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Intercomparison of Probability Distributions for Extreme Value Analysis of Rainfall Data

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ABSTRACT

For planning, design and management of hydraulic structures viz., dams, bridges, barrages, storm water drainage systems, extreme rainfall for a given return period is considered that depends on the design life of the structures. This can be computed by carrying out Extreme Value Analysis (EVA) of rainfall that involves of fitting of probability distributions to the observed annual 1-day maximum rainfall series. This paper illustrates a study on comparison of Extreme Value Type-I (EVI), 2-parameter Log Normal and Log Pearson Type-3 (LP3) probability distributions adopted for rainfall estimation at Anakapalli, Atchutapuram and Parvada sites wherein the parameters of the distributions are determined by maximum likelihood method. The adequacy of probability distributions adopted for EVA of rainfall is assessed by quantitative assessment using Goodness-of-Fit (Chi-square and Kolmogorov-Smirnov) and diagnostic (Root Mean Squared Error) tests, and qualitative assessment through fitted curves of the estimated values. Based on the quantitative and qualitative assessments, the study suggests that LP3 distribution is better suited for rainfall estimation at Anakapalli and EVI for Atchutapuram and Parvada.

Keywords: *Chi-square, Extreme Value Analysis, Extreme Value Type-I, Kolmogorov-Smirnov, Log Normal, Log Pearson Type-3, Rainfall, Root Mean Squared Error*

INTRODUCTION

Estimation of Extreme Rainfall (ER) for a desired return period is a pre-requisite for planning, design and management of various hydraulic structures viz., dams, bridges, barrages, storm water drainage systems, etc. Depending on the size and design-life of structure, the estimated ER corresponding to a given return period is used. Generally, 1000-year return period estimated ER will be considered for the design of hydraulic structures having a design life of 1000-year [1]. This can be computed by carrying out Extreme Value Analysis (EVA) by fitting probability distributions to the series of observed Annual 1-day Maximum Rainfall (AMR).

Out of a number of probability distributions, Extreme Value Type-I (EVI), Log Normal (LN2), Log Pearson Type-3 (LP3) and Pearson Type-3 distributions are widely used for EVA of rainfall [2].Number of studies has been carried out by different researchers which showed that there is no unique distribution available for EVA of rainfall for a region or country [3,4]. Lee [5] indicated that LP3 distribution gives better results while analyzing the rainfall distribution characteristics of Chia-Nan plain area. Bhakar et al. [6] adopted EVI distribution for frequency analysis of consecutive day's maximum rainfall at Banswara, Rajasthan. Study by Saf et al. [7] revealed that the Pearson Type-3 distribution is better suited for modelling of extreme values in Antalya and Lower-West Mediterranean sub-regions whereas the Generalized Logistic distribution for the Upper-West Mediterranean sub-region. Varathan et al. [8] expressed that the EVI distribution is the best fitting distribution to analyse the annual maximum rainfall of Colombo district. AlHassoun [9] carried out a study on developing empirical formula to estimate rainfall intensity in Riyadh region using EVI, LN2 and LP3. He concluded that the LP3 distribution gives better accuracy amongst three distributions studied in estimation of rainfall intensity. Baratti et al. [10] carried out flood frequency analysis on seasonal and annual time scales for the Blue Nile River adopting EVI distribution. Esteves [11] applied EVI distribution to estimate the ER depths at different rain-gauge stations in southeast United Kingdom. Rasel and Hossain [12] applied EVI distribution for development of intensity duration frequency curves for seven divisions in Bangladesh. Afungang and Bateira [13] applied Gumbel distribution to

estimate the maximum amount of rainfall for different periods in the Bamenda mountain region, Cameroon. Studies carried out by Sasireka et al. [14] indicated that the extreme rainfall for various return periods obtained from Gumbel distribution could be used for design purposes by considering the risk involved in the operation and management of hydraulic structures in Tiruchirappalli region. Moreover, when number of probability distributions used in EVA of rainfall, a common problem that arises is how to determine which model fits best for a given set of data. This possibly could be answered by Goodness-of-Fit (GoF) tests and the results are quantifiable and reliable. GoF tests viz., Chi-square (χ^2) and Kolmogorov-Smirnov (KS) are applied for checking the adequacy of fitting of probability distributions to the observed AMR [15]. In addition to χ^2 and KS tests, a diagnostic test viz., Root Mean Squared Error (RMSE) is used for identifying the best suitable probability distribution for estimation of rainfall. The procedures adopted in EVA of rainfall by EVI, LN2 and LP3 distributions are demonstrated with illustrative example.

