DESING FLOOD ESTIMATION OF RIVER KRISHNA –KOYANA CONFLUENCE BASIN CATCHMENT AREA IN WESTERN MAHARASHTRA USING LOG PERSON Type III DISTRIBUTION

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ABSTRACT

In this study, a flood frequency analysis of Krishna and Koyna river basin 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 confluence at city Karad. The annual peak flood series data for 10 years varying over period 1965 to 2010 for river gauge stations at Karad and Warunji are analyzed. These stations are important for flash flood point of view. Krishna River in India which comes under heavy rainfall. River Koyna is main tributaires of Krishna which recived enormouse amount of rainfall during the moonson every year causing a devasting flood The probability distribution function was applied to return periods (T) for 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.

Keywords: flood frequency analysis, return period, Log Pearson Type III.

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 (Prasuhn, 1992). Design flood is the discharge adopted for the design of a hydraulic structure (Asawa, 2005) 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.

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 (Upadhaya and Singh, 1998). 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 (Bruce and Clark, 1966).

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 (Bhakar *et al.*, 2006).

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)

1. The Geography of 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. The total geographical area of the Krishna basin in Satara is 10,816 km^2 (4%) and that of Sangli is 8,572 km^2 (3.2%). In Satara district alone, the length of the Krishna River is about 160 km. The confluence of Krishna and Koyna is at Karad.The soils in the study area are in-situ in nature and a major portion comprises mainly of medium black cotton (b.c) soils. These b.c. soils are the weathered derivations of the Deccan Basalts. Extensive bleaching and weathering of b.c. soils has given rise to red loamy and lateritic soils. Amongst all types of land uses, agriculture is dominant with 86% and 83%, 81% of the cultivable land is actually under plough in the districts of Satara and Sangli and Kolhapur respectively. (Report of Maharastra water and irrigation commission vol. 1, 2, 3.)

