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CHANGE OF MAXIMUM RAIN PATTERN BASED ON RAINFALL DATA OF BANJARBARU CLIMATOLOGY STATION CAUSED BY CLIMATE CHANGE

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ABSTRACT

According to the World Meteorological Organization that 2014 was the hottest year in which the hot weather alternated with high rainfall and floods which destroyed the people's economy. Banjarbaru, as one of the central cities of the government of South Kalimantan Province, has a topographic condition that is at an altitude of 0-500 m above sea level, causing rainfall, which is enough frequent. Banjarbaru itself is one of the cities affected by climate change in 2014. Disasters that occurred in the form of flooding at several points of residents and also crippled traffic at that time. Thus, it is important to know the pattern of maximum rainfall changes that occur. By knowing the pattern of maximum rainfall changes, the impact of the high rainfall that can occur will be minimized and can even be anticipated as early as possible.

Data processing is performed with maximum daily rainfall data of 30 years and divided into a database before and after climate change that is 25 years old data and 5 years of new data. Each database calculates the planned rainfall for the return period of 2-1000 years with the distribution obtained from the analyzed database. Next, analyze the deviation of the two data. The purpose of analyzing the deviation of old data and new data is to determine changes in the planned rainfall from both data. Deviation analysis uses the Peak-Weight Root Mean Square Error function.

The conclusion of the analysis is that based on the Statistical Parameters test, the Chi-Square test, and the Smirnov-Kolmogorov test on the old database using the Gumbel distribution and the new data using the Pearson Log Type III distribution for the calculation of the planned rain. Based on the analysis of the rain plan to get new data 5 years has the results of the rain plan is greater than the old data of 25 years and the analysis of the deviation to get the results of the new data 5 years has a greater value of deviation each time when revisiting the old data of 25 years. So it can be suggested that rainfall data with the same characteristics, can use 5 years of new data for the analysis of water building planning.

Keywords: Climate Change, Changing Rain Patterns, Deviation Analysis

I. INTRODUCTION

Indonesia is a country that has a tropical climate, where the most influential climate parameter is rainfall. The rainy season that occurs will vary by region, depending on the altitude, climate, and other factors. Rainfall patterns in Indonesia are generally dominated by monsoons, which are characterized by a significant difference between the rainy season and the dry season. Climate elements such as rainfall become a natural resource that is needed by living things. But rainfall can also be a disaster when climate change occurs. The disaster occurred when the transformation of rainfall into floods, landslides, and others.

According to the World Meteorological Organization (2014), 2014 was the hottest year in which the hot weather alternated with high rainfall and floods, which destroyed the people's economy. Banjarbaru, as one of the central cities of the government of South Kalimantan Province, has a topographic condition that is at an altitude of 0-500 m above sea level, causing rainfall, which is enough frequent. Banjarbaru itself is one of the cities affected by climate change in 2014. The disaster occurred in the form of flooding at several points of residents and also crippled the traffic at that time.

Then, it is important to know the pattern of maximum rainfall changes that occur. By knowing the pattern of maximum rainfall changes, the impact of the high rainfall that can occur will be minimized and can even be anticipated as early as possible. So there needs to be an analysis of the pattern of maximum rainfall change from old data on new data that begins with climate change that has already occurred. Where this analysis is intended to determine the magnitude of changes that occur from old data to the present, the results of this analysis can be used for planning for further prevention efforts when the rain repeats or even exceeds so that no disasters occur again.

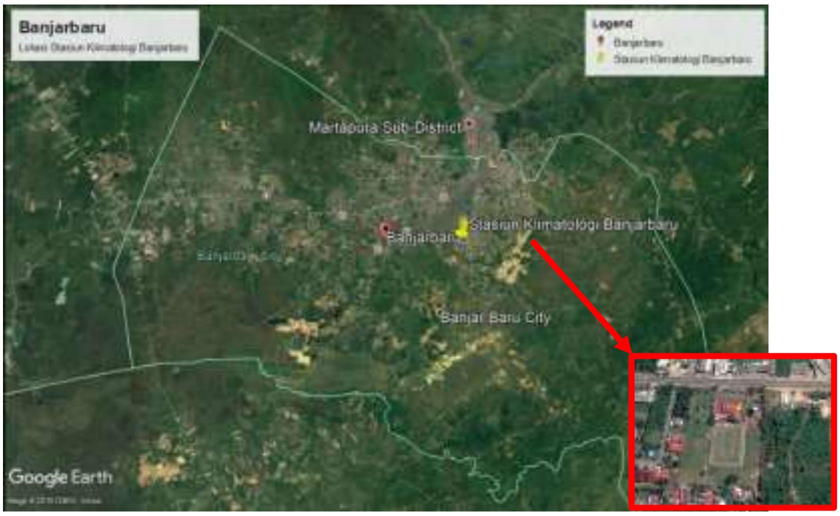
1. Research Objective

The objectives of the research discussed are as follows:

