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A Study on Peak Flood Estimation using Flood Frequency Analysis for Panam Dam Reservoir

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Abstract— Floods are the natural calamities which brings devastation to life and property. This paper describes the methods of estimating the peak floods up to 100 years for Panam dam site located at Kel Dazar, Godhra. The flood frequency analysis methods include Gumbel's Method, Log Pearson Type III Distribution and Log Normal Distribution. In addition to the following methods, a new and improved named Design Index Flood Method. For the study purpose, annual peak floods for 19 years i.e. from 2000 to 2018 has been taken into consideration. From the results, it has been observed that the peak floods estimated using Gumbel's method has a proximity towards the observed data as compared to other methods. The RMSE values and the Absolute difference also indicates a lower value for Gumbel's method. From this study, it is concluded that Gumbel's method is the suitable method for predicting the peak floods at the Panam Dam site.

Keywords— Peak Flood, Panam Dam, Flood Frequency Analysis, Design Index Flood, RMSE.

I. INTRODUCTION

The estimation of peak flow of a return period is a standard requirement in many civil engineering projects such as design of dams, bridge openings and culverts, drainage networks, flood relief/protection schemes etc. (Bhattara 2005). In the design of hydraulic structures, it is not practical from economic considerations to provide for the safety of the structure and the system at the maximum possible flood in the catchments. The structure is designed considering the past flood data of the planning period but after construction of dam, the reservoir operation is required to be revised based on the large span flood data available after construction of the dam. (Husain 2012). In this study, the frequency analysis of the available peak flood data has been carried out using Gumbel's method (Gumbel 1941), Log-Pearson method (Bobee 1975), Log Normal distribution method (Bobee 1975). In addition to this, a new method has also been used named as Design Index Flood Method. In simple words, index flood based regional flood-frequency analysis method can be said of three major steps: hydrologic homogeneous regionalization, selection of regional frequency distribution and estimation of index flood relationship (Binay Kumar Mishra, 2010).

II. STUDY AREA

Panam Dam lies between 23.0545°N latitude and 73.7167°E. The dam is constructed on the Panam River, a tributary of the Mahi River. The total catchment area of the dam is 2312km^2. The total length of the dam of spillway is 182.62m. The construction period of the dam 1971-1999. The dam was open to serve the purpose in the year 2000.the Panam Dam is surrounded by Wanakbori Weir on one side and on the other side is Kadana Dam.The fig 1 shows the map of the Panam Dam.

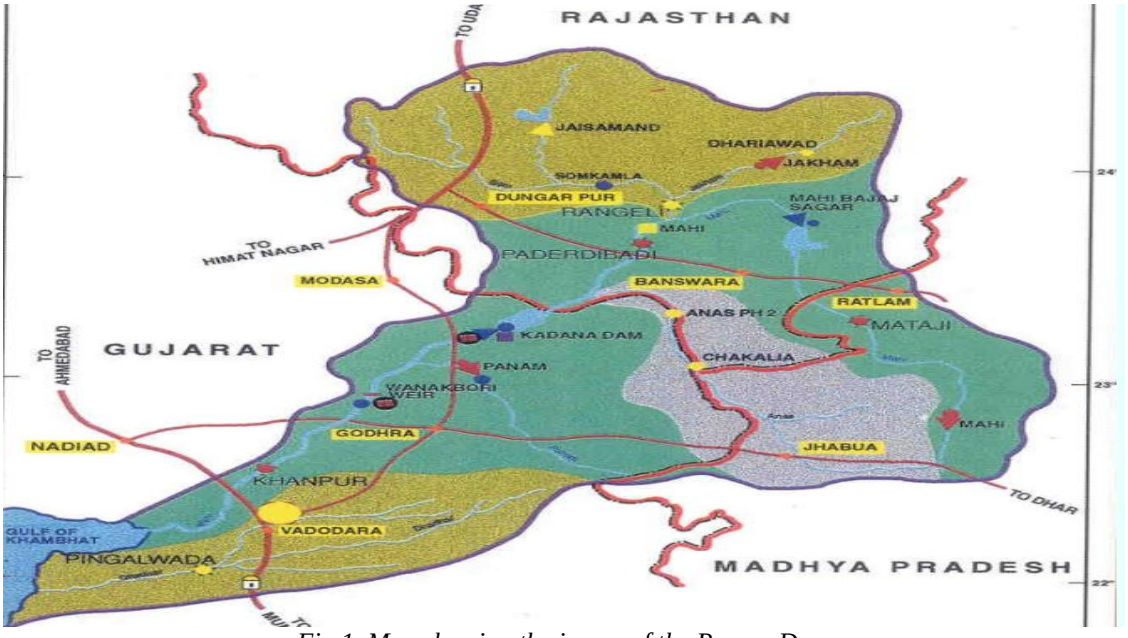

Fig 1. Map showing the image of the Panam Dam

III. METHODOLOGY

The primary objective of the flood frequency analysis is to determine the recurrence interval of a particular hydrologic event. The most commonly used methods are Gumbel's Method, Log Pearson Method and Log Normal Method (Subramanya, 2012). One more method has been proposed i.e. Design Index Flood Method for the statistical analysis of the annual peak floods (Binay Kumar Mishra, 2010). The Root mean Square Error has also been found for the above menthods.

