AN ANALYSIS OF A DESIGN FLOOD DISCHARGE IN THE DEVELOPMENTAL PLANNING OF THE LEMATANG WEIR

Fungky Pramana, Anis Saggaff, Febrian Hadinata

Abstract— The construction of a weir on the Lematang river in Semidang Alas village in the town of Pagar Alam of South Sumatra Province is intended to provide the irrigation water for the Lematang irrigation area with a planned area of paddy fields of 3000 ha. This study was conducted to analyze and evaluate the design flood discharge in the weir construction planning because it will be one of the main parameters in the construction of a strong and stable weir construction to be passed by flood discharges, with the RR (Rainfall-Runoff) method using the application of HEC-HMS (Hydrology Engineering Center-Hydrology Modeling System) and Gamma Synthetic Hydrograph (HSS) 1. The results of the calculation of the design flood discharge by means of the HEC-HMS applications are far more satisfying than those by means of the Gamma HSS 1. It is indicated by the difference in the value of the design flood discharge by means of the Gamma 1 HSS method which is not is too significant between that of the return period of 100 years and that of the return period of 1000 years. Unlike the case with the calculations using HEC-HMS, because in this method there is a distribution of parameters divided into several sub-watersheds, so the conditions in the field are more illustrated. The results of the simulation show that the design flood discharge with HEC-HMS was 119.3 m^3/s over a 100-year return period.

Index Terms— Design flood discharge, HSS Gamma I, hydrology, HEC-HMS, TRM, Weir.

1 INTRODUCTION

A weir is a construction building that is widely used in water engineering projects [1], intended to raise the river water level, in support of water supply for irrigation in an irrigation area. In its development it is very necessary to have a careful planning so that the weir construction is right on target and has a construction in accordance with hydrological conditions which is an indispensable component in research and management of water resources [2] at the construction site.

Hydrological conditions of an area must be known to support the planning of water structures and watershed management [3], such as river cross-section conditions and flow conditions. This study is limited to the problem of extreme flow conditions or flooding in support of the weir construction planning for infrastructure vulnerability analysis and to help develop flood risk management strategies [4].

The location of the study is in the village of Semidang Alas in the town of Pagar Alam in the province of South Sumatra. The study was conducted to disclose the hydrograph of the design flood in the framework of the construction of the Lematang Weir. The objective of constructing the Lematang Weir is to irrigate an area of 3000 ha of paddy fields. There are many methods that can be used to obtain design flood discharge. However, the most important thing in the preparation of the method is the need for calibration of the parameters of the river characteristics of the watershed studied. This is very important because the shape and size of the flood hydrograph depend on the characteristic conditions of the watershed, in which the characteristics of the watershed become the basis for improving planning, management and others [5]. In this study, the calculation of the design flood discharge by means of runoff with HEC-HMS software (Hydrology Engineering Center-Hydrology Modeling System) and HSS Gamma 1. There is a HEC-HMS suitability for continuous runoff simulation in the watershed that is complex with many micro catchments and their channel coverage [6] and HSS Gamma 1 is a very successful model in maintaining the rise in shape and retaining of the hydrograph unit [7].

2 METHODOLOGY

Many methods are used to reveal the shape of a flood hydrograph in a river. One of the methods that can be used is the R-R (Rainfall-Runoff) method. In general, this method can be used if there is no record of rain and discharge in the duration of hours.

The R-R method is actually a model that simplifies a natural condition in the field, in other words, the model is used to determine the meteorological response and topographic conditions of an area against the flow conditions that occur. The R-R method used in this study is with the help of HEC-HMS and HSS Gamma 1. The two-method approach is carried out to see the differences in design flood discharge generated.

The construction of this runoff model cannot be separated from the input data in the form of the rainfall, the land use, the basic flow characteristics and the topographic data. Fig. 1 is the thinking framework of the analysis of runoff in the context of calculating the design flood on a river.

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The steps in Fig. 1 show that the study activities are generally divided into 6 stages, namely the identification of the availability of the rainfall data and the discharge data, the identification of the satellite rain data grids against the extent of the study area, the correction of the satellite rain data, the determination of R-R model parameters, the calibration of model parameters and the calculation of the design flood hydrographs.

