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PERFORMANCE EVALUATION OF FIVE PROBABILITY DISTRIBUTION MODELS FOR THE ANALYSIS OF FLOOD DATA AT RIVER NIGER

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ABSTRACT

Accurate flood prediction is essential for hydrological planning, yet selecting the most suitable probability distribution model remains a challenge. This study evaluates five statistical models to determine the most reliable method for predicting extreme flood events at River Niger. Flood frequency analysis procedure was carried out on the annual maximum discharge data for River Niger at Onitsha bridge head from 1960 to 1991 using Normal distribution, Gumbel distribution, Log normal, Log Pearson Type III and Pearson type III. Flood discharge estimates for return periods of 2 to 200 years provide valuable insights for flood mitigation strategies, hydraulic infrastructure design, and disaster preparedness. The results shows that Gumbel distribution model predicted discharge values in range of 21997.78m^3/s for 2 years return period to 37389.68m^3/s for 200years return period. For Log Normal distribution; 18620.87m^3/s for 2 years return period to 32656.49m^3/s for 200 years were estimated. Normal distribution; 19051m^3/s for 2 years return period to 29367m^3/s for 200 years. Log Pearson Type III predicted discharge values ranging between 9081m^3/s for 2 years return period to 28732m^3/s for 200 years return period, and Pearson Type III predicted discharges were within the range of 1996.95m^3/s for 2 years return period to 24415.53m^3/s for 200 years return period. The models were assessed using Mean Absolute Deviation Index (MADI), Relative Root Mean Square Error (RRMSE), and Probability Plot Correlation Coefficient (PPCC). Scaling and ranging method was used to arrange the result from the comparative method used to model the five different probability distributions.

Keywords: Flood, River Niger, Onitsha Head Bridge

INTRODUCTION

Flooding, as a natural phenomenon, is not new to Nigeria. It had been occurring at different places and times in varying degree, but often at manageable or 'tolerable', magnitude. In recent years however, the country has been threatened by quite unprecedented flooding of abnormal magnitude and damage, which had left hundreds of people homeless, and on communities which had made the federal government to spend billions of naira. Much of these flood disasters are attributed to rivers that overflow or burst their banks and inundate downstream plain lands. The torrential rains falling for many days on the upstream highlands cause most rivers to swell and overflow or breach their courses, submerging the surrounding floodplains (Osahon 2012).

Flood by general understanding is a vigorous dynamic phenomenon where discharge is more than the water carrying capacity of a river resulting in overtopping of the banks and inundation of areas which are otherwise dry. Floods are associated with some extreme natural events that happen on a geographical area called drainage basin. Drainage basin can be rural or urban hence flooding may be rural or urban. (Ehiorobo, 2012)

The basic cause of rural or river basin flooding is heavy rainfall. Rural floods are river basin events whereas urban flood can have both area wide and local origin.

Intervention with the natural environment as cities and town continue to grow, uncontrollable land-use pattern continue to change drastically and more area of land start getting impervious due to uncontrolled construction activities. As a result, there occur dramatic changes in urban hydrology from gradual rising discharge to quicker and higher peak flow occur.

Sometimes urban flood may occur due to inflow from rivers into urban drainage system during high stage. The sharp peak discharge of flood hydrograph due to high intensity rainfall may stress existing drainage facilities resulting in stagnation of water on roadways and open spaces causing pluvial flooding in towns and cities.

Floods are among the most devastating natural disaster worldwide, and have increasingly significant socio-economic impacts. Although appropriate planning and protection measures can reduce the severity of floods and limit the damage they cause, flood can never be entirely prevented (Ehiorobo, 2012).

The Niger River is the principal river of western Africa, extending for about 4,180 km. Its drainage basin is 2,117,700 km^2 in area. Its source is in the Guinea Highlands in southeastern Guinea. It runs in a crescent through Mali, Niger, on the border with Benin and then through Nigeria, discharging through a massive delta, known as the Niger Delta or the Oil Rivers, into the Gulf of Guinea in the Atlantic Ocean. The Niger is the third-longest river in Africa, exceeded only by the Nile and the Congo River (Thomson 1948). Its main tributary is the Benue River (Welocomme, 1986).

The well watered and elongated lower Niger river basin is situated strategically on both sides of the Niger river and behind the tributaries of the river down south of Baro in Niger state (Gobo 1988). River Niger source is from Guinea and passes through Timbuktu, Niger and Benin to Nigeria, and discharged to the ocean as shown in fig 1. It runs about 672km from north to south and about 42km from east to west at its widest section (Okereke 2006). It has an estimated area of about 42,874km^2. Warri and Baro are the lower and upper limits of the catchment area respectively (Ologunorisa 2006). It is bounded in the north by Niger State, northwest by Edo and Kogi states, south by Rivers/Delta States, east by Anambra state and west by Delta state. Wide and extensive floodplains are formed by the Niger, Anambra, Benue, Gurara and Asse rivers both in the north and south. The general elevation of the floodplain ranges from less than 20m in the west to 550m above sea level on the north eastern side.

Onitsha Bridge is located at the boundary between Asaba capital of Delta State and Onitsha in Anambra State. The area falls within humid tropical climate or the rain forest area with hot sunny summers and general wetness over two thirds of the year (April-November) (Gobo 1988). The short dry season and the dry harmattan winds prevail over the area between December and March. The average annual rainfall is 200mm. Average temperatures of between 22.7^{0}C and 25.8^{0}C are observed in the raining season while during dry season an average of between 22.4^{0}C and 26.9^{0}C are observed (Jeje 2001). The catchment is an area of hydromorphic and ferruginous soils and mudstones, which is influenced by sheet wash and fluvial action, contributing to the development of extensive floodplains (Okereke 2006).

Flood Frequency Analysis

Flood frequency analysis is a critical component of hydrological studies, providing essential insights for infrastructure design, disaster preparedness, and sustainable water resource management. Accurate estimation of flood magnitudes and their return periods relies heavily on the selection of appropriate probability distribution models, which serve as the foundation for predicting extreme hydrological events. In regions traversed by major river systems like the River Niger, understanding flood behavior is paramount to mitigating risks and enhancing resilience against climate-induced variability (Nkwunonwo, 2020). Despite advancements in statistical hydrology, the challenge of identifying the most suitable probability distribution for flood data persists, as hydrological extremes often exhibit complex patterns influenced by catchment characteristics, climatic factors, and anthropogenic interventions. Commonly applied distributions such as the Normal distribution, Gumbel, Log-Normal, Log-Pearson Type III, and Pearson Type III models each possess unique assumptions and applicability, yet their performance can vary significantly depending on regional data dynamics (Oguntunde, 2015). While previous studies have explored flood frequency analysis in diverse basins, there remains a gap in comprehensive evaluations tailored to the specific hydrological regime of the River Niger, where fluctuating flow regimes and increasing climate variability necessitate updated and region-specific modeling approaches.

This study evaluates the performance of five probability distribution models in analyzing annual maximum flood data from the River Niger, aiming to identify the most robust framework for predicting design floods. By employing statistical goodness-of-fit tests, graphical diagnostics, and error metrics, the research assesses the suitability of each model in capturing the river's flood characteristics. The findings aim to inform policymakers, engineers, and hydrologists, enabling evidence-based decisions for floodplain management, dam design, and climate adaptation strategies in the Niger Basin. Ultimately, this work contributes to the broader discourse on enhancing hydrological modeling accuracy in the face of evolving environmental challenges.

Peak Flood Estimation Methods

A flood is an unusually high stage in a river – normally the level at which the river overflows its banks and inundates the adjoining area. The damages caused by floods in terms of loss of life, property and economic loss due to disruption of economic activity are all too well known. The hydrograph of extreme floods and stages corresponding to flood peaks provide valuable data for purposes of hydrologic design (Garg, 1973). Further, of the various characteristics of the flood hydrograph, probably the most important and widely used parameter is the flood peak. At a given location in a stream, flood peaks vary from year to year and their magnitude constitutes a hydrologic series which enable one to assign a frequency to a given flood-peak value. In the design of practically all hydrologic structures the peak flow that can be expected with an assigned frequency (say 1 in 100 years) is of primary importance to adequately proportion the structure to accommodate its effect. The design of bridges, culvert waterways and spillways for dams and estimation of scour at a hydraulic structure are some examples wherein flood-peak values are required.

To estimate the magnitude of a flood peak the following methods are available:

i. Rational method,
ii. Empirical method,
iii. Unit-hydrograph technique, and
iv. Flood-frequency studies.

The use of a particular method depends upon (a) the desired objective, (b) the available data and (c) the importance of the project.

The fundamental problem in hydrology is to predict from existing data, however meager it may be, what will happen in the future. Hydrologists arrive at the maximum possible discharge of a river by obtaining it from available data and making various assumptions.

Flood forecasting of a river presents a challenge to researchers, because without an accurate prediction of the maximum flood of the River, any water control structure or water management programs will be unfruitful along the river.

As a result of the recent flooding of the river Niger and increase in torrential rainfall which had caused the flooding condition in Nigeria in 2012, there is the need to evaluate the design flood of the river which can be used to develop early warning systems and design structural facility for flood control within the River basin.

MATERIALS AND METHODS

The daily discharge data of River Niger from 1960 to 1991 obtained from the measurements carried out by the Niger River Basin Development Authority were obtained and subjected to flood frequency analysis (FFA) utilizing five probability distribution methods namely: Gumbel (Extreme Value Type I), Normal, Lognormal and Log-Pearson type III, and Pearson type III.

