# Hydrological characteristics analysis of Ogan Watershed

*by* Eddy Ibrahim

**Submission date:** 15-May-2023 09:03AM (UTC+0700)
**Submission ID:** 2093193381
**File name:** EEC-61.pdf (1.69M)
**Word count:** 5248
**Character count:** 25783

*Eco. Env. & Cons. 27 (1) : 2021; pp. (427-435)*
*Copyright@ EM International*
*ISSN 0971–765X*

# Hydrological characteristics analysis of Ogan Watershed, South Sumatra, Indonesia

**Utari Hikmah Pratiwi[1], Eddy Ibrahim[2], Edward Saleh[3] and Ngudiantoro[4]**

***[1] Graduate School, Universitas Sriwijaya, Palembang 30139, Indonesia***
***[2]Mining Engineering Department, Universitas Sriwijaya, Inderalaya 30662, Indonesia***
***[3]College of Agriculture, Universitas Sriwijaya, Inderalaya 30662, Indonesia***
***[4]Mathematics Department, Mathematics and Natural Sciences Faculty, Universitas Sriwijaya, Inderalaya 30662, Indonesia***

(Received 22 July, 2020; accepted 1 September, 2020)

**ABSTRACT**

Ogan Sub-watershed in South Sumatra is one of the relatively large Musi river sub-watersheds which area crosses several cities with management complexity. The Ogan watershed experiences flooding during rainy season annually, especially in the downstream of Ogan Ilir District and one of the reasons of flooding in Palembang City. The information about hydrological characteristics was needed for water resources management. Therefore, it is necessary to analyze the hydrological characteristics of the Ogan watershed based on the morphometric conditions, geomorphology, and climatology. Data used was digital elevation model for analyzing the distribution and characteristic of sub-watersheds based on morphometric conditions, sentinel satellite imagery maps for land use analysis, and maximum daily rainfall data. Rainfall data used for analyzing climatology of sub-watersheds (hourly rainfall) using the Alternating Block Method (ABM) of the Intensity Duration Frequency (IDF) curve with time intervals of 10 minutes for 360 minutes in return periods of 2, 5, 10, 25, 50, and 100 years. Peak discharge was analysed by developing hydrological model of synthetic unit hydrograph SCS using HEC-HMS 4.3 software. Flood discharge hydrograph analysis measured with Soil Conservation Service (SCS) by inputting characteristic of sub-watersheds based on the morphometric condition, geomorphology, and climatology. The result of analysis showed that the total area of the Ogan Watershed is 841,721 ha, which is classified as a large watershed with a length of 343.19 km. Ogan watershed divided into 12 sub-watersheds, namely Ogan Tengah, Rambang, Kuang Besar, Sakatiga, Ual, Gelas, Kisam, Kurup, Ogan Ulu, Ogan Ilir, Kelekar, and Tebangka. Ogan sub-watersheds were dominated by rubber plantations, oil palm plantations, and dry land forests. The highest depth of the rain occurred at 180 minutes and the lowest depth at 360 minutes and 10 minutes. Result of hydrological model using HEC-HMS 4.3 software presented a peak discharge hydrograph with a return period of 2 years from 12 sub-watersheds revealed that Ogan Ulu sub-watershed had the highest discharge of 180.9 $m^3s^{-1}$ and the lowest was Kisam sub-watershed at 24.7 $m^3\ s^{-1}$. The results of the overall peak discharge analysis of the Ogan watershed with a return period of 2 years is equal to 516.4 $m^3\ s^{-1}$.

***Key words**: Hydrological characteristics, Morphometric of watershed, Geomorphology, climatology, Ogan watershed*

## Introduction

Watershed is an area bounded by ridges of mountains where rainfall water will flow into the main river which determined by using a topographic map with contour lines. Runoff flows from the highest points and flow towards lower points in a perpendicular direction to the contour lines (Farahani *et al.*, 2016). Integrated watershed management from upstream to downstream areas is necessary for disaster management, such as floods and drought (Brindha and Pavelic, 2016). The planning and management of watersheds required detailed data of watershed characteristics (Yilmaz *et al.*, 2011). Analysis of watershed characteristics is very important to identify the level of vulnerability and potential of a watershed. Understanding the characteristics of a watershed resulted more effective and efficient watershed management (Wang *et al.*, 2016).

Flow discharge characteristics of watershed strongly influenced by rainfall and watershed characteristics and these factors affect the occurrence of flooding. The effect of watershed characteristics, including: area, length, curve number, percentage of impervious, and slope can be used for analyzing peak discharge using the unit synthesis hydrograph method (Ramírez, 2010). The Synthetic Unit Hydrograph (HSS) is a method for estimating the use of unit hydrograph concept in a management planning that utilize watershed characteristic data (Yasril *et al*., 2017).

Surface runoff in watersheds is greatly influenced by several parameters, i.e. area, slope, shape, and vegetation. The wider area of a watershed, the greater amount of rainfall received and greater volume of run off. In addition, higher slope and wider watershed resulted faster runoff rate. The drainage areas affect surface runoff velocity. In contrary, vegetation increase the amount of water retained thereby reduce runoff rate (Jia *et al.*, 2020).