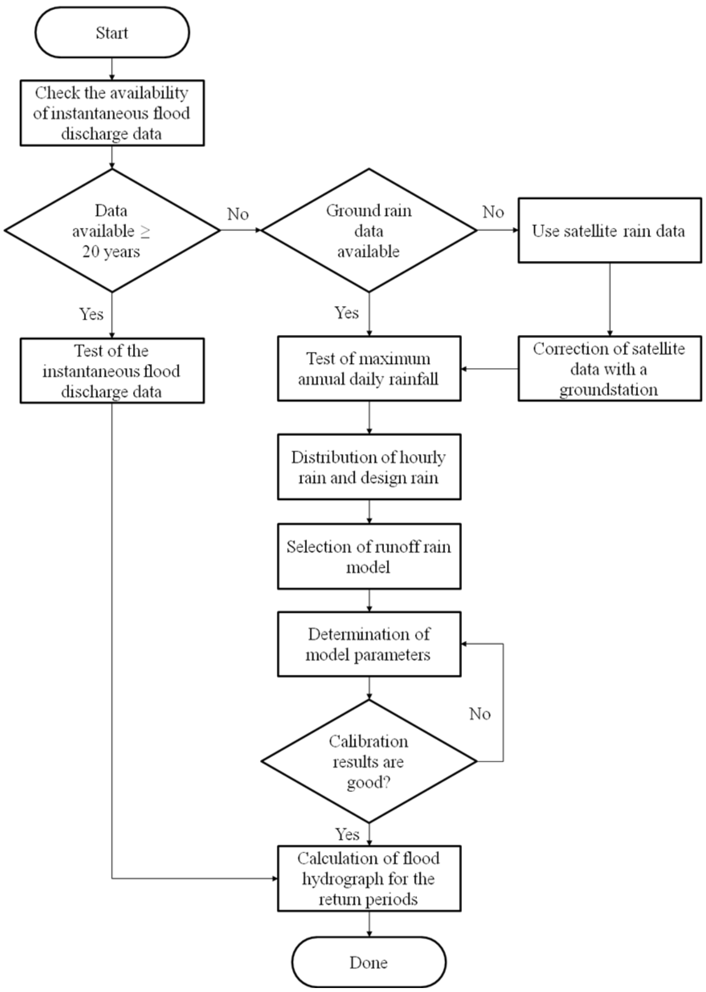

Fig. 1. *Thinking framework of design flood calculation*

The first model used in the calculation of the design flood hydrograph is HEC-HMS software. This model, was developed by the US Army Corps of Engineers. It was designed to simulate the rainfall run-off processes from the Dendritic watershed system [8]. This model has been widely used because various hydrological elements are connected in a dendritic network to simulate runoff processes [9]. Various methods are available to simulate infiltration losses, convert excess precipitation into surface runoff, calculate baseflow contributions, etc. [10]. This software provides various parameters such as the following description. Based on several studies that have been conducted, good parameters to be used in runoff rainfall calculations are the Transform and Losses parameter model, with parameter values in the form of a Curve Number generated from the land use maps and Hydrologic Soil Groups [11].

The transform parameter is the length of time the rainwater that falls changes into runoff, which is calculated with the following formula [12]:

$$t_{lag} = 0.6\ t_c \qquad (1)$$

in which:
t_{lag} = grace period
t_c = concentration time

The loss parameter calculates the thickness of the rain needed for the soil to become saturated and the remaining runoff is called surface runoff. This parameter can be disclosed from the condition of the land use and the soil type in a study area. Table 1 is the level of water loss for each type of soil.

Table 1. *Loss rates [12]*

Description	Range of loss rate (in/hr)
Deep sand, deep loess, aggregated silt	0.30-0.45
Shallow Loees, sandy loam	0.15-0.30
Clay loams, shallow sandy loam, soils low in organic content, and soils usually high in clay	0.05-0.15
Soils that swell significantly when wet, heavy plastic clays, and certain saline soils	0.00-0.05

The parameter used to determine the shape of the flood hydrograph is the recession constant parameter. The following Table 2 of the coefficients for Recession:

Table 2. *Recession constant [12]*

Flow component	Recession constant, daily
Groundwater	0.95
Interflow	0.8-0.9
Surface runoff	0.3-0.8

The second model is the HSS Gamma 1 calculation. The parameters needed in this model are the characteristics of the river in the watershed studied, such as the area of the watershed, the length of the main river, the number of river orders, the number of river confluence, and the land use conditions by calculating the composite C value.

3 Results and Discussion

3.1 Identification of Rain Data and Discharge Data

The results of the identification of the rain posts as shown in Fig. 2 reveal that there are 3 rain posts that are in the vicinity of the study area, even though they are outside of the watershed, namely the rain posts of Jarai, PTPN VII and Tanjung Tebat.

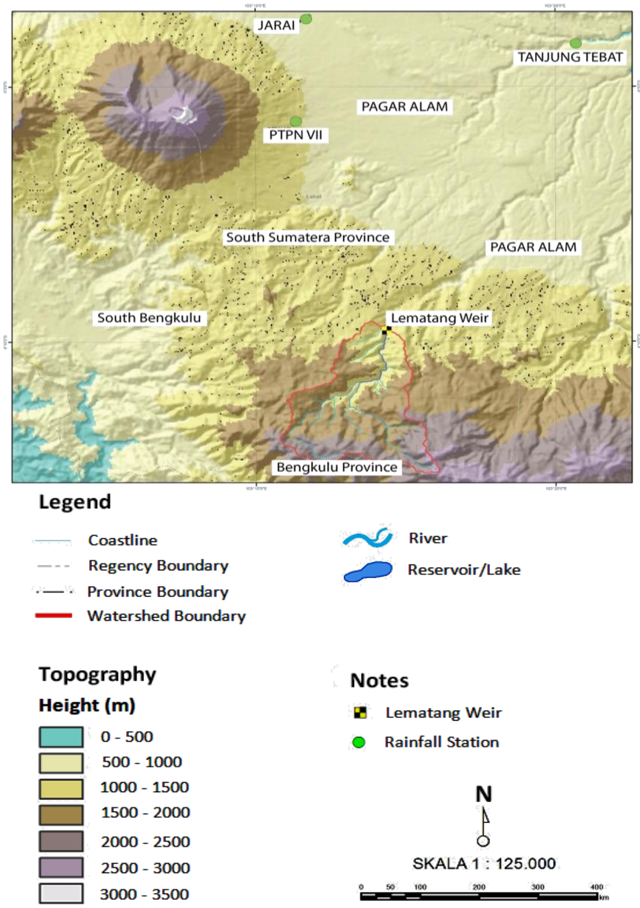

Fig. 2. *Map of rain post and water forecast post*

In addition, there is also a water forecast post located downstream of the watershed, namely the Lematang-Lebak Budi water forecast post. The discharge data at the water forecast post can be used for the calibration process of the R-R model calculated with the HEC-HMS model. The following is the distribution of hydrological posts and the resumes of the availability of data collected as shown in Table 3.

