186, 2011.

[8] C. T. Haan, "Statistical Methods in Hydrology." Iowa State University Press, Ames, Iowa. I '. Haefner, Journal of Water, 1997.

[9] S. B. Shaw and S. J.Riha, "Assessing Possible Changes in Flood Frequency Due to Climate Change in Mid-sized Watersheds." School of Civil and Environmental Engineering, Hollister Hall, Cornell University, Ithaca, NY 14853-3501, USA.

[10] N. Mujere, "Flood frequency analysis using the Gumbel distribution." International Journal on Computer Science and Engineering (IJCSE), vol. 3, pp. 2774–2778, July 2011.