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"STAGE DISCHARGE HYDROGRAPH AND FLOOD FREQUENCY ANALYSIS OF PAHUMARA RIVER, ASSAM, INDIA"

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Abstract :

The Pahumara River is one of the most important northern tributary rivers of the Brahmaputra river. The amount of discharge and impact of flood of this river vary spatio- temporally due to the various determining factors including the release of excess water from neighbouring dams. The frequent disastrous flood impacts of this river are mostly common in the entire Bajali area of Barpeta District of Assam affecting the academic atmosphere, the agrarian economy and existing infrastructural facilities. The ongoing variation and fluctuation in the nature of flood as well as the impact of flood in this area needs proper study and analysis on some aspect pertaining to nature, frequency, probability and magnitude of flooding. The present paper assumes much significance in understanding the fluctuations of discharge and flood estimation of the river Pahumara. The record of annual flood series of the Pahumara river at N. T. road crossing site for the duration of twenty three years (1982 to 2004) has been analyzed to examine the annual discharge fluctuation and probability of flood occurrence using the Gumbel's Extreme Value Distribution Method. The record of monthly peak discharge for the year 2013, 2019 and 2021 has also been analysed to have the better understanding of varied nature of hydrograph.

Key words: *Pahumara, spatio-temporal, probability, magnitude, Extreme.*

Introduction:

The hydrographs and flood frequency analysis of any river provide valuable data base for the purpose of hydrologic analysis. Hydrologic response leads to assessment of the potential of water resource in a watershed (1). At a given gauge site, the stage (WL) and water discharge (Q) vary from year to year and their magnitudes constitute a hydrologic data series to assign a frequency of a given flood-peak value. The flood in a catchment depends upon the nature of the catchment, rainfall and other conditions which are in turn dependent on a lot of constituent parameters. This investigation will assist in further study for forecasting floods and preparing safety design as a mitigation strategy for flood hazard in the study area. The present study may provide an important strategy to the flood hazard management approaches in case of the Pahumara river basin.

Study Area:

The tributary river Pahumara and its basin in Assam covers a substantial area to the south of Bhutan Himalaya and to the north of the Brahmaputra river. The entire basin area of this river comprises the foot hills, built-up, plain and active flood affected areas towards Brahmaputra. The river Pahumara and its entire basin area extends from $26^0 21^/$ N to $26^0 59^/$ N latitude and 91^0 E to $91^0 16^/$ E longitude. The entire basin has the dendritic drainage network pattern with its tributaries like Doisim Nadi, Kokoidong Nadi, Hawali Nadi and Digdari Nadi. This tributary river basin is connected with the neighbouring basin of Kaldia in the east and Beki in the west. This river has its source at Bhutan Himalaya and meets the mighty Brahmaputra passing through the Barpeta district of Assam.

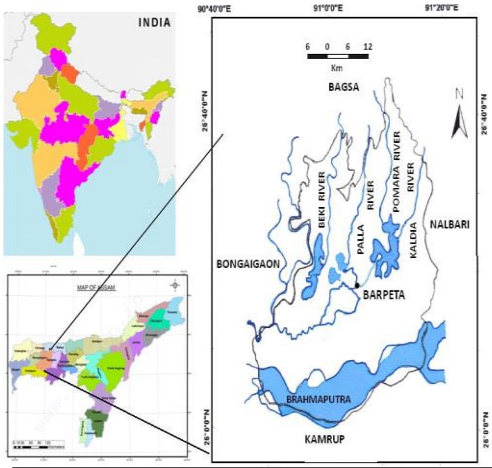

Fig. 1 : Location of the study area

The river flow towards South and it's ending part it turns towards South-West, in the part of upper catchment area number of tributaries meet with the river Pahumara e.g., Doisim Nadi, Kokoidong Nadi, Hawali Nadi, and Digdari Nadi etc (2). It passes through Kokilabari, Manikpur, Sarupeta , uttar Bajali, Dokhin Bajali, Hastinapur and Bhawanipur and at last it meets with Nokhanda and reach mightly Brahmaputra. The existence of abandoned channels in addition to marshes, swamps and beels etc, reflect the frequent channel shifting of the Pahumara river (fig. 1).

