e-ISSN 2581-0405
ajarcde
Asian Journal of Applied Research for Community Development and Empowerment

Journal home page: http://ajarcde-safe-network.org ISSN 2581-0405

Analysis of Planned Flood Discharge Using HEC-HMS Software on the Keser River, Trenggalek Regency

*Teddy Satria Kartadipura, Minarni Nur Trilita**\

Department of Civil Engineering, Faculty of Engineering. Universitas Pembangunan Nasional "UPN" Veteran Jawa Timur. Indonesia

ARTICLE INFO

Article History:
Received: 01 July 2026
Final Revision: 09 July 2026
Accepted: 11 July 2026
Online Publication: 12 July 2026

KEYWORDS

Design flood discharge; Rainfall; Watershed; HEC-HMS; Tugu Dam

CORRESPONDING AUTHOR

*E-mail: satriateddy18@gmail.com

A B S T R A C T

Keser River, located within the Tugu Watershed in Trenggalek Regency, East Java, has the potential to experience significant increases in discharge during the rainy season, making design flood discharge analysis essential for flood mitigation and water resources management. This study aims to analyze design rainfall and design flood discharge in the Keser River using the Hydrologic Engineering Center–Hydrologic Modeling System (HEC-HMS) based on rainfall data collected from 2014 to 2024.Rainfall analysis was carried out using the Thiessen Polygon method to determine areal average rainfall, followed by frequency analysis employing four probability distributions: Normal, Log-Normal, Gumbel, and Log Pearson Type III. The most appropriate distribution was selected using the Chi-Square and Kolmogorov–Smirnov goodness-of-fit tests. Hydrological modeling was performed using HEC-HMS with watershed characteristics derived from Digital Elevation Model (DEM) and land-use data. The watershed was divided into seven sub-watersheds with a total area of 43.06 km². The SCS Curve Number method was applied to estimate rainfall losses, while the SCS Unit Hydrograph method was used for rainfall-runoff transformation.The results indicate that Log Pearson Type III is the most suitable probability distribution for estimating design rainfall. The HEC-HMS simulation produced peak design flood discharges at the watershed outlet of 512.9 m³/s for the 2-year return period, 678.5 m³/s for the 5-year return period, 772.3 m³/s for the 10-year return period, 877.8 m³/s for the 25-year return period, 947.9 m³/s for the 50-year return period, and 1,011.7 m³/s for the 100-year return period. The simulated flood hydrographs exhibit a rapid rising limb followed by a gradual recession limb, representing the hydrological response of the Keser River watershed to design rainfall events.The findings demonstrate that the HEC-HMS model is capable of representing the hydrological characteristics of the Keser River watershed and can serve as a reliab

Contribution to Sustainable Development Goals (SDGs):
SDG 6: Clean Water and Sanitation
SDG 9: Industry, Innovation and Infrastructure
SDG 11: Sustainable Cities and Communities
SDG 13: Climate Action
SDG 15: Life on Land

e-ISSN 2581-0405
Asian Journal of Applied Research for Community Development and Empowerment
Journal home page: http://ajarcde-safe-network.org ISSN 2581-0405

1. INTRODUCTION

1.1. Research Background

Floods are among the hydrometeorological disasters that frequently occur in Indonesia due to high-intensity rainfall, which causes river discharge to exceed river capacity. Therefore, the analysis of planned flood discharge is necessary as a basis for the planning of water resource structures, such as bridges, embankments, and drainage channels, so that they can function according to their planned lifespan (Asdak, 2023).

The Keser River located in Trenggalek Regency is one of the rivers in the Tugu Watershed (DAS) that has the potential to experience an increase in discharge during the rainy season. The magnitude of flood discharge is influenced by the characteristics of the watershed and the distribution of rainfall; thus, a planned flood discharge analysis is needed to determine the peak discharge at various return periods.

One of the widely used methods in hydrological analysis is the Hydrologic Engineering Center–Hydrologic Modeling System (HEC-HMS). This model can simulate rainfall-to-runoff conversion based on watershed characteristics, thereby producing flood hydrographs and planned flood discharges (USACE, 2021).

Based on the description, this research aims to analyze the planned flood discharge on the Keser River using the HEC-HMS method by utilizing the hydrological data of the Keser River watershed. The research results are expected to provide supporting information for the planning of flood control structures and the management of water resources in the study area.

