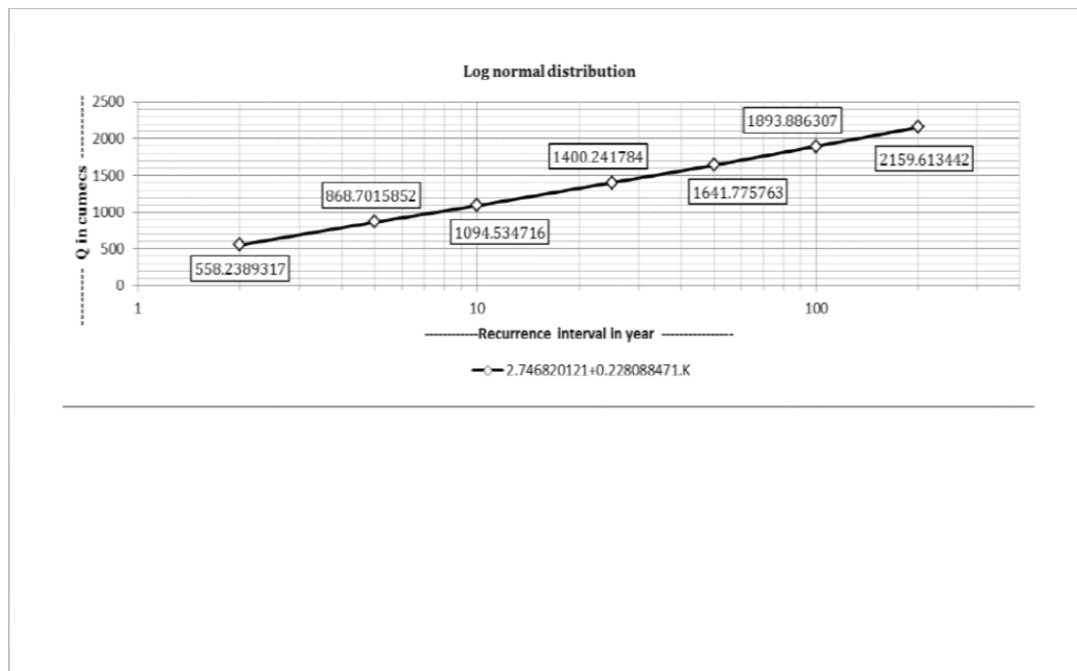


# FLOOD FREQUENCY ANALYSIS

(LECTURE NOTES)



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DEPT. OF GEOGRAPHY  
BHATTADEV UNIVERSITY, BAJALI

MA/MSc Fourth Semester  
Course No. GGY 4214 (3)  
Course Name: Fluvial Geomorphology  
Unit II: Practical Works (65 Marks)  
4. Flood Frequency Analysis  
A Syllabus for CBCS Based PG Course in Geography, 2017  
Department of geography  
Gauhati University

&

MA/MSc Fourth Semester  
Paper Code: 4206 (3)  
Course Name: Fluvial Geomorphology  
Unit II: River Basin Management (40 marks)  
2. Fluvio-geomorphic Hazards: Flood  
6. Basin Hydrology and River Processes  
Department of geography  
Gauhati University

**Course Objectives:**

1. To familiarize the students with the statistical analysis of floods,
2. To make the students understand about the dimensions or magnitudes of the flood and
3. To acquainted the students with the relationships of water discharge and flood magnitudes.

**Course Outcomes:**

1. The students will enrich themselves with the concept of flood frequency analysis.
2. The students will learn to apply the statistical techniques in hydrological analysis.
3. The students will be able to identify the sizes of floods.

## A COMPARATIVE APPROACH TO FLOOD FREQUENCY ANALYSIS OF THE PUTHIMARI RIVER IN ASSAM, INDIA

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### ***Abstract***

*The flood frequency analysis is a way of finding the number of occurrences and identification of largest flood for a certain period. On the other hand, the flood frequency analysis is a means of shorting out the flood events of a particular river or rivers of a geographical area of importance. There have been various methods of analysis which provided good results in flood forecasting with little variation depending on range of the data set. The article has been prepared based on two sets of hydrological data such as annual peak discharge and water level; which have been collected from Brahmaputra Board and Water Resources Department, Govt. of Assam. Here we have presented a comparative analysis of flood frequency of the Puthimari River in Assam. The analysis has been done based on the water discharge, water level or stage (maximum, minimum and danger level). The hydrograph, Log-Normal and Log-Pearson Type III methods have been deployed in MS Excel sheet to make a comparison of flood events from 1955 to 2008 and 1953 to 1993 respectively. The results show that there have been two mega floods during this period of time while the estimated flood discharges of Log-Normal and Log Pearson Type III methods show hardly any difference for the Puthimari River Basin.*