To satisfy the assumption of independence and identical distribution of data, the maximum of discharge which is the largest instantaneous peak flow occurring at any time during the year were selected in order to obtain annual series data and to ensure that annual peaks are independent of one another. Water year (flowyear) rather than calendar year was utilized for the analysis (Shaw, 1988). Based on available data from the Niger River Basin Authority on the discharge level, analysis of the river was carried out.

RESULTS AND DISCUSSION

Gumbel Parameter II Distribution Method

The discharge variates of the annual flood are arranged in descending order and the plotting position recurrence interval T for each discharge is obtained using Weibull plotting position. And the probability of exceedence is estimated using the formulae;

$P = \frac{1}{T}$

For the observed flood discharge data the sample mean is $\overline{Q}$ = 19,051 and the standard deviation σ = 4004.8.

The discharge magnitudes Q_T, the Frequency Factor K_T, and the reduced variate Y_T are calculated respectively; the results are shown in table 1. Q_T was then plotted against the corresponding T and Q_T was also plotted against the reduced variate Y_T as shown in fig. 1 and fig 2 respectively.

Then the frequency factor K_T, the reduced variate Y_T and discharge Q_T values was estimated for a return periods T of 2, 5, 10, 25, 50, 100, and 200 using the same equation, the result is tabulated in table 2.With the new Q_T, a graph of Q_T was plotted against T as shown in fig 3.

Table 1: The discharge magnitudes Q_T, and Weibull plotting position and the Frequency Factor K_T, and the reduced variate Y_T

Rank(m)	Year	Maximum discharge Q(cum/sec)	T=n-1/m	P= 100/T	T/(T-1)	Y_T	K_T	Q_T (cum/sec)
1	1962	26,100	31	3.23	0.03279	3.4176	3.114762	31525.00
2	1960	25,000	15.5	6.45	0.066691	2.7077	2.56121	29308.13
3	1964	24,500	10.33	9.68	0.101783	2.2849	2.231582	27988.04
4	1970	23,700	7.75	12.90	0.13815	1.9794	1.993383	27034.10
5	1969	23,400	6.20	16.13	0.175891	1.7379	1.80507	26279.95
6	1967	23,200	5.17	19.35	0.215111	1.5366	1.648123	25651.40
7	1966	23,100	4.43	22.58	0.255933	1.3628	1.512642	25108.83
8	1968	22,900	3.88	25.81	0.298493	1.2090	1.392701	24628.49
9	1963	22,400	3.44	29.03	0.342945	1.0702	1.284462	24195.01
10	1975	22,000	3.10	32.26	0.389465	0.9430	1.185281	23797.81
11	1974	21,700	2.82	35.48	0.438255	0.8250	1.093255	23429.27
12	1965	21,100	2.58	38.71	0.489548	0.7143	1.006957	23083.66
13	1971	20,800	2.38	41.94	0.543615	0.6095	0.925276	22756.55
14	1979	19,800	2.21	45.16	0.600774	0.5095	0.847325	22444.37
15	1978	19,700	2.07	48.39	0.661398	0.4134	0.772367	22144.17
16	1981	18,815	1.94	51.61	0.725937	0.3203	0.699772	21853.45
17	1961	18,300	1.82	54.84	0.79493	0.2295	0.628982	21569.95
18	1991	18,159	1.72	58.06	0.869038	0.1404	0.559486	21291.63
19	1977	18,000	1.63	61.29	0.949081	0.0523	0.490789	21016.51
20	1980	17,900	1.55	64.52	1.036092	-0.0355	0.422396	20742.61
21	1989	17,773	1.48	67.74	1.131402	-0.1235	0.353781	20467.82
22	1985	17,656	1.41	70.97	1.236763	-0.2125	0.284358	20189.80
23	1988	17,480	1.35	74.19	1.354546	-0.3035	0.213429	19905.74
24	1972	16,300	1.29	77.42	1.488077	-0.3975	0.140123	19612.17
25	1990	15,411	1.24	80.65	1.642228	-0.4961	0.06327	19304.38
26	1973	15,000	1.19	83.87	1.824549	-0.6013	-0.01882	18975.64
27	1986	14,726	1.15	87.10	2.047693	-0.7167	-0.10878	18615.36
28	1976	14,600	1.11	90.32	2.335375	-0.8482	-0.21128	18204.88
29	1987	13,566	1.07	93.55	2.74084	-1.0083	-0.3361	17704.99
30	1982	13,019	1.03	96.77	3.433987	-1.2337	-0.51189	17000.99
31	1983	12,079	1.00	100.00	-	-	-	-
32	1984	11,463	0.97	103.23	-	-	-	-

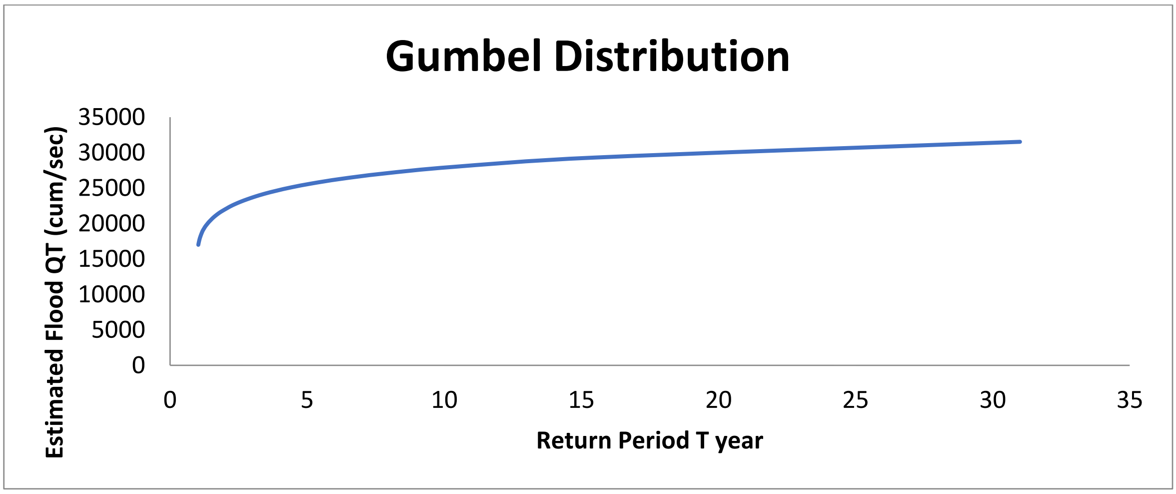

Figure 1: Estimated Flood Q_T plotted against Weibull plotting position of Return Period T

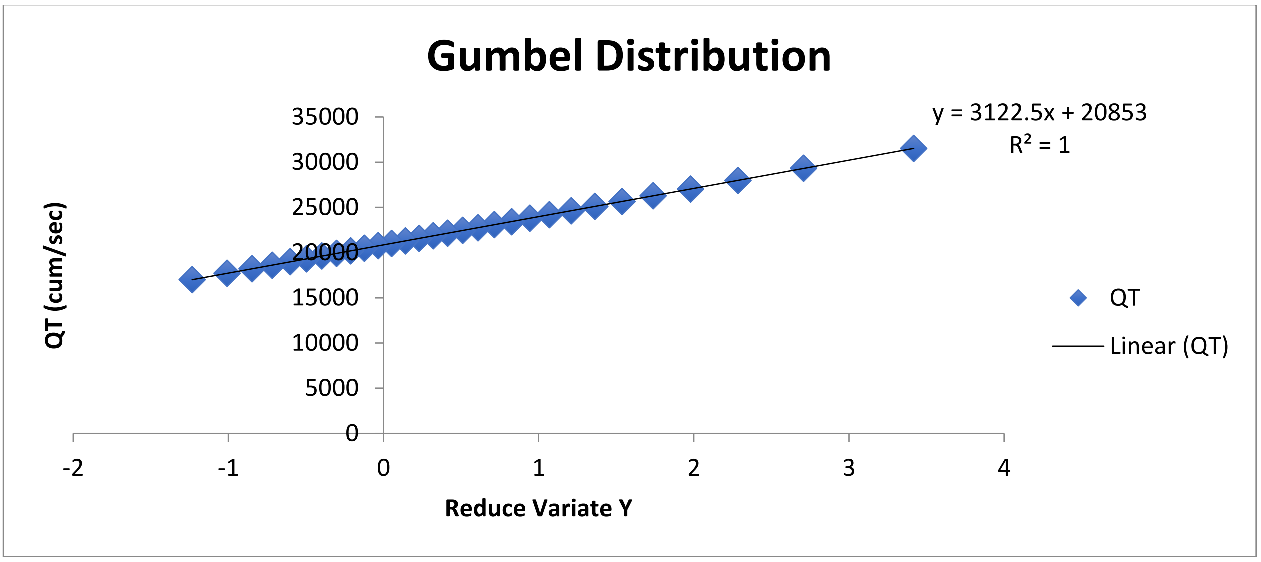

Figure 2: Estimated discharge $Q_T$against reduced Variate Y

From table 2 the estimated discharge increased as the number of the return period increases. For a return period of 2 years the estimated discharge was 2199.79m^3/s, and 25536.94 m^3/s for a 5 year return period, and 27880.18 m^3/s, 30840.86 m^3/s, 33037.26 m^3/s, 35217.45 m^3/s and 37389.68 m^3/s are the respective calculated discharge for the return period of 10, 25, 50, 100 and 200 years.

