DEVOTION
Journal of Research and Community Service

Volume 3, Number 14, December 2022
e-ISSN: 2797-6068 and p-ISSN: 2777-0915

ANALYSIS OF SATELLITE RAIN DATA USAGE ON THE RATIONALIZATION ACTIVITIES OF THE RAIN POST NETWORK (CASE STUDY: RATIONALIZATION OF THE JELAI WATERSHED RAIN POST NETWORK)

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KEYWORDS
rainfall, GPM, validation, Kagan

ABSTRACT

An alternative solution to the availability of inadequate rain data as hydrological data input is with the help of Global Precipitation Measurement (GPM) satellite rainfall data using remote sensing technology (satellite). The purpose of this study was to find correlations and corrections of data and validate GPM satellite data with rainfall data at rain stations and observation data in the Jelai watershed. The corrected GP M rain data validation results in Nash-Sutcliffe Efficiency (NSE), Root Mean Squared Error (RMSE), Correlation Coefficient (R), and Relative Error (KR). The validation results resulted in NSE values of 0.33, RMSE 48.54, Correlation Coefficient (R) of 0.75, and Relative Error of 0.19 for 2019 and yielded NSE values of -0.14, RMSE 100.24, Correlation Coefficient (R) of -0.36, and Relative Error of 0.23 for 2020. The overall analysis shows that GPM data can be used as an alternative to rain data if in a watershed there is a small number of rain posts that do not meet the WMO criteria. As a suggestion for further research, it is necessary to calibrate and validate by distinguishing between rain data in wet years and dry years

INTRODUCTION

Precipitation data information is very important for various analysis of water resources. Rainfall data can be temporal (time series) or spatial (Renaldhy et al., 2021). As one of the important data in hydrological analysis, rainfall data is obtained from measurements at the rain station post, so that the rainfall data obtained is expected to have sufficient accuracy (Abdaa et al., 2021).

Rainfall data in time series recording can provide trend information from the nature of rain in a place whether it has increased or vice versa (Arrokhman et al., 2021). From this description it can be said that rainfall data is quite important climatological data. Accurate and timely regional and global precipitation observations and forecasts are essential for a wide range of research and applications (Astuti et al., 2022).

In fact, to obtain representative rainfall observation data that is both in terms of quality and quantity or duration of observation data that is sufficient according to the requirements is very difficult (Azka et al., 2018). It is difficult to obtain rainfall data, due to the limited number of measuring instruments or gauges, especially in remote areas, so it will be difficult to conduct a study and analysis of water resources based on rainfall data in one place because not all places have manual or automatic rainfall monitoring stations (Derin et al., 2016).

According to Syaifullah, the latest technological developments, namely in the form of satellite technology (remote sensing) are able to make breakthroughs in terms of obtaining rainfall information (precipitation) because the current remote sensing technology has been able to measure rainfall from a distance (Faisol & Bachri, 2021). Areas that do not have adequate rain recording stations are almost impossible to measure rainfall, but with this technology it is possible to obtain rainfall data that is not limited in space and time, so that in simple terms it can be said that with satellite technology rainfall data can be obtained at any time. anywhere and anytime (Oktaverina et al., 2022).

On February 27, 2014, NASA and JAXA launched Global Precipitation Measurement (GPM) as a successor to the TRMM satellite (Sarwanta & Abdulgani, 2021). The aim of this satellite launch is to improve the quality of precipitation observations on a global scale. GPM has a global coverage of 65o North Latitude to 65o South Latitude with observations every 3 hours (Pangestu et al., 2021). The GPM constellation can estimate the intensity and type of precipitation, cloud structure in 3 dimensions, storm systems, microscopic ice and liquid in clouds, and the amount of precipitation that falls on the earth's surface (Orfa & Samad, 2019).

However, before the GPM satellite rain data can be used, it is necessary to evaluate whether the rainfall data from the GPM satellite and from the existing rain station post network will produce maximum information so that the amount of rainfall can be obtained at all points with sufficient accuracy or even very different (Tang et al., 2020). In the Jelai River Basin with an area of 7,682 km2 there are three rain stations which are within the DAS (Prabawadhani et al., 2016).

This study will examine how the correlation of postal rainfall station data with satellite rainfall data. After obtaining the corrected GPM satellite data, it will then be used to make an annual rainfall isohyet map with the location/network of rainfall posts based on the Kagan Method (Suryaningtyas, 2019).

RESEARCH METHOD

Consistency Test

A data consistency test was carried out to find out whether there are deviations in the available rainfall data, so that it can be seen whether the data is suitable for use in further hydrological analysis or not. In this study, 2 (two) methods were carried out, namely (1) multiple mass curves; (2) Rescaled Adjusted Partial Sums (RAPS).

Homogeneity Test

A series of hydrological data presented chronologically as a function at the same time is called a periodic series. The data is arranged in a series of periodic forms, so that it must be tested before being used for further analysis. The intended data tests are: (1) Test for the Absence of Trend; (2) Stationary Test; (3) Persistence Test. The three stages of testing are often referred to as data filtering.

GPM Rainfall Data Validation Test

For validation tests, the Nash-Sutcliffe Efficiency (NSE), Correlation coefficient (R), Root Mean Squared Error (RMSE) and Relative Error (RE) methods are used. Two validation analyzes were carried out, namely validation of GPM data that had not been corrected and validation of GPM data that had been corrected.

Uncorrected GPM data validation using uncorrected GPM and rain station rainfall data. The period used is monthly with a data length of 11 years.

As for the validation of the corrected TRMM data, a number of processes are carried out first, namely calibration, verification and validation. Calibration and verification using the scatter plot method. For calibration, a monthly period is used with a data length of 11 years (2007 and 2009-2018). While the verification and validation tests use a monthly period with a data length of 2 years (2019-2020) excluding the calibration year.

