

Malaria Spatial Pattern as an Outbreak Mitigation Effort in South Bengkulu Regency

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Abstract – Malaria is a disease caused by the parasite *plasmodium* sp, which is transmitted by the bite of an infected mosquitoes *Anopheles*. Bengkulu is a malaria endemic province located at western Indonesia. Climate change due to global warming causes malaria outbreak. This study aimed to describe distribution pattern of mitigating malaria through factors related climate. It used ecology study based on climate factors using Geographic Information System (GIS). Data were total of malaria incident, temperature, humidity, rainfall, wind speed and sunlight. Data were analyzed by correlation test. We found that rainfall was high potentially correlated to malaria incident in South Bengkulu Regency.

Keywords – Climate, Malaria, Mitigation.

I. INTRODUCTION

Malaria is a disease caused by the parasite *plasmodium* sp, which is transmitted by the bite of an infected mosquitoes *Anopheles*. The overall malaria incident was 228 million and mortality rate was 405.000 in 2018 [1]. Malaria prevalence was decreased since 2010 until 2017 at 44% (465.000 cases fell to 261.000 cases) [2]. Malaria endemic area in Indonesia is located in eastern Indonesia that is Papua, Nusa Tenggara Timur dan Maluku.

Bengkulu is known as malaria endemic province in western Indonesia. Morbidity rate of malaria is calculated by *Annual Parasite Incidence* (API). *Annual Parasite Incidence* (API) is total of malaria positive confirmed cases

in 1000 citizen per year. Bengkulu's API was 2.03 % in 2015, higher at 0.85% than Indonesia's [3]. The highest of malaria incident in Bengkulu Province was Lebong Regency at 28 % and South Bengkulu Regency at 21 % of total cases [4].

Annual Parasite Incidence (API) has significantly positive correlation with temperature, rainfall and humidity. Decreased rainfall and increased temperature because increased malaria incident in humid area [5]. Climate change affects carrier vectors, directly and indirectly. Environment affects directly vectors' reproduction, vectors' development, relative age population and parasites'

development in vectors' body; vegetation change and agricultural patterns affect whole vectors population [6].

The atmospheric temperature from 1.4°C to 5.8°C between 1990 and 2100 has been predicted. Global mean sea level is projected to increase by 0.09 m to 0.88 m by 2100. Productivity plants, pest distribution, diseases of plants and humans will be changed in the tropics. Increased temperature will change the rainfall and humidity distribution pattern [7]. Environmental change due to climate change will affect the malaria parasites' development [8]. Mosquito bionomics related climate leads to malaria incident caused climate patterns, especially in endemic areas. Climate fluctuations not only have an effect on mosquitoes' reproduction rate, but also on sporogonic stage development of malaria parasites in mosquito's body [9].

Higher temperature will increase mosquito activity. Higher rainfall will increase numbers of mosquito larvae [10]. Mosquitoes are active when dusk and dawn. Long-time sunlight exposure complicates it to find a place for laying eggs. Mosquitoes tend to disappear when winter or temperatures fell to below 10°C. Still, humans are an immediately origin of winter infections, because the virus can survive in low temperature, waiting for suitable temperature to reproduce [11].

Bengkulu's rainfall has a tendency to decrease with a maximum rainfall at 1065 mm / month and a maximum temperature at 29.4°C. Rainfall intensity change in Bengkulu occurs at each period of decadal-1 (1982-1991), decadal-2 (1992-2001) and the decadal-3 period (2002-2011) in June, July, and August. Bengkulu's rainfall pattern is a monsoonal pattern. Temperature depends on height of place above sea level and distance from the beach. The maximum average temperature is from 30°C to 33°C and the minimum average temperature is from 22°C to 23°C. Average relative air humidity is from 80 to 90% [12]. The malaria incident is positively correlated to wider area spreading rainfall with low rainfall (> 50 mm) and less rainy days (<10 days / month). It is correlated to rain intensity. Long-time heavy rain followed strong wind can eliminate larvae breeding place. The heavy water flow washes away, moves and kills larvae. It will break its life cycle [13].

