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## Description of the Variation of Environmental Temperature, Humidity, Rainfall and Wind Speed in the Dengue Fever Endemic Areas in South Sulawesi Province

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### Abstract

Climate change entails detrimental effects to the environment that include the change of warm to humid temperature, floods, drought, land slide disaster and also leads to the alteration of gases at the atmosphere. Such alarming impacts give rise to the adverse effects on the status of human health which in turn intensifies mortality rate, natural disaster and disease spread. This study aims to assess the variation of environmental temperature, humidity, rainfall and wind speed during the year 2006 in three dengue fever endemic areas in South Sulawesi province that includes Makassar Municipality, Maros and Gowa Regency. Results of this study revealed that the highest rate of rainfall was 27.7 °C in Makassar municipality and the lowest rate of rainfall was 26.7°C in Maros regency respectively. In addition, the highest rate of humidity was also observed in Makassar municipality at 87%, and the lowest rate of humidity was 65% in Maros regency. The highest rate of rainfall was 475 mm<sup>3</sup> in Gowa regency and the lowest rate of rainfall was 363 mm<sup>3</sup> in Makassar municipality. The wind speed in Makassar municipality was 4 knots, whereas the wind speed in Maros and Gowa regency was 3 knots respectively. Based on the assessment of three dengue fever endemic areas in South Sulawesi province in the year 2006, the highest rates of temperature, humidity and wind speed were observed in Makassar municipality, then it was followed by Gowa and Maros regency, whereas the highest rate of rainfall was identified in Gowa regency, then Makassar municipality.

**Keywords:** Temperature; Humidity; Rainfall; Wind Speed; Dengue Fever.

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## **1. Introduction**

Climate change entails detrimental effects to the environment that include the change of warm to humid temperature, floods, drought, land slide disaster and also leads to the alteration of gases at the atmosphere. Such alarming impacts give rise to the adverse effects on the status of human health which in turn intensifies mortality rate, natural disaster and disease spread. In terms of the national level, detrimental impacts due to climate change in Indonesia are parallel with wider spread of tropical diseases, such as malaria and dengue fever. Humid environmental temperature shortens the incubation period of mosquitoes that sustain the reproduction of malaria and dengue fever at a wider scale. Human populations that include children under five years old, children above five years old and old-aged persons are more susceptible to dengue fever disease due to climate change. This phenomenon is proven by the high rate of mortality among them due to malaria that accounts for up 1-3 million malaria cases/year in which 80% of the dengue fever patients including both children under five years old and those above five years old [1].

Climate change causes indirectly adverse effects on the status of human health. Floods attributable to high intensity of rainfall trigger higher frequency of diarrhea through the contamination of water sources and clean water supply and expanding the spread of malaria disease, dengue fever, chikungunya and other infectious diseases transmitted by rodents such as leptospirosis. Such adverse effects occur more strikingly at poor settlements all over the world. It is predicted that the prevalence of certain infectious diseases will increase due to climate change causing adverse effects on human health [2-3].

Climate change indirectly affects the spread and longevity of mosquitoes through their adaptation to response on favorable environmental condition for their reproduction [4]. The adverse impact of high intensity of rainfall due to climate change is the increase of habitats of mosquito larvae that entails population density of mosquitoes. High rate of humidity also affects the adaptability of mosquitoes to reproduce more rapidly and their aggressiveness at higher level in sucking human blood. Humid environmental temperature shortens the incubation period of viruses in the body of disease-borne vector. It also affects certain hosts along with their behavior due to climate change that exaggerate seasonal diseases and subsequently it enhances both mortality and morbidity cases. Rainy season is not only causing the spread of certain infectious diseases and their agents, but it is also exacerbated by human behavior as they response and adapt on climate change. Climate change as the causal factor of infectious diseases cannot be controlled but it can only be predicted and monitored as the valuable data to formulate and implement necessary preventive actions [5-6]

The estimated cases of dengue fever in Indonesia during the year 2014 accounts for up 100,347 cases with the mortality rate achieves 907 deaths (incidence rate/IR= 39.8 infected persons per 100,000 populations and case fatality rate-CFR/mortality rate= 0.9%). Both incidence rate and mortality rate due to dengue fever in the year 2014 represent a descending trend compared to the year 2013 with CFR of 112.511 and IR of 45.85. The provinces in Indonesia within the uppermost category of dengue fever cases in a series rate in the year 2014 are Bali with 204.22 cases, East Kalimantan with 135,46 cases, and North Kalimantan with 128,51 cases per 100,000 populations respectively. The incidence rate of dengue fever in South Sulawesi province in the year 2013 is 50.89 cases per 100,000 populations and showing a descending trend with 34.59 cases per 100,000

populations in the year 2014 [7].

