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RESEARCH ARTICLE

Statistical Analysis of Temporal Variations in Patterns of Rainfall and Temperature in the Klang Valley

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ABSTRACT - Malaysia is in the equatorial zone and experiences hot and humid climates throughout the year. During the rainy season, floods may occur in some parts of Malaysia, including the Klang Valley. During the flood occurrences, the residents may need to leave their houses and move to relief shelters. This disaster may happen because of the continuous heavy downpour in the area. Both incidents can be connected to climate change, and one way to investigate this is to examine differences in daily rainfall and daily temperature patterns through time. Climate change is inevitable and one of the causes is known as 'anthropogenic' in which it is caused by human activities. Geological records can provide evidence of climate change. However, there has been little statistical research on climate change in the Klang Valley. Even official organisations like the Department of Irrigation and Drainage Malaysia (DID) and the National Water Research Institute of Malaysia (NAHRIM) have not conducted this area of study. The goal of this study is to evaluate climate change in the Klang Valley using statistical analysis of temporal rainfall patterns. The data collection and statistical analysis are two critical parts of this study. Rainfall and average temperature data were obtained from their respective departments and websites. These data were sorted and filtered accordingly to get a satisfactory value for the analysis. Then, the correlation test and analysis of variance were conducted to find the relation between these data points. The results of this analysis were used to determine whether the variations in rainfall patterns in the Klang Valley are caused by climate change or otherwise. In addition to this, the statistical outputs indicate that there is a statistically significant finding in both data sets in which the decreasing temperatures may result in increasing rainfall and warmer conditions may lessen the rainfall. Surprisingly, the findings contradicted the expected outcome of this study, and it is believed that external factors are the primary contributors to these findings.

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1.0 INTRODUCTION

Malaysia generally has a tropical climate which is hot and humid weather throughout the year. Other than that, Malaysia experiences heavy rainfall throughout the year because it is situated in the equatorial zone[1] and is surrounded by water on all sides [1, 2]. Peninsular Malaysia has an annual average rainfall of 2,420 mm while Sabah and Sarawak have 2,630 mm and 3,830 mm, respectively [3]. Intense rainfall often happens from November to March due to the Northeast Monsoon [1]. There are two types of monsoon seasons in Malaysia which are the Southwest Monsoon and the Northeast Monsoon. The Southwest Monsoon refers to the dry season across the country while the Northeast Monsoon refers to the rainy season in the country [1,4].

Intense rainfall occurrences in certain areas in Malaysia including the Klang Valley often causes flooding. Continuous downpours in the Klang Valley often causes flooding and forces the affected residents to move to relief shelters after their homes are flooded [5-7]. The most recent event of flood crisis in the Klang Valley is reported as the worst flood situation in more than four decades [8-11]. Continuous heavy rainfall caused rivers in Selangor to overflow in which thousands of houses were flooded and thousands of motorists on major roads were left stranded [12, 13]. In [9, 12] nearly 1000 residents in Selangor were evacuated from their homes due to this recent flood situations in the Klang Valley. In Kuala Lumpur, more than 11,000 people fled from their homes due to this flooding [11]. Some of the residents in Shah Alam were stranded with no food at their homes for a few days before being rescued [10]. Flooding events can be associated with intense rainfall and wide-ranging rainfall variations. Both events can be attributed to climate change. Statistical analysis is one of the techniques to predict the relationship between climate change and rainfall. Malaysia, like many other countries, has been monitoring and studying climate change and its impacts. DID and NAHRIM have conducted various studies and reports on climate change in Malaysia, including the Klang Valley. However, there has not been much

[1] equatorial zone is the region between the Tropic of Cancer (23.5°N latitude) and the Tropic of Capricorn (23.5°S latitude) (Henry J, 2005).

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statistical research on climate change in the Klang Valley [14, 15]. Therefore, the purpose of this study is to use statistical analysis of temporal rainfall variations as an exploratory tool to investigate climate change in the Klang Valley.

2.0 METHODOLOGY

2.1 Data Collection

Climate change is defined as changes in climate condition that can be recognised by the differences of the mean and the changeability of its properties within the extended period either years, decades, or longer [16]. Therefore, this study requires data on daily rainfall and daily temperature in the Klang Valley for the period of January 2005 to December 2021 which is a total of 17 years of data collection. To conclude the effect of climate change, at least a 30-year of data must be used [17, 18]. Nevertheless, there were some studies using data that was less than 30-year period. In [19] a 10-year period of meteorological data was used to forecasts unpredictability of weather in Peninsular Malaysia meanwhile in [20], a 20-year period of data was used in correlation analysis between the daily rainfall and daily temperature in United States. This suggests that a 17-year period of data collection may be sufficient to predict the effects of climate change in the Klang Valley. The data collection was carried out either by completing the data collection application form from website or emailing their respective officer to request the data. For the rainfall data, it was collected using the "Sistem Permohonan Data Stesen Rangkaian Hidrologi Nasional (SPRHiN)", which is one of the DID website. Meanwhile, the temperature data was requested from the Malaysian Meteorological Department via email.

