IOSR Journal of Engineering (IOSRJEN)
ISSN: 2250-3021 Volume 2, Issue 8 (August 2012), PP 68-77
www.iosrjen.org

Flood Frequency Analysis of Upper Krishna River Basin catchment area using Log Pearson Type III Distribution

B. K. Sathe[1] M. V. Khire[2] R. N. Sankhua[3]
[1]*Research Scholar, CSRE, IIT-Bombay* [1]*Corresponding author*
[2]*Associate Professor, CSRE, IIT-Bombay,*
[3]*Director, National Water Academy, Pune-411024*

Abstract:-*In this study, a flood frequency analysis of Upper Krishna River basin in India is carried out by Log-Pearson Type-III probability distribution method. This method is a statistical technique for fitting frequency distribution data to predict the flood for a river at some site. In Upper Krishna River The annual peak flood series data for 10 years varying over period 1965 to 2010 for 7 important stations such as Karad ,Warna, Arjunwad, Kurundwad, Warungi, Terwad, Sadagli are analysed.out of these seven stations Arjunwad and Kurundwad river gauging stations are important for flash flood point of view. The probability distribution function was applied to return periods (T) of T = 2 yrs, 5yrs, 10yrs, 25yrs, 50yrs, 100yrs and 200 yrs commonly used in for engineering design of hydraulic structures. These values are useful for hydraulic design of structures in the catchment area and for storm water management .The model relates the expected discharge to return period for all tributaries of Upper Krishna River basin.*
Keywords: *- design discharge, flood frequency, gauge discharge, Log Person Type III, probability*

I. INTRODUCTION

Floods are the most common natural disasters that affect societies around the world. Dilley *et al.* (2005) estimated that more than one-third of the world's land area is flood prone affecting some 82 percent of the world's population. About 196 million people in more than 90 countries are exposed to catastrophic flooding, and that some 170,000 deaths were associated with floods worldwide between 1980 and 2000 UNDP (2004). These figures show that flooding is a major concern in many regions of the world. To protect lives and properties it is needful for hydraulic structures to be constructed to safely handle an approximate percentage of the probable maximum flood.. As much of the hydraulic data like flow rate (discharge) and rainfall are statistical in nature, statistical methods are most frequently needed to be used often with the goal of fitting a statistical distribution to the data [11]. Design flood is the discharge adopted for the design of a hydraulic structure and it is obviously very costly to design any hydraulic structure so as to make it safe against the maximum flood possible in the catchment. [3]

The procedure for estimating the frequency of occurrence (return period) of a hydrological event such as flood is known as (flood) frequency analysis. Though the nature of most hydrological events (such as rainfall) is erratic and varies with time and space, it is commonly possible to predict return periods using various probability distributions [17]. Flood frequency analysis was developed as a statistical tool to help engineers, hydrologists, and watershed managers to deal with this uncertainty. Flood frequency is utilized to determine how often a storm of a given magnitude would occur. It is an important tool for the building and design of the safest possible structures (e.g. dams, bridges, culverts, drainage systems etc.) because the design of such structures demands knowledge of the likely floods which the structure would have to withstand during its estimated economic useful life[6].

In particular, analysis of annual one day maximum rainfall and consecutive maximum days rainfall of different return periods (typically 2 to 100 years) is a basic tool for safe and economic planning and design of small dams, bridges, culverts, irrigation and drainage work as well as for determining drainage coefficients[4].
In this study the log Pearson Type III probability distribution function have been used to model the annual peak discharge data of Upper Krishna River Basin. The main objective of the study was to perform flood frequency analysis of the river catchment using annual peak flow or maximum discharge data obtained in the river in the water years 1965 to 2010. The specific objectives of the study were:
(i) Fit the Log Pearson Type III probability distribution to the annual peak discharge data and hence
(ii) Predict design for the following return periods (T= 2yrs, 5yrs, 10yrs, 25yrs, 50yrs, 100yrs and 200 years)

II. STUDY AREA

The study area comprises of an upland watershed and a major tributary of Krishna River in the upper Krishna basin. The river has its source in the Western Ghats on the leeward side of the mountains Maharashtra, India. The river is 310 kms long and the catchment covers an area of 14,539 sq. km falling in Survey of India (SOI) toposheet No: 47 /K,47 /L,47 / P on 1:250,000 scale. The investigated area is enclosed between latitudes 17°18’N and 16°15′N and longitudes 73°50′E and 75°54′E. (Figure 2)

The annual peak flood series data for 10 years varying over period 1965 to 2010 for 7 important stations such as Karad ,Warna, Arjunwad, Kurundwad, Warungi of Upper Krishna basin. The data were collected from the Maharashtra state irrigation department

III. HEORY OF LOG-PEARSON TYPE III PROBABILITY DISTRIBUTION

The Log-Pearson Type III distribution is a statistical technique for fitting frequency distribution data to predict the design flood for a river at some site. Once the statistical information is calculated for the river site, a frequency distribution can be constructed. The probabilities of floods of various sizes can be extracted from the curve. The advantage of this particular technique is that extrapolation can be made of the values for events with return periods well beyond the observed flood events. This technique is the standard technique used by Federal Agencies in the United States.

