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Determination of Rainfall Intensity Formula and Intensity Duration Frequency (IDF) Curve at the Quelicai Administrative Post, Timor-Leste

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ABSTRACT

The intensity of rainfall is a very important input in the work of water resources, especially related to flooding, erosion, and landslides. The flash flood that occurred in the study area was one of the impacts of the high intensity of the rain that occurred. This study aims to obtain a suitable empirical formula for estimating rainfall intensity and the Intensity Duration Frequency (IDF) curve. The empirical formula used includes Talbot, Sherman, Ishiguro while the design rainfall is obtained from the calculation of frequency analysis with various return periods. The selected method is based on the smallest error value which is determined by comparing the value of the rain intensity of the Mononobe method with the calculation results of the three equations through the Talbot, Sherman, and Ishiguro formula approaches. Test of the comparison with the peak-weighted root mean square error test. The results showed that the method of rainfall intensity according to the Quelicai daily rainfall data was the Mononobe method with the Sherman equation. The result of Sherman formula demonstrated that the formula has compatible with Mononobe method due to a smaller average error than the other two equations, therefore recommended to estimate the rainfall intensity and IDF curve in the study area.

Keywords: Rainfall Intensity, Intensity Duration Frequency (IDF), Sherman Formula, Mononobe method

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1. Introduction

Property damage and potential loss of life due to flooding is caused by extreme rainfall events.
Rainfall due to climate change has been put forward by many researchers and practitioners (Martel et al., 2021; Mirhosseini et al., 2012; WMO, 2019). Rainfall events gaining understanding of the potential change of frequency, intensity and volume of extreme (Courty et al., 2019; Sri Harto Br, 2000).

Characteristics of rain is important to understand in order to prepare anticipatory and mitigation plans in water resources work, both those relating to water resource management and disasters (floods, erosion, and landslides) (Courty et al., 2019; Solaiman and Simonovic, 2011).

Rainfall characteristic, which are intensity, duration, depth, and frequency. Intensity that is related to duration and frequency can be expressed by Intensity-Duration-Frequency (IDF) curve (Hamed, 2008; Paola et al., 2014; Sri Harto Br, 2000). The IDF relationship is a mathematical relationship between rainfall intensity i, duration d, and the return period T (Koutsoyiannis, 2018; Suripin, 2004). The IDF curve is a convenient form of rainfall information and need for updating IDF curves comes from the necessity to gain better understanding of Rainfall events (Courty et al., 2019; Sri Harto Br, 2000).

Rainfall IDF relationships are useful tools for various hydrologic analyses, represent essential means to study effects on the performance of drainage systems (Merz, 2012; Suripin, 2004), used to design flood protection structures (Ena et al., 2020; Harisuseno et al., 2020b), very fundamental input in analyses related to the estimation of runoff (Dourte et al., 2013), erosion, flooding, drought important for decision making that requires information about the character of rainfall (Courty et al., 2019; Solaiman and Simonovic, 2011; Sri Harto Br, 2000; Suripin, 2004).

Municipal Baucau is one of municipals of Timor Leste. Municipal Baucau is include Six (6) Post Administrative (TLCensus, 2016) and one of them is Post Administrative Quelicai. Quelecai is include as a historical region and be the one of protected area in Timor Leste based on the Decree Law No.5/2016 on National System on Protected Area. Quelecai has a mountainous geographical area and has some rivers flowing through the centre of city. Quelecai has the experience extreme rainfall that cause flooding and land slide. According to community who is live near the river, in 2017 and 2020 the landslide was happened due to the high intensity of rainfall. Some of river was flooded, and people was evacuating to another place that was not affected.

The protection of river flooding causes from extreme rainfall then needs a design of the flood protection structures. The characteristic of rainfall at that area need to analyze the rainfall intensity and establish the IDF curve to support the design of flood protection structure and drainage system. However, to date no have study about rainfall intensity and the appropriate IDF curve made in Quelecai. This research is objective to analyse the rainfall intensity and to establish the appropriate IDF Curve base on the daily rainfall data to

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support the design of flood protection structure at Quelicai Post Administrative.

