Study of the Effect of Synthetic Unit Hydrograph Parameters Based on Watershed Characteristics (Case Study of Kiru-Kiru Irrigation Area, Barru Regency)

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Abstrac:-Bili-Hydrograph discharge or flow is a very important part in overcoming problems related to hydrology. Because the flow hydrograph can describe a time distribution of surface runoff in a measurement area and determine the diversity of physical characteristics of the watershed. The presentation of the flood hydrograph can use the unit hydrograph reduction method from the measured flood hydrograph if data is available and use the empirical formula, namely Synthetic Unit Hydrograph (SUH), which is a hydrograph based on synthetic watershed parameters. This study tries to examine the effect of synthetic unit hydrograph parameters based on the characteristics of the watershed in the irrigated area of Kiru-kiru, Barru Regency.The research location is in Barru Regency, South Sulawesi Province, precisely in the Kiru-Kiru River Basin using daily rainfall data from Mareppang, Manuba, Mangkoso and Ralla Stations.Based on the results of the discussion carried out, the largest difference in flood discharge obtained based on the Nakayasu SUH and Modified SUH, which is 2.19, is in the 200-year return period, while the smallest difference is 0.01, which is in the 2-year return period. This shows that the Modified Synthetic Unit Hydrograph method is quite good in determining flood discharge.

Keywords:-*Hydrograph, Synthetic Unit, Synthetic Unit Hydrograph Nakayasu, Synthetic Unit Parameters*

I. INTRODUCTION

Barru Regency is a regency located on the west coast of South Sulawesi Province with a coastline of 78 km. Geographically, it is located between the coordinates of 4º0.5'35" - 4º47'35" South Latitude and 119º35'00" - 119º49'16" East Longitude with an area of 1.174.72 km^2 (117.472 Ha). Topographically, Barru Regency has a varied area consisting of sea, low land, and mountainous areas with an altitude between 300-1700 meters above sea level (masl). While the western part of the area is new, the topography of the area with an altitude of 0-300 meters above sea level is facing the Makassar Strait.

Based on the wet month (rainfall more than 200 mm/month) and dry month (rainfall less than 100 mm/month) so that the total rainfall for a year in Barru Regency is 162 days with a total rainfall of 5,266 mm. Based on its geographical location and varied geological conditions, Barru Regency can become one of the areas in South Sulawesi prone to natural disasters such as earthquakes, tsunamis, storms, floods, landslides, forest fires, and strong winds.

A. Formulation of the problem

a) How is the influence of the hydrograph parameters that occur based on the characteristics of the Kiru-Kiru River Basin, Barru Regency
b) How big is the difference in flood discharge between HSS Nakayasu and Modified HSS based on the Kiru-kiru River Basin, Barru Regency

B. Research purposes

a) To determine the effect of HSS parameters based on the characteristics of the Kiru-Kiru watershed in Barru Regency.
b) To find out the difference in flood discharge between the Nakayasu HSS and the Modified HSS based on the Kiru-Kiru watershed, Barru Regency.

C. Hypothesis

Based on the main problems that have been stated, the hypothesis can be proposed that the Synthetic Unit Hydrograph is generally formed based on the characteristics of the watershed. Generally, in this case the watershed parameters are used more in Synthetic Unit Hydrographs such as watershed area (A), and river length (L) so as to produce flood discharge values (Qp) and peak time (Tp).

II. THEORETICAL STUDIES

A. Watershed

A watershed is an area bounded by natural boundaries, such as ridges or mountains, as well as rock boundaries, such as roads or embankments, where rainwater falls in the area contributing to the flow to the control point (outlet) (Suripin, 2002). Kodoatie and Sugiyanto (2002) define a watershed as a unitary area / region / area of water management that is formed naturally where water is caught (derived from rainfall), and will flow from the area / region / area towards the rivers and rivers concerned. Also called the River Drainage Area or Water Catchment Area.