IV. FLOOD DISCHARGE COMPUTATIONAL ANALYSIS

The Log-Pearson Type III distribution is calculated using the general equation

$$\mathbf{X}=\bar{\boldsymbol{X}}+\mathbf{K}\boldsymbol{\sigma} \qquad (1)$$

Where k = frequency factor determined from Tables No5. The model parameters $\bar{\boldsymbol{X}}$, standard deviation and the skew coefficient (g) are computed from n observations X, with the following formula

$$\bar{\boldsymbol{X}} = \frac{\mathbf{1}}{\boldsymbol{n}}\sum_{i=1}^{n} \mathrm{Xi} \qquad (2)$$

$$\boldsymbol{\sigma} = \left[\frac{\mathbf{1}}{(\boldsymbol{n}-\mathbf{1})}\sum(\boldsymbol{X}-\bar{\boldsymbol{X}})^2\right]^{1/2} \qquad (3)$$

$$\mathbf{g} = \frac{\frac{\mathbf{1}}{(\boldsymbol{n}-\mathbf{1})}\sum(\boldsymbol{X}-\bar{\boldsymbol{X}})^2}{(\boldsymbol{n}-\mathbf{1})(\boldsymbol{n}-\mathbf{2})\boldsymbol{\sigma}^2} \qquad (4)$$

However, the Log Pearson Type III distribution of X which has been widely adopted to reduce skewness is equivalent to applying Pearson Type III to the transformed variable log X and it is represented in the literature

(e.g. HannC.T.(1977) Das and Saikia (2009); Jagadesh and Jayaram (2009); Wurbs and James, 2009) as:

$$\log X=\overline{logX}+\mathrm{K}\boldsymbol{\sigma}_{\log X} \qquad (5)$$

where X is the flood discharge value of some specified probability, $\overline{logX}$ is the average of the log X discharge values, K is frequency factor. $\boldsymbol{\sigma}_{\log X}$ is the standard deviation of log x values. The frequency factor K is a function of skewness coefficient and return period and can be read from published tables (Table 5) developed by integrating the appropriate probability density function.The flood magnitude for various return periods are found by solving the general equation. The mean,standard deviation of the data and skewness coefficient can be calculated using the following
formula

$$\overline{logX} = \frac{\sum \log X}{n} \qquad (6)$$

$$\boldsymbol{\varphi}_{\boldsymbol{logX}}=\left[\frac{\sum(\boldsymbol{logXi}-\boldsymbol{logX})^2}{(\boldsymbol{n}-\mathbf{1})}\right]^{1/2} \qquad (7)$$

$$g=\frac{\sum(\boldsymbol{logXi}-\overline{logX})^{\mathbf{2}}}{(\boldsymbol{n}-\mathbf{1})(\boldsymbol{n}-\mathbf{2})\boldsymbol{\sigma}^{\mathbf{3}}_{\boldsymbol{logx}}} \qquad (8)$$

Where n is the number of entries of X the flood of some specified probability $logX$ i is the average of the log x discharge value

V. METHODOLOGY

Log Pearson Type III distribution and given in equation

$$\boldsymbol{T} = \frac{\boldsymbol{n}+\mathbf{0.2}}{\boldsymbol{m}-\mathbf{0.4}}$$

where n is the number of years of record and m is the rank obtained by arranging the annual flood series in descending order of magnitude with the maximum being assigned the rank of 1.

In carrying out the flood frequency analysis using the log-Pearson Type III distribution, the following steps suggested by Jagadesh and Jayaram (2009) were adopted:

(i) The annual flood series (Xii) were assembled
(ii) The logarithms of the annual flood series were calculated as yi = log Xi
(iii) The mean *y*, the standard deviation *y* and skew coefficient Cs of the logarithm yi were calculated.
(iv) The logarithms of the flood discharge i.e. log Qi for each of the several chosen probability level P_j were calculated
using the following frequency formula
Log_i Q □ □ y □ □$_j$K where K_j is the frequency factor, a function of the probability Pj and Skewness coefficient Table 5 shows the frequency factor (k) for ten selected probability levels in the range from 0.5 to 95% and skewness coefficient in the range from -3. To 3.0
(v) The flood discharge Q_j for each Pi probability level (return period T_j) is obtained by taking antilogarithms of the logφ values.