2. Literature Review

Research on rainfall intensity has been carried out by several previous researchers. Previous research in Mexico zone by Ena et al., (2020) to assess rain behaviour and select a suitable method that provides the best results of IDF relationship. IDF relationship for the city for return periods of 10, 25, 50, and 100 years and annual maximum rainfall intensity has been analysed using to the statistical distribution of Generalized Extreme Value (GEV). The IDF relationship then recommended to replicated to other semi-arid zones with the same rain characteristics. Shrestha et al., (2017) have developing Intensity–Duration–Frequency (IDF) Curves under climate change scenarios in Thailand. The application of Generalized Extreme Value (GEV) distribution with annual maximum series to generate IDF curves. IDF curve from all Global Climate Models (GCMs) showed increasing intensities in the future for all return periods. Harisuseno et al., (2020) was determine the empirical method of rainfall intensity and IDF that are suitable in Malang, Indonesia. The methods used are Talbot, Mononobe, Hasper Der Weduwen, and Van Breen. The distribution of Log Pearson Tipe III has been using to estimate the rainfall intensity in various return period. The analysis found that the most suitable method for this location is Talbot Method. Mirhosseini et al., (2012) analysed the impact of climate change on rainfall Intensity Duration Frequency (IDF) curves in Alabama. Generalized Extreme Value (GEV) distribution was selected as the best probability distribution to find precipitation depths for different return periods. One of recommended for the uncertainty on projected rainfall intensity is to creating a probability based IDF curves to diminish the uncertainty. Maitsa et al., (2021) analysed the differences between Intensity Duration Curve (IDF) in Jakarta and Bogor Area. Rainfall intensity was calculated for 2-, 5-, and 10-year return periods. The equation analysis of the IDF with the approximate IDF curves calculated using the Mononobe Equation and SNI 03-3424-1994 Basis Curve. The IDF curve of the minute data was approximated using the Talbot, Sherman, and Ishiguro method. The results of the analysis show that the most suitable method to the data intensity pattern for Citeko Station in Bogor is the Talbot method. As for the Kemayoran Station in Jakarta, the most suitable equation is the Sherman method. Dourte et al., (2013) develop the rainfall intensity-duration-frequency (IDF) relationships in peninsular India where impacts on runoff and groundwater recharge. The IDF curves developed from the fitted Weibull cumulative distribution function (CDF) for each duration, using the various probabilities. The updated IDF relationships showed a significant change in rainfall characteristics compared with older relationships. The result is suggesting that the annual proportion of rainfall contributing to groundwater recharge may be declining as a result of increasing rainfall intensity.

The previous research to analyse the rainfall intensity and to establish the IDF curve has been doing in various location with various condition of rainfall data. Major of the location provide the hourly rainfall data with long periods. However, the rainfall data that available in Quelecai is the daily rainfall data. The method to develop the IDF curve is also different between hourly and daily rainfall data (Suripin, 2004). The condition of climate, topography and meteorology of each location also different and give impact for characteristic of rainfall that has resulted in the model of IDF curve (Mirhosseini et al., 2012; Solaiman and Simonovic, 2011).

3. Research Methodology

3.1. Location and Data

The climate of Quelicai is tropical, with a wet season running from December to March and a distinct dry season for the remainder of the year. Mean monthly temperatures range from about 21^{o}C in December to about 26^{o}C in August. Location of Quelicai Post Administrative as on the Figure 1 (DGE, 2019). The availability of daily rainfall data in Quelicai is limited. The nearest rainfall station reckoned around Quelicai and considered give an contribution of rainfall in location. The Quelicai Station, Baugia Station, and Ossu Station are the 3 stations providing ten years historical rainfall data from 2010 to 2019. Assume that the characteristic of rainfall for each location is uniform then using Arithmetic average methods to calculate the average maximum daily rainfall. The average maximum daily rainfall data from 3 station can be seen in Table 1 and Figure 2. Based on the 10-year record the area receives a total (average) of 2,320 mm annually. The rainfall is evenly distributed throughout the year. Highest monthly average rainfall is in May. The months from December to June generally experience intense rainfall.

