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RESEARCH ARTICLE

Analysis of Water Availability in the Upper Siak Basin Using the GR2M Model Application

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Abstract

The Siak watershed is one of the critical watersheds, where natural disasters such as floods, landslides and erosion often occur in this area. The Siak watershed has 4 main sub-watersheds, namely the Tapung Kanan sub-watershed, the Tapung Kiri sub-watershed, the Mandau sub-watershed and the Siak Hilir sub-watershed. The existence of these 4 sub-watersheds is also not able to meet the water needs of the community due to the rapid development of the region which will then cause the demand for water to continue to increase in line with the rate of population growth, especially in the Siak watershed area. Fulfillment of food needs and population activities is always closely related to the need for water. These demands cannot be avoided, but must be predicted and planned for the best possible use. The purpose of this study is to describe the application of the GR2M modeling and the amount of raw water availability in the Upper Siak Watershed.

The research method used is descriptive quantitative with data collection techniques in the form of map data, rain data, climatology data and field discharge data. And the research location is in the Upper Siak Watershed, namely the Tapung Kiri Sub-watershed.

The results of the study show that 1) GR2M modeling can be applied to the Tapung Kiri Sub-watershed with an R2 performance of 0.41 with a satisfactory interpretation, a correlation coefficient (R) of 0.67 with a strong interpretation, and an efficiency coefficient (CE) of 0.59 with sufficient optimization interpretation. The reliable discharge obtained based on the GR2M modeling data for the availability of drinking water (Q99%) in the Siak Hulu watershed is 15.69 m3/second.

Keywords: Tapung Kiri Sub-watershed, Evapotranspiration, GR2M

1. Introduction

1.1 Sub Introduction

The Siak watershed is a critical watershed, an area prone to flooding and landslides, erosion and siltation, as well as various kinds of pollution (PU, 2019). The Siak watershed has the potential to experience problems in the form of water availability that is unable to meet community needs. It was recorded that in 2018 the population of Riau Province based on data from the Central Statistics Agency (BPS) was 6,717,612 people with an area of 87,023.66 km2 (BPS Riau, 2022). The increase in population every year in Riau Province (especially in the Siak Watershed) will affect the level of development in the region, both infrastructure and infrastructure structure.

The Siak watershed consists of four sub-watersheds, namely the Tapung Kanan sub-watershed, the Tapung Kiri sub-watershed, the Mandau sub-watershed and the Siak Hilir sub-watershed (Ilva et al., 2020).

Water resources management is an effort to plan, implement, monitor, and evaluate the implementation of water resources conservation and control of the destructive power of water (Permen SDA, 2009). In managing water resources, debit data is needed so that it can be implemented properly.

Based on the problems mentioned above, the limited availability of water in the upstream Siak watershed can be an indicator that the condition of the watershed has been damaged and has an impact on the sustainability of the availability of raw water in the upstream Siak watershed. Considering that the problem of the upstream Siak river is quite complex and there are still very few studies regarding the availability of raw water in the upstream Siak watershed. So, researchers are interested in conducting research with the title, "Application of the GR2M Model for Analysis of Raw Water Supply in the Upstream Siak Watershed".

The discussion this time is to find out whether the GR2M modeling can be applied to the Tapung Kiri sub-watershed or not and to determine the amount of raw water availability in the Upper Siak watershed using data from the GR2M modeling results.

To obtain specific results, this research is limited to being carried out in the Upper Siak Watershed, namely the Tapung Kiri Sub-watershed which has a watershed area of 177,122, 23 Ha2. Rainfall data stations around the watershed studied are Batu Bersurat station, Ujung Batu station, Station Petapahan Baru, and Silam stations, use climatological data from Pasar Kampar station, hydrological data used from 2004-2020 (BWSS III, 2020), potential evapotranspiration analysis using the CROPWAT 8.0 program which is the program output of FAO (Food and Agriculture Organization), the results of the calculation of the mainstay debit are planned for the availability of drinking water use, in this study it does not discuss the community's water needs for available water.

2. Method

In this study using a quantitative descriptive method. Quantitative descriptive is a type of research that is used to analyze data by describing or describing the data that has been collected as it is. To support this research, secondary data is needed. Secondary data is a source of research data obtained indirectly in the form of books, notes, existing evidence or archives, both published and not published in general. These data include rainfall data at several stations around the watershed, namely Batu Bersurat station, Ujung Batu station and Petapahan Baru station, climatological data for Pasar

Kampar station, discharge data for Pantai Cermin station, river AWLR data for Pantai Cermin station which are used as filler for discharge data. unknown, the data catchment area of the Upper Siak Basin, namely the Tapung Kiri Sub-Das.

The stages in this study are determining the regional rainfall value, calculating the evapotranspiration value (ET0), calculating the flow rate value, determining the GR2M simulated rain value, determining the GR2M supply (model performance), and calculating the reliable discharge value.