Table 1: Annual peak Discharge data for river gauging stations (m^3 /s)

Sr.No.	Water Year	River gauging Stations						
		Arjunwad (krishna)	**Karad (Krishna)**	**Kurundwad (Krishna)**	**Samdoli (Warna)**	**Sadagli (Dudh ganga)**	**Terwad (Panchganga)**	**Warunji (Koyna)**
1	1965-1966	Data not Available	4760	Data not available		Data not Available	Data not Available	Data not Available
2	1966-1967		2673					
3	1967-1968		4482		2000			3830
4	1968-1969		1527		1068			757.4
5	1969-1970	3850	4267		1650	1225		1605
6	1970-1971	5079	2428		1555	1320		1492
7	1971-1972	2936	2156		1220	1190		1386
8	1972-1973	3989	2190	4239	1219	1230		1523
9	1973-1974	4950	3051	5659	2250	1397		1900
10	1974-1975	2469	3101	3436	1528	1304		1583
11	1975-1976	5270	3231	5781	2050	1759		1681
12	1976-1977	4890	4562	6854	2007	1103		2780
13	1977-1978	3460	3422	4953	1548	1129		1610
14	1978-1979	2579	2187	3584	1418	1244		1576
15	1979-1980	4904	2435	6070	1436	1429		1317
16	1980-1981	3800	2848	5175	1747	1103	1918	1868
17	1981-1982	3362	1942	5166	1741	1457	1790	1262
18	1982-1983	2241	1261	3438	1472	1368	1431	1156
19	1983-1984	3345	1931	5111	1682	2435	1545	1493
20	1984-1985	3284	1797	4427	1715	1514	1795	1334

21	1985-1986	3085	1363	4414	1530	1421	1570	1054
22	1986-1987	2868	1801	4587	1347	1048	2050	1284
23	1987-1988	2351	1323	3290	1080	872.6	1392	1073
24	1988-1989	4997	3205	4870	2025	1810	2080	2590
25	1989-1990	4954	2504	6000	2412	2100	2205	1600
26	1990-1991	6500	4361	5760	1675	1452	2250	2530
27	1991-1992	5938	3150	6322	2081	1379	2553	1800
28	1992-1993	2928	2127	3919	1178	773.1	1306	1238
29	1993-1994	2843	1812	4051	1463	1058	1447	1023
30	1994-1995	6300	3915	5730	2235	1900	2680	2675
31	1995-1996	2550	1356	2796	869.0	710.9	1170	772.1
32	1996-1997	3560	2944	5000	1610	1180	1900	1566
33	1997-1998	4780	5954	6800	1710	1350	3590	3529
34	1998-1999	2411	1541	3000	897.5	685.5	1051	828
35	1999-2000	3193	2111	3725	1199	1110	1540	1397
36	2000-2001	1747	774.1	2852	1001	853.6	890.0	676.7
37	2001-2002	1764	911.2	2594	637.2	594.6	1150	623.3
38	2002-2003	1678	1121	3014	694.6	827.9	1443	830.2
39	2003-2004	1333	936.6	2275	772.1	537.7	655.0	626.7
40	2004-2005	4211	4163	4650	1261	1287	1832	2716
41	2005-2006	9381	6312	10092	3064	2200	3340	4641
42	2006-2007	7505	6708	8819	2010	1978	2797	4973
43	2007-2008	3943	3868	5673	1569	891.2	1821	2243
44	2008-2009	3357	2884	5743	1403	1013	1952	1887

Table 2 Computation of statistical parameters for Warunji (Koyna)

Rank (m)	**Water Year**	**Qmax (X m3/s)**	**y = log X**	$(y-\bar{y})2$	$(y-\bar{y})3$	**T =** $\frac{n+0.2}{m-0.4}$	**P =** $\frac{100}{Tr}$
1	2006-2007	4973	3.6966	0.2562	0.1296	70.33	1.42
2	2005-2006	4641	3.6666	0.226	0.1079	26.37	3.79
3	1967-1968	3830	3.5831	0.1542	0.0605	16.23	6.16