The potential of watersheds in all regions of Indonesia has decreased in last ten years as indicated by the occurrence of floods during the rainy season and drought during the dry season (Case *et al.*, 2007). One of watersheds in South Sumatra province, Ogan sub-watershed experiences flooding during rainy season annually, especially in the downstream of Ogan Ilir District and contributed to flooding in Palembang City (Al Amin *et al*., 2017; Farid *et al.*, 2017). Miralti *et al.* (2020) revealed that sub-watersheds that experience flooding each year due to Ogan River discharge runoff. Ogan watershed is the biggest supplier of flooding in Musi due to high precipitation. Maximum daily rainfall in the Ogan Sub-watershed is 234 mm which is classified as very high rainfall. The peak discharge of Ogan watershed sub-watershed with a return period of 25 years is 1227.09 $m^3 s^{-1}$ (Farid *et al.*, 2017). The problem of flood disaster is closely related to the peak discharge potential. Flood control in a watershed can be done well if the planned peak discharge identified. Peak discharge can be calculated based on watershed characteristic data (Roy and Mistri, 2013). Thus, it is necessary to analyze the characteristics of the Ogan Sub-watersheds as the basic information for sustainable sub-watersheds management (Fulazzaky, 2014; Miralti *et al.,* 2020).

Watershed characteristic parameters are obtained from the digital elevation model (DEM) data analysis using GIS software. The peak discharge can be analysed by constructing a hydrological model. The hydrological model is a simple description of a watershed to predict hydrological events (Tegegne *et al.*, 2017). The hydrological simulation model was developed to explain the process of converting input (rain) to output (streams) by considering the physical characteristics of the watershed (Daniel, 2011). The study focused on the hydrological characteristics analysis of Ogan Watershed, South Sumatra, Indonesia. The flood hydrograph modeling utilized the SCS Synthetic Unit Hydrograph method with HEC-HMS 4.3 software.

## Methods

### Study area

The study area covered Ogan watershed located in Ogan Ilir district, Prabumulih city, Muara Enim district, Ogan Komering Ulu district, and Ogan Komering Ulu Timur district (Figure 1). The location of study area between -03°05′33′′S, 104°46′04′′E and -04°16′40′′S, 103°37′57′′E. Ogan watershed devided into 12 sub-watersheds, namely: Ogan Tengah, Rambang, Kuang Besar, Sakatiga, Ual, Gelas, Kisam, Kurup, Ogan Ulu, Ogan Ilir, Kelekar, and Tebangka (Figure 1).

### Data collection

This study used primary data by direct observation at study area and secondary data which were measured and observed by related institutions (Table 1).

### Data Analysis

#### Watershed morphometric condition analysis

The Digital Elevation Model (DEM) data in 2013 with the Pixel Resolution of 20 meters was extracted for Ogan Sub-watersheds morphometric condition. The data obtained were river area, river length, and slope of the sub-watershed.

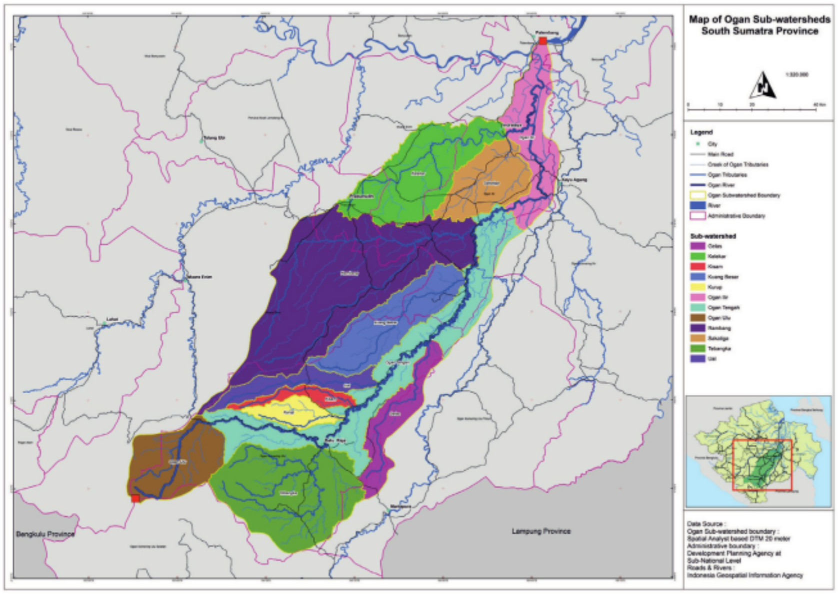


**Fig. 1.** Map of Ogan sub-watersheds

**Table 1.** Data collection

| No. | Data | Year | Source |
|---|---|---|---|
| 1 | Maximum daily precipitation | 2009-2018 | Meteorology, Climatology, and Geophysical Agency (*Indonesian: Badan Meteorologi, Klimatologi, dan Geofisika, abbreviated BMKG*) South Sumatra |
| 2 | Digital Elevation Model (DEM) | 2013 | Geospatial Information Agency (*Indonesian: Badan Informasi Geospasial abbreviated BIG*) |
| 3 | Sentinel Satellite Imagery Maps | 2019 | Copernicus Open Access Hub European Union |
| 4 | Soil type | 2013 | Sumatra River Basin Center VIII(*Indonesian: Balai Besar Wilayah Sungai Sumatra VIII, abbreviated BBWSS)* |

### Land use analysis

The sentinel Satellite Imagery Maps was extracted for analyzing land use, and soil type to determine value of CN and % impervious. The characteristic of soil texture in study area is categorized as B type, sandy loam.