Methodology and Data base :

The data base for this paper is mainly the data collected from secondary sources. viz, (i) Survey of India (SOI) toposheets (ii) Administrative Atlas Map of Assam, 2001 (Census of India), and (iii) Discharge data are collected from Water Resource Department. Two sets of hydrologic data – one set of annual peak discharge data for 1982 to 2004 and the other of peak stage discharge data for 2013, 2019 to 2021 of the river have been used for the preparation of hydrographs and flood occurrence probability analysis. For this purpose, the method of Gumbels' Extreme Value Distribution has been used.

Objectives:

The main objectives of the study are-

(i) to assess the pattern of fluctuations of stage and discharge represented by the hydrographs for Pahumara river and

(ii) to estimate the probability of flood occurrence by using Gumbel's Extreme Value Distribution method.

Annual Peak Discharge Hydrograph:

A hydrograph is a graph showing the rate of flow versus time in a river or other channel. The rate of flow is typically expressed in cubic meters or cubic feet per second. The hydrograph is the response of a given catchment to a rainfall input (3). It may also represent the fluctuation of stage, discharge, velocity and other properties of water flow with respect to time.

The annual peak discharge hydrograph for the period 1982-2004 of an arbitrarily chosen duration has been represented in fig. 2 for the Pahumara river from the recorded data (table1). This Hydrograph show the different waves of flood in the high flow season. The maximum flow is 136.48m^3/s in the year 1985 and minimum flow 28.72 m^3/s in 2000 respectively. The average of the mean annual flood for the season of 1982-2004 is found to be 88.07m^3/s.

Table 1: Annual Peak Discharge data of Pahumara River,Assam,1982-2004

Year	Annual Peak Discharge (m3/s)	Year	Annual Peak Discharge (m3/s)	Year	Annual Peak Discharge (m3/s)
1982	88.85	1990	102.01	1998	83.53
1983	122.53	1991	92.96	1999	66.85
1984	121.53	1992	77.84	2000	**28.72**
1985	**136.48**	1993	83.83	2001	68.56
1986	90.41	1994	51.46	2002	75.93
1987	117.85	1995	71.36	2003	70.79
1988	98.11	1996	88.07	2004	128.76
1989	78.86	1997	80.81	-	-

Data Source : Water Resource Department, Govt. of Assam

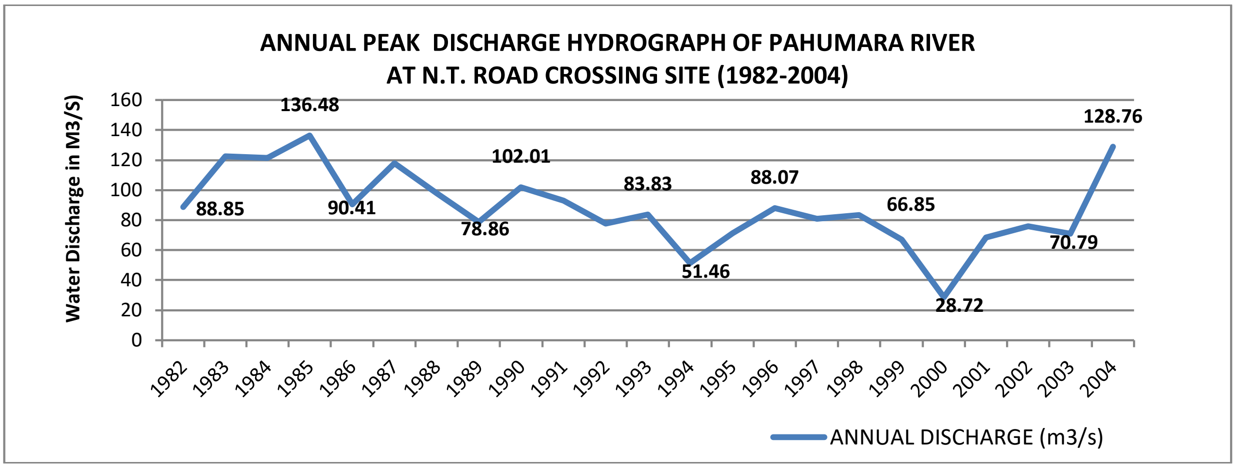

Fig. 2 : Annual Peak Discharge Hydrograph of Pahumara River (1982-2004)