Table 2: Estimated Values for Q_T, Y_T and K_T for Return Period of 2, 5, 10, 25, 50, 100 and 200

T(yrs)	Y	K	Q(cum/sec)
2	0.3665	0.73581	21997.78
5	1.500	1.619539	25536.94
10	2.250	2.204645	27880.18
25	3.1985	2.943928	30840.86
50	3.9020	3.49237	33037.26
100	4.600	4.036763	35217.45
200	5.2950	4.579169	37389.68

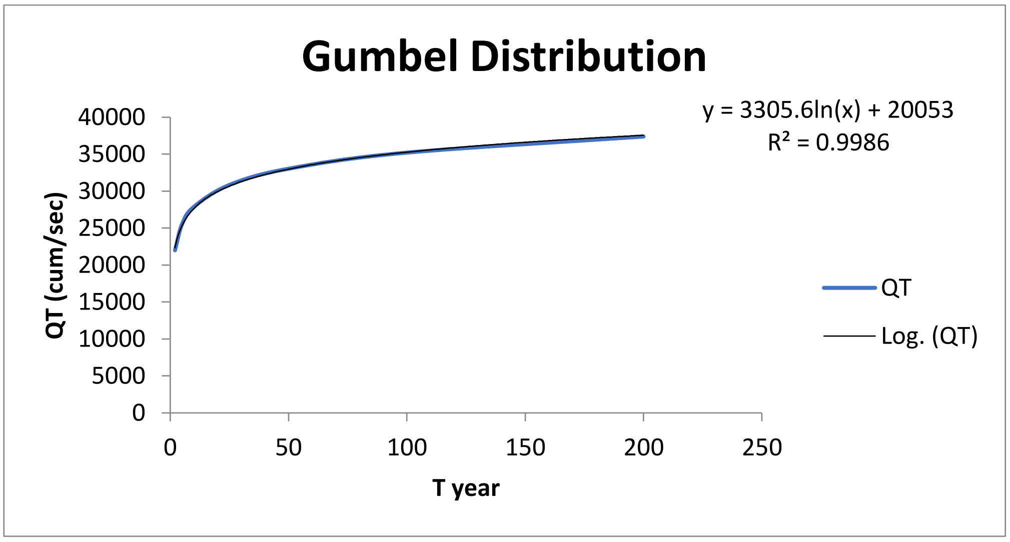

Figure 3: Estimated discharge Q_T against Return Period T of 2, 5, 10, 25, 50, 100, 200

Lognormal Parameter II Probability distribution

Lognormal distribution was fitted to the observed data by first ranking the data and then taking logarithms of each variate to transform the original series of peak flow data into log domain as shown in table 3. The return period and probability of exceedence is estimated using Gringoten plotting position formula.

Table 3: Data for log normal distribution and Gringoten plotting position

Rank(m)	Year	Maximum discharge (Xi) (cum/sec)	Y=log Xi	T= $\frac{n + 0.12}{m - 0.44}$	P =100/T
1	1962	26,100	4.4166	57.357	1.743
2	1960	25,000	4.3979	20.590	4.857
3	1964	24,500	4.3892	12.547	7.970
4	1970	23,700	4.3747	9.022	11.083
5	1969	23,400	4.3692	7.044	14.197
6	1967	23,200	4.3655	5.777	17.310
7	1966	23,100	4.3636	4.896	20.423
8	1968	22,900	4.3598	4.249	23.537
9	1963	22,400	4.3502	3.752	26.650
10	1975	22,000	4.3424	3.360	29.763
11	1974	21,700	4.3365	3.042	32.877
12	1965	21,100	4.3243	2.779	35.990
13	1971	20,800	4.3181	2.557	39.103
14	1979	19,800	4.2967	2.369	42.217
15	1978	19,700	4.2945	2.206	45.330
16	1981	18,815	4.2745	2.064	48.443
17	1961	18,300	4.2625	1.940	51.557
18	1991	18,159	4.2591	1.829	54.670
19	1977	18,000	4.2553	1.731	57.783
20	1980	17,900	4.2529	1.642	60.897
21	1989	17,773	4.2498	1.562	64.010
22	1985	17,656	4.2469	1.490	67.123
23	1988	17,480	4.2425	1.424	70.237
24	1972	16,300	4.2122	1.363	73.350
25	1990	15,411	4.1878	1.308	76.463
26	1973	15,000	4.1761	1.257	79.577
27	1986	14,726	4.1681	1.209	82.690
28	1976	14,600	4.1644	1.165	85.803
29	1987	13,566	4.1325	1.125	88.917
30	1982	13,019	4.1146	1.087	92.030
31	1983	12,079	4.0820	1.051	95.143
32	1984	11,463	4.0593	1.018	98.257
Mean			4.2700		
Std.dev			0.0947		

The normal reduced variable (z) corresponding to the probability of exceedence was determined using the probability of exceedence equations (Chow *et al*, 1988).

The Estimated flood discharge Log is presented in table 4. The estimated discharge and return periods that were obtained from table 4 were plotted, and the plot is shown in fig. 4.

Table 4: The Estimated discharge magnitudes Q_T and the Frequency Factor K_T for Lognormal Probability distribution

Rank(m)	year	maximum discharge (Xi) (cum/sec)	Y=log Xi	T= $\frac{n + 0.12}{m - 0.44}$	P =100/T	w	$K_T = z$	Log Q_T	Q_T= antilog (cum/sec)
1	1962	26,100	4.4166	57.357	1.743	2.8459	2.110423	4.4699	29502.38
2	1960	25,000	4.3979	20.590	4.857	2.4596	1.659243	4.4271	26738.08
3	1964	24,500	4.3892	12.547	7.970	2.2492	1.407344	4.4033	25309.03
4	1970	23,700	4.3747	9.022	11.083	2.0975	1.222264	4.3857	24307.95
5	1969	23,400	4.3692	7.044	14.197	1.9759	1.071536	4.3715	23522.01
6	1967	23,200	4.3655	5.777	17.310	1.8729	0.941906	4.3592	22866.44
7	1966	23,100	4.3636	4.896	20.423	1.7824	0.82643	4.3483	22297.84
8	1968	22,900	4.3598	4.249	23.537	1.7009	0.721011	4.3383	21791.13
9	1963	22,400	4.3502	3.752	26.650	1.6263	0.623095	4.3290	21330.80
10	1975	22,000	4.3424	3.360	29.763	1.5569	0.530834	4.3203	20905.95
11	1974	21,700	4.3365	3.042	32.877	1.4916	0.44288	4.3119	20508.82
12	1965	21,100	4.3243	2.779	35.990	1.4296	0.358282	4.3039	20133.96
13	1971	20,800	4.3181	2.557	39.103	1.3704	0.27621	4.2962	19776.85
14	1979	19,800	4.2967	2.369	42.217	1.3133	0.195976	4.2886	19433.85
15	1978	19,700	4.2945	2.206	45.330	1.2579	0.117061	4.2811	19102.30
16	1981	18,815	4.2745	2.064	48.443	1.2040	0.038932	4.2737	18779.62

17	1961	18,300	4.2625	1.940	51.557	1.2040	0.038932	4.2737	18779.62
18	1991	18,159	4.2591	1.829	54.670	1.2579	0.117061	4.2811	19102.30
19	1977	18,000	4.2553	1.731	57.783	1.3133	0.195976	4.2886	19433.85
20	1980	17,900	4.2529	1.642	60.897	1.3704	0.27621	4.2962	19776.85
21	1989	17,773	4.2498	1.562	64.010	1.4296	0.358282	4.3039	20133.96
22	1985	17,656	4.2469	1.490	67.123	1.4916	0.44288	4.3119	20508.82
23	1988	17,480	4.2425	1.424	70.237	1.5569	0.530834	4.3203	20905.95
24	1972	16,300	4.2122	1.363	73.350	1.6263	0.623095	4.3290	21330.80
25	1990	15,411	4.1878	1.308	76.463	1.7009	0.721011	4.3383	21791.13
26	1973	15,000	4.1761	1.257	79.577	1.7824	0.82643	4.3483	22297.84
27	1986	14,726	4.1681	1.209	82.690	1.8729	0.941906	4.3592	22866.44
28	1976	14,600	4.1644	1.165	85.803	1.9759	1.071536	4.3715	23522.01
29	1987	13,566	4.1325	1.125	88.917	2.0975	1.222264	4.3857	24307.95
30	1982	13,019	4.1146	1.087	92.030	2.2492	1.407344	4.4033	25309.03
31	1983	12,079	4.0820	1.051	95.143	2.4596	1.659243	4.4271	26738.08
32	1984	11,463	4.0593	1.018	98.257	2.8459	2.110423	4.4699	29502.38

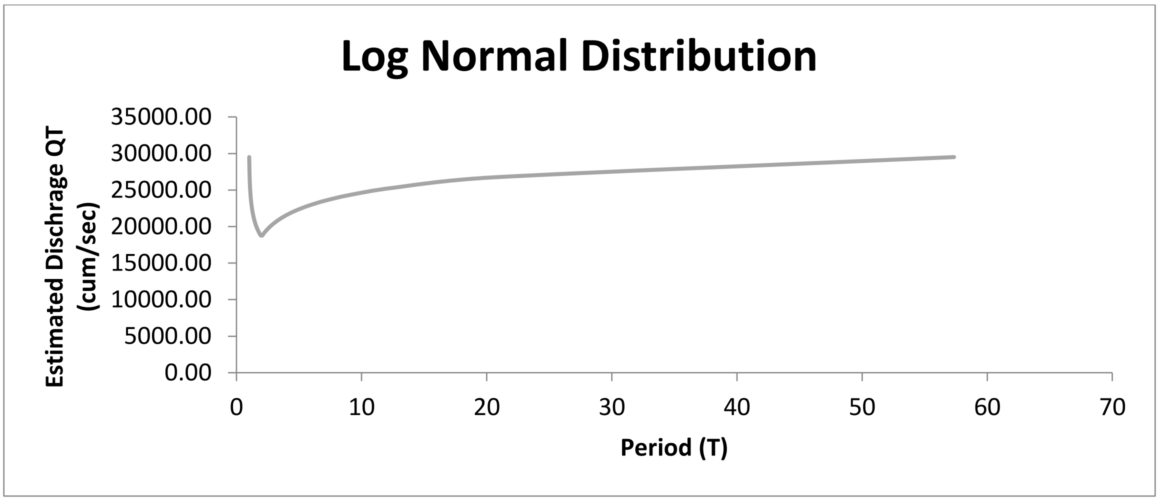

Figure 4: Plot of Estimated Discharge Q_T and Gringoten plotting position return Period T

The frequency factor (K) for Normal and log normal for different return periods can be obtained from the tables for Pearson and Log Pearson distribution but with skew (C_{sy}) equal to zero (Wurbs and James, 2009). The K values for Pearson Type III and Log- Pearson Type III distributions for zero skew coefficients are given in Table 5.

