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Flood Frequency Analysis by Statistical Methods for Kosi River

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ABSTRACT

There is a need to estimate format floods for areal making plans and the layout of essential infrastructure. An assignment is the mismatch between the period of the flood information and wished return duration. A majority of flood time collection are shorter than 50 years, and the preferred move returned intervals might be two hundred, 500, or 1,000 years. therefore, the estimation uncertainty is big. in this paper, we investigated how using historic information could likely beautify layout flood estimation. inside the present have a take a look at, flood frequency evaluation has been carried out for river Kosi in North factor of Bihar. The river Kosi is an important tributary of Ganga river gadget, which arising from Koshimool close to Kausani, Almora district flows at the western facet of the have a examine region and to satisfy at Ramganga River. The annual flood series assessment has been completed to estimate the flood quantities at one of a kind go back length at Kosi barrage web page of river Kosi. The statistical technique provided a benefit of estimation of flood at any internet web sites inside the homogeneous vicinity with very much less or no facts. within the at – internet site on line analysis of annual flood collection the normal, Log ordinary, Pearson type III, Log Pearson type III, Gumbel and Log Gumbel distribution were accomplished the usage of technique of moments . From the evaluation of various goodness of healthful checks, it's been discovered that the Log Gumbel distribution with approach of second as parameters estimation determined to be the brilliant-fit distribution for Kosi River and other websites within the location. it is recommended that the close by parameters for Kosi Basin can be used quality for primary estimation of flood and need to be reviewed while extra neighborhood data to be had.

Keywords: Flood Frequency Analysis, River Kosi, Frequency distribution methods, Return Period, Goodness of fit Test.

INTRODUCTION

Flood and drainage are the 2 vital interrelated troubles of Bihar, a poverty afflicted kingdom mainly in North Bihar. The North Bihar plains are drained bysome Himalayan rivers and the Ganga being the trunk drain. the ones rivers are perennial as the ones are rain similarly to snow fed. crucial rivers of North Bihar encompass the Kosi, Gandak, Baghmati, Burhi Gandak, Kamla, Kamla-Balan Mahananda, Kareh and few others. most of these rivers have relatively more youthful topography and are generated a huge quantity of water every year with maximum discharge and it engaged in channel deepening. They flow parallel to the Ganga within the South-east direction after which drain into it.Bihar is monsoonal in individual and its distribution shows big temporal and spatial variant. Rainfall is limited to few month most effective and is better in north-eastern element. this alteration in rainfall distribution reasons not unusual floods in North Bihar, big losses to plant life as massive areas are inundated every year. glaringly the most vital reasons ofthose recurrent floods are heavy and erratic rainfall and insufficient drainage.

The Kosi River (known as Kaushiki in Sanskrit literature) originates in Tibet at an elevation of 5500 m above MSL by using the use of the factor of foothills of Mount Everest and traverses through Nepal and India for a distance of about 720km earlier than turning into a member of the river Ganga close to Kursela. The river Kosi is the 0.33 biggest Himalayan River originating from the snowy peaks in the important Himalayas. Its three crucial tributaries in the Himalayasare the solar Kosi growing east of Katmandu,the Arun Kosi rising north of Mount Everest inside the Tibet and the Tamur Kosi growing west of Mount Kanchanjuna. These three tributaries join at Tribeni in Nepal and the river is called Kosi thereafter. The river upstream of Tribeni and for about 11 km downstream flows through deep gorge in Himalayas until it enters Gangetic undeniable at Chatra. From this element,the river runs in a sandy alluvial plainthrough Nepal terai upto Bhimnagar for a distance of 40 km. Thereafter, it flows through North Bihar and sooner or later falls into the Ganges near Kursela, the totaldistance from Bhimnagar to its fall in the Ganges being 260 km. Fig1.The higher Kosi river basin and the critical tributaries.

STUDY AREA

The entire catchment place of Kosi River Basin Bihar is about 74030 sq. km, and it is divided into sun Kosi, Arun and Tamur in the percentage of 32%, 58% and 10% respectively. The common rainfall in the secatchments varies from 1500 mm to 1250mm and in addition decreases by the use of 250 mm in the obvious. The common annual runoff measured at Baraksheta is set 53000 million cubic meters (five.3 million Ha m). eighty one% of this runoff is contributed at some point of June to October. the once a yr most discharge of the river varies from 5,665 m3/sec (2 lakh cusecs) to twenty-five,910 m three/sec (nine.15 lakh cusecs).