### Climatology analysis

### Rainfall intensity

Rainfall intensity is calculated using the Mononobe method. The maximum daily precipitation of 2009-2018 were collected and calculated using the thiessen polygon method. Then, rainfall frequency was calculated using average rainfall, standard deviation (S), coefficient of variation (Cv), and skewness coefficient (Cs). Design rainfall analysis was calculated using 4 different methods with return periods of 2, 5, 10, 25, 50, and 100 years. The methods used were: normal, normal log, gumbel, and log person type III. Based on Smirnov-Kolmogorov distribution fit test, Log person type III was the best design rainfall. The results obtained in the form of an IDF (Intensity Duration Frequency) curve with 10 minutes intervals for 360 minutes.

### Hyetograph Alternating Block Method (ABM)

Design rain distributed into hourly rain (hyetograph) is required for design flood calculations. Hyetograph from the IDF curve was created with Hyetograph Alternating Block Method (ABM). The Hyetograph ABM method is rain occurrence in sequential time series intervals with duration "t during time td = n x "t. For certain return periods, the rainfall intensity is obtained from the IDF curve at each time duration "t, 2"t, 3"t, and so on.

### Flood Discharge Hydrograph Analysis

Flood Discharge Hydrograph Analysis uses the Soil Conservation Service (SCS) method with the assistance of HEC-HMS 4.3 software by inputting characteristic of sub-watersheds base on the morphometric condition in watershed, geomorphology, and climatology. The parameters used were: watershed area, length river, slope, CN (curve number), impervious percentage, hourly rainfall (hyetograph), initial abstraction value, concentration time, and lag time. The schematic model created in HEC-HMS 4.3 were the duplication of the Ogan River geometry. Modeling was done with 3 days duration and a peak discharge hydrograph obtained with a certain return period.

### Calibration

Calibration was carried out by measuring river discharge directly. Measurements were conducted at the downstream point of the study area.

## Results and Discussion

### Watershed Morphometric Condition Analysis

The hydrological characteristics of a watershed are influenced by its natural character called morphometry. The morphometric condition of Ogan sub-watersheds analysed were river area and length (Table 2). The data was obtained from the delineation of the Digital Elevation Model. Acorrding to Hirpa et al. (2010) watershed area is one of the most important parameters in analysing river flow. The total area of the Ogan Watershed was 841,721 ha, classified as a large watershed. Among 12 Ogan sub-watersheds, 9 sub-watersheds classified as small (10,000 - <100,000 ha) and 3 sub-watersheds classified as medium (100,000 - <500,000 ha). The river length is the distance from the source of river channel to a given point or to the outlet (Dixon and Uddameri, 2016). Based on the results of morphometric analysis, the length of Ogan sub-watershed was of 343.19 km. The longest sub-watershed was Ogan Tengah of 251.90 km and the shortest was Kurup sub-watershed of 33.78 km.

**Table 2.** Sub-Watersheds Morphometric Condition

| No | Sub-watershed | Sub-watershed area (ha) | River length (km) |
|---|---|---|---|
| 1 | Ogan Tengah | 125,625 | 215.90 |
| 2 | Rambang | 202,448 | 137.00 |
| 3 | Kuang Besar | 64,472 | 73.07 |
| 4 | Sakatiga | 46,407 | 36.15 |
| 5 | Ual | 26,966 | 64.16 |
| 6 | Gelas | 36,975 | 68.00 |
| 7 | Kisam | 14,058 | 44.43 |
| 8 | Kurup | 18,173 | 33.78 |
| 9 | Ogan Ulu | 57,767 | 46.29 |
| 10 | Ogan Ilir | 49,791 | 81.00 |
| 11 | Kelekar | 85,882 | 79.10 |
| 12 | Tebangka | 113,157 | 53.88 |
| | Total | 841,721 | |

### Geomorphology Analysis

The hydrological characteristics of the watershed is strongly influenced by land use. The more impermeable area resulted a greater runoff discharge. The sentinel Satellite Imagery Maps was extracted for analyzing land use. The land use analysis of each sub-watershed (Table 3). Ogan Sub-watershed was dominated by rubber plantations, oil palm plantations and dryland forests which have higher ability in absorbing water compared to road network, open land, and settlements.

