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# Comparison of Model Hidrograf Synthetic Units (HSS) with the Model of Hidrograf Observations on DAS Jeneberang Gowa Regency, Indonesia

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**Abstract:-Some Synthetic Unit Hidrograf (HSS) is created by using the data of rainfall and river discharge data on Watersheds (DAS) located in the Jeneberang Gowa Regency of South Sulawesi province with major rivers namely the Jeneberang River. Model hidrograf produced from HSS saw different results with different models of hidrograf observations based on data. Brdasarkan analysis results by using the secondary debit data measurable and measured rainfall and WATERSHED characteristics Jeneberang obtained results with the method of discharge peaks have Snyder HSS flooding amounting to 9.6 m3/sec on time 9.12, with methods HSS Nakayasu flood peak discharge has amounted to 19.84 m3/sec on time 5.69, HSS Gama-I have a flood peak discharge of 14.77 m3/sec on time 2.64 hours. The results of this study showed that the Synthetic method of Hidrograf unit of Nakayasu has more calculation results approaching the measured data in the field is compared to the Synthetic method of Hidrograf Units (HSS) to another.**

**Keywords:-**Watersheds (DAS), Hidrograf

## I. INTRODUCTION

Watersheds (DAS) who becomes the object of research is the DAS Jeneberang, located on river basin (WS) Jeneberang. Watersheds (DAS) is partly located in the Gowa Makassar City and region. With the presence of several points of recording Automatic Water Level Recorder (AWLR) in DAS Jeneberang can do the study to test Hidrograf the unit of Synthesis (HSS) that approximates the result Hidrograf Oservasi based on the data field.

To create a model of the hidrograf flood in sungai river have a little observation data, then need to look for the characteristics or parameters area stream first. The characteristics or parameters, among others the time to reach the peak of hidrograf, the Basic, broad, wide slope, the length of the longest flow of runoff coefficients, and so on. For streams that do not have the hidrograf flood observation commonly used hidrograf-hidrograf synthesis has been developed in other countries, that the parameters should be adjusted in advance with the characteristics the area of the stream are reviewed. Hidrograf synthesis of Units (HSS) which has been developed by experts include HSS Snyder, HSS, HSS Nakayasu Gama I and others (Lily, 2009).

## II. THE CORNERSTONE OF THE THEORY

The understanding and application of hydrological science concerns the understanding of the process of transformation from a set of inputs into one output through a process in the system of hydrology. The simple scheme concerned the measurement-measurement of variables and parameters that quite a lot, because only with the data and information collected the hydrological process can be understood as a whole. Understanding requires detailed measurements and observations of a thorough and meticulous. These needs are based on information needs, both of magnitude or its spread as a function of time and space (time and special distribution).

### *A. Twists Calibration (Rating Curve)*

A reading of the record AWLR was transformed into the hidrograf stream with twists of calibration (rating curve) which is a graph of the relationship between the height of the face water with debit flow of the River at a location. Rating Curve DAS Jeneberang obtained from field measurements of high Analysis results advance water and cross-sectional area in DAS Jeneberang done in vulnerable years 1995-2014, the equation can be written as follows:

$$Q = 119{,}789\ h \wedge 1{,}8741 \qquad [1]$$

With:
Q = discharge (m3/sec)
h = height of the face of the waters (m)
Statistical Parameter
Frequency analysis hydrologic data aims to determine the value of the magnitude of extreme events that are related to the frequency of the occurrence through the application of a probability distribution. Frequency analysis using random variables and the variable probability distribution is part of the statistical methods.
In the analysis of statistics data, there are parameters that can help in determining the right type of distribution. The parameters are divided into four (4) large sections of measurement i.e., measurements of central tendency,

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variability, skewness and measurements of Cuneiform (kurtosis). And other types of distribution used was as follows:

Normal Distribution

Log Normal Distribution

Gumbel Distribution

Distribution Log Pearson III

Test The Fit Of The Distribution

To test the suitability of the frequency distribution of the sample distribution function against data obtained opportunities, required a test parameter. How common is the Chi-Square Test and Kolmogorov-Smirnov Test (Triatmodjo, 2008).

