ASSESSING CLIMATE FACTORS ON DENGUE SPREADING IN STATE OF PERAK

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Abstract: Dengue is an arthropod-borne or mosquito-borne viral infection that had rapidly spread in all state of World Health Organization (WHO) in current year. There are two types of dengue most severe such as Hemorrhagic Dengue Fever and Dengue Shock Syndrome. Disease dengue and dengue hemorrhagic fever is a mysterious disease that is usually found in tropical areas with the geographic distribution similar to malaria. Dengue virus is spread by female mosquito mostly it’s comes from species Aedes aegypti mosquito, there are also cases involving mosquitoes Aedes Albopictus. Climate change also contributes to the spread of the dengue virus in Malaysia such as rising temperatures, increased rainfall and humidity increased over the last four decades. In this study the climate factors such as rainfall distribution, humidity and temperature for every month are investigated towards the dengue spreading. Multiple regressions have been used to obtain the relationship between all climate factors for dengue spreading. One prediction model is proposed for State of Perak.

1.0 Introduction
Dengue is an arthropod-borne or mosquito-borne viral infection that had rapidly spread in all state of World Health Organization (WHO) in current year. The other definition is a disease caused by dengue virus infection where it is Genus Flavivirus spread by mosquito females [1]. There are two types of dengue is the most severe hemorrhagic Dengue Fever and Dengue Shock Syndrome. Disease dengue and dengue hemorrhagic fever is a mysterious disease that is usually found in tropical areas with the geographic distribution similar to malaria. There are four sorts of infection serotypes that are closely related to the Flavivirus infection but they will not be contaminated with the same infection within the event of a bite from Aedes mosquitoes. Multiple virus serotypes where it can happen. The dengue virus serotypes can categories as DEN-1, DEN-2, DEN-3, and DEN-4. The patient can be infected by
at least two and it’s not all four kinds at different times during their lifespan, but only once by the same kind [1, 2]. Dengue virus is spread by female mosquito mostly it’s comes from species *Aedes aegypti* mosquito, there are also cases involving mosquitoes *Aedes albopictus* and it also spread the other virus like chikungunya, yellow fever, and Zika infection. Dengue has grown from irregular diseases to a main public health problem with generous community and economic effect since of increased environmental extension, number of cases, and disease severity. The autonomous factors are day by day least temperature, every day most extreme and least temperature, day by day relative humidity, aggregate bi-weekly rainfall and every day mean wind speed. From the finding, they concluded that temperature, precipitation and wind speed all impact dengue transmission particularly in tall population density. In this paper, we will study the correlation and the regression of the climate factors such as daily rainfall, daily relative humidity and daily temperature on the dengue spreading for State of Perak, Malaysia. Our methodology is difference from the work of Cheong et al. [8]. By using multiple regressions with all three independent variables, we plot the surface response of two variables while one is fixed. This paper is made as follows. Section 1 gives the introduction to the subject matter. In Section 2, Methodology of the research is further elaborate. This includes the dengue factors, data collection and multiple regression models. Results and Discussion are given in Section 3. The finals section concludes the paper together with some future research recommendation.