B. Rain

Rain intensity is the height or depth of rainwater per unit time. The intensity of rain depends on the duration and amount of rain. The longer the rain lasts, the intensity will tend to be higher, and vice versa, the shorter the duration of the rain, the smaller the intensity. The intensity reviewed based on the repeat period will also be directly proportional, the longer the repeat period, the higher the intensity. A high intensity of rain generally lasts for a short duration and covers a not very wide area (Sudjarwadi 1987).

C. Data Repair

In measuring rain, two problems are often encountered. The first problem is that the rain data is not recorded due to damage to the equipment or the observer does not record the data. This missing data can be filled with approximate values. The second problem is due to changes in conditions at the recording site during a recording period, such as moving or repairing stations, changes in measurement procedures or due to other causes. Both problems need to be solved by making corrections based on data from several nearby stations.

D. Regional Rain Determination

The rain gauge station only gives the depth of rain at the point where the station is located, so the rain in an area must be estimated from that measurement point. If in an area there are more than one measurement station placed scattered, the rain recorded at each station may not be the same. In hydrological analysis it is often necessary to determine the average rainfall in the area, which can be done using the following three methods, namely the Arithmetic method, Thiessen polygon method and the Isohyet method.

a) Arithmetic Mean Method

The average rainfall over the entire watershed uses the following equation:

$$\bar{p} = \frac{p_1+p_2+p_3+\cdots+p_n}{n} \quad (1)$$

With :

$\bar{p}$= area average rain

$p_1, p_2, \ldots, p_n$= rain at the station 1, 2, 3, . . ., n

b) Thiessen Method

For the Thiessen method using the following equation:

$$\bar{R} = \frac{A_1 p_1 + A_2 p_2 + \cdots \ldots\ldots\ldots A_n p_n}{A_1 + A_2 + \cdots A_n} \quad (2)$$

With:

$\bar{R}$ = area average rain

$p_1, p_2 \ldots p_n$ = rain at the station 1,2,3………n

$A_1, A_2 \ldots A_n$= area representing the station 1,2,3…n

c) Isohyet Method

For the Isohyet method using the following equation:

$$\bar{p} = \frac{\sum_{i=1}^{n} A_i \frac{I_i + I_{i+1}}{2}}{\sum_{i=1}^{n} A_i} \quad (3)$$

With:

$\bar{p}$ = area average rain

$I_1, I_2, \ldots, I_n$ = isohyet line to 1, 2, 3 . . .,n, n+1

$A_1, A_2, \ldots, A_n$ = the area of the region bounded by the isohyet line 1dan 2, 2 dan 3, . . . , n dan n +1.

E. Frequency Analysis

The purpose of frequency analysis of hydrological data is to find the relationship between the magnitude of extreme events and the frequency of occurrences by using a probability distribution. The magnitude of the extreme event has an inverse relationship with the probability of the event.

Frequency analysis can be applied to river discharge data or rain data. The data used is the annual maximum discharge or rainfall data, which is the largest data that occurs for one year, which is measured over several years.

F. Design Rainfall

The calculation of the planned rainfall will be carried out on the annual maximum daily rainfall data and will be calculated with return periods of 2 years, 5 years, 10 years, 25 years, 50 years, 100 years, and 200 years.

The method used to analyze the distribution of daily rainfall data on its annual average value in a certain return period includes: Gumbel distribution, Pearson Type III log distribution, and Log Normal distribution.

G. Rainfall Distribution

In the calculation to obtain a flood hydrograph by means of a hydrograph unit, it is necessary to divide the rainfall that occurs in an interval of time, for that an interval of 5-7 hours is used. The distribution of rainfall for each hour is calculated by the rational method.

H. Synthetic Unit Hydrograph

Seyhan (1977) suggested that several physical watershed parameters play a role in determining the shape of the unit hydrograph in addition to rain characteristics. The physical parameters of the watershed are the area of the watershed, slope, drainage pattern, and so on. It is the physical parameters of the watershed that will be used to determine the unit hydrograph of the watershed concerned by the synthetic unit hydrograph method.