Table 3. *Barchart rain post data*

Post	Latitude	Longitude	Data of year	Number of data (year)
Jarai	-3.95381	103.19652	2008-2017	10
PTPN VII	-4.02456	103.18802	2008-2017	10
Tanjung Tebat	-3.97331	103.44659	2008-2017	10
Lematang-Lebak Budi	-3.78139	103.64194	1985, 1992, 1994-1996, 1998-1999, 2004, 2006-2009	12

Based on the identification of the TRMM grid map against the extent of the watershed studied as shown in Fig. 3, 13 TRMM grids are needed to be used to conduct R-R analysis specifically for HEC-HMS and 1 grid for HSS Gamma 1 HSS in the watershed. The following is the distribution of the grid used.

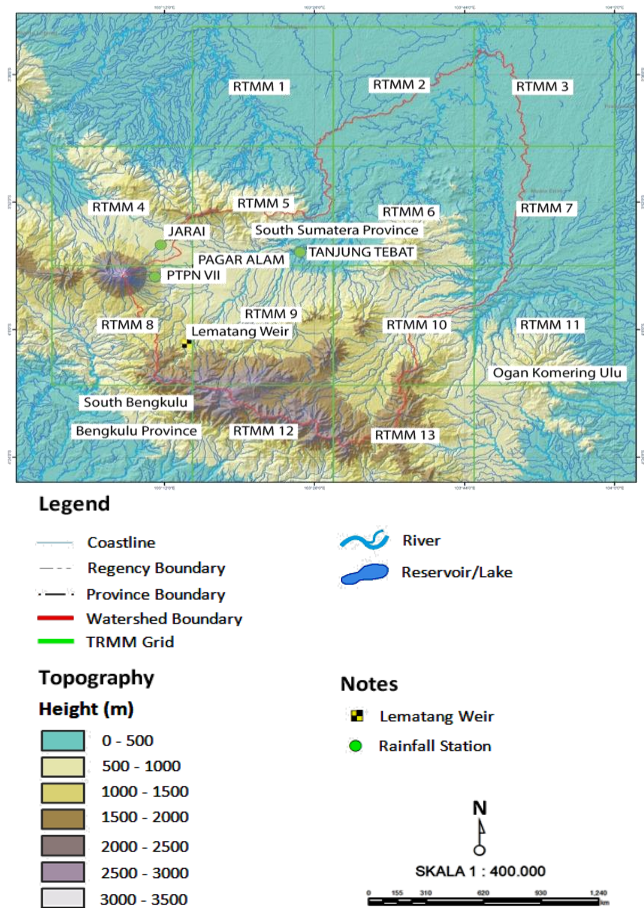

Fig. 3. *Distribution of the TRMM grid against the Studied Watershed*

To produce accurate flood discharge data, it is necessary to record or simulate a rain flow model with a data length of 20 years. Based on the data availability barchart shown in Table 3, the data are insufficient for the calculation needs to be performed. One of the steps taken for this is to use satellite rainfall products, namely satellite rain data TRMM (Tropical Rainfall Measuring Mission).

The satellite-based rainfall estimates have a long history and is one of the more intense research topics [13]. Rainfall products from satellites are considered as an important alternative option to obtain rainfall estimates [14], because it is very difficult for hydrologists to simulate water cycles in hilly areas without a network of rainfall measuring stations, especially in complex hilly or remote areas [15].

The use of rainfall data from the satellites is now gradually becoming an effective source of input for flood prediction under various conditions [16] because although the observations with rain measuring instruments produce relatively accurate rainfall point measurements but they are not available in most marine and terrestrial areas that are uninhabited [17].

The use of TRMM satellite daily information is proposed to estimate extreme rainfall in uncontrolled areas and time periods. This method can be applied to other stations as regionalization to obtain rainfall data sets as a solution to the completeness of the data [18].

Table 4. *Resume of the feasibility test for annual maximum daily rainfall data*

Grid TRMM	Wald-Wolfowitz's (independence test)		Notes
	Significant	U	
TRMM 1	5%	1.8	Accept
TRMM 2	5%	0.854	Accept
TRMM 3	5%	1.834	Accept
TRMM 4	5%	0.419	Accept
TRMM 5	5%	0.512	Accept
TRMM 6	5%	0.531	Accept
TRMM 7	5%	1.509	Accept
TRMM 8	5%	1.581	Accept
TRMM 9	5%	0.853	Accept
TRMM 10	5%	0.503	Accept
TRMM 11	5%	1.85	Accept
TRMM 12	5%	-1.603	Accept
TRMM 13	5%	1.723	Accept