*Aedes aegypti* mosquito is the vector of dengue fever that can only reproduce in the tropical regions within the temperature level of more than 16°C and at below an elevation of 1,000 metres of the sea surface. In the current time, *Aedes aegypti* mosquitoes spread in wider areas within the range of 1.000-2.195 metres of the sea surface. Higher endemic rate of *Aedes aegypti* might increase the risk of dengue fever disease in new areas that never infected before by this mosquito species.

Referring to the provincial level in Indonesia, there are three important areas estimated as the dengue fever endemic areas in South Sulawesi province that include Makassar municipality as the capital of South Sulawesi province and two nearby regencies, Gowa and Maros regency. Concerning to the problem background as stated above, this study aims to assess the variation of environmental temperature, humidity, rainfall and wind speed during the year 2006 in three dengue fever endemic areas in South Sulawesi province that includes Makassar Municipality, Maros and Gowa Regency.

## 2. Material and Methods

This study is a descriptive research that assesses the variation of environmental temperature, humidity, rainfall and wind speed in three dengue fever endemic areas in the year 2006 in South Sulawesi that consist of Makassar Municipality, Maros and Gowa Regency. Compilation of the study data within the dengue fever endemic areas in South Sulawesi were taken from Health Office of South Sulawesi provinsi, whereas the data of environmental temperature, humidity and rainfall were collected from Hall of Metereology and Geophysics. The overall data were represented in the form of tables that display minimum, maximum, mean and probability values.

## 3. Results

### 3.1 Environmental Temperature

**Table 1:** The Variation of Environmental Temperature in the Dengue Fever Endemic Areas in South Sulawesi Province of the year 2016.

Municipality/ Regency	Environmental Temperature (°C)				
	<i>N</i>	Minimum	Maximum	Mean	<i>p</i>
Makassar	20	22.4	33.2	27.4	
Gowa	10	21.8	33.5	31.5	0.000
Maros	10	21.8	31.3	26.5	
Total	40	21.8	33.5	28.2	

Source : Primary Data

As shown in Table 1, the mean of highest score of environmental temperature was 31.5°C in Gowa Regency,

whereas the mean of lowest score of environmental temperature was 26.5<sup>0</sup>C in Maros Regency. Results of the Anova test with  $p$ -value=0.000 ( $p<0.05$ ) indicated that there was statistically significant difference of environmental temperature rate among all the three endemic dengue fever areas in South Sulawesi Province.

### 3.2 Humidity

The variation of humidity in three dengue fever endemic areas (municipality/regency) is shown in the following table:

**Table 2:** The Variation of Humidity in the Dengue Fever Endemic Areas in South Sulawesi of the year 2006.

Municipality/ Regency	Humidity (%)				
	<i>N</i>	Minimum	Maximum	Mean	<i>p</i>
Makassar	20	57	90	77.0	0.475
Gowa	10	49	95	77.5	
Maros	10	50	87	72.6	
Total	40	49	95	76.0	

Source: Primary Data

As shown in Table 2, the mean of highest score of humidity was 77.5 % in Gowa, whereas the mean of lowest score of humidity was 72.6 % in Maros regency. Results of the Anova test with  $p$ -value=0.475 ( $p>0.05$ ) revealed that there were not any statistically significant difference of humidity rate among all the three dengue fever endemic areas in South Sulawesi province.

### 3.3 Rainfall

The variation of rainfall in three dengue fever endemic areas (municipality/regency) is shown in the following table:

**Table 3:** The Variation of Rainfall in the Dengue Fever Endemic Areas in South Sulawesi Province of the year 2016.

Municipality/ Regency	Rainfall (mm)				
	<i>N</i>	Minimum	Maximum	Mean	<i>p</i>
Makassar	20	180	210	190.8	0.213
Gowa	10	175	190	185.5	
Maros	10	180	195	187.5	
Total	40	175	210	188.6	

Source: Primary Data

Table 3 showed that the mean of highest score of rainfall was 190.8 mm in Makassar municipality and the mean of lowest score of rainfall was 185.8 mm in Gowa regency. Results of the Anova test with  $p = 0.213$  ( $p > 0.05$ ) showed that there was not any statistically significant difference of rainfall rate among all the three dengue fever endemic areas in this province.

