



## Linear Regression Analysis Using Log Transformation Model for Rainfall Data in Water Resources Management Krueng Pase, Aceh, Indonesia

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### ABSTRACT

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*climatology, rainfall, prediction, log transformation model, water resources*

Climate changes are one crucial factor that influenced water availability at one location since they affected the environmental, social, and agricultural systems. The study observed the agent factors that influenced the rainfall changes at Krueng Pasee Aceh watershed, Indonesia. The method used in this research is a linear regression with a log transformation approach on predictor variables. The data used in this study consisted of rainfall, a total of rainy days, temperature, humidity, duration of irradiation, and wind speed in the period ranging from 1992 to 2020. Results showed that the agent factors had not distributed normally. The regression model produced after log transformation had met the classical assumptions and can be used to predict the rainfall at R-square 24.61% with an RMSE value of 57.676. From all factors studied, the wind speed should be excluded. Further study is recommended to use the nonlinear method to improve the model for rainfall prediction.

## 1. INTRODUCTION

Water resource problems characterized by pollution and decreasing capacity of natural resources in providing environmental services require smart solutions and good approaches. The hydrological cycle, rainfall, and changing pattern of rainfall itself affect water resources [1]. The connection between rainfall volume and land use is the capacity of the land to store water from the rain. The characteristics of rainfall from one area to another are different. It is influenced by the location of the area or region, the closer an area position to the equator, the greater the rainfall. However, high rainfall conditions do not always cause flood. The flood can cause by many factors, such as improper land use management [2, 3].

Changes in rainfall patterns are a problem for water resource managers [4]. Cyclic changes and sea-level rise also directly impact hydrological processes in forested wetlands [5]. Most importantly, climate change and variability are related to land use change. Crop production is affected by soil moisture obtained from rainfall [6]. Weather and climate are usually described through several meteorological parameters: rainfall, air temperature, humidity, air pressure, and wind speed [7]. The relationship between rainfall and runoff is a complex and challenging to predict hydrological phenomenon [8]. It is very challenging to research its complexity and many factors included in the experimental physical process [9].

Rainfall impacts changes in water capacity, and the primary input to the watershed changes, mainly when heavy rains occur. A rainfall data analysis is critical for ecological, many

agricultural, and engineering activities. The average rainfall and rainfall volatility data will impact on the design of irrigation and drainage systems. In addition, Annual cycle changes such as accelerated-time of rainfall could determine to optimize the cropping time in agricultural planning. It is estimated yields also depend on the distribution of rainfall during the growing season. Extrapolation of long-term trends and the provision of short/medium-term forecasts, understanding the mechanisms and consequences of hydrological-ecosystem, and community conversion are critical to increasing capacity to develop effective adaptation strategies to climate change [10, 11].

Rainfall is one of the factors that influence climate change. Climate changes were determined by four variables: air temperature, rainfall, humidity, and wind velocity [12]. Climate change has begun to occur in the Krueng Peusangan, Indonesia watershed by looking at temperature as one of the climate variables indicators [13]. Temperature is one of the factors of rainfall. Prediction of rainfall discharge using the ARIMA model was good for short-term forecasting. It is not suitable for long-term forecasting accuracy because the trends of rainfall were flat [14]. Uncertainty in climatic events requires the need for an appropriate model to predict them [15]. Zhang et al. [16] has considered the rainfall parameters using sunny, foggy, cloudy weather types using a statistical support vector machine approach but is unable to provide accurate rainfall predictions because they cannot identify sudden weather changes.

Singhtrattna et al. [17] used multiple linear regression and non-parametric approach based on local polynomials with

parameters such as sea-surface temperature, sea-level pressure, wind speed, El Niño Southern Oscillation Index (ENSO), IOD. Dutta and Tahbider [18] using maximum temperature, minimum temperature, wind speed, Mean Sea level. While, Maran and Ponnusamy [19] using Mean temperature, Humidity, Wind gust, Wind direction, Barometric pressure and Wind speed for parameter prediction rainfall.