HSS Snyder Method

With these elements Snyder make formula as follows:

t_p = C_t (b. L_c) ^ 0.3 [2]

t_e = t_p/5.5 [3]

Q_p = 0,278 (C_p. A)/t_p [4]

T_b = 5.0 (t_p + t_r/2) [5]

With:

TP = time delay (minutes)

QP = peak discharge (m3/sec)

TB = basic time (hours)

Te = long time effective rainfall (hours)

TR = long standard eff rainfall (hours)

To speed up the work of the given formula Alexeyev, which gives the shape of the hidrograf unit. Alexeyev is the following equation (Soemarto, 1995):

$$Q_t = Y.Q_p \quad [6]$$

$$X = \frac{t}{T_p} \quad [7]$$

$$Y = 10^{-a\frac{(1-x)^2}{x}} \quad [8]$$

Where α is obtained from the following equation:

a = 〚 〛1,32 λ λ +0,15 ^ 2 + 0,045 [9]

λ = (Q_p. 〛〚 T _ p)/(A) [10]

After the λ and α is calculated, the value of Y for each X can be calculated (by creating a table), from the values obtained: t = X = y and Q T_p. Q_p, then made a graph of hidrograf units.

Nakayasu HSS Method

The formula of Hidrograf Synthetic Units (HSS) Nakayasu is:

Q_p = (CA. R_0)/3.6 (0, 3T_p + T_0, 3) [11]

With:

QP = peak flood discharge (m3/sec)

CA = wide catchment area (km2)

Ro = rain unit (mm)

TP = time lag from the beginning of the rain to flood peak (HRS)

T0, 3 = time needed by a decrease in discharge, from a peak of up to 30% of the peak discharge.

To determine the Tp and T0, 3 use the following formula: approach

$$T_p = tg + 0{,}8\ tr \quad [12]$$

$$T_{0,3} = a.tg \quad [13]$$

$$t_r = 0{,}75\ t_g$$

$t_g$ is the time lag between the day that the rain until the flood peak discharge (h). TG is calculated with the following conditions:

♣ River flow length L > 15 km;

$$tg = 0{,}4 + 0{,}058\ L \quad [14]$$

♣ the River with long strands of L < 15 km;

$$tg = 0{,}21\ L^{0,7} \quad [15]$$

1. With:
2. TR = units of time to rain (HRS)
3. α = hidrograf

4. At the time of ride:: $0 \le t \le T_p$

$$Q_t = Q_p \left(\frac{t}{T_p}\right)^{2,4} \quad [16]$$

5. on curve down (decreasing limbi)

a. the interval value: $T_p \le t < (T_p + T_{0,3})$

$$Q_t = Q_p\ .\ 0{,}3^{\left[\frac{t-Tp}{T_{0,3}}\right]} \quad [17]$$

b. theinterval value:

$$(T_p + T_{0,3}) \le t < (T_p + T_{0,3} + 1{,}5T_{0,3})$$

$$Q_t = Q_p\ .\ 0{,}3^{\left[\frac{t-Tp+0{,}5T_{0,3}}{1{,}5T_{0,3}}\right]} \quad [18]$$

c. the interval value, $t > (T_p + T_{0,3} + 1{,}5T_{0,3})$

$$Q_t = Q_p\ .\ 0{,}3^{\left[\frac{t-Tp+0{,}5T_{0,3}}{2.T_{0,3}}\right]} \quad [19]$$

Where : Qt = discharge at time t h (m3/sec)

Method Of HSS Gama-I

The unit of Hidrograf Synthetic Units (HSS) Gama-I was formed by three basic components, namely time ride (tr), peak discharge (Qp), basic time (Tb), with the explanation:

Peak time (TR)

t_r = 0.43 (L/(100 SF)) ^ 3 + 1,0665 + SIM 1,277 [20]

Peak discharge (Qp)

〚 0,1836 〛Q_p = ^ (A 0.5884) 〚 〚 0,2381 〛JN ^ t_r 〛^ (-0.4008) [21]

Basic time (Tb)

t_b = 〚 27,4132 〛0,1457 t_r ^ S ^ (-0.0986) 〚 〚 0,7344 〛SN ^ RUA 〛^ 0,2574 [22]

The recession coefficient

K = 〚 0,1798 〛0,5671 à ^ S ^ (-0.1446) 〛〚 SF ^ (-1.0897) D ^ 0,0452 [23]

Basic flow (Qb)

Q_B = 0,4751 0,6444 A ^ D ^ 0,9430 [24]

With:

A = wide DAS (km2)

L = length of the River (km)

SF = factor source

SIM = symmetry factors

WF = width factor

JN = number of Confluence

TB = basic time (hours)

S = average River landau

RUA = relatively broad upper WATERSHED

D = the density of the network.