2.1. Determine the area's rainfall value

Rain measuring stations only provide rain depth at the point where the station is located, so the rain in an area must be estimated from that measurement point. If in an area there is more than one measurement station that is placed scatteredly, the rainfall recorded at each station may be different. In hydrological analysis it is necessary to determine the average rainfall or regional rainfall in the area, which can be done by three methods namely the arithmetic average (algebraic) method, the Thiessen polygon method, and the isohyet method.

The following is a perimeter for determining the method that can be used to calculate regional rainfall,

Table 1. Use of the Regional Rain Method

Method	Wide (Ha)	Number of stations
Aritmatik	250 – 50.000	2 or 3
Poligon Thiessen	50.000 – 500.000	>3
Isohiet	>500.000	>3

Source: (Riki Rahmad, 2017)

Based on the perimeter above, the method used in this study is the Thiessen polygon method. The steps for forming Thiessen polygons are as follows:

The rain recording stations are depicted on the map of the studied watershed, including rain stations outside the adjacent watershed as shown in (Figure 1).

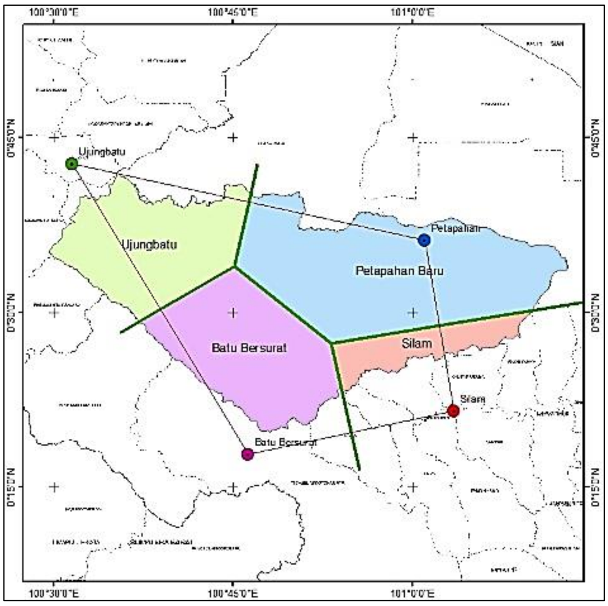

Fig 1. Map of the Thiessen polygon area

These stations are connected by a straight line (dotted line).

Draw a perpendicular line in the middle of the connecting line as shown in Figure 1

These lines (Step 3) will form a polygon surrounding each station. Each station represents the area formed by the polygon. For stations that are near the watershed boundary, the watershed boundary line is a polygon delimiter.

The area of each polygon is measured and then multiplied by the rain depth recorded at the station within the polygon.

The sum of the calculations in Step 5 for all stations is divided by the area under consideration to yield the average rainfall for that area. Mathematically it can be calculated by the following equation,

$$\bar{p} = \frac{A_1 p_1 + A_2 p_2 + \ldots\ldots + A_n p_n}{A_1 + A_2 + \ldots\ldots + A_n} \quad (1)$$

where:

$\bar{p}$	:	area average rainfall
p1, p2,….., pn	:	rain at station 1,2,3,…..,n
$A_1, A_2, \ldots.., A_n$	:	the area of the area representing stations 1,2,3,….,n

2.2. Calculating the value of evapotranspiration (ET0)

Evapotranspiration is evaporation that occurs on the land surface, which includes the soil surface and the plants that grow on that surface. The rate of evapotranspiration is expressed by the volume of water lost by the process per unit area in one unit of time which is usually given in mm/day or mm/month.

Based on research in wet areas (humid) published in FAO paper 56, the Penmann-Monteith method is the best method compared to other methods in calculating the amount of evapotranspiration of reference plants. The (Penmann-Monteith) method has been compiled in SNI 7745:2012 which can be formulated in the following equation,

$$ET_0 = \frac{0{,}408 R_n + \gamma \frac{900}{(T+273)} U_2 (e_s - e_a)}{\Delta + \gamma(1 + 0{,}34 U_2)} \quad (2)$$

where:

ET_0	:	evapotranspiration of reference plants, (*mm/day*).
R_n	:	net solar radiation above the plant surface, (*MJ/m2/day*).
T	:	average air temperature, (°*C*).
U_2	:	wind speed at a height of 2 m from the ground, (*m/s*).

In this study the Cropwat 8.0 program was used which was developed by FAO based on the Penman-Monteith method. The steps for using CropWat 8.0 to calculate the evapotranspiration value are as follows,

1. Prepare climatological data in the form of
   a. Locations of observation points include city name, station name, altitude, latitude and longitude.
   b. Monthly maximum air temperature (°*C*).
   c. Monthly minimum air temperature (°*C*).
   d. Monthly average wind speed (Km/Day).
   e. Broadcasting average every month (*%*).
   f. Average air humidity per month (*%*).
2. Open the Cropwat 8.0 application, select Climate/ET0 then a display will appear.
3. Enter the previously prepared data (Step 1) into the Cropwat 8.0 application according to the fields provided.
4. The daily ET0 value will be automatically obtained in one month in the ET0 column or the last yellow column. Then do a copy-paste into MS.Excel to recapitulate the ET0 data.
5. Because the results obtained are only for a certain year, do steps 1 to 4 repeatedly until the required data is sufficient
6. Do a recapitulation in MS.Excel and calculate the monthly ET0 to then be included in the GR2M modeling

5.3. Calculating the value of the flow rate

The flowrate value needed to determine the reliable value is the discharge data from 2004 – 2020 obtained from BWS III.