The advantage of using synthetic unit hydrographs is that it is possible to synthesize hydrographs from measured watersheds and use them for unmeasured watersheds (Seyhan 1977).The weakness of the synthetic unit hydrograph is that the synthetic unit hydrograph equation is made empirically with data obtained at local places. Therefore, the equation is limited to areas with similar geographical conditions to the area where the equation was obtained (Sethan 1977, Sri Harto 1993) in (Rata Musa 2020)

A synthetic unit hydrograph that utilizes watershed parameters and is well known is the method developed by Snyder in 1938. This method is based on the idea that the conversion of rain into flow is both translational and storage

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that can be affected by the watershed system (Seyhan 1977; Linsley et al. 1982, Viessman et al. 1989; Sri Harto 1993).

III. STUDY METHOLOGY

A. Location of Study

The research location is in Barru Regency, South Sulawesi Province, precisely in the Kiru-Kiru River Basin using daily rainfall data from Mareppang, Manuba, Mangkoso and Ralla Stations. Rainfall data and hydrological station maps were obtained from the Center for the Pompengan Jeneberang River Basin, Ministry of Public Works and Human Settlements. The map of the Kiru-Kiru watershed hydrological station in Barru Regency can be seen in Figure 1 as follows.

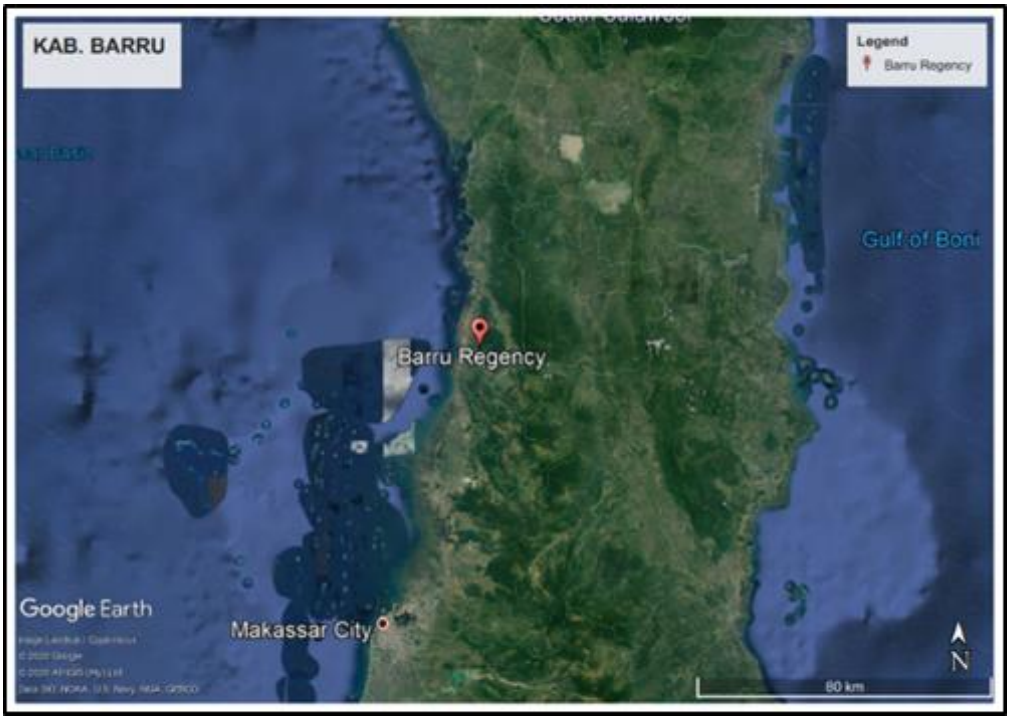

Fig. 1:Lokasi DAS kiru – kiru Kab. Barru

B. Type of Research

The method used in this study is a descriptive method, namely research aimed at describing existing phenomena, both natural phenomena and man-made phenomena. The phenomena can be in the form of forms, activities, characteristics, changes, relationships, similarities, and differences between one phenomenon and another.