### Climatology Analysis

### Rainfall intensity

Rainfall intensity analysis was conducted to determine the amount (depth) of rainfall that occurs in the period of time where water is concentrated. Intensity Duration Frequency (IDF) curves represent the amount of rainfall within a period of time in catchment areas (Elsebaie, 2012). In this study, IDF curve created to show the relationship between intensity and duration of design rainfall for each return period of 10 minutes for 6 hours. IDF curve of Ogan sub-watersheds for 2 years, 5 years, 10 years, 25 years, 50 years, and 100 years return period (Fig. 2). Results showed that the highest rainfall intensity is at 10 minutes, while the lowest rainfall intensity is

**Table 3.** Land use of each sub-watersheds

| No | Land use | Land use area of each sub-watershed (Ha) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ogan Tengah | Rambang | Kuang Besar | Sakatiga | Ual | Gelas | Kisam | Kurup | Ogan Ulu | Ogan Ilir | Kelekar | Tebangka | Total |
| 1. | Dry land forest | 5,488 | 17,848 | 4,121 | 425 | 5,519 | 3,576 | 1,363 | 887 | 45,943 | 388 | 2,371 | 51,760 | 139,689 |
| 2. | Road network | 207 | 217 | 50 | 90 | 10 | 49 | 13 | 17 | 25 | 124 | 241 | 108 | 1,151 |
| 3. | Open area | 3,078 | 3,908 | 411 | 615 | 1,085 | 656 | 605 | 289 | 187 | 2,345 | 861 | 4,933 | 18,973 |
| 4. | Mixed plantation | 5,880 | 23,816 | 4,848 | 8,082 | 1,930 | 946 | 2,343 | 2,793 | 4,094 | 1,875 | 10,064 | 8,771 | 75,442 |
| 5. | Rubber plantation | 68,157 | 93,176 | 23,895 | 9,243 | 8,972 | 26,205 | 3,859 | 3,527 | 5,074 | 2,578 | 46,918 | 35,888 | 327,492 |
| 6. | Oil palm plantation | 15,034 | 39,472 | 24,784 | 4,301 | 8,552 | 1,148 | 5,554 | 10,019 | 545 | 2,880 | 6,818 | 2,765 | 121,872 |
| 7. | Sugarcane plantation | 591 | 8,394 | 3,329 | 13,345 | 3 | 33 | - | 14 | 21 | 1,456 | 4,201 | 444 | 31,831 |
| 8. | Settlement | 5,542 | 4,623 | 1,038 | 2,045 | 191 | 1,638 | 178 | 173 | 179 | 5,139 | 6,171 | 1,395 | 28,312 |
| 9. | Swamp | 8,193 | 5,589 | 1,149 | 4,459 | 312 | 525 | 29 | 174 | 415 | 18,965 | 3,754 | 866 | 44,430 |
| 10. | Swamp grass | 5,168 | 1,471 | 384 | 482 | 8 | 742 | 21 | 117 | 234 | 2,179 | 1,277 | 1,101 | 13,184 |
| 11. | Irrigated paddy field | 3,126 | 1,845 | 413 | 2,174 | 164 | 791 | 91 | 50 | 766 | 14,858 | 1,635 | 2,117 | 28,030 |
| 12. | Shrub | 2,879 | 918 | - | 686 | 198 | 454 | - | - | 91 | 1,457 | 954 | 461 | 8,098 |
| 13. | River | 1,778 | 428 | 1 | 75 | 1 | 32 | 2 | 4 | 154 | 1,383 | 326 | 249 | 4,433 |
| 14. | Mixed plants | 504 | 743 | 49 | 385 | 21 | 180 | - | 109 | 39 | 67 | 291 | 2,299 | 4,687 |

at 360 minutes or equal to 6 hours for each return period of 2 years, 5 years, 10 years, 25 years, 50 years, and 100 years. This result indicated that the smaller of rain occurs in a short time, the greater rain intensity. Conversely, the bigger of rain occurs in a long time, the smaller rain intensity. The highest rain intensity showed in return period of 100 years in all 12 sub-watersheds. However, the amount of rainfall intensity was varied with the highest amount of 200 to 370 mm $h^{-1}$ in 5 sub-watersheds, namely Ogan Ilir, Kelekar, Sakatiga, Rambang, and Kuang Besar.

### Hyetograph of Alternating Block Method (ABM)

Depth of hourly rainfall analysis (hyetograph) of design rainfall data used for the calculation of flood design. Hyetograph analysis designed for Ogan sub watersheds for each return period with 10 minutes intervals for 6 hours. The depth of the rain is obtained by multiplying the rainfall intensity with the duration of rain. The difference between successive rain depth values is the increase in rainfall in the time interval “t. The highest depth of the rain occurred at 180 minutes and the lowest depth at 360 minutes and 10 minutes. Base on the hyetograph analysis, the highest depth of hourly rainfall at 180 minutes in Ogan Sub- watersheds for 2 years, 5 years, 10 years, 25 years, 50 years, and 100 years return period (Figure 3). The highest dept was more than 80 mm showed in Rambang and Kuang Besar sub-watershed.