Rainfall in the predicted year is required to predict water discharge. The use of transformation data analysis can build models for statistical predictions in the future, such as in designing models of humidity, temperature, wind speed, and other variables for a particular location [20]. Therefore, the objective of this study is to determine the data characteristics of the agent factors that influence changes in rainfall patterns in the Krueng Pasee Watershed in Aceh Utara district Indonesia, by modeling the relationship between rainfall variables with temperature, humidity, a total of rainy days, and wind speed through the log transformation approach. Therefore, the estimated values to be obtained can be used as a basis for future planning.

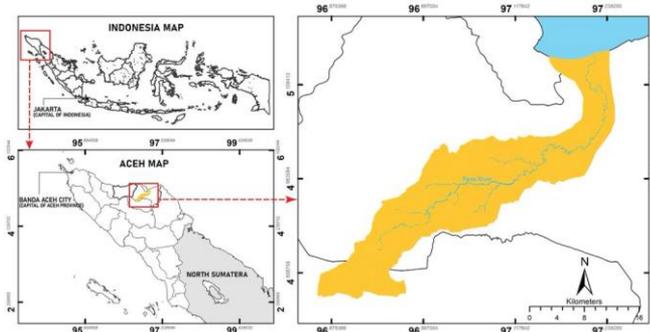
## 2. MATERIALS AND METHODS

### 2.1 Study location

Krueng Pase Watershed is located between 5°09'12" - 4°49'25" North Latitude and 96°51'27" - 97°14'55" East Longitude and the station meteorology is 5°13'4"N; 96°56'5"E. It is located in Lhokseumawe city, Aceh Utara district and Bener Meriah district. (Figure 1). The data used in this study is secondary data obtained from the Meteorology Climatology Geophysics Agency (BMKG), with five variables studied, namely rainfall, total rainy days, humidity, temperature, and duration of irradiation (exposure time). The research variables of rainfall in the Krueng Pase watershed and predictor variables are shown in Table 1.

**Table 1.** Research variable

Symbol	Variable	Unit	Type data
$Y$	rainfall	Millimeter	Ratio
$X_1$	Total Rainy day	day	Ratio
$X_2$	Temperature	Celsius	Interval
$X_3$	Humidity	Percentage	Ratio
$X_4$	Exposure Time	hour/day	Ratio
$X_5$	Wind velocity	Knot	Ratio



**Figure 1.** Map of the Krueng Pase watershed area and station Meteorology as the research location

### 2.2 Analysis

#### a. Kendall rank correlation analysis

Kendall rank correlation analysis is used to find relationships and test hypotheses between two or more variables if the data is ordinal or ranking value [21]. This method has advantages such as can be used to analyze samples more significant than ten and can be developed to find partial correlation coefficients. The Kendall rank correlation coefficient is given by using the notation  $\tau$ . The steps taken are (a) ranking the observation data on the X and Y variables; (b) Determining N objects so that X ranks the subjects in good order 1,2,3,...,n. If there are the same ranking, then the ranking is the average; (c) Observing the Y rank in the order corresponding to the X rank in the correct order then determine the number of concordant pairs ( $N_c$ ) and the number of discordant pairs ( $N_d$ ); (d) Determining the test statistic using the formula (1).

$$\tau = 2 \left( \frac{N_c - N_d}{N(N - 1)} \right) \quad (1)$$

Note:

$\tau$  = Kendall rank correlation coefficient;

$N_c$  = number of concordant pairs;

$N_d$  = sum of discordant pair numbers;

$N$  = sample size.

$H_0$  reject if  $\tau > \tau_{(N_c - N_d; N)}$ . As for  $N > 10$ , the distribution used is the normal distribution, by using the formula [18].

$$z = \frac{\tau}{\sqrt{\frac{2(2N + 5)}{9N(N - 1)}}} \quad (2)$$

Hereby,  $H_0$  is rejected if the p-value is less than the significance value. The hypotheses tested are as follows.  $H_0$ : there is no relationship between the two variables, and  $H_1$ : there is a relationship between the two variables.