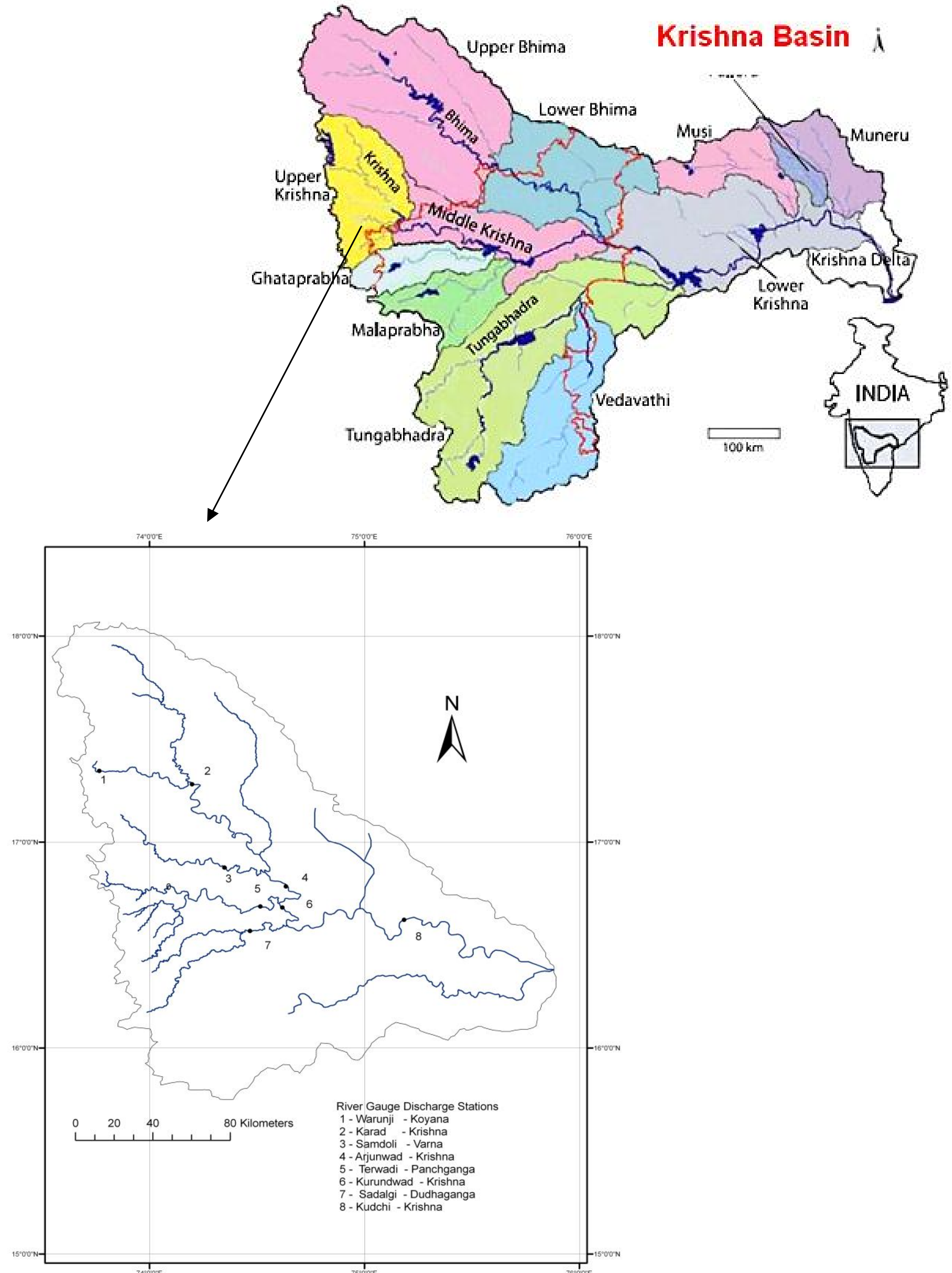

Krishna Basin
Upper Bhima
Bhima
Lower Bhima
Musi
Muneru
Krishna
Upper Krishna
Middle Krishna
Krishna Delta
Ghataprabha
Lower Krishna
Malaprabha
Tungabhadra
Vedavathi
INDIA
100 km
74°0'0"E
75°0'0"E
76°0'0"E
18°0'0"N
17°0'0"N
16°0'0"N
15°0'0"N
N
1
2
3
4
5
6
7
8
0 20 40 80 Kilometers
River Gauge Discharge Stations
1 - Warunji - Koyana
2 - Karad - Krishna
3 - Samdoli - Varna
4 - Arjunwad - Krishna
5 - Terwadi - Panchganga
6 - Kurundwad - Krishna
7 - Sadalgi - Dudhaganga
8 - Kudchi - Krishna

Figure No.1 Study Area and Location of Gauge Discharge.

2 .Data used

The daily annual peak flood series data for 10 years varying over period 1965 to 2010 for stations such as Karad (Krishna), Warungi (Koyna) of Upper Krishna basin. The data were collected from the Maharashtra state irrigation department (Table 1)

3. Theory 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.

3.1 Flood Discharge Computational Analysis

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

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

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

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

$$\boldsymbol{\sigma} = \left|\frac{1}{(n-1)}\sum(X-\bar{X})^2\right|^{1/2} \quad (3)$$

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

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:

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

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

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

$$\varphi_{logX} = \left[\frac{\sum(logXi-logX)^2}{(n-1)}\right]^{1/2} \quad (7)$$

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

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

4. Methodology

Log Pearson Type III distribution and given in equation

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

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 (X_{ii}) were assembled
(ii) The logarithms of the annual flood series were calculated as $y_i = \log X_i$

(iii) The mean y, the standard deviation $_y$ and skew coefficient Cs of the logarithm y_i were calculated.
(iv) The logarithms of the flood discharge i.e. log Q_i for each of the several chosen probability level P_j were calculated using the following frequency formula
Log $_i Q = y + K S$ where K_j is the frequency factor, a function of the probability P_j 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 P_i probability level (return period T_j) is obtained by taking antilogarithms of the $\log\varphi$ values.

