https://dx.doi.org/10.22161/ijaers.68.13 ISSN: 2349-6495(P) | 2456-1908(O)

Analysis of Flood Discharges on Way Samal River in Moluccas Province

Selviana Walsen

Politeknik Negeri Ambon, Indonesia

***Abstract*— *Way Samal river is one of the rivers in district of Central Maluku which is intended for agricultural activities. But when its rainy season, there are many problem caused by overflowing of river Way Samal. So, we need to find the right solution to overcome this problem. In general the best solution is technical engineering, by planning the building control and normalization of the river. It needs to be analyzed how much flood discharge that occurs in the Way Samal river flow. In this study a flood discharge planning analysis was conducted using annual maximum rainfall. This rainfall is analyzed for rainfall plans by using probability distributions Gumbel, Normal, Log-Normal, and Log-Pearson Type III. Furthermore, the distribution is tested for compatibility by using Chi-Square test and Kolmogorof Smirnov Test. After that based on the match test results, the design flood discharged was calculated by using the synthesis hydrograph method of Snyder and Nakayasu. Then these two synthesis methods are compared and select the closest to trend based on the linear average approach.*

***Keywords*— Rainfall, probability distribution, synthesis hydrograph.**

I. INTRODUCTION

The river has an important role in improving the welfare of the Indonesian people in the areas it supports, in terms of irrigation and other uses. However, not in accordance with climatological characteristics, topography and the quality of the soil environment and vegetation of the catchment area, it can bring disaster [1].

One of them is SungaiWay Samal which is located in the central Maluku district administration. In the rainy season, the flow on the Samal River is very superior in other places in the Regency. Central Maluku.

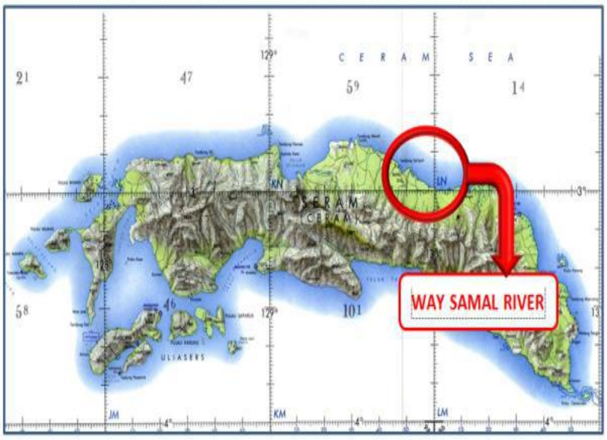

Fig.1. Research Location Map

2.2 Rainfall Design Analysis

Rainfall analysis plan, using the probability distribution method [1] :

1. Gumbel Probability Distribution

The impact of this is material losses, until it is approved by the community. Therefore it is necessary to analyze the discharge in the Wai Samal river to be able to determine the effectiveness of the capacity of the river. Can be approved during the rainy season.

II. METHOD

2.1. Research Location

The study location is in the Way Samal watershed in Central Maluku Regency.

$X_T = X_{rt} + S \times K$

with:

X_T = rain or discharge plan with a return period (T)

X_{rt} = average of rain or discharge.

S = standard deviation from rain or discharge data.

K = gumbel reduction factor.

2. Normal Probability Distribution

$X_T = X_{rt} + S \times K_T$

With :

X_T = rain or discharge plan with a return period (T)

X_{rt} = average of rain or discharge.

S = standard deviation from rain or discharge data.

K_T = frequency factor, depends on return period (T)

3. Log Normal Probability Distribution

$\text{Log } X_T = (\text{Log } X_{rt}) + K_T \times (S.\text{Log } X)$

With :

Log X_T = rain logarithmic value or discharge with return period (T).

Log X_{rt} = Average of Log X_T

S Log X = standard deviation of Log X_T :

S Log X = $\sqrt{\frac{\sum_{i=1}^{n}(\text{Log } X_i - \overline{\text{Log } X})^2}{n-1}}$

K_T = frequency factor, depends on return period (T)

4. Log Pearson Type III Probability Distribution

Log X_T= (Log X_{rata}) + K_T x (S.LogX)

With:

Log X_T = rain logarithmic value or discharge with return period (T).