*B. The Calibration of The Model*

The model developed for the estimation of flood discharge on a DAS, composed for the mensimulaikan process of surface flow that exists in nature. The output of the model is expected to approach the Genesis flood. Nevertheless, the model is almost impossible to simulate the processes in nature with precision. Therefore, it will always be a discrepancy between the output and the results of field observations.

## III. RESEARCH METHOD

The steps undertaken in the process of research are as follows:

*A. Study of Literature*

Study of literature is the study of librarianship to theories that will be used in research.

*B. Data Collection*

Data retrieval is performed in the great Hall Pompengan Jeneberang River Region. As for the data that is retrieved is the data AWLR/Discharge Curve of the year 2006-2015. daily rainfall data of the year 2006-2015 with the rainfall station coordinates, as well as other supporting data.
Analysis and discussion of the Analysis of that question is namely to calculate hydrological analysis in order to seek an annual

Rain maximum. Daily rainfall data on distribution pattern of rain station is made of rain. Calculation of area rainfall data using the method of Thiessen Polygons and after that do the calculations of rainfall Probability Distribution based on the plan and proceed with calculating rainfall intensity using method of Mononobe. Next is gather first the parameters that will be used to calculate the method using HSS Snyder, Nakayasu, Gamma-I. Hidrograf describes the results of calculation of HSS that were affected by the rain data region. Compare the graphs of HSS that were affected by the rain area from the results data AWLR/Discharge Curve.

## IV. DATA ANALYSIS AND DISCUSSION

Daily rainfall data of the annual maximum is taken from the StasiunBili-Bili, Malino, Jonggoa Station, Limbunga Station, Mangempang station. Then the data were analyzed using the Thiessen Polygon method. Data used totaled 10 with 10 years of observations (2006-2015), here's a recap of the rainfall data, can be seen in the following table:

| **Year** | **Rmax (mm)** |
|---|---|
| 2011 | 31.18 |
| 2015 | 64.81 |
| 2014 | 65 |
| 2012 | 67.9 |
| 2013 | 68.81 |
| 2010 | 85.69 |
| 2008 | 91.74 |
| 2009 | 103.79 |
| 2007 | 134.12 |
| 2006 | 217.37 |

Sources: The Results of the Data Processing

Tabel 1: Maximum Daily Rainfall Data of the year

*A. Statistical Parameter*

The selection of the type of distribution based on statistical parameter is strongly influenced by the kemencengan coefficient, kurtosis coefficients and variable coefficients, each set of data to search for types or patterns of distribution that best meet the so obtained accuracy the results of the analysis. Then it can be determined the type of distribution of the data according the terms of each type of distribution (Triatmodjo, 2008)

| Types Of Distribution | The terms of theththt | results matter | Description |
|---|---|---|---|
| Normal | | 1.70 | not appropriate |
| $C_s \approx 3C_v$ | $C_k \approx 3$ | 7.24 | not appropriate |
| Log Normal $C_s > 0$ | | 1.70 | not appropriate |
| | $C_s \approx 1.139$ | 0.55 | not appropriate |
| Gumbel | | 1.70 | not appropriate |
| | | 7.24 | not appropriate |
| Log Pearson III | Apart from the above values | | According |

Source: b. Triatmodjo, 2008:250 and Calculation Result

Tabel 2: The Calculation Of Statistical Parameters Test

*B. Test the Fit of the Distribution*

Test matches with Chi-Squared method and Kolmogorov-Smirnov test is a match by looking at the difference between the greatest opportunities between data distribution with the distribution from theoretical, which is obtained from the results of the calculation of each test method.