Table 5. *Resume of the feasibility test for annual maximum daily rainfall data*

Grid TRMM	Mann-Whitney (homogenitas test)				Notes
	Group 1	Group 2	Mann-Whitney	Significant test	
TRMM 1	10	11	36	-1.34	Accept
TRMM 2	10	11	39	-1.13	Accept
TRMM 3	10	10	28	-1.66	Accept
TRMM 4	10	11	37	-1.27	Accept
TRMM 5	10	10	45	-0.38	Accept
TRMM 6	10	10	28	-1.66	Accept
TRMM 7	9	10	22	0	Accept
TRMM 8	10	10	25	-1.89	Accept
TRMM 9	10	10	24.5	-1.93	Accept
TRMM 10	9	10	27	0	Accept
TRMM 11	10	11	28.5	-1.87	Accept
TRMM 12	10	10	48	-0.15	Accept
TRMM 13	10	10	23	-2.04	Accept

The distribution of rain posts in Fig. 3 shows that only PTPN VII rain posts and TRMM 8 grid are used in the calculations for the HSS Gamma I method because their locations is considered closer to the Bendung watershed. However, the entire TRMM grids in Fig. 3 are used for the HEC-HMS method because it requires a long period of data to support the calculation of peak flooding. The calculation of the design rain analysis uses annual maximum daily rainfall data on the rain posts. The design rain analysis is carried out in 2 stages, namely by conducting a data feasibility test and calculation of frequency analysis to get rain with various repeat periods. The results of the feasibility test for the rain post are shown in Table 4, Table 5 and Table 6.

Table 6. *Resume of feasibility tests for annual maximum daily rainfall data*

Grid TRMM	Grubbs & Becks's test (outlier)			Notes
	Kn statistic	Maximum limit	Minimum limit	
TRMM 1	2.407	185.9	61.7	Accept
TRMM 2	2.407	209.3	57.7	Accept
TRMM 3	2.384	172.2	58.1	Accept
TRMM 4	2.407	166.2	50.9	Accept
TRMM 5	2.384	157.9	60.4	Accept
TRMM 6	2.384	196.8	59.3	Accept
TRMM 7	2.36	172	61.8	Accept
TRMM 8	2.384	144.4	55.3	Accept
TRMM 9	2.384	167.8	55.9	Accept
TRMM 10	2.36	172	61.6	Accept
TRMM 11	2.407	226.3	58.3	Accept
TRMM 12	2.384	143.4	58.2	Accept
TRMM 13	2.384	161.2	56.9	Accept

To ensure that the TRMM data were feasible to use in frequency analysis to determine the designed rainfall for each TRMM Grid, some tests such as Independent Test with Wald-Wolfowitz method, Homogeneity Test with Mann-Whitney method and Outlier Test with Grubbs & Becks's method were necessary to be conducted. The Independent test was conducted to reveal whether or not the data used depended on other data, because in the frequency analysis, an independent data distribution which was not influenced by other data was needed. In addition, these data groups should also be tested for trends and outliers, because the nature of trends and outliers should be removed before frequency analysis was conducted. Especially for the outlier test, the maximum data detected by the outlier needs to be clarified regarding its correctness. This should be done because if the maximum outlier data are discarded, the accuracy of the frequency analysis will lessen.

Table 7. *Resume of the TRMM design rain*

Grid TRMM	Return periods of design rain				
	2	3	5	10	25
TRMM 1	105.9	117.2	129.5	144.6	163.3
TRMM 2	104.9	117.5	133.2	155.7	189.4
TRMM 3	97.2	107.6	119.8	135.9	157.7
TRMM 4	89.0	99.0	110.9	126.9	149.3
TRMM 5	99.6	110.6	122.7	138.0	157.4
TRMM 6	109.0	124.8	143.7	169.6	205.9
TRMM 7	106.9	120.3	135.2	154.0	178.1
TRMM 8	85.0	93.1	102.8	116.2	135.3
TRMM 9	95.8	106.4	117.8	131.9	149.1
TRMM 10	99.3	109.1	121.0	137.4	160.7
TRMM 11	103.3	113.5	126.3	145.2	174.1
TRMM 12	93.2	103.2	114.1	127.6	144.5

Grid TRMM	Return periods of design rain				
	2	3	5	10	25
TRMM 13	93.3	102.7	113.4	127.7	146.8

Table 8. *Resume of the TRMM design rain*

Grid TRMM	Return periods of design rain				
	50	100	200	500	1000
TRMM 1	176.8	190.0	202.8	219.3	231.4
TRMM 2	218.7	252.2	290.5	349.7	402.1
TRMM 3	175.0	193.2	212.4	239.4	261.2
TRMM 4	167.5	187.0	208.1	238.6	263.8
TRMM 5	171.7	185.9	200.1	218.8	233.0
TRMM 6	235.7	268.0	303.1	354.3	397.1
TRMM 7	196.0	213.9	231.9	255.8	274.0
TRMM 8	151.1	168.4	187.4	215.4	239.0
TRMM 9	161.5	173.5	185.1	199.9	210.7
TRMM 10	180.2	201.6	225.1	259.9	289.4
TRMM 11	200.0	230.2	265.4	321.4	372.1
TRMM 12	156.7	168.7	180.5	195.7	207.0
TRMM 13	161.9	177.6	194.0	217.0	235.4

The results of the data analysis shown in Table 4, Table 5 and Table 6, reveal that these posts passed the data feasibility tests in supporting the calculation of the design rainfall at various return periods. The next step is to conduct a frequency analysis based on annual maximum daily rainfall data that have been obtained. The frequency analysis used is the GEV (Generalized Extreme Value) distribution because this distribution is good enough to predict extreme events. The following are the results of the calculations of design rain and their return periods are shown in Table 7 and Table 8.

