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Analysis Of Flood Discharge Plan with The Der Weduwen Method in Area of Campus I Banjarmasin of Lambung Mangkurat University

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ABSTRACT

Floods in South Kalimantan Province were caused by high-intensity rain in mid-January 2021. The same flood inundated the Banjarmasin Campus I area of Lambung Mangkurat University (ULM Campus I). Another flood inundated Campus I ULM in mid-December 2021. The puddle in the area of Campus I ULM reached a height of 50 cm. The research method uses hydrological analysis of rain data to obtain a planned flood discharge with a return period of 2, 5, 10, 20, 25, 50, 100, and 200 years with the Der Weduwen method. Based on the results of the analysis of the flood discharge value for the 2 years return period was 48.68 m^3/s, 5 years was 66.63 m^3/s, 10 years of 78.35 m^3/s, 20 years was 89.30 m^3/s, 25 years was 91.56 m^3/s, 50 years was 103.57 m^3/s, 100 years was 114.46 m^3/s, and 200 years was 125.07 m^3/s.

Keywords: Flood, Campus I ULM, Der Werduwen Method, Return Period.

1. INTRODUCTION

Rain with moderate to high intensity caused flooding in mid-January 2021 in South Kalimantan Province. This wide-scale flood, triggered by high rainfall since January 9 2021, also inundated 11 regencies/cities in South Kalimantan. The Banjarmasin Campus I area of Lambung Mangkurat University (ULM Campus I) was inundated to a height of 50 cm. Floods caused by high tides coupled with several days of rain inundated most of the campus area which hindered access to learning and administration (Kanal Kalimantan, 2021). Furthermore, the inability of the drainage channel to drain rainwater that falls into the river has exacerbated the overflow of water that occurs, especially to the Campus I ULM road. (Apa Habar, 2021).

The city of Banjarmasin has a relatively flat topographical plain (often inundated by water) with an average height of 0.16 meters below sea level for the entire area. Located close to the mouth of the Barito River and divided by the Martapura River. It has a soil slope of 0.13% with a geological composition dominated by clay, fine sand, and alluvial deposits and the soil surface is covered by gravel, gravel, sand, and clay that settles in rivers and swamps (BPK Banjarmasin, 2022).

One of the stages of flood control both structural and non-structural requires a good and precise hydrological analysis. The hydrological analysis of the planned flood discharge is shown to determine the estimated flood that can occur so that prevention can be planned. This study aims to analyze the planned flood volume with a certain return period using the Der Weduwen method in a study area of 3.98 km^2 on Campus I ULM.

2. THEORITICAL STUDY

Parameters Statistical and Logarithms

Equations for calculating statistical parameters and logarithms (Suripin, 2004) are:

a. Mean ($\overline{X}$)

$$\overline{X} = \frac{1}{n}\sum_{i=1}^{n} Xi$$

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} \log X_i$$

b. Standard Deviation (S)

$$S = \sqrt{\left[\frac{1}{n-1}\sum_{i=1}^{n}(Xi - \overline{X})^2\right]}$$

$$S = \sqrt{\frac{1}{(n-1)}\sum_{i=1}^{n}(\log X_i - \log \bar{X})^2}$$

c. Coefficient of Skewness (Cs)

$$Cs = \frac{n\sum_{i=1}^{n}(Xi - \overline{X})^3}{(n-1)(n-2)s^3}$$

$$C_s = \frac{\sum_{i=1}^{n}(\log X_i - \log \bar{X})^3}{(n-1)(n-2)S^3}$$

d. Coefficient of Variation (Cv)

$$Cv = \frac{s}{\overline{X}}$$

$$C_v = \frac{S}{\log \bar{X}}$$

e. Coefficient of Kurtosis (Ck)

$$Ck = \frac{n\sum_{i=1}^{n}(Xi - \overline{X})^4}{(n-1)(n-2)(n-3)s^4}$$

$$C_k = \frac{\sum_{i=1}^{n}(\log X_i - \log \overline{X})^4}{(n-1)(n-2)(n-3)S^4}$$

Where:
X = rainfall (mm)
n = amount of data

Table 1 Determination of Distribution Type

Distribution	Requirements
Normal	Cs = 0 Ck = 3
Log Normal	Cs ≈ Cv^3 +3Cv Ck ≈ Cv^8 +6 Cv^6 + 15Cv^4 + 16Cv^2 + 3
Gumbel	Cs = 1,14 Ck = 5,4
Log Pearson III	Beside above values

