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Trend Analysis of Rainfall Characteristics in Kota Tinggi

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Abstract: Rainfall pattern analysis is significant in hydrological studies and it can be used to assess different planning criteria and the management of water supplies. Human activities might have altered the climate system, which reluctantly increased the intensity of rainfall events. This study aims to estimate the upcoming changes of the intensity of rainfall in Kota Tinggi by using a reliable model which is linear regression and it is also crucial to analyze the evidence of climate change. The data for monthly and annual rainfall was obtained from the Malaysia Meteorological Department (MMD) to be analyzed. Statistical analysis such as ANOVA has been performed in Microsoft Excel to assess significant differences from the data. Based on the assessment, the highest amount of monthly rainfall distribution is in December, with a value of 3371 mm while the lowest amount is in February, 1211 mm. The highest amount of annual rainfall distribution is in 2017, with a value of 2581 mm and the lowest is in 2018, with an estimated total of only 18 mm. The result of this study shows that the mean monthly and annual rainfall data has an irregular pattern and a statistically insignificant trend. Extensive researches and studies using different trend analysis models is recommended to achieve a more accurate result.

Keywords: Rainfall, Trend Analysis, Linear Regression

1. Introduction

Rainfall pattern analysis at a certain time is significant and appropriate in hydrological studies in particular as a method for detecting and recognizing changes that have taken place and for assessing the different planning criteria and the management of water supplies [1]. Previous studies have been performed and some findings indicate significant trends in rainfall such as several severe and drought events have been recorded in the recent years. MMD stated that an abnormally heavy rainfall have

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occurred for several days at the end of December 2006 and in the middle of January 2007 in Peninsular Malaysia, specifically the southern region, owing to the cold surges of the north-eastern monsoon, triggering major flooding in the area [2].

Besides being a crucial part of the tropical weather system, convective precipitation also provides to the spatial and temporal variations of rainfall. As a consequence of climate change, it is also vital to estimate the spatial and temporal distribution of rainfall [3]. The geographical distribution of susceptibility to climate change is not consistent across the world [4]. Climate change would have an effect on supply of water (surface runoff) [5]. World problems relating to climate variability and transition such as the rise in temperature which leads to drought and wild fires have already been a central consideration [6].

Global warming is believed to be causing the increase in the intensity and frequency of rainfall events [7]. Malaysia's allocation of water supplies has therefore become critical for future water supply planning and management [8]. One of the hazards includes flash floods. Johor is one of the flood-prone areas in Peninsular Malaysia, along with other states such as Selangor and Pahang [9]. Besides being extremely dangerous and possibly fatal, flash floods could cause other problems such as loss of personal property, fear of theft due to necessary evacuation and disconnection [10].

Hence, the objective of this study is to estimate the upcoming changes of the intensity of rainfall in Kota Tinggi by using linear of regression. At the end of this study, the trend analysis of rainfall can be identified.

2. Materials and Methods

Monthly and annual rainfall data have been acquired from the MMD. The rainfall data obtained for 16 years ranging from 2002 to 2018.

2.1 Materials

In order to study the significant difference of the monthly and annual rainfall data that have been provided, statistical analysis is performed. Graphs are also plotted in order to illustrate the trend of rainfall in Kota Tinggi. The statistical analysis is used to determine several factors of the trend such as the dispersion and the central tendency of rainfall.

2.2 Linear Regression

In this study, linear regression is chosen as statistical analysis as it shows the correlation between 2 parameters; dependent variables (X) and independent variables (Y) [11].

The positive or negative trend of the data is displayed by the slope of linear regression [12]. As the value x increase, y increase and this indicates positive relationship. the vice versa condtions for negative relationships.[12].