Malaria incident data presented in South Bengkulu Regency has not been obtained in distribution mapping form related to climate factors such as temperature, humidity, rainfall, wind speed and sunlight. The results were expected

becoming references to determine of making policies reducing malaria cases by local governments.

II. RESEARCH METHOD

It was ecology study that was exploration study tend to analytic observational [14]. We analyzed location using overlay analytic that was spatial analytic in GIS performed in thematic map [15]. Data were processed by SPSS 17.0 to found correlation coefficient (r) between total malaria incident (X variable) and temperature, humidity, rainfall, wind speed, sunlight (Y variable) then compared to significant level (0.05). Data were collected by Badan Meteorologi, Klimatologi dan Geofisika (BMKG) of South Bengkulu Regency included data of climate during 2017 [16]. Data of malaria suspected and malaria positive confirmed cases were collected by Dinas Kesehatan of South Bengkulu Regency during 2017[17]. Samples were total of malaria incident recorded in profile of South Bengkulu during 2017.

III. FINDING AND DISCUSSION

3.1. Finding

Mapping results based on climate's factors (temperature, humidity, rainfall, wind speed and sunlight) affecting malaria suspected and malaria positive confirmed cases (Figure 1).

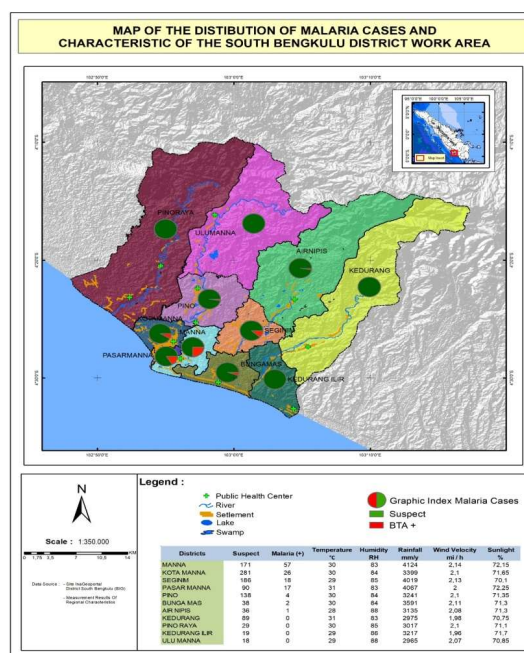


Figure 1. Distribution of Malaria Incident in South Bengkulu Regency during 2017.

Mapping distribution of malaria patients in South Bengkulu Regency was classified into two types, suspected and positive confirmed (+) cases. The highest and lowest numbers of suspected cases were Kota Manna sub-district at 281 cases and Ulu Manna sub-district at 18 cases consecutively. The highest numbers of positive confirmed cases were Manna sub-district at 57 cases. There were no malaria cases reported in Kedurang, Pino Raya, Kedurang Ilir, Ulu Manna sub-district. Based on map, the highest numbers of malaria cases were found in areas having characteristics as high temperature around 30-31°C, low humidity around 83-85 Rh, high rainfall around 3300-4200 mm/year, moderate wind speed around 2,1-2,2 mi/hour and strong sunlight around 71-73%. Humidity and rainfall were strongly correlated to malaria incident. Lower humidity made up higher malaria prevalence, as Manna and Kota Manna sub-district. Malaria incident was positively correlated to rainfall. Higher rainfall made up higher malaria incident, as Manna and Kota Manna sub-district having high rainfall.

Based on statistically correlation, we presented table 1.

Table 1. Correlation results between X and Y variable.

