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Research Paper

Calibration of Rainfall Variety Switching to Discharge with Hec HMS Method at Binalatung Tarakan

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ABSTRACT: *The approach to calculating the transfer of rainfall into discharge varies widely. The methods used to estimate the amount of river flow, such as in the Binalatung watershed, Tarakan City, North Kalimantan, are based on the assumption that during the rainy season there is excess water available and during the dry season there is a drought. Methods that can be used include HEC HMS. For HEC-HMS modeling after calibration, it is located on the rain data during when used from 10 years from 2010 to 2019, the value of the calibration is 80 and the Initial Abstraction (Ia) value is 0.5 with a correlation coefficient value of 0.85 and has a relative error percentage of 44.8%. The peak discharge from the simulation model after calibration is 3.0 m3/s and the total volume of outflow is 231836.19 mm.*
KEYWORDS: *HEC HMS, diversity, rainfall, discharge, runoff.*

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I. INTRODUCTION

Hydrological planning is always related to the characteristics of the watershed (DAS). In the watershed system, various components will be found including the physical components of the watershed, vegetation, soil types, water flow and rain that interact dynamically. Rainfall and the characteristics of the watershed greatly affect the condition of the river flow discharge. Conversion of rain to flow is a model to convert rain data into discharge. Discharge data in a watershed (DAS) is needed to find out how much discharge is available in a river that is used to meet the needs of human, animal and plant life. Usually in the watershed there is a rainfall measuring station, but this is not a discharge recording station, so a model is needed that changes from rain data to discharge data. In Indonesia, the rainfall-flow simulation method that is often used is the FJ method. Mock, NRECA and Tank Models. . This method illustrates that the rain that falls on an area either on the soil or on plants will partially experience evaporation, some will become surface runoff and some will experience infiltration and percolation. FJ method. Mock is most often used especially in areas with high to moderate rainfall. In the study area of the Binalatung watershed there is a discharge recording station where it is very necessary to calibrate the simulation results. With the success of this simulation, the parameters which are So the final results of the two methods can be applied to other watersheds in the vicinity, such as the Binalatung watershed with similar characteristics to this watershed. The purpose of the implementation of this study is to determine the effect of watershed characteristics parameters in the calculation of rainfall conversion to discharge using the HEC HMS method. It is also worth mentioning that HEC-HMS has been used successfully worldwide by researchers [1], [2], [4] and [13]. Next In this background, a study on the calibration and evaluation of a watershed simulation model, namely, the Hydrological Modeling System, was developed by the US Hydrological Engineering Center HEC-HMS with the Soil Moisture Accounting (SMA) Algorithm in 2000 [5].

There will be millions of people experiencing increased water stress and flooding due to increasing population and climate change worldwide in the decades to come. Effective water resources governance is very important [11]. If the hydrological process is able to predict the watershed response as a trigger on land use, including climate change [3], [6] and [9]. There is a need for an appropriate hydrological model for efficient watershed and ecosystem management [12] enabling it to predict hydrological responses for various watersheds [7], comparative assessment of watershed models for hydrological simulations is very much limited in developing countries [8] and [10].

II. RESEARCH METHODOLOGY

The study location is the Binalatung watershed which is located in Tarakan Regency, North Kalimantan Province. Geographically it is located at 3°14'23"-3°26'37" North Latitude and 117°30'50"-117°40'12" East Longitude with a watershed area of 1,500 km2 with 1 Juwata rain station located at Tarakan Regency and there is a river water level measuring instrument (AWLR). The supporting data needed are Study Supporting Data: Rainfall data, Binalatung watershed map, climatological data, watershed characteristics data, land use maps, AWLR discharge data for 2 years, topographic maps, geological maps, soil type maps.