In linear regression, it is essential to assume normal distribution. The statistical values of this particular analysis is calculated by using Microsoft Excel and the hypothesis is tested by comparing the Probability value (P value) or Significance F with the significance level, 0.05. These values can be determined using ANOVA. The value of R-square (R^2) of the correlation from the linear regression analysis indicates how strong the association and relationship between the variables are. An R^2 value of 1.0 signifies that the data fits the linear regression model perfectly. The value of R^2 lower than 1.0 indicates that there is a fraction of the variance that could not be explained by the model. For example, an R^2 value of 0.86 shows that 0.14 of the rainfall variance could not be explained by the model used [13].

The general equation of linear regression is as shown below:

$$Y = a + bX \quad \textbf{Eq. 1}$$

Y= the amount of rainfall, X= the year or month

The mean and the sample variance is determined for each set of data from **Eq. 2** and **Eq. 3**, respectively.

$$\bar{x} = \frac{\sum x_i}{n} \quad \textbf{Eq. 2}$$

$$s^2 = \frac{\sum (x_i - \bar{x})^2}{n-1} \quad \textbf{Eq. 3}$$

The sample variance of the data is represented by s^2, the value of one observation is symbolized by x_i, the mean value of all observations is $\bar{x}$ and the number of observations is n. **Eq. 4**, which is the value of standard deviation can then be derived from **Eq. 3.**

$$\sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}} \quad \textbf{Eq. 4}$$

The skewness is determined for each set of data from the formula given below:

$$\tilde{\mu}_3 = \frac{\sum_i^N (x_i - \bar{x})^3}{(N-1) * \sigma^3} \quad \textbf{Eq. 5}$$

3. Results and Discussion

The model that has been used for this analysis is linear regression. In order to decide whether there is a significant difference in the mean annual rainfall data, ANOVA is computed [14].

3.1 Hypothesis Testing

Table 1: Analysis of variance of mean annual rainfall from 2002 to 2018

	Df	SS	MS	F	Significance F
Regression	1	40023.7279	40023.7279	0.066585	0.799882
Residual	15	9016384.15	601092.277		
Total	16	9056407.88			

Table 1 shows an ANOVA of mean annual rainfall in Kota Tinggi from 2002 to 2018. A significance F value that is smaller than the significance level which is 0.05 indicates that the probability of the model to be wrong is lower while a higher value means the other way around [15]. The results indicated that significant difference existed in the mean annual rainfall over the period of 16 years (F=0.066585, Significance F=0.799882).

The kurtosis and skewness of the data are computed in Microsoft Excel. Skewness is a measure of lack of symmetry [16]. If the data set looks similar from both sides of the center point, then it is most likely symmetrical. Kurtosis is identified as a data flatness which is indicated by negative kurtosis or peakedness which is indicated by positive kurtosis. In other words, it is also a measure to determine whether the data are light-tailed or heavy-tailed corresponding to the normal distribution [17].

3.2 Descriptive Rainfall Statistics

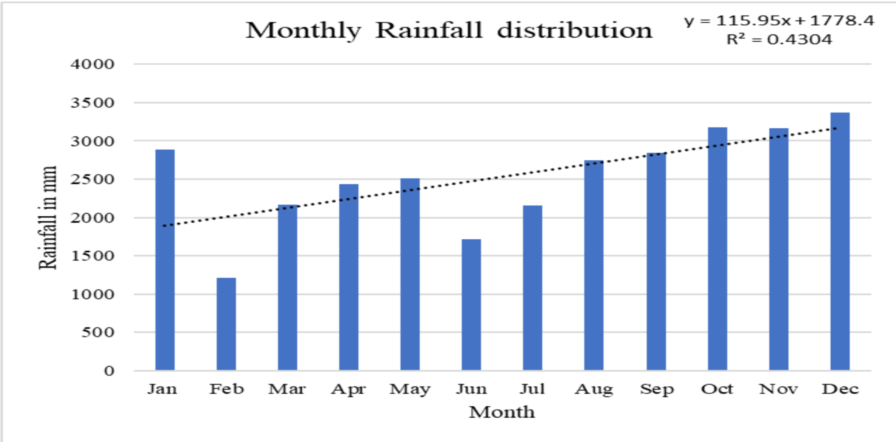

Figure 1: Monthly rainfall distribution (2002-2018)