#### b. Log Transformation in Linear Regression

The virtue of the transformation can minimize skewness and stabilize the value of variance. When the value of the variance changes with the mean based on the strength of the relationship for the positive variable, the Box-Cox class produces the appropriate transformation [22]. The Box-Cox transformation is defined as follows.

$$Y' = \begin{cases} \ln(Y) & \text{for } \lambda = 0 \\ \frac{Y^\lambda - 1}{\lambda} & \text{for } \lambda \neq 0 \end{cases} \quad (3)$$

where is  $Y$  the response of the variable in the original scale,  $Y'$  the response to the variable in the transformation scale, and  $\lambda$  is a measure of the strength of the parameter.

Natural log transformations ( $\lambda=0$ ) are commonly used, the most recent transformation  $Y'$  will be continued in ANOVA or regression calculations, where the advantage of least squares estimation in efficacy is still hidden [23, 24] with the following model:

$$\ln(Y) = \beta_0 + \beta_1 x_1 + \dots + \beta_k x_k + \varepsilon. \quad (4)$$

The response of the transformation  $\ln(Y)$  is expressed as a linear function of the predictor variable,  $x_i$  concerning, and the normal distribution and the term homoscedasticity error to estimate the effect of the explanatory variable ( $X$ ) in the mean of the response variable  $Y, E(Y)$ , based on multiple linear regression.

$$Y = \beta_0 + \beta_1 X + \beta_2 X_2 + \dots + \beta_k X_k + \varepsilon, \varepsilon \sim N(0, \sigma^2), \quad (5)$$

$X_2, \dots, X_k$  as other explanatory variables  $\beta_0$ , and  $\beta_1, \beta_2, \dots, \beta_k$  unknown parameters are intercepts of the model and regression coefficients  $\varepsilon$  are typically distributed residuals. For  $Y$  variables without transformation  $X$ , and log transformation, the estimate of the median or geometric mean of  $Y$  corresponding values  $X = x$  is as follows:

$$E[Y|X = x] = \hat{\beta} \log(x) + \hat{K}. \quad (6)$$

In this calculation, the variable  $Y$  is the response, and the variable  $X$  is the predictor concerning the effect  $X$ . It can be said that the measure is independent of both values  $X$  and  $\hat{K}$ . The additive change in cunits  $X$  is the result of a relative change in the median or geometric mean of  $Y$  or equivalent [25].

$$\Delta \hat{M}\% = 100 \frac{\hat{M}[Y|X = x + c] - \hat{M}[Y|X = x]}{\hat{M}[Y|X = x]} = 100(e^{\hat{\beta}c} - 1)\%, \quad (7)$$

c. Normality, multicollinearity, heteroscedasticity, and autocorrelation tests

The normality test aims to test whether the confounding or residual variables have a normal distribution in the regression model to detect whether the residuals are normally distributed or not, the one-sample Kolmogorov-Smirnov test is carried out with a decision-making basis, namely [26, 27]: (a) If the results of the one-sample Kolmogorov-Smirnov are above the 0.05 level of significance, it shows the distribution pattern. Then the regression model meets the normality assumption; (b) If the Kolmogorov-Smirnov one-sample result below the 0.05 level of significance does not indicate a typical distribution pattern, then the regression model does not meet the assumption of normality.

The next step is to do a multicollinearity test to determine whether there is a correlation between the independent variables in the regression model. Detection of the presence or absence of multicollinearity in the regression model can be seen from the tolerance value and variance inflation factor (VIF).

A heteroscedasticity test was carried out to test whether there was an inequality of variance from the residuals of one observation to another observation in the regression model. If the variance from the residual of one observation to another remains, it is called homoscedasticity, and if it is different, it is called heteroscedasticity [28]. An autocorrelation test was

carried out to test whether in the linear regression model there was a correlation between the confounding error in the period  $tt - 1$  and is the error in the (previous) period.

$$F = \frac{\frac{\sum_{i=1}^K n_i (\bar{Y}_i - \bar{Y})^2}{(K - 1)}}{\frac{\sum_{i=1}^K \sum_{j=1}^{n_i} (Y_{ij} - \bar{Y}_i)^2}{(N - K)}} \quad (8)$$

This test produces calculated DW ( $d$ ) and Durbin Watson table values ( $dl$  and  $du$ ). Decision-making related to the presence or absence of autocorrelation through the DW table criteria with a significance level of 5% and four independent variables ( $k=4$ ) [9]. It is an overall regression model test that determines whether the model made is feasible to be a good model. The test is carried out by calculating ANOVA to obtain the F value as follows [29-31].