The formulation of the problem in this study is: What are the results of the planned rainfall analysis in the Keser River watershed as input for HEC-HMS modeling? And How is the modeling result using the HEC-HMS software in obtaining the hydrograph and planned flood discharge on the Keser River.

2. MATERIALS AND METHODS

The research was conducted on the Keser River, Keser River Basin, Nglinggis Village, Tugu District, Trenggalek Regency, East Java, using hydrological data from the period 2014–2024, including rainfall data from BBWS Brantas and basin characteristics. This study employs a quantitative approach, using hydrological analysis with HEC-HMS software to calculate planned rainfall and planned flood discharge and to construct flood hydrographs. The research population consists of all daily rainfall data from the Keser River watershed during 2014–2024, which serves as the basis for the analysis.

3. RESULT AND DISCUSSION

3.1. Results of Planned Rainfall Analysis in the River Basin for HEC-HMS Modeling Input

In this study, rainfall data were obtained from three rain stations within the Watershed Area (DAS) of the Keser River: Tugu Station, Pule Station, and Bagong Dam Station. The data used consists of daily rainfall data for the period 2014–2024, which was then processed to determine the characteristics of rainfall and its distribution in the research area.

Because the distribution of rain stations within the watershed is uneven, the average regional rainfall is calculated using the Thiessen Polygon method. This method provides weighting factors based on each rain station's area of influence. The calculation results show that Tugu Station has the largest area of influence, while Pule Station and Bendungan Bagong Station have smaller areas of influence.

The average rainfall value for the area obtained is subsequently used as the basis for hydrological analysis, including rainfall frequency analysis and flood discharge calculation using the HEC-HMS method. Thus, the rainfall data used represents the hydrological conditions in the Keser River watershed, so the analysis results are expected to accurately depict the hydrological conditions of the research area. The average rainfall for the area was obtained using the Thiessen Polygon method, which considers the area of influence of each rain gage station within a watershed.

The Thiessen Polygon Method is used to determine the area influenced by each rain station in the study area. The working principle of this method is to divide the study area into several polygons based on the location of the rain stations, so that each station has its own area of influence. Every point within a polygon has the shortest distance to the rain station that serves as the center of that polygon. The process of forming the Thiessen polygon begins by connecting all the rain stations used, namely Tugu Station, Pule Station, and Bendungan Bagong Station. After that, at the midpoint of each connecting line, a perpendicular line is drawn. These perpendicular lines then form the polygon boundaries and illustrate the area of influence of each rain station.

The average rainfall in the Keser River Basin is calculated using the annual maximum rainfall data from three rain stations, namely Tugu Station, Pule Station, and Bagong Dam Station. Each station has a different coefficient or weight according to the area of its influence, with Tugu at (0.428), Pule at (0.572), and Bagong at (0.000). The annual maximum rainfall data from each station is then used to obtain a more representative average rainfall value for the area.

Calculation of the average rainfall in the area using the Thiessen method employs the equation:

$$\overline{R} = \frac{\sum(A_i \cdot R_i)}{\sum A_i}$$

Table 1. Maximum Daily Calculation of Rainfall at Tugu Station

Year	Observation Date	Rainfall Maximum			Weight x Tugu	Weight x Pule	Weight x Bagong	R Thiessen (mm)
		Tugu	Pule	Bagong	0.428	0.572	0.000	
2014	28 Feb	75	30	33	32.09	17.17	0.00	49.26
2015	25 Mar	118	26	20	50.48	14.88	0.00	65.36
2016	6 Apr	95	95	5	40.64	54.36	0.00	95.00
2017	17 Mar	61	61	0	26.10	34.90	0.00	61.00
2018	30 Nov	115	65	127	49.20	37.19	0.00	86.39
2019	29 Apr	110	87	45	47.06	49.78	0.00	96.84
2020	20 Apr	80	78	52	34.22	44.63	0.00	78.85
2021	19 Des	65	96	37	27.81	54.93	0.00	82.74
2022	18 Okt	110.6	122	142	47.31	69.81	0.00	117.12
2023	26 Feb	92	92	14	39.36	52.64	0.00	92.00
2024	15 Des	96.4	18	43	41.24	10.30	0.00	51.54
Amount		**876.10**						
Average		**79.65**						