C. Data Collection Techniques

a) Primary Data
- Primary data obtained directly in the field in the form of river observations and interviews.

b) Secondary Data

Secondary data obtained from library materials that are relevant to this research and related institutions of the Pompengan Jeneberang River Basin Center which include:
- Reading data using an AWLR (automatic water level recorder) device, is data on water level and discharge at the water guess post for the Jeneberang River Basin, especially the Bili-Bili Dam, which is used as the object of research so that it can strengthen the truth of the research results.Housing data: number of homes, population, percent of wastewater

D. Research Procedure

The stages of the research to be carried out are as follows:
- Collecting the data needed in this case is primary data and secondary data
- Determine the average rainfall at the stations, namely Mangkoso, Manuba, Mareppang and Ralla stations.
- Determine the area rainfall data using the Thiessen method.
- Calculating statistical parameters
- Determine the appropriate type of distribution based on the results of statistical parameters
- Testing the suitability of the distribution pattern with the Chi-Square test to find out whether the type of distribution selected and used is correct.
- From the selected distribution type, the design rainfall for the return period can be calculated
- Then calculate the effective hourly rain distribution.
- Performing hydrographic analysis and drawing hydrograph graphs
- Provide conclusions and suggestions

The initial step is to obtain the base flow so that a direct flow hydrograph is obtained:
- ➢ Base flow is obtained from the Hydrograph.
- ➢ After the basic flow is obtained from the total hydrograph then the DRO hydrograph is obtained.

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IV. RESULT OF RESEARCH AND DISCUSSION

A. Rating Curve Analysis

To fill in the missing rainfall data, this study uses the Normal Ratio Method using 4 stations, namely Mareppang, Mangkoso, Ralla and Manuba from 1996 to 2020.

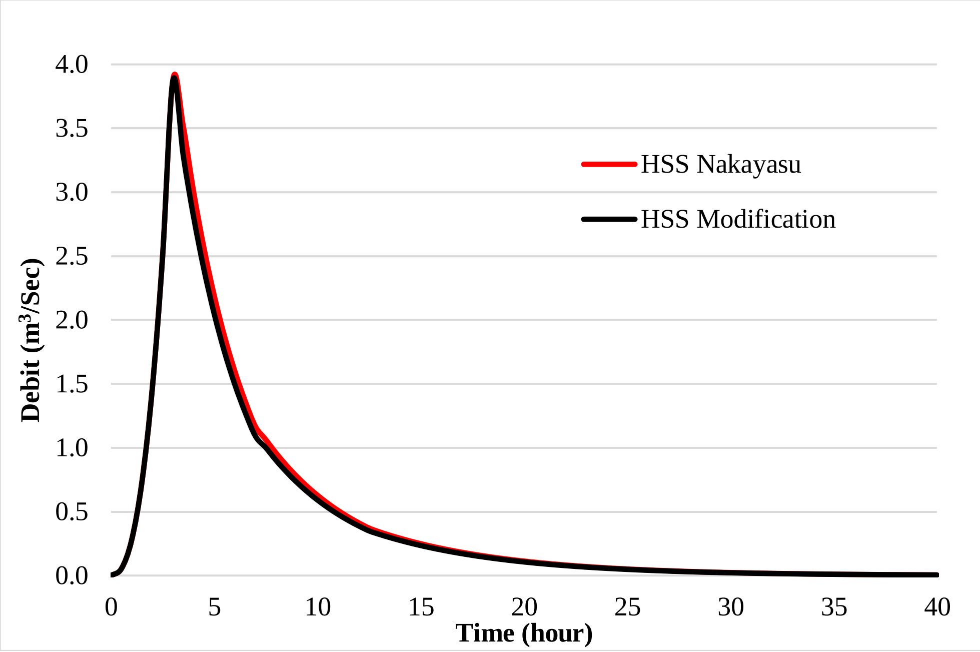

Fig. 2: Relationship between Debit (m^3/sec) and Time (hour)

Parameter	Unit	HSS Nakayasu	HSS Modifikasi	Deviation (%)
Peak Time	Hour	3,053	2,994	1,980
Peak Discharge	ltr/s	4,048	3,855	5,0
Base Time	Hour	39	39	0,0

Table 1: Nakayasu Synthetic Unit Hydrograph Components and Modified Synthetic Unit