The validation method formula used in this study is:

1) Nash-Sutcliffe Efficiency (NSE)

This method shows how well it plots the observed (measurement) values compared to the simulated-predicted values, according to the 1:1 line, with a range of values ∞ to 1. In other words, the closer to 1, the better the NSE value.

$$NSE = 1 - \frac{\sum_{i=1}^{N}(X_i - Y_i)^2}{(X_i - \overline{X}_i)^2}$$

With:

Xi = observation data (actual data)
Yi = estimated data (estimated yield data)
Xi = average observation data
N = amount of data

Table 1
Nash-Sutcliffe Efficiency (NSE) Score Criteria

NSE Value	Interpretation
NSE > 0.75	Good
0.36 < NSE < 0.75	Qualified
NSE <0.36	Not Qualified

2) Correlation Coefficient

The purpose of this analysis is to obtain patterns and close relationships between two or more variables.

$$R = \frac{N\sum_{i=1}^{N} X_i Yi - \sum_{i=1}^{N} X_i - \sum_{i=1}^{N} Yi}{\sqrt{N\sum_{i=1}^{N} X_i^2 - (\sum_{i=1}^{N} X_i)^2}\sqrt{N\sum_{i=1}^{N} Y_i^2 - (\sum_{i=1}^{N} Y_i)^2}}$$

With:

Xi = observation data (actual data)
Yi = estimated data (estimated yield data)
N = amount of data
Table 2.2 Correlation Coefficient Value Criteria
3) Root Mean Squared Error (RMSE)

$$\text{RMSE}=\sqrt{\frac{\sum_{i=1}^{N}(X_i-Y_i)^2}{N}}$$

With:
Xi = observation data (actual data)
Yi = estimated data (estimated yield data)
N = amount of data
4) Relative Error Test

This test is used to determine the comparison between the magnitude of one variable to another variable that is used as a benchmark for the actual variable.

$$\text{KR}=\frac{\sum_{i=1}^{N}(X_i-Y_i)}{Y_i}\times 100\%$$

With:
Xi = observation data (actual data)
Yi = estimated data (estimated yield data)
N = amount of data
Thiessen Polygon Method

This method is used to calculate the area's average rainfall, where in a watershed there are several rain posts.

Kagan's method

With the Kagan method, the ideal distance between the locations of the automatic rain posts and the distribution of the locations of the automatic rain posts can be identified.

Isohyet Map

After the distribution of rainfall stations is known based on the Kagan Method, an Isohyet Map will be made in the Jelai watershed based on the rainfall data and the corrected GPM satellite rain data, so that comparisons/differences can be identified.

RESULTS AND DISCUSSION

Hydrological Analysis

Consistency Test

The consistency test was carried out using two methods, the multiple mass curve method and the RAPS method.

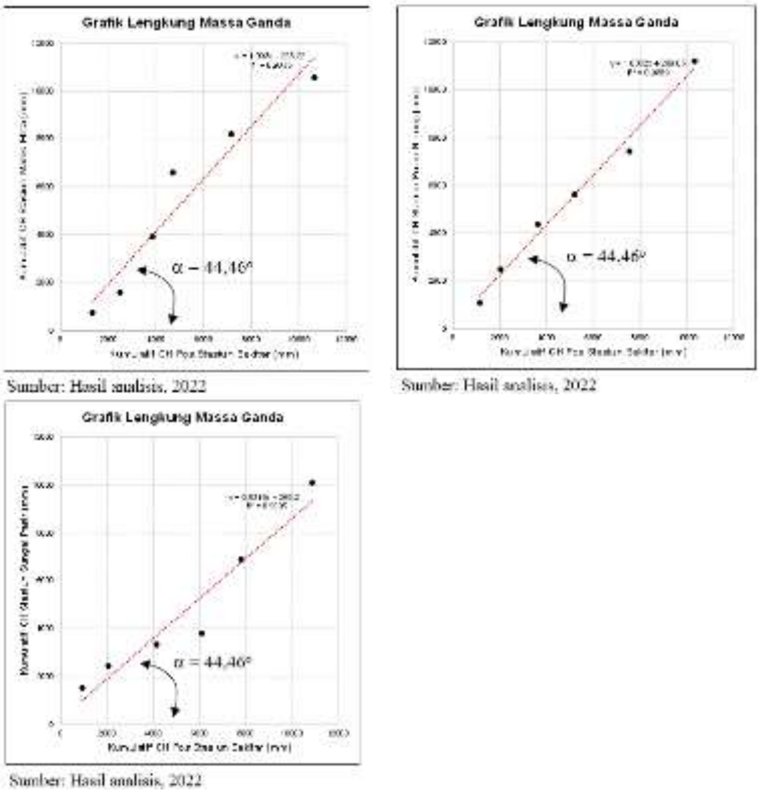
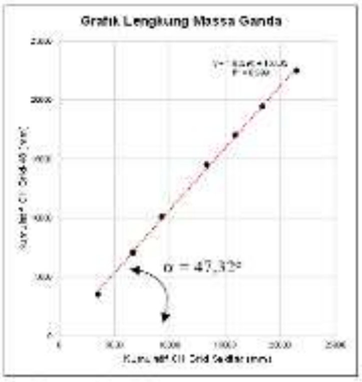


Figure 1
The Double Mass Curve of the Eye Sweet Rain Post, the Nibung Island Rain Post and the Pasir River Rain Post

Table 2
Recapitulation of α values at each rain station post

No	Rain Station Post	Markα	R value ^{2}
1	Sweet Eyes	44.46 °	0.9335
2	Nibung Island	48.70o -	0.9889
3	Sand River	43.89o -	0.9295

Source: Analysis results, 2022



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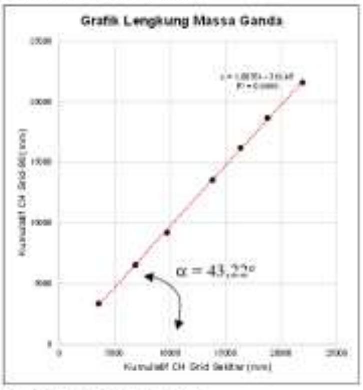

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Figure 2
Grid-48, Grid-78 and Grid-90 Multiple Mass Curves

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Recapitulation of α values in each gris (GPM data)

No	Grid Number	Markα	R^2 value
1	Grid-48	47.32o	0.9990
2	Grid-78	44.39 °	0.9988
3	Grid-90	43.22o	0.9996