A. Gumbel's Distribution

This extreme value of distribution was introduced by Gumbel (1941) and is commonly known as Gumbel's distribution. The following formula for determining the flood peaks (Q_T) at different return periods (T) using the average of the annual floods (Q_{bar}) is as follow.

$$Q_T = \overline{Q} + K*\sigma_{n-1} \quad (1)$$

B. Log Pearson Type III Distribution

In this, variate is first transformed into logarithmic form (base 10) and the transformed data is then analysed as discussed in Bobee, 1975.

$$Z_T = Z_{bar} + Kz*\sigma z \quad (2)$$
$$Q_T = \text{antilog}\ (Z_T) \quad (3)$$

C. Log Normal Distribution

When the coefficient of skewness is zero i.e. C_s= 0, the log Pearson Type III distribution reduces to Log normal distribution.

$$Z_T = Z_{bar} + Kz*\sigma z \quad (4)$$
$$Q_T = \text{antilog}\ (Z_T) \quad (5)$$

D. Design Index Flood Method

Design flood, Q_T (m^3/s) of T year return period is given by the following equation:

$$Q_T = 6.23\times A^{0.68}[0.726 - 2.73\{1 - \ln(T\text{-}1/T)\}^{-0.137}] \quad (6)$$

E. Root Mean Square Error

The RMSE between the estimated and observed peak flows were determined using the equation given by (O'Donnell 1995) and is expressed as

$$RMSE = [n^{-1}\sum_{i=1}^{n}(P - Q)^2]^{0.5} \quad (7)$$

where
RMSE is root mean square error (m^3/s),
P is estimated discharges under each distribution (m^3/s),
Q is observed discharges (m^3/s), n= no. of records

IV. RESULTS

The estimated peak flood values for the Gumbel's Method, Log Pearson Method, Log Normal Method and Design Index Flood Method has been shown in Table1. The RMSE values for the different methods have been shown in Table 2. The comparison graph for all the methods is shown in Figure 1.

Table 1 Estimated Peak Flood values using different Methods

Recurrence Interval	Estimated Peak Floods(m^3/s)			
	Gumbel's Method	Log Pearson Type III	Log Normal Distribution	Design Index Flood
5	1745.54865	2079.4	2113.49	1629.0886
10	2466.98265	3619.27	3527.04	2067.57
25	3159.0324	6673.47	6084.92	2690.11
50	4054.54275	10018.41	8655.06	3207.1
100	4725.71955	14454.39	11874.9	3771.99

Table 2 RMSE values for the different methods

Recurrence Interval	RMSE (m^3/s)			
	Gumbel's Method	Log Pearson Type III	Log Normal Distribution	Design Index Flood
5	1504.3	1703.5	1724.2	1437.5
10	2420.43	3060.23	3005.91	2225.51
15	2980.75	3933.88	3776.45	2840.21
19	3456.70	4540.8	4330.04	3349.84

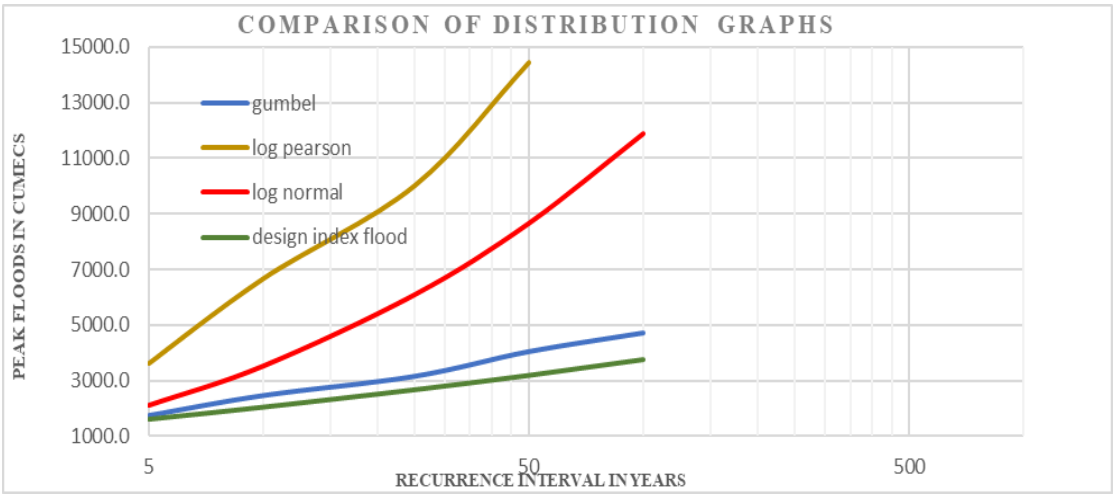

Fig 2 Comparison graph for the methods used

V. CONCLUSION

The study has been taken up for estimating peak floods for Panam dam site in Panam River basin, Gujarat using Gumbel's method, Log Pearson method, Log Normal method and Design Index Method. The results obtained shows that the methods considered in this study can be used practically for estimating the peak flood flows at different return periods. From this study, following conclusions are drawn:

i. Log Pearson Type III distribution gives the higher flood values for the different recurrence intervals.

ii. When a graph is plotted between the peak floods and the recurrence interval in semi-log graph, the Gumbel method gives a straight line for the estimated data which indicates the proximity between the observed and the estimated flood data.

iii. The RMSE value obtained from the different methods shows that for Design Index flood method, the values are the lowest as compared to other methods.

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