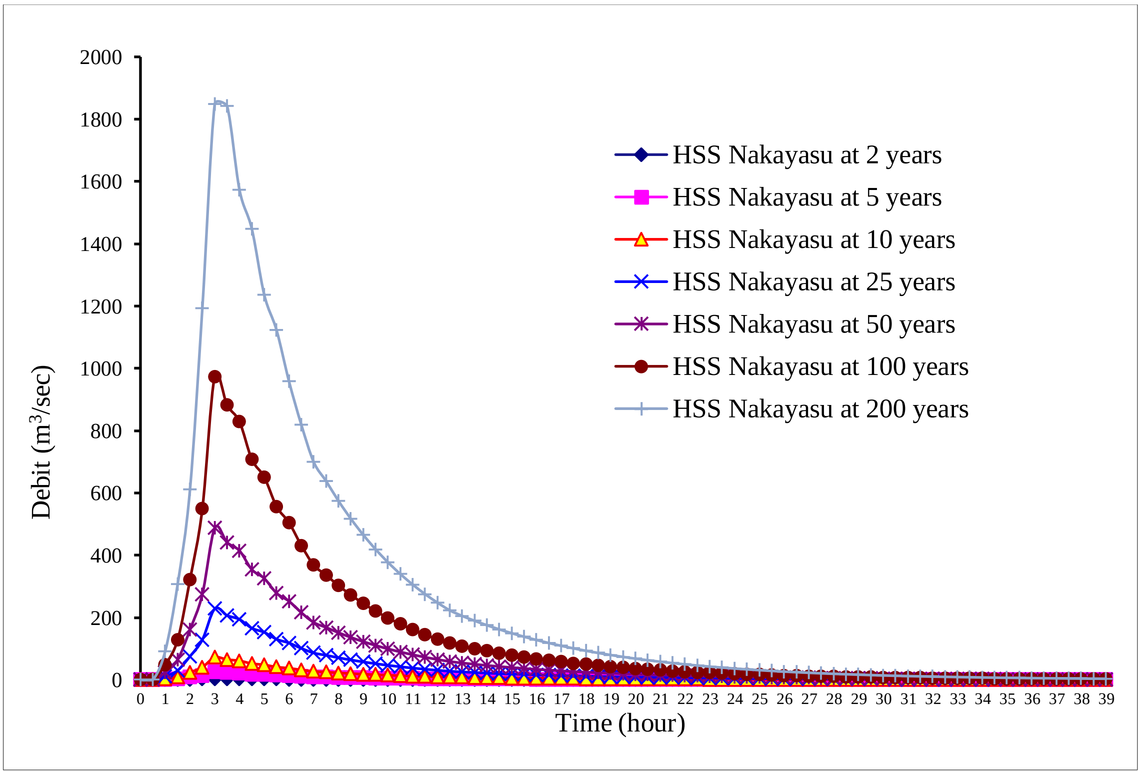

Fig 3: HSS Nakayasu Design Flood Hydrograph Graph

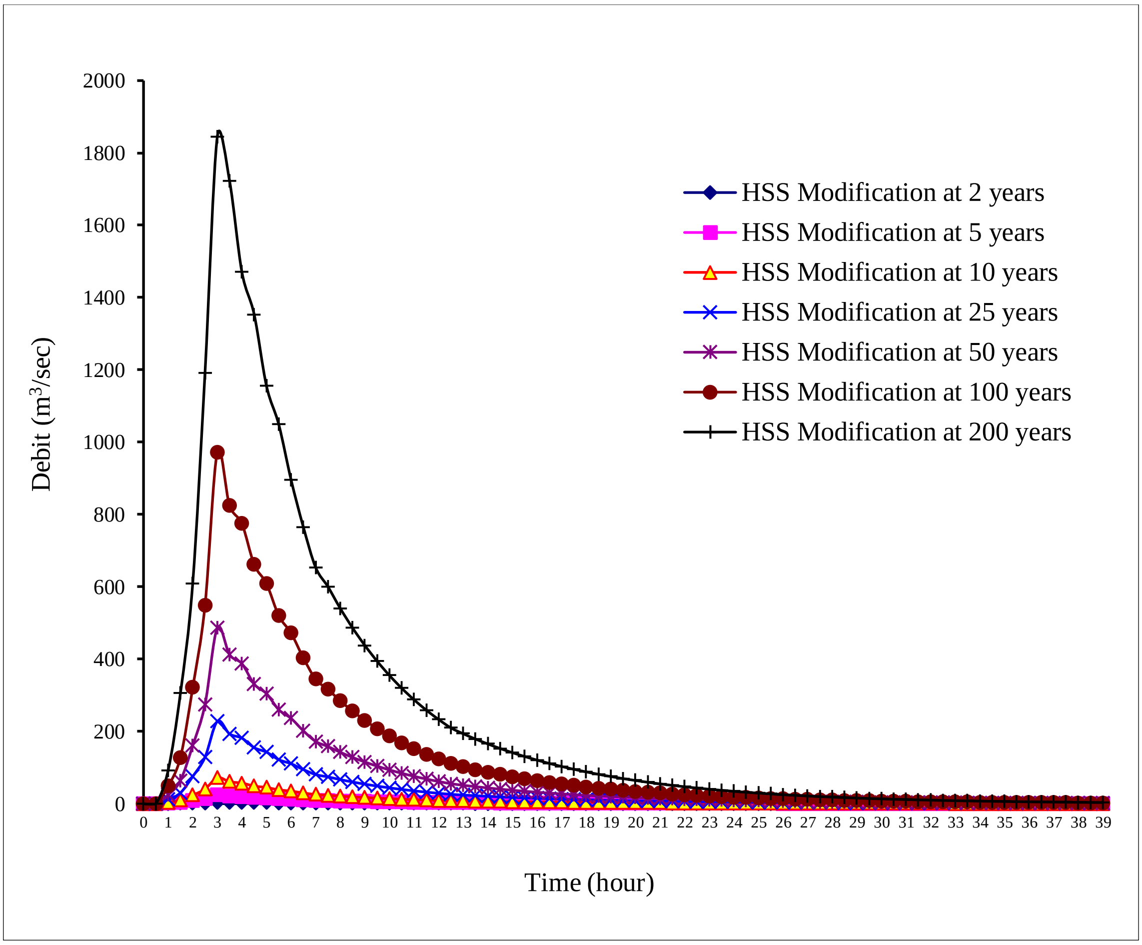

Fig 4: Modified HSS Design Flood Hydrograph Graph

Fig 3, Fig 4 and table 1 show that the hydrograph shape of the Nakayasu HSS and Modified HSS shows that there is almost no difference between the two. Where for the Nakayasu HSS, the peak flow time is 4.048 hours with a peak flow of 3.053 m3/s, while for the Modified HSS, the peak flow time is 2.994 hours with a peak flow of 3.855 m3/s. In this case the deviation that occurs between the two is 1.980% for the peak time and 5% for the peak discharge. Where in this case the deviation is smaller (< 10%).

V. CONCLUSION

Based on the results of the analysis and discussion that has been carried out, the characteristics of the watershed in the form of area, length of the river, and the shape of the watershed are important factors in this study, so that the following conclusions can be drawn:

- The characteristics of the watershed have a very strong relationship with the Synthetic Unit Hydrograph parameter, resulting in a peak time value of 3.053 hours and a peak discharge of 4.048 ltr/s for the Nakayasu HSS while for the Modified HSS the peak discharge value is 3.855 ltr/s and peak time of 2,994 hours. So get a deviation of 1.980% for the peak time and 5%. This shows that the deviation that occurs between the Nakayasu HSS and the Modified HSS is < 10% so that it is good enough to be used as a next reference.
- Based on the results of the discussion carried out, the largest difference in flood discharge obtained based on the Nakayasu HSS and Modified HSS is 2.19 in the 200 year return period while the smallest difference is 0.01 in the 2 year return period. This shows that the Modified Synthetic Unit Hydrograph method is quite good in determining flood discharge.

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