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| This Type Of Test Matches | The Results Of Calculations | The terms of the | Description |
|---|---|---|---|
| Test Chi-Kuadrat | $X^2_{count}$ = 3,00 | $X^2_{hitung}$ <5,991 | Meet |
| Test Smirnov-Kolmogorov | $D_{max}$ = 0,20 | $D_{max}$< 0,41 | Meet |

Source: Soewarno, 1995 and the results of Calculations

Tabel 3: Calculation of Test Matches

### C. *Distribution of Rain Mononobe*

The results of the calculation of the distribution of rain clock-era with the Mononobe method can be seen in the following table

| **Time (Clock)** | The Pattern Of Rain Clock-Era | | | | Plan of rainfall **(mm)** |
|---|---|---|---|---|---|
| | **Rt** | | **RT** | | **Periode 2 th** |
| 1 | 0,5503 | R24 | 0,5503 | R24 | 76,69 |
| 2 | 0,3467 | R24 | 0,1430 | R24 | 19,93 |
| 3 | 0,2646 | R24 | 0,1003 | R24 | 13,98 |
| 4 | 0,2184 | R24 | 0,0799 | R24 | 11,13 |
| 5 | 0,1882 | R24 | 0,0675 | R24 | 9,40 |
| 6 | 0,1667 | R24 | 0,0590 | R24 | 8,22 |
| Rain plan | | | | | **161,03** |
| The Coefficient Stream | | | | | **0,87** |
| Effective Rainfall | | | | | **139,35** |

Source: Calculation Result

Table 4: Calculation of the Distribution of Rain Clock-era Mononobe Method

### D. *Analysis of The Model of Synthetic Unit Hidrograf*

*a). HSS Snyder*

| Parameters | The value of the | Unit | Description |
|---|---|---|---|
| Extensive DAS (A) | 629.70 | Km² | Analysis Of Map |
| The Main River Length (L) | 54.40 | Km | Analysis Of Map |
| The distance between the point of heavy DAS and outlet (Lc) | 32.49 | Km | Analysis Of Map |
| Coefficient Of Ct | 0.90 | - | Time coefficient 0.9-3 |
| A Coefficient Cp | 0.50 | - | Peak coefficient of 0.5-1.4 |
| Tr | 1.00 | clock | |
| High Rainfall (h) | 1.00 | mm | |

Source: Analysis of The Map

Table 5: Parameters Calculation of HSS Snyder

Find the start time of heavy rain until the point of peak discharge ($t_p$).

$$t_p = C_t(L.L_c)^{0,3}$$

$$t_p = 0,9(54,40\ x\ 32,49)^{0,3}$$

$$t_p = 8,48 jam$$

Finding long effective rainfall ($t_e$)

$$t_e = \frac{t_p}{5,5} = \frac{8,48}{5,5} = 1,54 jam$$

calculate the time base ($T_b$)

$$T_b = 5\left(tp + \left(\frac{tr}{2}\right)\right) = 5(8,48+(1/2)) = 44,905\ jam$$

find the time reached the peak of the flood (Tp)

Because te > tr, then to find the value of Tp used the following equation.

$$tp' = t_p + 0,25\ x\ (te - tr) tp' = 8,48 + 0,25\ x\ (1,54 - 1) = 8,62\ jam$$

$$T_p = tp' + \frac{t_r}{2}$$

$$= 8,62 + \left(\frac{1}{2}\right) = 9,12 jam = 32819\ det$$

a. search for peak discharge ($Q_p$)

$$q_p = 0,278\frac{C_p}{T_p} = 0,278\frac{0,5}{9,12} = 0,02$$

$$Q_p = q_p\ .A = 0,02\ .629,70 = 9,6 m^3/det$$

Ordinat hidrograf units calculated with equation Alexeyev, namely: $\lambda = \frac{(Q_p x T_p)}{(hxA)} = \frac{(9,6x\ 32819)}{(0,001\ x\ (629,70x10^6)} = 0,5$