Not all of the data for 17 years is available, so it is necessary to do a calculation to determine the discharge value that is not available by converting AWLR data into discharge data using the calibration bend equation that has been determined by BWS III based on the Manning method, namely,

$$Q = 13{,}478 \times (H + 0{,}384)^{1{,}580} \tag{3}$$

where H is the height of the water level in meters.

5.4. Determine the simulated discharge value

GR2M (Global Rainfall-Runoff Model) is a conceptual method based on the concept of water balance. This conceptual method is expressed by an empirical formula that describes the way water flows in a watershed from time to time. DAS is considered as an assembly of interconnected tanks representing storage levels. GR2M is a hydrological model that manages evapotranspiration and rainfall values to obtain discharge values. The steps in using the GR2M program are as follows,

1. Prepare previously processed data such as monthly Evapotranspiration data, monthly Regional Rain Data and Field Debit Data for each month.
2. Open the GR2M program (based on MS.Excel), then select the GR2M sheet.
3. Enter the data prepared in step 1 into the program according to the columns provided (only the yellow column whose value can be changed).
4. Change the values of x1 and x2 in such a way that satisfactory Nash values are obtained. This step is done by trial and error.
5. The results obtained are shown in cell P39, the column "Simule Debit" is the GR2M simulated discharge value. This simulated discharge value is then processed to determine the reliable discharge value.

5.5. Determines the performance of the GR2M model

Model performance analysis is performed to determine the reliability of a hydrological model. In this study the results of the transformation of the GR2M modeling will be tested using statistical indicators. According to (Croke et al, 2005) Evaluation of model accuracy using statistical indicators including R2 and correlation (R). which can be determined by the following formula:

$$R^2 = 1 - \frac{\sum(Q_{Obs} - Q_{sim})^2}{\sum(Q_{obs} - \bar{Q}_{obs})^2} \tag{4}$$

$$R = \frac{\sum(Q_{sim} - \bar{Q}_{sim})\ (Q_{obs} - \bar{Q}_{obs})}{\sqrt{\sum(Q_{sim} - \bar{Q}_{sim})^2\ x\ \sum(Q_{obs} - \bar{Q}_{obs})^2}}$$

where:

Q_{Obs}	:	observation discharge or measured discharge (m3/second).
Q_{sim}	:	simulated discharge or calculated discharge (m3/sec),
$\bar{Q}_{obs}$	:	average measured or observed discharge,
$\bar{Q}_{sim}$	:	average calculated or simulated discharge.

Table 2. Nash-Sutcliffe Efficiency (NSE) Criteria

Nash-Sutcliffe Efficiency (NSE) Score Criteria	Interpretation
NSE > 0,75	Well
0,36 < NSE < 0,75	Fulfill
NSE < 0,36	Does not meet the

Source : (Motolivov, et al, 1999 dalam Putra.As,dkk 2016)

Table 3. Correlation Coefficient Value Criteria

Correlation Coefficient Value (R)	Interpretation
0	No correlation
0 – 0.25	Very weak
0.25 – 0.5	Currently
0.5 – 0.75	Strong
0.75 – 0.99	Very strong
1	Perfect Correlation

Source: (Suwarno, 2008 in Putra.As, et al 2016)

Meanwhile, according to (Hambali, 2008) analysis of model performance can be done using statistical indicators such as Correlation Coefficient (R), Efficiency Coefficient (CE). Each - each can be calculated using the following formula.

$$E = \left[\frac{\sum(Q_{Obs} - Q_{sim})^2}{\sum(Q_{obs} - \bar{Q}_{obs})^2}\right]$$

where:

Q_{obs}	:	observation discharge or measured discharge (m3/second),
Q_{sim}	:	simulated discharge or calculated discharge (m3/sec),
$\bar{Q}_{obs}$	:	average measured discharge or observation.

Table 4. Criteria for the Value of the Efficiency Coefficient

Efficiency Coefficient Value	Interpretation
CE > 0,75	Very Efficient optimazation
0,36 < CE < 0,75	Quite Efficient optimazation
CE < 0,36	Inefficient optimazation

Source: (Hambali, 2008 in Putra.As, et al 2016)

6.6. Calculating the value of Mainstay Debit

The mainstay debit is the final result in this study. The reliability needed for planning the availability of drinking water based on table 3.1 is 99% (Q 99%).