Origin: Tibet **Seasonality**: Perennial**Total length**: 260 km

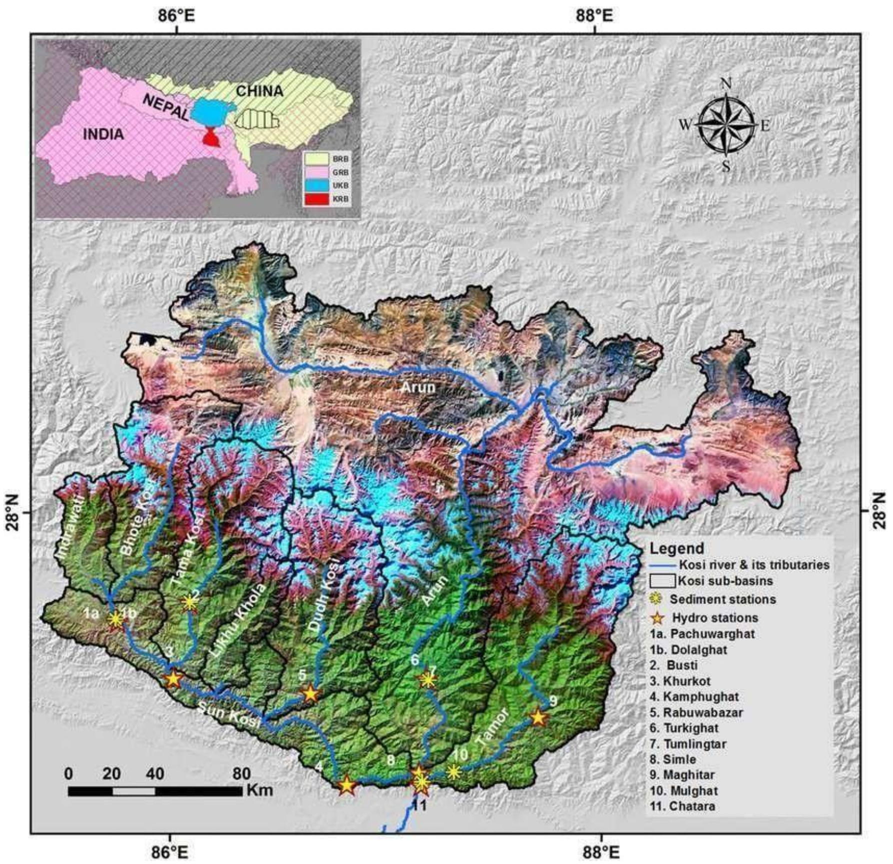

Fig1. The Upper Kosi river basin and the major tributaries.

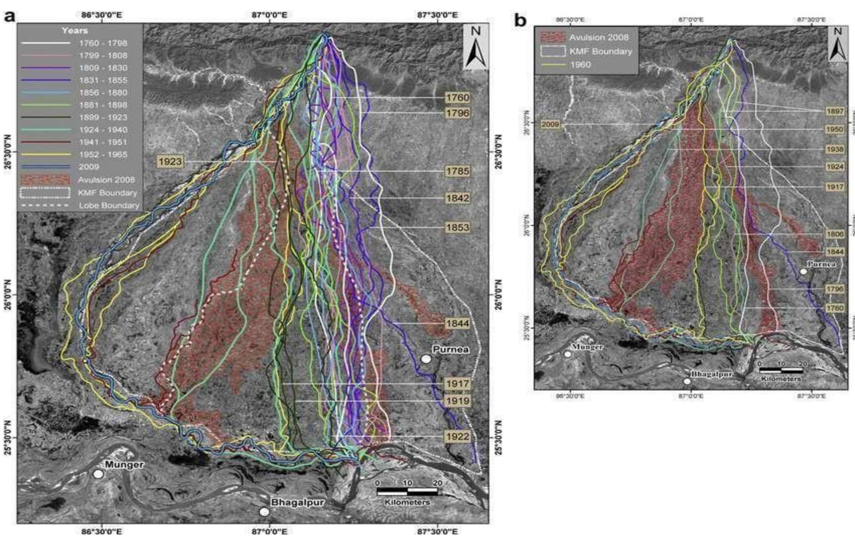

Fig. 2: Shifting courses of the River Kosi

METHODOLOGY: FLOODFREQUENCY ANALYSIS

Flood frequency analyses are used to assume layout floods for web sites along a river. The method entails the use of observed annual peak go with the flow discharge facts to calculate statistical records including suggest values, widespread deviations, skewness, and recurrence intervals. Flood frequency distributions can address many forms in keeping with the equations used to carry out the statistical analyses.