The results of the average rainfall analysis in the Tugu Watershed area for the period 2014–2024 show a variation in annual rainfall, with an average value of 79.65 mm per year. The annual rainfall results created using the Thiessen Polygon were further processed into frequency analysis using four methods: Normal, Log Normal, Gumbel, Log Pearson III.

a. Normal distribution

Table 2. Statistical Parameters Normal Distribution Analysis

No.	Observation Year	Xi	Xi-X	$(Xi-X)^2$	$(Xi-X)^3$	$(Xi-X)^4$
1	2014	49.25	-30.39	923.76	-28.076.34	853.337.24
2	2015	65.36	-14.29	204.09	-2.915.54	41.650.90
3	2016	95.00	15.35	235.76	3.620.04	55.584.10
4	2017	61.00	-18.65	347.65	-6.482.12	120.l861.97
5	2018	86.39	6.75	45.50	306.95	2.070.59
6	2019	96.84	17.19	295.65	5.083.54	87.408.69
7	2020	78.86	-0.79	0.62	-0.49	0.39
8	2021	82.74	3.09	9.56	29.56	91.41
9	2022	117.12	37.48	1.404.56	52.639.11	1.972.777.02
10	2023	92.00	12.35	152.64	1.885.74	23.297.56
11	2024	51.54	-28.10	789.85	-22.198.05	623.858.87
	Jumlah	876.10		4.l409.64	3.892.40	3.780.938.73

From Calculation Result Obtained:
n = 11
Average = 79.65

Table 3. Design Rainfall Normal Distribution Method

P. Repetation (yeat)	K	Sx	Rmax (mm)
2	0	20.9991	79.65
5	0.84	20.9991	97.28
10	1.28	20.9991	106.52
20	1.64	20.9991	114.08
25	1.75	20.9991	116.39
50	2.05	20.9991	122.69
100	2.33	20.9991	128.57

b. Log Normal distribution

Table 4. Statistical Parameters Log-Normal Distribution

No.	Data Year	Xi	Log Xi	Log Xi - Log X	$(\text{Log Xi - Log X})^2$	$(\text{Log Xi - Log X})^3$	(Log Xi - Log X)4
1	2014	49.25	1.6924	-0.1942	0.0377	-0.0073	0.0014
2	2015	65.36	1.8153	-0.0713	0.0051	-0.0004	0.0000
3	2016	95.00	1.9777	0.0911	0.0083	0.0008	0.0001
4	2017	61.00	1.7853	-0.1013	0.0103	-0.0010	0.0001
5	2018	86.39	1.9365	0.0499	0.0025	0.0001	0.0000
6	2019	96.84	1.9861	0.0995	0.0099	0.0010	0.0001
7	2020	78.86	1.8968	0.0102	0.0001	0.0000	0.0000
8	2021	82.74	1.9177	0.0311	0.0010	0.0000	0.0000
9	2022	117.12	2.0686	0.1821	0.0331	0.0060	0.0011
10	2023	92.00	1.9638	0.0772	0.0060	0.0005	0.0000
11	2024	51.54	1.7122	-0.1744	0.0304	-0.0053	0.0009
Amount			21.7352	0.0000	0.1443	-0.0056	0.0038

Amount Data = 11
Average (log Xi) = 1.887

Table 5. Design Rainfall Log-Normal Distribution Method

No.	Repetation	Log x_{rt}	K	S	Xt
1	2	1.887	0	0.1201	77.02
2	5	1.887	0.84	0.1201	97.16
3	10	1.887	1.28	0.1201	109.74
4	20	1.887	1.64	0.1201	121.23
5	25	1.887	1.75	0.1201	124.97
6	50	1.887	2.05	0.1201	135.79
7	100	1.887	2.33	0.1201	146.72

c. Gumbel distribution

Table 6. Statistical Parameters Gumbel Distribution Method

No.	Year Observation	Xi	Xi-X	(Xi-X)^2	(Xi-X)^3	(Xi-X)^4
1	2014	49.25	-30.39	4.409.64	-28.076.34	853.337.24
2	2015	65.36	-14.29	4.271.87	-2.915.54	41.650.90
3	2016	95.00	15.35	9.025.00	3.620.04	55.584.10
4	2017	61.00	-18.65	3.721.00	-6.482.12	120.861.97
5	2018	86.39	6.75	7.463.42	306.95	2.070.59
6	2019	96.84	17.19	9.377.97	5.083.54	87.408.69
7	2020	78.86	-0.79	6.218.21	-0.49	0.39
8	2021	82.74	3.09	6.845.50	29.56	91.41
9	2022	117.12	37.48	13.717.76	52.639.11	1.972.777.02
10	2023	92.00	12.35	8.464.00	1.885.74	23.297.56
11	2024	51.54	-28.10	2.656.50	-22.198.05	623.858.87
Amount		876.10		74.186.98	3.892.40	3.780,938.73