Planned Rainfall Height

a. Normal Distribution

Normal distribution method equation (Suripin, 2004) is:

$$X_T = \bar{X} + K_T.S$$

b. Log Normal Distribution

Log Normal distribution method equation (Suripin, 2004) is:

$$Log\ X_T = Log\ \bar{X} + K_T.S$$

c. Gumbel Distribution

Gumbel distribution method equation (Suripin, 2004) is:

$$X_T = \bar{X} + \frac{S}{Sn}(Yt - Yn)$$

d. Log Pearson III Distribution

Log Pearson III distribution method equation (Suripin, 2004) is:

$$Log\ X_T = Log\ \bar{X} + K.S$$

Where:

X_T = planned period T year

$\bar{X}$ = mean rainfall (mm)

K_T = probability factor (value of Gauss reduction variable)

S = standard deviation

Sn = standard deviation of total data (n)

Yt = the reduction value of the variable period T years

Yn = variable reduction value from data (n)

Distribution Compatibility Test

This method is intended to determine the suitability of the distribution equation that is selected and can represent the sample of the analyzed data. There are two types of alignment (Goodness of Fit Test), namely the Chi Square and Smirnov Kolmogorof alignment test (Soewarno, 1995).

Chi Square Test

Equation Chi Square test (Soewarno, 1995) are:

$$X^2 = \sum \frac{(E_i - O_i)^2}{E_i}$$

$$K = 1 + 3{,}3\ Log\ n$$

$$dk = K - R - 1$$

Where:

X^2 = value of Chi Square

O_i = the number of observation values in the i-th subgroup

E_i = the number of theoretical values in the i-th subgroup

K = number of subgroups

R = 2 for normal and binominal distribution, 1 for poisson distribution

dk = degree of trust

Smirnov Kolmogorov Method

Equation Smirnov Kolmogorov test (Soewarno, 1995) are:

$$\Delta_{max} = P_E(x) - P_t(x)$$

$$P_E(x) = \frac{1}{M + 1}$$

$$f_t = \frac{X_i - \bar{X}}{S}$$

$$P_t(x) = 1 - Z$$

Where:

$P_E(X)$= The position of the data x according to the empirical distribution

$P_t(X)$ = The position of the data x according to theoretical distribution

M = serial number data

$\bar{X}$ = mean rainfall

Z = area under the Normal curve

Rainfall Intensity of Dr. Mononobe

Equation of rainfall intensity Dr. Mononobe (Soewarno, 1995) is:

$$I_t = \left[\frac{R_{24}}{24}\right]\left[\frac{24}{t}\right]^{2/3}$$

Where:

It = rainfall intensity (mm/jam)

R_{24} = maximum daily rainfall (mm)

t = rainfall period (jam)

Planned Flood Discharge of Der Weduwen

This method is the most widely developed so that the formula is obtained, one of which is Der Weduwen for a watershed area of 100 km^2 as follows (Loebis, 1987):

$$Q_n = \alpha.\beta.q_n.A$$

$$\alpha = 1 - \frac{4.1}{\beta.q + 7}$$

$$\beta = \frac{120 + \frac{t+1}{t+9}A}{120 + A}$$

$$q_n = \frac{R_n}{240}.\frac{67,65}{t + 1,45}$$

$$t = 0,25.L.Q^{-0,125}.I^{-0,25}$$

Where:

Qn = flood discharge (m^3/s) with probability of not being fulfilled n%

Rn = maximum daily rainfall (mm/day) with probability of not being met n%

qn = rainfall (m^3/s.km^2)

A = flow area (km^2) to 100 km^2

t = duration of rainfall (hours)

L = river length (km)

I = gradient (Melchior) river or terrain

3. METHOD

Research Location

The research location is in the Banjarmasin Campus I area of Lambung Mangkurat University which is located on Brigadier General H. Hasan Basri Kayu Tangi road, North Banjarmasin District, Banjarmasin City, South Kalimantan Province.

