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COMPARISON OF GEV AND GUMBLE'S DISTRIBUTION FOR DEVELOPMENT OF INTENSITY DURATION FREQUENCY CURVE FOR FLOOD PRONE AREA IN SABAH

Nicklos Jefrin[1]*, Nurmin Bolong[1], Justin Sentian[2], Ismail Abustan[3], Thamer Ahmad Mohammad[4], Janice Lynn Ayog[1]

[1]Civil Engineering Program, Engineering Faculty, Universiti Malaysia Sabah, 88400 Kota Kinabalu, Sabah, Malaysia
[2]Faculty of Science and Natural Resources, Universiti Malaysia Sabah, 88400 Kota Kinabalu, Sabah, Malaysia
[3]School of engineering, Engineering Campus, Universiti Sains Malaysia, 14300 Nibong Tebal, P.Pinang, Malaysia
[4]Faculty of Engineering, Universiti Putra Malaysia, 43400 Serdang, Selangor Darul Ehsan, Malaysia
** Corresponding author email: nicklosjefrin@gmail.com*

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ABSTRACT

Rainfall data has a significant role in hydrological design which is, it's produce the intensity duration frequency curve. IDF curve gives critical information that needed in the design of water management infrastructure, it gives information by showing the mathematical relation of rainfall intensity, recurrence interval of the storm and duration of storm. This paper aims to compares and develop IDF curve using two frequency distribution which is generalized extreme value distribution (GEV) and Gumbel distribution (EV1). Then, the best fit distribution for flood-prone area in Sabah will be choose and determined from the two-mentioned distribution. The goodness of fit test that used to determine the best distribution is chi-square test, it works by determining the differences between observe data value from Weibull formula and the estimated values from GEV and Gumbel's distribution method. After that the chi-square value for GEV and Gumbel is compared to the critical value from chi-square table at significant level of 5%. From the Chi-square test, it is concluded that Gumbel's (chi square value Tandek:0.47952, patiu:1.0531, babagon: 1.026931, Ulu Moyog:0.382415) shows a better fit distribution compared to GEV distribution (chi square value Tandek:59.7598, patiu:16.5746, babagon: 3.3555347, Ulu Moyog:22.1315)

KEYWORDS

Gumbel's distribution, GEV, flood, rainfall intensity, return period, Sabah.

1. INTRODUCTION

Rainfall data played an important role in hydrological designed because it was used to develop IDF curve and designed water management infrastructures, bridge, spillways, flood protection structures, and many other civil engineering structures involving hydrologic flows [1]. Extreme rainfall was a complicated phenomenon and its marginal distributions were not necessarily similar or distributed as normal [2]. According to, historical rainfall data obtained from various rainfall stations can be used to develop Intensity-Duration- Frequency (IDF) curve and it was the most frequently used tool to estimate rainfall [3]. Extreme rainfall was a complicated phenomenon and its marginal distributions were not necessarily similar or distributed as normal [2]. In order to get accurate hydrologic analyses, reliable rainfall intensity estimations were necessary. The IDF relationship included the estimations of rainfall intensities of different durations and returned periods [4]. After the IDF curve was derived, the most suitable probability distribution to analyse the data must be determined. There are frequently used theoretical distribution functions that were applied in different regions all over the world for example Generalized Extreme Value Distribution (GEV), Gumbel, Log normal, Log Pearson Type III (LP3) distribution [5, 6]. According to, GEV used 3 parameters distributions whereas Gumbel used 2 parameters [7].

2. MATERIALS AND METHODS

Secondary rainfall data for selected rainfall station is supplied from department of Irrigation and Drainage Sabah (DID). All rainfall station selected is located around Penampang district and Kota Marudu district which is a flood prone area that hit by flood every year. Kota Marudu has suffered frequent occurrences of flooding which occurred at least a year with the latest case is in 18th January 2017 that effecting 2874 peoples. For penampang district ulu moyog and babagon station is selected, and for Kota marudu district tandek PH and Patiu station is selected. Gumble's distribution and GEV distribution is used to analyse the rainfall data and construction of the IDF curve for the selected station.