**Keywords:** flood frequency, hydrograph, Log-Normal, Log-Pearson Type III and Puthimari River.

### **Introduction**

The flood frequency analysis is one of the means of finding the number of occurrences and identification of largest flood. On the other hand, the flood frequency analysis is also a means of shorting out the flood events of a certain river or rivers of a particular area. The flood-frequency analysis is the basis for the analysis of flood control and mitigation projects including the design of many other projects. There have been various methods of analysis which provided good results in flood forecasting with little variation depending on range of the data set. Several methods have been used to find out the relationship between flood magnitudes and occurrences all over the world. A number of statistical analysis methods have been proposed in the hydrological literature over the years. The Log Pearson Type III distribution using conventional moment estimators is obligatory for all Federal agencies in the USA but it is the recommended method in Australia where the method had been found appropriate for the estimates of extreme flood discharges (Alexander, 2002). For the log-normal and Pearson Type III methods, average departures and the bias are small. The results of these methods represented, in general, a middle position among the values computed. Based both on departures from the data and on the relative values all those computed, the

Log-Normal and Log Pearson Type III appear to be preferable. The Log-Pearson Type III method includes the Log-Normal as a special case when the skew of the logarithms is zero, so that the log-normal can be considered as a part of this. (Benson, 1968).

As such the Log-Norman and Log Pearson Type III distributions have been found more applicable and popular among the methods of flood frequency analysis (Al-Mashidani, et al., 1978). For the range of regional-average flood statistics observed across the United States, Griffis and Stedinger (2007a; 2007b) demonstrate that the Log Pearson Type III distribution is a reasonable and flexible model of flood risk analysis (Griffis & Stedinger, 2009).

The development of all design flood estimation procedures begins with the direct statistical analysis of recorded data at gauged sites. The purpose of statistical analyses is to determine the flood magnitude and frequency (Q&T) relationship at the site (Alexander, 2002). Approaches to the problem of flood reconstruction include the use of regime based palaeohydraulic techniques, or palaeocompetence equations (Wohl & Enzel, 1995). These techniques have been widely applied with a great deal of success. However, often such techniques can only identify the largest or last flood to have occurred in a particular location (Marren, 2002).

In India, a river is said to be in flood when its water level crosses the danger level (DL) at that particular site. Central Water Commission (CWC), New Delhi, the nodal agency in India for the development of water resources, has fixed DLs at important gauge discharge (G/D) sites on most of the rivers in consultation with the Engineers of State Governments. As such, when water level in a river touches or exceeds the DL at a particular G/D site, the river at that site is said to be in flood. Major floods are those when water level is 1 m or more above the DL and if it is 5 m or more above the DL, that flood is said to be catastrophic *cf.* (Roy & Husain, 2014; Dhar & Nandargi, 2000).

The rivers in the alluvial plains normally spill over their banks several times in a year causing floods. It is a common feature and also essential for the river to accommodate its water flowing in excess to its carrying capacity during high storm period on its flood plain. However, extreme flood, which occurs rarely causes misery to the people and resources. Hence, it is necessary to assess the flood magnitudes and frequencies from hydrological point of views (Roy & Husain, 2014). This article describes methods for identifying individual high magnitude floods and also evaluation of magnitude and frequency regimes based on the hydrological record. It has been prepared considering the fundamental aims to make a comparison between the two basic methods of flood frequency analysis i.e. Log-Normal and Log Pearson Type III and to high light the floods in the Puthimari River Basin (PRB) of Assam in India.