### 3.4 Wind speed

The variation of wind speed in three dengue fever areas (municipality/regency) is shown in the following table:

**Table 4:** The Variation of Wind Speed in the Dengue Fever Endemic Regions in South Sulawesi Province of the year 2016.

Municipality/ Regency	Wind Speed (Knot)				<i>p</i>
	<i>N</i>	Minimum	Maximum	Mean	
Makassar	20	4	16	6.5	0.081
Gowa	10	3	18	5.3	
Maros	10	1	15	3.3	
Total	40	1	18	5.4	

Source: Primary Data

Table 4 indicated that the mean of highest score of wind speed was 6.5 knots in Makassar municipality and the mean of lowest score of wind speed was 3.3 knots in Maros. Results of the Anova test with  $p$ -value=0.081 ( $p < 0.05$ ) indicated that there was statistically significant difference of wind speed rate among all the three dengue fever endemic regions in this province.

## 4. Discussion

Results of this study revealed that the highest rate of rainfall was 27.7 °C in Makassar municipality and the lowest rate of rainfall was 26.7°C in Maros regency respectively. In addition, the highest rate of humidity was also observed in Makassar municipality at 87%, and the lowest rate of humidity was 65% in Maros regency. The highest rate of rainfall was 475 mm<sup>3</sup> in Gowa regency and the lowest rate of rainfall was 363 mm<sup>3</sup> in Makassar municipality. The wind speed in Makassar municipality was 4 knots, whereas the wind speed in Maros and Gowa regency was 3 knots respectively.

Extremely high number of dengue fever cases might occur in a seasonal or regular period in certain dengue fever endemic areas. Such remarkable dengue fever cases are affected by the cumulative causal factors. The first causal factor is a virus which called the dengue virus as the agent of dengue fever disease. Dengue viruses represent various number of populations/distributions, serotypes and virulences. The second factor is human as the host. This factor is affected by high density of human populations, mobility, immunity and proportion of viremic. The third factor is the dengue fever-borne vector. Density of populations and bionomics of *Aedes* spp.

persevere extremely high number of dengue fever cases. The fourth factor is the environmental factors (climate conditions) that include land elevation from the sea surface, environmental temperature, humidity, rainfall and wind speed.

Environmental conditions might favor the endemic of dengue fever disease by giving favorable conditions to mosquitoes to breed and having potency to contact with human to transmit infectious disease. There are several environmental factors that increase dengue fever cases, such as relative humidity and humid temperature that intensify the reproduction of mosquitoes. The more intensity rate of rainfall, the more water puddle as the favorable media of breeding places for *Aedes aegypti* mosquitoes, which in turn increases the frequency of mosquito bites [8].

Climate change causes the variation of rainfall, environmental temperature, humidity, direction of wind speed affecting land and sea ecosystem shifts as well as its impacts on human health specifically related with the reproduction of disease-borne *Aedes aegypti* [9] (McMichael, Woodruff, & Hales, 2006). Chakravarti and Kumaria in India reported in their study that rainfall, environmental temperature, and relative humidity were the foremost causal factors either individually or cumulatively persisting the epidemic of dengue fever [10].

Rainy season leads to higher rate of mosquito bites. The peak period of mosquito bites occurs at afternoon and early evening. Climate change affects human behavior by spending more time staying at home during rainy season and this behavior relates with higher frequency of mosquito bites. Rainfall and humidity at higher rate are in line with the increase of dengue fever patients and vice versa. This condition gives an indication that the intensity rate of rainfall significantly increases dengue fever cases during rainy season in which breeding places of mosquitoes will be flooded by water giving favorable condition for *Aedes Aegypti* mosquitoes to breed faster and increasing the incidence of dengue fever [11].