1. It is knowing the changes in the maximum rainfall pattern from old data to new data after the occurrence of climate change in 2014 based on rainfall data from the Banjarbaru Climatology Station.
2. It is knowing the magnitude of changes in the maximum rainfall pattern from old data to new data after the occurrence of climate change in 2014 based on rainfall data from the Banjarbaru Climatology Station.
3. Knowing the rainfall data that can be used for the analysis of Banjarbaru water area planning.

2. Research Location

Banjarbaru Climatology Station is located in the city of Banjarbaru, which is one of the cities in the province of South Kalimantan, Indonesia. The location of the Banjarbaru Climatology Station is at coordinates 3 ° 27'41.29 "S and 114 ° 50 '26.74" E. Banjarbaru City, which is administratively the result of division from Banjar Regency. The city has an area of 371.30 km2 (37,130 ha). For more details about field conditions, can be seen in Figure 1. below.



Source : Google Earth

Figure 1. Location of Banjarbaru Climatology Station

II. THEORETICAL STUDY

1. Analysis of Rain Plan

a. Statistical Parameters

Parameters related to data analysis include the equations summarized in Table 1. below:

Table 1. Statistical parameters for frequency analysis

Parameter	Formula
Rata-rata	$\bar{x} = \frac{1}{n} \Sigma_{i=1}^{n} x_1$
Deviasi Standar	$S = \sqrt{\frac{\Sigma_{i=1}^{n} (x_i - \bar{x})^2}{(n-1)}}$
Koefisien Variasi	$Cv = \frac{S}{\bar{x}}$
Koefisien Skewness	$Cs = \frac{n \Sigma_{i=1}^{n} (x_i - \bar{x})^3}{(n-1)(n-2)S^3}$
Koefisien Kurtosis	$Ck = \frac{n^2 \Sigma_{i=1}^{n} (x_i - \bar{x})^4}{(n-1)(n-2)(n-3)S^4}$

with :

x_i= variable value to i

$\bar{x}$ = average value of the variant

n = the amount of data

b. Selection of Distribution Types

The distribution equation used is summarized in Table 2. below

Table 2. Requirements of each distribution

No.	Distribusi	Requirements	Formula
1.	Normal	$Cs \approx 0$	$X_T = \bar{x} + K_T Sx$
		$Ck \approx 3$	$S = \sqrt{\frac{\Sigma_{i=1}^{n} (x_i - \bar{x})^2}{(n-1)}}$
2.	Log Normal	$Cs = 3Cv$	$\log X = \overline{\log X} + K_T . S \log X$
		$Ck = Cv^8 + 6 Cv^6 + 15 Cv^4 + 16 Cv^2 + 3$	$S \log X = \sqrt{\frac{\Sigma_{i=1}^{n} (\log x_i - \log \bar{x})^2}{(n-1)}}$
3.	Gumbel	$Cs \approx 1,14$	$X_T = \bar{x} + K_T Sx$
		$Ck \approx 5,4002$	$S = \sqrt{\frac{\Sigma_{i=1}^{n} (x_i - \bar{x})^2}{(n-1)}}$
4.	Log Pearson Type III	Apart from values above	$\log X = \overline{\log X} + K_T . S \log X$
			$S \log X = \sqrt{\frac{\Sigma_{i=1}^{n} (\log x_i - \log \bar{x})^2}{(n-1)}}$

with :

X_T = the estimated value expected to occur with a T-year return period (mm)

$\bar{x}$ = the maximum average rainfall value(mm)

Sx = standard deviation

K_T = Gauss reduction variable (Normal and Log Normal distribution)

$\log X$ = logarithm of T-year rainfall

$\overline{\log X}$ = logarithm of average maximum rainfall

$S \log X$ = standard deviation value of logarithm X

K_T = *skewness*(Cs) (Log Pearson Tipe III distribution)