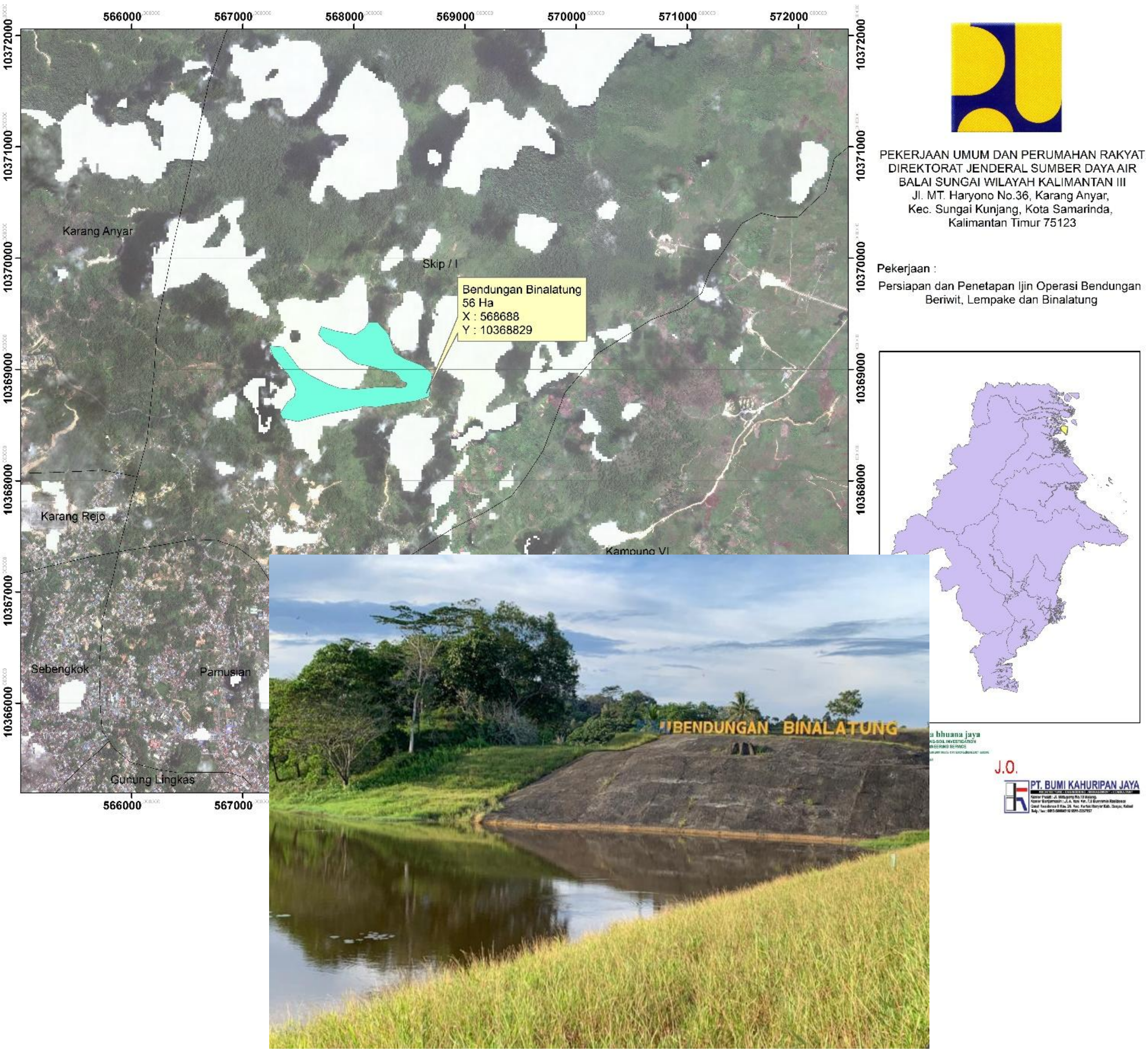


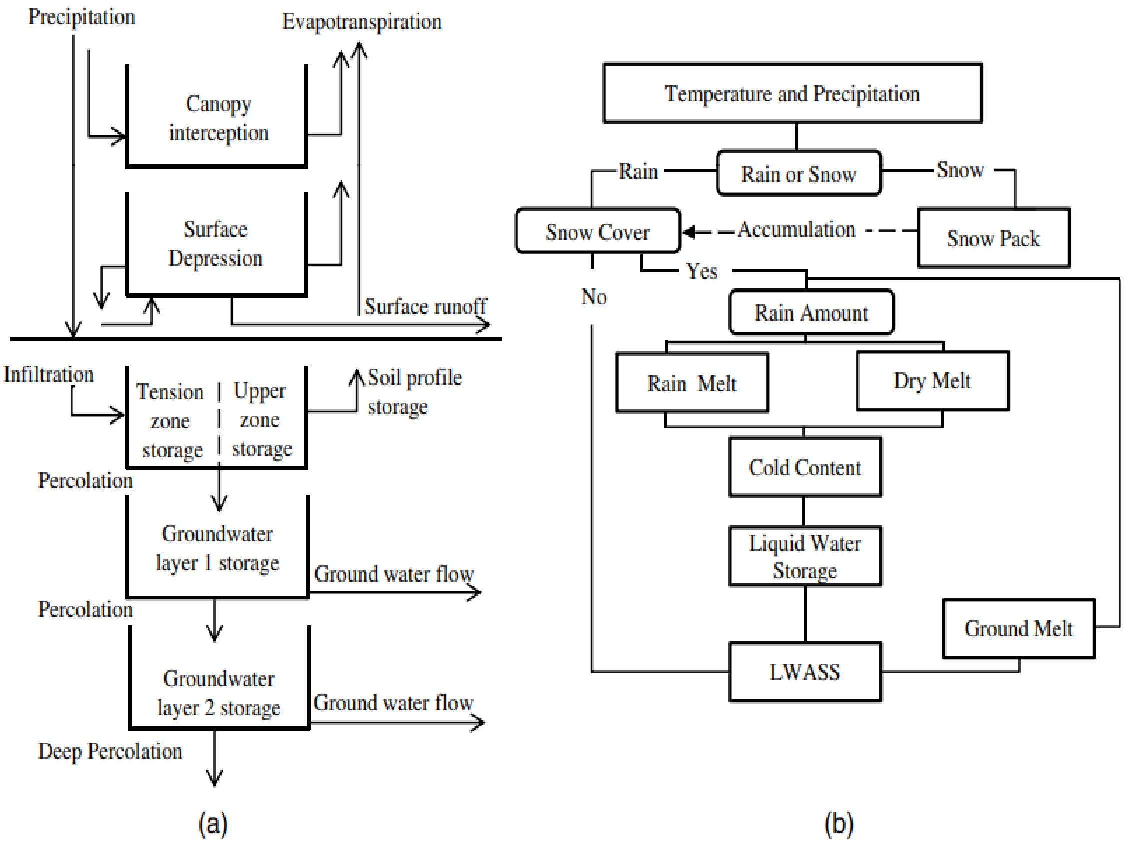
Figure 1: Binalatung Dam

Furthermore, it is necessary to use statistical tests to determine the quality and reliability of the data to be used in subsequent calculations. The tests used were Consistency Test (Multiple Period Curve Analysis and RAPS), Absence of Trend Test (rank correlation of Spearman method, Mann and Whitney test, and sign test of Cox and Stuart), Outlier Test, Stationary Test, and Persistence Test. The steps for calculating the HEC HMS method are as follows:

a. Determining the Watershed Model
b. Determining the process of water loss
c. Performing the hydrograph transformation of runoff units
d. Performing basic flow Process
e. Filling Rain Data

f. Determine the running time of the process
g. Configure data execution
h. Perform Model calibration
i. Aligning rain data into discharge

The suitability analysis of the method is carried out by comparing the data of river flow discharge (AWLR) with the simulation calculation of the variation of rain by looking for the smallest deviation. The tests used are the Nash-Sutcliffe efficiency test, the Mean Absolute Error (MAE) test, the correlation coefficient test, and the coefficient of determination test. The analysis of the suitability of the selected method and according to the characteristics of the study location will then be validated with discharge data from observations for 1 year.



III. ANALYSIS AND DISCUSSION

Hydrognomon is a free computer application to assist the analysis and processing of hydrological data, especially in the form of a time series. Hydrological data analysis is in the form of time series processing applications, such as aggregation, time steps, interpolation, regression analysis including filling in missing values, consistency testing, data filtering and graphical and tabular visualization of time series. The program also supports specialized hydrological applications such as evapotranspiration calculations, flow and sediment discharge analysis, homogeneity tests and water balance methods. This software is free software with a license from the GNU GPLv3 (General Public License). The development of Hydrognom is intended to process hydrological data, especially for data series. In this study, the distribution of data is limited to 3, namely Gamma, Pearson III and Normal. The tests performed were 2 and Kolmogorov-Smirnov. The distribution used to predict the return period is the 'ACCEPT/ACCEPTED' distribution of the two tests at the level of significance (α) = 1%. By entering the maximum annual daily rainfall data in units (mm) starting from 2000 to 2019. Press view then Add time series to graph, rain data can be displayed in the form of graphs and bar charts. Next, do a hydrological analysis, then select Pythia-Statistical analysis. Then select Log Pearson III then it looks in Figure 2.