$$a = 1,32\lambda^2 + 0,15\lambda + 0,045$$

$$= 1,32(0,5)^2 + 0,15\ (0,5) + 0,045 = 0,45$$

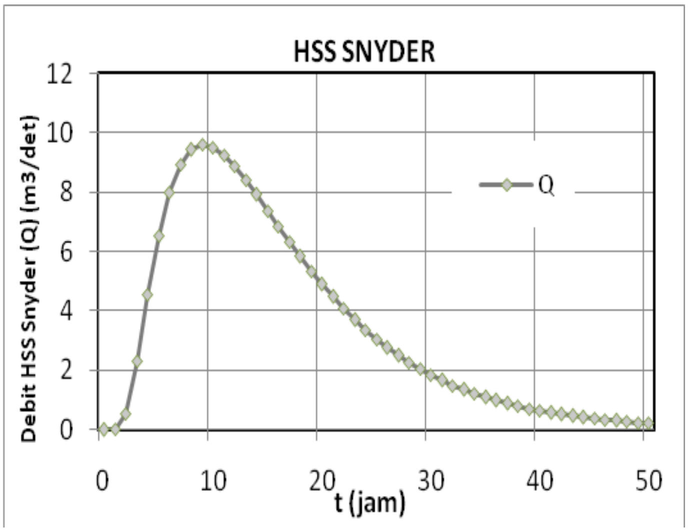


Figure 1. Hidrograf Synthetic Units (HSS) Snyder

b). HSS Nakayasu

| Parameters | **Value** | **Unit** | Description |
|---|---|---|---|
| Extensive DAS (CA) | 629.70 | Km² | Analisis Peta |
| River Length (L) | 54.40 | Km | Analisis Peta |
| Unit Price (Ro) | 1.00 | Mm | Tetapan |

Source: Analysis of The Map

Table 6: Calculation of the HSS Nakayasu Parameter.

a. Calculate the time of concentration of rain

For the length of the river L > 15 km,
then t_g = 0.40 + 0,058 L
t_g = 0.40 + = 0,058 (54.40) 3, 56jam
t_r = 0.75 t_g, then
t_r = 0.75 (3.56 out) = 2, 67jam

b. Calculate the time (time lag) from the beginning of the rain to flood peak
T_p = t_g + 0.8 t_r = 3.56 out + 0.8 (2.67) = 5, 69jam

c. Calculate the time decrease in debit
Take the value of α = 2 for normal stream
T_0, 3 = α. t_g = 2.3.56 out = 7, 11jam

d. Calculate the maximum discharge$Q_p = \frac{CA.R_0}{3{,}6\ (0{,}3T_p + T_{0,3})}$

$$= \frac{629.70\ .\ 1}{3{,}6\ .[(0{,}3\ .\ 5{,}69) + 7{,}11]} = 19{,}84\ m^3/det$$

e. Calculate the curve rises and curves down hidrograf
The curve rises
0 ≤ t Tp <, then
0 ≤ t < 5.69
The formula of the curve rises Q_t = Q_p (t/T_p) ^ 2.4, then
Q_t = 19,84. (t/5,69) ^ 2.4 (the equation of the curve up)

- Curve down

a) Curve down first

TP ≤ t < (Tp + T0, 3), then
5.69 ≤ t < 12.80
The formula of the curve down Q_t 1 = 〖 Q_p 〗 0.3. ^ ((t-T_p)/T_0, 3), then
Q_t 1 = 〖 〗 0.3 19,84. ^ ((t-5,69)/7,11) (equation of the curve down 1)

b) Curve down both

TP + T0, 3 ≤ t < (Tp + T0, 3 + 1, 5T0.3), then
12.80 ≤ t < 23.46
The formula of the curve down Q_t 2 = 〖 Q_p 〗 0.3. ^ ((t-T_p + (〖 〗 _ 0.3 to 0.5 T))/1.5 〖 〗 _ 0.3 T), then
Q_t 2 = 〖 〗 0.3 19,84. ^ ((t-0.5 + (5,69. 7,11))/(1.5. 7.11)) (equation of the curve down 2)

c) Curve down the third

t ≥ (Tp + T0, 3 + 1.5 T0, 3), then t ≥ 23.46

the formula of the curve down Q_t 3 = 〖 Q_p 〗 0.3. ^ ((t-T_p + (〖 〗 _ 0.3 to 1.5 T))/〖 2. 〗 _ 0.3 t), then
Q_t 3 = 〖 〗 0.3 19,84. ^ ((t-1.5 + (5,69. 7,11))/(2. 7.11)) (equation of thecurvedown3)