To determine the value of the reliable debit, the method of calculating the discharge duration curve is used based on SNI No. 6738 of 2015

Based on SNI 6738: 2015 reliable discharge is the amount of a certain discharge whose occurrence is associated with a certain recurrence probability. Calculation of reliable discharge using the discharge duration curve method can use the Weibull probability calculation formula as the following equation:

$$P = \frac{m}{n+1} 100\% \tag{7}$$

where:

P	:	the value of the probability of occurrence of an event (%)
m	:	data ranking
n	:	amount of data

According to (Soemarto, 1987) the amount of reliability taken for various purposes of water use is as follows.

Table 5. Amount of Debt Reliability Based on Usability

Need	Mainstay Debt (%)
Drinking water	99
Irrigation Water	95 – 98
Irrigation Water	
- Semi-humid climate areas	70 – 85
- Dry Climate Areas	80 – 95
Hydroelectric Power Plant	85 – 90

Source: (Soemarto, 1987 in Zulkipli, et al 2012)

3. Results and Discussion

1. Regional Rain
   Regional rainfall is one of the most important variables in the GR2M modeling. Rainfall data for the area were obtained using formula 1. The monthly rainfall data recapitulation for the Tapung Kiri Sub-watershed area in 2004-2020 can be seen in table 6.
2. Evapotranspiration
   Monthly evapotranspiration is a variable used in the GR2M modeling. Monthly evapotranspiration was obtained using the Cropwat 8.0 program. for more details, the recapitulation of monthly evapotranspiration data can be seen in table 7.
3. Field Debt
   Field discharge is discharge data obtained from the River Basin Office III [12]. In addition, there are some discharge data obtained through AWLR data processing which are converted into discharge data using formula 3. Field discharge data is needed to be compared with the simulated discharge data from the GR2M modeling results to produce model performance values. The recapitalization of field discharge data for the Siak River at Cermin Beach Station is presented in table 8.
4. GR2M Modeling Simulation Debit
   The simulated discharge is the debit data from the GR2M modeling. The simulation data is used to obtain model performance values by comparing them with field discharges. After processing the data by entering the regional rainfall value and evapotranspiration value, a Nash value of 41.9% was obtained with parameters X1 and X2 of 6.8 and 0.48.

A comparison graph of simulated discharge with field discharge to rainfall can be seen in Figure 2.

Table 6. Monthly Rainfall Recapitulation of the Tapung Kiri Sub-watershed 2004-2020 (mm)

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	197.91	165.58	168.89	387.69	115.65	52.34	192.04	144.16	117.11	407.06	458.43	550.52
2005	183.48	140.13	264.88	177.19	162.44	74.78	235.05	160.03	284.85	271.42	255.65	169.69
2006	237.67	277.81	124.88	257.82	271.11	244.99	83.24	116.43	269.81	186.34	342.25	492.46
2007	335.89	281.37	269.64	478.99	282.04	317.29	219.88	219.73	170.12	467.9	231.91	264.83
2008	278.36	150.07	663.84	324.92	76.16	196.67	123.43	257.74	491.89	289.22	397.85	253.76
2009	220.78	362.07	442.62	262.49	113.91	122.87	108.06	215.38	144.17	268.62	464.3	626.06
2010	339.6	379.75	383.74	438.41	307.09	216.31	434.41	479.6	406.29	169.77	309.6	260.04
2011	442.99	200.7	222.72	374.76	284.96	89.25	29.27	143.7	182.43	270.36	341.86	191.35
2012	241.91	400.09	118.63	308.1	154.7	61.98	235.41	321.15	181.56	451.18	457.87	589.35
2013	130.34	156.68	169.38	107.26	200.83	135.81	92.93	101.62	103.55	96.57	109.64	86.39
2014	59.41	22.62	79.36	37.6	98.82	82.57	26.53	96.9	44.8	83.2	198.23	265.18
2015	118.06	87.24	177.88	257.58	146.64	115.81	28.68	88.71	75.67	118.46	342.48	296.38
2016	161.32	112.86	66.82	80.09	104.67	56.96	66.48	31.28	50.29	38.45	220.47	60.99
2017	174.2	195.61	225	250.43	239.98	98.16	99.33	197.57	301.83	235.82	403.16	446.76
2018	213.23	302.77	311.65	287.14	208.31	214.69	224.56	186.65	297.95	665.34	586.75	527.83
2019	502.64	185.3	162.38	294.65	232.6	376.66	140.27	168.82	165.6	366.42	394.62	463.88
2020	231.19	182.81	330.79	384.97	207.77	178.79	203.89	178.32	266.53	263.27	464.81	253.91
Total annual average rainfall (mm)	4068.98	3603.46	4183.1	4710.09	3207.68	2635.93	2543.46	3107.79	3554.45	4649.4	5979.88	5799.38
Average annual rainfall (mm)	239.35	211.96	246.06	277.06	188.68	155.05	149.61	182.81	209.08	273.49	351.75	341.14
Average(mm)	235.51											