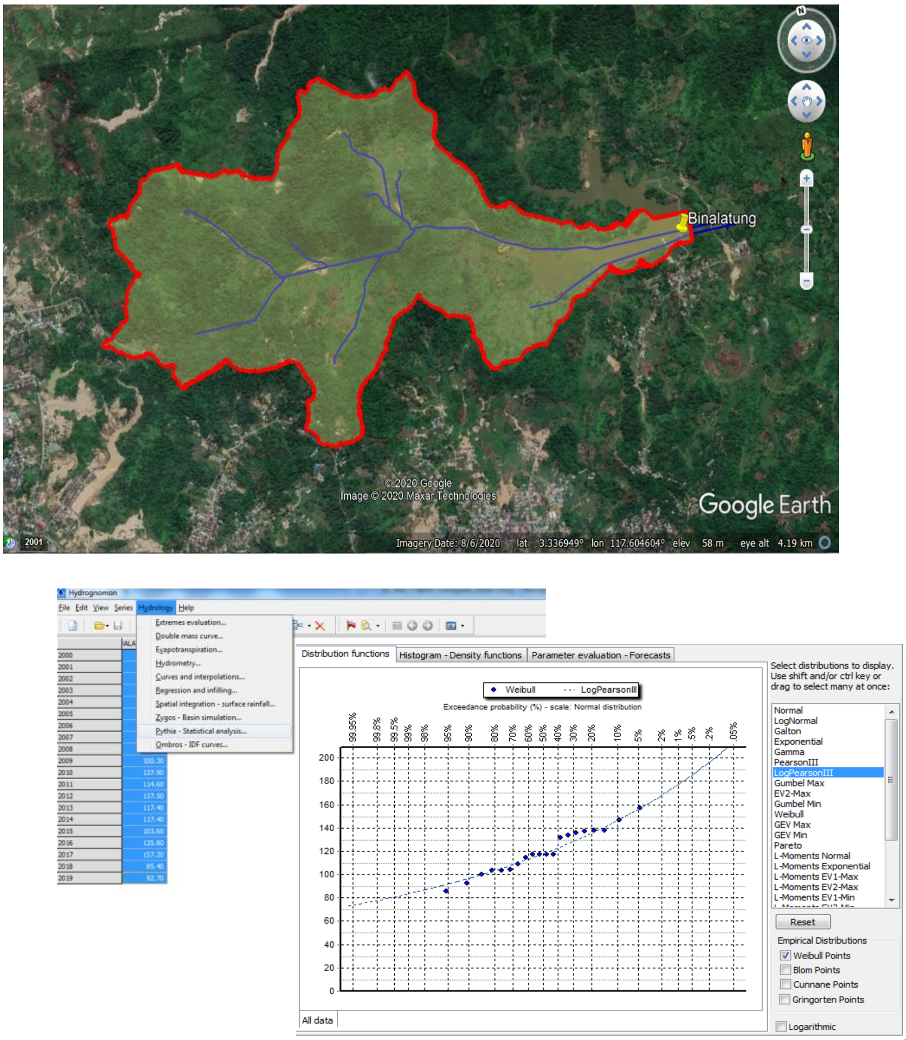


Figure 2: Catchment Area Binalatung and Frequency distribution analysis

Followed by the Smirnov Kolmogorov Test, then select Log Pearson III, the graph will appear as below, then the Smirnov Kolmogorov test results will appear at various significant levels in %, Select Forecast, then select To Return Period (Max). Then enter Tr = 100 years, the results of the calculation of design rain with a return period of 100 years are 164,366 mm which are presented in Figure 3. The results of the calculation of planned rainfall with various return periods are presented in table 1.