Source: Analysis results, 2022

Information:
Grid-48 →GPM grid that corresponds to the location of the Sweet Rain Eye Post
Grid-78 →GPM grid corresponding to the location of the Nibung Island Rain Post
Grid-90 →grid GPM which corresponds to the location of the Pasir Sungai Rain Post

Table 4
Recapitulation of Consistency Test Results

No	Name Post	Curve Method Double Mass	RAPS method				Ket.
		Corner	$Q/n^{0.5}$ count	$Q/n^{0.5}$ table	$R/n^{0.5}$ count	$R/n^{0.5}$ table	
1	Sweet Eyes	44,46	0.413	1.172	0.778	1,340	Consistent
2	Nibung Island	48,70	0.731	1.116	1,080	1.235	Consistent
3	Sand River	43.89	0.505	1.116	0.947	1.235	Consistent
4	Grid-48	47,32	0.577	1.172	0.888	1,340	Consistent
5	Grid-78	44,39	0.412	1.172	0.787	1,340	Consistent
6	Grid-90	43,22	0.628	1.172	0.993	1,340	Consistent

Source: Analysis results, 2022

Based on Figure 1 and Figure 2 as well as Table 1 and Table 2, it can be said that the post rainfall data of the rain station and the GPM data used after being tested using the Multiple Mass Curve Method are consistent because the resulting angles are in the range of values $^{42o} < \alpha < ^{48o}$. Meanwhile, based on Table 3, the rainfall data consistency test using the RAPS method also meets the test requirements because the $Q_{count} < Q_{table}$ and $R_{count} < R_{table}$ so that the results can be considered consistent.

The results of this test indicate that the selected data can be used for further hydrological testing and analysis.

Homogeneity Test

In this study, the annual rainfall data of rainfall stations were tested for no trend using the Spearman method using a 2-tailed T-Test. Recapitulation of test results is presented as follows.

Table 5
Summary of Absence Test Results for Annual Period

No	Post Name	t_{count}	α	t_c	Information
1	Sweet Eyes	-1,582	5%	2,179	Does not show a trend
2	Nibung Island	-2,840	5%	2,571	Does not show a trend
3	Sand River	-1.419	5%	2,571	Does not show a trend
4	GPM Grid-48	0.206	5%	2,179	Does not show a trend
5	GPM Grid-78	0.175	5%	2,179	Does not show a trend

No	Post Name	t_{count}	α	t_c	Information
6	GPM Grid-90	0.659	5%	2,179	Does not show a trend

Source: Analysis results, 2022

Based on Table 5 it can be seen that all data does not show a trend by showing $t_{count} < t_{table}$ at the 5% confidence level. Thus, the data can be analyzed further.

Table 6
Summary of Variance Stability Test Results (Test F) Annual Period

No	Post Name	F count	α	Fc _	Information
1	Sweet Eyes	1.013	5%	4,280	The variance value is stable
2	Nibung Island	0.095	5%	19,160	The variance value is stable
3	Sand River	0.496	5%	19,160	The variance value is stable
4	Grid-48	1,638	5%	3,410	The variance value is stable
5	Grid-78	0.743	5%	3,410	The variance value is stable
6	Grid-90	1,339	5%	3,410	The variance value is stable

Source: Analysis results, 2022

Table 7
Summary of Average Stability Test Results (t test) Annual Period

No	Post Name	t_{count}	α	t_c	Information
1	Sweet Eyes	-0.400	5%	2,179	The average value is stable
2	Nibung Island	-1,713	5%	2,571	The average value is stable
3	Sand River	-2,407	5%	2,571	The average value is stable
4	Grid-48	0.216	5%	2,179	The average value is stable
5	Grid-78	0.328	5%	2,179	The average value is stable
6	Grid-90	0.363	5%	2,179	The average value is stable

Source: Analysis results, 2022

From Table 6 and Table 7 above it can be seen that the $_{calculated\ F}$ value < F_{table} value and the $t_{calculated}$ value < $t_{table\ value}$, so it can be concluded that the rainfall data from the three rain station posts and the GPM rainfall data used have variance and average stable average. The persistence test is an independent test for each value in the periodic series. First, the number of serial correlation coefficients must be calculated using the Spearman method, then the persistence test is calculated using the T-Test. Recapitulation of test results is presented as follows.

Table 8
Summary of Annual Period Persistence Test Results

No	Post Name	t_{count}	α	t_c	Information
1	Sweet Eyes	0.492	5%	2,179	Data is random
2	Nibung Island	1.116	5%	2,571	Data is random
3	Sand River	1.007	5%	2,571	Data is random
4	Grid-48	-0.038	5%	2,179	Data is random
5	Grid-78	-0.437	5%	2,179	Data is random
6	Grid-90	0.099	5%	2,179	Data is random

Source: Analysis results, 2022

Table 8 it can be seen that almost all of the data is random by showing tcount <ttable at the 5% level of confidence. Thus, the data can be analyzed further.

Rain Station Data Correlation Rain Station and GPM

Based on Table 8, the results of the correlation analysis of all rain posts with GPM data have a good correlation for the Sweet Eyes Rain Post and the Nibung Island Rain Post (the correlation coefficient value is at a value > 0.6), while for the Sungai Pasir Rain Post it is not good (the value of the correlation coefficient which is at a value of <0.6).

Table 9
Recapitulation of Correlation Results for Annual, Monthly, and Monthly Average Data

No	Nama Pos	Korelasi Sesuai Data		
		Tahunan	Rerata Bulanan	Bulanan
1	Manis Mata dan Grid-48			
	- Panjang data 14 tahun	0.50	0.89	0.40
	- Panjang data 13 tahun	**0.61**	**0.89**	**0.40**
	- Panjang data 12 tahun	0.68	0.76	0.35
	- Panjang data 11 tahun	0.92	0.71	0.38
2	Pulau Nibung dan Grid-78			
	- Panjang data 7 tahun	0.65	0.78	0.55
	- Panjang data 6 tahun	0.74	0.80	0.59
3	Sungai Pasir dan Grid-90			
	- Panjang data 7 tahun	0.14	0.54	0.26
	- Panjang data 6 tahun	0.25	0.51	0.29

Source: Analysis results, 2022

GPM Rain Data Calibration

Rainfall calibration uses an 11-year period (2007 and 2009-2018 rain data) from the Manis Mata rain post, while for verification and validation it uses 2019 and 2020 rain data. This is determined by considering the length of the data and the correlation results in Table 9

Table 9 and Table 10 show the results of the regression equation and the resulting coefficient of determination (R^2). From the regression equation that has been obtained to obtain the corrected GPM rain data, then the regression equation with the largest R value is used. The results of the GPM rainfall regression equation in the Jelai watershed with R^2 = 0.6120 with the intercept linear equation (when using monthly rainfall data) and R^2 = 0.9788 with the intercept linear equation (when using monthly average rainfall data). Because the value of R2 with monthly average data is greater than using monthly data, then to correct the GPM rain data use the equation: y = 0.4762x.