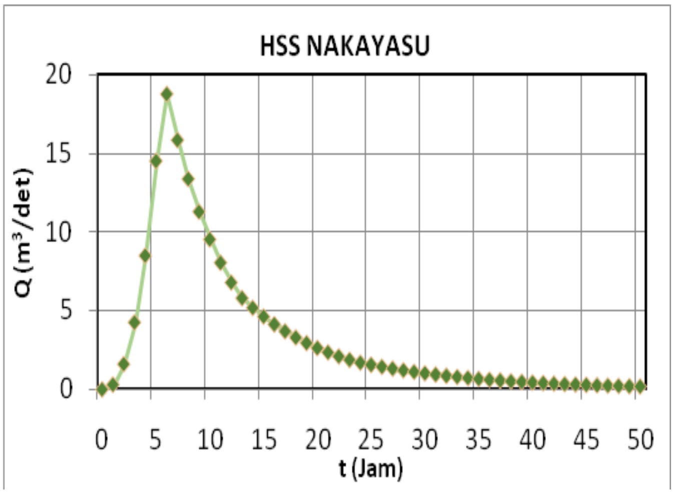


Figure 2. Hidrograf Synthetic Units (HSS) Snyder

*E. HSS Gamma I*

| Parameters | Value | Description |
|---|---|---|
| Extensive DAS (A) | 629.70 | analysis of map |
| The Main River Length (L) | 54.40 | analysis of map |
| The Average Slope Of The River (S) | 0.015 | Calculation |
| Kuras Network Density (D) | 0.581 | calculation |
| Spacious upper WATERSHED (R UA) | 0.530 | analysis of map |
| Width Factor (WF) | 1.553 | analysis of map |
| The Symmetry Factor (SIM) | 0.824 | Calculation |
| The Resource Factor (SF) | 0.523 | analysis of map |
| Frequency Sources (SN) | 0.827 | analysis of map |
| The Number Of Confluence (JN) | 62 | analysis of map |

Source: Analysis of The Map

Table 7: TheParameters Calculation Of HSS Gamma I

a. Calculate the time it reaches peak discharge (Tr)T_r = 0.43 (L/(100. SF))^ 3 + 1,0655.1,2775 + SIM= 0.43 (54.40/(100.0.523)) ^ 3 + 1,0655. 0.824 + 1,2775 =2.64 hours

b. Calculate the hidrograf peak discharge (Qp)Q_p = A ^ 0,1836 0,5886 〗 〖 T_r ^ (-0.4008) 〗 〖 JN ^0,2381= 14, 77m3/sec

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c. Calculate the time base of T_b = 〖 27,4132 〗 0,1457 T_r ^ S ^ (-0.0986) 〖 〖 0,7344 〗 SN ^ RUA 〗 ^ 0,2574= 35, 23jam

d. Calculate the coefficient of spool (K)K = 0, 5617A ^ 0,1793 S ^ (-0.1446) 〗 〖 SF ^ (-1.0897) D ^ 0,0452= 6, 46 hours