Monthly average stage discharge hydrograph :

This is very much easy to observe the frequent change of stage in a river cross section but observation of water discharge needs measurement of other relevant parameters like depth and velocity (4). The monthly average stage discharge hydrographs of Pahumara river has been prepared for the three years e.g., 2013, 2019 and 2021 based on the recorded data of water resource department, government of Assam. The table 2, 3 and 4 along with their graphical representation in figure 3, 4 and 5 highlights the fluctuation of water level and discharge of Pahumara river. These hydrographs represent a comparative study of the stage discharge or flow of the Pahumara river. From the tables and figures it is seen that the fluctuation in terms of water level and water discharge is noticeable. The maximum values for water level for the selected years are 41.41 (July, 2013), 42.56 (July, 2019) and 41.37 ((June, 2021). The fluctuation of minimum water level is also noticeable for the selected years which are 40.09 (Sept, 2013), 39.37 (Sept, 2019) and 39.33 (April, 2021). The maximum and minimum values for water discharge are 101.41 & 17.18 (Sept & April, 2013), 35.68 & 21.08 (July & Dec, 2019) and 40.47 & 39.29 (July & March, 2021). The recorded values for water discharge and water level show significant variation for these three selected years.

Table 2 : Monthly average stage discharge of Pahumara river (2013)

MONTH	WATER LEVEL (m)	DISCHARGE (cumec)	MONTH	WATER LEVEL (m)	DISCHARGE (cumec)
January	41.08	22.59	July	**41.49**	73.28
February	41.04	21.11	August	41.51	52.99
March	41.00	19.30	September	**40.09**	**101.41**
April	40.95	**17.18**	October	41.29	28.99
May	41.01	28.12	November	41.22	26.75
June	40.83	41.04	December	41.17	25.40

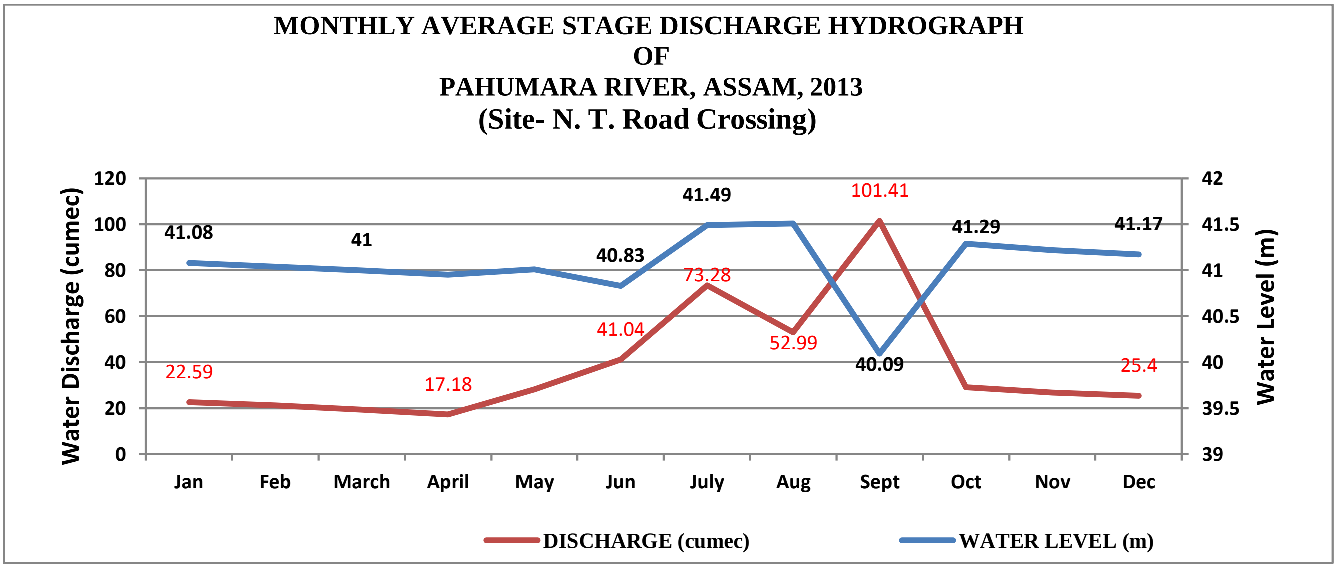

Fig. 3 : Monthly Average Stage Discharge Hydrograph of Pahumara River (2013)