High intensity of rainfall commonly increases the incidence of dengue fever, as shown in Palembang Municipality, one of the provincial capitals in Indonesia. Rainfall intensifies disease spread transmitted by a disease vector that sustains breeding places of mosquitoes, but very high rainfall can reduce mosquito populations by flushing disease-borne vectors from their habitat in pooled water. High intensity of rainfall magnifies breeding places of *Aedes aegypti* mosquitoes. In addition to that, seasonal variation between the rainy season and the summer leads to different effects on bionomic variation of *Aedes Aegypti* [12].

Significant intensity of rainfall with a relatively long duration will make possible mosquitoes to reproduce optimally [13]. Dengue fever is one the infectious diseases transmitted through the infection of a virus (as a pathogen) and it is transmitted by a vector (*Aedes aegypti*). On the other hand, rainfall is the determinant of the existence of breeding places for mosquitoes as the disease-borne vectors. Adequate intensity of rainfall will form puddles in water containers around homes or holes as the hatchery places of mosquito eggs until achieve the pupal phase before pass through the newly formed adult flying mosquito from the pupal skin and leaves the water. High intensity of rainfall leads to water runoff from puddles that spreads larvae or pupae to either any suitable or unsuitable places to complete their life cycles to transmit infectious disease.

*Aedes aegypti* species has higher longevity on the exposure effect of wind speed and rainfall than *Culex* species. *Aedes aegypti* species at the preadult phase will swim to the bottom of the container to get away from the runoff of rainfall or warm rainfall, whereas *Culex* species at the same phase is commonly washed away together with water runoff [14]. It is predicted that the extremely high number of dengue fever cases every year in Indonesia have significant association to all regions in Indonesia have close association with the weather pattern in Southeast Asia region. Viral spread rate increase during the seasonal change characterized by the high intensity of rainfall and air temperature [15-16].

Climate affects significantly habitat ecosystems of disease-borne animals as well as natural proliferation of germ colonies. Moreover, climate has direct and indirect roles on the manifestation of infectious disease. Commonly, dengue fever and malaria have close association with humidity and rainfall. The increase of global temperature is related with the variation of transmission pattern for several parasites and disease through either indirect or direct transmission by insects. Climate and weather conditions have also significant roles in sustaining reproductive systems of disease-borne vectors and the occurrence of transformation process of viral incubation in the internal organs of insects. In addition, climate change and disease incidence have a close association particularly the incidence of infectious disease. Climate can also be used as the predictor of incidence of infectious disease as an indication to formulate and implement the management of health, specifically for zones-based diseases. Various vector-borne diseases are sensitive to a small scale variation of climate change. This small variation significantly affects dramatically the transmission of certain infectious disease, such as the transmission of dengue fever by *Aedes aegypti* mosquito. The incidence of infectious disease has close relationship with dense populations in urban areas, such as dengue fever [17].

High rate of humidity assists mosquitoes to proliferate at humid and wet places either as the sticking or rest places. At humidity rate of lower than 60%, mosquitoes go through a shorter phase of life cycle that preventing them become disease vectors since they do not have insufficient duration of time for the transmission of viruses that pass through from the stomach to the salivary glands of mosquitoes. Lower humidity within the range of 71.9% to 83.5% indirectly sustains the longevity of mosquitoes to pass through longer time of the development phase of viruses in their bodies. Humidity at optimal level increases the longevity of mosquitoes [18]. Several studies in health literatures have identified a significant association between dengue fever incidence and humidity. Pham HV and colleague identified that there was significant correlation between humidity and dengue fever incidence among several provinces in Vietnam [19].

At a relatively low humidity, the life cycles of mosquitoes will be halted, whereas at a relatively high humidity or saturated water (RH 100%), insects or their eggs will be submerged faster. The effect of low humidity or high humidity can be determined if collected data are available. Humidity rate also affects the intense activities of mosquitoes to bite and suck human blood [13].

It is suggested to do future studies on the association between the climate change and genetic variation of mosquitoes and their adverse effects to be used as valuable knowledge to formulate and implement preventive actions and therapies of dengue fever in a more meaningful way.

## **5. Conclusion**

Based on the assessment of three dengue fever endemic areas in South Sulawesi province in the year 2006, the highest rates of temperature, humidity and wind speed were observed in Makassar municipality, then it was followed by Gowa and Maros regency, whereas the highest rate of rainfall was identified in Gowa regency, then Makassar municipality.

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## **Competing Interest**

The authors declare that they have no competing interests.

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