Table 7. Monthly Evapotranspiration Summary of the Tapung Kiri Sub-watershed 2004-2020 (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	108.50	107.59	115.01	118.50	115.01	106.20	106.02	120.90	111.60	114.39	108.30	97.03
2005	99.51	100.24	114.08	117.30	112.22	103.50	108.81	121.52	122.70	126.48	103.80	104.16
2006	110.36	108.64	110.98	104.70	102.92	95.70	99.20	105.40	105.90	108.19	102.00	101.68
2007	97.34	101.08	123.69	119.10	116.87	111.60	106.02	115.63	111.90	115.32	105.90	99.82
2008	113.46	86.13	119.66	110.40	104.16	100.80	106.64	117.49	118.50	128.65	105.00	91.14
2009	95.17	99.68	100.75	92.10	93.31	85.20	88.35	90.21	92.40	95.17	92.70	90.52
2010	109.74	111.44	113.46	105.60	96.72	91.80	97.96	110.36	107.10	113.15	93.00	100.44
2011	84.01	86.24	93.62	89.40	77.19	67.80	73.47	74.09	84.90	99.82	95.40	86.18
2012	111.29	89.32	99.51	108.60	107.88	98.70	105.40	99.82	87.30	87.42	103.50	93.31
2013	108.50	94.36	104.78	99.60	79.36	98.40	105.40	99.82	87.90	107.88	97.20	87.73
2014	79.67	75.04	79.98	93.60	91.76	93.30	95.79	96.10	79.20	115.01	105.00	118.42
2015	105.40	78.68	87.11	87.90	86.18	108.30	99.51	108.19	101.70	100.44	92.70	100.44
2016	110.05	92.22	93.93	92.40	92.69	89.40	104.16	101.06	99.30	99.82	96.30	103.54
2017	112.84	85.12	117.18	103.80	97.65	101.40	104.78	113.77	115.80	122.14	87.90	92.07
2018	90.21	76.44	120.59	110.40	100.13	93.60	3.10	111.91	107.70	103.85	96.00	94.24
2019	127.10	121.52	166.78	156.00	163.99	125.40	155.62	165.23	138.00	151.28	127.50	105.09
2020	122.76	142.10	186.31	150.30	157.17	131.40	143.84	179.18	143.40	140.12	120.30	128.34
Average	105.65											

Table 8. Summary of Field Debit of Sungai Siak, Pantai Cermin, 2004-2020 (m^3/sec)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	61.05	80.52	66.65	109.86	75.64	20.32	24.28	25.49	15.96	56.50	118.15	156.94
2005	133.39	68.51	48.46	66.52	55.60	36.67	32.76	29.38	51.97	57.07	85.70	69.07
2006	62.59	66.94	48.63	72.31	53.54	58.21	21.95	13.99	68.59	47.47	91.03	144.56
2007	127.79	54.49	53.19	127.21	102.31	102.14	65.55	69.88	91.88	114.48	96.45	102.01
2008	82.59	67.42	139.85	92.17	36.33	40.28	31.09	37.84	125.47	108.37	96.42	94.59
2009	75.49	54.04	95.78	89.62	49.43	21.55	20.63	34.11	75.52	36.68	147.57	169.24
2010	128.65	100.25	112.35	103.16	46.55	30.63	65.36	76.66	68.96	54.86	65.25	78.32
2011	132.06	73.46	91.44	89.85	70.01	28.17	16.00	22.62	43.31	55.59	105.12	113.85
2012	63.25	119.66	81.27	116.42	73.23	55.53	37.30	36.65	45.27	97.08	151.32	167.97
2013	59.81	70.25	89.86	53.76	47.25	25.94	19.09	15.18	58.21	120.69	166.51	159.17
2014	50.70	25.94	37.61	47.24	46.89	32.54	19.43	21.67	31.32	61.41	138.67	157.59
2015	87.27	38.22	49.81	59.71	43.98	39.79	8.74	12.62	9.19	13.47	35.12	97.60
2016	107.71	100.17	53.88	60.50	36.98	24.82	12.53	7.77	10.86	5.86	73.96	31.36
2017	23.11	35.08	72.09	79.52	80.11	36.66	40.20	28.61	50.34	47.87	110.97	93.38
2018	92.43	36.57	48.54	58.55	37.59	53.97	30.16	20.76	16.70	77.54	111.04	121.68
2019	81.30	61.90	27.99	41.54	33.17	67.64	24.28	14.37	17.10	30.20	81.20	117.92
2020	67.47	96.17	36.47	65.96	63.03	57.01	42.15	29.76	57.51	35.68	81.24	63.64
Average						65.29						