Log X_{rata} = Average of Log X_T

K_T = Standard variable, the amount depends on the coefficient of precision (Cs or G)

2.3 Conformity Test

1. Chi Square Test

The chi-square test is intended to determine whether the opportunity distribution equation that has been chosen can represent the distribution of the statistical samples of the analyzed data. Taking this test decision uses the parameter χ2, therefore it is called the Chi-Square test [2]. The parameter χ2 can be calculated by the equation:

$$\chi^2 = \sum_{I=1}^{n} \frac{(O_f - E_f)^2}{E_f}$$

with:

χ^2 = calculated of chi-square parameters

n = number of sib-groups

O_f = number of observations in sub group-i

E_f = number of theoretical values in the i-sub-grouop

Certain degrees of trust (α)= 5%

Dk = K – (p + 1)

K = 1 + 3,3 Log n

with:

Dk = independent variables

P = number of parameters, =2

K = number of distribution class

N = number of data

Furthermore, the probability distribution used to determine the planned rainfall is a probability distribution which has the smallest maximum deviation and is smaller than the critical deviation, or formulated as follows:

$$\chi 2 < \chi 2cr$$

With :

χ^2 = Calculated chi-square parameter

$\chi^2 < \chi^2_{cr}$ = Critical chi-square parameter

2. Smirnov-Kolmogorof Test

The Smirnov – Kolmogorov suitability test, often also called a non parametric test, is because the test does not use a certain distribution function. The testing procedure is as follows:

X_1 → $P(X_1)$

X_2 → $P(X_2)$

X_m → $P(X_m)$

X_n → $P(X_n)$

Determine the value of each theoretical opportunity from the description of the data (distribution equation) :

X_1 → $P'(X_1)$

X_2 → $P'(X_2)$

X_m → $P'(X_m)$

X_n → $P'(X_n)$

Determine whether $\Delta Pi < \Delta P$ is critical, to find out whether the distribution is rejected or accepted.

2.4. Flood design-discharge analysis

2.4.1. Snyder Unit Hydrograph

Calculation step of Snyder Unit Hydrograph [3]:

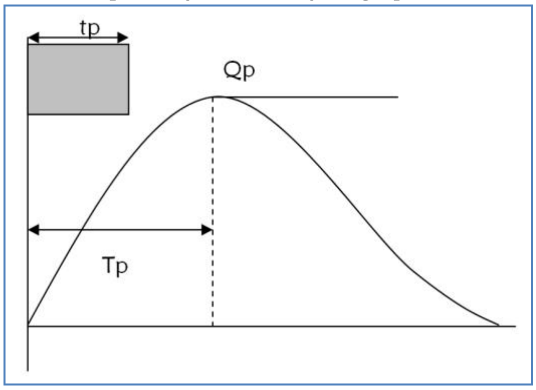

Fig.2. Synthetic Unit Hydrograph Model According to Snyde

Determine log-time:

Tp= 1.1 - 1.4(L.Lg)0.3 (hour)

Keterangan :

Tp = Log time and center of rainfall are effective during tr to peak Hydrograph Unit in hours

L = Distance from station to the upper limit of the drainage area in km

Lg = Distance from station to specific weight of the drainage area in km.

Effective rain time :

Tp1 = tp + 0.25(tr - te)

Rise to peak :

Tp = tp +tr

Peak discharge (1/second), for effective rainfal at 1 km^2 :

$$qp = \frac{275.Cp}{tp}$$

https://dx.doi.org/10.22161/ijaers.68.13 ISSN: 2349-6495(P) | 2456-1908(O)

Peak discharge for effective 1 inci (25.4 mm) rain in an area of A km²

$$Q_P = qp\frac{25.4}{1000}A \quad (m^2/s)$$

2.4.2. akayasu Unit Hydrograph

Calculation of design flood discharge using Nakayasu metade. The general equation of Nakaysu synthetic unit hydrograph is as follows [4]:

$$Qp = \frac{C.A.R_0}{3{,}6(0{,}3\,Tp + T_{0,3})}$$

Tp = tg + O,8 tr

tg = 0,21 x $L^{0,7}$ (L < 15 km)

tg = 0,4 + 0,058 x L (L > 15 km)

$T_{0,3}$ = α x tg

with: Debit puncak banjir

Qp = peak flood discharge (m³/second)

C = runoff coefficient

$R_{0,3}$ = rain unit (mm)

Tp = time period from the start of the rain to the peak of the flood (hour)

$T_{0,3}$ = the time required for a decrease in discharge (m3/second)

A = watersheed area (km²)

tg = time of concentration (hour)

Tr = rain unit, used 1 hour

α = hydrograph parameters, between 1,5 - 3,5

L = river length (m)