4	1997-1998	3529	3.5476	0.1275	0.0455	11.72	8.53
5	1976-1977	2780	3.4440	0.0643	0.0163	9.173	10.90
6	2004-2005	2716	3.4339	0.0592	0.0144	7.535	13.27
7	1994-1995	2675	3.4273	0.0561	0.0132	6.39	15.63
8	1988-1989	2590	3.4132	0.0496	0.0110	5.55	18.00
9	1990-1991	2530	3.4031	0.0452	0.0096	4.90	20.37
10	2007-2008	2243	3.3508	0.0257	0.0041	4.39	22.74
11	1973-1974	1900	3.2787	0.0077	0.00068	3.98	25.11
12	2008-2009	1887	3.2757	0.0072	0.0006	3.63	27.48
13	1980-1981	1868	3.2713	0.0065	-0.0018	3.34	29.85
14	1991-1992	1800	3.2552	0.004	0.0002	3.10	32.22
15	1975-1976	1681	3.2255	0.0012	4.33148E-05	2.89	34.59
16	1977-1978	1610	3.2068	0.0002	4.39277E-06	2.70	36.96
17	1969-1970	1605	3.2054	0.0002	3.39299E-06	2.54	39.33
18	1989-1990	1600	3.2041	0.0001	2.55537E-06	2.39	41.70
19	1974-1975	1583	3.1994	8.15857E-0	7.36921E-07	2.26	44.07
20	1978-1979	1576	3.1975	5.05205E-05	3.59089E-07	2.15	46.44
21	1996-1997	1566	3.1947	1.88645E-05	8.19344E-08	2.048	48.81
22	1972-1973	1523	3.1826	6.00397E-05	-4.6522E-07	1.95	51.18
23	1983-1984	1493	3.1740	0.00026	-4.40177E-06	1.86	53.55
24	1970-1971	1492	3.1737	0.00027	-4.64043E-06	1.78	55.92
25	1999-2000	1397	3.1451	0.00204	-9.26647E-05	1.71	58.29
26	1971-1972	1386	3.1417	0.00237	-0.00011	1.64	60.66
27	1984-1985	1334	3.1251	0.00426	-0.0002	1.58	63.033
28	1979-1980	1317	3.1195	0.00502	-0.00035	1.52	65.40
29	1986-1987	1284	3.1085	0.00670	-0.0005	1.47	67.77
30	1981-1982	1262	3.1010	0.00799	-0.00071	1.42	70.14
31	1992-1993	1238	3.0927	0.00955	-0.00093	1.37	72.51
32	1982-1983	1156	3.0629	0.01625	-0.00207	1.33	74.88
33	1987-1988	1073	3.0305	0.02555	-0.00408	1.29	77.25
34	1985-1986	1054	3.0228	0.02809	-0.00470	1.25	79.62
35	1993-1994	1023	3.0098	0.03260	-0.00588	1.21	81.99
36	2002-2003	830.2	2.9191	0.07358	-0.01996	1.185	84.36
37	1998-1999	828	2.9180	0.0742	-0.02021	1.153	86.72
38	1995-1996	772.1	2.8876	0.09167	-0.0277	1.12	89.09
39	1968-1969	757.4	2.8793	0.09679	-0.03011	1.093	91.46
40	2000-2001	676.7	2.8303	0.12963	-0.04667	1.0656	93.83
41	2003-2004	626.7	2.7970	0.15475	-0.0608	1.039	96.20
42	2001-2002	623.3	2.7946	0.15661	-0.0619	1.014	98.57
	Average	$\bar{X}$ **=1769.748**	$\bar{y}$ **=3.1904**	**Sum = 2.011**	**Sum = 0.1250**		
		Std. deviation $\sigma = 0.2214$		**Skew coeff. g = 1.790**			

Table 3: Sample Calculation of Discharges for return periods for Warunji (Koyna)

River Gauge Station	Return period T(yrs)	Probability P(%)	Frequency factor K g = 1.790	yi = log Q yi = $\bar{y} + K\, X\, Sy$	Xi = Q m3 /s	Relation between Expected Discharge and Return Period
Warungi	2	50	- 0.274	3.129	1345.860	y = 1980.ln(x) - 1392
	5	20	0.545	3.311	2046.444	
	10	10	1.165.	3.361	2296.14	
	25	4	1.986	3.543	3491.403	
	50	2	2.606	3.767	5847.900	
	100	1	3.226	3.818	6576.578	
	200	0.5	3.936	4.061	11508.003	