Table 9. Summary of GR2M Simulated Discharge in the Tapung Kiri Sub-watershed 2004-2020 (m3/sec)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	63.50	34.75	63.17	65.00	35.72	17.35	23.59	18.41	27.45	73.48	76.56	67.32
2005	52.29	29.63	38.66	34.49	35.36	15.69	26.46	55.20	42.47	73.19	79.15	86.76
2006	85.94	56.00	73.69	66.77	45.27	34.27	20.93	33.07	25.46	37.23	49.22	145.21
2007	165.16	63.96	65.39	65.01	50.53	31.22	22.73	24.91	39.08	82.27	66.05	84.47
2008	87.99	52.83	93.92	67.21	31.92	40.77	30.48	47.38	59.98	59.58	73.80	108.47
2009	77.93	56.12	101.36	68.76	34.05	19.16	18.16	38.45	51.60	63.03	85.05	140.96
2010	108.52	69.73	109.08	82.66	62.44	61.67	47.01	48.31	70.44	56.60	89.75	69.32
2011	148.36	42.55	46.92	67.42	50.09	35.20	21.02	30.98	47.71	77.98	119.00	110.89
2012	61.11	84.64	84.87	50.92	49.75	19.39	20.46	20.41	24.99	62.66	74.46	114.29
2013	80.96	86.01	45.79	55.04	36.75	20.49	15.93	26.38	36.56	75.47	94.20	127.35
2014	85.43	20.54	28.66	49.99	47.57	25.56	22.55	41.81	56.02	66.55	103.01	81.64
2015	66.90	37.73	68.28	64.44	42.37	32.54	13.37	35.53	34.33	28.45	76.02	119.75
2016	98.41	63.09	73.52	57.81	68.77	51.63	36.70	37.12	38.63	57.25	85.10	117.28
2017	114.98	68.11	75.46	77.00	64.33	25.59	23.45	28.40	55.72	61.01	124.95	95.92
2018	93.50	52.18	81.80	53.40	77.68	45.01	32.38	29.07	32.04	88.01	102.31	106.50
2019	154.24	51.83	30.31	47.46	37.93	72.05	27.16	21.41	17.87	54.51	85.04	127.47
2020	62.86	38.04	60.80	79.67	40.98	28.18	28.73	22.22	33.56	40.58	103.46	62.25
Average						59.28						

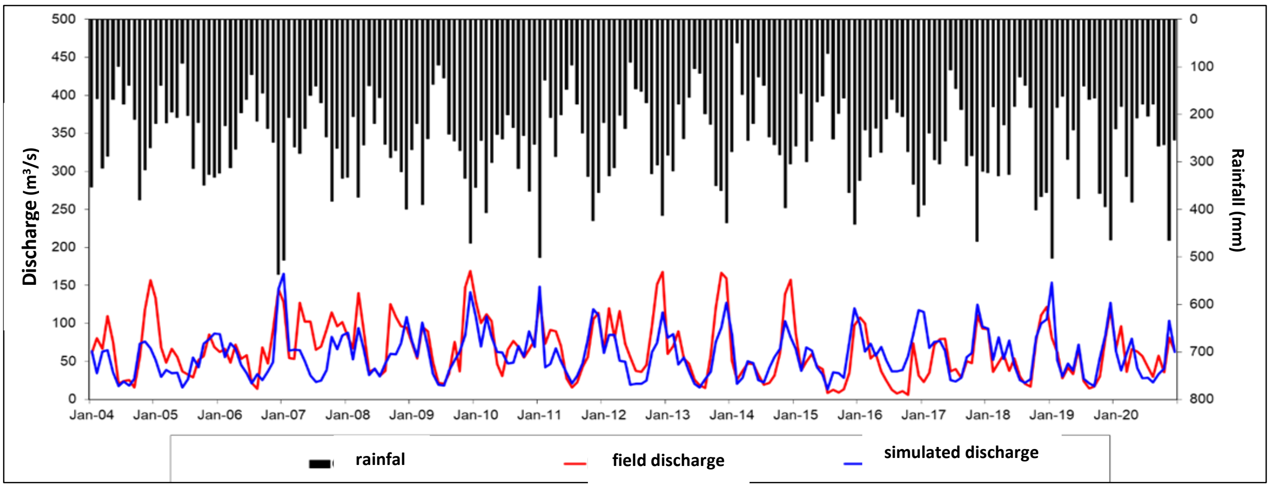

Fig 2. Graph of Comparison of Simulation Discharge with Field Discharge against Rainfall

Based on the graph of Figure 2, it can be seen that there is no significant difference between the simulated discharge and the field discharge. In addition, it can be seen that the simulated discharge is strongly influenced by high rainfall, that is, if the rainfall value is high, then the simulated discharge value will be large. Conversely, if the rainfall value is low, the simulated discharge value will be small.

5. *Performa Model GR2M*

Model performance is an evaluation of the model based on statistical indicators that determine the level of accuracy of the model. The statistical indicator used in this study is R2 which is based on the NSE model efficiency indicators, correlation coefficient (R), and efficiency coefficient (CE).

Based on data processing and referring to stage 5, the GR2M model performance is obtained as follows:

Table 10. GR2M Model Performance

Statistical Indicator	Mark	Interpretation
R^2 (NSE)	0,41	Fulfill
R	0,67	Strong
CE	0,59	Optimization is quite efficient

Source: Results of Data Processing

Based on the table above, it can be concluded that the GR2M modeling can be applied to the Tapung Kiri sub-watershed.