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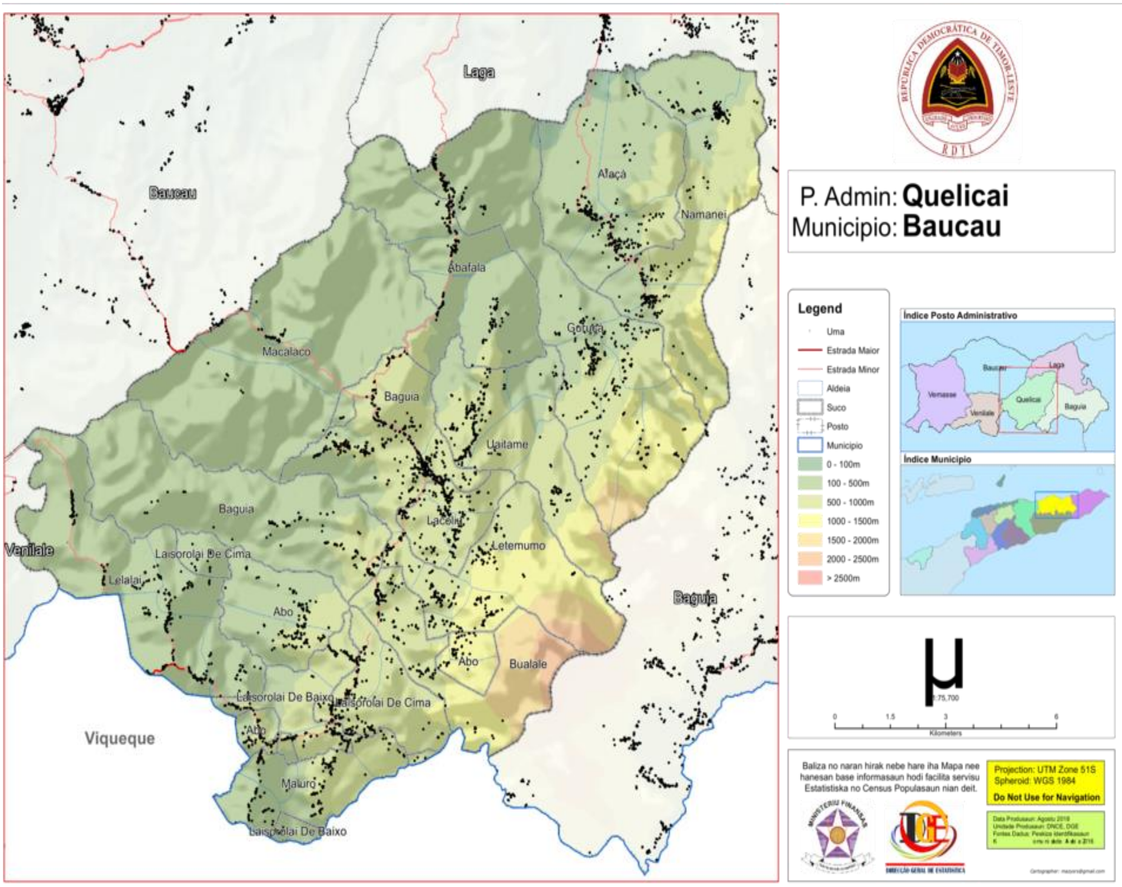

Figure 1. Map of Quelicai Post Administrative

Table 1. Maximum Average Daily Rainfall

Year	Maximum Daily Rainfall (mm)
2010	75.7
2011	72.2
2012	103.7
2013	181.3
2014	85.8
2015	50.7
2016	104.4
2017	106.3
2018	60.0
2019	126.0

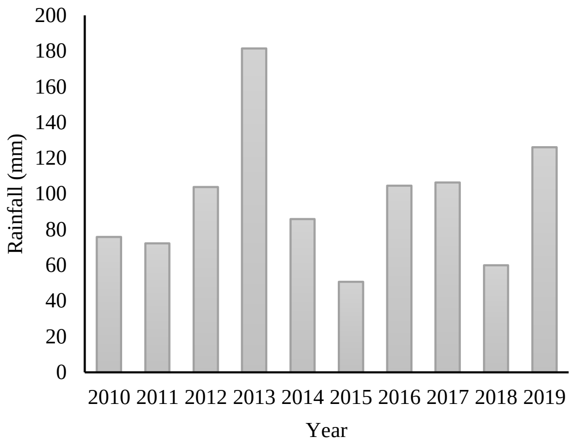

Figure 2. Maximum Average Daily Rainfall Graph

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3.2. Methodology

The analytical procedure in this study begins with collecting rain data and grouping hourly rain data according to the desired rain duration. A statistical approach consisting of a RAPS consistency test was carried out to test the rain data obtained. To ensure that the distribution of frequency analysis used has a probability distribution that matches the rainfall data series, a frequency distribution suitability test is carried out using the Smirnov-Kolmogorov test and the Chi Square test.

The next step is the calculation of the design rainfall intensity with various rain durations and return times. For the daily rainfall data is calculated using Mononobe formula (Harisuseno et al., 2020b; Sri Harto Br, 2000; Suripin, 2004). Furthermore, determining the most appropriate method of analysis of rainfall intensity obtained using an approach through methods from empirical formula.

Furthermore, the validation test of the selected empirical formula by comparing the results of the IDF curve from the selected empirical formula with the IDF curve of the observed rainfall intensity which is determined based on the probability approach.