Data Analysis and Method

Rainfall data obtained from the BMKG Syamsuddin Noor station in the form of maximum annual rainfall data for the last 20 years. Statistical and logarithmic parameters were calculated, and the results were matched with the requirements for each type of distribution, namely Normal, Log Normal, Gumbel and Log Pearson III. Then the distribution suitability test was carried out with the Chi Square Test and the Smirnov Kolmogorov Conformity Test and continued with the calculation of the planned rain. The planned rainfall is calculated in the formula of rainfall intensity using the Dr. Mononobe then calculates the planned flood discharge using the Der Weduwen method.

4. RESULT AND DISCUSSION

Used rain data for the last 20 years from 2002-2021. Based on the analysis of rainfall data in 2002, 2003, 2010, and 2013 it was declared invalid and not recorded/lost. So that the 4 years are omitted in the analysis process. The rainfall at Syamsuddin Noor Station used in the analysis process can be seen in Table 2.

Table 2 Maximum Annual Daily Rainfall at Syamsuddin Noor Station

Year	Rainfall (mm)
2004	136,1
2005	62,2
2006	80
2007	109,3
2008	145
2009	105,2
2011	113
2012	92,4
2014	118,2
2015	117,5
2016	98,9
2017	111,8
2018	112,1
2019	70,5
2020	122,1
2021	249

Statistic and Logarithmic Parameters

The results of the calculation of statistical and logarithmic parameters can be seen in Table 3.

Table 3 Statistic and Logarithmic Parameters

Parameter	Statistic	Logaritmic
Mean (mm)	115,206	2,040
Standard Deviasi (S)	41,858	0,136
Coefficien Variation (Cv)	0,363	0,067
Coefficien Skewness (Cs)	0,138	0,001
Coefficien Kurtosis (Ck)	0,040	0,023

Based on Table 1 and Table 3, it is concluded in Table 4.

Table 4 Determination of the Type of Distribution Based on the Requirements

Distribution	Information
Normal	Unsuitable
Log Normal	Unsuitable
Gumbel	Unsuitable
Log Pearson III	**Suitable**

Based on Table 4, the type of Distribution that suitable is Log Person III.

Distribution Compatibility Test

Chi Square Test

The results of the Chi Square test on the four types of Distribution, namely Normal, Log Normal, Gumbel and Log Pearson III can be seen in Table 5, used α = 0.05 or 5% confidence degree and the value of dk = 2.

Table 5 Chi Square Test Recapitulation

Distribution Type	X^2	X^2cr	Information
Normal	9,625	5,991	Unsuitable
Log Normal	5,875	5,991	**Suitable**
Gumbel	9,625	5,991	Unsuitable
Log Pearson III	4,625	5,991	**Suitable**

Based on Table 5, the distributions that meet the Chi Square test requirements are Log Normal and Log Pearson III Distributions.

Smirnov Kolmogorov Test

The results of Smirnov Kolmogorov's test for the four types of Distribution, namely Normal, Log Normal, Gumbel and Log Pearson III can be seen in Table 6, used α = 0.05 or 5% confidence degree and the value of n = 16.

Table 6 Smirnov Kolmogorov Test Recapitulation

Distribution Type	Δmax	Δcritical	Information
Normal	0,201	0,328	**Suitable**

Log Normal	0,132	0,328	**Suitable**
Gumbel	0,167	0,328	**Suitable**
Log Pearson III	255,857	0,328	Unsuitable

Based on the results of the Chi Square Test and the Smirnov Kolmogorov Test, the type of Distribution that suitable and can be used is the **Log Normal Distribution**.

Planned Rainfall Height

The recapitulation of the planned rainfall results from the Normal Distribution, Log Normal, Gumbel, and Log Pearson III with return periods of 2, 5, 10, 20, 25, 50, 100, and 200 years is presented in Table 7. The selected distribution is Log Normal.

Table 7 Rainfall Recapitulation with Normal Distribution, Normal Log, Gumbel, and Log Pearson III

Return Periods,	Rainfall with Distribution (mm)			
T (year)	**Normal**	**Log Normal**	**Gumbel**	**Log Pearson III**
2	115,21	109,62	109,16	109,62
5	150,37	142,71	155,16	142,80
10	168,78	163,85	185,62	163,96
20	183,85	183,46	214,83	180,90
25	186,71	187,44	224,10	189,98
50	201,02	208,66	252,64	208,95
100	212,74	227,84	280,98	227,59
200	223,20	246,44	309,21	246,19

Rainfall Intensity Dr. Mononobe

The rainfall intensity by the method of Dr. Mononobe is presented in Chart 1.