Table 10
Tabulation of GPM Monthly Rainfall Regression Equation Results in Jelai Watershed

No	Regression Equation	"y" value	Value "R^2"
1	linear	y = 0.3796x + 27.555	0.1625
2	**Linear Intercepts**	**y = 0.4684x**	**0.6120**
3	Logarithmic	y = 65.631ln(x) – 228.26	0.1609
4	Polynomial	$y = -0.0007x^2 + 0.744x - 9.1964$	0.1730
5	Polynomial Intercept	y = -0.0006x2 + 0.6746x	0.1728
6	rank	-	-

Source: Analysis results, 2022

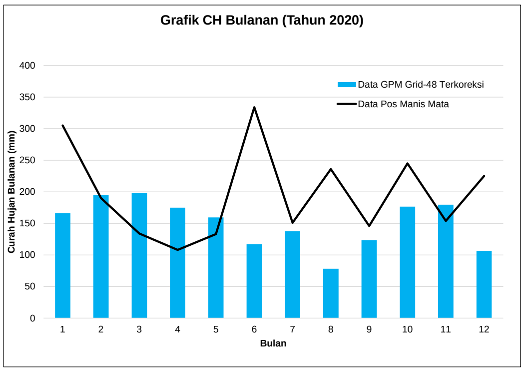
Table 11
Tabulation of GPM Monthly Mean Rainfall Regression Equation Results in Jelai Watershed

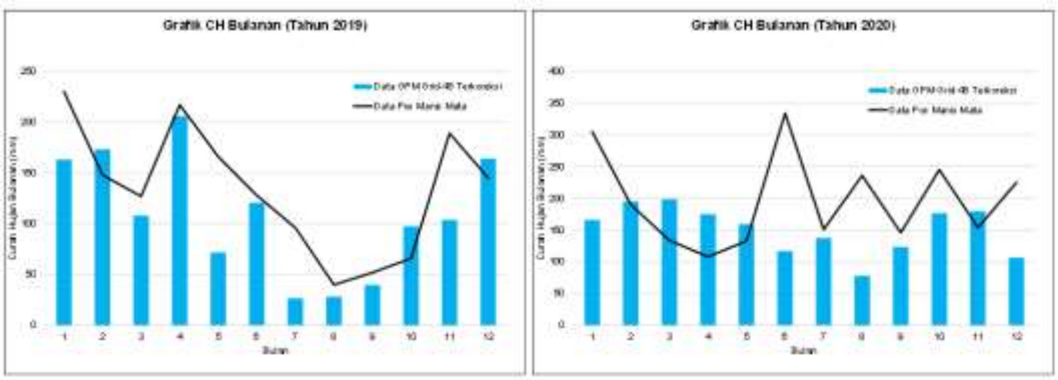
No	Regression Equation	"y" value	Value "R^2"
1	linear	y = 0.3464x + 35.98	0.7580
2	**Linear Intercepts**	**y = 0.4762x**	**0.9788**
3	Logarithmic	y = 73.743ln(x) – 280.32	0.6869
4	Polynomial	$y = 0.0012x^2 – 0.2393x + 99.385$	0.8025
5	Polynomial Intercept	y = -0.0005x2 + 0.6175x	0.7214
6	rank	$y = 4.0806x^{0.6167}$	0.7341

Source: Analysis results, 2022

GPM Rain Data Verification

For verification, rain data for 2019 and 2020 was used. The following is a graph of rain data for 2019 and 2020 for the Sweet Rain Post and the corrected GPM data (grid-48).





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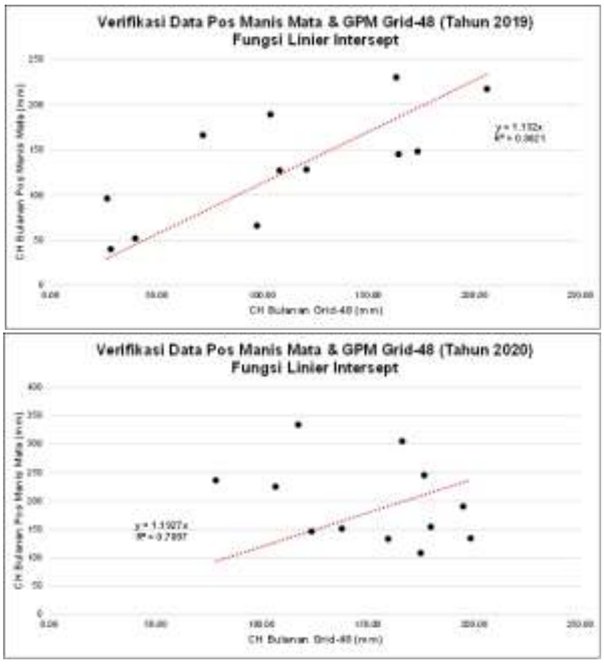
Graph of Corrected GPM Rainfall in 2019 and 2020



Source: Analysis results, 2022

Figure 3

GPM Rainfall Verification for 2019 and 2020

Based on Figure 3 and Figure 4 it can be seen that for 2019 it produces a greater correlation value than in 2020.

GPM Rain Data Validation

Validation is carried out on data outside of the data used for calibration (2019 and 2020). To be able to measure the magnitude of the difference in the results of corrected GPM rainfall calculations against postal rainfall data, a mathematical model validation test can be used using *Nash Sutcliffe Efficiency* (NSE), *Root Mean Square Error* (RMSE), Correlation Coefficient, and Relative Error. The smaller the RMSE value, the closer the simulated data is to the observed data, conversely the greater the NSE value (maximum equal to 1), the closer the simulation results to the observations.