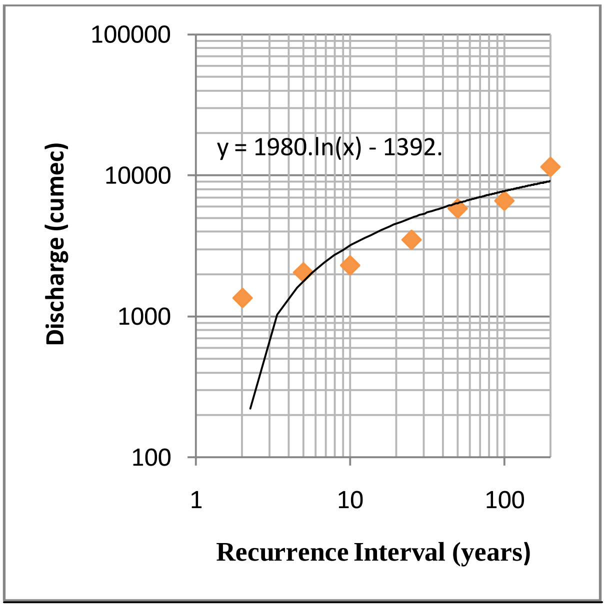

Figure 1: Relation between discharge and return period

Table 4 Calculation of Discharges for return periods for River Gauge Stations

Gauge Staion	Frequency factor K	Return period T(yrs)		yi = log Q yi = $\bar{y} +$ $X\, Sy$	Xi = Q m3 /s	Relation between Expected Discharge and Return Period
Argunwad	**g = 0.2682**	**2**	-0.029	3.558	3610	**y = 1662.ln(x) + 2430.**
		5	0.831	3.712	5149	
		10	1.299	3.796	6245.8	
		25	1.812	3.887	7715.3	
		50	2.148	3.948	8864.7	
		100	2.457	4.003	10069	
		200	2.744	4.054	11333	
Karad	**g = 0.0112**	**2**	-0.001	3.413	2590.5	**y = 1615.ln(x) + 1405**
		5	0.842	3.606	4034.9	
		10	1.283	3.707	5088.6	
		25	1.754	3.814	6518.2	
		50	2.058	3.884	7650	
		100	2.332	3.946	8833.9	
		200	2.584	4.004	10083	

Kurundwad	**g = -0.0215**	**2**	0.081	3.675	4731.2	**y = 981.4ln(x) + 4431**
		5	0.859	3.788	6139	
		10	1.221	3.841	6931.9	
		25	1.574	3.892	7804.1	
		50	1.788	3.923	8383.5	
		100	1.967	3.949	8901.3	
		200	2.120	3.972	9369.6	
Sadalgi	**g = -0.4028**	**2**	-0.048	3.295	1973.4	**y = 4020.ln(x) - 2395**
		5	0.825	3.603	4004.8	
		10	1.311	3.774	5940.6	
		25	1.848	3.963	9186.9	
		50	2.208	4.090	12299	
		100	2.539	4.207	16096	
		200	2.851	4.316	20725	
Samdoli	**g = 1.7248**	**2**	-0.423	3.182	1521.2	**y = 5975.ln(x) - 7428**
		5	0.472	3.402	2521.9	
		10	1.257	3.595	3931.6	
		25	2.334	3.859	7223.6	
		50	3.181	4.066	11654	
		100	4.054	4.281	19084	
		200	4.934	4.497	31375	
Terwad	**g = -0.3109**	**2**	0.084	3.248	1770	**y = 426.1ln(x) + 1631.**
		5	0.857	3.375	2369.6	
		10	1.215	3.433	2712.3	
		25	1.564	3.491	3094.3	
		50	1.771	3.524	3345.2	
		100	1.945	3.553	3571.7	
		200	2.096	3.578	3782.3	