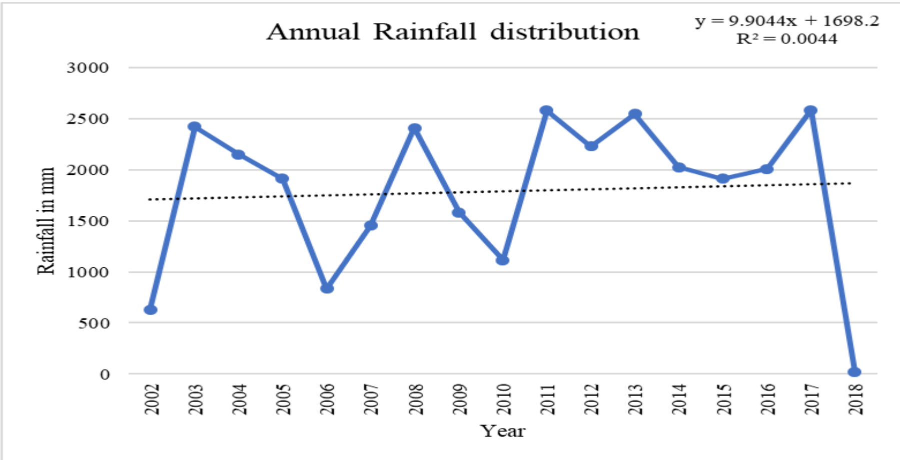

Figure 2: Annual rainfall distribution (2002-2018)

Based on **Figure 1**, the highest amount of monthly rainfall is in December which is 3371 mm and it is equivalent to its mean value, 198.2941 mm. The standard deviation for the amount of rainfall in December is 103.4044. On the other hand, the lowest amount of monthly rainfall is in February with only 1211 mm and a mean value of 71.2353 mm. However, the highest standard deviation of the monthly rainfall distribution is in January with a value of 165.5993 mm. This indicates that the rainfall distribution in January was inconsistent or highly distributed. The dispersion of the data from their respective means is measured by its standard deviation [18].

Figure 2 shows that 2017 has the most amount of annual rainfall which is 2581 mm with the highest mean value, 215.0833 mm. The standard deviation in 2017 is 87.9736 mm. Meanwhile, the lowest amount of annual rainfall is in 2018 which is estimated to be only 18 mm due to several missing rainfall data. In this case, the outlier must be calculated. From 2002 to 2018, the highest standard deviation is 143.4525 which is during 2004.

The range of rainfall can be associated with the value of standard deviation [19]. As the value of standard deviation increases, the range of rainfall also increases. This can be proven in **Table 2.** For example, the lowest value of standard deviation is in 2018 which is 5.1962 mm, as well as the range of rainfall which also has the lowest value of only 18 mm.

Table 2: Descriptive analysis of annual rainfall data

Year	Mean (mm)	Median (mm)	S.D. (mm)	Sample Variance	Skewness	Kurtosis	Min (mm)	Max (mm)	Range (mm)
2002	52.500	0	75.756	5739.000	1.158	0.025	0	213	213
2003	201.750	184	123.004	15130.023	0.348	-0.356	8	413	405
2004	178.917	151	143.453	20578.629	1.196	1.804	3	521	518
2005	159.333	176	111.029	12327.515	-0.046	-1.377	0	337	337
2006	69.500	32.5	77.358	5984.273	0.803	-0.542	0	226	226
2007	121.000	85	134.107	17984.546	0.829	-0.447	0	390	390
2008	200.500	211	93.435	8730.091	-0.305	-0.939	43	342	299
2009	131.833	143.5	45.976	2113.788	-0.684	-0.602	43	189	146
2010	92.750	94	70.973	5037.114	0.185	-1.365	1	210	209
2011	214.750	185	126.652	16040.750	0.772	0.226	31	476	445
2012	185.750	171	46.833	2193.296	0.679	-0.374	115	265	150
2013	212.000	214	67.215	4517.819	-0.425	-0.032	77	302	225
2014	168.500	141.5	88.949	7911.909	0.378	-0.596	24	321	297
2015	159.333	152	117.682	13848.970	1.271	2.320	21	447	426
2016	167.083	178.5	70.128	4917.902	-0.787	0.407	15	249	234
2017	215.083	195	87.974	7739.356	0.954	0.795	86	401	315
2018	1.500	0	5.196	27.000	3.464	12.000	0	18	18