From Calculation Result Obtained :
n = 11
Average = 79.65

Table 7. Design Rainfall Gumbel Distribution Method

P. Repetation (Year)	Yt	K	Rmax (mm)
2	0.3665	-0.1421	76.66
5	1.4999	0.9806	100.24
10	2.2502	1.7238	115.84
20	2.9606	2.4275	130.62
25	3.1985	2.6632	135.57
50	3.9019	3.3600	150.20
100	4.6001	4.0516	164.73

d. Log Person III distribution

Table 8. Statistical Parameters Log Pearson Type III

No.	Year Data	Xi	Log Xi	Log Xi - Log X	(Log Xi - Log X)^2	(Log Xi - Log X)^3	(Log Xi - Log X)^4
1	2014	49.25	1.6924	-0.1942	0.0377	-0.0073	0.0014
2	2015	65.36	1.8153	-0.0713	0.0051	-0.0004	0.0000
3	2016	95.00	1.9777	0.0911	0.0083	0.0008	0.0001
4	2017	61.00	1.7853	-0.1013	0.0103	-0.0010	0.0001
5	2018	86.39	1.9365	0.0499	0.0025	0.0001	0.0000
6	2019	96.84	1.9861	0.0995	0.0099	0.0010	0.0001
7	2020	78.86	1.8968	0.0102	0.0001	0.0000	0.0000
8	2021	82.74	1.9177	0.0311	0.0010	0.0000	0.0000
9	2022	117.12	2.0686	0.1821	0.0331	0.0060	0.0011
10	2023	92.00	1.9638	0.0772	0.0060	0.0005	0.0000
11	2024	51.54	1.7122	-0.1744	0.0304	-0.0053	0.0009
Amount			20.7524	0.0000	0.1443	-0.0056	0.0038

Amount Data = 11
Average (log Xi) = 1.887

Table 9. Design Rainfall Using the Log Pearson Type III Distribution Method

No.	Repetation	G	G X S	Log X	Xt
1	2	0.066	0.0079	1.8945	78.43
2	5	0.855	0.1027	1.9893	97.56
3	10	1.231	0.1479	2.0345	108.27
4	20	1.544	0.1855	2.0721	118.06
5	25	1.607	0.1931	2.0796	120.13
6	50	1.836	0.2205	2.1071	127.97
7	100	2.031	0.2440	2.1306	135.08

e. Determination of distribution

Table 10. Distribution Determination Results

No	Data	Normal	Log Normal	Gumbel	Log Pearson Type III
1	Sx	20,999	0.120	20,999	0,120
2	Cv	0,264	0.064	0,264	0.064
3	Cs	-0,051	-0.111	0,051	-0.397
4	Ck	3,268	3,055	3,268	3,055

Based on the table, there are two types of distributions that can be used, namely the Gumbel distribution and the Log Pearson III distribution. However, in this study, the Gumbel and Log Pearson Type III distributions were chosen because the distribution fit tests showed that they meet the necessary requirements.

Distribution Test to ensure that the maximum annual rainfall data truly follows a certain distribution pattern, this study applies a distribution fit test. The two methods used are the Chi-Squared test and the Kolmogorov-Smirnov test, each of which has its own advantages in assessing the difference between observed data and the theoretical values of the distribution being tested. The Chi-Squared test emphasizes the comparison of data frequencies grouped into interval classes, while the Kolmogorov-Smirnov test measures the maximum distance between the empirical

 https://doi.org/10.29165/ajarcde.v10i2.407

cumulative distribution function and the theoretical distribution. Thru the application of these two tests, a convincing picture was obtained regarding the suitability of the Log Pearson Type III distribution in representing the distribution of maximum annual rainfall data.