2.2 Refinement and Selection

A total of 45 rainfall stations and 2 temperature stations were requested in the data application form. For the temperature, there are only two temperature stations located in the Klang Valley which are at Subang and Petaling Jaya. This situation causes imbalance in data collection and may cause bias in the statistical analysis results since the temperature stations do not cover Kuala Lumpur. Other studies that are related to the temperature measurement in the Klang Valley also highlight the fewer number of available temperature stations in the area [21, 22]. However, it is vital for this research to include the temperature data. Therefore, these two temperature stations were chosen without hesitation for this study.

After receiving the data from their respective department, both data sets were filtered and scanned using Microsoft Excel to identify the finest rainfall stations that had the lowest data loss. This also helped to foresee the total percentages of data loss for each parameter. Most rainfall stations experience data loss due to a variety of factors such as being inoperable because of old equipment, insufficient data distributions as the site conditions were in a poor condition or temporary shutdown due to maintenance routines. Meanwhile, the temperature stations experienced fewer data loss over the years. Overall, the data sets were filtered and scanned accordingly and the percentage of data loss for each year are stated in the colour coded cell. Table 2 and Table 3 depicts the filtered data for the selected rainfall stations and two temperature stations respectively.

Each station is divided into years, and each year is filtered and classified based on its colour. These colours represent the percentages of data loss for each year, with red indicating a data loss greater than 50%, orange indicating a data loss between 30% and 50%, light green indicating a data loss between 20% and 30%, and dark green indicating a data loss less than 20% or with a complete data set. Table 1 indicates the colour coded cells that are used in this filtering process.

Table 1. The colour coded cells

Colour	Percentages
Red	More than 50% data loss
Orange	30% - 50% of data loss
Light green	20% - 30% of data loss
Dark Green	Complete data or below 20% of data loss

After filtering a total of 45 rainfall stations, only 14 were chosen because they present the least data loss over the past 17 years while the number of temperature stations was maintained at two. Table 2 and Table 3 show the selected filtered stations for rainfall and temperature respectively. Meanwhile, Table 4 and Table 5 show summary of the selected stations for both parameters.

Table 2. The filtered rainfall stations that were selected from 2005 to 2021

No.	Rainfall Station	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	0000011RF	0.5	23.8	6.8	8.5	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	63.8
2	0220121RF	78.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	2.5	0.0	98.1
3	0230651RF	55.3	53.4	44.1	46.7	49.3	39.2	43.0	37.2	2.7	0.3	0.0	0.0	0.8	0.0	0.3	0.5	24.7
4	0230731RF	52.3	49.3	41.4	46.4	48.8	42.5	46.8	44.5	0.0	0.0	0.3	0.0	1.1	0.3	0.0	0.3	0.8
5	0240331RF	14.8	15.1	0.0	57.1	78.6	0.0	0.0	0.0	13.2	0.0	0.0	0.0	0.0	0.0	0.0	46.4	91.5
6	0240441RF	12.1	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
7	0230031RF	0.0	0.0	5.5	26.5	0.0	0.0	21.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	45.4	8.5
8	0230641RF	39.7	5.5	4.7	2.5	44.9	55.3	57.5	45.9	0.0	0.3	0.0	0.0	0.3	0.0	0.0	0.0	0.5
9	0230681RF	51.0	40.8	44.4	44.0	49.0	38.1	46.0	24.3	0.0	0.5	0.3	0.0	0.3	0.3	0.0	0..5	0.5
10	0230741RF	100.0	99.5	55.1	65.8	65.2	42.2	46.3	33.3	0.0	0.3	0.3	0.0	0.3	0.5	0.0	0.3	0.3
11	0231561RF	100.0	100.0	100.0	28.7	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	8.2	60.5
12	0230171RF	6.6	10.1	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.3
13	0231361RF	95.3	9.3	0.0	7.9	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.3	45.9	100
14	0231541RF	100.0	100.0	100.0	28.7	0.0	0.0	0.0	0.0	0.0	0.3	0.8	0.0	0.0	3.3	0.0	46.2	100

Table 3. The filtered temperature stations that were selected from 2005 to 2021

No.	Temperature Station	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	48648	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.3
2	48647	0.0	2.5	0.8	2.2	1.6	0.5	0.5	0.0	1.4	0.5	1.9	0.5	27.1	1.6	0.0	0.0	2.5

Table 4. The summary of the selected rainfall stations in the Klang Valley from 2005 to 2021

Station	Rainfall Stations	Station No.	Districts
1	Jabatan Pengairan dan Saliran Pulau Lumut Selangor	0000011RF	Klang
2	Ladang Harpenden	0220121RF	Klang
3	Ladang Edinburgh Site 2	0230651RF	Federal Territory of Kuala Lumpur
4	Ibu Bekalan KM. 16	0230731RF	Gombak
5	Pintu Kawalan P/S Telok Gong	0240331RF	Klang
6	Sekolah Kebangsaan Kampung Lui	0240441RF	Hulu Langat
7	Pemasokan Ampang	0230031RF	Hulu Langat
8	Ibu Pejabat Jabatan Pengairan dan Saliran Malaysia	0230641RF	Klang
9	Kampung Sungai Tua	0230681RF	Klang
10	Gombak Damsite	0230741RF	Klang
11	TTDI Jaya Fasa 2	0231561RF	Petaling
12	Pusat Penyelidikan Getah	0230171RF	Klang
13	Rumah Pam Rantau Panjang	0231361RF	Klang
14	Kampung Melayu Subang	0231541RF	Petaling