Table No. 1: Annual peak Discharge data for river gauging stations (m^3 /s)

Sr.No.	Water Year	River gauging Stations		Sr.No.	Water Year	River gauging Stations	
		Karad (Krishna), Q(cumecs)	Warunji (Koyna) Q(cumecs)			Karad (Krishna), Q(cumecs	Warunji (Koyna) Q(cumecs
1	1965-1966	4760	Data not Available	23	1987-1988	1323	1073
2	1966-1967	2673		24	1988-1989	3205	2590
3	1967-1968	4482	3830	25	1989-1990	2504	1600
4	1968-1969	1527	757.4	26	1990-1991	4361	2530
5	1969-1970	4267	1605	27	1991-1992	3150	1800
6	1970-1971	2428	1492	28	1992-1993	2127	1238
7	1971-1972	2156	1386	29	1993-1994	1812	1023
8	1972-1973	2190	1523	30	1994-1995	3915	2675
9	1973-1974	3051	1900	31	1995-1996	1356	772.1
10	1974-1975	3101	1583	32	1996-1997	2944	1566
11	1975-1976	3231	1681	33	1997-1998	5954	3529
12	1976-1977	4562	2780	34	1998-1999	1541	828
13	1977-1978	3422	1610	35	1999-2000	2111	1397
14	1978-1979	2187	1576	36	2000-2001	774.1	676.7
15	1979-1980	2435	1317	37	2001-2002	911.2	623.3
16	1980-1981	2848	1868	38	2002-2003	1121	830.2
17	1981-1982	1942	1262	39	2003-2004	936.6	626.7
18	1982-1983	1261	1156	40	2004-2005	4163	2716
19	1983-1984	1931	1493	41	2005-2006	6312	4641
20	1984-1985	1797	1334	42	2006-2007	6708	4973
21	1985-1986	1363	1054	43	2007-2008	3868	2243
22	1986-1987	1801	1284	44	2008-2009	2884	1887

Table No.2 Computation of statistical parameters for Karad (Krishna)

Rank (m)	Water Year	Qmax (X m^3/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	2003-2004	9366	3.971	0.2626	0.1345	42.2	2.369
2	2001-2002	9112	3.959	0.2505	0.1254	21.1	4.739
3	2000-2001	7741	3.888	0.1846	0.0793	14.06	7.109
4	2006-2007	6708	3.826	0.1350	0.0496	10.55	9.478
5	2005-2006	6312	3.800	0.1163	0.0397	8.440	11.848
6	1997-1998	5954	3.774	0.0996	0.0315	7.033	14.218
7	1965-1966	4760	3.677	0.0477	0.0104	6.028	16.587
8	1976-1977	4562	3.659	0.0400	0.0080	5.275	18.957
9	1967-1968	4482	3.651	0.0370	0.0071	4.688	21.327
10	1990-1991	4361	3.639	0.0326	0.0059	4.220	23.696
11	1969-1970	4267	3.630	0.0292	0.0050	3.836	26.066
12	2004-2005	4163	3.619	0.0257	0.0041	3.516	28.436
13	1994-1995	3915	3.592	0.0178	0.0024	3.246	30.805
14	2007-2008	3868	3.587	0.0165	0.0021	3.014	33.175
15	1977-1978	3422	3.534	0.0056	0.0004	2.813	35.545
16	1975-1976	3231	3.509	0.0025	0.0001	2.637	37.914
17	1988-1989	3205	3.505	0.0022	0.0001	2.482	40.284
18	1991-1992	3150	3.498	0.0015	0.0001	2.344	42.654
19	1974-1975	3101	3.491	0.0010	0.0000	2.221	45.02
20	1973-1974	3051	3.484	0.0006	0.0000	2.110	47.393
21	1996-1997	2944	3.468	0.0001	0.0000	2.009	49.763
22	2008-2009	2884	3.459	0.0000	0.0000	1.918	52.132
23	1980-1981	2848	3.454	0.0000	0.0000	1.834	54.502
24	1966-1967	2673	3.426	0.0010	0.0000	1.758	56.872
25	1989-1990	2504	3.398	0.0037	-0.0002	1.688	59.241
26	1979-1980	2435	3.386	0.0053	-0.0004	1.623	61.611
27	1970-1971	2428	3.385	0.0055	-0.0004	1.562	63.981
28	1972-1973	2190	3.340	0.0141	-0.0017	1.507	66.350
29	1978-1979	2187	3.339	0.0142	-0.0017	1.455	68.720
30	1971-1972	2156	3.333	0.0157	-0.0020	1.406	71.090
31	1992-1993	2127	3.327	0.0173	-0.0023	1.361	73.459
32	1999-2000	2111	3.324	0.0181	-0.0024	1.318	75.829
33	1981-1982	1942	3.288	0.0292	-0.0050	1.278	78.199
34	1983-1984	1931	3.285	0.0301	-0.0052	1.241	80.568
35	1993-1994	1812	3.258	0.0404	-0.0081	1.205	82.938
36	1986-1987	1801	3.255	0.0415	-0.0084	1.172	85.308
37	1984-1985	1797	3.254	0.0419	-0.0086	1.140	87.677
38	1998-1999	1541	3.187	0.0736	-0.0200	1.110	90.047
39	1968-1969	1527	3.183	0.0758	-0.0209	1.082	92.417
40	1985-1986	1363	3.134	0.1054	-0.0342	1.055	94.786
41	1995-1996	1356	3.132	0.1069	-0.0349	1.029	97.156
42	1987-1988	1323	3.121	0.1140	-0.0385	1.004	99.526
43	1982-1983	1261	3.100	0.1285	-0.0460	0.981	101.895
44	2002-2003	1121	3.049	0.1677	-0.0687	0.959	104.265
Average		$\bar{X}$ = **340.75**	$\bar{y}$ = **3.459**	**Sum = 2.385**	**Sum =0.196**		
		Std. deviation σ =3.171		**Skew coeff. g = 0.0112**			