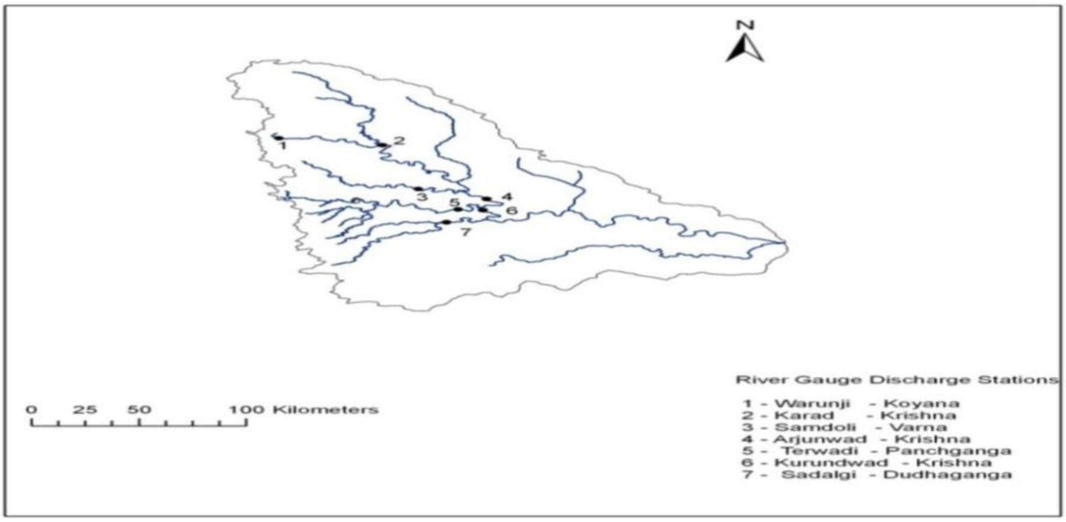

Figure 2: Study area

Table 5.Frequency Factors K for Gamma and log-Pearson Type III Distributions (Haan, 1977)

	Recurrence Interval In Years							
	1.0101	**2**	**5**	**10**	**25**	**50**	**100**	**200**
SKEW COEFFICIENT	**Percent Chance (>=) = 1-F**							
Cs	**99**	**50**	**20**	**10**	**4**	**2**	**1**	**0.5**
3	**-0.667**	**-0.396**	**0.420**	**1.180**	**2.278**	**3.152**	**4.051**	**4.970**
2.9	**-0.690**	**-0.390**	**0.440**	**1.195**	**2.277**	**3.134**	**4.013**	**4.904**
2.8	**-0.714**	**-0.384**	**0.460**	**1.210**	**2.275**	**3.114**	**3.973**	**4.847**
2.7	**-0.740**	**-0.376**	**0.479**	**1.224**	**2.272**	**3.093**	**3.932**	**4.783**
2.6	**-0.769**	**-0.368**	**0.499**	**1.238**	**2.267**	**3.071**	**3.889**	**4.718**
2.5	**-0.799**	**-0.360**	**0.518**	**1.250**	**2.262**	**3.048**	**3.845**	**4.652**
2.4	**-0.832**	**-0.351**	**0.537**	**1.262**	**2.256**	**3.023**	**3.800**	**4.584**
2.3	**-0.867**	**-0.341**	**0.555**	**1.274**	**2.248**	**2.997**	**3.753**	**4.515**
2.2	**-0.905**	**-0.330**	**0.574**	**1.284**	**2.240**	**2.970**	**3.705**	**4.444**
2.1	**-0.946**	**-0.319**	**0.592**	**1.294**	**2.230**	**2.942**	**3.656**	**4.372**
2	**-0.990**	**-0.307**	**0.609**	**1.302**	**2.219**	**2.912**	**3.605**	**4.298**
1.9	**-1.037**	**-0.294**	**0.627**	**1.310**	**2.207**	**2.881**	**3.553**	**4.223**
1.8	**-1.087**	**-0.282**	**0.643**	**1.318**	**2.193**	**2.848**	**3.499**	**4.147**
1.7	**-1.140**	**-0.268**	**0.660**	**1.324**	**2.179**	**2.815**	**3.444**	**4.069**
1.6	**-1.197**	**-0.254**	**0.675**	**1.329**	**2.163**	**2.780**	**3.388**	**3.990**
1.5	**-1.256**	**-0.240**	**0.690**	**1.333**	**2.146**	**2.743**	**3.330**	**3.910**
1.4	**-1.318**	**-0.225**	**0.705**	**1.337**	**2.128**	**2.706**	**3.271**	**3.828**
1.3	**-1.383**	**-0.210**	**0.719**	**1.339**	**2.108**	**2.666**	**3.211**	**3.745**
1.2	**-1.449**	**-0.195**	**0.732**	**1.340**	**2.087**	**2.626**	**3.149**	**3.661**
1.1	**-1.518**	**-0.180**	**0.745**	**1.341**	**2.066**	**2.585**	**3.087**	**3.575**
1	**-1.588**	**-0.164**	**0.758**	**1.340**	**2.043**	**2.542**	**3.022**	**3.489**
0.9	**-1.660**	**-0.148**	**0.769**	**1.339**	**2.018**	**2.498**	**2.957**	**3.401**