Table 5: K values for different T values for lognormal distribution

Skew coefficient(C_{sy}=0)	Recurrence Interval (yrs)						
	2	**5**	**10**	**25**	**50**	**100**	**200**
K	0.000	0.842	1.282	1.751	2.054	2.326	2.576

Substitute K into this Log $Q_T = \overline{\log Q} + K\sigma_{logx}$ the result is shown in Table 6, and the calculated discharge obtained was plotted against the return period of 2, 5, 10, 25, 50, 100, 200 years, the plot is shown in fig. 5.

Table 6: Application of Lognormal distribution to observed data

T	K_T	σ_{logx}	$K_T\sigma_{logx}$	$\overline{\log X}$	$LogQ_T=\overline{\log X} + K_T\sigma_{logx}$	$Q_T=10^{(YT)}$(m3/s)
2	0	0.0947	0	4.2700	4.2700	18620.87
5	0.842	0.0947	0.07974	4.2700	4.3497	22371.03
10	1.282	0.0947	0.12141	4.2700	4.3914	24625.20
25	1.751	0.0947	0.16582	4.2700	4.4358	27278.91
50	2.054	0.0947	0.19451	4.2700	4.4645	29142.83
100	2.326	0.0947	0.22027	4.2700	4.4903	30927.63
200	2.576	0.0947	0.24395	4.2700	4.5140	32656.49

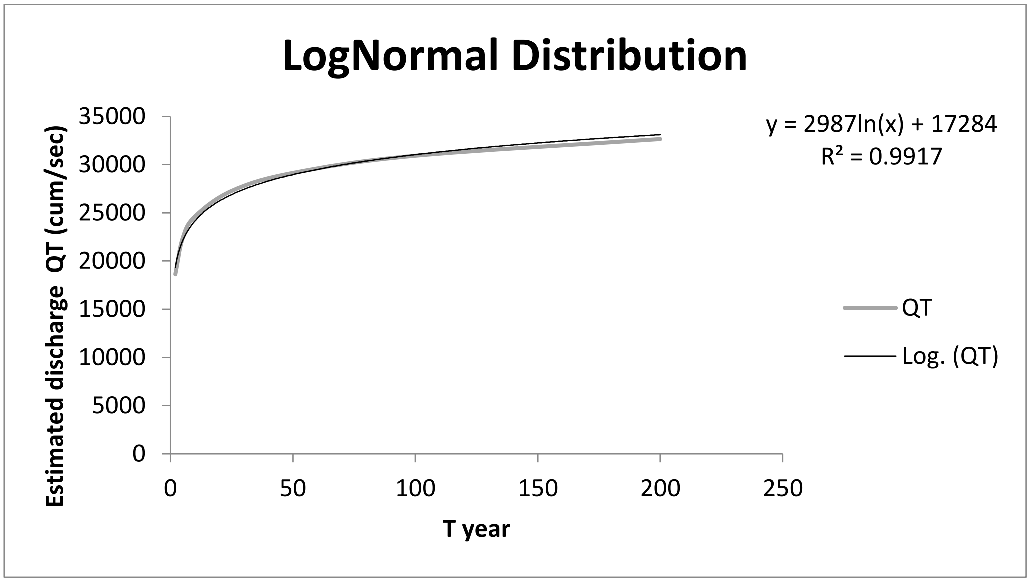

Figure 5: Estimated Discharge Q_T against Return Period T of 2, 5, 10, 25, 50, 100, and 200

From table 6 the various discharge calculated for return period of 2, 5, 10, 25, 50, 100, and 200 years are18620.87m^3/s, 2237.03m^3/s,24625.20m^3/s, 27278.91m^3/s, 29142.83m^3/s, 30927.63m^3/s and 32656.49m^3/s respectively.

Log Pearson Parameter III Distribution

In applying log- Pearson type III probability distribution to the annual series data of the river, the Parameter mean, standard deviation and skew coefficient of the log transformed data are: 4.27, 0.0963 and -0.5111 respectively (see Table 7).

Table 7: Data for log Pearson type III distribution and Cunnane plotting position.

Rank (m)	Year	maximum discharge (Xi) (cum/sec)	Y=log Xi	$T=\frac{n+0.2}{m-0.4}$	P=100/T
1	1962	26,100	4.4166	53.667	1.863
2	1960	25,000	4.3979	20.125	4.969
3	1964	24,500	4.3892	12.385	8.075
4	1970	23,700	4.3747	8.944	11.180
5	1969	23,400	4.3692	7.000	14.286
6	1967	23,200	4.3655	5.750	17.391
7	1966	23,100	4.3636	4.879	20.497
8	1968	22,900	4.3598	4.237	23.602
9	1963	22,400	4.3502	3.744	26.708
10	1975	22,000	4.3424	3.354	29.814
11	1974	21,700	4.3365	3.038	32.919
12	1965	21,100	4.3243	2.776	36.025
13	1971	20,800	4.3181	2.556	39.130
14	1979	19,800	4.2967	2.368	42.236
15	1978	19,700	4.2945	2.205	45.342
16	1981	18,815	4.2745	2.064	48.447
17	1961	18,300	4.2625	1.940	51.553
18	1991	18,159	4.2591	1.830	54.658
19	1977	18,000	4.2553	1.731	57.764
20	1980	17,900	4.2529	1.643	60.870
21	1989	17,773	4.2498	1.563	63.975
22	1985	17,656	4.2469	1.491	67.081
23	1988	17,480	4.2425	1.425	70.186
24	1972	16,300	4.2122	1.364	73.292
25	1990	15,411	4.1878	1.309	76.398
26	1973	15,000	4.1761	1.258	79.503
27	1986	14,726	4.1681	1.211	82.609
28	1976	14,600	4.1644	1.167	85.714
29	1987	13,566	4.1325	1.126	88.820
30	1982	13,019	4.1146	1.088	91.925
31	1983	12,079	4.0820	1.052	95.031

32	1984	11,463	4.0593	1.019	98.137
Average		19,051	4.2700		
Std derv.		4004.8	0.0947		
Skewcoeff.			-0.5111		

The results for Q_T and K_T are presented in table 8, and the results of T and discharge obtained from table 8 were plotted on Fig. 6

The K factor values for different return values for the skew coefficient (-0.5111) have been interpolated from the table in Appendix 1 and are presented in table 10, and the discharge Q_T obtained from table 10 were plotted against return period of 2, 5, 10, 25, 50, 100, 200 years, see fig 7.

Table 8: The Estimated discharge magnitudes Q_T and the Frequency Factor K_T for Log Pearsontype III Probability distribution

Rank(m)	Year	maximum discharge (Xi) (cum/sec)	Y=log Xi	T= (n + 0.2)/(m – 0.4)	P=100/T	z	K_T	Log Q_T	Q_T= antilog (cum/sec)
1	1962	26,100	4.4166	53.667	1.863	2.083345	1.79256	4.4398	27526.78
2	1960	25,000	4.3979	20.125	4.969	1.648226	1.49000	4.4111	25769.35
3	1964	24,500	4.3892	12.385	8.075	1.400292	1.30539	4.3936	24752.57
4	1970	23,700	4.3747	8.944	11.180	1.217145	1.16315	4.3802	23996.65
5	1969	23,400	4.3692	7.000	14.286	1.067581	1.04323	4.3688	23377.29
6	1967	23,200	4.3655	5.750	17.391	0.938744	0.93718	4.3588	22842.88
7	1966	23,100	4.3636	4.879	20.497	0.82382	0.84040	4.3496	22365.88
8	1968	22,900	4.3598	4.237	23.602	0.718898	0.75023	4.3410	21930.43
9	1963	22,400	4.3502	3.744	26.708	0.621329	0.66482	4.3330	21525.75
10	1975	22,000	4.3424	3.354	29.814	0.529362	0.58291	4.3252	21144.71
11	1974	21,700	4.3365	3.038	32.919	0.441718	0.50358	4.3177	20782.1
12	1965	21,100	4.3243	2.776	36.025	0.357346	0.42604	4.3103	20433.65
13	1971	20,800	4.3181	2.556	39.130	0.275507	0.34971	4.3031	20096.35
14	1979	19,800	4.2967	2.368	42.236	0.195491	0.27400	4.2959	19767.33
15	1978	19,700	4.2945	2.205	45.342	0.116759	0.19848	4.2888	19444.46
16	1981	18,815	4.2745	2.064	48.447	0.038832	0.12270	4.2816	19125.81
17	1961	18,300	4.2625	1.940	51.553	0.038832	0.12270	4.2816	19125.81
18	1991	18,159	4.2591	1.830	54.658	0.116759	0.19848	4.2888	19444.46
19	1977	18,000	4.2553	1.731	57.764	0.195491	0.27400	4.2959	19767.33
20	1980	17,900	4.2529	1.643	60.870	0.275507	0.34971	4.3031	20096.35
21	1989	17,773	4.2498	1.563	63.975	0.357346	0.42604	4.3103	20433.65
22	1985	17,656	4.2469	1.491	67.081	0.441718	0.50358	4.3177	20782.1
23	1988	17,480	4.2425	1.425	70.186	0.529362	0.58291	4.3252	21144.71
24	1972	16,300	4.2122	1.364	73.292	0.621329	0.66482	4.3330	21525.75
25	1990	15,411	4.1878	1.309	76.398	0.718898	0.75023	4.3410	21930.43
26	1973	15,000	4.1761	1.258	79.503	0.82382	0.84040	4.3496	22365.88
27	1986	14,726	4.1681	1.211	82.609	0.938744	0.93718	4.3588	22842.88
28	1976	14,600	4.1644	1.167	85.714	1.067581	1.04323	4.3688	23377.29
29	1987	13,566	4.1325	1.126	88.820	1.217145	1.16315	4.3802	23996.65
30	1982	13,019	4.1146	1.088	91.925	1.400292	1.30539	4.3936	24752.57
31	1983	12,079	4.0820	1.052	95.031	1.648226	1.49000	4.4271	25769.35
32	1984	11,463	4.0593	1.019	98.137	2.083345	1.79256	4.4699	27526.78