Table 5. The summary of the selected temperature stations in the Klang Valley

Station	Rainfall Stations	Station No.	Districts
1	Petaling Jaya	48648	Klang
2	Kampung Melayu Subang	48647	Petaling

2.3 Statistical Analysis

Statistical analysis was conducted using the IBM SPSS statistics software. The techniques applied in the SPSS analysis were correlation and analysis of variance (ANOVA) tests to interpret the rainfall and temperature data. Initially, two hypotheses were made which were the null hypothesis and the alternative hypothesis.

- The null hypothesis (H0): There is no significant difference between rainfall pattern with the climate change as represented by temperature data.
- The alternative hypothesis (H1): There is a significant difference between rainfall pattern with the climate change as represented by temperature data.

Significance level α was assumed 0.05 for the analysis with a confidence interval of 95%. When the analysis was conducted, two parameters were measured namely correlation coefficient and significance value.

Based on the correlation coefficient, the connection between the rainfall pattern and the climate change can be identified as either a strong, moderate, or weak connection. Meanwhile, the significance value can determine whether the evidence is enough to reject the null hypothesis or accept the null hypothesis.

For example, when the significance value is greater than 0.05, the correlation results may not be statistically significant. It means that the changes of the rainfall pattern occur by chances. Meanwhile, if the significance value is lesser than 0.05, the correlation results may be statistically significant. This means that the changes of the rainfall pattern are interrelated with the climate change.

3.0 RESULTS AND DISCUSSION

3.1 Normality Test

The term normality in SPSS is defined as specific statistical distribution which is normally represented by a bell-shaped curve or normal distribution graph [23, 24]. The data set should be normally distributed to conduct the parametric tests such as correlation test, T-test or analysis of variance test. If the data is not normally distributed, nonparametric test will be chosen [24]. However, if the samples are larger than 30, the sampling distribution is considered to have a normal distribution due to Central Limit Theorem [25]. Table 6 shows the summary of normality test results for the daily mean of rainfall and temperature data. Based on the table, there are a total of 6205 data point for both parameters.

Table 6. The result of normality test

	Kolmogorov-Smirnov Statistic	Degree of Freedom (df)	Significant Value.
Daily Mean Rainfall	0.217	6205	0.000
Daily Mean Temperature	0.028	6205	0.000