Table 3 : *Monthly average stage discharge of Pahumara river (2019)*

MONTH	WATER LEVEL (m)	DISCHARGE (cumec)	MONTH	WATER LEVEL (m)	DISCHARGE (cumec)
January	41.25	24.68	July	**42.56**	**35.68**
February	39.55	23.71	August	41.26	33.79
March	40.92	23.12	September	**39.37**	25.63
April	42.44	24.91	October	40.50	24.87
May	41.35	27.44	November	40.39	21.44
June	41.51	34.75	December	40.19	**21.08**

Data Source : Water Resource Department, Govt. of Assam.

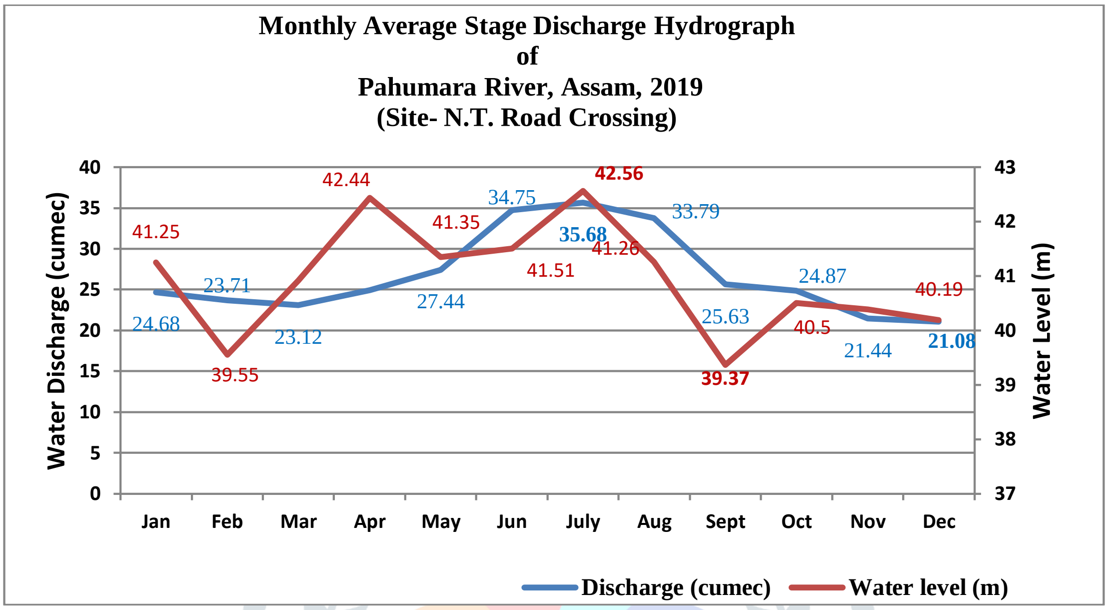

Fig. 4 : Monthly Average Stage Discharge Hydrograph of Pahumara River (2019)

Table 4 : *Monthly average stage discharge of Pahumara river (2021)*

MONTH	WATER LEVEL (m)	DISCHARGE (cumec)	MONTH	WATER LEVEL (m)	DISCHARGE (cumec)
January	39.64	39.53	July	**41.37**	**40.47**
February	39.47	39.41	August	41.00	39.95
March	39.35	**39.29**	September	40.65	40.01
April	**39.33**	39.51	October	40.05	39.93
May	39.83	39.45	November	39.86	39.81
Jun	40.83	39.95	December	39.78	39.75

Data Source : Water Resource Department, Govt. of Assam.