2.0 Methodology

2.1 Dengue Factors

In Malaysia there two species of mosquito which carries the dengue virus where it is *Aedes aegypti* and *Aedes albopictus*. Usually these two-mosquito species a clearly found in buildings that built by humans. The spread of dengue it started from water reservoirs where it can be causing *Aedes* mosquito breeding. *Aedes* mosquitoes breed in clear water reservoir inside and outside the house. It cannot breed in dirty water. According to Cheong [7], Cheong et al. [8] and Paupy et. Al [23], The contributors to Aedes mosquito breeding are natural components that are not clean with waste that can be a breeding ground such as plastic holders, cans, unused tires, buckets, polystyrene, insect traps, flower pots and more. Banu et. A. [4] observed that climate change also contributes to the spread of the dengue virus in Malaysia such as rising temperatures, increased rainfall and humidity increased over the last four decades [4]. Dengue infection is very sensitive to weather conditions such a relatively high temperature may encourage adult mosquito behavior in terms of food and gonotrophic cycle as well as larval development and the spread of the dengue virus and also rain render water accumulation where mosquitoes can breed. Normally, entire immature or aquatic cycle from egg to adult in an estimate for 7-9 days. Various studies from of various associations reported that the effects of weather and climate correlate closely with dengue. Between the effects of the climate impact directly related to the increase in dengue cases was El Nino-Southern Oscillation (ENSO) and dengue in the state in the 10 countries of South Pacific Islands and throughout the islands of Indonesia and the northern United States, Thailand and Malaysia [5, 6, 12-15, 17]. Based the Sunday newspaper, the Minister of Health Malaysia Datuk Seri Dr S. Subramaniam was said for the first three weeks of 2015, the number of dengue cases reported was 8502 and it increase with 65% from the previous year with 5141 cases. One of the reasons for the rise the number of cases and deaths cause by dengue is dengue serotype shift. This happened in August of 2016 where it dominant serotype from DEN 2 to DEN 1. Malaysia have experienced towards change of the dengue serotype which it happens in March and Jun 2014. Afterward, the epidemic peak followed from July until September in 2015. The Ministry of Health (MOH) have monitored that 4 to 6 months after serotype shifts, it is more likely surged of dengue cases to occur. Human mobility elsewhere may also have an impact on the increase in dengue cases in Malaysia. The dengue virus is spread when a patient has been infected with the dengue virus to go visit other places. In addition, the arrival of the refugees’ illegal immigrants (PATI) to Malaysia also contributed the increase of dengue cases in Malaysia. They enter Malaysia without test-screening and caused this problem, the health authorities failed to identify those who enter Malaysia carry viruses that can spread through them. Furthermore, in Malaysia, dengue is the most part of an urban disease due to the plenty of the principle vector *Aedes aegypti* which is at a close proximity to high densities of susceptible hosts. The states of Selangor, Wilayah Persekutuan Kuala Lumpur and Johor are the ranges that have been to a
great extent influenced by the illness and are announcing tall numbers of cases. Components like populace development in urban zones, the unpredictable transfer of squander coupled with the need of proficient strong waste administration and the expanded and productive development of dengue infections in contaminated people through present day transportation have all contributed to the marked increment within the event of dengue. Thus, much needed actions are required in order to reduce the total number of dengue cases. For instance, the use of bacteria in controlling the Aedes etc. Details can be found in [10, 11, 16, 19, 20, 21, 22, 24, and 25]. Besides that, the prediction model also very important for the relevant agency in predicting the dengue cases for the following years.

2.2 Data Collection
State of Perak is second largest state in Peninsular Malaysia after Pahang, and the fourth largest in Malaysia and it is located at 4.5921° N, 101.0901° E, the total area at Perak is 21035 km². It covers an area of 12 districts. Perak selected as the study site because the land area and population density living in Perak. The number of people who live in Perak by 2, 457, 800 persons have been recorded in the Department of Basic Data Malaysia in 2015. Data deaths and dengue cases is a secondary data because these data are found from a variety of sources. From Ministry of Health (MOH) and the Department of Local Government get the data sources that having dengue cases and deaths records from 2013 until 2016 [18]. Data rainfall, humidity and temperature are obtained from Department of Meteorology Malaysia [9]. But in this study, we only use the data set on year 2014.

2.3 Multiple Regression Model
We apply the multiple regression analysis as follows:

\[ y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_1 x_2 + \beta_5 x_1 x_3 + \beta_6 x_2 x_3 + \beta_7 x_1^2 + \beta_8 x_2^2 + \beta_9 x_3^2 \]  

(1)

Where the independent variables are:

\[ x_1 = \text{Rainfall} \]
\[ x_2 = \text{Humidity} \]
\[ x_3 = \text{Temperature} \]

While the dependent variable \( y \) correspond for total dengue cases for each month in State of Perak. Next, we determine the estimate of the coefficients \( \beta_j, j = 0, \ldots, 9 \) including their confidence limits at the 95% confidence level. The values of \( R^2, F_0 \), and p-value is calculated in order to test whether the null hypothesis should be reject or not. Finally, we plot the residuals (Figure 4) and the normal probability (Figure 5) to determine whether they are normally distributed or not and then we will plot the surface \( y \) over the range of \( x_1 \) and \( x_2 \) for two values of \( x_3 \) (Figure 6).