Table 9. *Resume of 12 hour PSA 007 rainfall distribution*

Hour of-	Return periods					
	5	10	25	50	100	1000
0	0.00	0.00	0.00	0.00	0.00	0.00
1	0.02	0.02	0.02	0.03	0.03	0.03
2	0.04	0.04	0.04	0.04	0.04	0.04
3	0.07	0.07	0.08	0.08	0.08	0.08
4	0.11	0.12	0.12	0.11	0.11	0.10
5	0.60	0.57	0.55	0.54	0.53	0.51
6	0.04	0.04	0.04	0.04	0.04	0.04
7	0.04	0.04	0.04	0.04	0.04	0.04
8	0.02	0.02	0.02	0.03	0.03	0.03
9	0.02	0.02	0.02	0.03	0.03	0.03
10	0.02	0.02	0.02	0.03	0.03	0.03
11	0.02	0.02	0.02	0.03	0.03	0.03
12	0.02	0.02	0.02	0.03	0.03	0.03

After the distribution used is known, the next step is the distribution of hourly rainfall in the area is needed as shown in Table 9. The distribution used in this method is a 12-hour PSA 007.

3.2 Topographic Characteristics for Selecting Model Parameters

Based on the analysis of the map and the software of Geographic Information System (GIS), it was concluded that the topographic characteristics of the watershed in Lematang has an area of 59.889 km^2. Because the model scheme area used is up to the downstream for the calibration process at the water forecast post of Lematang-Lebak Budi, then watershed area studied has an area of 3857.9 km^2 and the number of TRMM used is 13 grids. In terms of land cover, the watershed studied is dominated by plantations by 45%, forest by 26.5% and the remainder is in the form of rice fields and shrubs. The details of the resume of the watershed land use at the study site are shown in Table 10.

Table 10. *Resume of the land use of the watershed studied*

Types of areas	Area in km^2	Percentage
Body of water	24.59	0.64%
Jungle/forest	1020.59	26.45%
Plantations/garden	1747.69	45.30%
Settlement and places of activities	49.76	1.29%
Paddy fields	178.83	4.64%
Shrubs	671.96	17.42%
Dry farm lands/fields	164.54	4.26%

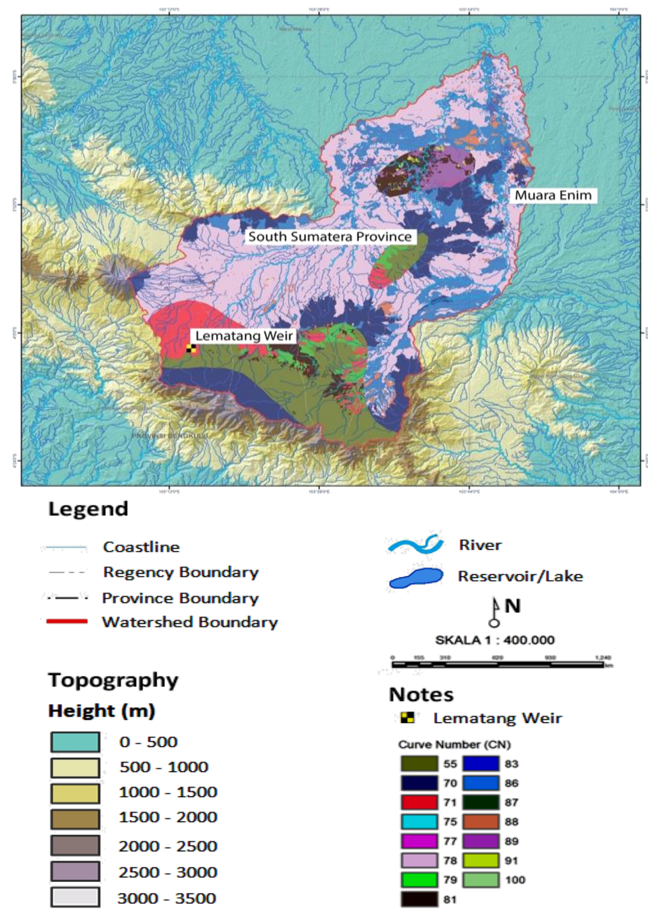

Fig. 4. *Map of the curve number in the studied watershed*

In the flood calculation model using HEC-HMS, a CN value which is divided based on the sub-watershed is used. This is different from the calculation using the HSS Gamma 1 method, which uses a CN value which is first compiled based on its area. The following is the curve number values for the studied area as shown in Fig. 4.