### Soil Conservation Service (SCS) Method

Flood hydrograph modeling used the SCS-CN Synthetic Unit Hydrograph method with the help of HEC-HMS 4.3 software. The data compulsory data needed for the analysis including hourly rainfall (hyetograph), the area of the watershed, river length, curve number (CN), impervious percentage, potential water retention, initial abstraction value, slope, concentration time, and lag time (Table 4).

CN value determine the land use and soil type of the catchment area. More impervious land surface and lower soil permeability resulted the greater CN value, while smaller impervious and higher soil permeability resulted smaller CN value. The present study revealed that, the highest CN value found in Kurup sub-watershed followed by Kuang Besar and Kisam sub-watersheds. Kousari *et al.* (2010) reported that CN strongly effect peak discharge. CN increment will exponentially peak dis-

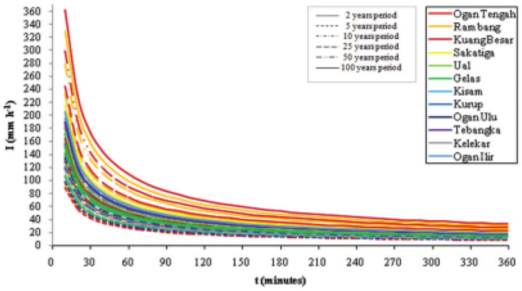


**Fig. 2.** IDF curve of Ogan Sub-watersheds

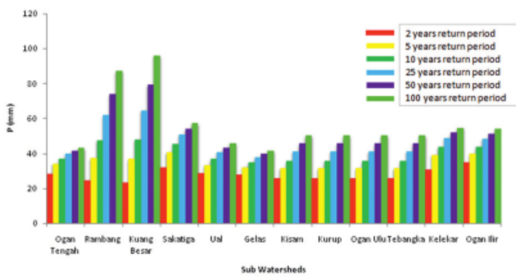


**Fig. 3.** The highest depth of hourly rainfall in Ogan Sub-watersheds

charge, especially in high return period and watershed area. Thus, high CN will increase runoff and decrease the time of concentration. Concentration time is the time taken by water particles to flow from the farthest point in a rain catchment area to the outlet point. Result of this study was inconsistent with previous study, which highest CN (70.87) in Kurup did not showed the lowest time of concentration (39.15 hours). CN had been reported to be affected by land use change (Rietz and Hawkins, 2004). In addition, CN influencing water saturation in soil. A greater CN will decrease the potential water retention value, which means lowered infiltration. Potential water retention (S) is the maximum infiltration in which condition of soil pores are full of water. The highest potential water retention value found in Tebangka sub-watershed (141.95 mm), while the lowest in Kurup sub-watershed (104.42 mm).

Initial abstraction (Ia) is the amount water lost before occurrence of surface runoff due to surface storage and intercept influenced by the potential water retention. In linear with the largest potential water retention value, the highest Ia value was also in Tebangka sub-watershed at 28.39 mm and the lowest in Kurup sub-watershed at 20.88 mm.

Concentration time determine the time spend for the flow of water particles from the farthest point in a rain catchment to the outlet point. Concentration time influenced by the river length (L), potential water retention (S), and slope (Y). Concentration time counts between rain stop until the peak discharge. While, time lag indicated the time between the occurrence of rain until the peak discharge and mainly affected by concentration time. The greatest concentration time and lag time were found in Rambang sub-watershed. These characteristics decrease the speed of water particles flow compared to other sub-watersheds. In contrary, the lowest con-

**Table 4.** Characteristic of sub-watersheds used for synthetic unit hydrograph of SCS-CN

| No | Sub-watershed | Sub-watershed area ($km^2$) | River length (km) | *Curve Number* | % *Impervious* | Potential water retention (mm) | Initial abstraction (mm) | Slope (%) | Concentration time (hour) | Lag time (hour) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Ogan Tengah | 1256.25 | 215.90 | 69.27 | 4.78 | 112.69 | 22.54 | 0.94 | 142.06 | 85.24 |
| 2 | Rambang | 2024.48 | 137.00 | 70.20 | 3.49 | 107.81 | 21.56 | 0.30 | 168.93 | 101.36 |
| 3 | Kuang Besar | 644.72 | 73.07 | 70.59 | 3.03 | 105.82 | 21.16 | 0.27 | 106.66 | 63.99 |
| 4 | Sakatiga | 464.07 | 36.15 | 70.24 | 4.88 | 107.59 | 21.52 | 0.10 | 100.95 | 60.57 |
| 5 | Ual | 269.66 | 64.16 | 69.76 | 2.57 | 110.09 | 22.02 | 0.54 | 69.83 | 41.90 |
| 6 | Gelas | 369.75 | 68.00 | 70.09 | 4.77 | 108.37 | 21.67 | 0.27 | 102.66 | 61.59 |
| 7 | Kisam | 140.58 | 44.43 | 70.39 | 2.95 | 106.86 | 21.37 | 0.56 | 50.47 | 30.28 |
| 8 | Kurup | 181.73 | 33.78 | 70.87 | 2.71 | 104.42 | 20.88 | 0.58 | 39.15 | 23.49 |
| 9 | Ogan Ulu | 577.67 | 46.29 | 67.39 | 2.23 | 122.90 | 24.58 | 3.21 | 23.51 | 14.10 |
| 10 | Ogan Ilir | 497.91 | 81.00 | 67.80 | 7.65 | 120.62 | 24.12 | 0.31 | 119.07 | 71.44 |
| 11 | Kelekar | 858.82 | 79.10 | 70.17 | 6.48 | 107.97 | 21.59 | 0.14 | 158.49 | 95.09 |
| 12 | Tebangka | 1131.57 | 53.88 | 64.15 | 3.00 | 141.95 | 28.39 | 0.89 | 54.90 | 32.94 |
| | Total | 8417.21 | | | | | | | | |