Table No.3 Computation of statistical parameters for Warunji (Koyna)

Rank (m)	Water Year	Qmax ($X m^3/s$)	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	0.12968	70.33	1.42
2	2005-2006	4641	3.6666	0.226	0.10796	26.37	3.79
3	1967-1968	3830	3.5831	0.1542	0.06058	16.23	6.16
4	1997-1998	3529	3.5476	0.1275	0.04557	11.72	8.53
5	1976-1977	2780	3.4440	0.0643	0.01630	9.173	10.90
6	2004-2005	2716	3.4339	0.0592	0.01443	7.535	13.27
7	1994-1995	2675	3.4273	0.0561	0.01329	6.39	15.63
8	1988-1989	2590	3.4132	0.0496	0.01106	5.55	18.00
9	1990-1991	2530	3.4031	0.0452	0.00961	4.90	20.37
10	2007-2008	2243	3.3508	0.0257	0.00412	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	0.00062	3.63	27.48
13	1980-1981	1868	3.2713	0.0065	-0.00180	3.34	29.85
14	1991-1992	1800	3.2552	0.004	0.00027	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	2.04	48.81
22	1972-1973	1523	3.1826	6.00397E-05	-4.6522E-07	1.95	51.18
23	1983-1984	1493	3.1740	0.000268	-4.40177E-06	1.86	53.55
24	1970-1971	1492	3.1737	0.000278	-4.64043E-06	1.78	55.92
25	1999-2000	1397	3.1451	0.002047	-9.26647E-05	1.71	58.29
26	1971-1972	1386	3.1417	0.002370	-0.000115	1.64	60.66
27	1984-1985	1334	3.1251	0.004263	-0.000278	1.58	63.03
28	1979-1980	1317	3.1195	0.005021	-0.000355	1.52	65.40
29	1986-1987	1284	3.1085	0.006704	-0.000549	1.47	67.77
30	1981-1982	1262	3.1010	0.007990	-0.000714	1.42	70.14
31	1992-1993	1238	3.0927	0.009550	-0.000933	1.37	72.51
32	1982-1983	1156	3.0629	0.016253	-0.002072	1.33	74.88
33	1987-1988	1073	3.0305	0.025551	-0.004084	1.29	77.25
34	1985-1986	1054	3.0228	0.028092	-0.004708	1.25	79.62
35	1993-1994	1023	3.0098	0.032606	-0.005887	1.21	81.99
36	2002-2003	830.2	2.9191	0.073585	-0.019961	1.18	84.36
37	1998-1999	828	2.9180	0.074211	-0.020216	1.15	86.72
38	1995-1996	772.1	2.8876	0.091672	-0.02775	1.12	89.09
39	1968-1969	757.4	2.8793	0.096797	-0.030115	1.09	91.46
40	2000-2001	676.7	2.8303	0.129637	-0.046676	1.06	93.83
41	2003-2004	626.7	2.7970	0.154754	-0.060878	1.03	96.20
42	2001-2002	623.3	2.7946	0.156619	-0.061982	1.01	98.57
Average		$\bar{X}$ =**1769.74**	$\bar{y}$ =**3.1904**	**Sum = 2.011**	**Sum = 0.1250**		
		Std. deviation σ = $\mathbf{0.2214}$		**Skew coeff. g = 1.790**			