METHODOLOGY

In this paper, a study has been carried out to assess the Probability Distribution Functions (PDFs) adopted in EVA of rainfall. For this, it is required to process and validate the data of the variate for application such as (i) perform statistical tests such as independency, homogeneity and outliers; (ii) determine the parameters of EVI, LN2 and LP3 distributions by Maximum Likelihood Method (MLM); (iii) Analyse the EVA results through quantitative and qualitative assessments, and recommendations made thereof. Table 1 gives the PDF with the corresponding quantile estimator (x_T) of PDFs used for EVA.

Table1. *PDF and quantile estimator of EVI, LN2 and LP3 distributions*

Distribution	PDF	Quantile estimator
EVI	$f(x;\alpha,\beta)=\frac{e^{-(x-\alpha)/\beta}e^{-e^{-(x-\alpha)/\beta}}}{\beta}$, $\beta>0$	$x_T=\hat{\alpha}+Y_T\hat{\beta}$
LN2	$f(x;\alpha,\beta)=\frac{1}{\beta\sqrt{2\pi}}\exp\left(-\frac{(x-\alpha)^2}{2\beta^2}\right)$, $-\infty<x<\infty$, $\beta>0$	$x_T=e^{\hat{\alpha}+K_P\hat{\beta}}$
LP3	$f(x;\alpha,\beta,\gamma)=\frac{1}{\beta x\Gamma\gamma}\left(\frac{\ln(x)-\alpha}{\beta}\right)^{\gamma-1}e^{-\left(\frac{\ln(x)-\alpha}{\beta}\right)}$, $\beta,\gamma,>0$	$x_T=e^{(\hat{\alpha}+\hat{\beta}\hat{\gamma})+K_P\hat{\beta}\sqrt{\hat{\alpha}}}$

In Table 1, the symbols viz., α, β and γ denote the location, scale and shape parameters of the distributions respectively. Also, the symbols viz., $\hat{\alpha},\hat{\beta}$ and $\hat{\gamma}$ denote the MLM estimators of the parameters of the probability distributions. The procedures adopted in determining the parameters of the distributions considered for EVA are briefly described in the text book titled "Flood frequency analysis" by Rao and Hamed [16]. For EVI, the reduced variate (Y_T) for a return period (T) is given by Y_T =-ln(-ln(1-(1/T))) while in the mathematical representation of LN2 and LP3, K_P denotes the frequency factor corresponding to the probability of exceedance. For LN2, the value of CS is considered as 0.0 whereas CS is based on the log transformed series of the observed data for LP3.

Goodness-of-Fit Tests

The adequacy of fitting of EVI, LN2 and LP3 distributions used in EVA is assessed by GoF tests. Theoretical descriptions of GoF tests are as follows:

$$\chi_c^2=\sum_{j=1}^{NC}\frac{(O_j(x)-E_j(x))^2}{E_j(x)} \quad \text{.....} \quad (1)$$

where, $O_j(x)$ is the observed frequency value of j^{th} class, $E_j(x)$ is the expected frequency value of j^{th} class and NC is the number of frequency classes. A rejection region of χ^2 statistic at the desired significance level (η) is given by $\chi_C^2 \geq \chi_{1-\eta,NC-m-1}^2$. Here, m denotes the number of parameters of the distribution and χ_C^2 is the computed value of statistic by PDF used in EVA.

KS test statistic is defined as below:

$$KS=\underset{i=1}{\overset{N}{Max}}\,(F_e(x_i)-F_D(x_i)) \quad \text{.....} \quad (2)$$

Here, $F_e(x_i)$ is the empirical CDF of x_i and $F_D(x_i)$ is the derived CDF of x_i by PDF. In this study, Weibull plotting position formula is used for computation of empirical CDF. If the computed value of KS test statistic by a PDF is less than that of its theoretical value at the desired significance level then the PDF is assumed to be suitable for EVA at the level of significance.