## **Study Area**

The Puthimari River is one of the north bank tributaries of the Brahmaputra River. The PRB is a transnational river basin located within political boundaries of Bhutan and the state of Assam in India (Fig.1). After originating in Bhutan Himalaya at an altitude of 3750 m the river flows north to south through the old Nalbari, Kamrup and Darrang districts (Roy &

Husain, 2014) and newly form districts of Baksa, Odalguri and Kamrup (Rural) of Assam and debouches in to the Brahmaputra River. The river has come across various geographic and geologically complex regions from the source at (27°26'55" N latitudes and 91°55'34" E longitudes) Tethyan Himalaya, a part of Eastern Himalaya in Bhutan to mouth at (26°14'52" N latitudes and 91°26'55" E longitudes) the Brahmaputra River near Barsulia village, 7.6 km downstream from Hajo in Assam, India. The latitudinal and longitudinal extent of the PRB falls between 26°10'50" N to 27°20'27" N and 91°25'57" E to 91°56'12" E (Fig. 1). The basin is extended in north-south direction from the high Tethyan Himalayas to flat flood plains of the River Brahmaputra in the state of Assam in India.

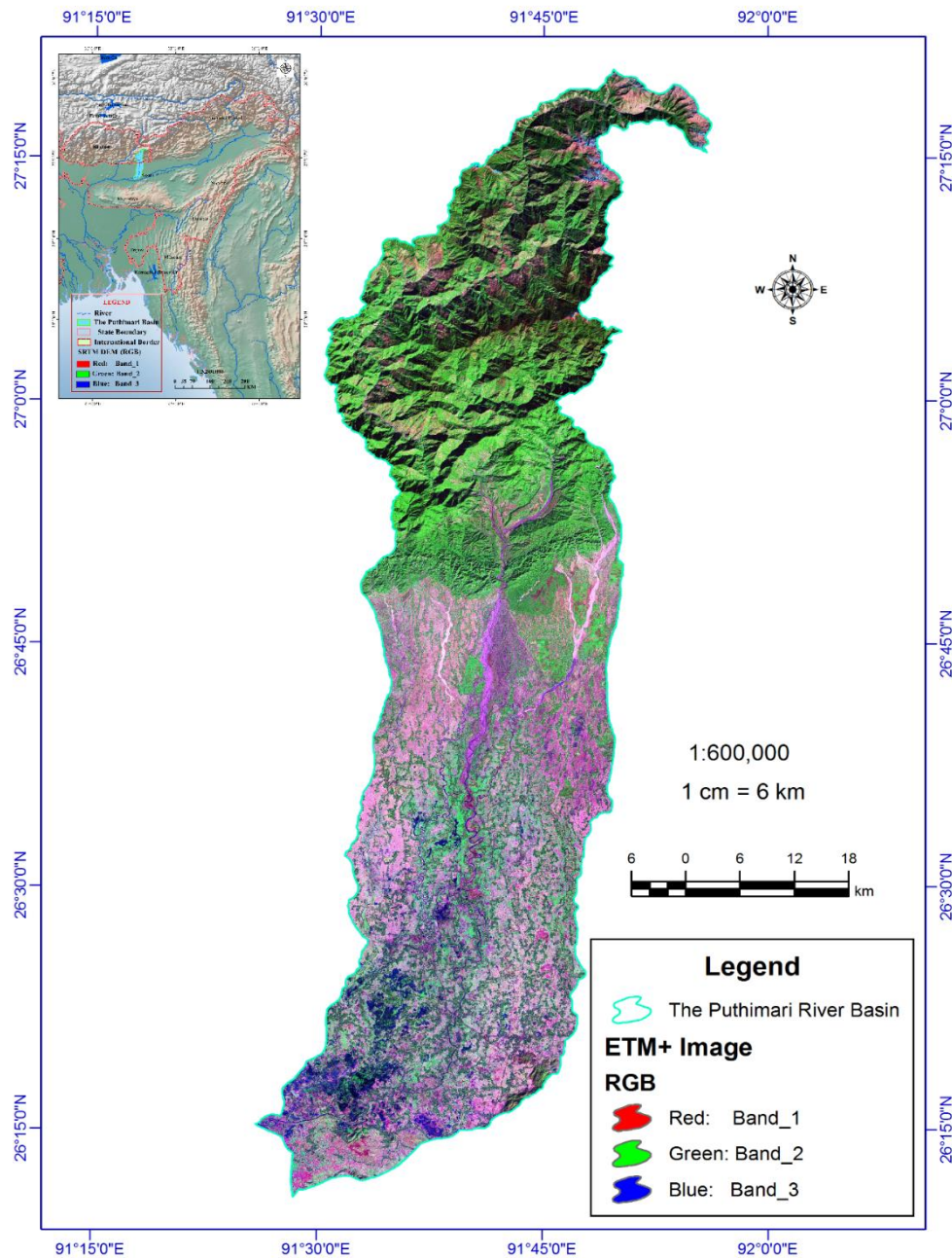


Figure-1: The location of the study area in Enhanced Thematic Mapper Plus image of the Puthimari River Basin.