0.8	**-1.733**	**-0.132**	**0.780**	**1.336**	**1.993**	**2.453**	**2.891**	**3.312**
0.7	**-1.806**	**-0.116**	**0.790**	**1.333**	**1.967**	**2.407**	**2.824**	**3.223**
0.6	**-1.880**	**-0.099**	**0.800**	**1.328**	**1.939**	**2.359**	**2.755**	**3.132**
0.5	**-1.955**	**-0.083**	**0.808**	**1.323**	**1.910**	**2.311**	**2.686**	**3.041**
0.4	**-2.029**	**-0.066**	**0.816**	**1.317**	**1.880**	**2.261**	**2.615**	**2.949**
0.3	**-2.104**	**-0.050**	**0.824**	**1.309**	**1.849**	**2.211**	**2.544**	**2.856**
0.2	**-2.178**	**-0.033**	**0.830**	**1.301**	**1.818**	**2.159**	**2.472**	**2.763**
0.1	**-2.252**	**-0.017**	**0.836**	**1.292**	**1.785**	**2.107**	**2.400**	**2.67**
0	**-2.326**	**0.000**	**0.842**	**1.282**	**1.751**	**2.054**	**2.326**	**2.576**
-0.1	**-2.4**	**0.017**	**0.846**	**1.27**	**1.716**	**2.000**	**2.252**	**2.482**
-0.2	**-2.472**	**0.033**	**0.850**	**1.258**	**1.680**	**1.945**	**2.178**	**2.388**
-0.3	**-2.544**	**0.050**	**0.853**	**1.245**	**1.643**	**1.890**	**2.104**	**2.294**
-0.4	**-2.615**	**0.066**	**0.855**	**1.231**	**1.606**	**1.834**	**2.029**	**2.201**
-0.5	**-2.686**	**0.083**	**0.856**	**1.216**	**1.567**	**1.777**	**1.955**	**2.108**
-0.6	**-2.755**	**0.099**	**0.857**	**1.200**	**1.528**	**1.720**	**1.880**	**2.016**
-0.7	**-2.824**	**0.116**	**0.857**	**1.183**	**1.488**	**1.663**	**1.806**	**1.926**
-0.8	**-2.891**	**0.132**	**0.856**	**1.166**	**1.448**	**1.606**	**1.733**	**1.837**
-0.9	**-2.957**	**0.148**	**0.854**	**1.147**	**1.407**	**1.549**	**1.660**	**1.749**
-1	**-3.022**	**0.164**	**0.852**	**1.128**	**1.366**	**1.492**	**1.588**	**1.664**
-1.1	**-3.087**	**0.180**	**0.848**	**1.107**	**1.324**	**1.435**	**1.518**	**1.581**
-1.2	**-3.149**	**0.195**	**0.844**	**1.086**	**1.282**	**1.379**	**1.449**	**1.501**
-1.3	**-3.211**	**0.210**	**0.838**	**1.064**	**1.240**	**1.324**	**1.383**	**1.424**
-1.4	**-3.271**	**0.225**	**0.832**	**1.041**	**1.198**	**1.270**	**1.318**	**1.351**
-1.5	**-3.33**	**0.240**	**0.825**	**1.018**	**1.157**	**1.217**	**1.256**	**1.282**
-1.6	**-3.880**	**0.254**	**0.817**	**0.994**	**1.116**	**1.166**	**1.197**	**1.216**
-1.7	**-3.444**	**0.268**	**0.808**	**0.970**	**1.075**	**1.116**	**1.140**	**1.155**
-1.8	**-3.499**	**0.282**	**0.799**	**0.945**	**1.035**	**1.069**	**1.087**	**1.097**
-1.9	**-3.553**	**0.294**	**0.788**	**0.920**	**0.996**	**1.023**	**1.037**	**1.044**
-2	**-3.605**	**0.307**	**0.777**	**0.895**	**0.959**	**0.980**	**0.990**	**0.995**
-2.1	**-3.656**	**0.319**	**0.765**	**0.869**	**0.923**	**0.939**	**0.946**	**0.949**
-2.2	**-3.705**	**0.330**	**0.752**	**0.844**	**0.888**	**0.900**	**0.905**	**0.907**
-2.3	**-3.753**	**0.341**	**0.739**	**0.819**	**0.855**	**0.864**	**0.867**	**0.869**
-2.4	**-3.800**	**0.351**	**0.725**	**0.795**	**0.823**	**0.830**	**0.832**	**0.833**
-2.5	**-3.845**	**0.360**	**0.711**	**0.711**	**0.793**	**0.798**	**0.799**	**0.800**
-2.6	**-3.899**	**0.368**	**0.696**	**0.747**	**0.764**	**0.768**	**0.769**	**0.769**
-2.7	**-3.932**	**0.376**	**0.681**	**0.724**	**0.738**	**0.740**	**0.740**	**0.741**
-2.8	**-3.973**	**0.384**	**0.666**	**0.702**	**0.712**	**0.714**	**0.714**	**0.714**
-2.9	**-4.013**	**0.390**	**0.651**	**0.681**	**0.683**	**0.689**	**0.690**	**0.690**
-3	**-4.051**	**0.396**	**0.636**	**0.660**	**0.666**	**0.666**	**0.667**	**0.667**

VI. CONCLUSIONS

Flood frequency analysis is one of the most challenging problems in hydrology. The hydrologic phenomena are often characterized by great variability and uncertainty precipitation, discharge. For this reason, a systematic approach to handling the problem is absolutely essential.