Unit hydrograph equation:

- Rising curve

$$Q \le t < Tp \quad Qt = \left(\frac{t}{Tp}\right)^{2,4} x\ Q_p$$

- Downward curve

✓ Tp < t (Tp + $T_{0,3}$)

✓ (Tp + $T_{0,3}$) ≤ t < (Tp + $T_{0,3}$ + 1,5$T_{0,3}$)

$$Qt = Qp\ x\ 0{,}3^{\left[\frac{t - Tp + 0{,}5T_{0,3}}{1{,}5Y_{0,3}}\right]}$$

t > (Tp + $T_{0,3}$ + 1,5 $T_{0,3}$)

$$Qt = Qp\ x\ 0{,}3^{\left[\frac{t - Tp + 0{,}5T_{0,3}}{1{,}5Y_{0,3}}\right]}$$

III. RESULT AND DISCUSSION

3.1. Rainfall Design Analysis

To calculating rainfall design, we use probability distribution namely Gumbel probability distribution, Normal probability distribution, Log Normal probability distribution, Log Pearson III probability distribution. The result can see on table 1-4.

Table 1. Result of Gumbel Distribution Rainfall design

Return Period (Year)	Gumbel
2	170.63
5	351.97
10	466.01
25	598.99
50	716.97
100	823.06
500	1068.44
1000	1173.61

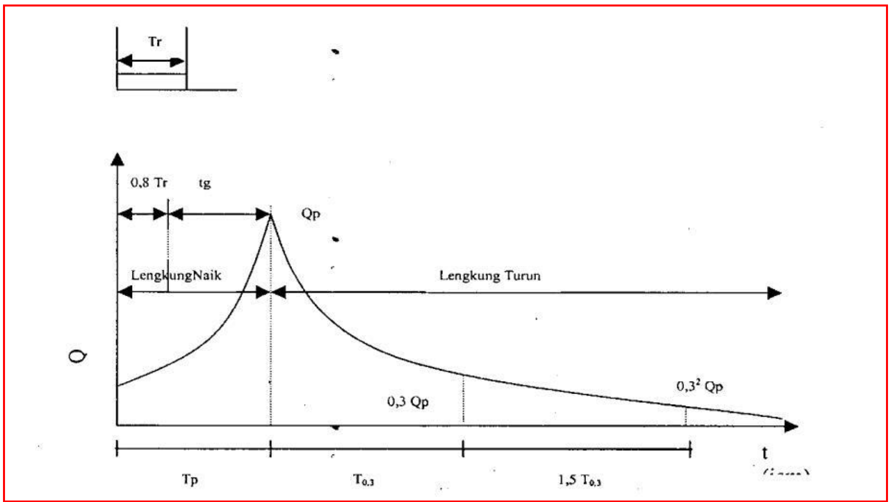

Fig.3. Nakayasu Unit Hydrograph

https://dx.doi.org/10.22161/ijaers.68.13 ISSN: 2349-6495(P) | 2456-1908(O)

Table 2. Result of Normal Distribution Rainfall design

Return Period (Year)	Normal
2	199.30
5	320.52
10	384.02
25	445.83
50	495.14
100	535.55
500	614.92
1000	645.22

Table 3. Result of Log-Normal Distribution Rainfall design

Return Period (Year)	Log Normal
2	166.25
5	278.32
10	364.55
25	474.10
50	584.65
100	694.22
500	972.80
1000	1106.55

Table 4. Result of Log-Pearson III Distribution Rainfall design

Return Period (Year)	Log Pearson Type III
2	158.45
5	273.28
10	373.91
25	533.79
50	680.32
100	853.21
. 500	1660.61
1000	2194.26

3.2. Conformity Test

After calculating the design rainfall, the next step is to test the suitability of the result. Using the Chi-square and Smirnov-Kolmogorof test method. (the result can be seen on tables 5 and tables 6)

Table 5. Result of Chi Square Test

Probability Distribution	Chi-Square		
	X^2 Calculate	X^2_{cr}	Result
Gumbel	2.167	3.841	Accepted
Normal	5.667	3.841	Rejected
Log Normal	2.333	3.841	Accepted
Log Pearson Type III	2.667	3.841	Accepted

https://dx.doi.org/10.22161/ijaers.68.13 ISSN: 2349-6495(P) | 2456-1908(O)

Table 6. Result Smirnov-Kolmogorof Test

Probability Distribution	Smirnov Kolmogorof		
	ΔP Maximum	ΔP critical	Result
Gumbel	0.921	0.41	Rejected
Normal	0.187	0.41	Accepted
Log Normal	0.102	0.41	Accepted
Log Pearson Type III	0.102	0.41	Accepted

In Table 5 and 6, there are two distributions received, namely normal log distribution and type II log pearson distribution.