The shape of the basin is elongated. The basin is fat in the middle tapering at the source and mouth resembling with a leaf of Olive tree (Fig. 1). The width of the catchment varies from 36 km in the lower most portions to 3.40 km in the upper most portion of Bhutan Himalaya. The PRB covers an area of 3,090.11 sq. km; out of which, 1,315.87 sq. km (43%) lies in Bhutan and 1,774.24 sq. km (57%) falls in Assam, India (Roy, 2015) (refer to a paper which has been communicated).

The area of the flood plain in the basin is 385sq km out of which an area of 374.38 sq. km is more prone to flood. The total number of villages of the basin is 448 and 234 villages are in the flood plains. The agricultural land covers an area of 68,126 ha. out of which, 47,638 ha. are located in the flood plain of the basin (Roy & Husain, 2014; Brahmaputra Board, 1995).

### **Database and Methodology**

The article has been prepared based on two sets of hydrological data. The hydrological data such as water level and water discharge have been collected from two different sources depending on its availability. The first set of hydrological data i.e. water discharge of PRB from 1955 to 1993 has been collected from Brahmaputra Board. The second set of hydrological data i.e. maximum and minimum water level of the river from 1958 to 2008 have been collected from Water Resource Department, Govt. of Assam.

The stage hydrographs have been prepared using maximum and minimum water levels for a period of 51 years from 1958 to 2008. The flood magnitudes or flood lifts have been calculated for each year deviating DL from Maximum water level. The DL for the river is 51.81 m which has been considered as reference level for quantification of magnitudes of the floods (Roy & Husain, 2014).

The two common statistical techniques used here for flood frequency analysis are Log-Normal distribution and Log-Pearson Type III distribution. The magnitude and frequency of floods at National Highway (NH-37) crossing gauge site have been determined using flood-frequency curves for a period of 39 years from 1955 to 1993. Both the techniques need to use these observed annual peak flow discharge data to calculate statistical information such as mean values, standard deviations, skewness and recurrence intervals. These statistical data are then used to construct frequency distributions, which are graphs and tables that tell the likelihood of various discharges as a function of recurrence interval or exceedance probability.

The Log-Pearson Type III method includes the skew coefficient as a variable and therefore more flexible than the log-normal, which has a skew value of zero of the logarithms. The Pearson Type III method is capable of fitting frequency relations that highly skewed may be due to hydrologic reasons.

These curves relate maximum annual discharge to probability of occurrence or recurrence interval of 2, 5, 10, 25, 50, 100 and 200 years. The recurrence intervals have calculated and plotted on a flood frequency graph from the peak annual flood data. The hydrographs, flood frequency analysis and probability graphs have been done in MS Excel.



Probability of occurrence is the chance that a given flood magnitude will be equalled or exceeded in any year. If there is 1 chance in 10, the probability is 0.1. Recurrence interval is the reciprocal of the probability of occurrence. For example, a flood with a probability of occurrence of 0.01 in any year has a recurrence interval of 100 years. This does not mean that a 100-year flood will only occur every 100 years or 100 years from now. The 100-year flood is a flood of such magnitude that the odds are 1 in 100 (or 1 percent chance or 0.01 probability) that it will be exceeded in any year. Several 100-year floods could occur in a single year. The line on a flood frequency graph allows investigators to estimate the average number of years that will elapse until a flood of a particular magnitude reoccurs (Roy & Husain, 2014).