6. Mainstay Discharge

The mainstay debit is the final result in this study. The reliability required for planning the availability of drinking water based on table 3.1 is 99% (Q 99%).

To determine the value of the reliable debit, the method of calculating the discharge duration curve is used based on SNI No. 6738 of 2015 using table 9 as input in the ranking which is sorted from the largest value to the smallest value. After ranking, a graph of the discharge duration curve is obtained as shown in Figure 3.

Based on the calculation of the reliable discharge, the potential availability of the Siak Hulu watershed with a probability of 99% is 15.69 m^3/second (figure 3), meaning that the water discharge that occurs most often (available) in the Tapung-left sub-watershed is 15.69 m3/second. These results can be used as information by PDAM Tirta Siak Pekanbaru for the availability of drinking water.

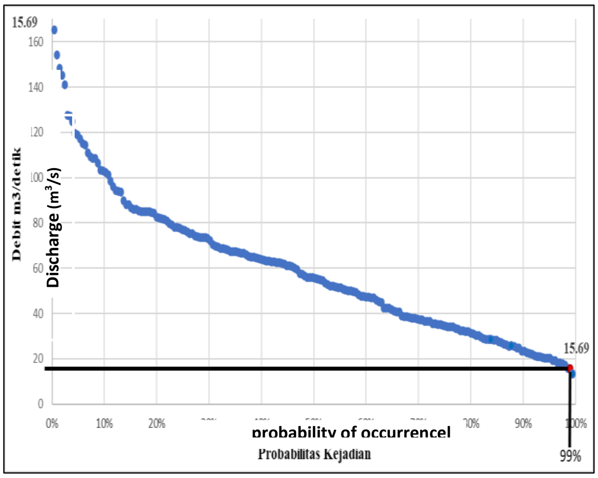

Fig 3. Results of the m3/second discharge duration curve

4. Conclusion

Based on the results and discussion that has been carried out in the previous chapter, it can be concluded that the GR2M modeling can be applied to the Tapung Kiri Sub-watershed with the performance of the GR2M model obtained, namely, R2 of 0.41 with a satisfactory interpretation, correlation coefficient (R) of 0, 67 with a strong interpretation, and an efficiency coefficient (CE) of 0.59 with a fairly efficient optimization interpretation. With the optimal parameters X1 and X2 in the GR2M model in the Tapung Kiri Sub-watershed, namely 6.8 and 0.48. In addition, the GR2M modeling is quite easy to understand and use because it only requires evapotranspiration data and rainfall data. Among these data, the value of rainfall is a variable that greatly affects the accuracy of the GR2M modeling. And the reliable discharge obtained based on the GR2M modeling data for the availability of drinking water in the Siak Hulu watershed (Q 99%) is 15.69 m3/second.

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References

A. B. Supangat, "Analisis Perubahan Nilai Pendugaan Evapotranspirasi Potensial Akibat Perubahan Iklim di Kawasan Hutan Tanaman Eucalyptus pellita," . *Semin. Nas. Geogr. UMS 2016*, pp. 112–122, 2016.

Adi, S. H., Kartiwa, B., Apriyana, Y., Sosiawan, H., Rejekiningrum, P., & Gumilar, G. (2021, February). Developing the swamp planting calendar based on the hydrological model application. In IOP Conference Series: Earth and Environmental Science (Vol. 648, No. 1, p. 012116). IOP Publishing.

Asdak, *Hidrologi dan Pengelolaan Daerah Aliran Sungai*. Yogyakarta: Gadjah Mada University Press, 2010.

Badan Pusat Statistik (BPS). (2022). Provinsi Riau dalam Angka 2022. https://riau.bps.go.id/publication/2022/02/25/85c4ce5fd9662f99e34a5071/provinsi-riau-dalam-angka2022.html (accessed 3.19.23)

C. D. Soemarto, *Hidrologi Teknik. Surabaya. Usaha Nasional*. 1987. https://kotaku.pu.go.id/view/7647/antara-kotaku-sungai-dan-sahabat-sungai/print (accessed 3.19.23)

Chen, H., Huang, S., Xu, Y. P., Teegavarapu, R. S., Guo, Y., Xie, J., & Nie, H. (2022). Quantitative Assessment of Impact of Climate Change and Human Activities on Streamflow Changes Using an Improved Three-Parameter Monthly Water Balance Model. Remote Sensing, 14(17), 4411.

Ditthakit, P., Pinthong, S., Salaeh, N., Binnui, F., Khwanchum, L., Kuriqi, A., ... & Pham, Q. B. (2021). Performance evaluation of a two-parameters monthly rainfall-runoff model in the Southern Basin of Thailand. Water, 13(9), 1226.

El Harche, S., Chikhaoui, M., Naimi, M., Choukri, F., & Chaaou, A. (2021). Comparative analysis between KINEROS2 and SWAT for hydrological modeling: A case study from Tleta Watershed in Morocco. International Journal of Environment, Agriculture and Biotechnology, 6(1), 270-281.