Table 12

GPM Data Validation Test Recapitulation Before and After Correction

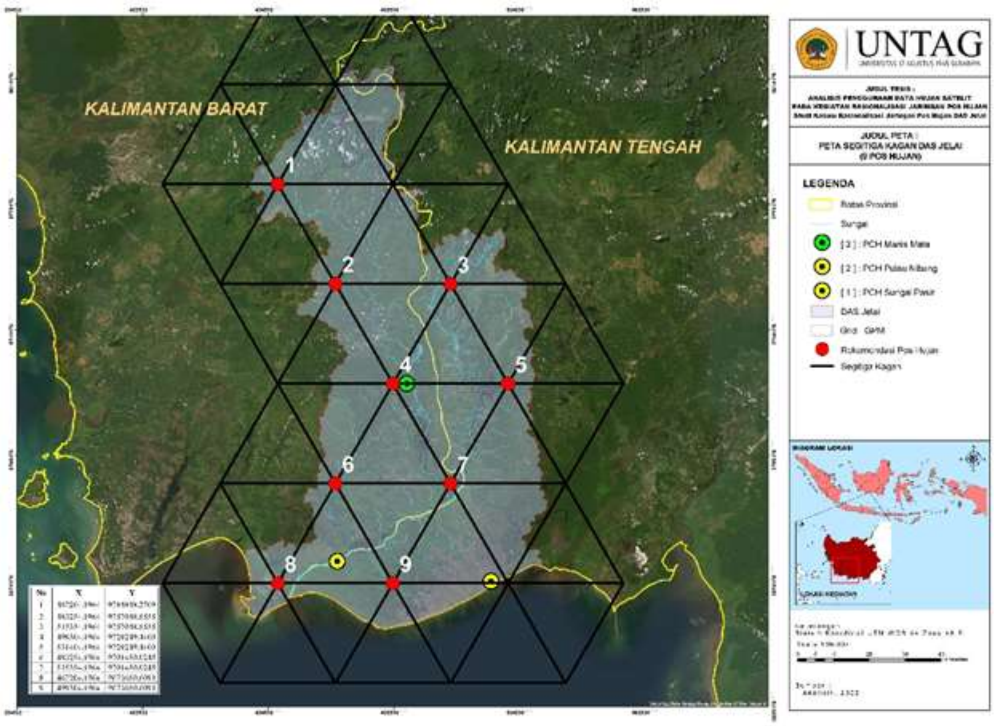
2019 year			2020 year		
	Before	**After**		**Before**	**After**
NSE	-3.61	0.33	**NSE**	-2.31	-0.14
RMSE	127,26	48,54	**RMSE**	170.38	100.24
KR	-0.70	0.19	**KR**	-0.61	0.23
R	0.75	0.75	**R**	-0.36	-0.36

Source: Analysis results, 2022

Based on the results of Table 12, it is known that the results of the corrected GPM data are better than before being corrected. The validation results in 2019 were better than in 2020. Thus the other grid GPM data will be corrected using the equation y = 0.4762x.

Determination of Rainfall Post Network Kagan Method

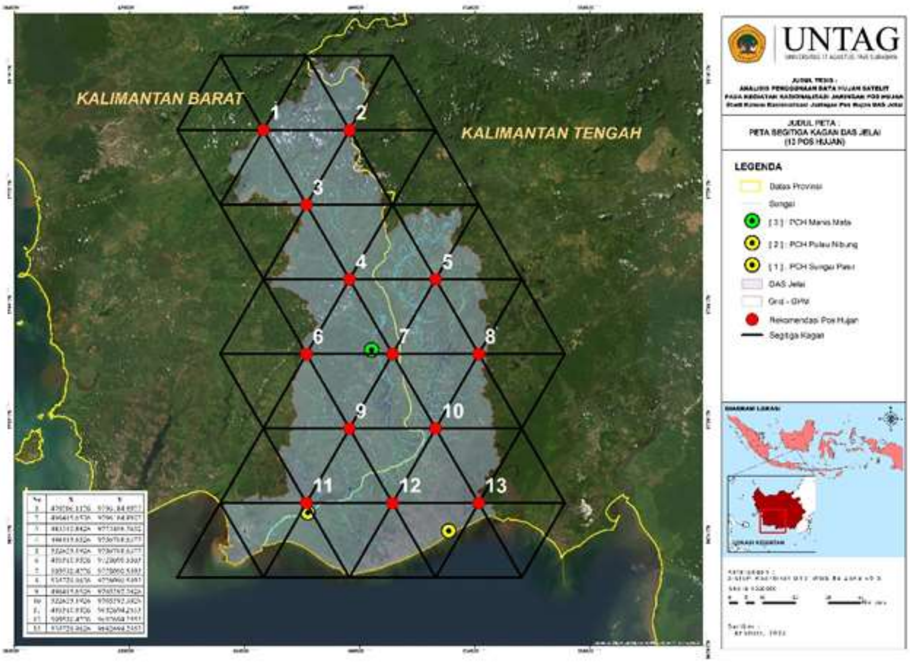
Based on several ways of determining existing rainfall postal networks, Kagan's method is relatively simple, both in terms of understanding and calculation procedures. Besides being able to produce the required number of posts with a certain level of accuracy, the Kagan method can also provide a clear pattern of placement of rainfall posts. Based on the WMO criteria, it is known that with the condition of the plains and the area of the Jelai watershed 7,682 km ^{2}, a minimum of 9 automatic rain posts and a maximum of 13 automatic rain posts are needed. Using the Kagan formula ($l = 1{,}07\sqrt{\frac{A}{N}}$), the distance between posts is 32.10 km (if there are 9 postal units) and 26.21 km (if there are 13 postal units).