4 of the commonplace paperwork are:

- **Normal Distribution**
- **Generalized excessive price**
- **Gumbel Distribution**
- **Log-Pearson Type III Distribution**

Each distribution can be used to are waiting for format floods; however, there are advantages and disadvantages of each approach. in the present paper handiest distributions were used to are looking ahead to the probable floods of diverse recurrent intervals as defined under.

Gumbel's Method

Extreme value distribution introduced by Gumbel (1941) is commonly used. In probability theory and statistics, the Gumbel distribution (Generalized Extreme Value Distribution Type-I) is used to model the distribution of the maximum (or the minimum) of a number of samples of various distributions. This distribution might be used to represent the distribution of the maximum level of a river in a particular year if there was a list of maximum values for the past ten years. It is useful in predicting the chance that an extreme earthquake, flood or other natural disaster will occur. T= Return period,

Yt = Reduced Variant = - [ln T/T-1], K= (Yt - $Y\overline{n}$) / Sn,Xt = Estimated Discharge,
X = peak flow data.

Where $Y_T = -\left[\ln.\ln\frac{T}{T-1}\right]$

Y_n = Reduced mean, a function of sample size N and is arranged in Table-2. For $N \to \infty$,

$$Y_n \to 0.577$$

S_n = Reduced Standard Deviation function of sample size N and is arranged in Table-2.

For $N \to \infty$, $Y_n \to 1.2825$

K is also determined by formula given below

$$K = -\frac{\sqrt{6}}{\pi}\left\{0.5772 + \ln\left(\ln\frac{T}{T-1}\right)\right\} \qquad \text{For N >100}$$

LOG-PEARSON TYPE III DISTRIBUTION

The Log-Pearson type III distribution is a statistical technique for becoming frequency distribution information to are anticipating the layout flood for a river at some internet page. once the statistical data is calculated for the river net web page, a frequency distribution can be built. The possibilities of floods of various sizes can be extracted from the curve. The Log- Pearson type III distribution tells us the in all likelihood values of discharges to expect inside the river at diverse recurrence intervals primarily based totally on the available historic document. that is help full when designing structures in or close to the river that may be suffering from floods.in this the variate X is first transformed into logarithmic form (base 10) and the converted statistics is then analyzed. If X is the variant of random hydro-logic series.

Then the gathering of Z variate

Where $Z = \log_{10}X$

For this Z series, for any return period (T)

$$Z_T = \bar{Z} + K_z\sigma_Z$$

$\bar{Z}$ = Mean of Z values

σ_Z = Standard deviation of Z variate sample

N = Number of Samples

$$\sigma_Z = \sqrt{\frac{\Sigma(Z - \bar{Z})^2}{N-1}}$$

This variate K_z

$= f(C_s, T)$

K_z is determined from C_s and T relation table

Where C_s = Coefficient of skew of variate Z

$$= \frac{N\sum(Zi - \bar{Z})^3}{(N-1)(N-2)(\sigma_z)^3}$$

after finding ZT the corresponding value of XT is obtained XT = Antilog (ZT) base 10.

K_Z is also approximated by KITE (1977) as

$$K_Z = W - \frac{(2.515517 + 0.802853W + 0.0328W^2)}{(1 + 1.432788W + 0.189269W^2 + 0.001308W^3)}$$

Where $W = [\log(1/P^2)]^{1/2}$

$P = 1/T$ & $O < P \leq 0.5$

It is assumed that Maximum of the Maximum value of PMP calculated at each rain gauge stations will be the PMP for whole basin.

Test of Goodness of Fit

The validity of opportunity distribution characteristic proposed to in shape the empirical frequency distribution of a given sample can be tested graphically or by means of analytical techniques. The goodness in shape measure involves figuring out a distribution that suits the determined information. while computing the magnitudes of severe occasions, which include flood flows, it's far required that the chance distribution characteristic be revertible, in order that a given cost of recurrence c program language period (T) and the corresponding cost of frequency factor (ok) can be determined. For plotting formula were followed and compared to select the best flood frequency distribution that nice outfitted annual maximum flood flow of Kosi river catchment.