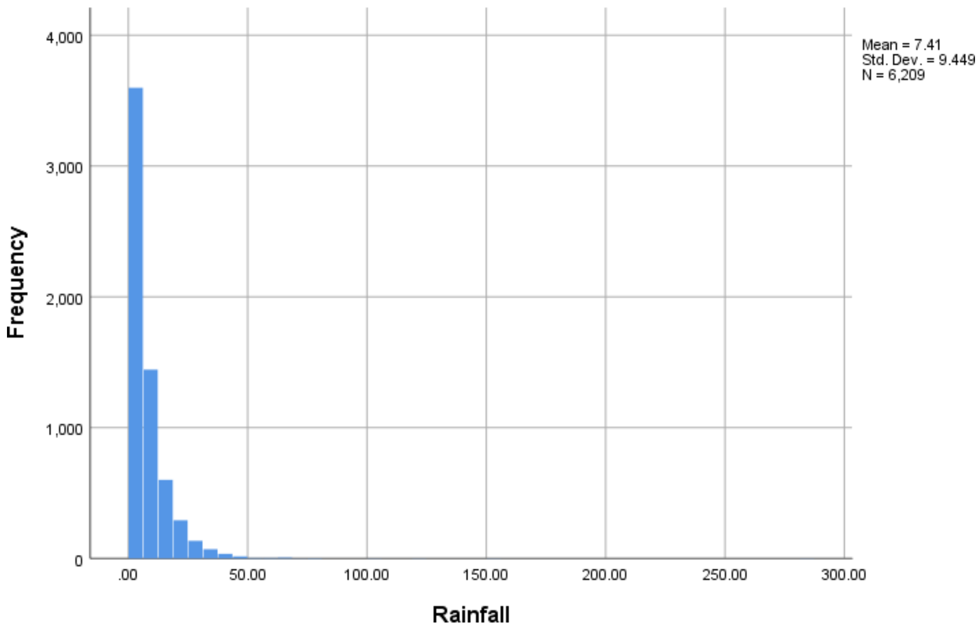

Figure 1. Distribution of rainfall data from 2005 to 2021

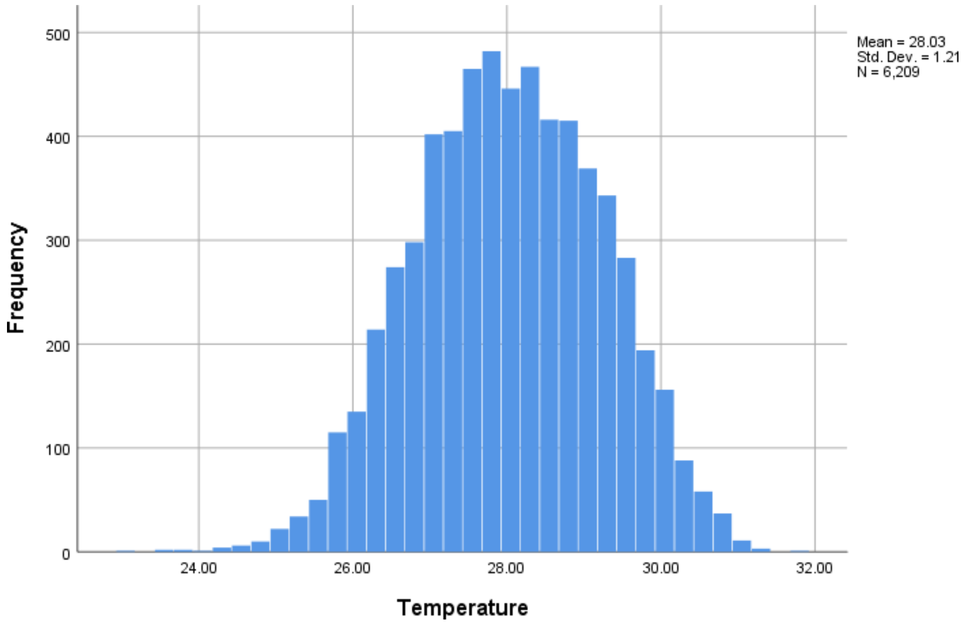

Figure 2. Distribution of temperature data from 2005 to 2021

Based on Table 6, the parameters show the violation of the assumption of normality in which the Kolmogorov-Smirnov statistic is less than 0.5 and the significant values is 0.000. Therefore, both data are considered non-normal distributed pattern. In Fig. 1, almost half of the daily rainfall data shows less rainfall which may cause the exponential pattern on the rainfall distribution. Since this study employs the Central Limit Theorem, these data are still eligible for parametric tests such as Correlation test, ANOVA test or T-test since the data sets have more than 30 samples which are 6205 data point for each parameter [23-25].

3.2 Correlation Test

In SPSS, Correlation test is a statistical method to determine the interrelationship between two variables [26, 27]. In this study, the test measured the strength of the linear relationship between daily mean rainfall and daily mean temperature data in the Klang Valley. Based on Fig. 3, the line of the best fit shows a slight drop and the drop indicates a negative direction of the correlation between rainfall and temperature in the Klang Valley [24]. In addition to this, the points in the graph are grouped in a nearly narrow cigar shape, indicating a moderate correlation between the variables [24]. It suggests that if the rainfall increases, the temperature may decrease, or if the rainfall decreases, the temperature may increase. In [28, 29] these studies found that the rainfall pattern tends to affect the temperature pattern in the study area.

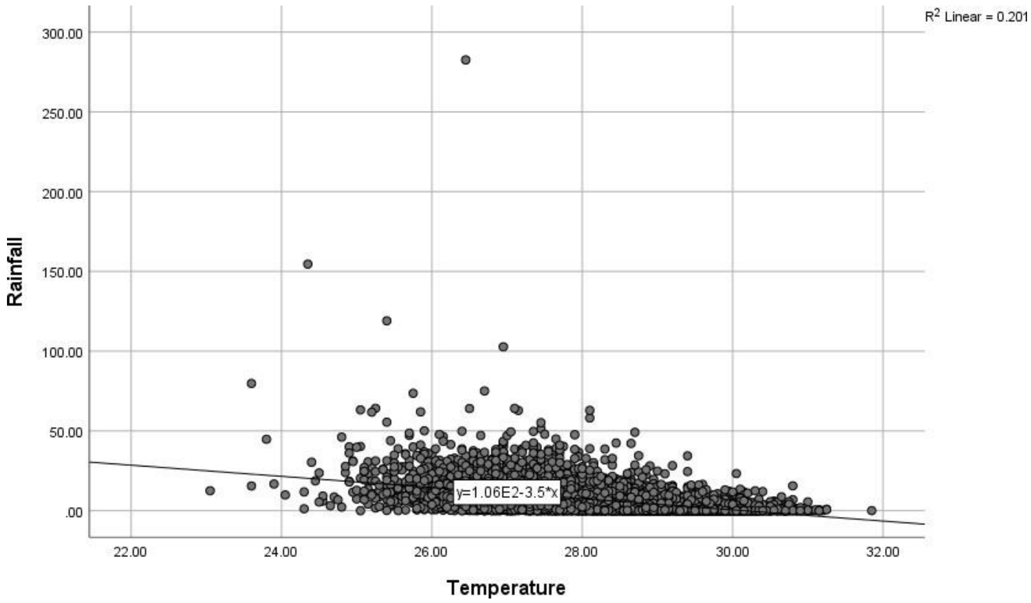

Figure 3. Correlation plot between mean rainfall and mean temperature

In the previous figure, there is no violation on the correlation assumptions. As a result, a correlation analysis can be carried out. Table 7 below shows the correlation results for mean of rainfall and temperature on daily data sets from 2005 to 2021.

