ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

SUGGESTING BEST FITTING DISTRIBUTION FOR ESTIMATING FLOOD FOR RIVER SARDA AT UTTARAKHAND, INDIA

Saurabh Sah[1], Dr (Mrs) Jyothi Prasad[2], Dr. H.J. Shiva Prasad[3]

Department of Civil Engineering, College of Technology, G.B. Pant University of Agriculture & Technology. Pantnagar, 263145, Uttarakhand, India

Manuscript Info

Manuscript History:

Received: 15 July 2015
Final Accepted: 22 August 2015
Published Online: September 2015

Key words:

Best fitting distributions, Flood Frequency Analysis, , Annual Peak Flood discharge, Return Period, Goodness of fit Test

Corresponding Author

Jyothi Prasad

Abstract

Estimates of flood frequency quantiles are important in planning and design of water reource structures, Hence there is a need to seek for the most appropriate design estimator that would meet both safety and economic considerations of such structures. Flood frequency analysis is a tool used to estimate the frequencies of likely an occurrence of future floods. The objective of study is to estimate flood parameters of Sarda River of Uttarakhand, for different return period using statistical approaches, screening test using Anderson's Correlogram, Chow test for Outlier Detection and Kendall's Rank Correlation. Goodness of Fit tests Chi-square test, D-Index and K-S tests are applied to all the chosen, six probability distributions namely Normal, Log normal, Pearson type III, Log Pearson type III, Gumbel, Log Gumbel distributions using method of moments. By applying Model efficiency test, Coefficient of determination, root mean square errors for distributions and to suggest for best fitting distribution for Sarda River.

1.0 INTRODUCTION

One way of estimates the flood of specific recurrence interval is by performing flood frequency analysis of the recorded annual peak discharge over number of the years at the site under consideration. Generally in frequency analysis, an appropriate statistical distribution function is used to fit past available records and then inferences are made about the future likely flows. Two main approaches are available for flood estimation viz., deterministic approach and statistical approach. Deterministic approach assumes that input as precipitation is related the output, as discharge. Whereas, the statistical approach treats, the inter-relationship between processes as governed by the theory of statistics. The inter-relationship between processes is established through the measure of correlation. Generally in the frequency analysis, an appropriate statistical distribution function is used to fit past available records and then inferences are made about the future likely flows. Commonly used probability distribution for flood frequency analysis include log normal two parameter, log normal three parameter, extreme value type I distribution, Pearson type III distribution and log Pearson type III distribution. Various methods for estimating the parameters of these distributions are available in flood frequency analysis literature. Among those the method of moments are more popular. Although one can estimate the parameter of the distributions by method of moments with the help of simple scientific calculator, but the parameter obtained by this method are sometime biased. Flood frequency analysis uses historical records of peak flows to produce guidance about the expected behavior of future flooding. Primary applications of flood frequency analyses are to predict the possible flood magnitude over a certain time period and to estimate the frequency with which floods of a certain magnitude may occur.

For the present study river Sarda near Banbassa barrage of Champawat districts are taken up with the following objectives are

- To Preliminary analysis of hydrometeorological data.
- To estimate the statistical parameters such as mean, Standard deviation, Coefficient of Variance, Kurtosis and Skewness Coefficient for both original and Log transformed series for annual flood series.
- To study Six distribution values namely Normal, Log normal, Pearson type III, Log Pearson type III, Gumbel, Log Gumbel values and to determine flood magnitudes for different return period.
- To check the Test of Independent and Goodness of Fit using Chi-Square, K-S test, D-index test for all the distribution mentioned above.
- To apply Model efficiency test, Coefficient of determination (R^2), root mean square errors for distributions and to suggest for best fitting distribution for Sarda River.
- To give general recommendation of the approach.

2.0 MATERIALS AND METHODS

For the present study **Sharda or Sarda River** or **Mahakali River** is also called Kali Gad or Kali Ganga in Kumaoun region, Champawat district of Uttarakhand is taken up due to the data availability. The river demarcates Nepal's western border with India. This boundary was established by the 1816 Sugauli treaty. The river descends from 3,600 metres at Kalapani to 200 metres entering the Terai plains. It lies at latitude of 28°59'57"N to longitude of 80°06'32' E. The discharge data are available from the year 1930 to 2014 with a record length of 85 years are shown in Figure 1. The Catchment area of the basin is 15100 square kilometres. Its minimum discharge of 3284 m^3/s, maximum discharge of 15417 m^3/s and its average discharge 7903 m^3/s.

The following are the methodologies applied for the analysis of data

- Screening of the annual peak discharge data of the river station collected from Department of Irrigation, Uttarakhand using Anderson's Correlogram test for randomness, Kendall's rank test , trend and Chow test for outliers.
- Apply the Method of moments for the selected distributions are shown in Table 1,
- Prediction discharge for different Return Period for 1000, 500, 200, 100, 75, 50, 25 and 10 years respectively for flood frequency analysis.
- Applying Test of Goodness test Chi-Square, K-S test, D-index test for the distribution mentioned in Table.1.