D-Index Test

In order to compare the relative fit of different distribution to hydro logical data. The probability of exceed of observation estimated by Weibull plotting position formula.

$$P(X \geq x) = \frac{m}{(N+1)}$$

where, P is the probability of exceed.

RESULT AND DISCUSSION

The commutated Statistical parameters are shown in Table 2, The probability distribution method is carried out to determine the predicted discharge for the return period of 10, 25, 50, 100, 200, 500,1000 in years are shown in Table 3.

Table 1.Computation of Statistical parameter

S. No	DISTRIBUTION	MODEL EFFICIENCY	RMSE	D-INDEX
1	GUMBLE	93.06	123.5	3.69
2	LOG PEARSON TYPEIII	92.31	118.6	3.48

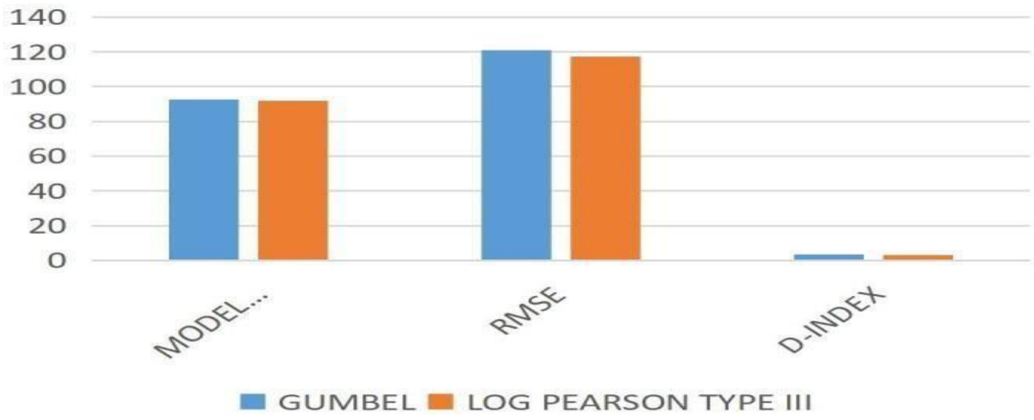

Fig. 3. Comparison of Gumbel and Log Pearson on Model, RMSE and D-index

Table 2.Values of Return Period Using Log-Pearson Type III Distribution

Return Period	Computed Discharge (m*3/s)	Standard Error (m*3/s)	Upper Confidence Level (m*3/s)	Lower Confidence (m*3/s)
10	2451	356	3180	1533
25	4477	514	5197	2837
50	6444	609	7299	4569
100	9340	714	10960	7851
200	13948	890	16783	12012
500	20149	950	28110	20927
1000	34117	1197	33055	33278

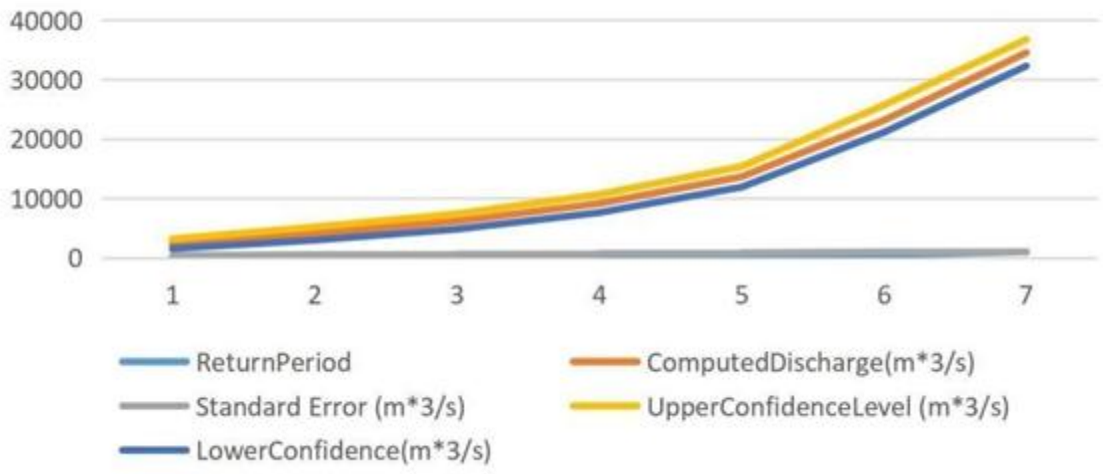

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Table 3. Data Analysis Using Gumble Method