Extreme value distribution and is commonly known as Gumbel's distribution. The following equation used to provide the inflow for every period of return.

$$Q = \bar{Q} + K \cdot S$$

Where, Q is value of variate with a return period, T, $\bar{Q}$ is Mean of the variate, S is standard deviation of the sample, K is frequency factor

Chi-square test decides the best fit distribution. The equation for chi-square test is:

$$X^2 = \sum_{i=1}^{K} \frac{(Oi - Ei)}{Ei}$$

Where, Oi is the observed rainfall and Ei is the expected rainfall and will have chi-square distribution with (N-k-1) degree of freedom, By comparing both distribution Chi-square value, the smallest Chi-square value will be chosen as the best probability distribution, at the 5% significance level as it was used by researches [4].

As mentioned before, GEV distribution used three parameters which were location parameter (ξ), scale parameter (α) and the shape parameter (k) for the estimation of extreme rainfalls. In order to find the three parameters of GEV, Probability Weighted Moments (4 PWM's (M100, M110, M120, M130).) are needed for the calculation of L-Moments. Firstly, the data obtained must be arranged in ascending order and then be applied. After that, 4 L-Moments ($\lambda 1$, $\lambda 2$, $\lambda 3$, 4) are determined by using the PWMs. Finally, using the desired return period, all parameters were applied to the return period to estimated return value Qt.

3. RESULTS AND DISCUSSION

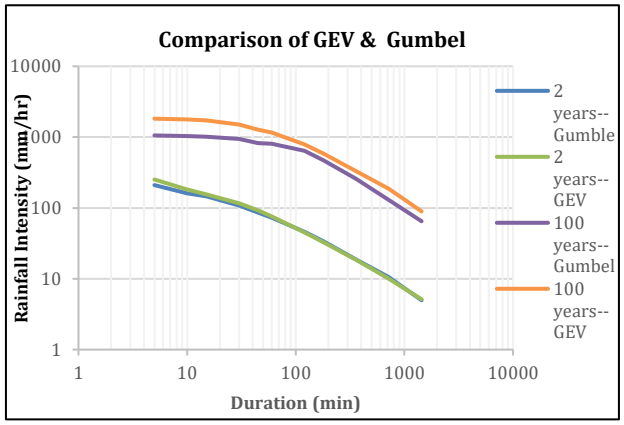

Figure 1: Tandek rainfall station

Figure 1 shows the comparison of Gumbel and GEV distribution for 2-years and 100-years return period at Tandek station. Based on the result obtained, for the return period of 2-year, GEV distribution show slightly higher rainfall intensity estimation. On the other hand, for the return period of 100-year, GEV distribution show higher rainfall estimation compared to 100 years Gumbel.

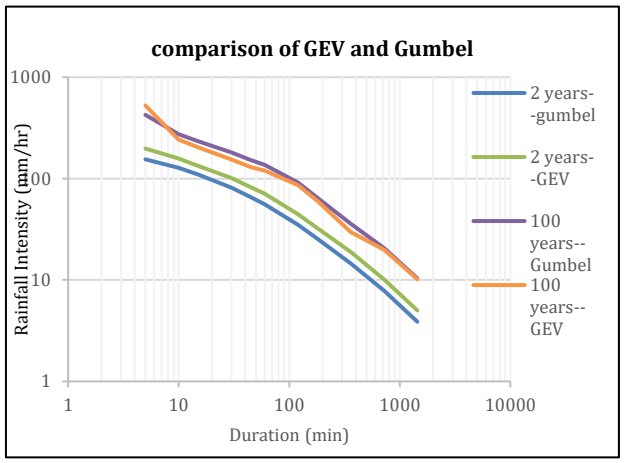

Figure 2: Patiu Rainfall station

Figure 2 represents the comparison of Gumbel and GEV at Patiu Station. Based on Figure 2, for the return period of 2-years, it was shown that GEV distribution gave a higher estimation of rainfall intensity compare to the Gumbel distributions. For the return period of 100-years, Gumbel distribution yielded slightly higher intensity expectation with a smooth curve, compared to GEV distribution that gives a fluctuated curve.