Diagnostic Test

Sometimes the GoF test results would not offer a conclusive inference thereby posing a bottleneck to the user in selecting the suitable probability distribution for application. In such cases, a diagnostic test in adoption to GoF is applied for making inference. A selection of most suitable probability distribution for EVA of rainfall is performed by RMSE [17], which is defined as below:

$$RMSE = \left(\frac{1}{N} \sum_{i=1}^{N} \left(x_i - x_i^* \right)^2 \right)^{1/2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Here, x_i is the observed rainfall data of i^{th} sample and x_i^* is the estimated rainfall by PDF for i^{th} sample. A distribution has least RMSE is considered as best fit distribution for EVA.

APPLICATION

EVA of rainfall data was carried out to estimate the ER (x_T) adopting EVI, LN2 and LP3 distributions. MLM was used for determination of parameters of the distributions. Daily rainfall data (with missing values) observed at Anakapalli for the period 1970 to 2017, Atchutapuram for the period 1989 to 2017 and Parvada for the period 1992 to 2017 was used. The AMR series was extracted from the daily rainfall data and used for EVA. From the scrutiny of the daily rainfall data, it was observed that the data for the intermittent period for Anakapalli (2004) and Parvada (1994, 1995 and 2013) are missing. However, the data for the missing years were not considered in EVA. Table 2 gives the descriptive statistics of AMR.

Table2. *Descriptive Statistics of AMR*

Site	Average(mm)	SD (mm)	CS	CK
Anakapalli	107.8	52.9	1.539	2.707
Atchutapuram	115.1	66.9	2.588	8.485
Parvada	98.8	41.7	0.260	-0.870

SD: Standard Deviation; CS: Coefficient of Skewness; CK: Coefficient of Kurtosis

Data Validation

The data series used for EVA should satisfy certain basic assumption such as data should be independent and identically distributed with the meteorological process. The term independent denotes that no observation in the data series has any influence on any other observation following i.e., the data series are random. Similarly, homogeneity of the sample elements in the data series has to be checked to identify whether the data originates from a single population or not. The presence of outliers in a data sample has undesirable effect on frequency analysis. Therefore, the sample also needs to be checked for outliers if any. In the present study, Wald-Wolfowitz and Mann-Whitney Wilcoxon tests were used for checking the independency and homogeneity of the data series of AMR. Grubbs test was used for detection of outliers in the data series [18]. From the results, it is observed that the computed values of Wald-Wolfowitz and Mann-Whitney Wilcoxon tests statistic for the series of AMR of Anakapalli, Atchutapuram and Parvada are less than its theoretical value (either 5 % or 1 % level); and at this level, the data series were found to be independent and homogeneous. The Grubbs test results showed that there is an outlier in AMR series of Anakapalli (280 mm for the year 1982) and Atchutapuram (378.2 mm for the year 2014) whereas there is no outlier in the rainfall series of Parvada. However, the entire data was used for EVA by considering the importance of the actually observed extremes in the region under consideration.

RESULTS AND DISCUSSIONS

The procedures described above for estimating ER have been implemented adopting computer codes and used in EVA of rainfall. The program computes the (i) statistical tests results for the data series; (ii) parameters of EVI, LN2 and LP3 distributions; (iii) ER estimates with lower and upper confidence limits (LCL and UCL) at 95% level for different return periods; and (iv) GoF and diagnostic tests values.

Estimation of Extreme Rainfall

The analysis of AMR series passed the statistical tests required for EVA. The parameters of EVI, LN2 and LP3 distributions were determined by MLM; and also used for estimation of ER. The EVA results are presented in Tables 3 to 5 while the plots are shown in Figures 1 to 3. From EVA results, it is noted that the estimated rainfall by LP3 distribution is higher than the corresponding values of EVI and LN2 distributions from 10-year and above.

Analysis Based on GoF Tests

The GoF tests statistic values of EVI, LN2 and LP3 distributions were computed and are presented in Table 6. Based on GoF tests results, it is noted that:

- The χ^2 test supported the use of EVI, LN2 and LP3 distributions for EVA of rainfall for Anakapalli and Parvada.
- For Atchutapuram, EVI and LN2 distributions

are found to acceptable for EVA of rainfall.