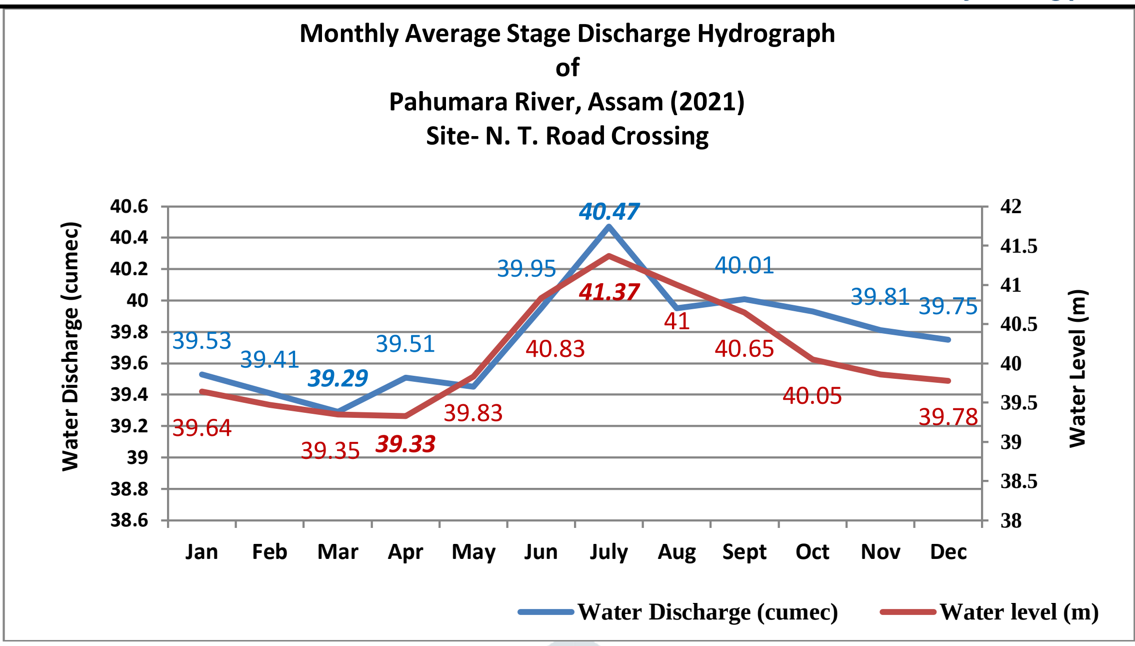

Fig. 5 : Monthly Average Stage Discharge Hydrograph of Pahumara River (2021)

Flood frequency analysis:

A flood is unusually a high stage of water discharge or level in a river at which the river over flows its blanks and inundates its adjoining area. The values of annual maximum flood from a given catchment area for large number of successive years constitute hydrologic data series called the annual series. The flood frequency analysis is a multivariate statistical method for predicting the frequency of flooding and this is determined by discharge information (5).The estimation of flood in a catchment area is a very complex problem as it dependent on a host of relevant parameters like characteristics of catchment, rainfall and antecedent conditions which in turn depend upon a number of constituent parameters. This makes the estimation of flood peak a very complex and problematic leading to many approaches. The statistical method of frequency analysis is one of the most important methods of this kind which is also applicable to other hydrologic processes. The estimation of discharge of a stream is the outmost important prerequisite for any engineering and geological and geological project (6) . There are three commonly methods applied for measuring the flood frequency of a particular river basin viz. i) Plotting Position Method ii) Log Pearson Type III Method and iii) Gumbel's Extreme Value Distribution method. Out of these methods, Gumbel's method is considered as the most widely accepted method for Flood Frequency Analysis.

Gumbel's Extreme Value Distribution Method:

The Extreme Value Distribution Method was introduced by Gumbel in the year 1941 and is commonly known as Gumbel;s distribution. It is one of the most widely used probability-distribution functions for extreme values in hydrologic and meteorologic studies for prediction of flood peaks, maximum rainfall, maximum wind speed, etc. Gumbel defined a flood as the largest of the 365 daily flows and the annual series of flood flows constitute a series of largest values of flows. He used the formula $\mathbf{X_T = X^* + K\,(S_{n-1})}$, where, X^* = mean of the sample ($\sum X/N$), S_{n-1} = Standard deviation of the sample [$\sqrt{\sum (X-X^*)^2 / (N-1)}$], and K = frequency factor expressed as [$Y_T - Y^*_N$ / SN] in which Y_T = reduced variate, a function of T expressed as-[In. In. T / (T-1)], Y^*_N = reduced mean and S_N = reduced standard deviation, a function of sample size N. The annual peak flood or maximum discharge values of the Pahumara River at N.T. road crossing site for the period of twenty three years (1982 - 2004) are considered to carry out the flood frequency analysis using Gumbel's Extreme Value Distribution Method. The peak flow data at the said site of Pahumara River are arranged in descending order and the plotting position recurrence interval (Tp) for each of the flows is obtained by using equation : Tp =(N+1)/m. The peak discharge data of the river are plotted against the corresponding Tp in relation to reduced variate Y_T on a Gumbel's Extreme Value probability paper. Figure 4 highlights the plotting of expected peak discharges against different return periods. Different parameters of Gumbel's Extreme Value Distribution Method for the flood series of 23 years are computed and presented in the table 5 and 6.

Table 5 : Annual peak flood magnitude (m^3/s) of Pahumara river for the duration from 1982-2004

Year	Peak Flood magnitude (m^3/s)	Flood magnitude in descending order (X)	Order (m)	Return period T_r=N+1/m	Reduced variate= -[1n.1n T_r/T_r-1]	$(X-X)^2$
1982	88.85	136.48	1	24	3.15	48.41
1983	122.57	128.76	2	12	2.44	40.69
1984	121.17	122.53	3	8	2.01	34.46
1985	136.48	121.17	4	6	1.70	33.1
1986	90.41	117.85	5	4.8	1.45	29.78
1987	117.85	102.01	6	4	1.24	13.94
1988	98.11	98.11	7	3.4	1.05	10.04
1989	78.86	92.96	8	3	0.90	4.89
1990	102.01	90.41	9	2.6	0.72	2.34
1991	92.96	88.85	10	2.4	0.61	0.78
1992	77.84	88.07	11	2.1	0.43	0
1993	83.83	83.83	12	2	0.36	-4.24
1994	51.46	83.53	13	1.8	0.20	-4.54
1995	71.36	80.81	14	1.7	0.11	-7.26
1996	88.07	78.86	15	1.6	0.01	-9.21
1997	80.81	77.84	16	1.5	-0.09	-10.23
1998	83.53	75.93	17	1.4	-0.22	-12.14
1999	66.85	71.36	18	1.3	-0.38	-16.71
2000	28.72	70.79	19	1.2	-0.58	-17.28
2001	68.56	68.56	20	1.2	-0.58	-19.51
2002	75.93	66.85	21	1.1	-0.87	-21.22
2003	70.79	51.46	22	1.09	-0.91	-36.61
2004	128.76	28.72	23	1.04	-1.18	-59.35

N=23 ΣX=2025.74

Table 6: Computation of estimated flood magnitude for different Return Period

Return Period (Tr)	Reduced Return Period (YT)	$\bar{X}$	Sx (cumec)	Reduced Mean $\bar{Y}n$	Sn	Frequency factor KT = $(YT - \bar{Y}n) / Sn$	Flood magnitude $XT = \bar{X} + KT . Sx$
2	0.3665					0.1497	84.3515
5	1.4999					0.8987	110.3937
10	2.2504					1.5929	127.6376
20	2.9702	88.07	24.84	0.5283	1.0811	2.2587	144.1761
25	3.1985					2.4699	149.4223
50	3.9019					3.1205	165.5832
100	4.6001					3.7663	181.6249
200	5.2958					4.4099	197.6119