Root Mean Square Error (RMSE) is used to calculate the error rate of the two experimental models. The amount of RMSE value can be calculated by the following equation [32].

$$RMSE = \sqrt{MSE} = \sqrt{\frac{1}{M} \sum_{l=1}^M (Z_{n+l} - \hat{Z}_n(l))^2} \quad (9)$$

The  $M$  is the number of predictions made, while  $Z_{n+l}$  is the actual data and  $\hat{Z}_n(l)$  the forecast data.

### 3. RESULTS AND DISCUSSION

In the first step of the research, data exploration was carried out using descriptive statistics and graphic visualization. Data exploration is needed to determine the characteristics of the data [28, 29] so that it can determine or apply the appropriate analysis method. The characteristics of the rainfall data and the influencing factors consisting of Rainy Days, Temperature, Humidity, Wind Speed, and Length of Radiation in the Krueng Pase Watershed in North Aceh Regency from January to December between 1992 and 2020 (Table 2).

Based on Table 2, it can be seen that the characteristics of the data studied had been explained by using the average value (mean), the distribution of the data contained in the sample (standard deviation), the minimum value (min), the maximum value (max), the slope of the distribution (skewness) and the sharpness of the distribution (kurtosis). The value of skewness and kurtosis indicates the degree of asymmetry of a distribution. Table 2 indicates that the rainfall variable has the most significant standard deviation value of 89.45 mm, followed by the wind speed variable of 54.55 knots. This shows that the two variables have the most considerable variance among other variables with relatively small standard deviation.

**Table 2.** Descriptive statistics of rainfall changes

Variable	Mean	Deviation Standard	Min	Max	Skewness	Kurtosis
Rainfall (1)	118.3	89.45	2	571	1.53	3.16
Rainy day (2)	14.557	5.691	2	29	0.15	-0.55
Temperature (3)	26.782	1.125	24.9	34.819	2.66	13.28
Humidity (4)	81.338	3.876	70.733	94	-0.18	-0.14
Exposure time (5)	6.2704	1.2514	0.7	9.2	-0.57	0.93
Wind Velocity (6)	125.27	54.55	10	360	1.48	5.28

Based on Table 2, it also shows that the humidity and irradiation time (exposure time) variables have a skewness value of -0.18 and -0.57, respectively, where the value is below 0, which indicates that the data has a slope to the right and shows that the distribution of the data is not symmetrical and has negative skewness. While the variables of rainfall, rainy days, temperature, and wind speed showed a skewness value greater than 0, indicating that the data had a slope to the left and indicated that the data distribution was not symmetrical and had a positive skewness. Lastly, the kurtosis value on a rainy day and humidity variables with  $(k) < 0$  is -0.55, and -0.14 indicates that the data is much heterogeneous. This also implies that the other variables have homogeneous data. The visualization of the skewness and kurtosis shows by Figure 2, indicates that all the variables are not normally distributed.

Based on Figure 3, it is found that there are outliers in the variables of rainfall, temperature, humidity, and duration of irradiation, so it is necessary to pre-process the data to minimize bias analysis. The boxplot in Figure 3 also indicates that the rainfall variable has an enormous variance value compared to other variables. Boxplot visualization also shows the value of Quartile 1, Median (middle value), Quartile 3, minimum value (smallest observation value), and maximum value (most considerable observation value). In this study, it can be seen that all the variables studied have different characteristics.