- The KS test supported the use of EVI, LN2 and LP3 distributions for EVA of rainfall for Anakapalli, Atchutapuram and Parvada.

Table3. *Estimated 1-day maximum rainfall with confidence limits by EVI, LN2 and LP3 for Anakapalli*

Return Period (year)	EVI			LN2			LP3		
	ER (mm)	LCL (mm)	UCL (mm)	ER (mm)	LCL (mm)	UCL (mm)	ER (mm)	LCL (mm)	UCL (mm)
2	98.7	86.7	110.6	97.5	85.1	109.8	95.3	85.4	105.2
5	139.1	120.7	157.4	141.3	120.4	162.1	140.1	120.2	160.1
10	165.8	142.3	189.3	171.5	145.1	197.9	173.6	145.1	202.1
20	191.5	162.6	220.3	201.3	172.5	230.1	208.6	175.3	242.0
25	199.6	169.1	230.1	210.9	180.2	241.6	220.3	185.1	255.6
50	224.7	188.8	260.5	241.1	205.3	276.8	258.4	215.2	301.7
100	249.6	208.4	290.7	271.9	225.1	318.6	299.4	242.8	356.0
200	274.3	227.8	320.9	303.5	250.1	356.9	343.6	270.1	417.1
500	307.1	253.4	360.7	346.8	280.3	413.2	407.7	298.1	517.3
1000	331.8	272.7	390.9	415.9	310.4	461.4	460.9	315.4	606.3
10000	413.9	336.7	491.0	502.4	400.2	604.7	671.5	356.9	986.1

Table4. *Estimated 1-day maximum rainfall with confidence limits by EVI, LN2 and LP3 for Atchutapuram*

Return period (year)	EVI			LN2			LP3		
	ER (mm)	LCL (mm)	UCL (mm)	ER (mm)	LCL (mm)	UCL (mm)	ER mm)	LCL (mm)	UCL (mm)
2	104.5	88.0	121.0	102.5	75.0	130.0	99.6	80.2	119.1
5	148.3	123.1	173.7	151.0	118.5	183.4	149.9	120.4	179.4
10	177.3	145.0	209.9	184.8	150.3	219.4	188.6	145.2	232.1
20	205.2	165.6	245.0	218.5	185.2	251.7	230.1	175.3	284.9
25	214.0	172.1	256.2	229.4	195.4	263.3	244.2	183.2	305.1
50	241.2	192.0	290.8	263.7	225.0	302.3	290.5	220.5	360.5
100	268.3	211.7	325.2	298.9	260.3	337.5	341.3	260.4	422.3
200	295.2	231.2	359.5	335.2	295.5	375.0	397.2	300.2	494.2
500	330.7	256.9	404.9	385.3	340.2	430.3	479.8	360.5	599.1
1000	357.5	276.3	439.2	424.5	375.2	473.8	549.7	400.2	699.1
10000	446.6	340.5	553.3	567.2	498.5	635.9	836.6	525.3	1147.9

Table5. *Estimated 1-day maximum rainfall with confidence limits by EVI, LN2 and LP3 for Parvada*

Return period (year)	EVI			LN2			LP3		
	ER (mm)	LCL (mm)	UCL (mm)	ER (mm)	LCL (mm)	UCL (mm)	ER (mm)	LCL (mm)	UCL (mm)
2	92.1	75.0	109.1	89.7	72.3	107.1	86.5	68.2	104.9
5	132.3	106.1	158.4	132.3	102.5	162.2	135.5	100.1	170.9
10	158.9	125.4	192.4	162.2	122.1	202.2	175.0	125.2	224.7
20	184.5	143.5	225.5	191.8	142.3	241.3	218.5	145.0	292.0
25	192.6	149.1	236.0	201.4	148.2	254.6	233.5	150.3	316.8
50	217.5	166.5	268.6	231.7	166.1	297.2	284.0	165.5	402.5
100	242.3	183.7	300.9	262.8	180.0	345.5	340.8	180.0	501.6
200	267.0	200.8	333.3	294.9	195.4	394.3	404.7	195.2	614.2
500	299.6	223.2	376.0	339.1	215.2	462.9	501.8	215.3	788.4
1000	324.2	240.1	408.4	375.2	235.3	515.1	586.1	228.4	943.9
10000	406.0	296.7	515.9	500.0	295.1	704.9	949.4	287.1	1611.6