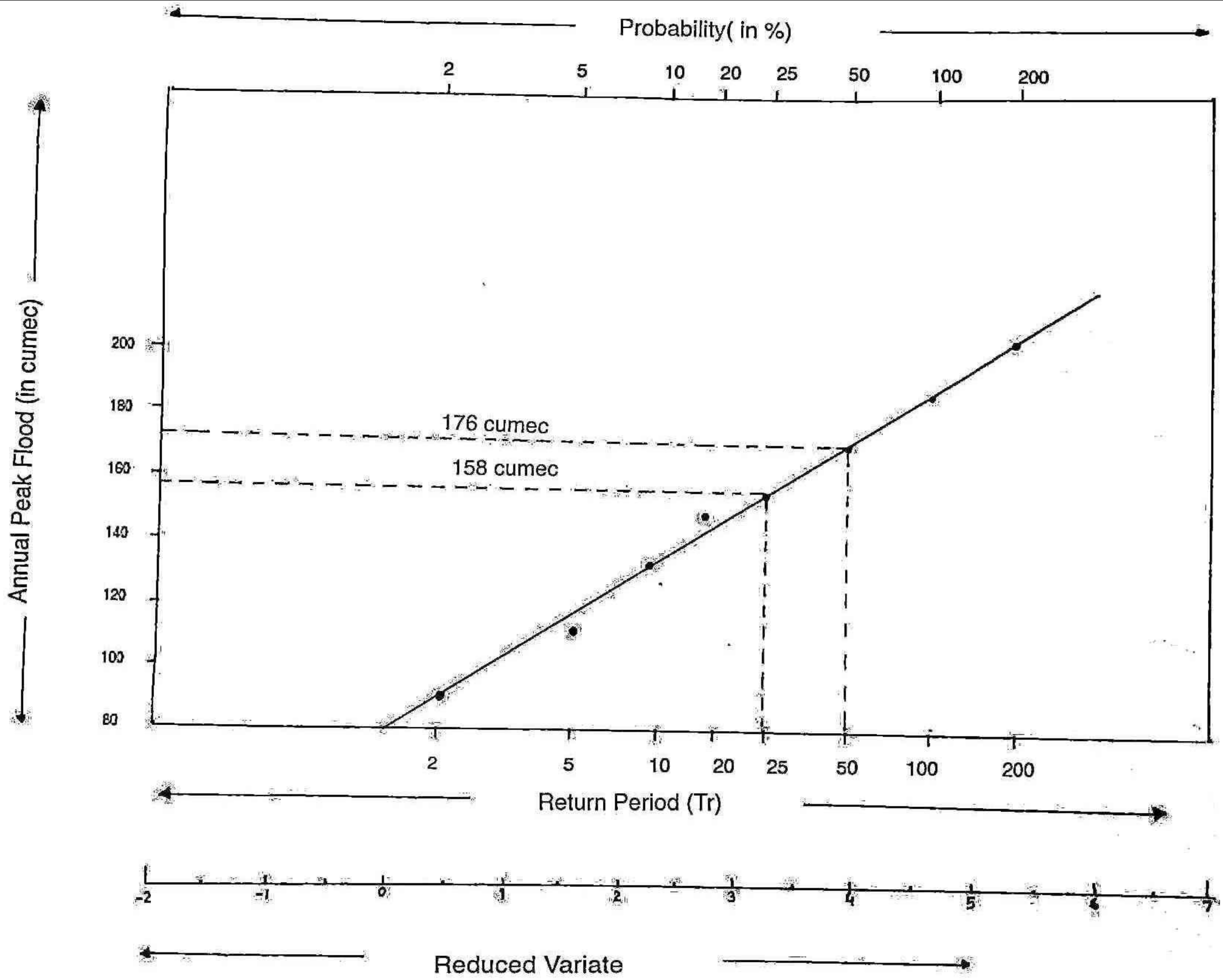

Fig. 6 : Estimation of peak flood of Phumara river using Gumbel's Extreme value distribution method (1982-2004).

Analysis of Gumbel's Method

The annual peak floods of the river for the duration of twenty three years (1982 to 2004) have been considered to estimate the flood for some selected return periods, The observed data represent the maximum size of flood and minimum size of flood magnitudes i.e. 28.72 m^3/s and 136.48 m^3/s in the year of 2000 and 1985 respectively. The estimated peak flood data for given return period say 2, 5, 10, 20, 25, 50, 100 and 200 yrs. have been calculated and shown in the table 6 and figure 6. The table and figure reveal that flood magnitude for the return period of 50 yrs., 100 yrs. and 200 yrs. are 165.58 m^3/s, 181.62 m^3/s and 197.61 m^3/s respectively. It means the size of flood amounting 165.58 m^3/s, 181.62 m^3/s, 197.61 m^3/s and are possible to receive after every 50 yrs., 100 yrs. and 200 yrs. respectively.