Table 11. Chi-square Test

Probability Distribution	X^2 Effective	X^2_{cr}	Comparison	Explanation
Gumbel	5.727	5.9910	$X^2 < X^2_{cr}$	Accepted
Normal	5.727	5.9910	$X^2 < X^2_{cr}$	Accepted
Log Normal	3.909	5.9910	$X^2 < X^2_{cr}$	Accepted
Log Pearson Type 3	3.909	5.9910	$X^2 < X^2_{cr}$	Accepted

Table 12. Smirnov Kolmogorov Test

Probability Distribution	ΔP maximum	ΔP Critical	Comparison	Explanation
Gumbel	0.18	0.3910	ΔP max < ΔP critical	Accepted
Normal	0.10	0.3910	ΔP max < ΔP critical	Accepted
Log Normal	0.12	0.3910	ΔP max < ΔP Critical	Accepted
Log Pearson Type 3	0.38	0.3910	ΔP max < ΔP Critical	Accepted

3.2. The results of the HEC-HMS software modeling obtained the hydrograph and planned flood discharge on the Keser River

The processing of DEMNAS data begins with downloading the National Digital Elevation Model (DEMNAS) data from the official DEMNAS website. After registering and logging in, the DEMNAS data covering the research area is downloaded for analysis. The downloaded DEMNAS data is then imported into ArcGIS software. Next, the coordinate system is set using the Universal Transverse Mercator (UTM) projection system with the WGS 1984 datum adjusted to the research location zone.

The next step is to merge the imported DEMNAS data into a single raster file and save it as a GeoTIFF file. After the merging process is complete, a coordinate system definition (Define Projection) is performed to ensure the data has the appropriate spatial reference. Hydrological analysis begins by running the Flow Direction process to determine the direction of water flow based on topographic conditions. The results of this process are then used as input for the Flow Accumulation process to obtain flow accumulation that depicts the main flow paths.

Next, a Conditional (Con) process is carried out to classify the raster values, making it easier to identify the river network. The classified data is then processed using the Stream to Feature function to convert the river network from raster format to vector. The next step is to form the boundaries of the Watershed Area (DAS) using the Raster to Polygon process, so that the DAS boundaries are obtained in polygon format, ready to be used in the next analysis stage. The final result of the spatial processing is then exported into PDF format as a watershed map, which is used as a basis for hydrological modeling using HEC-HMS.

The geometric data results of the sub-watershed obtained thru the delineation process, the next step is to calculate the hydrological parameters needed in the HEC-HMS model. This calculation includes estimating the lag time, the Curve Number (CN), the maximum retention (S), the initial abstraction (Ia), and the impervious area. Each parameter is calculated using the SCS (Soil Conservation Service) methodology and considering the specific conditions of the study area. Here are the calculation steps:

The determination of the Curve Number (CN) value begins with exporting the delineation results of the sub-DAS from HEC-HMS into shapefile format (.shp). Next, the shapefile data is imported into QGIS software for spatial processing. In QGIS, the sub-DAS layer is overlaid with land-use and soil-type maps to obtain characteristic information for each sub-DAS based on their combination. The overlay produces attribute data, including land use, soil type, and the area of each land unit, which serve as a basis for determining the Curve Number value.

The Curve Number value is determined using the Field Calculator thru a classification expression that refers to the Soil Conservation Service (SCS) method. Each combination of land-use and soil-type groups is assigned a CN value according to the SCS standard table. For example, the land use of plantation forests on Andosol soil has a CN value of 55, while residential land use on Luvisol soil has a CN value of 85. The classification process is carried out automatically using logical expressions so that each land unit receives the appropriate CN value..

The classification results in a new attribute column containing Curve Number values for each combination of land use and soil type. These CN values are then summarized and further processed as one of the main parameters in hydrological modeling using HEC-HMS.

The Concept and Selection of the Unit Hydrograph (UH) Method: a direct runoff hydrograph generated by an effective rainfall of 1 mm uniformly distributed over the entire watershed for a specified duration. In HEC-HMS modeling, the unit hydrograph is used as a transformation method to convert effective rainfall into a runoff hydrograph at the watershed outlet.