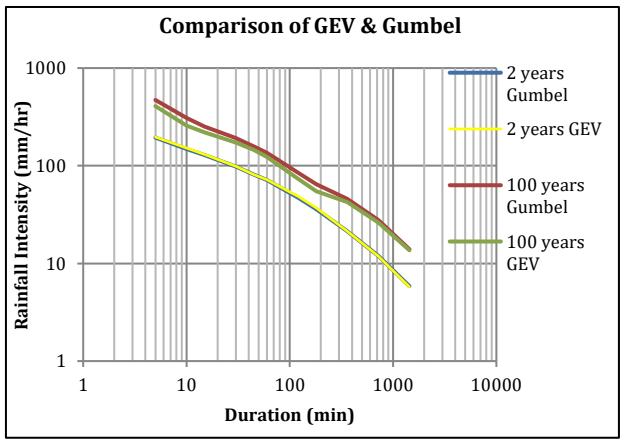

Figure 3: Babagon rainfall station

Figure 3 shows the comparison of Gumbel and GEV distribution for 2-years and 100-years return period at Babagon Station. In accordance to Figure3, for the return period of 2-years, it was obviously shown that GEV distribution gave the same estimation of rainfall with Gumbel . However, On the other hand, for the return period of 100-years, Gumbel distribution have slightly higher and smooth curve compared to GEV same as patiu Rainfall station

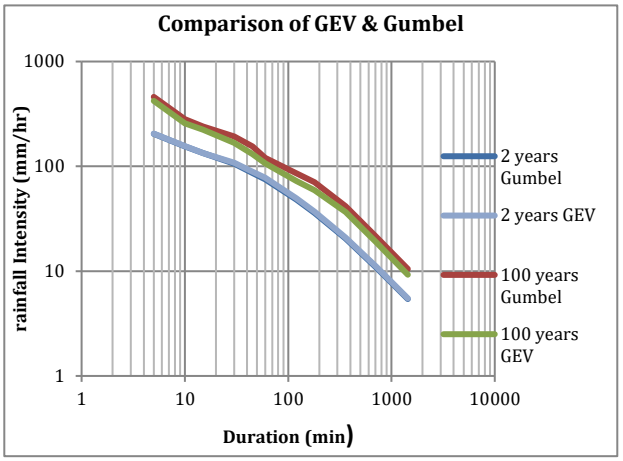

Figure 4: Ulu Moyog rainfall station

Figure 4 shows the comparison of Gumbel and GEV distribution for 2-years and 100-years return period at ulu Moyog Station. Rainfall intensity of 2-years and 100-years return period was chosen to be compare because the minimum and maximum of the intensity. In accordance to Figure 4, for the return period of 2-years, it was obviously shown that GEV distribution yielded higher estimation of rainfall compared to the Gumbel distribution. On the other hand, for the return period of 100-years, Gumbel gave slightly higher estimation of rainfall compared to GEV distributions.

Table 1: Comparison of Chi square value for both frequency distributions

Rainfall station	Gumbel's distribution	GEV
Tandek	0.469	16.573
Patiu	2.46	12.736
Babagon	1.865	18.537
Ulu Moyog	2.847	24.856

Table 1 shows the chi-square value for 4 stations by Gumbel's distribution and GEV distribution. Significant level of 5% is used for this research. There are 2 parameters used to compare therefore, the degree of freedom is 1 and critical value used from chi-square table is 3.84. Following the work[7], any value greater than 3.84 will be rejected and value lower that 3.84 will be accepted as the best fit distribution [7]. The distribution that has a lower Chi-square value compare to other distribution will be chosen as the best fit distribution [4]. From the comparison of Chi-square value of 3.84 with the chi-square from both distribution, its clearly show that Gumbel's distribution has a lower Chi-square value and accepted as the best distribution. Overall all 4 Station favor GumbeL distribution for analysis of rainfall intensity and development of IDF curve in Kota Marudu and Penampang area.

4. CONCLUSION

From the IDF curve, it shows that GEV method may overestimate the rainfall intensity compare to Gumbel. From the goodness of fit test, Gumbel's distribution shows better fit than GEV, therefore Gumbel's distribution is more suitable distribution for flood frequency analysis and development of IDF curve in Kota Marudu and Penampang

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