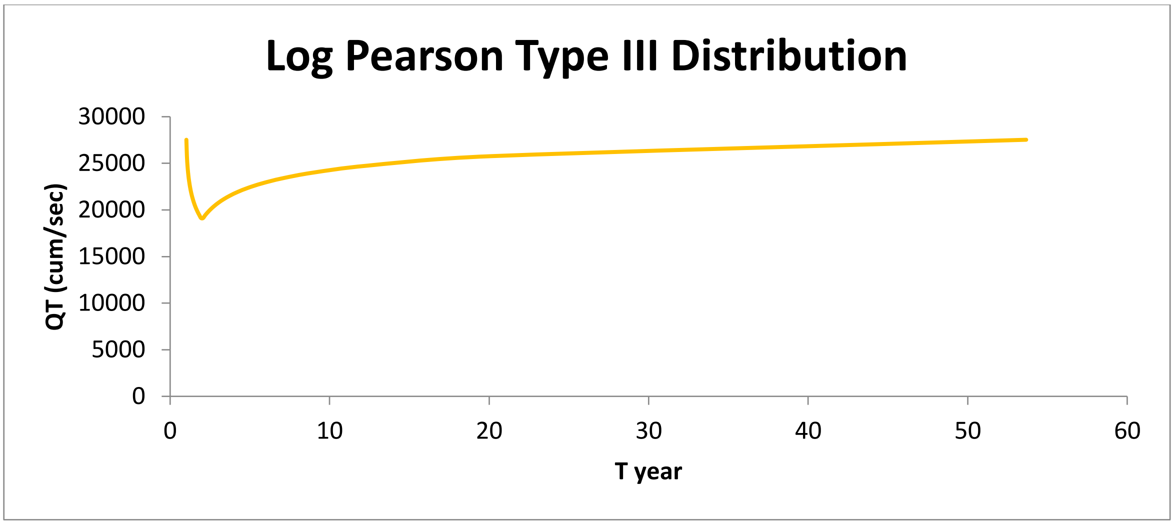

Figure 6: Plot of Estimated Discharge and Cunnane plotting position return Period T

Table 9: Application of Log Pearson type III distribution to observed data

Return Period (T)	Probability of exceedenace (P%)	K	k*σ	$\bar{y}$	logQ	antilog Q(cum/sec)
2	50	0.1101	0.0106	4.27	4.2806	19,081
5	20	0.8567	0.0825	4.27	4.3525	22,516
10	10	1.1886	0.11446	4.27	4.3845	24,236
25	4	1.5012	0.14457	4.27	4.4146	25,976
50	2	1.6818	0.16196	4.27	4.4320	27,037
100	1	1.8308	0.17631	4.27	4.4463	27,945
200	0.5	1.956	0.18836	4.27	4.4584	28,732

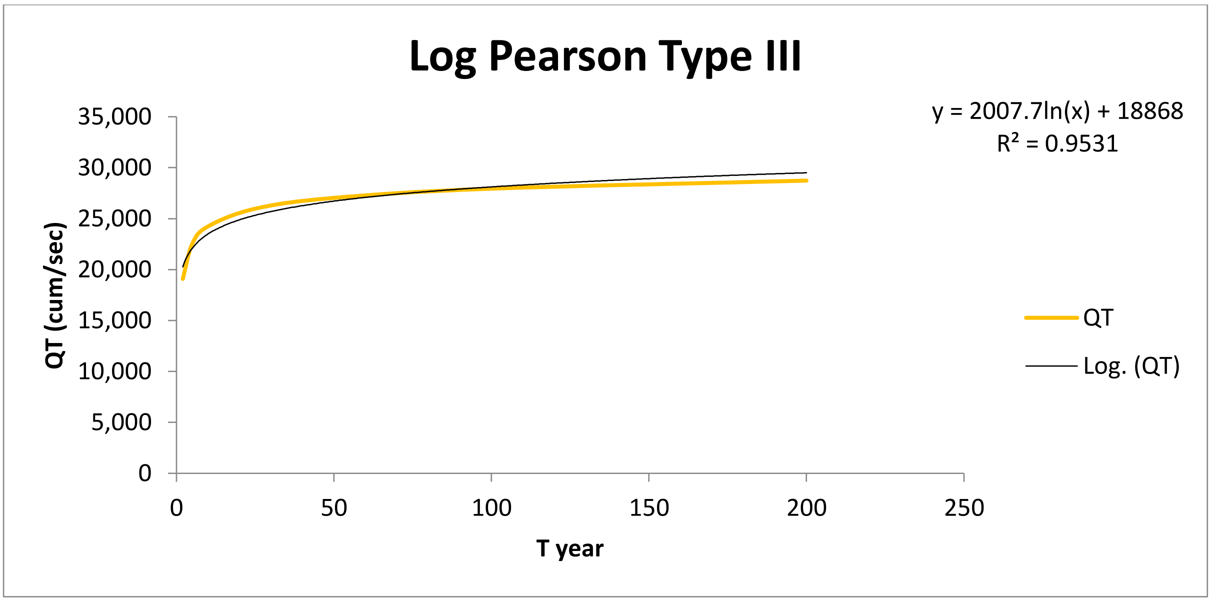

Figure 7: Estimated discharge Q_T against Return Period T of 2, 5, 10, 25, 50, 100, and 200

From table 9, the various discharge calculated for return period of 2, 5, 10, 25, 50, 100, and 200 years are19081m^3/s,22516m^3/s,24236m^3/s, 25976m^3/s, 27027m^3/s, 27945m^3/s and 28732m^3/s respectively.

Normal Parameter II Probability distribution

Normal distribution was fitted to the observed data by first ranking the data and then taking the mean and standard derivation. The return period and probability of exceedence is estimated using Blom plotting position formula. The results are presented on table 10.

Table 10: Data for Normal distribution and Blom plotting position

Rank (m)	year	maximum discharge x(cum/sec)	$\bar{x}$	σ	$T=\frac{n+0.25}{m-0.375}$	P=100/T
1	1962	26,100	19,051	4004.806	51.600	1.938
2	1960	25,000	19051	4004.806	19.846	5.039
3	1964	24,500	19051	4004.806	12.286	8.140
4	1970	23,700	19051	4004.806	8.897	11.240
5	1969	23,400	19051	4004.806	6.973	14.341
6	1967	23,200	19051	4004.806	5.733	17.442
7	1966	23,100	19051	4004.806	4.868	20.543
8	1968	22,900	19051	4004.806	4.230	23.643
9	1963	22,400	19051	4004.806	3.739	26.744
10	1975	22,000	19051	4004.806	3.351	29.845
11	1974	21,700	19051	4004.806	3.035	32.946
12	1965	21,100	19051	4004.806	2.774	36.047
13	1971	20,800	19051	4004.806	2.554	39.147
14	1979	19,800	19051	4004.806	2.367	42.248
15	1978	19,700	19051	4004.806	2.205	45.349
16	1981	18,815	19051	4004.806	2.064	48.450
17	1961	18,300	19051	4004.806	1.940	51.550
18	1991	18,159	19051	4004.806	1.830	54.651
19	1977	18,000	19051	4004.806	1.732	57.752
20	1980	17,900	19051	4004.806	1.643	60.853
21	1989	17,773	19051	4004.806	1.564	63.953
22	1985	17,656	19051	4004.806	1.491	67.054
23	1988	17,480	19051	4004.806	1.425	70.155
24	1972	16,300	19051	4004.806	1.365	73.256
25	1990	15,411	19051	4004.806	1.310	76.357
26	1973	15,000	19051	4004.806	1.259	79.457
27	1986	14,726	19051	4004.806	1.211	82.558
28	1976	14,600	19051	4004.806	1.167	85.659
29	1987	13,566	19051	4004.806	1.127	88.760
30	1982	13,019	19051	4004.806	1.089	91.860
31	1983	12,079	19051	4004.806	1.053	94.961
32	1984	11,463	19051	4004.806	1.020	98.062

The Estimated flood discharge Q_T was calculated and the antilog taken. For the observed flood discharge data the sample mean $\bar{\bar{Q}}$ = 19051 and standard deviation
σ = 4004.806
The frequency factor (K) for Normal and log normal for different return periods can be obtained from the Tables for Pearson and Log Pearson distribution but with skew (C_{sy}) equal to zero The K values for zero skew coefficients are given in table 11. These values of K was used to obtain the corresponding values of Q_T see table 12. The discharge calculated from table 11 was plotted against return period on table 12, fig. 8 shows the plot.