Based on Figure 4, it is known that all the variables studied are not normally distributed. This is indicated by P-Value  $< 0.05$ , where  $H_0$  had been rejected, which means the data is not normally distributed. A transformation log can help the distribution become more normalized [31]. Through visualization, it can also be seen that the distribution of plotting points is not on a diagonal line, so it is necessary to transform the data to meet the assumption of normality [32, 33]. Abnormalities in the data are due to outlier values or extreme values in a data set, resulting in a skewness distribution (skew) in the analyzed data.

The data used in this study is continuous in the period 1992 to 2020, so that the abnormal distribution can also be caused by differences in the shape of the distribution. There is overlap in the data so that round-off errors or measurement devices with low resolution can make it true. It is true that continuous data and normally distributed data look discrete and not expected.

Correlation Analysis with Kendall-Tau aims to measure the strength of the relationship between the variables studied as well as to determine whether there is a relationship among variables [21]. In this study, correlation analysis was used to determine the relationship between rainfall and the influencing factors in the Krueng Pase Watershed in North Aceh Regency. The analytical method used in this study is the Kendall-Tau correlation with the following output (Table 3).

Based on Table 3, it can be seen that all variables have P-Value  $< 0.01$ , indicating that there is a relationship among all predictor variable (rainy day, temperature, humidity, and Exposure time /duration of irradiation) to the response variable (rainfall). The exception is for the wind speed that has no relationship to other variables, so that the wind speed variable is not used in subsequent regression analysis. The strength of the correlation can also be known through the value of the correlation coefficient, if the value is close to 1, it is indicated to have a very strong correlation.

The results of the analysis of data characteristics found that

all variables were not normally distributed, so it was necessary to transform them to make assumptions [34, 35]. The analytical method used is Log Transformation Linear Regression, and the output can be seen in (Table 4).

The statistical theory used to develop the classic techniques for constructing confidence intervals for population means and performing statistical tests of hypotheses begins with the assumption that the response of interest has a normal distribution. If this assumption is true, inferences from the results are valid (e.g., statistical significance of P values and width of confidence intervals). One common type is the logarithmic transformation. If the data are continuous and nonnegative and have a positively skewed distribution, they may have a distribution that is referred to as log normal [26].