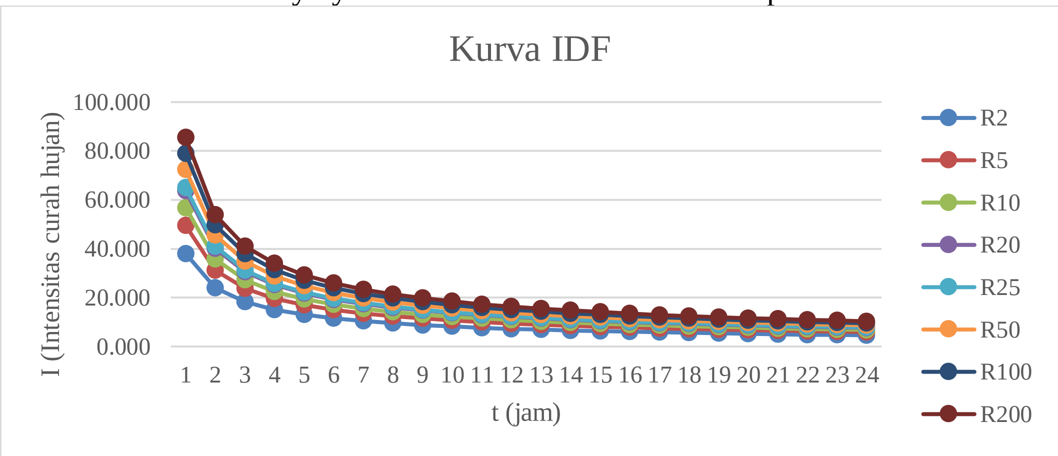

Chart 1 IDF (Intensity Duration Frequency) Curve Dr. Mononobe (24 hours)

Chart 1 shows the intensity of rainfall for 24 hours based on return periods of 2 years, 5 years, 10 years, 20 years, 25 years, 50 years, 100 years, and 200 years. Where the longer the duration (hours), the lower the intensity of the rain. On the other hand, the shorter the duration (hours) used, the higher the intensity of the rain.

Planned Flood Discharge of Der Weduwen

The planned flood discharge with Der Weduwen has an area requirement of < 100 km^2, based on the study area in this research is 39.8 hectares or 3.98 km^2. Then this method is considered eligible and can be used. Based on direct measurements in the field, with a river length of 536.6 m. The slope of the river is calculated as 0,0005 or 0,05%.

Table 8 Planned Flood Discharge of Der Weduwen

Return Periods	**2**	**5**	**10**	**20**	**25**	**50**	**100**	**200**
B	0,973	0,973	0,973	0,973	0,973	0,973	0,973	0,973
qn ($m^3/s/km^2$)	15,44	20,32	23,46	26,37	26,97	30,15	33,02	35,81
A	0,814	0,847	0,863	0,874	0,877	0,887	0,895	0,902
Q (m^3/s)	48,68	66,63	78,35	89,30	91,56	103,57	114,46	125,07
t (jam)	0,551	0,530	0,519	0,511	0,509	0,501	0,495	0,490
R (mm)	109,62	142,71	163,85	183,46	187,44	208,66	227,84	246,44

The results of calculating the flood discharge plan of the Der Weduwen method can be seen in Table 8. Based on the results of the analysis of the flood discharge value for the 2 years return period was 48.68 m^3/s, 5 years was 66.63 m^3/s, 10 years of 78.35 m^3/s, 20 years was 89.30 m^3/s, 25 years was 91.56 m^3/s, 50 years was 103.57 m^3/s, 100 years was 114.46 m^3/s, and 200 years was 125.07 m^3/s.

5.CONCLUSIONS

Based on the results of the analysis of the value of the planned flood discharge using the Der Weduwen method on Campus I Banjarmasin, Lambung Mangkurat University, it was found that the planned flood discharge with a return period of 2 years was 48.68 m^3/s, 5 years was 66.63 m^3/s, 10 years of 78.35 m^3/s, 20 years was 89.30 m^3/s, 25 years was 91.56 m^3/s, 50 years was 103.57 m^3/s, 100 years was 114.46 m^3/s, and 200 years was 125.07 m^3/s.

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