K_T = $K_T = \frac{Y_{TR}-Y_n}{S_n}$ (Gumbel distribution)

c. The Goodness Of Fit Test

The distribution test equation used is as follows:

Distribution Test	Formula
Chi-Kuadrat	$X^2 = \Sigma_{i=1}^{N} \frac{(O_f - E_f)^2}{E_f}$
Smirnov-Kolmogorov	$\Delta_{max} = \lvert P_{empirik} - P_{teoritik} \rvert < \Delta_{kritik}$

with :

X^2 = chi square parameters are calculated

N = the number of sub groups in one group

O_f = the number of observations in the sub group i

E_f = the number of theoretical values in the sub group i

$P_{empirik}$ = empirical probability

$P_{teoritik}$ = theoretical probability based on the chosen distribution

2. Deviation Analysis

This analysis uses the Peak-Weighted Root Mean Square Error function. This function is used to test data reliability by using the mean square error function. The formula for testing data reliability is as follows.

$$Z = \left\{\frac{1}{NX}\left[\Sigma_{i=1}^{NX}\left(X_0(i) - X_s(i)\right)^2 \left(\frac{X_0(i) + X_0(mean)}{2X_0(mean)}\right)\right]\right\}^{\frac{1}{2}}$$

with :

Z = the value of *peak-weighted root mean square error*

NX = the amount of rainfall data

X_0 = old data rainfall value

X_s = new data rainfall value

X_0(mean) = the average value of rainfall observed

III. METHOD

The methodology begins with the preparation of 30 years of maximum rainfall data from 1989 to 2018. The data will be divided into two databases to be analyzed. The data is divided based on before and after the occurrence of climate change, which is precisely in 2014, and obtained the old data 25 years before the occurrence of climate change and new data 5 years after the occurrence of climate change.

Data analysis begins with the analysis of statistical parameters to produce the type of distribution method used by looking at the results of the parameters of the mean value (Mean), standard deviation (standard deviation), skewness coefficient (Cs), coefficient of shaking/curtosis (Ck), and the coefficient of variation (Cv). After that, determine the type of distribution of several choices based on the results of the statistical parameters and tested using the Chi-Square test and Smirnov Kolmogorov to find out whether the preferred distribution method represents the statistical distribution of the sample data analyzed. After testing, the distribution will proceed with the calculation of rainfall plans on two databases.

The results of the calculation of the planned rain are not only compared through graphs but also by analyzing the data deviation from two databases before and after climate change. The function used is Peak-Weighted Root Mean Square Error. The purpose of analyzing the deviation of old data and new data is to determine changes in the planned rainfall from both data

IV. RESULT AND DISCUSSION

1. Hydrological Analysis

a. Rainfall Data

The data used in this study is the maximum rainfall data from the Banjarbaru Climatology Station. The data is 30 years old, from 1989 to 2018, divided into two databases that will be analyzed, namely the 25-year old database and the 5-year new data. The following rainfall data used are presented in Table 3.

Table 3. Recapitulation of annual maximum rainfall data

No.	Year	Maximum Rainfall (mm)	No.	Year	Maximum Rainfall (mm)
1	1989	98.3	16	2004	135.9
2	1990	101.5	17	2005	66.3
3	1991	150	18	2006	90.9
4	1992	124	19	2007	86.5
5	1993	116.5	20	2008	182.1
6	1994	78	21	2009	98.6
7	1995	158.5	22	2010	90.5
8	1996	75	23	2011	158.6
9	1997	87	24	2012	95.6
10	1998	124.5	25	2013	87.8
11	1999	91.2	26	2014	213.9
12	2000	95.5	27	2015	116
13	2001	88.7	28	2016	108
14	2002	70.2	29	2017	87.2
15	2003	159.5	30	2018	91.3

Source: Rainfall Climatology Station Banjarbaru data

b. Statistical Parameters

In statistics, there are several parameters related to data analysis including the average value, standard deviation, coefficient of variation, skewness coefficient, and kurtosis coefficient. The following are the results of the statistical parameter analysis presented in Table 4.