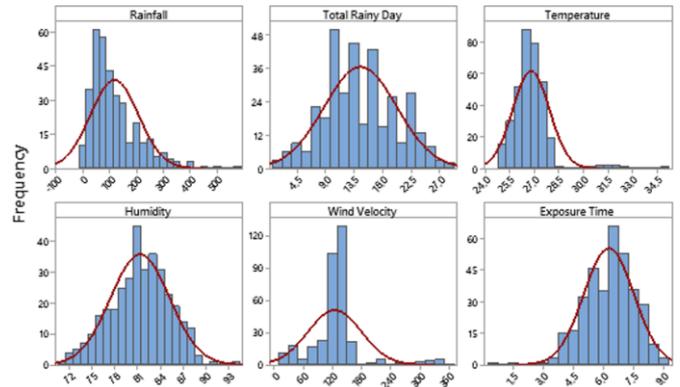


Figure 2. Distribution plot for all variables

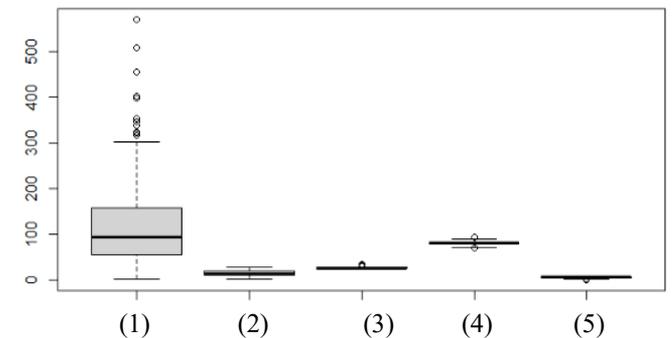


Figure 3. Boxplot visualization on all variables

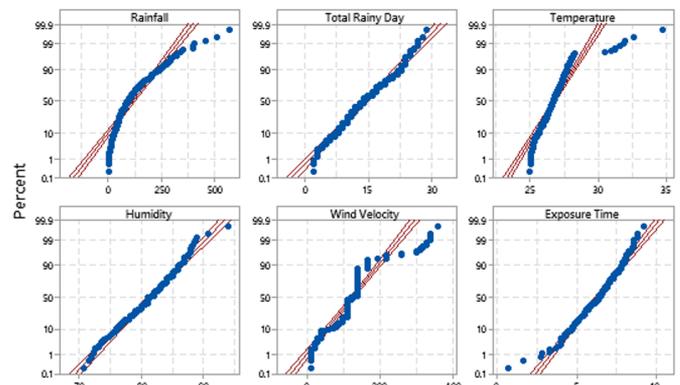


Figure 4. Visualization of probability plots on all variables studied

Simple Linear Regression shows the pattern of relationship between X and Y variables. The X variable consisted of rainy days, temperature, humidity, and exposure time. Variable Y is

rainfall. Linear regression is used to predict quantitative outcomes based on a single variable on a single predictor by constructing a mathematical model defined as a function of the variables. The prediction results using simple linear regression can be seen in Table 4. The Coefficients column can be seen as follows:

$$Y = 826.92 + 82.27X_1 - 116.94X_2 - 135.59X_3 + 21.22X_4$$

The model represents; Y= rainy day as the variable response. And other variables are X<sub>1</sub> = rainy day, X<sub>2</sub>= temperature, X<sub>3</sub>= humidity, and X<sub>4</sub> = Exposure time. The regression equation above explained that, if other variables are constant, the value of rainfall will change automatically by a constant value of 826.92. If other variables are constant, the value of Rainy Days will change by 82.27 per unit, Temperature by -116.94, Humidity by -135.59, and the irradiation time of 21.22 per unit. The increase of 1 rainy day will increase the rainfall about 82.27mm, the increase of 1°C temperature will decrease the Y by 116.94 mm.

Table 5 shows the results of the F test. It's used to predict the contribution of the independent variable (X) to the dependent variable (Y). Using a confident interval of 95% and an error value of 5%, the P-Value <0.05, which means rejecting H<sub>0</sub>, indicates that the regression model is linear. It shows that the regression model Y to X is significant.

The regression results in Table 4 indicated that the variables of rainy days, temperature, humidity, and Exposure time have a relationship with rainfall.

Linear regression analysis must meet several assumptions, including normality, multicollinearity, heteroscedasticity, and autocorrelation. Normality test aims to assess the distribution of data in a group of variables. In multiple linear regression analysis, the normality test was carried out for the residual results that have been analyzed.

The homoscedasticity tests the similarity of variance from the residual observations to others in the regression model. It means that heteroscedasticity is the opposite of homoscedasticity. A good regression model is one with homoscedasticity without any heteroscedasticity. The following is the output of the normality test using the Kolmogorov Smirnov with an alpha value of 0.05 and a homoscedasticity test.

The generalized linear model (GLM) equation cannot be interpreted as a normal regression [24, 35] because the model has an exponential. It requires a "DHARMA" approach that simulates GLM as an ordinary linear regression equation [36]. Based on Figure 5 on the QQ plot of residuals, it can be seen that the residuals through regression testing meet the normal distribution. From the graph, it can also be seen that the Kolmogorov Smirnov test obtained P-Value > 0.05 indicates that the residuals are normally distributed.

**Table 3.** Correlation analysis with Kendall-tau

	Rainfall	Rainy day	Temperature	Humidity	Exposure time	Wind velocity
Rainfall	Correlation Coefficient	1.000	.401**	-.204**	.323**	-.235**
	Sig. (2-tailed)	.	.000	.000	.000	.000
	N	348	348	348	348	348
Rainy day	Correlation Coefficient	.401**	1.000	-.262**	.329**	-.322**
	Sig. (2-tailed)	.000	.	.000	.000	.000
	N	348	348	348	348	348
Temperature	Correlation Coefficient	-.204**	-.262**	1.000	-.365**	.191**
	Sig. (2-tailed)	.000	.000	.	.000	.000
	N	348	348	348	348	348
Humidity	Correlation Coefficient	.323**	.329**	-.365**	1.000	-.218**
	Sig. (2-tailed)	.000	.000	.000	.	.000
	N	348	348	348	348	348
Exposure time	Correlation Coefficient	-.235**	-.322**	.191**	-.218**	1.000
	Sig. (2-tailed)	.000	.000	.000	.000	.
	N	348	348	348	348	348
Wind velocity	Correlation Coefficient	-.023	.032	-.052	-.194**	-.077*
	Sig. (2-tailed)	.562	.427	.181	.000	.050
	N	348	348	348	348	348