Source: Analysis results, 2022

Figure 4

Kagan Triangle For Number of Rain Post 9 Units



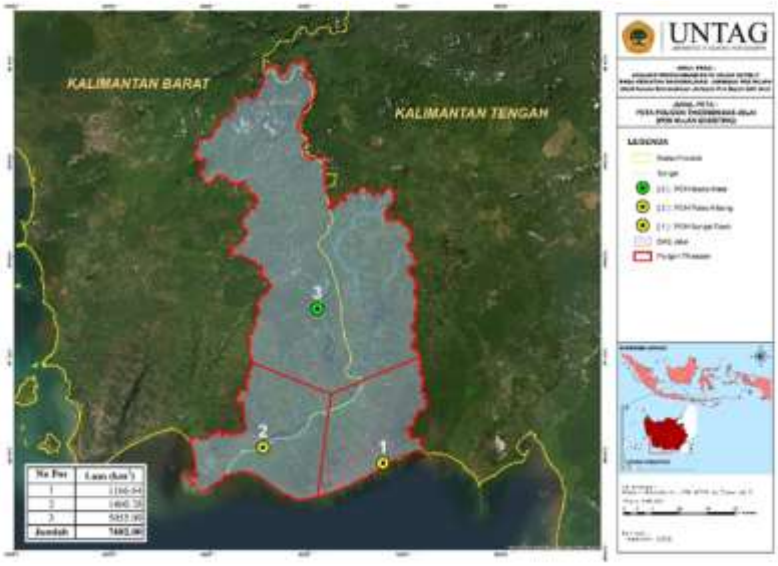
Source: Analysis results, 2022

Figure 5

Kagan Triangle For Rain Post Number 13 Units

Regional Rainfall Calculation

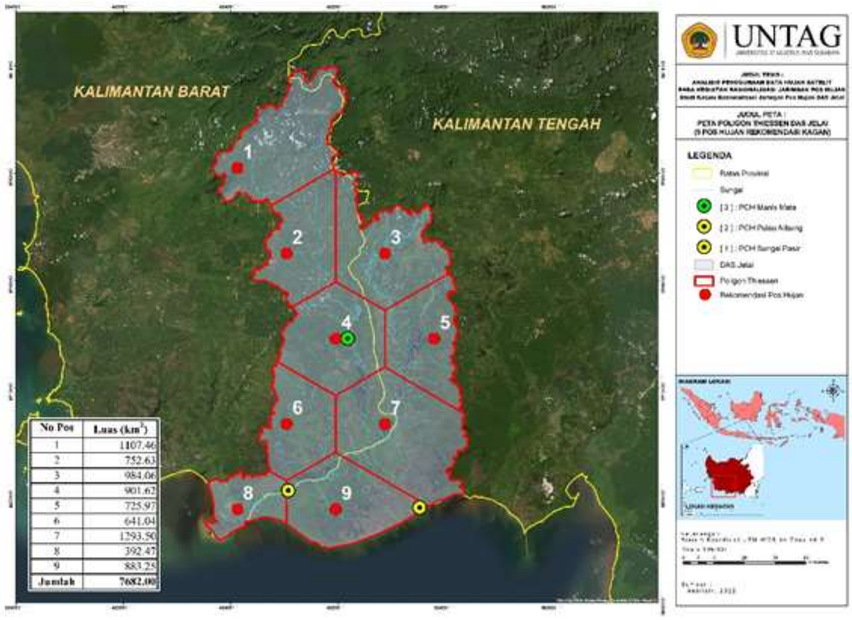
Regional average rainfall analysis or regional rainfall analysis in this study was carried out on postal rain data and corrected GPM data. Regional rainfall analysis in this study uses the Thiessen polygon method, which in principle is to create an area of influence for each rain station post on the watershed area under review.



Source: Analysis results, 2022

Figure 6

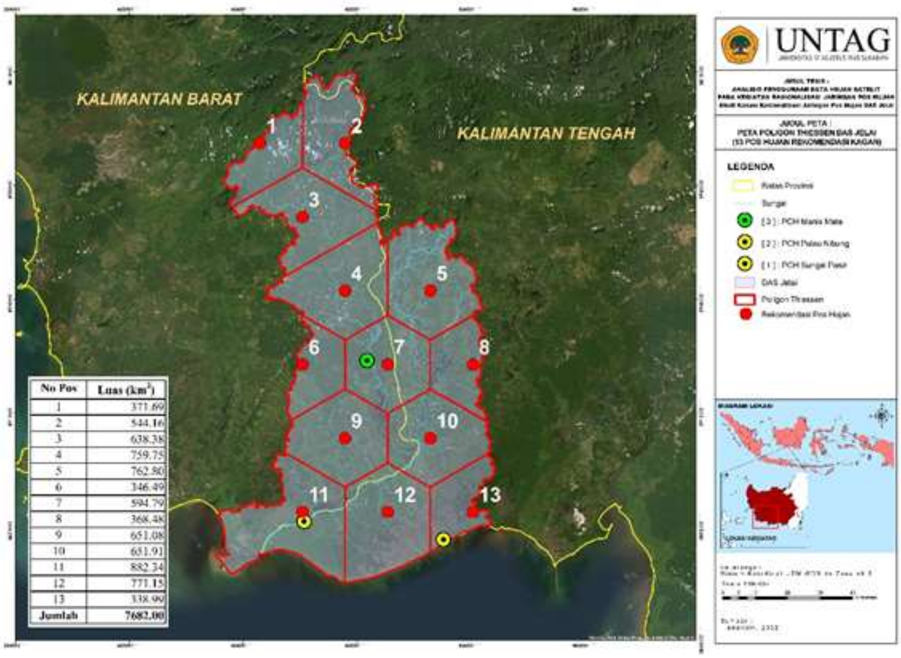
Thiessen Polygon Existing Rain Post



Source: Analysis results, 2022

Figure 7

Thiessen Polygon 9 Recommended Rain Post



Source: Analysis results, 2022

Figure 8

Thiessen Polygon 13 Recommended Rain Posts

Table 13
Rain Region With Rain Post Data

No	Tahun	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jumlah
1	2014	115.16	27.39	202.68	75.10	187.69	61.75	12.05	46.77	25.12	26.97	86.44	76.94	**944.06**
2	2015	93.84	3.95	177.05	113.73	117.15	145.86	0.19	6.58	0.00	32.56	88.88	184.55	**964.33**
3	2016	179.43	139.95	130.40	145.20	179.18	60.17	135.54	153.32	196.10	252.69	306.65	127.66	**2006.29**
4	2018	165.66	122.86	161.00	510.46	225.86	165.28	32.73	15.79	115.16	124.37	196.75	234.92	**2070.85**
5	2019	423.81	161.81	131.73	240.24	141.64	188.31	68.92	26.32	36.71	76.49	197.39	174.59	**1867.94**
6	2020	296.90	225.62	211.55	147.05	211.14	313.32	233.36	199.52	202.08	248.77	233.30	237.74	**2760.36**
	Rerata	**212.47**	**113.60**	**169.07**	**205.29**	**177.11**	**155.78**	**80.47**	**74.72**	**95.86**	**126.97**	**184.90**	**172.73**	**1768.97**