Conclusion:

The Pahumara River flowing through the Barpeta district, Assam has the variation in water level and discharge resulting in the variation of flood magnitude. An attempt has been made through this paper to focus the stage discharge variation as well as design of flood magnitude of the Pahumara River. The non availability of adequate data has come in the way for proper analysis of stage, discharge and estimation or designing of flood of this river. The major findings of the study are highlighted in the following points.

- The table 1 and figure 2 for annual peak discharge hydrograph highlights that the maximum flow is 136.48m^3/s in the year 1985 and minimum flow 28.72 m^3/s in 2000 respectively.
- The comparative analysis of monthly average stage discharge hydrographs (table 2,3 & 4 and fig. 3,4 & 5) for three selected year (2013, 2019 and 2021) reveal that The maximum values for water level for the selected years are 41.41 (July, 2013), 42.56 (July, 2019) and 41.37 ((June, 2021). The fluctuation of minimum water level is also noticeable for the selected years which are 40.09 (Sept, 2013), 39.37 (Sept, 2019) and 39.33 (April, 2021). The maximum and minimum values for water discharge are 101.41 & 17.18 (Sept & April, 2013), 35.68 & 21.08 (July & Dec, 2019) and 40.47 & 39.29 (July & March, 2021).
- The Gumbel's Distribution method of FFA for this river reveals that that flood magnitude for the years 50 yrs., 100 yrs. and 200 yrs. return periods are 165.58 m^3/s, 181.62 m^3/s and 197.61 m^3/s respectively. It means the size of flood 165.58 m^3/s, 181.62 m^3/s, 197.61 m^3/s and are possible to receive after every 50 yrs., 100 yrs. and 200 yrs. respectively.

The fluvio-geomorphological setting of this river and its basin area have been overwhelmed by so many problems like river bank erosion and channel shifting, floods of low to high magnitudes causing damage to human settlements, crop lands, and wet lands etc. The précised investigations on the subject under study may be highly helpful to understand the flood and associated problems. The present study does not end unless different parameters of the topic are completely analyzed.

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Reference & Bibliography:

i) Khusuwaha NL & Bhardwaj A – *"Hydrologic response of Takaria- Ballowal watershed in Shivalik foot hills based on morphometric analysis using RS & GIS ,* J Indian water resource society, 2016.

ii) Sarma, J. N. (2008): Asamar Nad-Nadi, Assam Sahitya sabha, *Kiran Prakashan*, Dhemaji, Assam.

iii) Subramanya K (1997), *"Engineering Hydrology",* Second Edition, pp 181 – 270 , published by Tata McGraw-Hill Publishing Company Limited, New Delhi

iv) https://nhp.mowr.gov.in – Hydrology project on *Understanding stage discharge relation* (pp 7-8)

v) Mandal K. K. and et.al – *Application of Gumbel's Distribution Method for FFA of Lower Ganga Basin (Farrakka Barrage Station),* West Bengal, India, Disaster Advances, Vol. 14 (8) , August (2021)

vi) Hussain T. A. – *Discharge estimation of Disang River, Assam for Micro hydropower & diversion based Irrigation Project*, Imperial Journal of Interdisciplinary Research (IJIR), Vol-3, Issue-10, 2017.

vii) Book on "*The Brahmaputra Basin Water Resources*". Editors : Vijoy P. Sing, Nayan Sharma, C. Shekhar, P.Ojha *(Springer Link)*

viii) https ://portal.iucn.org – *Physical Assessment of the Brahmaputra River*, pp 5-40 (International Union for conservation of Natural Resources).

ix) .Raghunath H.M (1996), "*Hydrology *Principles, Analysis and Design",* pp 122, 230, 367, published by New Age International (P) Limited, Ansari Road, Dariyaganj, New Delhi.

x) Feldman Arlen D., " *Flood Hydrograph and Peak Flow Frequency Analysis*", presented at Engineering foundation Conference on Improved Hydrologic Forecating, Asilomar, California, March,1979.

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