3.2.1. Frequency Analysis

Techniques are used to develop the relationship between the rainfall intensity, storm duration, and return periods from rainfall data is Frequency Analysis (Sri Harto Br, 2000; Suripin, 2004). Frequency analysis is used to determine the design rainfall in various return periods based on the most suitable distribution between the theoretical rainfall distribution and the empirical rainfall distribution. In this study, the design daily rainfall was calculated with a return period for 2, 5, 10 and 20, 50 and 100 years return periods. The steps of frequency analysis are as follows (Sri Harto Br, 2000):

1) Determine the statistical parameters of the rainfall data that have been sorted from large too small. The statistical parameters namely: Mean, Standard Deviation, Coefficient of Variation, Coefficient of Skewness, Coefficient of kurtosis. The equation as follow:
   a. Mean

$$\bar{X} = \frac{\sum Xi}{n} \quad \text{..........................} \quad (1)$$

   b. Standard Deviation

$$S^2 = \frac{\left[\sum Xi^2 - (\bar{X}.\sum Xi)\right]}{n-1} \quad (2)$$

   c. Coefficient of Variation

$$CV = \frac{S}{X} \quad \text{............................} \quad (3)$$

   d. Coefficient of Skewness

$$CS = \frac{n}{(n-1)(n-2)S^3}\sum\left(Xi - X\right)^3 \text{.....} (4)$$

   e. Coefficient of kurtosis

$$CK = \frac{n^2}{(n-1)(n-2)(n-3)S^4}\sum\left(Xi - X\right)^4 \cdots \quad (5)$$

   Where, X = design rainfall; $\bar{X}$ = average maximum rainfall; S= standard deviation and n = number of data.

2) Determine the appropriate distribution
   Analysis of distribution for rainfall frequency is based on the Gumbell distribution , which is commonly used in Timor Leste (Merz, 2012). The Gumbel Method formula is as follows (Sri Harto Br, 2000):

$$Xt = X + k\, S_x \quad \text{……………………….}(6)$$

   where: Xt = X in return period of t years; X = average of data Xi; Xi = maximum rainfall data i years; Sx = standard deviation; n = number of data.

$$k = \frac{Y_t - Y_n}{S_n} \quad \text{………………………. } (7)$$

$$Y_t = -\ln\left(-\ln(\tfrac{t-1}{t})\right) \text{……………… } (8)$$

   where: Yn= reduced mean depends on number of sample or data; Sn= reduced standard deviation depends on number of data; Yt= reduced variate; t= return period

3) Chi-square test and Smirnov Kolmogorov test on the selected distribution type
   a) Chi-Square Test
      Basically, this test is a check of the mean deviation of the analysed data based on the selected distribution. The deviation is measured from the difference between the probability values of each X variable according to the theoretical frequency distribution calculation and according to the calculation using the empirical approach. The formula used is as follows:

$$X^2 = \sum_{t=1}^{N} \frac{\left(Of - Ef\right)^2}{Ef} \text{...............}(9)$$

      where: X_2 = calculated Chi-Square value; Ef = the expected frequency; Of = frequency read in the same class; N = number of subgroups in one group. The value of X_2 here must be less than X_2cr (Critics Chi-Square) for a certain degree of significance as 5%.

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b) Smirnov Kolmogorov test
The test is carried out by finding the difference in the probability value of each Xi variable according to the empirical and theoretical distribution, which is symbolized by Δ. The maximum Δi value must be less than the $\Delta_{critical}$

3.2.2. Rainfall Intensity Analysis

The rainfall intensity is a function of the variables T and d (Koutsoyiannis, 2018). The calculation to get rainfall intensity is based on the table on daily rainfall data with a return period T is using Mononobe formula as follows (Chalid and Prasetya, 2020; Sosrodarsono and Takeda, 1983; Suripin, 2004) :

$$I = \left(\frac{R_{24}}{24}\right)\left(\frac{24}{t}^{2/3}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Where I = rainfall intensity (mm/h); R_{24} = design rainfall, maximum daily (mm); t = duration of design rainfall (hrs).

3.2.3. Selection of Rainfall Intensity Method

Determining the most appropriate method of analysis of rainfall intensity, it is carried out using an approach through 3 (three) methods, as follows (Harisuseno et al., 2020a):

1). Ishiguro Formula

This formula was stated by Dr. Ishiguro in 1953. The formula as follow (Sosrodarsono and Takeda, 1983):

$$I = \frac{a}{\sqrt{t+b}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

where I is the intensity of rainfall (mm/hour), t is the duration of rainfall (hours), a, b are constants that depend on the duration of rainfall.