In this study, the SCS Unit Hydrograph method (NRCS Unit Hydrograph) is used because it is compatible with the SCS Curve Number (SCS-CN) method for calculating runoff. In addition, this method is available as a transformation method in HEC-HMS and requires only the Lag Time (tlag) parameter, making it suitable for application in the Keser River watershed, which lacks observed discharge data for calibration.

The HEC-HMS Curve Number modeling is empirical from the SCS used to estimate surface runoff based on land use type, soil type, and infiltration conditions. The CN value ranges from 30 to 100 and can be used in hydrological modeling in HEC-HMS. The determination of CN is carried out by combining land use data and soil type using the field calculator function in QGIS thru the CASE WHEN expression, with each combination assigned a CN value according to its standard. After the CN value (subbasin 1 as an example) is formed, the average value is calculated with

$$CN_{amount} = \frac{\sum(CN_i \times A_i)}{\sum A_i}$$

The results of the calculation of the Potential Maximum Retention (S) and Initial Abstraction (Ia) values for each Sub Watershed.

Lag Time and UH Parameters are calculated using the NRCS/SCS formula (NRCS, 2010; Chow, Maidment & Mays, 1988) as follows:

$$t_{lag} = \frac{L^{0.8}(S+1)^{0.7}}{1900Y^{0.5}}$$

Dimensionless SCS Unit Hydrograph

SCS Unit Hydrograph uses the same dimensionless shape for all watersheds. Table 4.32 presents the dimensionless coordinates (NRCS, 2010). The actual hydrograph is obtained by multiplying the time axis by Tp and the discharge axis by Qp of the relevant sub-catchment.

Table 13. Dimensionless SCS Unit Hydrograph Coordinates

t / Tp	q / qp	t / Tp	q / qp
0.0	0.000	1.1	0.980
0.1	0.015	1.2	0.920
0.2	0.075	1.4	0.750
0.3	0.160	1.6	0.560
0.4	0.280	1.8	0.390
0.5	0.430	2.0	0.280
0.6	0.600	2.5	0.147
0.7	0.770	3.0	0.055
0.8	0.890	4.0	0.012
0.9	0.970	5.0	0.000
1.0	1.000	—	—

Geometric data for sub-watersheds resulting from HEC-HMS delineation and CN values in Table 4.28 were used to calculate the parameters tlag, Tc, Tp, and Qp for each sub-watershed. The length of the river (L) is estimated using L = 1.3√A km, where A is the drainage area; the slope (Y) is set at 20% based on the characteristics of the Trenggalek mountain watershed. Recapitulation results: Initial Abstraction (Ia) is the amount of initial rainfall loss before surface runoff occurs. The initial losses include vegetation interception, surface depression storage, and initial infiltration into the soil. In the SCS Curve Number method, the Initial Abstraction value is assumed to be 20% of the Potential Maximum Retention (S) value. The Potential Maximum Retention (S) value is calculated using the following equation.

$$S = \frac{25400}{CN} - 254$$

Unit Hydrograph per Sub-Watershed, the image below displays the SCS Unit Hydrograph in two forms: (a) absolute discharge for sub-watersheds 1, 3, and 4 as representation; (b) a dimensionless curve applicable to all sub-watersheds. Sub-watershed 1 has the largest Qp (10.60 m³/s/mm) due to its larger area, whereas the smaller sub-watersheds (5–7) reach their peak very quickly, with Tp < 1 hour.

UH, which has been established as a transfer function in HEC-HMS, is used to convert effective rainfall into direct runoff thru convolution operations. Mathematically:

$$Q_n = \sum_{i=1}^{n} P_i \, U_{n-i+1}$$

This convolution process is automatically performed by HEC-HMS for each recurrence interval Q2–Q100. The flood hydrographs in Figures 4.37–4.42 are the result of convolving the hourly rainfall distribution with the UH per sub-catchment as described above. The accuracy of the Lag Time value is the key to the precision of the simulation results.

Meteorological Model Settings and Control Specifications

After all hydrological parameters are determined, the next step is to construct the Meteorological Model in HEC-HMS. The Meteorological Model defines the rainfall scenarios used as input to the hydrological simulation. In this study, the Specified Hyetograph method is used, which utilizes planned rainfall hyetograph data as input for the simulation. The planned rainfall data that has been compiled is then linked with the appropriate rain gage so that it can be used in the modeling process.