Table 7. The result of correlation test

		Daily Mean Rainfall	Daily Mean Temperature
Daily Mean Rainfall	Pearson Correlation	1	-0.448**
	Sig. (2-tailed)		0.000
	N	6205	6205
Daily Mean Temperature	Pearson Correlation	-0.448**	1
	Sig. (2-tailed)	0.000	
	N	6205	6205

Based on the results above, there is negative correlation between rainfall and temperature since there is a negative sign in front of the Pearson correlation coefficients [23-25] (r-value) which is -0.448. Other than that, the r-value in Table 7 is between 0.30 to 0.49, suggesting a moderate connection between rainfall and mean temperature [23-25]. Overall, the scatterplot and analysis results are similar, indicating that the correlation is more likely to be accurate.

Next, the interpretation of the correlation is statistically significant since there is enough evidence to reject the null hypothesis [30]. Therefore, it may be presumed that the temperature is linked to changes in rainfall pattern in the Klang Valley. Although there is a moderate connection between these parameters, it is inaccurate to state that the changes of rainfall occur because of the changes of the temperature. This is because, the statistical measurement does not reveal the cause-and-effect relationship between the parameters since it only describes the size and direction of a relationship between two variables [24, 27, 31]. The statistical correlation is not able to predict the causes of the variation between the parameters as this relationship may be coincidental, or it may be due to a third factor that causes both variables to vary. Therefore, analysis of variance (ANOVA) test was conducted to determine the differences of each year for both parameters and foresee the pattern of the rainfall and temperature in the Klang Valley.

3.3 ANOVA Test

The analysis of variance (ANOVA) is used to compare the mean score of the rainfall and temperature in the Klang Valley throughout the years as well as to foresee the mean plots of the data sets [23-25, 32]. According to [33], the degree of freedom is reduced by one for each mean that must be determined to figure out the deviation results. Therefore, the total degree of freedom in this test will be 6204 instead of 6205. Table 8, Table 9 and Table 10 show the results of the ANOVA analysis for rainfall and mean temperature from 2005 to 2021.

Table 8. Tests of homogeneity of variances

		Levene Statistic	Degree of Freedom 1	Degree of Freedom 2	Significant Value
Daily Mean Rainfall	Based on Mean	6.274	16	6188	0.000
	Based on Median	3.378	16	6188	0.000
	Based on Median and with adjusted Degree of Freedom	3.378	16	2836.538	0.000
	Based on trimmed mean	4.262	16	6188	0.000
Daily Mean Temperature	Based on Mean	3.711	16	6188	0.000
	Based on Median	3.653	16	6188	0.000
	Based on Median and with adjusted Degree of Freedom	3.653	16	6072.584	0.000
	Based on trimmed mean	3.696	16	6188	0.000

Based on Table 8, the significant value is 0.000 indicating a violation of the assumption in the analysis thus showing that there is no significant difference between the groups [24, 25]. Although the assumption is violated, there are a few more outputs that can be referred to, which are Robust Tests of Equality of Means and the table of ANOVA [24]. The result of Robust Test of Equality of Means for both parameters is shown in the Table 9.

Table 9. Robust tests of equality of means

		Statistic	Degree of Freedom 1	Degree of Freedom 2	Significant Value
Daily Mean Rainfall	Welch	2.763	16	2319.611	0.000
	Brown-Forsythe	3.468	16	3691.236	0.000
Daily Mean Temperature	Welch	56.714	16	2320.357	0.000
	Brown-Forsythe	53.383	16	6079.034	0.000

In the table above, the Significant value for the Robust Tests is 0.000 which indicates a violation of the assumption. For that reason, there is no significant difference between group variables can be observed in accordance to [24]. However, there is an ANOVA table that could be reviewed to finalise the results of this analysis [24, 25]. The assumption of this ANOVA table is totally different from the previous tables. In [24], the Significant value should be less than or equal to 0.05 in order to avoid violating the ANOVA assumption. Table 10 shows the ANOVA analysis for both parameters.

Table 10. Tests of homogeneity of variances

		Sum of Squares	Degree of Freedom	Mean Square	F	Significant Value
Daily Mean Rainfall	Between Groups	4925.085	16	307.818	3.468	0.000
	Within Groups	549251.826	6188	88.761		
	Total	554176.911	6204			
Daily Mean Temperature	Between Groups	1101.117	16	68.820	53.383	0.000
	Within Groups	7977.363	6188	1.289		
	Total	9078.480	6204			

Based on the Table 10, the Significant value is less than 0.05 which shows a significant difference among the mean scores for both parameters [23-25]. Fig. 4 and Fig. 5 illustrate the mean plots for the parameters.