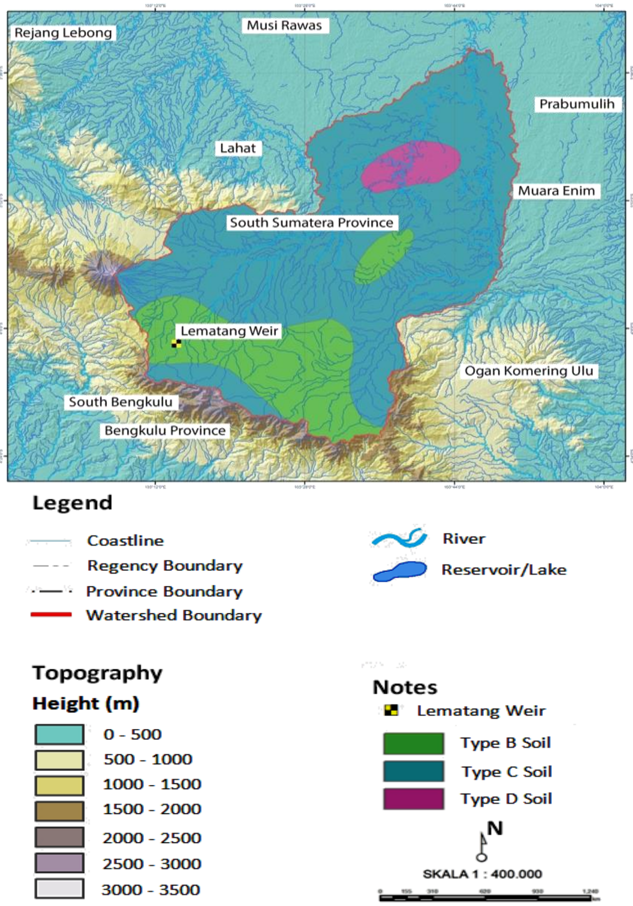

Fig. 5. *The map of the hydrologic soil group in the studied watershed*

The map of hydrologic soil group where we can find the types of soil in the study area is shown in Fig. 5.

Table 11. *The value of composite C for the lematang weir watershed*

Land cover	Total area (km^2)	C value	C*A	Average C
Jungle/forest	50.41	0.08	4.03	0.130501
Plantation/garden	9.43	0.4	3.77	
Dry farm/fields	0.05	0.2	0.01	
Total area	59.89		7.82	

The C value is seen on the basis of land use conditions in the studied watershed. The C value is generated from the land use analysis in the Lematang Weir Watershed Area. The following is the results of the calculation of the composite C value for the watershed as shown in Table 11.

3.3 Modeling of Runoff Rain

Before calculating flood hydrograph using HEC HMS, due to the unavailability of hourly discharge data, one way to do this model is to calibrate the daily debit data, as shown in Fig. 6. The calibration results carried out by means of trial and error produce a satisfactory NSE value of 0.328, referring to a range of NSE value level of reliability of the hydrological model in Table 12. These results are very good considering that the observation data which are a little iffy during the months at the end of the year.

Table 12. *Range of NSE values for the reliability level of the hydrological model [19]*

Goodness of fit	NSE
Very Good	NSE > 0.6
Goodness of fit	0.40 < NSE ≤ 0.60
Satisfactory	0.20 < NSE ≤ 0.40
Unsatisfactory	NSE < 0.20

A calibration is used to reveal the closeness between the value of the simulation model generated and the observation discharge data obtained from the field. In addition to the graphic form, the closeness can also be seen from the Nash-Sutcliffe coefficient (NSE) value. The following are the categories of model reliability that are based on these coefficient values.

The calibration calculation performed using the parameters above is intended to look for the smallest absolute error so that the discharge of calculation result is close to the discharge of observation. The calibration was carried out at the Lematang-Lebak Budi water forecast post in 1999, the data were quite feasible to use. The feasibility of the data of the water forecast post of Lematang-Lebak Budi is supported by several factors, namely the discharge curve used and the form of daily hydrograph in 1 year. Fig. 6 is a resume of debit data publication based on the use of the discharge curve.

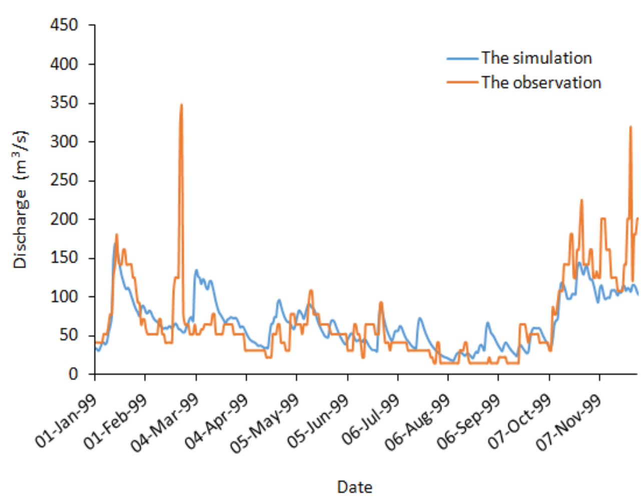

Fig. 6. *The calibration of HEC-HMS at the water forecast post*

of Lamatang-Lebak Budi

After the HEC-HMS parameters are calibrated, the next stage is to divide the watershed into smaller sub-watershed with the scheme as shown in Fig. 7, namely 70 sub-watersheds.