2). Talbot Formula

The Talbot equation was developed by Prof. Talbot in 1881 and is a formula that is often used in calculating rainfall intensity (Sosrodarsono and Takeda, 1983) . Talbot rainfall intensity can be obtained by the formula as follow:

$$I = \frac{a}{t+b} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

where I is the intensity of rainfall (mm/hour), t is the duration of rainfall (hours), a, b are constants that depend on the duration of rainfall.

3). Sherman Formula

The Sherman equation produced by Prof. Sherman in 1905 (Sosrodarsono and Takeda, 1983). The intensity of rain based on the Sherman formula can be obtained through the following formula as follow:

$$I = \frac{a}{t^n} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (13)$$

where I is the intensity of rainfall (mm/hour), t is the duration of the rain (hours), a and n are a constant.

3.2.4. Intensity Duration Frequency (IDF)

The IDF relationship is a mathematical relationship between the rainfall intensity i, the duration d, and the return period T (Koutsoyiannis, 2018). The average IDF curve should be taken from several selected probability distribution functions. The average IDF curves from the selected distribution functions is taken as the final IDF curve for 24-hour duration for various average return periods (Gautama, 2012; Sosrodarsono and Takeda, 1983). To determine IDF curve, short-term rainfall data such as 5, 10, 30 minutes and hours are needed to form the curve of the IDF curve. The depiction of the IDF curve is determined based on one of the equations between the formulas of Talbot, Sherman and Ishiguro

4. Result

4.2. Frequency Analysis

Design rainfall with various return periods is determined by frequency analysis to determine the type of distribution that can represent the distribution of maximum daily rainfall data. However, before that, the statistical parameters were calculated using equation (1) to (5). Statistical parameters, such as rain average parameters, standard deviation (S), Skewness coefficient (Cs), Kurtosis coefficient (Ck), and coefficient of variance (Cv). The results of the statistical parameter can be seen in Table 2 below.

Table 2. Statistical Parameters of Max. Average Daily Rainfall

Statistical Parameters	Maximum Average Daily Rainfall
Mean (X)	96.617
Standard Deviation (S)	37.786
Coficient of Variance (CV)	0.391
Coeficient of Skewness (CS)	1.195
Coeficient of Kurtosis (CK)	1.987

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The results of the calculation of the statistical parameters are a reference for selecting the frequency analysis method for daily rainfall data. The method used is the Gumbell frequency distribution. To ensure the selection of the distribution, a comparison of the results of statistical calculations with the Chi-Square and Smirnov-Kolmogorov tests was also carried out. The results of the test are qualified as listed in Table 3 below.

Table 3. Chi Square and Smirnov Kolmogorov Test

Distribution Gumbell	**Chi Square**			**Smirnov-Kolmogorov**		
	X_2Cr table	X_2Cr analysis	Test result	D_0	Dmax	Test result
	5.991	1.000	accepted	0.410	0.098	accepted

Next is to calculate the design rainfall. The results of the calculation of the design rainfall based on the return period of 2, 5, 10, 20, 25, 50, and 100 years can be seen in Table 4.

4.3. Rainfall Intensity

In order to get the rainfall intensity in a 1-hour period from daily rainfall data, the Mononobe formula is used as in equation (10). The results of the analysis are shown in Table 5. The Mononobe method determines the probability of rainfall with intensity and duration is equalled or exceeded. From this probability determination, the return period of time interval measured in years, over which a given storm event may be expected to occur again, can be predicted. The results of the analysis are presented in curves or graphs of relation rainfall intensity and the duration to the probable frequency periods.

Table 4. Design Rainfall

No	**Return Period (yrs.)**	**Design Rainfall (mm)**
1	2	90.4
2	5	123.8
3	10	145.9
4	20	167.1
5	25	173.9
6	50	194.6
7	100	215.2

Table 5. Rainfall Intensity of Quelecai

No	**Duration (min)**	**Return Period (years)**						
		2	**5**	**10**	**20**	**25**	**50**	**100**
		Rainfall Intensity (mm)						
1	2	302.58	414.38	488.35	559.31	581.74	651.36	719.98
2	5	164.27	224.96	265.12	303.64	315.82	353.61	390.86
3	10	103.48	141.72	167.01	191.28	198.95	222.76	246.23
4	20	65.19	89.28	105.21	120.50	125.33	140.33	155.11
5	30	49.75	68.13	80.29	91.96	95.65	107.09	118.37
6	40	41.07	56.24	66.28	75.91	78.95	88.40	97.72
7	60	31.34	42.92	50.58	57.93	60.25	67.46	74.57
8	80	25.87	35.43	41.75	47.82	49.74	55.69	61.56
9	120	19.74	27.04	31.86	36.49	37.96	42.50	46.98
10	180	15.07	20.63	24.32	27.85	28.97	32.43	35.85