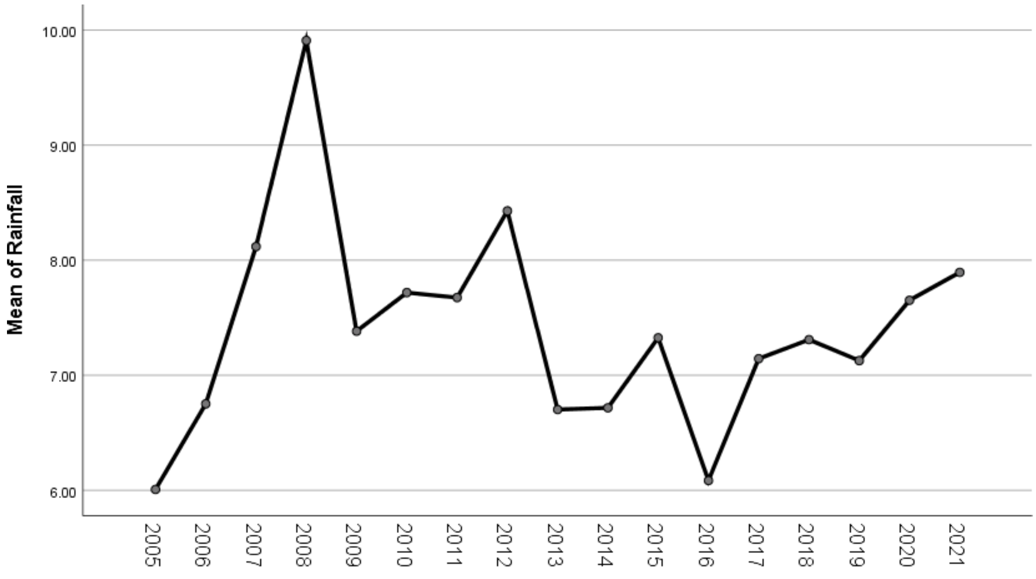

Figure 4. Mean plots for the rainfall from 2005 to 2021

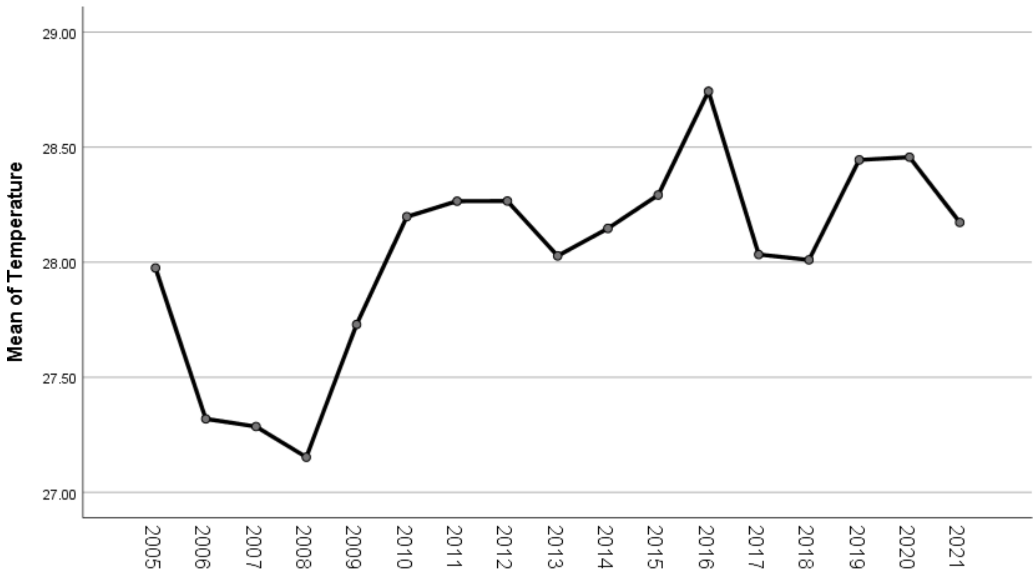

Figure 5. Mean plots for the temperature from 2005 to 2021

The temperature mean plots show a depression and a bump in 2008 and 2016, respectively. As compared to the rainfall mean plots, it presents the highest peak during 2008 while in 2016, the mean rainfall depresses to the lowest mean rainfall over the years. These occurrences indicate that there may be an uncommon incident happened during 2008 and 2016. Overall, ANOVA analysis shows significant differences in 2008 and 2016 for both figures. This event suggests that the results of the previous correlation analysis which is the existence of moderate connection between these two parameters is more likely to be accurate.

4.0 DISCUSSIONS

To investigate the climate change in the Klang Valley, records of temporal rainfall variations in the Klang Valley is collected. The statistical analysis shows a statistically significant findings for this research. The Correlation test indicates that there is a moderate relationship between the rainfall and temperature in the Klang Valley. These parameters also show a negative correlation in the analysis in which a decrease in temperature may cause an increase in rainfall and warmer conditions appear to lessen the rainfall. However, these findings contradict the expected outcome of this study. Initially, it was predicted that climate change was a contributing factor to the temporal variations in rainfall pattern that caused more rain in the Klang Valley (as discussed in Introduction section).