Table 11: K values for different T values for Normal distribution

Skew coefficient(G=0)	Recurrence Interval (yrs)						
	2	5	10	25	50	100	200
K	0.000	0.842	1.282	1.751	2.054	2.326	2.576

The value of K obtained from table 11 was used to calculate discharge Q_T and the results are presented in table 13. The discharge Q_T obtained from table 14 was plotted against return period of 2, 5, 10, 25, 50, 100, 200 years, see fig. 9.

Table 12: The Estimated discharge magnitudes Q_T and the Frequency Factor K_T for Normal Probability distribution

Rank (m)	Year	maximum discharge x (cum/sec)	$\bar{x}$	σ	$T=\frac{n+0.25}{m-0.375}$	P=100/T	K=z	Q_T (cum/sec)
1	1962	26,100	19,051	4004.806	51.600	1.938	2.067166	27329.6
2	1960	25,000	19051	4004.806	19.846	5.039	1.64144	25624.65
3	1964	24,500	19051	4004.806	12.286	8.140	1.395962	24641.56
4	1970	23,700	19051	4004.806	8.897	11.240	1.213995	23912.81
5	1969	23,400	19051	4004.806	6.973	14.341	1.065145	23316.7
6	1967	23,200	19051	4004.806	5.733	17.442	0.936758	22802.53
7	1966	23,100	19051	4004.806	4.868	20.543	0.8222	22343.75
8	1968	22,900	19051	4004.806	4.230	23.643	0.717567	21924.71

9	1963	22,400	19051	4004.806	3.739	26.744	0.620234	21534.92
10	1975	22,000	19051	4004.806	3.351	29.845	0.528467	21167.41
11	1974	21,700	19051	4004.806	3.035	32.946	0.440972	20817.01
12	1965	21,100	19051	4004.806	2.774	36.047	0.356759	20479.75
13	1971	20,800	19051	4004.806	2.554	39.147	0.275064	20152.58
14	1979	19,800	19051	4004.806	2.367	42.248	0.195184	19832.67
15	1978	19,700	19051	4004.806	2.205	45.349	0.116582	19517.89
16	1981	18,815	19051	4004.806	2.064	48.450	0.038757	19206.21
17	1961	18,300	19051	4004.806	1.940	51.550	0.038757	19206.21
18	1991	18,159	19051	4004.806	1.830	54.651	0.116582	19517.89
19	1977	18,000	19051	4004.806	1.732	57.752	0.195184	19832.67
20	1980	17,900	19051	4004.806	1.643	60.853	0.275064	20152.58
21	1989	17,773	19051	4004.806	1.564	63.953	0.356759	20479.75
22	1985	17,656	19051	4004.806	1.491	67.054	0.440972	20817.01
23	1988	17,480	19051	4004.806	1.425	70.155	0.528467	21167.41
24	1972	16,300	19051	4004.806	1.365	73.256	0.620234	21534.92
25	1990	15,411	19051	4004.806	1.310	76.357	0.717567	21924.71
26	1973	15,000	19051	4004.806	1.259	79.457	0.8222	22343.75
27	1986	14,726	19051	4004.806	1.211	82.558	0.936758	22802.53
28	1976	14,600	19051	4004.806	1.167	85.659	1.065145	23316.7
29	1987	13,566	19051	4004.806	1.127	88.760	1.213995	23912.81
30	1982	13,019	19051	4004.806	1.089	91.860	1.395962	24641.56
31	1983	12,079	19051	4004.806	1.053	94.961	1.64144	25624.65
32	1984	11,463	19051	4004.806	1.020	98.062	2.067166	27329.6

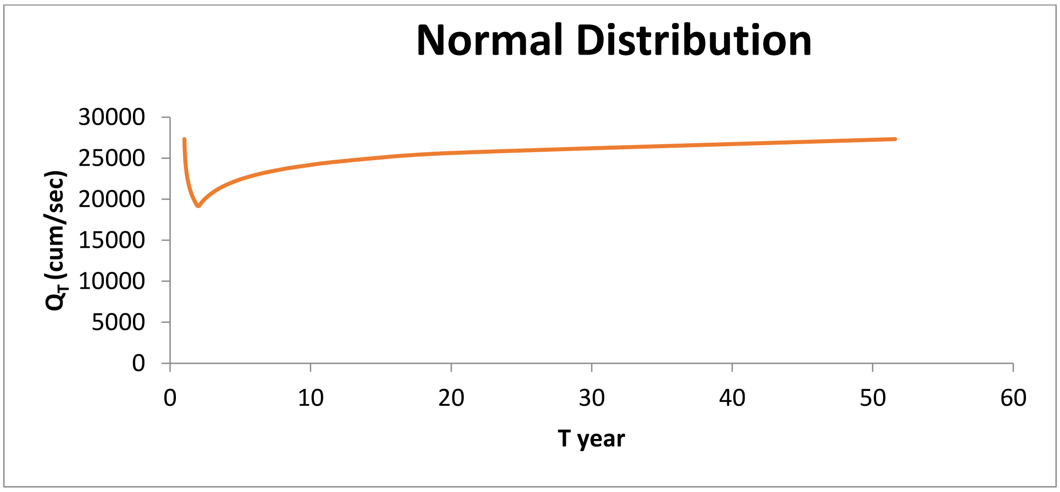

Figure 8: Plot of Estimated Discharge and Blom plotting position of return Period T

Table 13: Application of Normal distribution to observed data

T	K_T	σ(cum/sec)	$K_T\sigma$	$\bar{x}$	$Q_T = \bar{x} + K_T\,\sigma$ (cum/sec)
2	0	4004.806	0	19,051	19,051
5	0.842	4004.806	3372.047	19,051	22,423
10	1.282	4004.806	5134.161	19,051	24,185
25	1.751	4004.806	7012.415	19,051	26,063
50	2.054	4004.806	8225.872	19,051	27,277
100	2.326	4004.806	9315.179	19,051	28,366
200	2.576	4004.806	10316.38	19,051	29,367

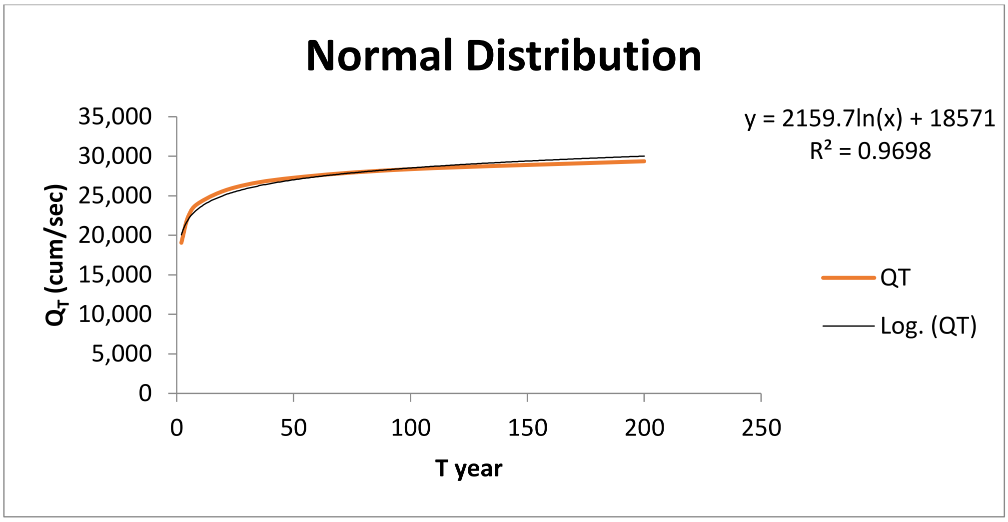

Figure 9: Estimated discharge Q_T against Return Period T of 2, 5, 10, 25, 50, 100, and 200

From table 13, the estimated discharge increased as the number of the return period increases. For a return period of 2 years the estimated discharge was 19051m^3/s, 22423 m^3/s for 5 years return period, 24185 m^3/s for 10 years return period, 26063m^3/s for 25 years return period, 27277m^3/s for 50 years return period, 28366m^3/s for 100 years return period, and 29367m^3/s 200 years return period.

Pearson Parameter III Distribution

In applying Pearson type III probability distribution to the annual series data of the river, the Parameter mean, standard deviation and skew coefficient of the data are: 19051, 4004.806 and -0.1217 respectively and are shown in table 14.

Table 14: Data for Pearson type III distribution and Cunnane plotting position.