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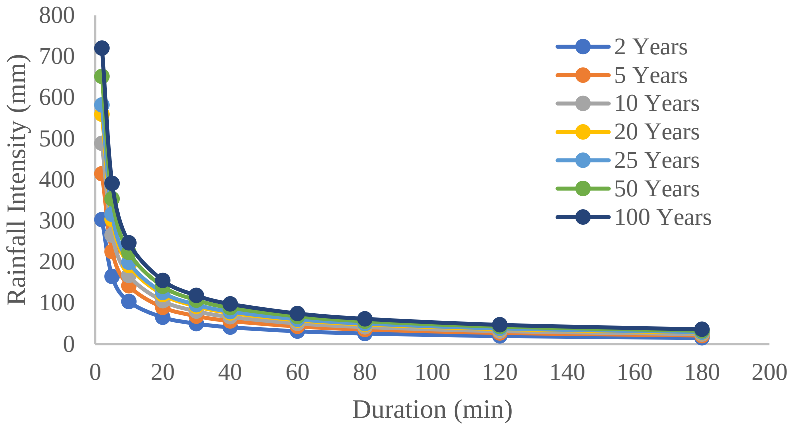

Figure 3. IDF Curve of Quelicai Rainfall Intensity

4.4. Rainfall Intensity Method Selection

Determining the method of analysis of rainfall intensity, the most appropriate approach is through three formula, Talbot, Sherman and Ishiguro. The determination of the chosen method is based on the comparison of the measured data with the estimated results that will result in a deviation. In order to determine the value of Rainfall intensity using the three formulas, first should determine the constant of each formula. The equation (11), (12) and (13) is used to determine the constant. The constant of each formula as calculated in Table below.

Table 6. Constant of rainfall Intensity Formula

Return Period	Talbot			Sherman		Ishiguro	
	a	b	Log a	a	n	a	b
2	2099.966	6.19	2.682	480.32	0.667	221.62	2.789
5	2875.838	6.19	2.818	657.78	0.667	303.50	2.789
10	3389.215	6.19	2.889	775.20	0.667	357.68	2.789
20	3881.685	6.19	2.948	887.85	0.667	409.65	2.789
25	4037.324	6.19	2.965	923.45	0.667	426.07	2.789
50	4520.502	6.19	3.015	1033.96	0.667	477.07	2.789
100	**4996.711**	**6.19**	**3.058**	**1142.88**	**0.667**	**527.32**	**2.789**

At the same duration and return period, the constant value of each empirical formula has a different value which has an impact on the value of varying rainfall intensity. Table 7 to Table 9 respectively is the result of the calculation of the intensity rain using the Talbot, Sherman and Ishiguro formula.

Table 7. Talbot Rainfall Intensity

No	Duration (min)	Return Period (years)						
		2	5	10	20	25	50	100
		Rainfall Intensity (mm)						
1	2	256.31	351.01	413.67	473.77	492.77	551.74	609.87
2	5	187.61	256.93	302.79	346.79	360.70	403.86	446.41
3	10	129.68	177.60	209.30	239.71	249.32	279.16	308.57
4	20	80.17	109.79	129.39	148.19	154.14	172.58	190.76
5	30	58.02	79.46	93.64	107.25	111.55	124.90	138.06
6	40	45.46	62.26	73.37	84.03	87.40	97.86	108.17
7	60	31.72	43.45	51.20	58.64	60.99	68.29	75.49
8	80	24.36	33.37	39.32	45.03	46.84	52.45	57.97
9	120	16.64	22.79	26.86	30.76	31.99	35.82	39.60
10	180	11.28	15.45	18.20	20.85	21.68	24.28	26.84

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Table 8. Sherman Rainfall Intensity

No	Duration (min)	Return Period (years)						
		2	5	10	20	25	50	100
		Rainfall Intensity (mm)						
1	2	302.58	414.38	488.35	559.31	581.74	651.36	719.98
2	5	164.27	224.96	265.12	303.64	315.82	353.61	390.86
3	10	103.48	141.72	167.01	191.28	198.95	222.76	246.23
4	20	65.19	89.28	105.21	120.50	125.33	140.33	155.11
5	30	49.75	68.13	80.29	91.96	95.65	107.09	118.37
6	40	41.07	56.24	66.28	75.91	78.95	88.40	97.72
7	60	31.34	42.92	50.58	57.93	60.25	67.46	74.57
8	80	25.87	35.43	41.75	47.82	49.74	55.69	61.56
9	120	19.74	27.04	31.86	36.49	37.96	42.50	46.98
10	180	15.07	20.63	24.32	27.85	28.97	32.43	35.85