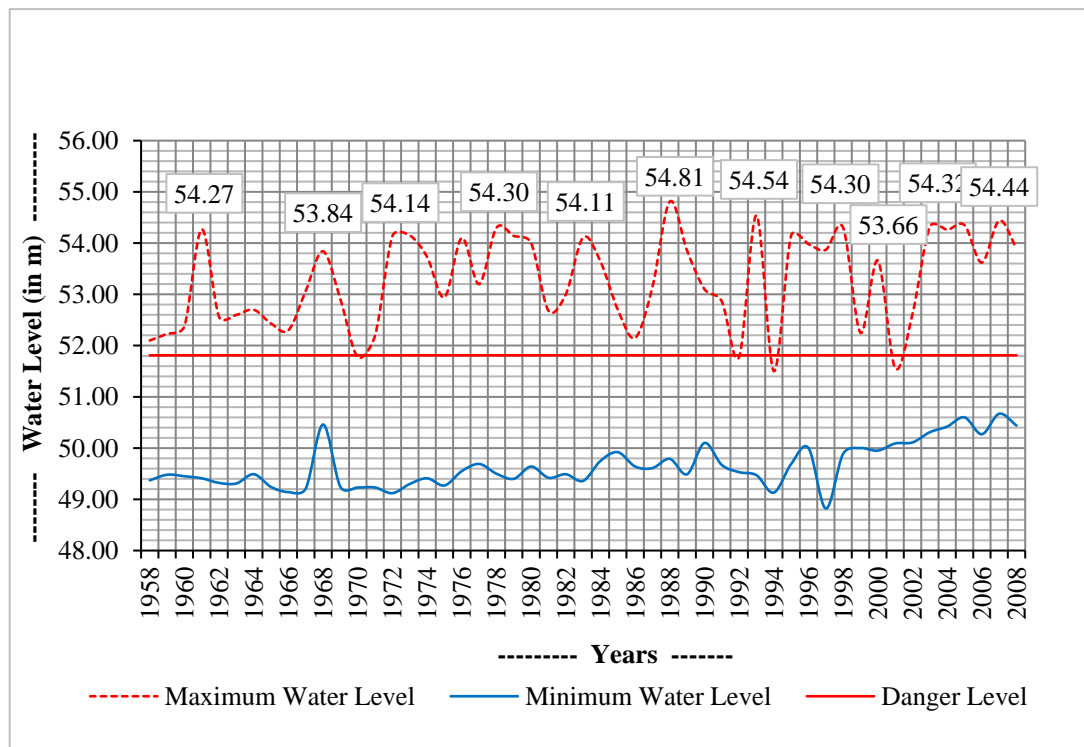


Figure-2: Time series of water level from 1958 to 2008 shows the chronological flood history of the PRB.

## Results and Discussion

### Comparison of Stage Hydrographs for Flood Magnitudes

The stage hydrograph of 1958-2008 has been shown in Fig 2. From the graph it is clearly found that there had been 9 mega floods marking the water level more than 54.00 m. Amongst them the flood of 1988 has been found as the highest flood ever recorded in the PRB with (54.81-51.81) 3.0 m deviation from DL. The flood marked the highest water level (54.81m) and water discharge (1588.38cumecs) ever recorded in flood history of the PRB. Interestingly, this flood has been found 2nd largest (Fig.4) from the hazard perspective in another study of the first author (Roy & Husain, 2014). The 2nd and 3rd largest floods have

been identified (Fig.2) in the years of 1993 and 2007 flowing (54.54m-51.81m) 2.73m and (54.44m-51.81m) 2.63m above the DL respectively.

Considering the floods for the entire period of 51 years from 1958 to 2008, it has been found that the river flow had been above the danger level in every year ranging from 0.29m to 3.0m except in 1970, 1992, 1994 and 2001 (Fig. 2). By comparing both the stage hydrographs (Fig.2) it is clear that flood occurred every year except 1970, 1992 and 1994. The maximum annual water level of the river has been above that particular level which had been marked as the DL in every year indicating the chronical flood events in the PRB.

