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ESTIMATION OF FLOOD MAGNITUDES FOR VARIOUS RETURN PERIODS FOR SELECTED STRETCH OF DUDHGANGA RIVER

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Abstract – *This paper presents an estimation of flood peak magnitudes for various return periods on selected stretch of Dudhganga River using commonly used frequency distributions for periods from 1974 to 2014. The Gumbel's Extreme Value type-I and Log Pearson type-III distributions have been used in the present analysis and the best fit for the observed data is found out. Both graphical as well as statistical methods are used to test the acceptance of results obtained from distributions. The results indicated that Gumbel's Extreme Value type-I fits better than the other distribution for the observed annual flood peaks of Farale station on Duhudganga River. The results are helpful for the hydraulic and structural engineers in the design of various structures like bridges, dams, levees, and spillways etc. The flood maps can also be prepared corresponding to various return periods for the selected stretch to propose the flood mitigation measure.*

Key Words: Frequency distribution, return period, Gumbel's Extreme Value type-I, Log Pearson type-III

1. INTRODUCTION

Increase in population will increase the demands upon vital resources like water are becoming ever more severe. From the history it has been found that most of the human settlement started close to the river streams because of proximity to water, whether it is rural and urban. At times this useful water becomes dangerous to both human and animal life due to a situation like floods.

At the same time, due to decrease in permeability, infiltration in the urban area usually decreases and thereby chances of flooding increases. Thereby it affects the life of the people, living animals and damages the property. These include destruction of houses, electric poles, railways, canals, erosion of soil which may damages the road path. Due to this flooding most of the floating material get transported to anywhere in the low lying area, which further causes hindrances to smooth functioning of certain structures. Sometimes it also affects human health. To reduce the damage many efforts are made to control flood either by structural or non structural measure. Therefore it becomes necessary to take precaution against flood occurrence. Hence it is imperative to know the magnitude and the frequency of likely flood in the region.

In order to estimate the annual flood peaks for various return periods, flood frequency analysis is carried out with the available observed discharge data.

2. STUDY AREA AND DATA USED

The Dudhaganga River is a tributary of the Krishna in western India. It originates in Sindhudurg district of Maharashtra in the Western Ghats and flows eastward through Kolhapur district and Belgaum district in Karnataka before joining the Krishna.

The river is dammed to form the Kalammawadi reservoir in the west of Kohlapur district. Kalammawadi is a prestigious canal irrigation project on the river Dudhaganga at Asangaon in Radhanagari taluka district Kolhapur, Topo sheet No.47 H 14/15/16, L 1/2/3/5/6/7, Longitude North (N)16° 21' 00" N and Latitude East (E) 74° 01' 00" E and is a joint venture of States of Maharashtra and Karnataka.

The total command area of the project is 93,209 ha. (73,340 ha. in Maharashtra and 29,869 ha. in Karnataka). Presently, it irrigates an area of 59933 ha [46937 ha in Maharashtra and 12996 ha in Karnataka] partly by flow and partly by lift. In Rainy season due to heavy rainfall and as per the survey done and by the knowledge from the villagers after conversation, the villages like Turambe, Bidri, Walve, Nigave, Chuye, Bachani will be affected by flooding. In the present case, a small stretch of Dudhganga River from Bidri to Bachani having the river length 16.4 km is selected for the analysis as the place is experiencing floods frequently. Fig. 1 illustrates the stretch selected on Dudhganga River for the analysis.

Fig -1: Dhudganaga River at the station Bidri village

The data on annual flood peaks were collected for the Farale station, located at the upstream part of the selected stretch at Bidari village from the period 1974 to 2014.

Table -1: Annual Flood Peak values for river Dudhganga at Farale Station

Sl. No.	Year	Magnitude of Annual Peak Flood(cumecs)	Sl. No	Year	Magnitude of Annual Peak Flood(cumecs)
1	1974	401.64	22	1995	7272.4
2	1975	356.02	23	1996	5644.73
3	1976	464.58	24	1997	10468.99
4	1977	393.97	25	1998	4607.547
5	1978	472.28	26	1999	4216.984
6	1979	627.75	27	2000	3826.421
7	1980	375.42	28	2001	1254.214
8	1981	330.47	29	2002	5066.348
9	1982	377.25	30	2003	2200.961
10	1983	362.81	31	2004	13091.81
11	1984	573.08	32	2005	16796.16
12	1985	342.53	33	2006	10104.81
13	1986	1418.85	34	2007	7440.244
14	1987	344.11	35	2008	9859.861
15	1988	859.79	36	2009	6119.051
16	1989	1375.46	37	2010	8473.745
17	1990	471.09	38	2011	6699.009
18	1991	726.33	39	2012	5752.833
19	1992	7583.8	40	2013	7955.737
20	1993	181.59	41	2014	5698.763
21	1994	13454.4			

3. METHODOLOGY AND ANALYSIS

In the present study, data collected from the department were subjected to frequency analysis over two commonly used frequency distributions (Fig 2). To know the best fit distribution Graphical as well as statistical methods have been used. Then flood magnitudes corresponding to various return periods were determined. The flow chart given below highlights the work flow.