Variable	Sig. Values (2 tailed)	Strength of Correlation	Related Correlation
Temperature	.349	Very weakness	Negative
Humidity	.248	Very weakness	Negative
Rainfall	.000	Very strength	Positive
Wind speed	.022	Weakness	Positive
Sunlight	.193	Very weakness	Negative

Table 1 showed that temperature had no significant correlation with malaria incident, particularly, it was very weak correlation between temperature and malaria incident. It meant that temperature was negatively correlated to malaria incident. We found that temperature and humidity had no significant correlation with malaria incident. Second variable, humidity, had no significant correlation with malaria incident, particularly, humidity was very weakly correlated to malaria incident. It meant that humidity was negatively correlated to malaria incident. Rainfall had significant correlation with malaria incident, particularly, rainfall was very strongly correlated to malaria incident. It meant that rainfall was positively correlated to malaria incident. Wind speed had significant correlation to malaria incident, particularly, wind speed was weakly correlated to malaria incident. It meant that wind speed was positively correlated to malaria incident. Sunlight had no significant correlation with malaria incident, particularly, sunlight was

very weakly correlated to malaria incident. It meant that rainfall was negatively correlated to malaria incident. Table 1 represented that rainfall had very strongly correlated to malaria incident.

3.2. Discussion

Increased malaria incident is identified one of major effect of global warming and climate change. Increased temperature will increase malaria incident along with increased rainfall and surface area. It makes up longer transmission period in endemic areas [18]. Malaria incident distribution is restricted by tolerance of vectors in endemic areas. If it was dry caused by less rainfall and dry surface area, it will limit the mosquitoes' distribution as vector. Malaria distribution is affected by biological condition of mosquitoes to maintain it [19].

Based on mapping, humidity was strongly correlated to malaria incident. Humidity is concentration of water vapour present in the air. Ideal humidity for mosquitoes' growth and development is 60 – 70%. Humidity is very important on mosquitoes' reproduction, especially in egg cycle. If humidity is decreased, the eggs will hatch in longer period, taking period up to three months. Dry season decreases numbers of mosquitoes' population because of none place hatching eggs. In rainy season, there are puddles making higher humidity hatching eggs [20]. Humidity will affect mosquitoes' respiration impacting probability of hatching eggs. Hatching eggs take normally 8 to 10 days. Hatching eggs take period up to 8 days in high temperature and humidity and up to 10 days in low temperature and humidity [21].

Rainfall is a tough factor affecting Anopheles' population fluctuation. Rainfall is close to increase rate of population in an area. In dry season, there are many scraps that are cans, plastic cups, used plastics, used tires and another discarded and placed irregularly. The disposal or placing scraps are usually in an open area such as vacant land or land available in urban areas and rural areas. When dry season becomes rainy season, most of surface and scraps will collect rainwater. If the place or scraps contain hibernation eggs, it will hatch into larvae in a short time leading to adult mosquitoes in a period of time (9-12 days) [22].

Mosquitoes and malaria parasites are very sensitive to temperature change. So, climate change can affect the malaria distribution and transmission. The reproduction, growth, age and vector distribution process will be affected by macro and micro climate factors. The habitat's type and

amount of vector development, temperature and relative humidity are affected by quantity of rainfall. Climate change can increase vector population and human contact to vectors. Increased temperature and humidity predispose growth of malaria parasites plasmodium sp.

Global warming has no directly relationship with infectious diseases, but its continued effect increases potentially the mosquito population growth as a cause of disease and even trigger the emergence of new infectious diseases. Recent studies showed that higher temperature enlarges mosquito's flying areas and longer survival. It makes more widespread disease outbreaks [23].

Malaria susceptibility analysis is based on the accumulation of components of exposure, sensitivity and adaptive capacity [24]. High vulnerability and very high malaria incident due to global warming and climate change are thought as results of bionomic changes. Climate change is triggered by the greenhouse gas effect, so that it can be handled in reduction of carbon emission gas [25].

Climate change adaptation is an effort to improve adapting ability for climate change and minimize the damage predicted in the socio-economic and health sector caused by climate change (including climate diversity and extreme climate events). It will reduce the potential damage caused by climate change. Eventually, opportunities of climate change can be used and its consequences can be handled [26].

IV. CONCLUSIONS AND IMPLICATIONS

4.1. Conclusion

The most rate of malaria's area distribution in South Bengkulu has characteristics as highest rainfall and humidity. State apparatus were done efforts to adapt, they attempted preventions to citizen and government.

4.2. Implication

We found that climate change due to global warming will affect the structure of Anopheles as a humans' parasite carrier leading to impacted health sector. Individual needs to adapt against climate change through manipulating damaged environment.

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