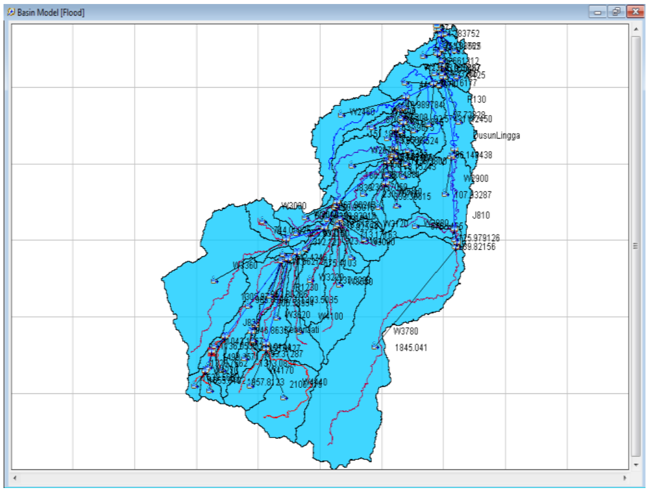

Fig. 7. *Rainfall model scheme – flow of studied watershed using HEC-HMS*

Table 13. *Ia and curve number parameters*

Sub watershed	Ia	CN	Sub watershed	Ia	CN
W2270	26.683	75.768	W3030	24.588	77.812
W2280	30.4991175	72.439	W3080	29.447	73.311
W2290	32.389	70.953	W3090	34.854	69.155
W2300	24.52	77.881	W3120	43.934	63.634
W2310	31.097	71.958	W3150	33.026	70.474
W2320	21.331	81.354	W3170	30.108	72.759
W2330	22.908	79.579	W3220	35.714	68.562
W2340	30.2444016	72.647	W3340	33.067	70.443
W2350	31.057	71.99	W3360	36.372	68.119
W2390	24.387	78.017	W3370	32.3023558	71.019
W2430	29.826996	72.992	W3450	39.083	66.39
W2440	27.763	74.778	W3530	38.422	66.798
W2450	28.88	73.794	W3620	35.969	68.389
W2460	30.065	72.7949	W3780	40.717	65.417
W2490	27.587	74.936	W3980	67.661	54.294
W2530	25.32	77.079	W4090	73.633	52.648
W2550	23.481	78.963	W4100	41.516	64.958
W2570	23.66	78.773	W4170	62.219	55.989
W2610	23.969	78.449	W4270	57.355	57.693
W2670	29.3590816	73.385	W4290	49.721	60.812
W2680	23.614	78.822	W4440	60.904	56.431
W2710	24.107	78.306	W4520	45.156	63
W2720	25.347	77.052	W4530	63.3584303	55.617
W2730	25.942	76.472	W4570	32.912	70.559
W2780	31.1084874	71.949	W4580	41.539	64.945
W2790	25.556	76.847	W4630	38.995	66.444
W2800	32.644	70.76	W4670	27.421	75.087
W2810	37.665	67.276	W4680	25.38	77.02
W2880	33.659	70.008	W4720	25.016	77.381
W2900	34.438	69.448	W4730	24.21	78.199
W2970	30.679	72.293	W4780	29.13	73.58
W2980	43.388	63.925	W4820	31.183	71.89
W2990	31.0833552	71.969	W4830	32.389	70.953
W3000	35.26	68.873	W4870	24.704	77.695
W3010	31.7312895	71.459	W4880	29.218	73.505

And then calculating the design flood hydrograph by changing the type of parameters used, namely the curve number value in Table 13 and the recession constant in Table 14.

In general this method does not change the parameters that have been calibrated, These parameters only determine the shape of the desired hydrograph. Because there is no comparative flood hydrograph, it is not possible to adjust the shape of the flood hydrograph. The following are the flood parameters used.

Table 14. *Recession constant and ratio to peak parameters*

Sub watershed	Recession constant	Ratio to peak	Sub watershed	Recession constant	Ratio to peak
W2270	0.2	0.01	W3030	0.2	0.01
W2280	0.2	0.01	W3080	0.2	0.01
W2290	0.2	0.01	W3090	0.2	0.01
W2300	0.2	0.01	W3120	0.2	0.01
W2310	0.2	0.01	W3150	0.2	0.01
W2320	0.2	0.01	W3170	0.2	0.01
W2330	0.2	0.01	W3220	0.2	0.01
W2340	0.2	0.01	W3340	0.2	0.01
W2350	0.2	0.01	W3360	0.2	0.01
W2390	0.2	0.01	W3370	0.2	0.01
W2430	0.2	0.01	W3450	0.2	0.01
W2440	0.2	0.01	W3530	0.2	0.01
W2450	0.2	0.01	W3620	0.2	0.01
W2460	0.2	0.01	W3780	0.2	0.01
W2490	0.2	0.01	W3980	0.2	0.01
W2530	0.2	0.01	W4090	0.2	0.01
W2550	0.2	0.01	W4100	0.2	0.01
W2570	0.2	0.01	W4170	0.2	0.01
W2610	0.2	0.01	W4270	0.2	0.01
W2670	0.2	0.01	W4290	0.2	0.01
W2680	0.2	0.01	W4440	0.2	0.01
W2710	0.2	0.01	W4520	0.2	0.01
W2720	0.2	0.01	W4530	0.2	0.01
W2730	0.2	0.01	W4570	0.2	0.01
W2780	0.2	0.01	W4580	0.2	0.01
W2790	0.2	0.01	W4630	0.2	0.01
W2800	0.2	0.01	W4670	0.2	0.01
W2810	0.2	0.01	W4680	0.2	0.01
W2880	0.2	0.01	W4720	0.2	0.01
W2900	0.2	0.01	W4730	0.2	0.01
W2970	0.2	0.01	W4780	0.2	0.01
W2980	0.2	0.01	W4820	0.2	0.01
W2990	0.2	0.01	W4830	0.2	0.01
W3000	0.2	0.01	W4870	0.2	0.01
W3010	0.2	0.01	W4880	0.2	0.01

After the flood parameters are determined, the next step is to calculate the design rain for the entire TRMM grid and to distribute hourly rain using the desain rain of PSA 007. This design rain will be used as input data for the design flood calculation. The resume of the calculation of the design rain for the entire TRMM grid can be seen again in Table 7, Table 8 and the resume of the hourly design rain of PSA 007 can be seen in Table 9.