Table6. *Theoretical and computed values of GoF tests statistic by EVI, LN2 and LP3 distributions*

Site	Computed value						Theoretical value			
	χ^2			KS			χ^2			KS
	EVI	LN2	LP3	EVI	LN2	LP3	EVI	LN2	LP3	
Anakapalli	3.936	3.936	3.936	0.098	0.077	0.067	7.82	7.82	5.99	0.184
Atchutapuram	4.517	4.241	4.213	0.125	0.108	0.063	5.99	5.99	3.84	0.228
Parvada	1.522	1.522	1.522	0.116	0.118	0.095	5.99	5.99	3.84	0.253

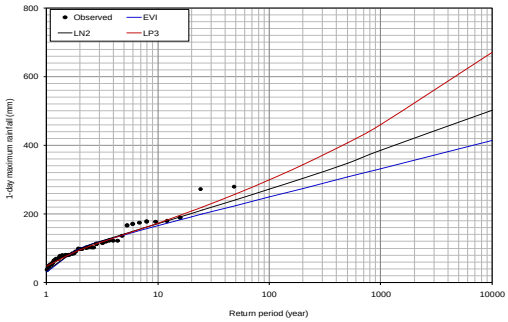

Figure1. *Estimated 1-day maximum rainfall by EVI, LN2 and LP3 distributions with observed data for Anakapalli*

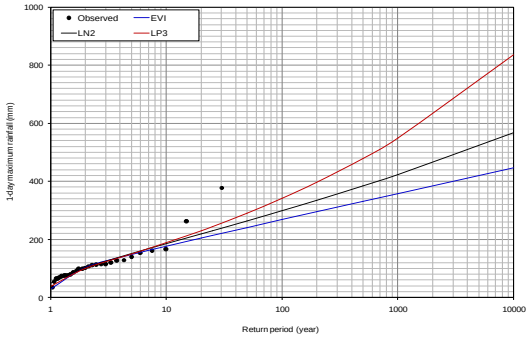

Figure2. *Estimated 1-day maximum rainfall by EVI, LN2 and LP3 distributions with observed data for Atchutapuram*

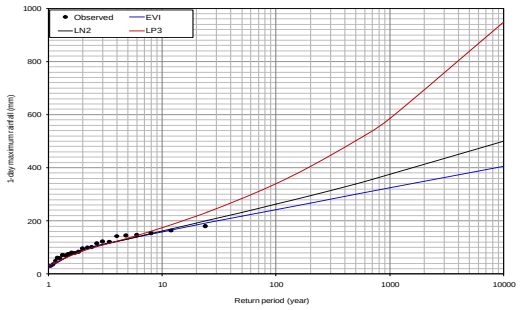

Figure3. *Estimated 1-day maximum rainfall by EVI, LN2 and LP3 distributions with observed data for Parvada*

From Figures 1 to 3, it can be seen that the fitted curves of the estimated rainfall by LP3 distribution is in the form of exponential pattern while the fitted curves of the estimated rainfall by EVI and LN2 distributions are in the form of linear pattern.

Analysis Based on Diagnostic Test

In addition to χ^2 and KS tests, for identifying the best suitable distribution for rainfall estimation, second line of action i.e., RMSE was applied and these values were computed for EVI, LN2 and LP3 distributions and presented in Table 7. From the results, it is noted that RMSE value obtained from LP3 distribution is minimum for Anakapalli whereas EVI distribution has minimum RMSE for Atchutapuram and Parvada.

Table7. *RMSE values given by EVI, LN2 and LP3*

Site	EVI	LN2	LP3
Anakapalli	5.813	8.607	3.562
Atchutapuram	6.751	8.809	9.343
Parvada	9.462	15.700	15.054

Selection of PDF for EVA of Rainfall

Based on the findings obtained through GoF and diagnostic tests results, the study suggested that LP3 is the most appropriate distribution for EVA of rainfall for Anakapalli whereas EVI for Atchutapuram and Parvada. The plots of estimated1-day maximum rainfall by the selected probability distribution together with confidence limits and observed data for Anakapalli, Atchutapuram and Parvada sites are presented in Figures 4 to 6.