Rank(m)	Year	Maximum discharge (Xi)(cum/sec)	$T=\frac{n+0.2}{m-0.4}$	P=100/T
1	1962	26,100	53.667	1.863
2	1960	25,000	20.125	4.969
3	1964	24,500	12.385	8.075
4	1970	23,700	8.944	11.180
5	1969	23,400	7.000	14.286
6	1967	23,200	5.750	17.391
7	1966	23,100	4.879	20.497
8	1968	22,900	4.237	23.602
9	1963	22,400	3.744	26.708
10	1975	22,000	3.354	29.814
11	1974	21,700	3.038	32.919
12	1965	21,100	2.776	36.025
13	1971	20,800	2.556	39.130
14	1979	19,800	2.368	42.236
15	1978	19,700	2.205	45.342
16	1981	18,815	2.064	48.447
17	1961	18,300	1.940	51.553
18	1991	18,159	1.830	54.658
19	1977	18,000	1.731	57.764
20	1980	17,900	1.643	60.870
21	1989	17,773	1.563	63.975
22	1985	17,656	1.491	67.081
23	1988	17,480	1.425	70.186
24	1972	16,300	1.364	73.292
25	1990	15,411	1.309	76.398
26	1973	15,000	1.258	79.503
27	1986	14,726	1.211	82.609
28	1976	14,600	1.167	85.714
29	1987	13,566	1.126	88.820
30	1982	13,019	1.088	91.925
31	1983	12,079	1.052	95.031
32	1984	11,463	1.019	98.137

Average	19,051
Std.derv.σ	4004.8
Skewcoeff.C_{sy}	-0.1217

The Pearson Type III distribution is also called the Three-Parameter Gamma distribution, the frequency factor depend on both the return period, T, and the skewness coefficient C_{sy}. If the skewness coefficient is known, the approximate values of the frequency factor for the Gamma/Pearson Type III distribution, K_T, can be estimated. Table 15 gives the result for Q_T and K_T. Cunnane plotting position was used to calculate the return period, the values of z was estimated, the value of K_T was also calculated, the various value of K_T was used to estimate Q_T and the results of all these parameters were presented in table 15. The discharge and the return period calculated and presented in Table 15 were plotted in fig. 10.

Table 15: The Estimated discharge magnitudes Q_T and the Frequency Factor K_T for Pearson type 3 Probability distribution

Rank(m)	Year	Maximum discharge (Xi) (cum/sec)	$T=\frac{n+0.2}{m-0.4}$	P=100/T	z	K	Q_T (cum/sec)
1	1962	26,100	53.667	1.863	2.083345	2.014832	27120.01
2	1960	25,000	20.125	4.969	1.648226	1.612424	25508.45
3	1964	24,500	12.385	8.075	1.400292	1.379817	24576.9
4	1970	23,700	8.944	11.180	1.217145	1.206437	23882.55
5	1969	23,400	7.000	14.286	1.067581	1.063865	23311.57
6	1967	23,200	5.750	17.391	0.938744	0.940341	22816.88
7	1966	23,100	4.879	20.497	0.82382	0.829599	22373.38
8	1968	22,900	4.237	23.602	0.718898	0.728035	21966.64
9	1963	22,400	3.744	26.708	0.621329	0.633195	21586.82
10	1975	22,000	3.354	29.814	0.529362	0.54345	21227.41
11	1974	21,700	3.038	32.919	0.441718	0.457609	20883.64
12	1965	21,100	2.776	36.025	0.357346	0.374681	20551.53
13	1971	20,800	2.556	39.130	0.275507	0.293969	20228.29
14	1979	19,800	2.368	42.236	0.195491	0.214793	19911.2
15	1978	19,700	2.205	45.342	0.116759	0.136636	19598.2
16	1981	18,815	2.064	48.447	0.038832	0.059031	19287.41
17	1961	18,300	1.940	51.553	0.038832	0.059031	19287.41
18	1991	18,159	1.830	54.658	0.116759	0.136636	19598.2
19	1977	18,000	1.731	57.764	0.195491	0.214793	19911.2
20	1980	17,900	1.643	60.870	0.275507	0.293969	20228.29
21	1989	17,773	1.563	63.975	0.357346	0.374681	20551.53
22	1985	17,656	1.491	67.081	0.441718	0.457609	20883.64
23	1988	17,480	1.425	70.186	0.529362	0.54345	21227.41
24	1972	16,300	1.364	73.292	0.621329	0.633195	21586.82
25	1990	15,411	1.309	76.398	0.718898	0.728035	21966.64
26	1973	15,000	1.258	79.503	0.82382	0.829599	22373.38
27	1986	14,726	1.211	82.609	0.938744	0.940341	22816.88
28	1976	14,600	1.167	85.714	1.067581	1.063865	23311.57
29	1987	13,566	1.126	88.820	1.217145	1.206437	23882.55
30	1982	13,019	1.088	91.925	1.400292	1.379817	24576.9
31	1983	12,079	1.052	95.031	1.648226	1.612424	25508.45
32	1984	11,463	1.019	98.137	2.083345	2.014832	27120.01

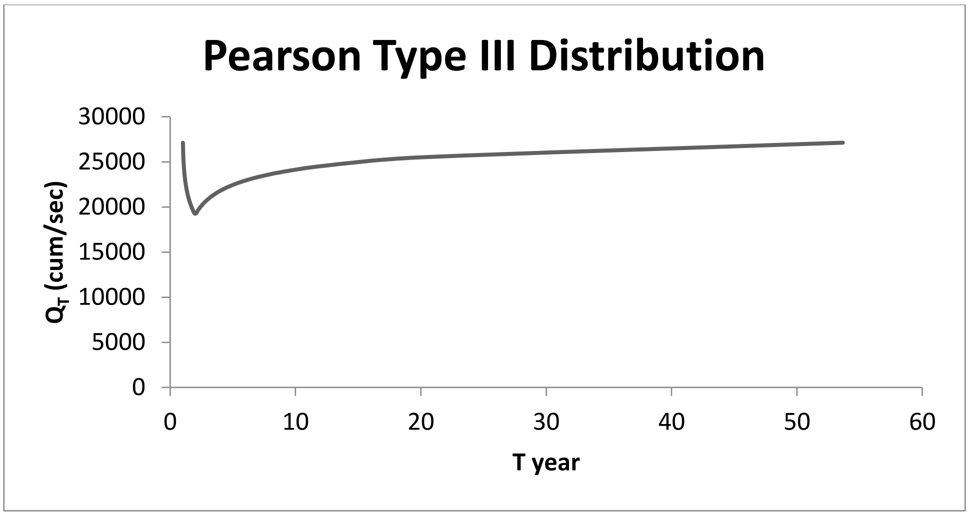

Figure 10: Plot of Estimated Discharge and Cunnane plotting position of return Period T

C_{sy} = -0.1217
The corresponding value of k was obtained using the frequency factor Table for log Pearson type III in the Appendix 1. The results are presented in table 16 and fig. 11 respectively.

Table 16: Application of Pearson type III distribution to observed data

Return Period	Probbility of Exceedeed P%	K	σ	$k\sigma$	$\overline{x}$	$Q = \overline{x} + K\sigma$ (cum/sec)
2	50	0.1976	4004.8	910.95	19051	19961.95
5	20	0.8430	4004.8	3326.89	19051	22377.89
10	10	1.0822	4004.8	4153.00	19051	23204.00
25	4	1.2749	4004.8	4769.84	19051	23820.84
50	2	1.3697	4004.8	5050.69	19051	24101.69
100	1	1.4379	4004.8	5237.14	19051	24288.14
200	0.5	1.4883	4004.8	5364.53	19051	24415.53

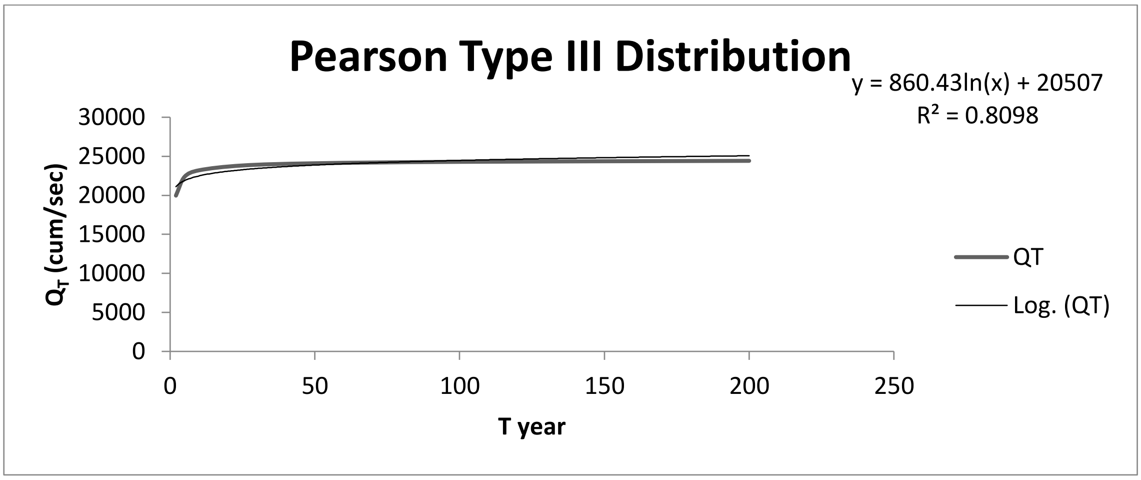

Figure 11: Estimated discharge Q_T against Return Period T of 2, 5, 10, 25, 50, 100, and 200

From table 16, the various discharge calculated for return period of 2, 5, 10, 25, 50, 100, and 200 years are18620.87m^3/s, 2237.03m^3/s,24625.20m^3/s, 27278.91m^3/s, 29142.83m^3/s, 30927.63m^3/s and 32656.49m^3/s respectively.

Discussion of Results

Table 17 shows the summary of the estimated discharge for the river at the point under Onitsha bridge head using the Gumbel distribution, Normal distribution, lognormal distribution, log Pearson type III distribution and Pearson type III distribution for the different return Period.

For a 2 year return Period, Gumbel distribution gave the highest estimated discharge of 21997.78m^3/s, followed by Pearson type III with a discharge of 19961.95m^3/s, next was log-Pearson type III discharge of 19081m^3/s, followed by Normal distribution of 19051m^3/s discharge, then log-Normal distribution gave the lower discharge value 18630m^3/s for two year return period.