centration time and pause time found in Ogan Ulu watershed. The low values of concentration and lag time indicated that flow acceleration and water concentration at the slope base during torrential rainfall occurrence would cause a rapid transmission of flood and exponential growth of discharge in a short time (Costache, 2014).

### HEC-HMS 4.3 Modelling

The model scheme built on the HEC-HMS 4.3 program is in the form of geometry duplication of the Ogan River and flow patterns in to the Ogan River (Figure 4). Then data of sub-watersheds characteristic inputted (Table 4). Modeling of peak discharge

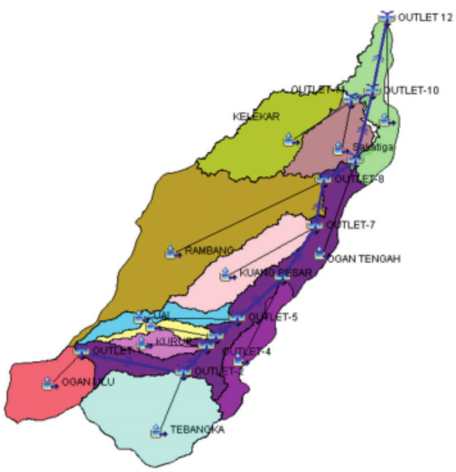


**Fig. 4.** Ogan River Hydrological Modeling Scheme

hydrograph in Ogan watershed for 2 years return period (Figure 5). The top six largest sub-watersheds were Rambang, Ogan Tengah, Tebangka, Kelekar, Kuang Besar, and Ogan Ulu sub-watersheds. However, Ogan Ulu sub-watershed is the shorter sub-watershed but largest slope, the result show that Ogan Ulu sub-watershed having the highest peak discharge value. In addition, Tebangka has shorter length river with a large slope, these characteristics caused a widened watershed shape and let the second highest peak discharge after the Ogan Ulu sub-watershed.

A simulation of the peak discharge of Ogan sub-watershed was conducted for 3 days (Table 5). This simulation revealed that the largest peak discharge was in the Ogan Ulu sub-watershed of 180.9 $m^3 s^{-1}$ and the lowest peak discharge was in the Kisam sub-watershed of 24.7 $m^3 s^{-1}$. This phenomenon occurred because of the interaction inputted parameters which influence each other, such as sub-watershed area, river length, curve number, impervious percentage, potential water retention, initial abstraction, slope, concentration time, and lag time.

Due to the limitation of measurement discharge data, calibration was carried out by measuring river discharge three times during the dry and rainy season by using a current meter. Measurements were made at the downstream point of the research area in outlet 12. The highest discharge was obtained during the rainy season on June 1, 2020 with an average velocity of 9.53 m $s^{-1}$, a wet cross-sectional area of 52.75 $m^2$, and a discharge of 502.72 $m^3 s^{-1}$.