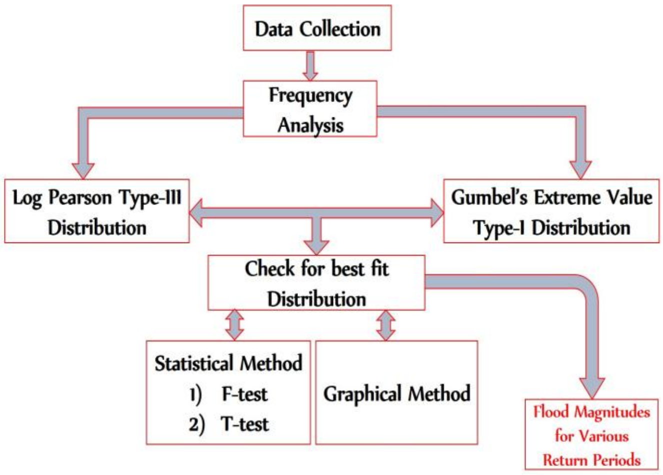

Fig -2: Work Flow

There are many probability distributions that have been found to be useful for hydrologic frequency analysis. Of the various statically methods available, the Log-Pearson type III and Gumbel's Extreme Value type I distribution are found to give reasonably good results and hence they are used in the present study. The analysis of work is divided into following parts:

1. At first, the frequency analysis was done using Gumbel's Extreme Value type I distribution and Log-Pearson type III distribution one observed annual peak discharge values collected for the Farale station, located on Dudhaganga river for the period 1974 to 2014.
2. Best fit distribution is judged based on statistical method and graphical approach.

i. Statistical method:

In this case, the observed and the estimated discharge values are evaluated using t-test and k-test. In both the cases p-value is estimated. The acceptance of hypothesis mainly depends on the p-value obtained. If the p-value is more than 0.05 then hypothesis shall be accepted or lesser than 0.05 then it will be rejected.

ii. Graphical Method:

In this method, graph is plotted between estimated and the observed annual flood peak values. A 45 degree line is plotted to judge the best fit distribution. The values of the distribution which are close to 45 degree line is selected as the best fit as the deviation for such distribution is less.

3. The distribution which fits well among the two methods employed is used to estimate the annual flood peak magnitudes for various return periods.

4. RESULTS AND DISCUSSIONS

The observed flood values for Farale gauging station is analyzed for flood frequency analysis by GEV type -Ii and LP type-III distributions. Subsequently, flood magnitudes for known return period corresponding the observed values are estimated for both the distribution methods.

A plot of estimated discharge values Vs. the observed discharge values is drawn to evaluate the deviations (Fig. 3) in both cases of distribution fitting.

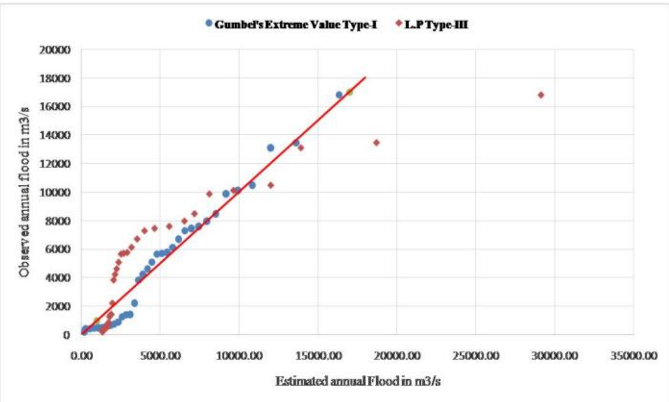

Fig -3: Comparison of estimate and observed flood

From the above graph it is evident that, the deviation from the 45^0 line for the Gumbel's distribution is less between estimated and the observed values when compared to L.P Type-III distribution. Also L.P. Type-III distribution underestimates the discharge values for lower magnitudes of observed flood peak values. Hence Gumbel's Extreme value Type-I Distribution is found to give good estimates compared to the other method.

The F-test for both the distributions is carried out using the actual discharge and the estimated discharge and hence the p-value was found out. For the G.E.V type-I distribution the p-value was found to be 1.488 and L.P type-III distribution the p-value was found to be 0.058.

Similarly the T-test for both the distributions is carried out using the actual discharge and the estimated discharge and hence the p-value was found out. For the G.E.V type-I distribution the p-value was found to be 0.999 and L.P type-III distribution the p-value was found to be 0.908.

From the above statistical test results, it is clear that the p-value is more than 0.05 for both the distributions, however the p-value for G.E.V type-I distribution is more compared to L.P type-III distribution. Hence it can be concluded that G.E.V type-I distribution fits well.

As both the statistical method and graphical method reveals that Gumbel's Extreme value type-I distribution fits well to the observed data and hence this distribution is used to estimate annual flood magnitudes for various return periods. The values obtained for various return periods are shown in Table 2.

Table -2: Annual Flood Peaks for Various Return Periods

Return Period (yrs)	Discharge (m^3/s)
5	7933
10	10828
15	12462
20	13605
50	17200
100	19894
150	21465
200	22578

5. CONCLUSIONS

The flood frequency analysis using flood frequency distribution by Gumbel extreme value type –I id found to fit well to the observed values. The statistical and graphical method can be used to verify the suitability of the method. The present study estimates the flood magnitudes for various return periods.

For the economic design of hydraulic and concrete structures such as bridges, dams, levees , and spillways etc. the results of flood magnitudes for various return periods can be used based on the life of the structure. The flood maps can be prepared for different return period to know the extent of area submerged correspondingly and it will help to suggest suitable measures against possible damages.

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