In other similar research [18, 28, 34], similar findings are reported. This research indicates a negative correlation between the rainfall and temperature in their studies. It is discussed that the analysis may be influenced by external factors such as physical properties of the rainfall droplets, geological features in Malaysia, heat island effects in the Klang Valley or El Nino effects that happened in the early of 2008 [29, 35-36].

ANOVA analysis also shows a statistically significant result. It presents that the mean rainfall in 2008 is the highest as compared to other years while the mean temperature in 2008 is the lowest over the 17 years. Meanwhile, the rainfall plot for 2016 is the lowest, while the temperature level is the highest. These occurrences are deduced to be the result of the ENSO effects which are the cold phase of the El Nino effects in early 2008 while experiencing the warm phase during 2016 [37, 38]. Consequently, the mean plots from the ANOVA analysis are more likely to be accurate since the ENSO phases occurred concurrently according to the Fig. 6.

5.0 CONCLUSION

To conclude this, the statistical analysis able to observe the climate change in the Klang Valley but, the statistical findings for this study contradicts with the initial expected outcome which is the lower temperature may cause a lot of rain while warmer weather was expected to reduce the rainfall. As discussed in Section 3, the relationship between the rainfall and temperature is found as having a negative correlation. It is deduced that the negative correlation is influenced by the external factors.

It is important to note that this research did not gather enough data collection for temperature data because of the limitations in infrastructure of temperature stations in the Klang Valley and this may influence the statistical results. Therefore, longitudinal research is recommended to study the climate change as well as to observe the current external factors that may affect the climate in the Klang Valley. However, the statistical findings for this research is deduced to be likely acceptable.

6.0 AUTHOR CONTRIBUTIONS

Muhammad Khalid Ramli: Conceptualisation, Data collection, Data refinement and selection, Data analysation, Writing, Editing, Reviewing

Dani Irwan Masbah: Conceptualisation, Supervision, Reviewing

7.0 FUNDING

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8.0 DATA AVAILABILITY STATEMENT

The data used for this study is included in the article.

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10.0 CONFLICTS OF INTEREST

The authors declare no conflict of interest.

11.0 REFERENCES

[1] N.H. Mohamed, A. Ismail, Z. Ismail, C.W.M.S.W. Adnan, and M.F.A. Raji, "Trend analysis and forecasting of rainfall and floods in the klang valley," *Defence S and T Technical Bulletin*, vol. 7, pp. 112-120, 2014.

[2] K. Ulaganathen, T.A. Rahman, S.K.A. Rahim, and R.M. Islam, "Review of rain attenuation studies in tropical and equatorial regions in Malaysia: An overview," *IEEE Antennas and Propagation Magazine*, vol. 55, no. 1, pp. 103–113, 2013.

[3] F. Ahmad, T. Ushiyama, and T. Sayama, "Determination of Z-R relationship and inundation analysis for Kuantan river basin," (Malaysian Meteorological Department (MMD)), 2017.

[4] T. Chew, and T. Chew, "The monsoon seasons in Malaysia," *ExpatGo*, 28th June 2013. https://www.expatgo.com/my/2013/06/28/the-monsoon-seasons-in-malaysia/

[5] Bernama, "Surau, petrol station suffers damages in KL flash floods," *Malaysiakini*, 21st November 2018. https://www.malaysiakini.com/news/451579

[6] "Flash floods hit several neighbourhoods in Klang, 31 evacuated to relief shelters," *The Star*, 20th October 2021. https://www.thestar.com.my/news/nation/2021/10/20/flash-floods-hit-several-neighbourhoods-in-klang-31-evacuated-to-relief-shelters

[7] "Floods cause Klang residents to evacuate homes," *The Star*, 21st October 2021. https://www.thestar.com.my/news/nation/2021/10/21/floods-cause-klang-residents-to-evacuate-homes

[8] Wani Muthiah, "Floods: Residents say Klang worst hit in more than four decades," *The Star*, 18th December 2021. https://www.thestar.com.my/news/nation/2021/12/18/floods-residents-say-klang-worst-hit-in-more-than-four-decades

[9] Agence France-Presse, "Malaysia's worst flooding in years leaves 30,000 people displaced," *The Guardian*, 19th December 2021. https://www.theguardian.com/world/2021/dec/19/malaysias-worst-flooding-in-years-leaves-30000-people-displaced

[10] Death toll from Malaysia's worst floods in years rises to 27, *Aljazeera.com*, 22nd December 2021. https://www.aljazeera.com/news/2021/12/22/14-dead-70000-displaced-in-malaysian-floods

[11] L. Rozanna, and L. Lee, "Thousands displaced by foods in Malaysia," *Reuters*, 19th December 2021. https://www.reuters.com/markets/commodities/thousands-malaysia-displaced-after-non-stop-rainfall-2021-12-18/

[12] New Delhi Television, "Over 22,000 people displaced in Malaysia floods, thousands flee homes," *New Delhi Television*, 19th December 2021. https://www.ndtv.com/world-news/malaysia-floods-malayasia-flood-update-malayasia-flood-news-today-over-22-000-people-displaced-in-malaysia-floods-thousands-flee-homes-2659211