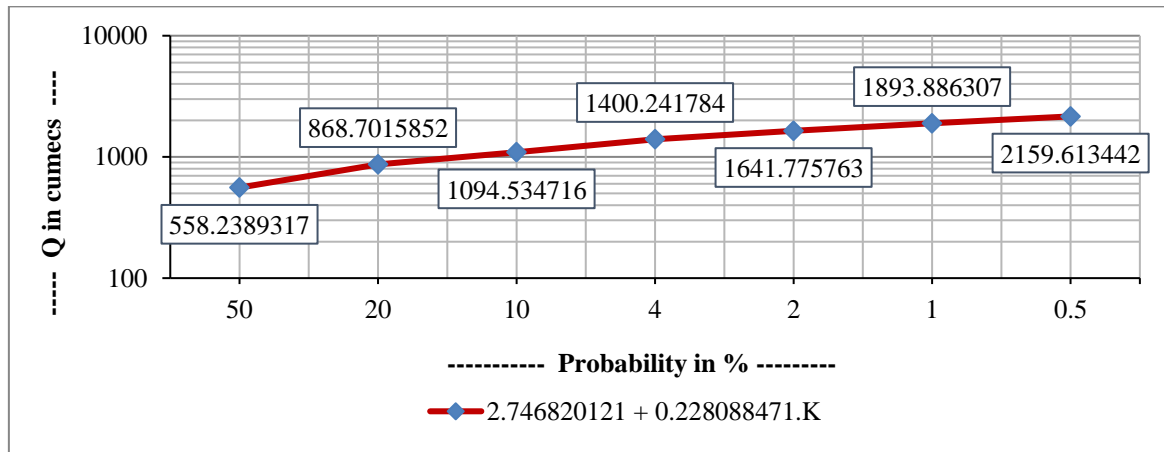


Figure -3: Lognormal probability distribution graph for the floods of 2,5,10, 50, 100 and 200 years' recurrence intervals.

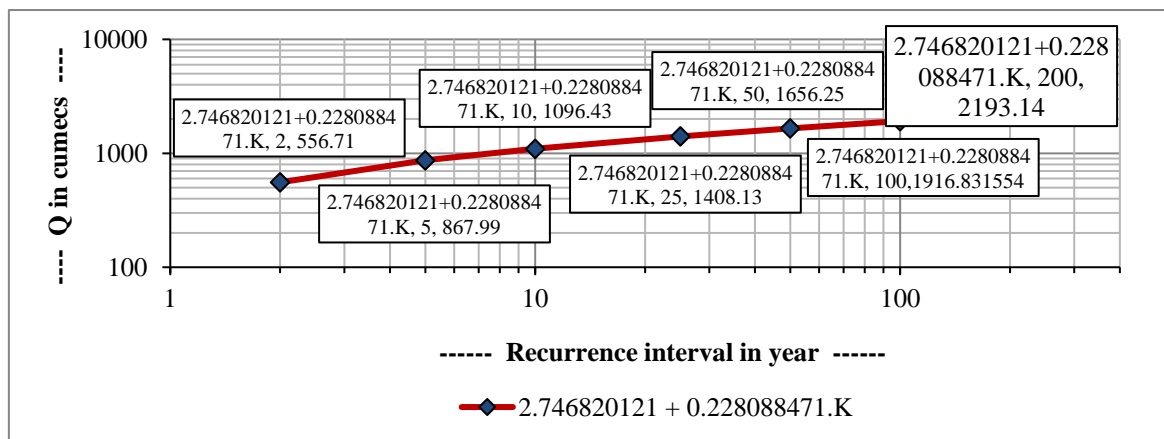


Figure-4: Log-Pearson Type III distribution graph for flood estimation of 2,5,10, 50, 100 and 200 years' intervals.

It is found that flooding is a common phenomenon during the period of 21 years from 1976 to 2007 in the PRB. It occurs almost each and every year. The floods of 2004, 1988 and 2007 are been found the 1st, 2nd and 3rd largest respectively (Fig. 2). But, the floods of 1988 and 1993 can be considered as the largest ever occurred in the 2nd half of the 20th Century causing widespread loss to the people of the basin. On the other hand, the flood of 2004 has been the mega flood of 1st decade of the 21st century.



### Comparison of Log-Normal and Log Pearson Type III Distributions

The estimated of floods in the PRB for 2, 5, 10, 25, 50, 100 and 200 year return period has been found as 558.24, 868.70, 1094.53, 1400.24, 1641.77, 1893.89 and 2159.61 cumecs by using log normal distribution method (Table. 1& Fig. 5). On the other hand, the values of flood estimation for the same return periods have been found by applying Log-Pearson Type III distribution method with minor variations as 556.71, 867.99, 1096.43, 1408.13, 1656.25, 1916.83 and 2193.14 cumecs (Table. 1 & Fig. 5). It has been found that the 20 floods already occurred in the PRB showing more than 50% probability by log-normal and Log-Pearson Type III methods as well. The floods of 1988 and 1993 have been seen the largest ever occurred with more than 4% probability in both the distribution cases. The estimation of floods by both the methods have given almost the same results with very little variation which can be better understood from the Table-1 and Fig.-5.