Table 9. Ishiguro Rainfall Intensity

No	Duration (min)	Return Period (years)						
		2	5	10	20	25	50	100
		Rainfall Intensity (mm)						
1	2	52.72	72.19	85.08	97.44	101.35	113.48	125.44
2	5	44.10	60.39	71.17	81.51	84.78	94.92	104.92
3	10	37.23	50.99	60.09	68.83	71.59	80.15	88.60
4	20	30.52	41.79	49.25	56.41	58.67	65.70	72.62
5	30	26.81	36.71	43.27	49.55	51.54	57.71	63.79
6	40	24.32	33.30	39.24	44.95	46.75	52.34	57.86
7	60	21.04	28.81	33.95	38.88	40.44	45.28	50.05
8	80	18.89	25.87	30.48	34.91	36.31	40.66	44.94
9	120	16.12	22.08	26.02	29.81	31.00	34.71	38.37
10	180	13.68	18.73	22.07	25.28	26.29	29.44	32.54

5. Discussion

The selection of rain intensity that can be used at Quelicai among the three methods of rain intensity (Talbot, Sherman and Ishiguro), tested using the peak-weight root mean square error test. The selection of the rain intensity method uses the peak-weight root mean square error test by taking the smallest error value. The test is carried out by comparing the peak size/distance, volume and time of two hydrographs. Then look for the smallest difference between the intensity of the rain of each method, with the intensity of the rain that results from an automatic tool (hourly). The results of the peak-weight root mean square error test can be seen in the following Table 10 and Figure 4.

The average value for the peak-weight root mean square error for each method is the Talbot method (33.05), Sherman (0.01), Ishiguro (167.22). Therefore, the intensity formula that is suitable for the Quelicai is the Mononobe Method and Sherman formula.

The Talbot and Ishiguro methods have the same tendency, the greater the return period, the greater the peak-weight root mean square error. This is in accordance with the general nature of rain, the greater of the return period, the higher the intensity of the rain that occurs, so that the resulting error value is even greater according to the return period

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Table 10. Peak Weight Root Mean Square Error Test

Return Period	peak-weight root mean square error		
	Talbot	Sherman	Ishiguro
2	18.73	0.03	88.89
5	16.72	0.03	121.73
10	30.26	0.01	143.50
20	34.66	0.01	164.35
25	36.76	0.01	174.34
50	43.57	0.01	206.55
100	50.63	0.01	240.04

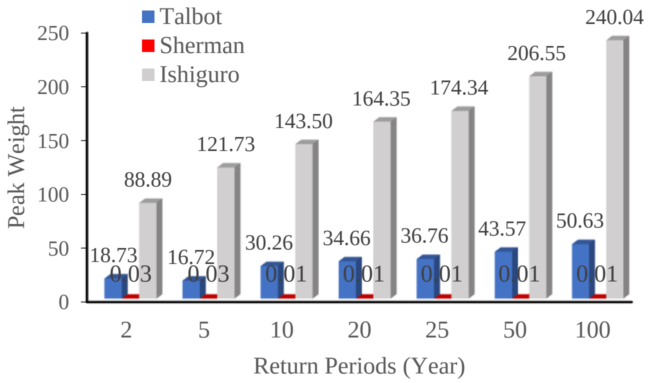

Figure 4. Peak Weight Root Mean Square Error Test

In contrast to the Sherman methods, the larger the return period, the smaller the peak-weight root mean square error. The IDF curve of the selected rain intensity formula of the Sherman with a return period of 2 and 5 years, can be seen in Figure 5. The larger the return period used, the smaller the error. Meanwhile, if viewed from the duration used, it can be concluded that the longer of the duration then the smaller the rainfall intensity, both from the observation rainfall intensity or the selected empirical method rain intensity (Sherman method), the results of this calculation can be seen in Table 11.

Table 11. Rainfall Intensity for Mononobe method and Sherman formula

No	Duration (min)	Return Period (years)			
		2	5	2	5
		I - Mononobe (mm)		I - Sherman (mm)	
1	2	302.48	414.28	302.58	414.38
2	5	164.27	224.86	164.27	224.96
3	10	103.48	141.72	103.48	141.72
4	20	65.19	89.28	65.19	89.28
5	30	49.75	68.13	49.75	68.13
6	40	41.07	56.24	41.07	56.24
7	60	31.34	42.92	31.34	42.92
8	80	25.87	35.43	25.87	35.43
9	120	19.74	27.04	19.74	27.04
10	180	15.07	20.63	15.07	20.63

The Frequency Duration Intensity Curve (IDF) has described that the greater the duration, the rainfall intensity also decrease and the greater of the return period, the rainfall intensity become increase. The comparison of the IDF curve generated from the Sherman formula and the observed rainfall intensity at various return period showed that the Intensity Duration Frequency (IDF) curve of Sherman's formula with observations has a good match because in the depiction of two curves have the same pattern and coincide with each other. Estimates of the rainfall intensity-duration-frequency (IDF) and an assumed temporal distribution of rainfall for return period of 2 and 5 years can be used to Hydrologic design of storm sewers, culverts, retention/detention basins and other components of storm water management systems in Quelicai.