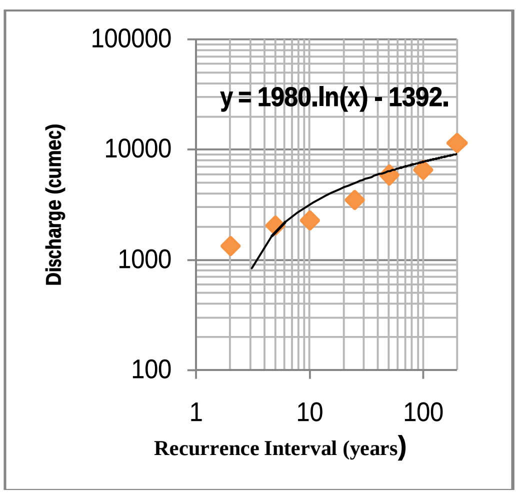
Table No.4: Calculation of Discharge for return period for Karad (Krishna)

River Gauge Station	Return period T(yrs)	Probability P(%)	Frequency factor K g = 0.0112	yi = log Q $yi = \bar{y} + K\,X\,Sy$	Xi = Q m^3/s	Relation between Expected Discharge and Return Period
Karad	2	50	-0.001	3.413	2590.5	y = 1615.ln(x) + 1405
	5	20	0.842	3.606	4034.9	
	10	10	1.283	3.707	5088.6	
	25	4	1.754	3.814	6518.2	
	50	2	2.058	3.884	7650	
	100	1	2.332	3.946	8833.9	
	200	0.5	2.584	4.004	10083	

Table No.5:Calculation of Discharge for return period 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 m^3/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	

Fig.No.2: Relation between Discharge and return period



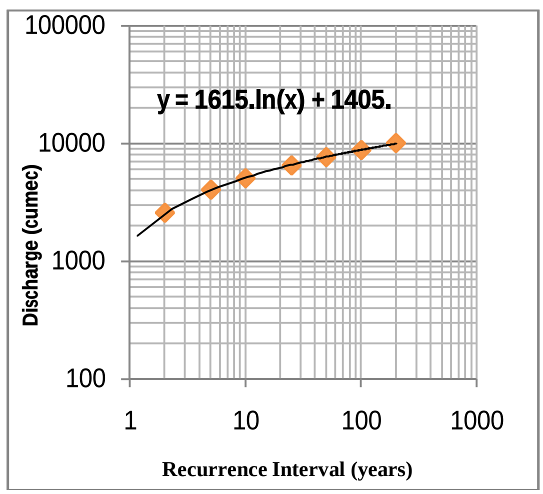


Table No.6:.Frequency Factors K for Gamma and log-Pearson Type III Distributions (Haan, 1977)

	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

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. These flood frequencies and design can be used as a guide in determining the capacity and design of structure like bridges, culverts.

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