\*\* . Correlation is significant at the 0.01 level (2-tailed).

\* . Correlation is significant at the 0.05 level (2-tailed).

**Table 4.** Coefficient of log transformation linear regression

	Estimate	Std. Error	t-value	Pr(> t )
(Intercept)	826.92	591.93	1.397	0.1635
Rainy day	82.27	8.81	9.338	< 0.01 ***
Temperature	-116.94	133.52	-0.876	0.3819
Humidity	-135.59	78.23	-1.733	0.0842
Exposure Time	21.22	21.38	0.993	0.3217

**Table 5.** Residual and ANOVA

Min	1 <sup>st</sup> Q	Median	3 <sup>rd</sup> Q	Max	R <sup>2</sup>	Adj (R <sup>2</sup> )	F	P
-123.052	-38.397	-9.139	32.077	200.669	0.2461	0.2352	22.53	< 0.05

Based on Figure 5 on the prediction plot model, it is known that the data distribution pattern spreads evenly and homoscedasticity pattern, which means it does not form a certain pattern. Through this analysis, it can be seen that the model meets the assumptions of normality and homoscedasticity. The next test is multi-collinearity with the value of Variance Inflation Factor (VIF) ( $X_1$ ) 1.032099; ( $X_2$ ) 1.022586; ( $X_3$ ) 1.049068; ( $X_4$ ) 1.013003. The model simulation using generalized linear bivariate produces good performance for future and past rainfall [37]. Prediction of rainfall is highly dependent on physical phenomena and atmospheric conditions as well as mathematical models.

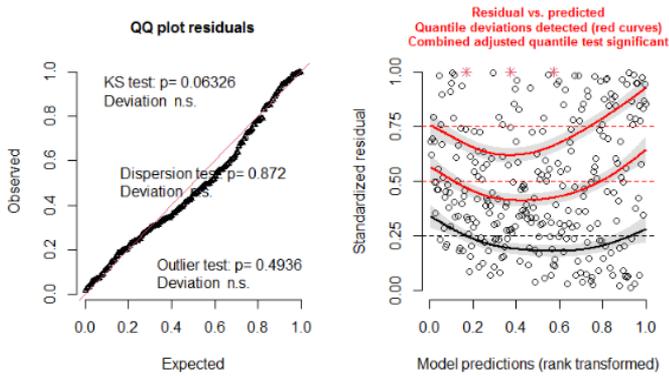


Figure 5. DHARMA residual diagnostics

Multicollinearity (Double Collinearity) is the existence of a perfect or definite linear relationship between or several independent variables (explanatory) from multiple linear regressions. The multicollinearity test aims to identify the occurrence of multicollinearity in multiple linear regression analysis. The value of the Variance Inflation Factor in each predictor variable. The multicollinearity test found that all predictor variables had a VIF value below 10, indicating that there was no multicollinearity in the data. It can be concluded that the model meets the multicollinearity assumption in the data. The next test is autocorrelation using Durbin Watson with DW (2.0104) and P-value (0.4871).

Autocorrelation in the concept of linear regression means that the error component correlated with the time sequence (periodic data or within a certain period). In other words, autocorrelation is a correlation in itself. The classical linear regression method assumes that autocorrelation does not occur. Through testing with the Durbin-Watson test, the  $p$ -value  $> 0.05$  indicates no influence between the previous and latest data, so it can be concluded that the model meets the correlation assumption.