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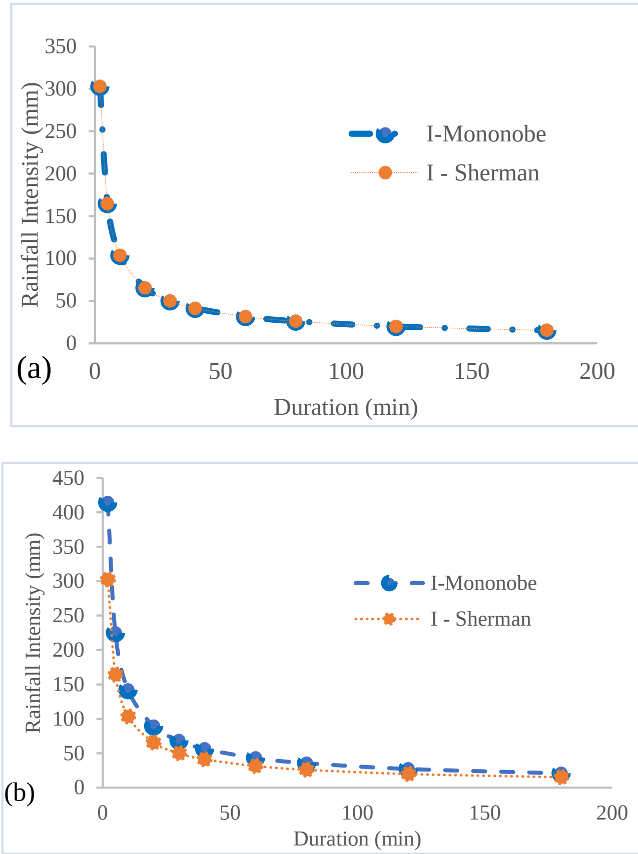

Figure 5. IDF Curve of Sherman formula and Mononobe method for Return period: (a) 2 years and (b) 5 years

6. Conclusion and Implication

The rainfall intensity values generated by all empirical formulas have high rainfall values with short duration and large return periods. At the same duration and return period, the constant value of each empirical formula has a different value which has an impact on the value of varying rainfall intensity. However, the value of rainfall intensity produced by Sherman empirical formula has relatively no different values with observed daily rainfall data. On the other hand, the rainfall intensity produced by the Talbot and Ishiguro formula shows a quite different magnitude compared to the Sherman empirical formulas. The results of the suitability analysis show that the Sherman formula has the best fit among other empirical formulas. Furthermore, the validation process carried out confirms that the Sherman formula has good reliability and accuracy in estimating the rainfall intensity as indicated by the average peak error of 0.01. The same thing is shown by the results of the analysis of the suitability of the Intensity Duration Frequency (IDF) curve where the IDF curve of the Sherman formula with the IDF curve of observations has a conformity indicated by the same pattern and coincides with each other. The overall results show that the Sherman formula has a good level of reliability in estimating the rainfall intensity and the IDF curve at the study site so that it can be used to estimate the rainfall intensity in the study area.

The temporal distribution of rainfall in return period 2,5,10,20,25,50 and 100 years have useful in design of flood protection structure and in water management system in Quelicai. The result of rainfall IDF relation have essential means in analysis of drainage system and as a base information to develop the mitigation plan relate to climate change in Quelicai. Timor Leste government can use the rainfall IDF information in the process of decision making and policy development relate to water management system in Baucau municipality.

7. Limitation and Future Research

The rainfall data to be analysed should be for at least (ideally) 30 consecutive years of observation. The longer the rainfall data used will affect the better results in the selection of methods and method validation. The selection of rainfall duration would be better if the duration intervalused was 5 minutes. Therefore, the results obtained will be more accurate. Timor Leste government should give more attention to develop the rainfall data for all of Administrative Post and Municipality in Timor Leste. The important rainfall data is hourly rainfall data than daily rainfall data due to result detail analysis of rainfall duration. Another research in determine rainfall intensity and IDF curve should be continuing with hourly rainfall data and based on the trend of climate change

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