The last stage is the simulation stage to obtain the hydrograph and the peak flood discharge at some return periods, namely 5 years, 10 years, 25 years, 50 years, 100 years and 1000 years using HEC-HMS. The resume of flood hydrograph can be seen in Fig. 8.

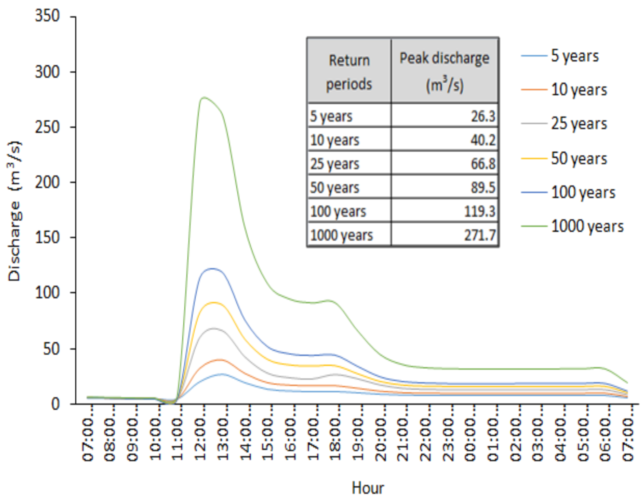

Fig. 8. *Resume of peak floods in lematang weir using the HEC-HMS method*

The next step is calculating the flood hydrograph by means of HSS Gamma 1 for the return periods of 5, 10, 25, 50, 100 and 1000 years. The parameters required by this method are to calculate the river length of each order, the number of orders, the slope of the watershed, etc., as shown in Table 15.

Table 15. *HSS Gamma 1 parameters*

Parameters of HSS Gamma-I			
Watershed area	A	59.890	km^2
Area of upstream watershed	Au	35.810	km^2
The length of the main river	L	17.760	km
Total length of river order 1	L1	31.280	km
Total length of rivers of all levels	Ln	46.440	km
Length of 0.75L (OB along river)		13.320	km
Length of 0.25L (OA along river)		4.440	km
Number of river confluences	JN	11	
Width of watershed of 0.75 L (bb')	WU	4.810	km
Width of watershed of 0.25 L (aa')	WL	8.270	km
Number of river order 1	P1	12	
Number of rivers of other orders	Pn	3	
Number of rivers of all orders		15	
The average slope of the river	S	0.05233	
Parameters of hydrograph form			
Source factor	SF	0.674	
Source frequency	SN	4.000	
Drain network density	D	0.775	
Width factor	WF	0.582	
Comparison of upstream and downstream watershed area	RUA	0.598	
SIM = RUA*WF	SIM	0.348	

The following is the result of the calculation of flood discharge that has been done which can be seen in Fig. 9 that produces a resume of peak flood of the weir using the HSS Gamma 1 method.

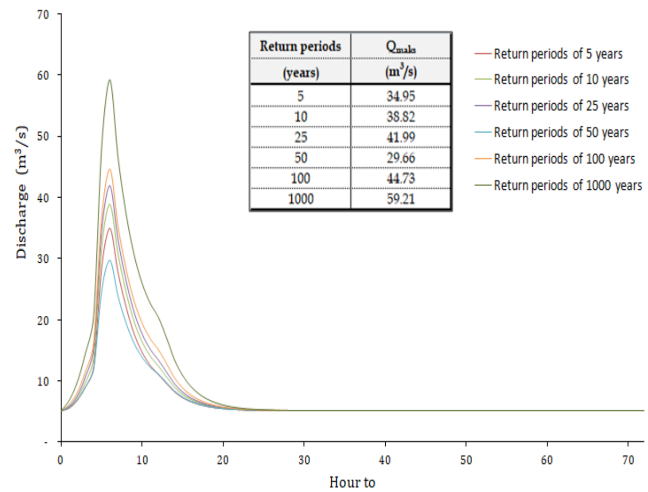

Fig. 9. *Resume of peak flooding in the lamatang weir using the Gamma 1 HSS method*

4 Conclusion

Based on the results of the study, it can be concluded that:

1. The results of calibration of the HEC-HMS model show an NSE value of 0.328. This indicates that the runoff rain model formed is satisfactory. The results of simulation show that the design flood discharge for the construction of the Lematang Weir is 119.3 m^3/s in the 100-year return period and 271.7 m^3/s in the 1000-year return period.
2. The calculation of the design flood discharge using the HSS Gamma 1 method results in a flood discharge of 44.73 m^3/s over a 100 year return period, whereas for a 1000 year return period the design flood discharge result is not significantly different, namely 59.21 m^3/s. The difference in the magnitude of flooding for that significant change in the return period should be more significant.
3. The difference in the results of the calculation of the design flood discharge in the two methods is due to the parameters used which are very different. In terms of watershed characteristics, the HEC-HMS method is more detailed in describing its parameters for each sub-watershed. In terms of land use, the HEC-HMS method is also more detailed, because the division of CN values as parameters in the calculation of lag time is divided for each sub-watershed. Unlike the case of the Gamma 1

HSS calculation method that uses CN composite values for one watershed.

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