[13] Pfordten, "Flood alert: Water levels at 11 rivers in Selangor at dangerous levels," *The Star*, 19th December 2021. https://www.thestar.com.my/news/nation/2021/12/19/flood-alert-water-levels-at-11-rivers-in-selangor-at-dangerous-levels

[14] Department of Irrigation and Drainage (DID). Hydrology Publication, 2022. https://www.water.gov.my/-index.php/pages/view/660?mid=336

[15] National Water Research Institute of Malaysia (NAHRIM), Penyelidikan, R&D dan Perkhidmatan, 2022. https://www.nahrim.gov.my/perkhidmatan/penyelidikan.html

[16] M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. Van der Linden, and C.E. Hanson, Climate Change 2007: Impacts, adaptation and vulnerability (Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Issue. C. U. Press, 2007.

[17] G. Arvind, P. A. Kumar, S. G. Karthi and C. R. Suribabu, "Statistical analysis of 30 years rainfall data: A case study," 2017.

[18] W. Zhao, and M.A.K. Khalil, "The relationship between precipitation and temperature over the contiguous United States," *Journal of Climate*, vol. 6, pp. 1232-1236, 1992.

[19] M.A.M. Razi, W. Tahir, N. Alias, L.H. Ismail, and J. Ariffin, "Development of rainfall model using meteorological data for hydrological use," *International Journal of Integrated Engineering*, vol. 5, pp. 64-73, 2013.

[20] National Oceanic and Atmospheric Administration (NOAA), Temperature and precipitation correlations within the United States, 1978.

[21] M.L. Tan, L. Juneng, F.T. Tangang, J.X. Chung, and R.B. Radin Firdaus, "Changes in temperature extremes and their relationship with ENSO in Malaysia from 1985 to 2018," *International Journal of Climatology*, 2020.

[22] A. Mahdi, Y.F. Huang, and T.S. Lee, "Recent trends in temperature and precipitation in the Langat River Basin, Malaysia," *Advances in Meteorology*, p. 579437, 2015.

[23] D. Flynn, "Student guide to SPSS," www. Barnard, 2003. edu/sites/default/files/inline/student_user_guide_for_-spss. pdf.

[24] J. Pallant, SPSS Survival Manual: A step by step guide to data analysis using SPSS (4 ed.), 2010.

[25] A. Field, Discovering Statistics Using SPSS. 3 ed. 2009, SAGE Publications Ltd., 2009.

[26] K.R. Das, and S.U. Khandoker, "How to Conduct Correlation and Regression Analysis through SPSS," *Australian Journal of Basic and Applied Sciences*, vol. 15, no. 3, pp. 16-23, 2021.

[27] J. Lani, "Correlation in SPSS," 14th July 2022. https://www.statisticssolutions.com/correlation-in-spss/

[28] T.R. Nkuna, "The relationship between temperature and rainfall variability in the Levubu sub-catchment, South Africa," *International Journal of Environmental Science*, vol. 1, pp. 65-75, 2016.

[29] I.M. Tania, and M. Zakaria, "Interdependency between rainfall and temperature using correlation analysis in the Barishal District of Bangladesh," *IOSR Journal of Mathematics (IOSR-JM)*, vol. 15, no. 5, pp. 49-55, 2019.

[30] Brunel, Interpret SPSS Output for Correlations: Pearson's R., 8th May 2013. https://www.youtube.com/watch?v=pgQ9T_SdzoQ&ab_channel=BrunelASK

[31] R.A. Oster, and F.T. Enders, „The importance of statistical competencies for medical research learners," *Journal of Statistics Education*, vol. 26, no. 2, pp. 137-142, 2018.

[32] Lund, A. Lund, and M. Lund. One-way ANOVA in SPSS Statistics, 2022. https://statistics.laerd.com/spss-tutorials/one-way-anova-using-spss-statistics.php

[33] D.Z. Warren, Chapter 17 Introduction to one-way ANOVA | APS 240: Data Analysis and Statistics with R., 2021. Retrieved 14 January 2021 from https://dzchilds.github.io/stats-for-bio/introduction-to-one-way-anova.html

[34] B. Timbal, B. Archevarahuprok, N. Golding, and D. Gunawam, "Observed and Modelled Temperature and Precipitation Extremes Over Southeast Asia from 1972 to 2010," *International Journal of Climatology*, 2018.

[35] National Oceanic and Atmospheric Administration (NOAA). What is El Niño and La Niña? 2022. Available from: https://oceanservice.noaa.gov/facts/ninonina.html

[36] T. Means, "Understanding the various temperatures of rain drops," 2018. Available from: https://www.thoughtco.com/what-determines-rain-temperature-3443616

[37] National Oceanic and Atmospheric Administration (NOAA). 2008 Annual Report, 2022. Available from: https://www.ncei.noaa.gov/access/monitoring/monthly-report/enso/200813

[38] National Oceanic and Atmospheric Administration (NOAA). What is El Niño-Southern Oscillation (ENSO)? 2022, Available from: https://www.weather.gov/mhx/ensowhat