Rainfall prediction using log transformation obtained  $R^2$  of 24.61%. The Box-Jenkins approach is applied to the SARIMA model. Experimental results show that rainfall will not change in the future unless there are some human and industrial activities that interfere with it [17]. Rainfall predictions from past events that are too long produce poor predictions [14].

In general, the log transformation can reduce the variability of the data and make the data more fit close to the normal distribution. However, the log-transformed data is often irrelevant for the original untransformed data [38]. Since climate change has begun to occur in the Krueng Peusangan, there might be more other factors influence it to be related to climate data. The model made by this method depends on the data (in case Krueng Pase watershed) obtained, and the possibility of irrelevance might be increased. However, using

more relevant variables and updated dataset shall reduce this kind of weakness, and this method will be a great tool. Alternatively, a spatio-temporal model is needed to estimate the complex climatological distribution using the normal distribution [39]. To strengthen the results of the analysis conducted model accuracy testing using RMSE and obtained for the Log-Transformation linear regression model method with an RMSE value of 57.67584.

Weather forecasting is an application of knowledge and technology that is used to predict rainfall in the future depending on input attributes. Historical data used in several studies to predict rainfall are temperature, wind speed, wind direction, humidity and atmospheric pressure [40]. In this study, we consider rainy days to predict rainfall forecasting is a scientifically and technologically challenging problem. Many forecasters are in the health sector, trade and meteorology. For forecasting can be done through an empirical approach and a dynamic approach. Empirical approach based on historical analysis of rainfall and the relationship with various atmospheric variables using regression methods, artificial neural networks, fuzzy logic and data collection groups. The dynamic approach is implemented using the numerical rainfall forecasting method on a large scale and long term [41].

The rainfall-runoff process is an essential part of the hydrological cycle and explains the transformation of rainfall into river discharge. River discharge in the catchment is influenced by many interrelated processes. Heterogeneity is one of the transformation processes such as heterogeneity of the transformation process of temperature and humidity variables into rainfall. Rainfall prediction becomes a consideration in discharge calculation.

Climate also affects the evapotranspiration from hydrology cycle. One of the studies that explore the performance of rainfall and Evapotranspiration (ETo) data from the global European Centre for *Medium-Range Weather Forecasts* found that the comparison between ETo and flow time series exhibit a similar variability for the whole hydrologic year and follow a strong seasonal cycle. The peak normal evapotranspiration occurred from January to February because of a very high wet soil profile and low ETo during the period of December to February. Similar interpretation can be observed from ETo and flow time series, like temperature increased and high evaporation through the period April–May to August–September led to a progressive soil drying [6].

In many cases especially in areas where accurate data collection is difficult, reliable ETo estimates derived from Thornthwaite method can be used to calculate the ETo when temperature is the only input parameter available. In such cases, it will be a good consideration to compare and validate with other methods based on the precise evaluation considering the land coverage and topographical condition to reduce the range of uncertainty [42]. Rainfall–baseflow and runoff models based on flow logarithms provide a good representation of the baseflow for the catchment based on rainfall prediction [43, 44]. So that the initial step for the prediction of rainfall as a climate variable is very much needed for the accuracy of the prediction of discharge and its relation to land use changes.

#### 4. CONCLUSION

Linear regression test by using log transformation obtained

$R^2$  of 24.61% with an RMSE value of 57,676. The rainfall regression equation (Y) will change by itself at a constant value of 826.92 and if other variables are constant then the value of Rainy Days will change by 82.27 per unit, The temperature is -116.94, the humidity is -135.59, and the irradiation time is 21.22 per unit. It indicates an influence between rainfall and other influencing factors such as rainy days, temperature, humidity, and duration of irradiation. Wind speed at the research location has no relationship with other variables because it has a no significant correlation value. The overall analysis was found that the model meets the classical assumptions. Other variables also need to be considered in the subsequent analysis, such as regional characteristics that affect climate (geographical location, altitude, and eco-hydrology related land use conditions. It will also strengthen the results of the study. In the research method, it is necessary to compare all the available methods to find the best method in modeling the relationship between rainfall and the factors that influence it. The method suggested in the following research is a nonlinear method.

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