The results of the statistical parameter analysis are summarized in Table 4 :

Table 4.Recapitulation of the old database and new data statistical parameters

Years	Distributions	Requirements	equiremen	Calculate	Rank	Conclusion
25	Normal	Cs ≈ 0	0	0.865	1	Ya
		Ck ≈ 3	3	2.979		Ya
	Log Normal	Cs = 3Cv + Cv^3	0.91	0.865	2	Tidak
		Ck = Cv^8 + 6 Cv^6 + 15 Cv^4 + 16 Cv^2 +3	4.52	2.979		Tidak
	Gumbel	Cs ≈ 1,14	1,14	0.865	3	Tidak
		Ck ≈ 5,4002	5.4002	2.979		Tidak
	Log Pearson Type III	Other than value above		0.865	4	Tidak
				2.979		Tidak
5	Normal	Cs ≈ 0	0	1.956	4	Tidak
		Ck ≈ 3	3	9.993		Tidak
	Log Normal	Cs = 3Cv + Cv^3	1.34	1.956	2	Tidak
		Ck = Cv^8 + 6 Cv^6 + 15 Cv^4 + 16 Cv^2 +3	6.36	9.993		Tidak
	Gumbel	Cs ≈ 1,14	1,14	1.956	3	Tidak
		Ck ≈ 5,4002	5.4002	9.993		Tidak
	Log Pearson Type III	Other than value above		1.956	1	Ya
				9.993		Ya

Source: Calculation results

c. Rainfall Distribution Testing

Distribution testing is carried out to determine whether the distribution obtained from statistical parameters already illustrates or represents the distribution of the rainfall data. The following results for the Chi-Square and Smirnov-Kolmogorov tests are presented in Table 5 and Table 6.

Table 5. Recapitulation of the chi-square test for each type of distribution of old databases and new data

Distribution Test	Years	Distribution	X^2	X^2cr	Opportunity (%)	Limit (α) (%)	Rank	Conclusion
Chi Kuadrat	25	Normal	11.6	5.991	0.138	5	3	Gumbel
		Log Normal	5.2	5.991	56.045	5	2	
		Gumbel	1.2	5.991	86.616	5	1	
		Log Pearson Tipe III	18.8	5.991	-2.457	5	4	
	5	Normal	3.8	3.841	50.481	5	3	Log Pearson Tipe III
		Log Normal	2.2	3.841	69.245	5	2	
		Gumbel	8.6	3.841	-0.005	5	4	
		Log Pearson Tipe III	0.6	3.841	88.009	5	1	

Source: Calculation results

Table 6. Recapitulation of the Smirnov-kolmogorov test for each type of old database distribution and new data

Distribution Test	Years	Distribution	Δ_{max}	Δ_{kritik} (5%)	Conclusion
Smirnov-Kolmogorov	25	Normal	0.095	0.27	Gumbel
		Log Normal	0.095	0.27	
		Gumbel	0.095	0.27	
		Log Pearson Tipe III	0.095	0.27	
	5	Normal	0.126	0.56	Log Pearson Tipe III
		Log Normal	0.121	0.56	
		Gumbel	0.126	0.56	
		Log Pearson Tipe III	0.121	0.56	

Source: Calculation results

d. Calculation Of Rain Plan

The planned rainfall results from the distribution obtained for the old database, and new data are summarized in Table 7 below:

Table 7. Recapitulation of rainfall calculation for old database plans and new data

Return Periode T (Years)	Rainfall Plan (mm) Database	
	25 Years	5 Years
2	103.630	105.822
5	136.913	147.807
10	158.950	187.512
15	169.519	207.612
20	180.087	229.868
25	186.793	254.509
50	207.448	319.328
100	227.953	399.560
200	248.379	499.124
1000	295.701	837.905

Source: Calculation results

From the calculation of the rainfall plan for the 25-year old database and the new 5-year data as in Table 7 above. Then it can be seen for a comparison of the two data in Figure 2 below.