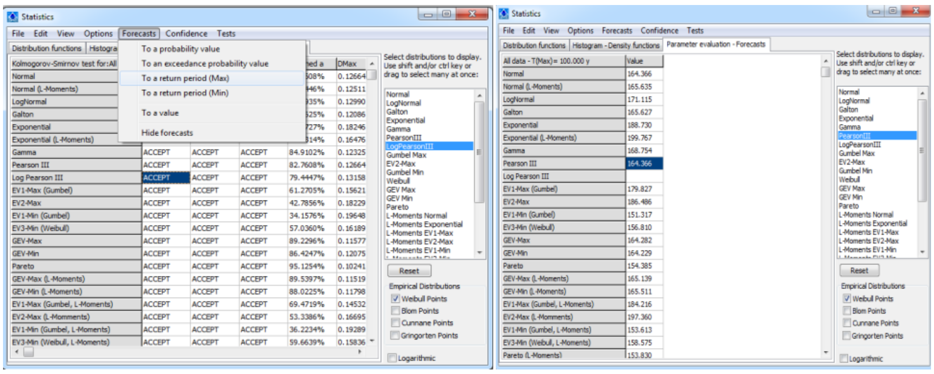


Figure 3: Calculation of Planned Rainfall

Table 1. Calculation of Planned Rainfall using Hydrognomon 4.1.0

No	Return Periode (Year)	Planned Rainfall (mm)
1	1000	174.726
2	200	168.083
3	100	164.282
4	50	159.743
5	20	152.316
6	10	145.274
7	5	136.455
8	2	119.583

Furthermore, the calculation of the Loss Rate Method is a way of calculating the water loss that occurs through the infiltration process. The SCS Curve Number consists of several parameters that must be inputted, namely initial loss or initial infiltration value, SCS Curve Number, and imperviousness (watertightness). For the initial infiltration value and SCS Curve Number By entering the Lag Time value to calculate the peak and hydrograph time, the SCS model will automatically form the ordinates for the hydrograph peak and the time function can be seen in Figure 4.

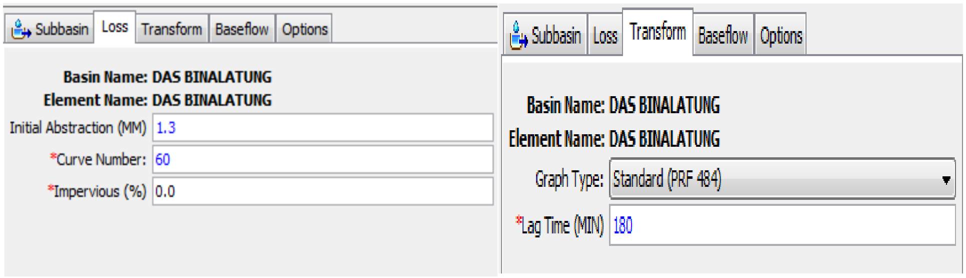


Figure 4: Sub-basin Loss Rate and Sub-basin Transform

Baseflow can be interpreted as base flow, this model is used to describe the base flow that occurs during runoff so that the peak height of the hydrograph can be calculated. In the modeling, the recession method is used with the assumption that the base flow is always present and has a hydrograph peak at one time unit and has a relationship with rainfall (precipitation). The parameters used in this recession model are initial flow, recession ratio and threshold flow. Initial flow is the initial base flow value that can be calculated or from observational data, the recession ratio constant is the ratio value between the current and yesterday's flow which constantly has a value of 0 to 1. While the threshold flow is the threshold value for the separation of runoff flow and base flow. To calculate this value, the exponential method can be used or it is assumed with a large value of the peak-to-peak ratio (US Army Corps of Engineering, 2001). The design of the hydrograph should be based on recording real rainfall events. Input precipitation data or effective rainfall during a flood, it can be in the form of 5 minutes, hourly or daily. It should be noted that regional rainfall is obtained from the average rainfall of the Thiessen method by taking into account the influence of rainfall stations in the area. Control Specifications contain input time when the program starts and ends execution (running) and the desired time interval (15 minutes, 1 hour, or 1 day). The procedure used is the same as for the basin model and meteorological model. After all the input variables above are entered, to execute the modeling to run, the basin model and the meteorological model must be combined. The results of the execution of this method can be seen in the graph and the output values below. The output below is the planned flood discharge for a return period of 1 year.

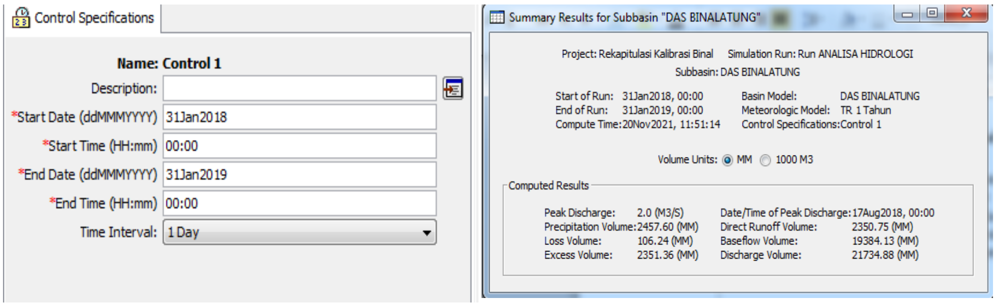


Figure 5: Control Specifications (running process time)

After all the input variables above are entered, to execute the modeling to run, the basin model and the meteorological model must be combined. The results of the execution of this method can be seen in the graph and the output values below. The output below is the planned flood discharge for a return period of 1 year.