Table 1: Difference between Log-Normal and Log Pearson Type III Distributions

T	Probability %	Log-Normal (A)	Log-Pearson Type III (B)	A ~ B
2	50	558.24	556.71	1.53
5	20	868.70	867.99	0.71
10	10	1094.53	1096.43	1.90
25	4	1400.24	1408.13	7.89
50	2	1641.77	1656.25	14.48
100	1	1893.89	1916.83	22.94
200	0.5	2159.61	2193.14	33.53

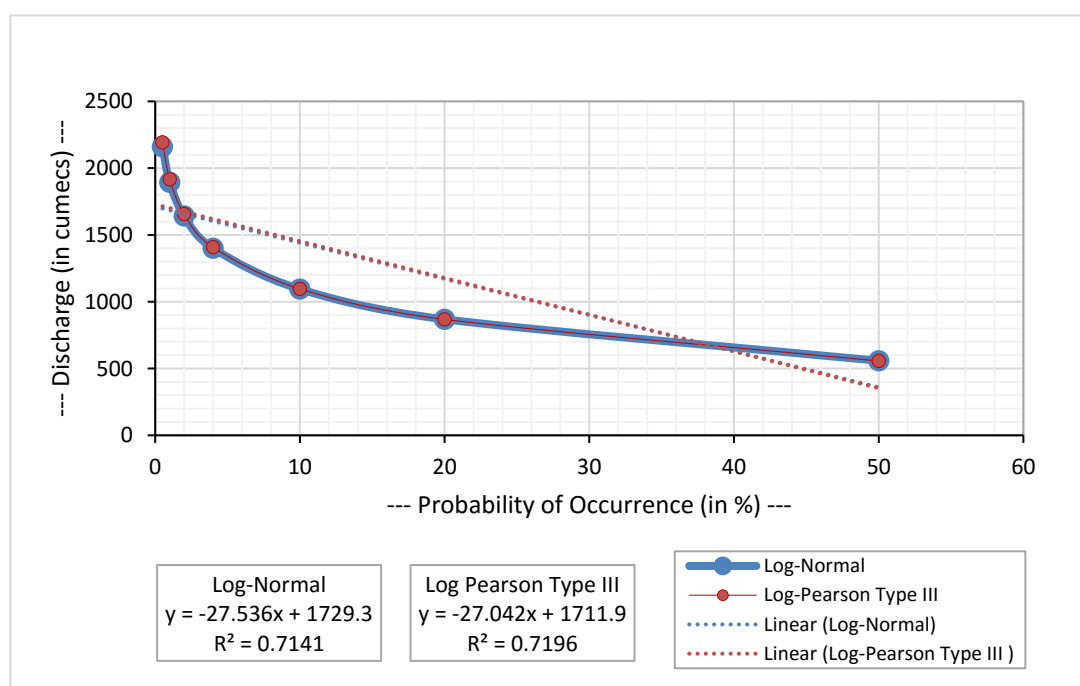


Figure-5: Comparison of flood estimations between Log-Normal and Log Pearson Type III distributions.

## Conclusion

The results show that flood had been occurred almost every year in the PRB. There had been nine historical mega floods with more than 2.00m deviation from DL during the period of 51 years. The flood of 1988 has been found the highest flood ever occurred during 20<sup>th</sup> century in the PRB. Therefore, it is concluded that the PRB is a chronically flood affected basin in Assam.

The Log-Normal and Log Pearson Type III distribution methods have been applied to estimate the floods. Both the methods have shown almost similar result for the given recurrence interval. Thus, it is recommended that any one method can be used among the applied two methods of flood frequency distributions since the estimated flood discharges of Log-Normal and Log Pearson Type III methods show hardly any difference for the Puthimari River Basin. These two methods can be experimented in any river of the Brahmaputra valley.

## Acknowledgement

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