3.0RESULTS AND DISCUSION

Table .1. Selected Distributions

S.N	Distributions	f(x)
1	Normal	$f(X) = \frac{1}{\sigma\sqrt{2\pi}} exp\left[-\frac{1}{2}\left(\frac{X-\mu}{\sigma}\right)^2\right]$
2	Log Normal	$f(X) = \frac{1}{\sigma_y\sqrt{2\pi}} exp\left[-\frac{1}{2}\left(\frac{log_e(X)-\mu_y}{\sigma_y}\right)^2\right]$
3	Pearson Type III	$f(X) = \frac{(X-X_o)^{\gamma-1} e^{-(X-X_o)/\beta}}{\beta^{\gamma}(\gamma)}$
4	Log Pearson Type III	$f(X) = \frac{1}{\lvert\beta\rvert(\gamma).X}\left[\frac{log_e X - y_o}{\beta}\right]^{\gamma-1} exp\left[-\frac{log_e X - y_o}{\beta}\right]$
5	Gumbel	$f(X) = \frac{1}{\alpha} exp\left[-\frac{X-U}{\alpha} - e - \frac{(X-U)}{\alpha}\right]$
6	Log Gumbel	$f(X) = \frac{1}{\alpha}\left[1-k\left(\frac{X-\mu}{\alpha}\right)\right]^{\frac{1}{K}-1} e\left[1-K\left(\frac{X-\mu}{\alpha}\right)\right]^{\frac{1}{K}}$

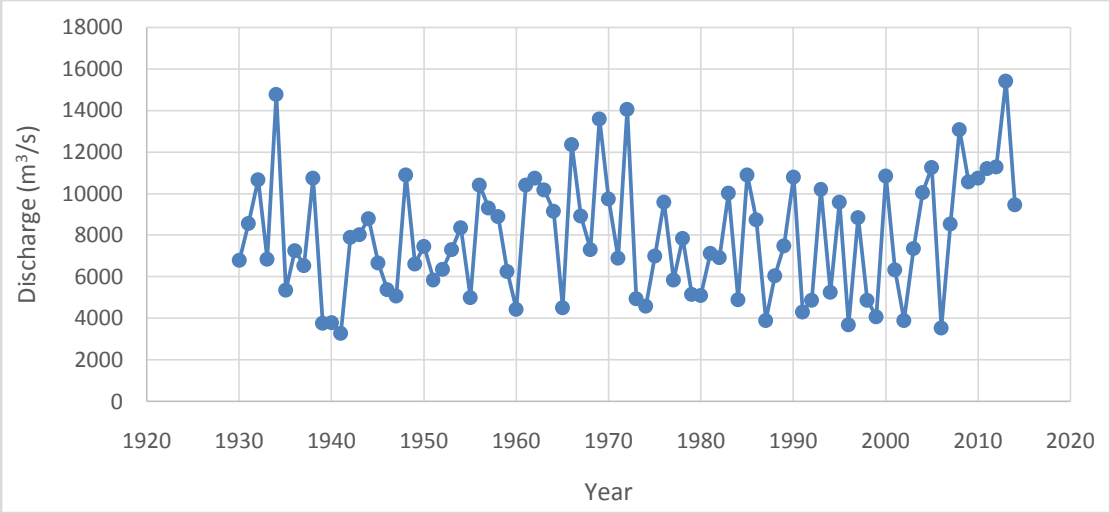

Figure:1 Annual Peak Discharge data for river Sarda river(1930-2014)

The following are the results obtained after applying the methods mentioned above using annual peak discharge data of the river Sarda

- It has been found that from statistical parameter for original Series of the Sarda River mean 7903.4483 m^3/s, standard deviation 2861.2137, and coefficient of variance 0.3620, coefficient of Skewness 0.4080 and kurtosis coefficient 2.6477.

- Anderson's Correlogram test shows that Sarda's river stations annual flood series data's are random, From Chow test for Outlier detection that river station is free from outlier and from Kendall's rank correlation test shows that the Z values calculated and it is checked for the 5% significance level for the rivers, Z computed is less than Z tabulated value of 1.96, it means that no trend has been observed.
- In this study six distributions are considered and worked out the flood quantiles for different return period like 1000, 500, 200, 100, 75, 50, 25 and 10 years, here we are assumed that all the distributions are fittings for all three rivers stations.
- Tests of Goodness fit namely Chi squared test, K-S test and D-index test applied to the chosen probability distributions, it shows that Log normal and Log Gumbel distributions are fitted for both K-S test and D-index tests. However from the most of literature review recommends the use Log Gumbel distribution for estimation of flood quantities.
- Model tests shows that for river Sarda stations having model efficiency 98.37 % and root mean square error 240.97 %, Log Pearson Type III distribution are best fitting for both the rivers.
- Discharge verses return period shows that flow pattern is of scattered and narrow, however the trend line equation gives the maximum value of Coefficient of determination (R^2), is 0.8873 for Log Gumbel distribution.
- Hence it is recommended to use the Log Gumbel distribution for predicting floods in River Sarda River stations of Kumaon Region.

4.0 CONCLUSION:

It has been found that Log Gumbel distribution is the best most fitting distribution for Flood frequency analysis of Sarda River of Uttarakhand. However still more number of distributions needs to be studied so that proper recommendations may be given for use of the distributions.

ACKNOWELDGEMENET

The authors wish to acknowledge to G.B. Pant University of Agriculture and Technology Pantnagar for permission for publication and TEQIP-II of College of Technology, Pantnagar for financial assistance.

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