Source: Analysis results, 2022

Table 14
Regional Rain with GPM Data 9 Kagan Recommendation Posts

No	Tahun	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jumlah
1	2007	159.74	130.70	132.24	215.95	146.66	117.85	136.03	75.05	67.48	142.68	203.85	225.92	**1754.14**
2	2008	68.85	91.73	147.93	160.21	98.43	137.27	59.51	184.23	116.77	248.68	185.99	225.97	**1725.55**
3	2009	134.70	61.78	144.96	178.59	114.15	59.46	60.60	29.08	31.81	178.16	219.43	240.55	**1453.27**
4	2010	134.05	192.24	206.12	123.32	173.29	212.53	208.72	163.88	182.87	158.53	201.34	110.15	**2067.03**
5	2011	148.27	86.27	135.46	110.53	100.65	52.27	62.66	16.90	53.72	165.20	149.70	205.05	**1286.68**
6	2012	107.45	146.44	97.13	166.82	74.70	42.84	51.53	53.51	21.10	136.57	146.84	209.45	**1254.38**
7	2013	102.38	110.84	98.67	201.60	190.76	85.69	149.50	81.82	68.03	83.36	149.58	206.19	**1528.43**
8	2014	76.67	74.47	140.51	125.55	161.63	118.40	20.01	75.09	34.82	53.68	158.24	134.16	**1173.23**
9	2015	126.77	155.03	149.94	153.02	98.47	61.55	36.29	12.78	5.79	39.04	105.53	207.10	**1151.30**
10	2016	184.42	175.99	219.72	174.80	218.26	104.56	71.44	45.87	114.47	177.38	137.94	155.53	**1780.38**
11	2017	123.95	111.38	97.20	138.03	121.06	101.00	93.69	114.60	90.58	124.63	162.79	138.12	**1417.02**
12	2018	96.10	113.51	166.98	182.23	171.90	93.69	30.56	19.24	77.58	145.50	167.21	185.71	**1450.21**
13	2019	141.13	189.34	107.69	224.85	78.26	139.86	20.59	23.32	26.36	82.32	125.48	182.26	**1341.47**
14	2020	180.94	157.94	209.74	168.91	146.77	135.37	159.94	81.51	150.91	174.02	212.36	112.06	**1890.47**
	Rerata	**127.53**	**128.40**	**146.73**	**166.03**	**135.36**	**104.45**	**82.94**	**69.78**	**74.45**	**136.41**	**166.16**	**181.30**	**1519.54**

Source: Analysis results, 2022

Table 15
Regional Rain with GPM Data 13 Kagan Recommendation Posts

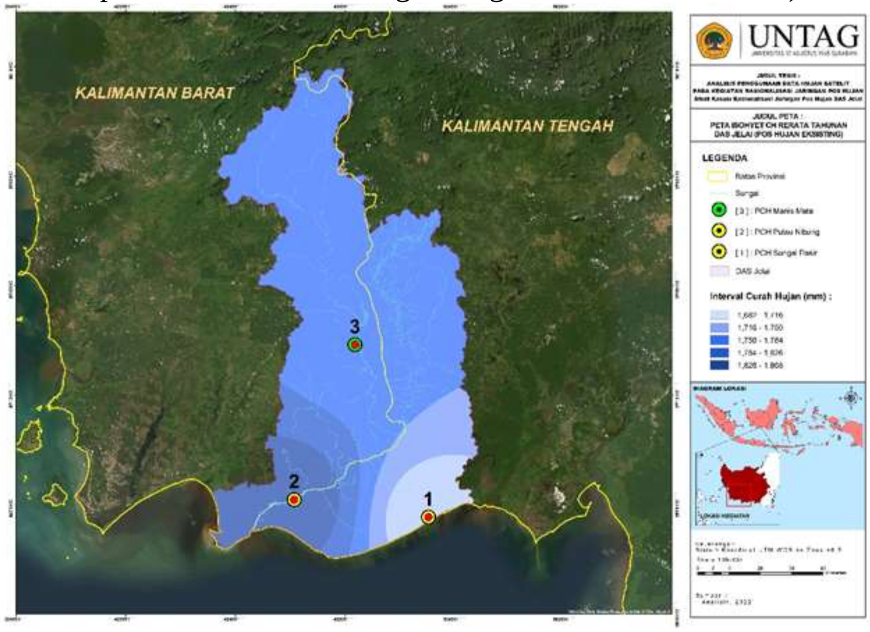
No	Tahun	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jumlah
1	2007	161.86	136.93	131.90	220.55	143.18	115.48	136.63	77.99	68.22	150.25	196.71	224.91	**1764.58**
2	2008	68.11	95.96	150.23	164.24	95.20	132.40	62.22	172.28	116.62	243.14	182.10	219.02	**1701.52**
3	2009	130.43	61.47	151.30	168.93	111.83	54.82	63.27	29.33	33.43	180.90	213.18	240.61	**1439.51**
4	2010	140.44	171.58	200.93	123.05	175.23	211.16	206.15	160.35	182.58	149.54	196.57	105.87	**2023.43**
5	2011	151.02	91.50	140.81	116.41	104.92	51.03	60.44	17.19	52.83	161.62	150.01	201.66	**1299.45**
6	2012	104.53	150.40	96.22	169.52	76.59	43.60	56.80	50.78	17.63	139.74	150.22	198.18	**1254.22**
7	2013	103.91	109.03	111.19	202.18	180.21	86.41	154.70	80.57	75.22	73.33	154.43	208.09	**1539.27**
8	2014	76.29	75.28	148.11	117.89	160.52	114.22	19.22	71.37	37.09	52.76	167.77	132.58	**1173.10**
9	2015	125.36	152.02	151.77	153.01	102.04	60.18	37.72	12.36	4.71	36.75	103.42	205.20	**1144.55**
10	2016	181.60	174.67	216.08	173.07	210.86	101.17	70.47	47.59	114.86	181.18	129.54	156.06	**1757.15**
11	2017	119.48	111.60	97.60	135.90	122.78	98.87	97.18	119.88	85.82	123.38	160.79	132.68	**1405.95**
12	2018	89.63	114.78	164.78	180.62	163.93	93.88	27.77	16.77	76.68	130.62	163.58	170.45	**1393.48**
13	2019	133.02	174.64	105.74	222.40	78.56	138.68	18.37	23.42	24.68	86.07	125.43	180.27	**1311.28**
14	2020	167.50	164.15	203.07	169.64	153.43	134.02	156.33	81.12	149.93	166.78	208.18	110.93	**1865.08**
	Rerata	**125.23**	**127.43**	**147.84**	**165.53**	**134.23**	**102.57**	**83.38**	**68.64**	**74.31**	**134.00**	**164.42**	**177.61**	**1505.18**