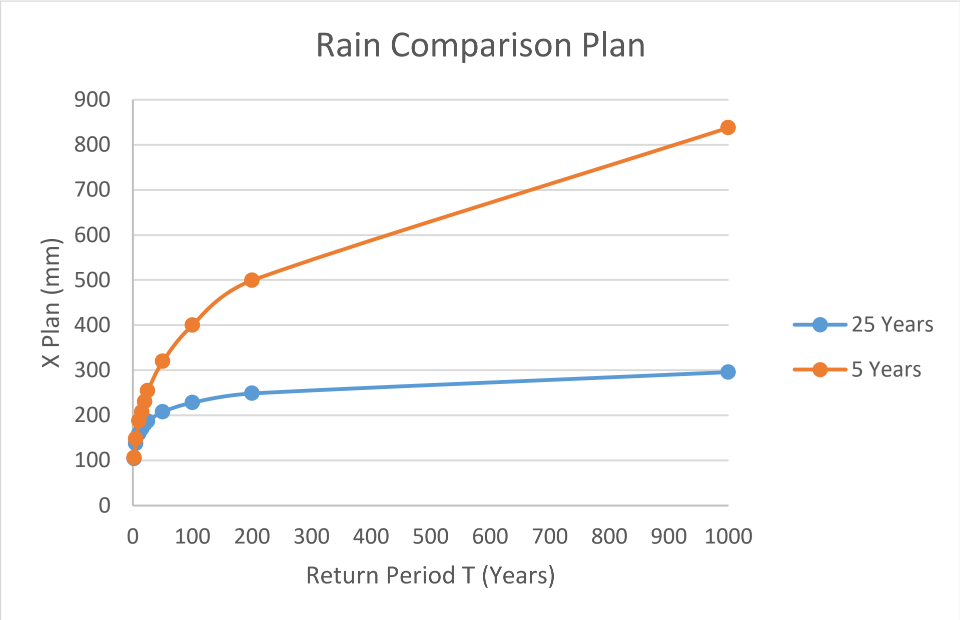


Figure 2. Comparison Chart of Old Database and New Data Plan Rain

From Figure 2., it can be seen that the new 5-year database has rainfall plan results that are above the results of the 25-year old database for the return period of 2 years to 1000 years.

e. Deviation Analysis

The results of the deviation analysis from 25 years old data and 5 years new data using the Peak-weighted root mean square error formula are summarized in Table 8 below:

Table 8. Recapitulation of peak weighted root mean square error results of the old database and new data

Return Period (T)	Old Data (25 Years)	New Data (5 Years)	Deviation
2	103.63	105.82	0.64
5	136.91	147.81	3.36
10	158.95	187.51	9.11
15	169.52	207.61	12.33
20	180.09	229.87	16.34
25	186.79	254.51	22.43
50	207.45	319.33	38.06
100	227.95	399.56	59.86
200	248.38	499.12	89.57
1000	295.70	837.90	203.83
Average	191.54		

Source: Calculation results

2. Discussion

Based on the results of the analysis that has been done, the following discussion is obtained:

1. Analysis of statistical parameters from the 25-year old database and the new 5-year data found that the representative distribution for the 25-year data is the Normal distribution, and the 5-year data is the Pearson Log Type III distribution. After testing the distribution using the Chi-Squared and Smirnov-Kolmogorov test for a 25-year database, the Gumbel distribution was found to be eligible, and the 5-year data obtained that the Pearson Log Type III distribution was eligible.
2. The planned rain for the 25-year old database and the new 5-year data results for the 5-year old data have a greater value of the planned rainfall at 2, 5, 10, 15, 20, 25, 50, 100, 200, and 1000 years.
3. Rain plans for the 25-year old database and 5-year new data after analyzing statistical deviations using the Peak Weighted Root Mean

Square Error function, the value of the deviation from the new data to the old data is getting bigger each time that indicates that the values of the new database 5 years has a greater value than 25 years-old data.

V. CONCLUSION

1. Conclusion

Based on the results and discussion of the research, the conclusions obtained from the changes that occurred in 2014 caused a change in the maximum pattern by obtaining the Gumbel distribution for before climate change and the distribution of the Pearson Log Type III to replace the changes. Where the rain data after climate change has a plan rainfall value that is greater than the data before climate change and gets a deviation value from the two data. The value of the deviation from the results of the Peak Root Mean Square Error test on 25 years old data and 5 years new data for 2, 5, 10, 15, 20, 25, 50, 100, 200, and 1000 years of help data is 0,64; 3,36; 9,11; 12,33; 16,34; 22,43; 38,06; 59,86; 89,57 and 203.83. It takes 5 years of new data to have a greater value of the rain plan that can be used for air building planning analysis in the Banjarbaru region.

2. Suggestion

a. Based on the characteristics of rainfall (statistical parameters) that are different for each region in Indonesia, it is likely to produce a different analysis as well. For this reason, further research is needed on rainfall data with other regional characteristics.
b. The results of the analysis of changes in the pattern of maximum rainfall data at the Banjarbaru Climatology Station are expected to be able to be used to analyze rainfall data in the South Kalimantan region.

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