YEAR	Discharge(Cumecs)	Discharge(1000' Cumecs)(X)	Mean Discharge (1000' Cumecs)(x)	(X-x)	(X-x)^2
1976	298589	298.589	364.3321	-65.7431	4322.155198
1977	255952	255.952	364.3321	-108.38	11746.24608
1978	407685	407.685	364.3321	43.3529	1879.473938
1979	332737	332.737	364.3321	-31.5951	998.250344
1980	804843	804.843	364.3321	440.5109	194049.853
1981	331663	331.663	364.3321	-32.6691	1067.270095
1982	467043	467.043	364.3321	102.7109	10549.52898
1983	434743	434.743	364.3321	70.4109	4957.694839
1984	364222	364.222	364.3321	-0.1101	0.01212201
1985	418578	418.578	364.3321	54.2459	2942.617667
1986	404461	404.461	364.3321	40.1289	1610.328615
1987	348117	348.117	364.3321	-16.2151	262.929468
1988	307826	307.826	364.3321	-56.5061	3192.939337
1989	295929	295.929	364.3321	-68.4031	4678.98409
1990	356708	356.708	364.3321	-7.6241	58.12690081
1991	423456	423.456	364.3321	59.1239	3495.635551
1992	308053	308.053	364.3321	-56.2791	3167.337097
1993	280759	280.759	364.3321	-83.5731	6984.463044
1994	315008	315.008	364.3321	-49.3241	2432.866841
1995	303327	303.327	364.3321	-61.0051	3721.622226
1996	518430	518.43	364.3321	154.0979	23746.16278
1997	350963	350.963	364.3321	-13.3691	178.7328348
1998	299606	299.606	364.3321	-64.7261	4189.468021
1999	540414	540.414	364.3321	176.0819	31004.83551
2000	416833	416.833	364.3321	52.5009	2756.344501
2001	489056	489.056	364.3321	124.7239	15556.05123
2002	417318	417.318	364.3321	52.9859	2807.505599
2003	377652	377.652	364.3321	13.3199	177.419736
2004	308229	308.229	364.3321	-56.1031	3147.55783
2005	334025	334.025	364.3321	-30.3071	918.5203104
2006	268655	268.655	364.3321	-95.6771	9154.107464
2007	262057	262.057	364.3321	-102.275	10460.19608
2008	347872	347.872	364.3321	-16.4601	270.934892
2009	301511	301.511	364.3321	-62.8211	3946.490605
2010	328272	328.272	364.3321	-36.0601	1300.330812
2011	397001	397.001	364.3321	32.6689	1067.257027
2012	340762	340.762	364.3321	-23.5701	555.549614
2013	279639	279.639	364.3321	-84.6931	7172.921188
2014	413553	413.553	364.3321	49.2209	2422.696997
2015	406613	406.613	364.3321	42.2809	1787.674505
2016	415312	415.312	364.3321	50.9799	2598.950204
2017	303016	303.016	364.3321	-61.3161	3759.664119
2018	208591	208.591	364.3321	-155.741	24255.29023
2019	298616	298.616	364.3321	-65.7161	4318.605799
2020	251785	251.785	364.3321	-112.547	12666.84972
		16335.48			432338.4531

Table 4. Data Analysis Using Log Pearson Type Iii Method

YEAR	DISCHARGE(CUMECS) (X)	Z= log10X	$\bar{Z}$=Mean o log10X	$(Z - \bar{Z})$	$(Z - \bar{Z})$^2	(Z-Z)^3
1976	297389	5.4733249	5.465731	0.0075939	5.7667E-05	4.379E-07
1977	254752	5.4061176	5.465731	-0.0596134	0.00355376	-0.000212