Based on **Table 3**, the linear trend lines of the monthly rainfall shows a downward trend in January, March, September and October while the remaining months indicated an upward trend. The annual rainfall data also indicated an upward trend. The probability values (P values) of the trend lines is higher than the significance level = 0.05. Thus, there is no statistically significant trend in both data which increases the possibility for the null hypothesis to be false. The y value represents the amount of rainfall while x is the month or year.

Table 3: Regression statistic results for monthly and annual rainfall

Month	Regression equation	R-square	P value	Statically significant
Jan	y= -3.9142x+8037.1628	0.01	0.11	No
Feb	y=6.549x-13092.2941	0.16	0.11	No
Mar	y= -3.9951x+8157.9918	0.03	0.48	No
Apr	y=2.902x-5.689.82355	0.03	0.50	No
May	y=7.7598x-15449.4412	0.14	0.14	No
Jun	y=2.6005x-5125.75	0.05	0.41	No
Jul	y=3.8137x+7792.4118	0.03	0.47	No
Aug	y=3.9044x-7686.4559	0.05	0.41	No
Sep	y= -3.2255x+6650.2941	0.04	0.44	No
Oct	y= -6.7059x+13665.4706	0.08	0.27	No
Nov	y=8.0221x-15937.9265	0.11	0.21	No
Dec	y=0.1789x+557.9265	0.00	0.96	No
Annual	y=9.9904x+1698.2	0.00	0.82	No

4. Conclusion

The result of this study shows that the mean monthly and annual rainfall data has an irregular pattern and a statistically insignificant trend. The linear regression analysis indicated downward trend in January, March and September while the remaining months indicated an upward trend. Between the period of 16 years, the most amount of annual rainfall is in 2011, 2013 and 2017 while the least amount of annual rainfall is in 2018. Trend analysis of rainfall data is crucial as it facilitates policy decisions regarding the cropping pattern, sowing date, construction of roads and providing drinking water to urban and rural areas [20].

Extensive researches and studies using different trend analysis models is recommended to achieve a more accurate result. More studies regarding rainfall characteristics should also be carried out to verify the significant trend of rainfall in the area studied.

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References

[1] Z. Hashim, N. Nayan, Y. Saleh, and G. Scheme, “Reauthentication of the rainfall region within peninsular reauthentication of the rainfall region within peninsular malaysia in the,” no. August, 2020.

[2] T. Hujan and M. Barat, “Trends in Peninsular Malaysia Rainfall Data During the Southwest Monsoon and Northeast Monsoon Seasons : 1975 – 2004,” vol. 39, no. 4, pp. 533–542, 2010.

[3] M. Suhaily, Y. Che, I. Reid, and M. Hashim, “Rainfall Trend Analysis Using 50 Years Historical Data in Newly Developed Catchment in Peninsular Malaysia Rainfall Trend Analysis Using 50 Years Historical Data in Newly Developed Catchment in Peninsular Malaysia,” no. July, 2017.

[4] O. O. Mayowa, S. H. Pour, and S. Shahid, “Trends in rainfall and rainfall-related extremes in the east coast of peninsular Malaysia,” *J. Earth Syst. Sci.*, no. December, 2015.

[5] Haliza Abdul Rahman, “Global climate change and its effects on human habitat and environment in Malaysia,” *Malaysian J. Environ. Manag.*, vol. 10, no. 2, pp. 17–32, 2011.