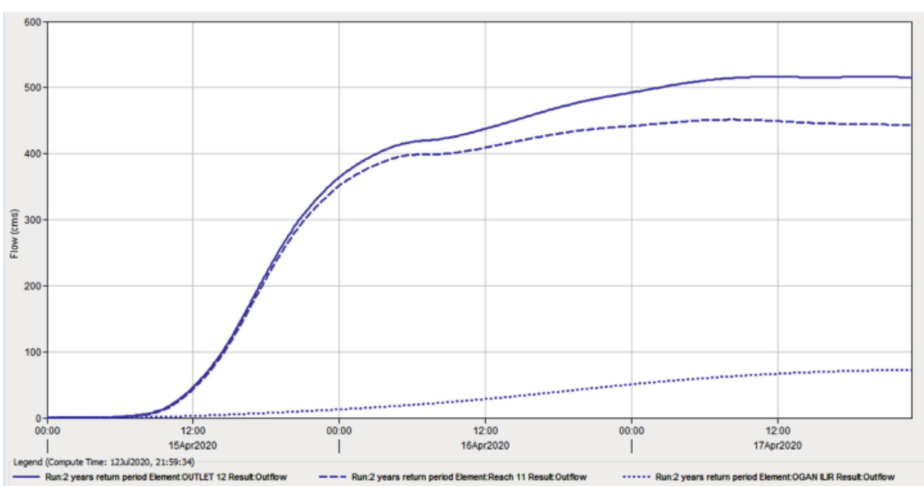


**Fig. 5.** Hydrograph of peak discharge in Ogan watershed for 2 years return period

**Table 5.** Simulation of peak discharge

| No | Sub watershed | Rain duration (hour) | Peak time (hour) | Q peak for each return periode ($m^3/s$) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 2 years | 5 years | 10 years | 25 years | 50 years | 100 years |
| 1 | Ogan Tengah | 16.33 | 81.85 | 86.7 | 122.9 | 142.1 | 162.3 | 174.8 | 185.7 |
| 2 | Rambang | 12.77 | 63.98 | 73.8 | 167.0 | 249.1 | 377.2 | 490.6 | 619.4 |
| 3 | Kuang Besar | 8.91 | 44.66 | 44.5 | 107.2 | 166.8 | 264.8 | 355.2 | 461.4 |
| 4 | Sakatiga | 12.28 | 61.52 | 63.7 | 97.6 | 117.6 | 140.1 | 154.7 | 168.7 |
| 5 | Ual | 6.69 | 33.52 | 41.1 | 54.8 | 65.9 | 78.7 | 87.5 | 95.7 |
| 6 | Gelas | 7.19 | 36.03 | 38.4 | 50.5 | 58.5 | 67.6 | 73.7 | 79.3 |
| 7 | Kisam | 6.67 | 33.42 | 24.7 | 36.7 | 46.0 | 59.4 | 70.2 | 82.1 |
| 8 | Kurup | 5.12 | 25.66 | 41.9 | 62.1 | 77.7 | 100.2 | 118.3 | 138.2 |
| 9 | Ogan Ulu | 2.65 | 13.26 | 180.9 | 277.4 | 353.3 | 463.3 | 553.4 | 652.4 |
| 10 | Ogan Ilir | 12.25 | 61.40 | 72.4 | 91.6 | 107.9 | 126.7 | 139.5 | 151.4 |
| 11 | Kelekar | 14.12 | 70.75 | 59.9 | 91.9 | 110.3 | 131.6 | 144.7 | 156.3 |
| 12 | Tebangka | 3.90 | 19.55 | 130.2 | 204.4 | 263.6 | 350.3 | 422.0 | 501.2 |
| 13 | Ogan watershed | 32.37 | 162.21 | 516.4 | 838.7 | 1089.8 | 1445.2 | 1737.9 | 2058.6 |

The results of modeling with the help of HEC-HMS 4.3 software with a return period of 2 years obtained a peak discharge of 516.4 $m^3 s^{-1}$. Thus, the results of the peak discharge simulation similar with the measurement discharge in the field during the rainy season. A bit greater value of the peak discharge simulation because the measurement results in the field were not at the peak time.

The flood peak discharge of the Ogan sub-watershed calculated with a 25-year return period was 1227.09 $m^3 s^{-1}$ (Farid *et al.*, 2017). Based on the comprehensive study of water management in the Musi watershed of Indonesia. The peak discharge of the Ogan sub-watershed with a 25-year return period was 1168 $m^3 s^{-1}$ (Ministry of Public Works Republic of Indonesia Water Resources Management, 2003). In this present study. the peak discharge of the Ogan sub-watershed calculated based on the division of 12 sub-watersheds which the results of peak discharge the simulation in 12 downstream outlets with a return period of 25 years was 1445.2 $m^3 s^{-1}$. Based on the simulation results. the peak discharge obtained were almost similar but greater than the simulation results from previous studies. It caused by the different series rain data from the past with more update data at present.

## Conclusion

The total area of the Ogan Watershed is 841,721 ha, which is classified as a large watershed with a length of 343.19 km. Ogan watershed divided into 12 sub-watersheds, namely Ogan Tengah, Rambang, Kuang Besar, Sakatiga, Ual, Gelas, Kisam, Kurup, Ogan Ulu, Ogan Ilir, Kelekar, and Tebangka. Ogan sub-watersheds were dominated by rubber plantations, oil palm plantations, and dry land forests. The highest depth of the rain occurred at 180 minutes and the lowest depth at 360 minutes and 10 minutes. Result of hydrological model using HEC-HMS 4.3 software presented a peak discharge hydrograph with a return period of 2 years from 12 sub-watersheds revealed that Ogan Ulu sub-watershed had the highest discharge of 180.9 $m^3s^{-1}$ and the lowest was Kisam sub-watershed at 24.7 $m^3 s^{-1}$. The results of the overall peak discharge analysis of the Ogan watershed with a return period of 2 years is equal to 516.4 $m^3 s^{-1}$.

## Acknowledgement

Authors would like to express gratitude to Graduate Program of Sriwijaya University, Meteorology, Climatology, and Geophysical Agency of South Sumatra, Geospatial Information Agency, Copernicus Open Access Hub European Union, and Sumatra River Basin Center VIII for providing secondary data of this manuscript. Authors thank the reviewers and editor of this journal for their comments and suggestions for the manuscript improvement.

## Reference

Al Amin, M.B., Sarino, Haki, H. 2017. *Floodplain simulation for Musi River using integrated 1D/2D hydrodynamic* *model*. MATEC Web of Conferences, 1–6.