For a 5-year return period the distribution that gave the highest discharge value was Gumbel 25536.95m^3/s, followed by log-Pearson 2251m^3/s, Normal 22423 m^3/s, Log-Normal 22387 m^3/s, and then Person type III 22377.89m^3/s.

Gumbel distribution also gave the highest estimated discharge for a 10 years, 25 years, 500 years, 100 years and 200 years return period with values of 27880.18m^3/s, 30840.86m^3/s, 33037.26m^3/s, 35217.45m^3/s and 37389.68m^3/s respectively. The next distribution that gave the second highest estimated discharge for 10 years, 25 years, 50 years, 100 years and 200 years return period was log- Normal, with the discharges values of 24604m^3/s, 27290m^3/s, 29174m^3/s, 30903m^3/s and 32659m^3/s respectively. A comparative plot of the Estimated Discharge for various return period are shown in fig 12.

The results of the 2,5,10,25,50,100 and 200 years return period frequency analysis based on maximum instantaneous flow recorded on the River Niger from 1960 to 1991 using Gumbel (Extreme value Type 1), Lognormal, Normal, Log Pearson Type III and Pearson Type III distributions are summarized below in Table 17. Summary of the graph linear relationship and correlation coefficient for the five distributions are listed in table 18.

Table 17: Summary of the estimated discharge for five distributions

Return Period	Gumbel Q(cum/sec)	Normal Q(cum/sec)	Lognormal Q(cum/sec)	Log Pearson type3 Q(cum/sec)	Pearson type3 Q(cum/sec)
2	21997.78	19,051	18630	19081	19961.95
5	25536.94	22,423	22387	22516	22377.89
10	27880.18	24,185	24604	24236	23204.00
25	30840.86	26,063	27290	25976	23820.84
50	33037.26	27,277	29174	27037	24101.69
100	35217.45	28,366	30903	27945	24288.14
200	37389.68	29,367	32659	28732	24415.53
$\bar{Q}$	30271.45	25247	26521	25075	23453
σ	5472.559	3628.189	4958.813	3402.26	1827.207

Table 18: Summary of the graph linear relationship and the correlation coefficient for the Five probability distribution method

Gumbel	Normal	Lognormal	Log Pearson type3	Pearson type3
$y = 64.10x + 26682$ $R^2 = 0.715$	$y = 3.8.99x + 23064$ $R^2 = 0.602$	$y = 56.34x + 23362$ $R^2 = 0.662$	$y = 3.5.33x + 23096$ $R^2 = 0.563$	$y = 3.25x + 22425$ $R^2 = 0.366$

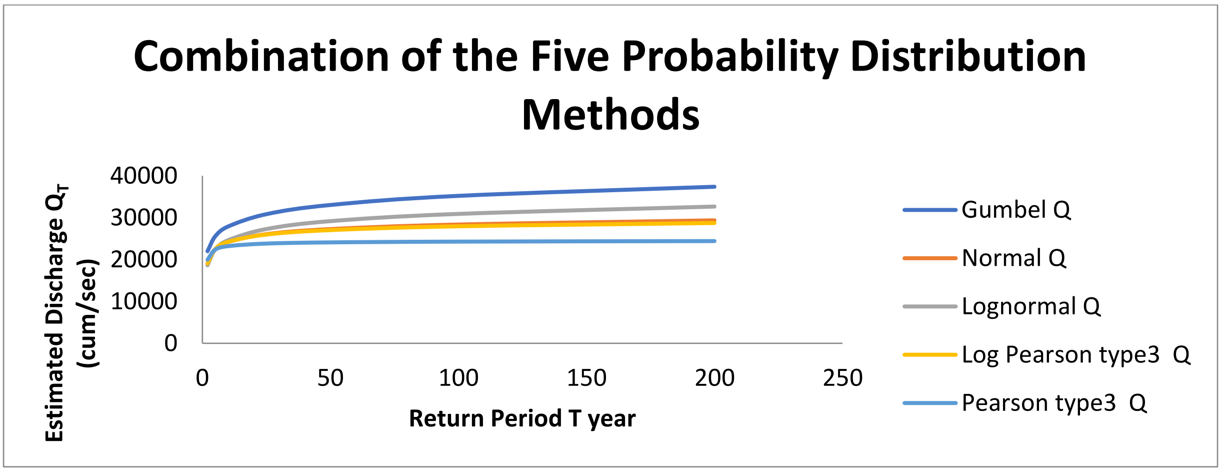

Figure 12: Estimated discharge Q_T against Return Period T of 2, 5, 10, 25, 50, 100, and 200 for the Five Probability Distribution

Comparison of Results

Using Goodness of Fit, the computed Mean Deviation Index for the five distributions are presented in table 19.

Table 19: Comparison of results using Goodness of fit

	Gumbel	Normal	Lognormal	Log Pearson type3	Pearson type3
MADI	0.0893	0.22689	0.23492	0.2281	0.22741
RRMSE	0.302051	0.428588	0.460763	0.432438	0.425958
PPCC	0.8526	0.3909	0.49097	0.39541	0.3801

According to applied mathematical science, (2011) the smaller value obtained from MADI method gives the best fit for any distribution. From the results obtained using MADI method for the five different distributions, Gumbel distribution had the smallest value, therefore it is taken as the best fit for the data.

Also for RRMSE and PPCC method, the smallest values of RRMSE correspond to the best fitting distribution whereas in the case of PPCC, the distribution with the computed PPCC

closest to 1 indicates the best (Surobhi 2011). The results of the distributions shown in Table 19 Gumbel distribution meant the best requirement for both RRMSE and PPCC.
Mean Deviative Index (MADI), Relative Root Mean Squared Error (RRMSE) and Probability Plot Correlation Coefficient (PPCC) were computed and the results are presented in table 19.

From the RRMSE results Gumbel distribution has the smallest value of 0.302051 which made it the best fit for the data. Also from the PPCC results, Gumbel distribution had the value (0.8526) closest to 1, which indicates that Gumbel Distribution is the best fitting distribution for this data.

Table 20: Summary of the Equation from the graph for the Five Probability Distribution

Gumbel	Normal	Lognormal	Log Pearson type3	Pearson type3
Y=3305ln(x)+20053	Y=2159ln(x)+18571	Y=2987ln(x)+17284	Y=200ln(x)+18868	Y=8640.4ln(x)+20507
R^2 = 0.998	R^2 = 0.969	R^2 = 0.991	R^2 = 0.953	R^2 = 0.809

From table 20 the correlation coefficient of Gumbel distribution gave a value closer to 1, than the others, followed by log normal distribution, Normal distribution, log Pearson III and Pearson III.

Performance of Models Using Scoring and Ranking Scheme

Using a scoring and ranking scheme to arrange the performance of the different methods, a score of 5 – 1 was used for the best fit model to the less fit model, while the highest ranked will have a value of 1, while the least ranked will be score 5. The scoring and ranking are arranged in table 21 below.

Table 21: Performance of Models using Scoring and Ranking Scheme

Distribution	Gumbel score	Normal score	Lognormal score	Log Pearson III score	Pearson III score
MADI	5	4	1	2	3
RRMSE	5	3	1	2	4
PPCC	5	2	4	3	1
Rank	1	2	5	4	3

From the score for all the distribution a ranking scheme was used to classify the distribution based on the scored performance from the comparative methods. They were ranked from 1-5 (best to less). Gumbel distribution was scored with 5 as the best fit from all three comparative methods and ranked as 1, while Normal distribution was scored 4 for MADI, 3 for RRMSE and 2 for PPCC, and ranked as 2. Pearson III was scored 3, 4 and 1 for MADI, RRMSE and PPCC respectively, with a rank of 3, log Pearson III was scored 2 for MADI, 2 for RRMSE and 3 for PPCC, and was ranked 4. The less fitted distribution was lognormal according to the comparative method sand was scored 1, 1and 4 for MADI, RRMSE and PPCC respectively and was ranked 5.
From all indication, Gumbel distribution gave the best fit for the annual maximum discharge data for River Niger at Onitsha bridge head.
Since Gumbel distribution gave the best fit, the discharge it's predicted are listed in table 22 below.

Table 22: Estimated Values for Q_T, Y_T and K_T for Return Period of 2, 5, 10, 25, 50, 100 and 200

T(yrs)	Y	K	Q
2	0.3665	0.73581	21997.78
5	1.500	1.619539	25536.94
10	2.250	2.204645	27880.18
25	3.1985	2.943928	30840.86
50	3.9020	3.49237	33037.26
100	4.600	4.036763	35217.45
200	5.2950	4.579169	37389.68

CONCLUSION

From a comparative analysis using MADI, the best fitted distribution of the five distributions is Gumbel Distribution with a value of 0.0893, which was the smallest value of the five distribution models, making Gumbel distribution the best fitting distribution for the annual maximum discharge data for River Niger at Onitsha bridge head. From RRMSE the smallest value obtained from the distribution gave the best fitted distribution for the data. Gumbel distribution have the smallest value of 0.302051, making Gumbel distribution the best fitted distribution for the given data. PPCC method of comparison yielded Gumbel distribution as the best fitted distribution for the data with a value of 0.8526.
From the scoring and ranking scheme used to assess the performance of the methods Gumbel distribution gave the best fit. It can therefore be concluded that Gumbel distribution is the best fitted distribution for the annual maximum discharge data for River Niger at Onitsha bridge head and should be used for flood discharge assessment for any hydraulic structure within the area.

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