Fathi, M. M., Awadallah, A. G., & Aldahshoory, W. (2023). An Improved Monthly Water Balance GR2M Model with a Seasonally Variable Parameter. *Journal of Hydrology*, *617*, 129127.

Ilva, H., Suprayogi, I., & Fauzi, M. (2020). Analisis Kondisi Hidrologi DAS Siak Bagian Hulu Berdasarkan Peta Tata Guna Lahan Tahun 2014 Menggunakan Model Flow Persistance. *Jurnal Teknik*, *14*(1), 22-26.

K. M. dkk Tumiar, "Evaluasi Metode Penman-Mointeith dalam menduga Laju Evaprotranspirai (ETo) di Daratan Rendah Provinsi Lampung, Indonesia," *J. Keteknikan Pertan. Jur. Tek. Pertan. Univ. Lampung*, vol. Vol. 26 No, pp. 121–128, 2012.

Kiranaratri, A. H. (2020, July). Hydrological Study The Upstream Part of Siak Watershed (Case Study: Tapung Kanan River & Tapung Kiri River). In IOP Conference Series: Earth and Environmental Science (Vol. 537, No. 1, p. 012005). IOP Publishing.

Louvet, S., Paturel, J. E., Mahé, G., Rouché, N., & Koité, M. (2016). Comparison of the spatiotemporal variability of rainfall from four different interpolation methods and impact on the result of GR2M hydrological modeling—case of Bani River in Mali, West Africa. Theoretical and Applied Climatology, 123, 303-319.

Mahyudin, "Model Prediksi Liku Kalibrasi Menggunakan Jaringan Saraf Tiruan (JST) (Studi Kasus : Sub DAS Siak Hulu)," Universitas Riau, 2013.

Mvoundou, C. N., Tathy, C., Obami-Ondon, H., Moukoko, G. B. M., & Niere, R. R. (2022). Calibration and validation of the GR2M hydrologic model in the Kouilou-Niari Basin in Southwestern Congo-Brazzaville. *Open Journal of Modern Hydrology*, *12*(3), 109-124.

N. A. Setyawati, *DAS Sungai Siak Provinsi Riau*. Pekanbaru, 2019.

Pratiwi, dkk. 2015. Transformasi Hujan Debit berdasarkan Analisis Tank Model dan GR2M di DAS Dengkeng". Jurnal. Jakarta. Universitas Muhammadiyah Jakarta.

Putra,As, et all. 2016. Model Hidrologi Runtun Waktu Untuk Analisis Hujan-Aliran Menggunakan Metode Gabungan Model Transformasi Wavelet-Ihacres. Jurnal. Pekanbaru. Universitas Riau.

R. Hambali, "Analisis Ketersediaan Air dengan Model Mock.," in *Bahan Ajar*, Yogyakarta: Universitas Gadjah Mada, 2008.

Rahmad, R., Nurman, A., & Wirda, M. A. (2017). Integrasi Model SWAT dan SIG dalam Upaya Menekan Laju Erosi DAD Deli, Sumatera Utara. *Majalah Geografi Indonesia*, *31*(1), 46-55.

Sukmanda, Terunajaya. 2016. Analisa Ketersediaan dan Kebutuhan Air Pada Daerah Aliran Sungai Percut Untuk Memenuhi Kebutuhan Air Bersih di Kabupaten Deli Serdang. Jurnal. Medan. Universitas Sumatera Utara.

Suripin, *Sistem Drainase Perkotaan Yang Berkelanjutan*. Yogyakarta: Andi.

Tarigan, R. E. B., Fauzi, M., & Sujatmoko, B. (2019). Analisis Model Ketersediaan Air Pada Sungai Siak Bagian Hulu Dengan Menggunakan Model GR2M (Studi Kasus: Daerah Aliran Sungai Siak Bagian Hulu, AWLR Pantai Cermin). *Sainstek (e-Journal)*, *7*(2), 86-91.

Tumiar, K.M. dkk, 2012. Evaluasi Metode Penman-Mointeith dalam menduga Laju Evaprotranspirai (ETo) di Daratan Rendah Provinsi Lampung, Indonesia. Jurnal Keteknikan Pertanian Jurusan Teknik Pertanian Universitas Lampung.Vol. 26, No. 6, Page: 121-128.

V. Perrin, Charles. Michel, Claude. Andréassian, "Modèles hydrologiques du Génie Rural (GR)," *UR Hydrosystèmes Bioprocédés Parc Tourvoie*, 2007.

Yanti, N. R., & Rusnam, R. (2020). TRANSFORMASI DATA HUJAN–DEBIT MENGGUNAKAN MODEL GR2M PADA DAS AIR DINGIN. Jurnal Teknologi Pertanian Andalas, 24(2), 202-209.

Zulkipli, Z., Soetopo, W., & Prasetijo, H. (2012). Analisa neraca air permukaan DAS Renggung untuk memenuhi kebutuhan air irigasi dan domestik penduduk Kabupaten Lombok Tengah. *Jurnal Teknik Pengairan: Journal of Water Resources Engineering*, *3*(2), 87-96.