Brindha, K. and Pavelic, P. 2016. Identifying priority watersheds to mitigate flood and drought impacts by novel conjunctive water use management. *Environ Earth Sci.* 75 : 399.

Case, M., Ardiansyah, F. and Spector, E. 2007. Climate Change in Indonesia Implications for Humans and Nature. Climate change in Indonesia: implications for humans and nature.

Costache, R. 2014. *Using gis techniques for assessing lag time and concentration time in small river basins*. Case study: Pecineaga river basin, Romania. *Geogr. Tech.* 9 : 31–38.

Daniel, E.B. 2011. Watershed Modeling and its Applications: A State-of-the-Art Review. *Open Hydrol J.* 5: 26–50.

Dixon, B. and Uddameri, V. 2016. *GIS and Geocomputation for Water Resource Science and Engineering*. GIS and Geocomputation for Water Resource Science and Engineering.

Elsebaie, I.H. 2012. Developing rainfall intensity–duration–frequency relationship for two regions in Saudi Arabia. *J King Saud Univ - Eng. Sci.* 24 : 131–140.

Farahani, S., Soheili-Fard, F. and Amin Asoodar, M. 2016. Effects of contour farming on runoff and soil erosion reduction. *Elixir Agric*. 101 : 44089–44093.

Farid, M., Marlina, A. and Kusuma, M.S.B. 2017. Flood hazard mapping of Palembang City by using 2D model. *AIP Conference Proceedings*. 1–11.

Fulazzaky, M.A. 2014. Challenges of integrated water resources management in Indonesia. *Water* (Switzerland), 6 : 2000–2020.

Hirpa, F.A., Gebremichael, M. and Over, T.M. 2010. River flow fluctuation analysis: Effect of watershed area. *Water Resour Res*. 46 : 10.

Jia, C., Sun, B., Yu, X. and Yang, X. 2020. Analysis of runoff and sediment losses from a sloped roadbed under variable rainfall intensities and vegetation conditions. *Sustain*. 12 : 2077.

Kousari, M.R., Malekinezhad, H., Ahani, H. and Asadi Zarch, M.A. 2010. Sensitivity analysis and impact quantification of the main factors affecting peak discharge in the SCS curve number method: An analysis of Iranian watersheds. *Quat. Int.* 226 : 66–74.

Ministry of Public Works Republic of Indonesia Water Resources Management. 2003. *Comprehensive Water Management Study in the Musi River Basin in the Republic of Indonesia* (In Indonesian). Japan International Cooperation Agency: CTI Engineering International. Co., Ltd.: NIKKEN Consultants, Inc., Indonesia.

Miralti, A., Saggaff, A. and Sarino. 2020. The effects of the watershed characteristics on ogan river flood discharge. *Int J Sci Technol Res*. 9 : 4164–4167.

Pramono, I.B. and Putra, P.B. 2017. Watershed typology for flood mitigation in Musi Watershed. *Journal of Wathershed Management Research*. 1(2): 143-165.

Ramírez, J.A. 2010. Prediction and Modeling of Flood Hydrology and Hydraulics. *Inland Flood Hazards*. 1–53.

Rietz, D.A. and Hawkins, R.H. 2004. *Effects of land use on runoff Curve Number*. Watershed Management and Operations Management, India.

Roy, S. and Mistri, B. 2013. Estimation of Peak Flood Discharge for an Ungauged River: A Case Study of the Kunur River, West Bengal. *Geogr J*. 1–11.

Tegegne, G., Park, D.K. and Kim, Y.O. 2017. Comparison of hydrological models for the assessment of water resources in a data-scarce region, the Upper Blue Nile River Basin. *J Hydrol Reg Stud*. 14 : 49–66.

Wang, G., Mang, S., Cai, H., Liu, S., Zhang, Z., Wang, L. and Innes, J.L. 2016. Integrated watershed management: evolution, development and emerging trends. *J for Res.* 27 : 967–994.

Yasril, Y., Aprizal, A., On A.N.-I.C. 2019, U. 2017. Evaluation Calculation of Flood Design with Hydrograph Method Nakayasu, Limantara and Snyder in Catchhement River Way Tebu. *International Conference on Engineering and Technology Development (ICETD).* 60-69.

Yilmaz, H., Göl, C. and Edis, S. 2011. The importance of watershed characteristics in integrated watershed management (a case of Gökdere watershed, Turkey). *Fresenius Environ Bull*. 20 : 3126-3134.

# Hydrological characteristics analysis of Ogan Watershed

ORIGINALITY REPORT

| 17% | 15% | 12% | 9% |
|---|---|---|---|
| SIMILARITY INDEX | INTERNET SOURCES | PUBLICATIONS | STUDENT PAPERS |

MATCH ALL SOURCES (ONLY SELECTED SOURCE PRINTED)

1%

★ garuda.kemdikbud.go.id

Internet Source

| | | | |
|---|---|---|---|
| Exclude quotes | Off | Exclude matches | Off |
| Exclude bibliography | Off | | |