[6] J. J. Pereira, “Issues of Climate Change and Water Resources in Peninsular Malaysia : The Case of,” no. August 2017, 2009.

[7] A. H. Syafrina, M. D. Zalina, and L. Juneng, “Historical trend of hourly extreme rainfall in Peninsular Malaysia,” *Theor. Appl. Climatol.*, vol. 120, no. 1–2, pp. 259–285, 2015, doi: 10.1007/s00704-014-1145-8.

[8] C. Loong Wong, J. Liew, Z. Yusop, T. Ismail, R. Venneker, and S. Uhlenbrook, “Rainfall Characteristics and Regionalization in Peninsular Malaysia Based on a High Resolution Gridded Data Set,” vol. 8, p. 500, 2016, doi: 10.3390/w8110500.

[9] M. Y. Safiah Yusmah *et al.*, “Understanding urban flood vulnerability and resilience: a case study of Kuantan, Pahang, Malaysia,” *Nat. Hazards*, vol. 101, no. 2, pp. 551–571, Mar. 2020, doi: 10.1007/s11069-020-03885-1.

[10] M. M. Yusoff and G. H. Chin, “Psychological impacts of flash flooding in the Klang Valley, Malaysia,” *Proc. 2010 Int. Conf. Humanit. Hist. Soc. Sci. 2010)Singapore, 26-28 Febr. 2010*, no. Chhss, pp. 26–28, 2010, [Online]. Available: https://core.ac.uk/display/11437383.

[11] S. Prabakaran, P. N. Kumar, P. Sai, and M. Tarun, “Rainfall Prediction Using Modified Linear Regression,” vol. 12, no. 12, 2017, Accessed: Jul. 01, 2021. [Online]. Available: www.arpnjournals.com.

[12] D. Kiernan, “Chapter 7: Correlation and Simple Linear Regression.” Open SUNY Textbooks, Jan. 16, 2014.

[13] D. F. Hamilton, M. Ghert, and A. H. R. W. Simpson, “Interpreting regression models in clinical outcome studies,” *Bone and Joint Research*, vol. 4, no. 9. British Editorial Society of Bone and Joint Surgery, pp. 152–153, Sep. 01, 2015, doi: 10.1302/2046-3758.49.2000571.

[14] N. R. Biometric,“Chapter 5: One-Way Analysis of Variance | Natural Resources Biometrics.” https://courses.lumenlearning.com/suny-natural-resources-biometrics/chapter/chapter-5-one-way-analysis-of-variance/ (Accessed Jul. 01, 2021).

[15] G. Tutor, “Interpreting Regression Output (Without all the Statistics Theory).” https://www.graduatetutor.com/statistics-tutor/interpreting-regression-output/ (accessed Jul. 01, 2021).

[16] A. Saxena, “How transformation can remove skewness and increase accuracy of Linear Regression Model | by Anshika Saxena | Medium.” https://anshikaaxena.medium.com/how-skewed-data-can-skrew-your-linear-regression-model-accuracy-and-transfromation-can-help-62c6d3fe4c53 (accessed Jul. 01, 2021).

[17] N. Sematech, “Measures of Skewness and Kurtosis.” https://www.itl.nist.gov/div898/handbook/eda/section3/eda35b.htm (accessed Jul. 01, 2021).

[18] The Economic Times, “What is Standard Deviation? Definition of Standard Deviation, Standard Deviation Meaning -” https://economictimes.indiatimes.com/definition/Standard-Deviation (accessed Jul. 03, 2021).

[19] M. Nyatuame, V. Owusu-Gyimah, and F. Ampiaw, “Statistical Analysis of Rainfall Trend for Volta Region in Ghana,” *Int. J. Atmos. Sci.*, vol. 2014, pp. 1–11, Oct. 2014, doi: 10.1155/2014/203245.

[20] S. Harsha “Role of Statistics in Monitoring Rainfall,” *IOSR J. Environ. Sci.*, vol. 11, no. 3, pp. 7–19, 2017, doi: 10.9790/2402-1103030719.