In addition to the Meteorologic Model settings, Control Specifications are also prepared to determine the simulation period. These settings include the simulation start time, simulation end time, and the time interval, which is adjusted to match the rainfall data interval. The simulation period is determined to fully capture the rainfall process and the watershed's hydrological response.

The configured Meteorological Model and Control Specifications are then connected to the Basin Model, ensuring all modelling components are ready for use in the flood discharge simulation process with HEC-HMS.

The next step is to conduct a hydrological simulation using HEC-HMS. Before the simulation is run, the planned rainfall data for each return period is entered into the Time Series Data as time-series input. In this study, the rainfall data is arranged for each return period, namely 2, 5, 10, 25, 50, and 100 years, with a one-hour time interval.

After all the rainfall data has been entered, each precipitation gage is connected to the previously prepared Meteorologic Model. Next, the Basin Model, Meteorologic Model, and Control Specifications are combined in the Simulation Run so that all modeling components are integrated with each other.

The simulation process was then run using the Compute facility in HEC-HMS. The simulation results included runoff hydrographs and flood discharge for each sub-watershed and watershed outlet. The simulation data were subsequently used to analyze the characteristics of the flood hydrograph and determine the planned flood discharge for each return period.

The simulation results using HEC-HMS show that each sub-watershed produces flood hydrographs with different characteristics depending on the catchment area, land-use conditions, and the hydrological parameters used. In general, all the hydrographs show the same pattern: discharge increases rapidly until it reaches the peak (rising limb), then decreases gradually (recession limb).

Sub-Watershed 2 produces the largest peak discharge, which is 569.8 m³/s with a 2-year return period, in line with its area being the largest among all sub-watersheds (183.39 km²). Conversely, Sub-Watershed 6 has the smallest peak discharge, which is 0.4 m³/s, because its catchment area is only 0.12 km². The difference in peak discharge values indicates that watershed size and the area's physical characteristics significantly influence runoff volume.

The hydrograph from each sub-watershed is then routed through the river network in HEC-HMS, resulting in a combined hydrograph at the watershed outlet, which is used to determine the planned flood discharge for various return periods.

 https://doi.org/10.29165/ajarcde.v10i2.407

Table 14. Recap of Flood Hydrograph Simulation Results

Time	Inflow Total Q2	Inflow Total Q5	Inflow Total Q10	Inflow Total Q25	Inflow Total Q50	Inflow Total Q100
0	0.00	0.00	0.0	0.0	0.0	0.0
1	1.4	2.0	2.8	3.5	3.9	4.3
2	7.8	12.0	14.6	17.5	19.6	21.5
3	22.1	33.0	39.6	47.2	52.4	57.2
4	45.6	66.0	79.4	93.9	103.7	112.7
5	78.4	113.0	133.7	157.1	173	187.5
6	120.2	171.0	201.7	235.9	259	280.2
7	169.7	239.0	280.8	327.2	358.4	387.1
8	224.2	314.0	366.4	425.5	465.2	501.5
9	280.6	389.0	453.3	524.6	572.5	616.3
10	335.7	463.0	536.7	619.4	674.7	725.3
11	386.8	529.0	612.3	704.7	766.4	822.8
12	430.4	585.0	674.7	774.3	840.8	901.4
13	463.8	626.0	719.9	823.8	893.1	956.2
14	487.0	653.0	749	854.9	925.4	989.6
15	501.7	669.0	765.4	871.7	942.3	1006.7
16	509.8	677.0	772.3	877.8	947.9	1011.7
17	512.9	678.0	772.2	876.1	945.1	1007.9
18	512.1	674.0	766.7	868.6	936.2	997.6
19	508.4	667.0	757.3	856.8	922.7	982.6
20	502.4	657.0	745	841.8	905.9	964.2
21	494.7	645.0	730.6	824.7	886.9	943.5
22	485.9	632.0	714.8	806	866.3	921.2
23	476.2	618.0	698.1	786.4	844.8	897.9
24	465.9	603.0	680.8	766.3	822.8	874.2

4. CONCLUSION

Land area, labour, number of seeds, subsidized fertilizer, and pesticides influence rice production in Madang Suku I District, East OKU Regency. The factor with the greatest influence is land area, with a standard partial regression coefficient (beta) of 0.567. The subsidized fertilizer policy, namely urea fertilizer (X1) and NPK fertilizer (X2), individually and simultaneously contributes to increasing rice production in Madang Suku I District, East OKU Regency. This is evident from the increase in rice production in East OKU which reached 689,678 tons of milled dry grain (GKG) or 811,385 tons of GKP from a planting area of 108,141 hectares (Ha). This production has increased by 20 per cent compared to 2021, and at the beginning of 2023, rice production in Ogan Komering Ulu Timu Regency was included in one of the districts with the highest rice production in South Sumatra province.