Because the calculation of the chi-square test in the normal log distribution has x2 calculated smaller than the other methods, the normal log distribution is chosen.

3.3. Design Discharges Analysis

To estimate the design flood discharge, a hydrological analysis can be carried out using the Nakayasu Hydrograph Unit method, Snyder. Analysis of flood discharge was carried out at the return period of 2 years, 5 years, 10 years, 25 years, 50 years, 100 years, 500 years and 1000 years. This flood discharge is used in hydraulic analysis and water building planning.

Table 7. Result of Snyder Synthetic Unit Hydrograph and Nakayasu Synthetic Unit Hydrograph

Return Period (Year)	Design Rainfall (mm)	Flood Discharges (m^3/second)	
		Snyder	Nakayasu
2	166.25	447.79	307.15
5	278.32	749.66	514.22
10	364.55	981.94	673.55
25	474.10	1277.02	875.95
50	584.65	1574.80	1080.20
100	694.22	1869.91	1282.63
500	972.80	2620.28	1797.34
1000	1106.55	2980.54	2044.45

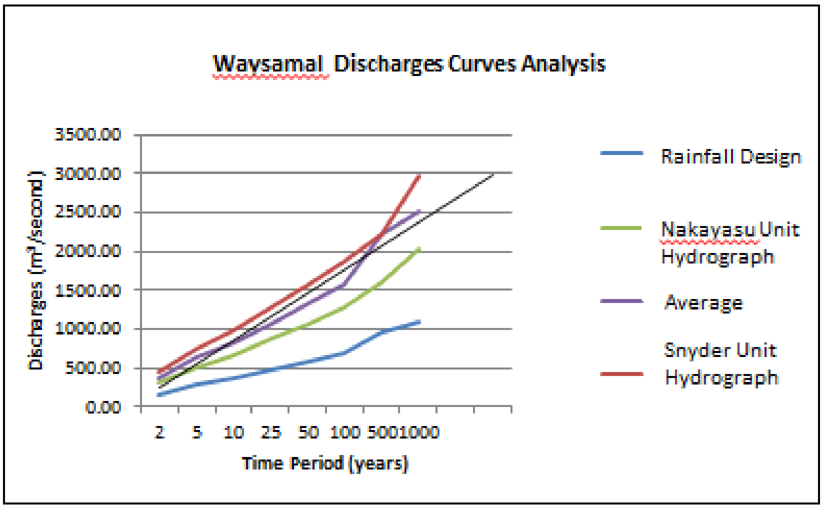

Fig.4. Way Samal Discharges Curves Analysis

Furthermore, from the recapitulation of the calculation of Snyder and Nakayasu Synthetic Unit Hydrograph, a comparison with graphical assistance was made to the mean with a linear approach. The results of these comparisons can be seen from Figure 4.
From the results of the comparison, it can be seen that the Snyder method is the closest, the design flood discharge chosen is the flood discharge design calculated by Snyder Synthetic Unit Hydrograph.

IV. CONCLUCIONS AND RECOMMENDATIONS

4.1. Conclusions

1. In calculating the design rainfall, the distribution chosen based on the compatibility test is the Log Normal distribution, because it has the following suitability values:
   Chi-Square Test
   (X^2 calculated < X^2_{cr})
   (2.333 < 3.841)→**accepted**
   Smirnov-Kolmogorof Test
   $\Delta max < \Delta cr$
   (0.102<0.41) →**accepted**
2. For the calculation of the design flood discharge, by comparing the two methods of the Hydrograph Synthesis Unit, then the selected design flood discharge is the design flood discharge using Snyder Synthetic Unit Hydrograph.

V. REFERENCES

[1] Harto, S. Br, 1993: Analisis Hidrologi, PT.Gramedia Pustaka Utama, Jakarta.
[2] Soewarno. 1995. *Hidrologi Aplikasi Metode Statistik untuk Analisa Data Jilid I*, Bandung: Nova.
[3] Soemarto, C.D. 1995, *Hidrologi Teknik*. Penerbit Erlangga, Jakarta.
[4] Montarcih L, dan Widandi Soetopo, 2009: *Statistika Terapan Untuk Teknik Pengairan*, CV Citra, Malang