Source: Analysis results, 2022

Based on Tables 13 to 15 it can be seen that the rainfall in areas with postal rain data is greater than using corrected GPM rain data.

Isohyet Map Creation

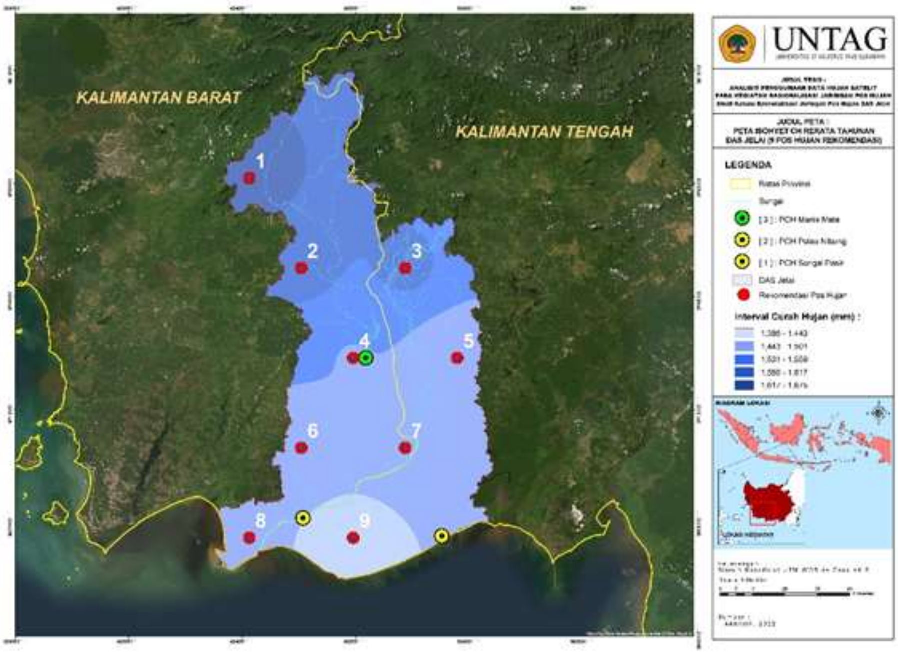
Isohyet is a line on the map to connect positions that have the same rainfall value. The following isohyet map based on rain post data and corrected GPM rain data (with rain post locations according to Kagan's recommendations).



Source: Analysis results, 2022

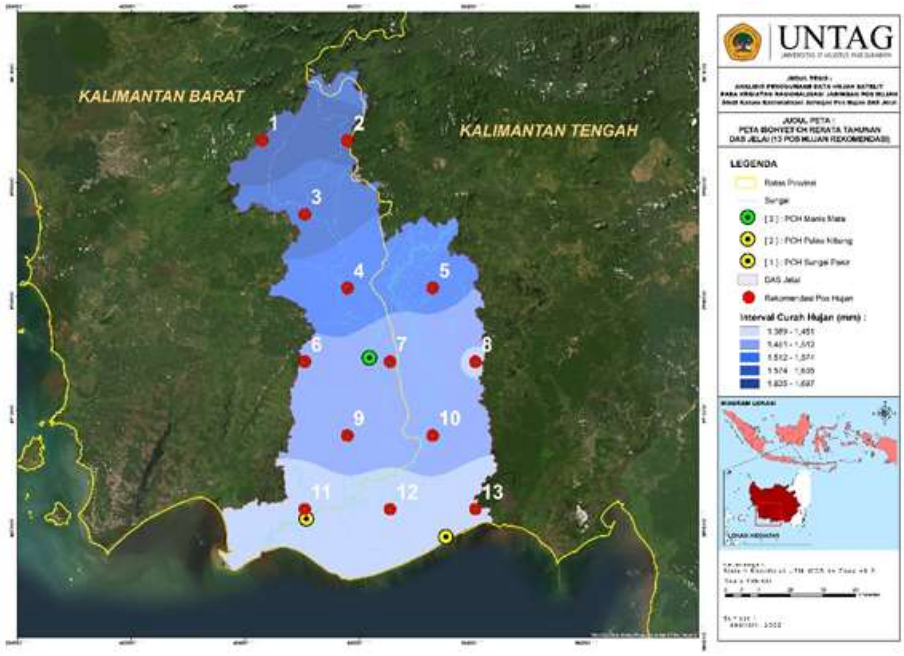
Figure 10

Map of Annual Average Rainfall Isohyet Rain Post Data



Source: Analysis results, 2022

Figure 9
Map of Annual Average Rainfall Isohyet GPM Data 9 Pos



Source: Analysis results, 2022

CONCLUSION

The results of the correlation analysis of GPM satellite rainfall data and rainfall data from the rain station post have good results when using annual rainfall data and monthly average rainfall data. The results of the validation of rainfall data for the Manis Mata station post with the GPM show that the results of the corrected data validation have better results than the GPM data before being corrected. The validation for 2019 is better than for 2020. This shows that the validation of rain data does not always produce good results for all validation years, and further research is needed regarding the validation of rain data which are included in the category of wet years and dry years.

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