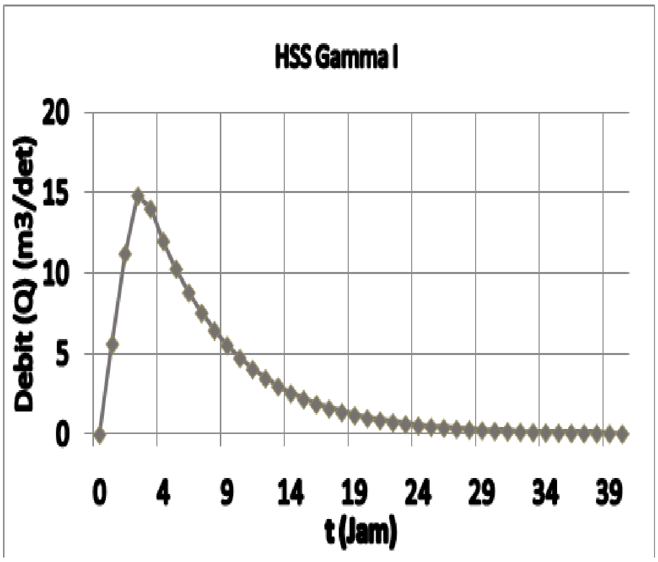


Figure 3. Hidrograf Synthetic Units (HSS) Snyder

Comparison of Synthetic and Measured Debit Hidrograf

Hidrografsintetik calculated based on measurable rainfall. The following is comparison method Snyder HS, Nakayasu, Gamma-I Debit, and measurable.

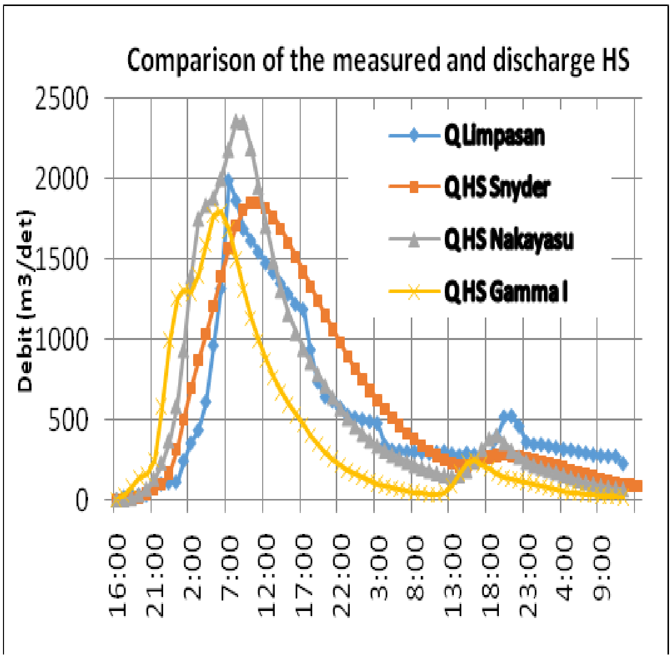


Figure 4. Comparison HS Against Debit Runoff

The Calibration of The Model

Calibration is necessary to know the methods which most appropriate HSS if used in DAS Jeneberang. Calibrated data is data the peak discharge.

The Calibration of the Model

| Method HSS | Peak Discharge HS (m3/det) | Peak Discharge inpasse (m3/det) | ΔQp' (%) |
|---|---|---|---|
| Snyder | 1847.01 | 1986.28273 | 7.01 |
| Nakayasu | 2358.99 | | 18.76 |
| Gamma I | 1790.55 | | 9.85 |

Source: Calculation

Table 8: Calibration Against Discharge Peak Runoff

Result

| Method HSS | Peak TimeHS (clock) | Peak Time Scalable(clock) | ΔTp (%) |
|---|---|---|---|
| Snyder | 18 | 15 | 20 |
| Nakayasu | 16 | | 6.67 |
| Gamma I | 14 | | 6.67 |

Source: Calculation Result

Table 9: Calibration Against The Measured Peak Time

| Metode HSS | the volume of the flood HS (m3) | the volume of the flood scalable(m3) | ΔVb (%) |
|---|---|---|---|
| Snyder | 155072389.47 | 135091106.72 | 14.79 |
| Nakayasu | 151822544.31 | | 12.39 |
| Gamma I | 101544184.99 | | 24.83 |

Source: Calculation Result

Table 10: Calibration Against Flood Volume Measured

Based on the results of the analysis of the five units of the Synthetic method of Hidrograf (HSS) using the data obtained to the same river that Hidrograf the most Synthetic Unit approaches the discharge terukur is Hidrograf Synthetic Nakayasu Units, where deviation ten more than 18.76%, 6.67 percent, 12.39%.

## V. CONCLUSION

Based on the analysis that has been done then the conclusion of research results is a Synthetic unit of Hidrograf (HSS) Nakayasu is a Synthetic unit of Hidrograf (HSS) that has a value that is adjacent to the hidrograf observation results based on data DAS Jeneberang.

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