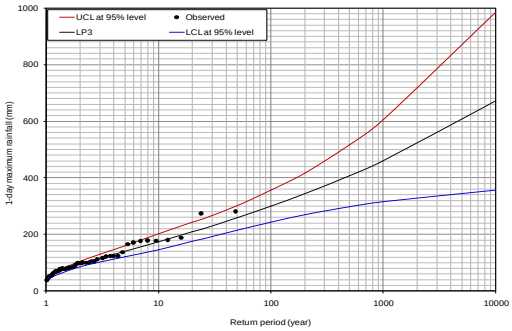

Figure4. *Estimated 1-day maximum rainfall by LP3 distribution with confidence limits and observed data for Anakapalli*

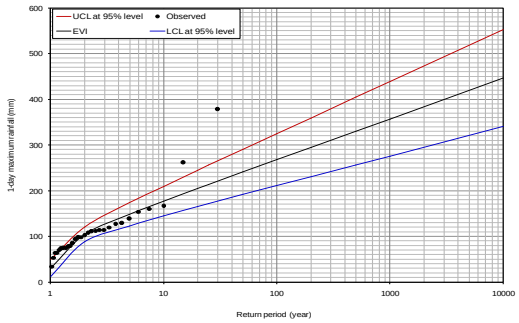

Figure5. *Estimated 1-day maximum rainfall by EVI distribution with confidence limits and observed data for Atchutapuram*

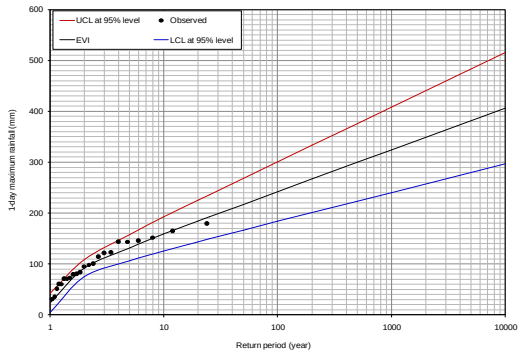

Figure6. *Estimated 1-day maximum rainfall by EVI distribution with confidence limits and observed data for Parvada*

The estimated 100-year, 1000-year and 10000-year return period 1-day maximum rainfall with confidence limits for Anakapalli, Atchutapuram and Parvada sites are presented in Table 8, which could be considered for design purposes while designing hydraulic structures with a design life of 100-year, 1000-year and 10000-year in the respective sites.

Table8. *Estimated 1-day maximum rainfall with confidence limits by the selected probability distribution*

Site	Probability distribution	1-day maximum rainfall with confidence limits for		
		100-year	1000-year	10000-year
Anakapalli	LP3	299.4 (242.8, 356.0)	460.9 (315.4, 606.3)	671.5 (356.9, 986.1)
Atchutapuram	EVI	268.3 (211.7, 325.2)	357.5 (276.3, 439.2)	446.6 (340.5, 553.3)
Parvada	EVI	242.3 (183.7, 300.9)	324.2 (240.1, 408.4)	406.0 (296.7, 515.9)
Figures given within the brackets indicate the lower and upper limits of the estimated rainfall.				

CONCLUSIONS

EVA of hydrometeorological parameters is essential in design consideration of establishment of hydraulic and civil structures. An effort is made to conduct a study and compare the EVI, LN2 and LP3 distributions adopted in EVA of rainfall for Anakapalli, Atchutapuram and Parvada through quantitative (GoF and diagnostic tests) and qualitative assessments. The following conclusions were drawn from the study:

- Analysis based on GoF tests results:
  - The χ^2 test suggested the applicability of EVI, LN2 and LP3 distributions for EVA of rainfall for Anakapalli and Parvada.
  - The χ^2 test ascertained the acceptability of EVI and LN2 distributions for EVA of rainfall for Atchutapuram.
  - The KS test confirmed the applicability of EVI, LN2 and LP3 distributions for EVA of rainfall for all three sites considered in the study.
- Qualitative assessment (plots of EVA results) of the outcomes was weighed with RMSE values and accordingly LP3 distribution was found to be acceptable for Anakapalli whereas EVI for Atchutapuram and Parvada.
- The upper limit of 1000-year return period estimated 1-day maximum rainfall of 606.3 mm for Anakapalli, 439.2 mm for Atchutapuram and 408.4 mm for Parvada, could be considered for designing of hydraulic structures having a design life of 1000-year.