1978	406485	5.60904452	5.465731	0.14331352	0.02053877	0.0029435
1979	331537	5.520532	5.465731	0.054801	0.00300315	0.0001646
1980	803643	5.90506317	5.465731	0.43933217	0.19301275	0.0847967
1981	330463	5.51912284	5.465731	0.05339184	0.00285069	0.0001522
1982	465843	5.66823957	5.465731	0.20250857	0.04100972	0.0083048
1983	433543	5.63703218	5.465731	0.17130118	0.02934409	0.0050267
1984	363022	5.55993295	5.465731	0.09420195	0.00887401	0.0008359
1985	417378	5.62052955	5.465731	0.15479855	0.02396259	0.0037094
1986	403261	5.60558622	5.465731	0.13985522	0.01955948	0.0027355
1987	346917	5.54022558	5.465731	0.07449458	0.00554944	0.0004134
1988	306626	5.48660898	5.465731	0.02087798	0.00043589	9.101E-06
1989	294729	5.46942287	5.465731	0.00369187	1.363E-05	5.032E-08
1990	355508	5.55084938	5.465731	0.08511838	0.00724514	0.0006167
1991	422256	5.62557583	5.465731	0.15984483	0.02555037	0.0040841
1992	306853	5.48693037	5.465731	0.02119937	0.00044941	9.527E-06
1993	279559	5.44647348	5.465731	-0.01925752	0.00037085	-7.14E-06
1994	223808	5.34987561	5.465731	-0.11585539	0.01342247	-0.001555
1995	302127	5.48018954	5.465731	0.01445854	0.00020905	3.023E-06
1996	517230	5.71368371	5.465731	0.24795271	0.06148054	0.0152443
1997	349763	5.54377387	5.465731	0.07804287	0.00609069	0.0004753
1998	298406	5.47480755	5.465731	0.00907655	8.2384E-05	7.478E-07
1999	539214	5.73176116	5.465731	0.26603016	0.07077205	0.0188275
2000	415633	5.61871002	5.465731	0.15297902	0.02340258	0.0035801
2001	487856	5.68829165	5.465731	0.22256065	0.04953324	0.0110242
2002	416118	5.6192165	5.465731	0.1534855	0.0235578	0.0036158
2003	376452	5.57570961	5.465731	0.10997861	0.01209529	0.0013302
2004	307029	5.4871794	5.465731	0.0214484	0.00046003	9.867E-06
2005	332825	5.52221594	5.465731	0.05648494	0.00319055	0.0001802
2006	267455	5.42725072	5.465731	-0.03848028	0.00148073	-5.7E-05
2007	260857	5.4164025	5.465731	-0.0493285	0.0024333	-0.00012
2008	346672	5.53991877	5.465731	0.07418777	0.00550382	0.0004083
2009	300311	5.47757124	5.465731	0.01184024	0.00014019	1.66E-06
2010	327072	5.51464337	5.465731	0.04891237	0.00239242	0.000117
2011	395801	5.59747689	5.465731	0.13174589	0.01735698	0.0022867
2012	339562	5.53091908	5.465731	0.06518808	0.00424949	0.000277
2013	278439	5.44473007	5.465731	-0.02100093	0.00044104	-9.26E-06
2014	402353	5.60460724	5.465731	0.13887624	0.01928661	0.0026785
2015	405413	5.60789767	5.465731	0.14216667	0.02021136	0.0028734
2016	414112	5.61711782	5.465731	0.15138682	0.02291797	0.0034695
2017	301816	5.47974226	5.465731	0.01401126	0.00019632	2.751E-06
2018	207391	5.31678991	5.465731	-0.14894109	0.02218345	-0.003304
2019	297416	5.47336433	5.465731	0.00763333	5.8268E-05	4.448E-07
2020	250585	5.39895507	5.465731	-0.06677593	0.00445902	-0.000298
		249.383413			**0.77298907**	**0.1746469**

CONCLUSION

In the present examine the end result shows that values of Kosi flood discharge for 10 years and two hundred years recurrence periods expected thru Log Pearson kind III are greater in comparison to that via Gumbel's technique. similarly for 25, 50 and a hundred years recurrence intervals the values from Gumbel's method are greater in comparison to that from Log Pearson kind III method. however, for Indian conditions, Log Pearson type III have to be used if there can be no scarcity of data. The Kosi river in north Bihar plains, eastern India indicates intense variability in phrases of flood significance and frequency each spatially in addition to temporally. Such efforts need to be part of non-structural measures of flood manage to lessen brief time period and prolonged-term damages and to carry interest a number of the clinical community on the functionality want of one of these take a look at. The flood embankments can't save you the shifting tendency of the river route. elevating of embankments will also be essential because of upward push in water degree as a result of aggravation. The embankments ought to be built sufficiently big with recognize to the khadirs of the river Kosi in order that the embanked river is capable of deliver the flood peaks retaining in view of the reality that the earthen embankments cannot stand velocities adjacent to banks exceeding approximately.

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