The hypothesis test is

\[ H_0 : \beta_j = 0 \quad \text{for at least one} \ j \]
\[ H_1 : \beta_1 = \beta_2 = \ldots = \beta_9 = 0 \]  

(3)

Rejection of \( H_0 \) implies that at least one regresses variable makes a statistically significant contribution. The test statistic is

\[ F_0 = \frac{(\hat{\beta}X\hat{y} - \sigma^2)/k}{(\hat{\beta}X\hat{y} - \hat{\beta}X\hat{y})/(n-k-1)} \]

(4)

We reject \( H_1 \) (or accept \( H_0 \)) if \( F_0 \) have the value bigger than \( f_{\alpha,k,n-k-1} \).
3.0 Results and Discussion

Data in Table 1 shows the dengue cases in Malaysia for year 2014. Data for State of Perak further is split into monthly data set and data are used for multiple regression analysis. Figures 1-3 show the dengue cases vs. rainfall, temperature and humidity in State of Perak for year 2014.

**Figure 1:** Dengue Cases VS Rainfall in Perak, 2014

**Figure 2:** Dengue Cases VS Temperature in Perak, 2014

**Figure 3:** Dengue Cases VS Humidity in Perak, 2014
We apply multiple regression analysis given in (1) by using MATLAB programming. Below are the results: Regression coefficients and their confidence limits

-929450.2565 ≤ β₀ = 21967.9921 ≤ 973386.2408
-601.1610182 ≤ β₁ = 185.791053 ≤ 972.7431247
-14690.45945 ≤ β₂ = -1774.03151 ≤ 11142.39643
-57188.0231 ≤ β₃ = 2233.10073 ≤ 61654.22456
-7.380283705 ≤ β₄ = -1.0244091 ≤ 5.331465499
-25.66217986 ≤ β₅ = -3.91485726 ≤ 17.83246533
-270.779277 ≤ β₆ = -12.2565798 ≤ 246.2661174
-0.1524908502 ≤ β₇ = 0.004585066 ≤ 0.1616609827
-52.91014425 ≤ β₈ = 14.8913328 ≤ 82.69280987
-1107.407853 ≤ β₉ = -11.7310287 ≤ 1083.945796

Coefficient of determination R² = 0.96808

Test statistic F₀ = 6.7402 and corresponding p-value = 0.13582. Thus H₀ is accepted. We conclude that, based on statistics, all climate factors significantly contribute to the dengue spreading in State of Perak.

Figure 4. Residual Case Order Plot
Since the dengue spreading also depend to the other factors such as human mobility and construction sites exists nearby housing area, then the model given in (1) need some modification if we want to use it to predict the dengue spreading in State of Perak for year 2015, 2016 and so on. Figure 7 shows the prediction of dengue cases in Perak for year 2014. Clearly the model fit the actual dengue cases very well.
4.0 Conclusion
This paper studies the climate factors that contribute to the dengue spreading at State of Perak. We use the 2014 data sets. Multiple regression model is used to obtain the predict model for dengue cases in Perak for year 2014. Through this model, it has been proved that all three climate factors i.e. rainfall, temperature and humidity has statistically significant with 95% confidence interval. Future research will be focusing on the climate factors for dengue death cases as well as we will consider other factors also for instance human mobility and housing development in the residential areas.

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Table 1. Dengue Cases in Malaysia from 2013-2016

| State                | Dengue Cases |
|----------------------|--------------|
|                      | 2013 | 2014 | 2015 | 2016 |
| Perlis              | 230  | 317  | 258  | 179  |
| Kedah               | 833  | 1014 | 1000 | 957  |
| P.Pinang            | 1094 | 3141 | 5830 | 2498 |
| Perak               | 2648 | 7525 | 9466 | 3623 |
| Selangor            | 26260| 54290| 63198| 50157|
| WP KL &Putrajaya    | 2664 | 7185 | 8332 | 8421 |
| Negeri Sembilan     | 1323 | 3781 | 2454 | 2731 |
| Melaka              | 1549 | 2770 | 2420 | 2216 |
| Johor               | 4977 | 6323 | 15743| 10457|
| Pahang              | 744  | 2170 | 3001 | 2955 |
| Terengganu          | 621  | 1688 | 1455 | 1991 |
| Region     | Value1 | Value2 | Value3 | Value4 |
|------------|--------|--------|--------|--------|
| Kelantan   | 1454   | 14456  | 2850   | 5993   |
| Sarawak    | 1311   | 2571   | 1923   | 2688   |
| Sabah      | 744    | 1456   | 2904   | 3559   |
| W/P Labuan | 14     | 11     | 2      | 13     |