REFERENCE

[1] Affandy, N. A. (2011). Rain-Runoff Modeling Using the Hec-HMS Model in the Sampean Baru Watershed, in Proceedings. VII National Seminar on Civil Engineering, ITS Surabaya.

[2] Chow, V. T., Maidment, D. R., & Mays, L. W. (1988). Hidrología aplicada. McGraw-Hill.

[3] Ward, R. C., & Robinson, M. (2000). Principios de hidrología (4ª ed.). McGraw-Hill.

[4] IPCC. (2021). Cambio Climático 2021: La Base Científica Física. Contribución del Grupo de Trabajo I al Sexto Informe de Evaluación del Panel Intergubernamental sobre Cambio Climático. Cambridge University Press.

[5] BNPB. (2020). Data and information on disasters in Indonesia. National Disaster Management Agency.

[6] Balai Besar Wilayah Sungai (BBWS) Brantas. (2021). Tugu Dam Profile. Ministry of Public Works and Public Housing.

[7] Asdak, C. (2018). Hydrology and river basin management. Gadjah Mada University Press.

[8] Adidarma, W.K. (2014). Design Flood Calculation Techniques for Dams with Limited Data, Especially in Indonesia. Journal of Hydraulic Engineering, 4(2), 105-116

[9] Arsjad, A.B.S.M. (2012). Identificación del Riesgo Potencial de Deslizamientos de Tierra a Través de Técnicas de Teledetección y SIG en el Distrito de Cianjur, Java Occidental. División de Investigación Geomática. Bakosurtanal. Cibinong.

[10] Asdak Chay. (2010). Hydrology and River Basin Management, Gajah Mada University Press, Yogyakarta.

[11] Indarto. (2012). Hydrology: Basic Theory and Examples of Hydrological Model Applications. Bumi Aksara, Jakarta

[12] Khairun, La Baco S., and U. O. Hasani. (2017). Morphometric Characteristics Determine the Hydrological Conditions of the Roraya Watershed. Ecogreen, 3(2), 105-115.

[13] Mesa, L. M. (2006). Análisis Morfométrico de una Cuenca Andina Subtropical (Turuman, Argentina). Geología Ambiental, 50, pp. 1235-1242.

[14] Ningsih, D. H. U. (2012). Thiessen Polygon Method for Predicting Rainfall Distribution Over a Specific Period in Areas Lacking Rainfall Data. DINAMIK Journal of Information Technology, 17(2), 154-163

[15] Prasojo, Sri Irawan Laras. 2015. Prediction of Sub-Watershed Areas Triggering Floods in the Sampean River Basin Using ARCGIS and HEC-HMS (Thesis). Jember University: East Java.

[16] Rozin M. (2012). Analysis of Water Availability Using HEC-HMS Software (Case Study in the Meninting River Basin), Department of Civil Engineering, Faculty of Engineering, University of Mataram, Mataram

[17] Salsabila, A. and I. L. Nugraheni. (2020). Introduction to Hydrology. Aura, Bandar Lampung.

[18] oemarto, C. (1987). Technical Hydrology. Usaha Nasional: Surabaya.

[19] Soewarno. (2014). Hydrometry and Technosabo Application in Water Resource Management. Graha Ilmu, Yogyakarta.

[20] Sujono, Joko. (2008). Brief Instructions for Hec-HMS Application Version 3.2. Gadjah Mada University: Yogyakarta.

[21] Syaifullah, M. D. (2014). Validation of Actual Rainfall Data in Three Watersheds in Indonesia. Journal of Meteorology and Geophysics, 15(2),

[22] Triatmodjo, B. (2014). Applied Hydrology. Beta Offset, Yogyakarta

[23] USACE. (2000). Sistema de Modelado Hidrológico HEC HMS Técnico