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REFERENCES

[1] Naghavi, B., Yu, F.X. and Singh, V.P., 1993, "Comparative evaluation of frequency distributions for Louisiana extreme rainfall", *Water Resources Bulletin*, 29(2): 211-219.

[2] Di Balldassarre, G., Castellarin, A. and Brath, A., 2006, "Relationships between statistics of rainfall extremes and mean annual precipitation: an application for design storm estimation in northern central Italy", *Hydrology and Earth System Sciences*, 10(2): 589–601.

[3] Mujere, N., 2011, "Flood frequency analysis using the Gumbel distribution", *Journal of Computer Science and Engineering*, 3(7): 2774-2778.

[4] Haberlandt, U., and Radtke, I., 2014., "Hydrological model calibration for derived flood frequency analysis using stochastic rainfall and probability distributions of peak flows", *Hydrology and Earth System Sciences*, 18(1):353-365.

[5] Lee, C., 2005, "Application of rainfall frequency analysis on studying rainfall distribution characteristics of Chia-Nan plain area in Southern Taiwan", *Journal of Crop, Environment & Bioinformatics*. *2*(1): 31-38.

[6] Bhakar, S.R., Bansal, A.K., Chhajed, N., and Purohit, R.C., 2006, "Frequency analysis of consecutive days maximum rainfall at Banswara, Rajasthan, India", *ARPN Journal of Engineering and Applied Sciences*, 1(1): 64-67.

[7] Saf, B., Dikbas, F., and Yasar, M., 2007, "Determination of regional frequency distributions of floods in West Mediterranean River Basins in Turkey", *Fresenius Environment Bulletin*, 16(10): 1300–1308.

[8] Varathan, N., Perera, K., and Nalin., 2010, Statistical modelling of extreme daily rainfall in Colombo, Board of Study in Statistics and Computer Science of the postgraduate institute of science, *University of Peradeniya, Sri Lanka*.

[9] AlHassoun, S.A., 2011, "Developing empirical formulae to estimate rainfall intensity in Riyadh region", *Journal of King Saud University-Engineering Sciences*, 23(1): 81–88.

[10] Baratti, E., Montanari, A., Castellarin, A., Salinas, J.L., Viglione, A., and Bezzi, A., 2012, "Estimating the flood frequency distribution at seasonal and annual time scales", *Hydrological Earth System Science*, 16(12): 4651–4660.

[11] Esteves, L.S., 2013, "Consequences to flood management of using different probability

distributions to estimate extreme rainfall", *Journal of Environmental Management*, 115(1): 98-105.

[12] Rasel, M., and Hossain, S.M., 2015, "Development of rainfall intensity duration frequency equations and curves for seven divisions in Bangladesh", *International Journal of Scientific and Engineering Research*, 6(5): 96-101.

[13] Afungang, R., and Bateira, C., 2016, "Statistical modelling of extreme rainfall, return periods and associated hazards in the Bamenda Mountain, NW Cameroon", *Geography and Spatial Planning Journal*, 1(1): 5-19.

[14] Sasireka, K., Suribabu, C.R., Neelakantan, T.R., 2019, "Extreme Rainfall Return Periods using Gumbel and Gamma Distribution", *International Journal of Recent Technology and Engineering*, 8(4): 27-29.

[15] Zhang, J., 2002, "Powerful goodness-of-fit tests based on the likelihood ratio", *Journal of Royal Statistical Society*, 64(2): 281-294.

[16] Rao, A.R., and Hamed, K.H., 2000, Flood frequency analysis, CRC Press, Florida, USA.

[17] USWRC, 1981, Guidelines for deter-mining flood flow frequency, Bulletin No. 17B, United States Water Resources Council.

[18] Weaver, B., 2002, Non-parametric tests, Probability and Hypothesis Testing.

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