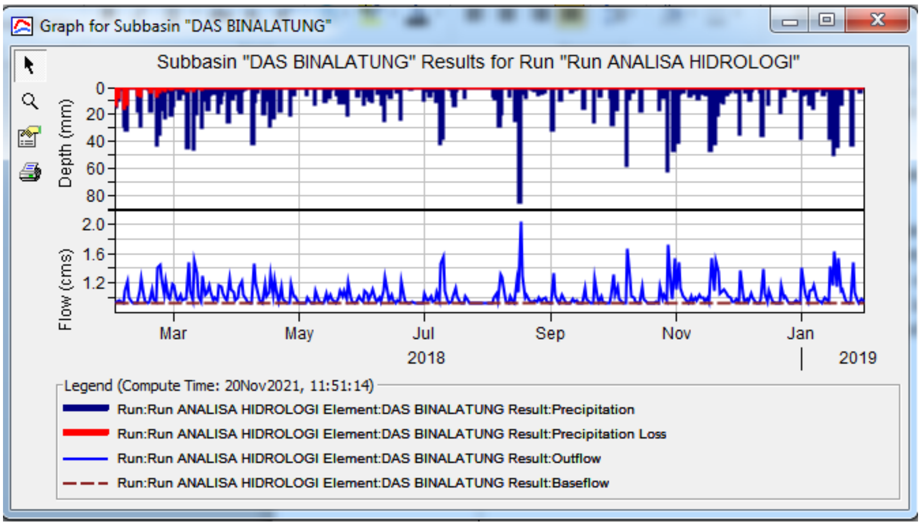


Figure 6: Flow Hydrograph of Binalatung Watershed

The results of the HEC-HMS model simulation for February 2018 to January 2019 are as shown in Figure 4.23 above. The peak discharge simulation model results is 2.0 m3/s and volume total outflow is 21734.88 mm with peak discharge time at August 17, 2018. For the initial stage of testing, calibration of the model was carried out based on rain data and measured discharge data in February 2017. 2018 to January 2019. The calibration is carried out based on the parameters contained in the basin model, namely the initial abstraction value, curve number, and time lag. The calibration data can be observed for model work by looking at the difference between the observed discharge and the theoretical discharge.

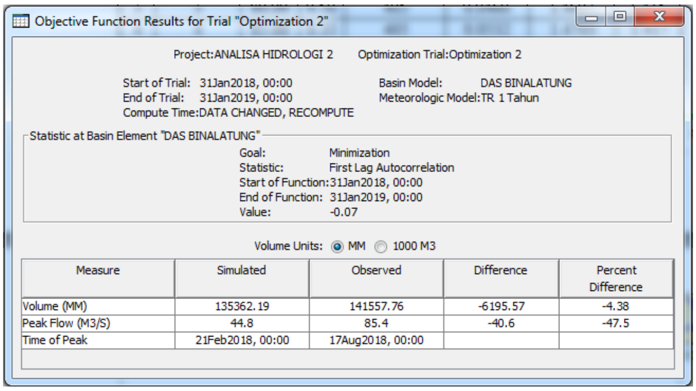


Figure 7: Calculation of correlation coefficient and error rate

Based on results of analysis of the HEC-HMS method, the peak discharge of simulation model is 2.0 m3/s and volume total outflow is 21734.88 mm with peak discharge on August 17, 2018. As for the field discharge, the results recorded in the field obtained a peak discharge of 2.1 m3/s and a total outflow volume of 2113.81 mm with the peak discharge time occurring on February 10, 2020. By simulating the simulation, at various variations of the CN values, the correlation coefficient values and relative errors were varied. After comparing the HEC-HMS experiments presented in tabular form, it was concluded that the experiment had a correlation coefficient with a value of 85.4 and a relative error percentage of 44.8% with a difference between the correlation coefficient and a relative error of -40.6. From these results, HEC-HMS modeling will be carried out to find the highest planned flood discharge value using data. The difference in entered for HEC-HMS modeling after calibration lies in rainfall data for time period used, which is for 10 years starting 2010 to 2019, the CN obtained from calibration is 80 and the Initial Abstraction (Ia) is 0. ,5. The results of the modeling after being calibrated are as follows:

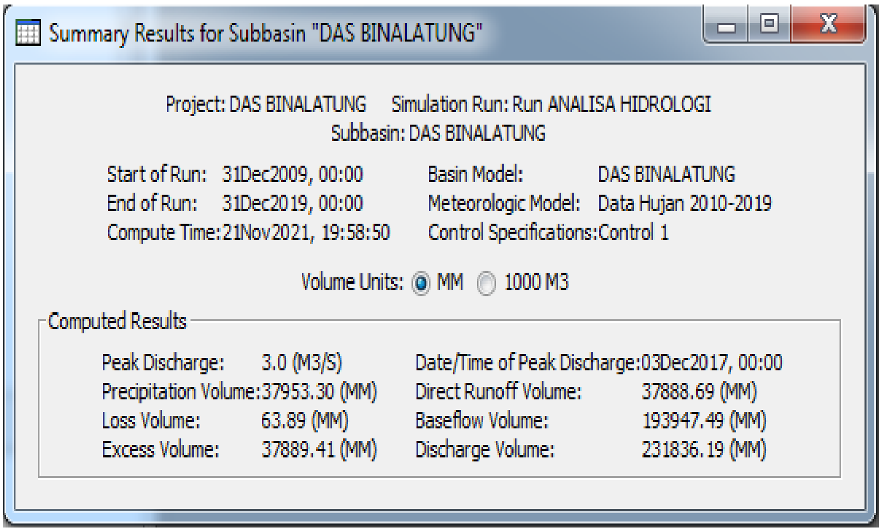


Figure 8: The modeling for 10 years after calibration

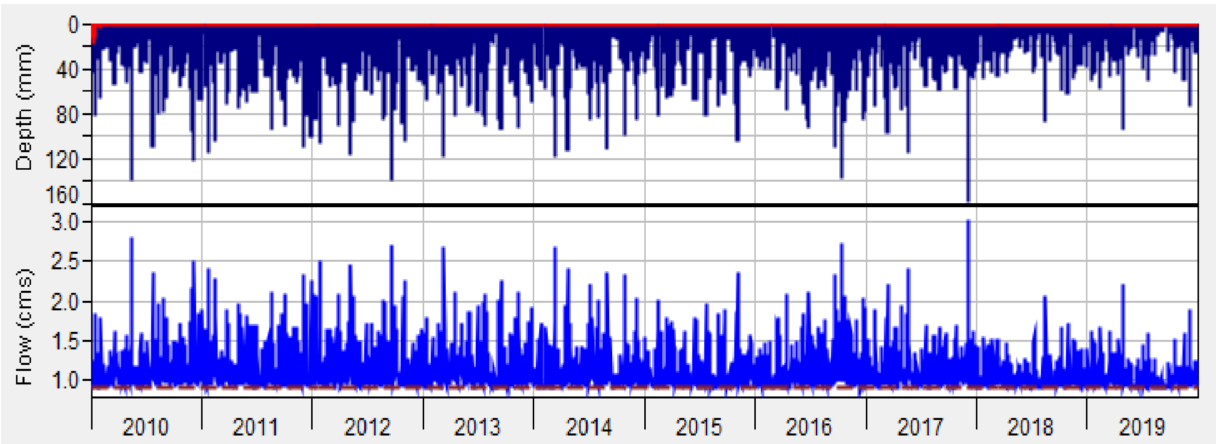


Figure 9: Graph of modeling for 10 years after calibration

Based on analysis results of the HEC-HMS models, the peak discharge from simulation model after calibration is 3.0 m3/sec and volume total outflow is 231836.19 mm with peak discharge on December 3, 2017.

IV. CONCLUSION

The approach to calculating the conversion of rainfall into discharge using the HEC-HMS modeling in the Binalatung watershed, Tarakan City, North Kalimantan after calibration lies in time period rain data used, which is for 10 years from 2010 to 2019, the CN obtained from the calibration is of 80 and the value of Initial Abstraction (Ia) of 0.5 with a correlation coefficient with a value of 85.4 and has a relative error percentage of 44.8% with the difference between the correlation coefficient and relative error of -40.6.

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