From the flood frequency study carried out on Upper Krishna River basin catchment for 2 yrs, 5yrs, 10yrs, 25yrs, 50yrs, 100yrs and 200 yrs The estimated discharges obtained . It has been observed that design floods for return period of 2 year were flood to be almost same as the observed data and verified with historical data. Arjunwad river gauging station is having very high design flood as compare to other gauging station in the study area. These flood frequencies and design can be used as a guide in determining the capacity and design of structure like bridges, culverts.

ACKNOWLEDGEMENT

The author is pleased to acknowledge to Chief Er.C.A.Birajdhar and H.T.Dhumal, Department of Water recourse, Govt .of Maharashtra for availability of data and encouragement to write this paper.Greatful acknowledgement are also due to Prof. Nayan Sharma, Professor &Head Department of WRD&M, and Prof. Pradeep Kumar Garg, Indian Institute of Technology,Roorkee who reviewed and given insightful comments on drafting of this paper.

REFERENCES

[1] Akintola, J.O. 1986 Rainfall distribution in Nigeria 1892-1983, Impact publishers Nig. Ltd., Ibadan.
[2] Arora, K.R. 2007. Irrigation, Water Power and Water resources Engineering. Standard Publishers Distributors, New Delhi
[3] Asawa, G.L. 2005. Irrigation and Water resources Engineering. New Age International Ltd. Publishers,New Delhi
[4] Bhakar, S.R., Bansal, A.N. Chhajed, N., and Purohit, R.C. 2006. Frequency analysis of consecutive days maximum rainfall at Banswara, Rajasthan, India. ARPN Journal of Engineering and Applied Sciences. 1(3): 64-67.
[5] Borbda and Benin Owena 2005.River basin Hydrological year Book, 1995-1998
[6] Bruce, J.P., and Clark, P.H. 1988. Introduction to hydrometeorology. Pergamon Press, Oxford
[7] Chow, V.T., D.R.Maidment and L.W.Mays 1988. Applied Hydrology. McGraw Hill Book Company,Singapore.
[8] Garg P.K., K.P.Sharma.and S.C.Jain.1986 Satellite Remote Sensing for Mapping of Flood-Plains and Allied Features, Int. Symp. on Flood Frequency and Risk Analysis, Louisiana, USA.
[9] Haktan Y.T 1992. Comparison of Various flood frequency distribution using annual flood peaks data of rivers in Anatolis. Journal of Hydrology. Vol.136; pp1-31
[10] Haan, C.T. 1977. Statistical methods in hydrology. Ames, IA: Iowa State University Press.
[11] Ibrahim M.H., and E.A. Isiguzo, 2009. Flood Frequency Analysis of Guara River Catchment at Jere, Kaduna State, Nigeria,. Scientific Research and Essay Vol. 4 (6), pp. 636 – 646.
[12] Jagadesh, T.R. and M.A.Jayaram 2009. Design of bridge Structures. 2nd Edition. PHI Learning PVT Ltd, New Delhi India
[13] Prasuhn, A. 1992. Fundamentals of Hydraulic Engineering. Oxford University Press New York
[14] O.C.Izinyon,N.Ihimkpen. Flood Frequency Analysis of Ikpoba River Catchment at Benin city Using Log Prearson Type III
[15] Distribution, Journal of Emerging Trends in Engineering and Applied Sciences Vol.2(1) pp-50-55
[16] Ojha, G.S.P.,R Berndtsson .and P.Bhunya 2008. Engineering Hydrology. 1st Edition, Oxford University Press. New Delhi, India
[17] Sankhua, R.N.N. Sharma, P.K.Garg, and A.D.Pandey, 2005. Use of remote sensing and ANN in assessment of erosion activities in Majuli, the world's largest river island: Int. Journal of Remote Sensing, Vol. 26, pp. 4445 – 4454.
[18] Upadhaya, A., and Singh, S.R. 1998. Estimation of consecutive days Maximum Rainfall by Various Methods and their Comparison. Indian Journal of S. Cons. 26(2): 193-2001.