

# CLIMATE AND MOSQUITO-BORNE DISEASES IN BANJARNEGARA: PROSPECT FOR AN EARLY WARNING SYSTEM

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**Abstract.** Dengue and malaria are mosquito-borne diseases that are transmitted through the bites of *Aedes aegypti* and *Anopheles* mosquitoes. Climate change may have an impact on the development of these mosquito vectors because weather conditions have an impact on metabolism, growth, development, and population. This study aimed to examine the relationship between climate with dengue and malaria incidence in Banjarnegara Regency. This research used secondary data with a cross-sectional approach. The research variables were climate data (temperature, humidity, rainfall, and wind velocity) recorded at the Banjarnegara Class III Meteorology, Climatology and Geophysics Agency (BMKG), while data on dengue and malaria cases during 2010-2019 were obtained from the Banjarnegara Health Office. Data analyses were univariate and bivariate, which were preceded by a data normality test. The results showed that the incidence of dengue and malaria in Banjarnegara tended to decrease during the period 2010 to 2019. Temperature and rainfall were correlated with the incidence of dengue (11.9%), while humidity and wind velocity were correlated with malaria (28.6%). Linear regression analysis shows that the climatic factor that can be used to predict the dynamics of dengue transmission is temperature, while that of malaria is wind velocity. This model can be used to help mitigate dengue and malaria transmission by determining the timing of prevention and providing infrastructure for dengue and malaria control.

**Keywords:** dengue, malaria, early warning system, climate, temperature

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## INTRODUCTION

Climate change is one of the environmental factors that affect public health. Climate change has the potential to increase the transmission of vector-borne diseases because it is related to temperature, humidity, and rainfall which all affect mosquito populations, extend the life span and expand the spread of vectors so that they have an impact on increasing cases of infectious diseases such as: malaria and dengue hemorrhagic fever.

Malaria is an ecological disease that is highly influenced by the enabling environmental conditions for mosquitoes breeding and potential contact with humans and can transmit malaria parasites. Transmission occurs when infected mosquitoes carry the parasites from an infected human to non-infected human. Malaria disease in Banjarnegara Regency is allegedly correlated with the density of *Anopheles* mosquitoes as a vectors, the more vectors will have a positive correlation with the high cases of malaria (Rozendal, 1997). High vector population densities can increase contact vectors that are infective to humans (McKelvey *et al*, 1981). *Anopheles* mosquitoes that have been found in contact with humans in Banjarnegara include *An. maculatus*, *An. balabacensis*, *An. aconitus*, *An. vagus*, and *An. kochi* (Djati *et al*, 2012). The incidence of malaria in Banjarnegara Regency from 2016 to 2020 has decreased, this can be seen from the annual parasite rate (API) of 0.22%, 0.09%, 0.02%, 0.01%, and 0.003%, respectively (Banjarnegara District Health Office, 2021).

Dengue hemorrhagic fever caused by the dengue virus (DENV) is endemic in more than 100 countries in Asia, America, Africa, and the West Pacific, most of which are in the tropics (WHO, 2022). This disease is transmitted to humans through the bite of a mosquito that is infected with the dengue virus. The main vectors of the disease are the *Aedes aegypti* mosquito, and to a lesser extent, *Aedes albopictus*. Dengue is caused by a virus of the Flaviviridae Family and there are four distinct, but closely related, serotypes of the virus that cause dengue (DENV-1, DENV-2, DENV-3 and DENV-4) (WHO, 2022). Other factors that influence the spread of dengue

include community behavior, global climate change, economic growth, and the availability of clean water (Pebrianti *et al*, 2021). Until now there is no specific drug or vaccine for dengue, but if the patient is treated as early as possible, and gets adequate management, the patient can be saved. Efforts that can be done so far are to avoid or prevent mosquito vector bites and to limit deaths due to dengue.

Transmission of dengue occurs through interactions between humans-hosts, mosquitoes-vectors, and viruses that are influenced by environmental and climatic factors (Higa, 2011). Dense populations in urban areas will increase vector-human contact, and DENV circulates more efficiently (Bhatt *et al*, 2013). However, recent seroprevalence studies have shown that rural populations have been exposed to as much DENV as urban populations (Doum *et al*, 2020). The high rate of seropositivity in rural areas is likely due to an increase in the mobile population of infected DENV from urban areas, and the transition from rural areas to urban areas.

In Indonesia, cases of dengue fever in 2021 were reported as many as 73,518 cases with 705 deaths (incidence rate (IR) = 27.0/100,000 population; case fatality rate (CFR) = 0.96%) originating from 474 regencies/cities in 30 provinces (Ministry of Health Indonesia, 2022). Banjarnegara Regency is one of the dengue-endemic districts in Central Java Province. In the last five years (2013-2017), there has been an increase in dengue cases with as many as 134, 147, 197, 591 and 48 cases, respectively (Banjarnegara District Health Office, 2017a; Banjarnegara District Health Office, 2017b; Banjarnegara District Health Office, 2018; Banjarnegara District Health Office, 2019).

The effect of climate on the population dynamics of *Aedes aegypti*, rainfall and temperature are known to be predictors of the ability of *Ae. aegypti* lays eggs (Stewart Ibarra *et al*, 2013). The *Ae. aegypti* mosquitoes will amplify and transmit dengue viruses only if exposed to temperatures within the range of 20 to 35°C (Carrington, 2013). These suitable temperature conditions are one of the factors that may explain why the presence of a competent species for transmitting a pathogen is not sufficient for disease

transmission, even if the pathogen is introduced in a new region. When environmental conditions are changing because of climate change, the genetically determined vector competence will not be affected, but the vectorial capacity may dramatically change and provide conditions that are more favorable to outbreak transmission. The vectorial capacity is a function of vector density, which is strongly related to rainfall patterns in the case of mosquitoes (Oo, 2011), of vector survival related to temperature and humidity (Brady, 2013), of the extrinsic incubation period (EIP) also related to temperature, and of the biting behavior which was found to be both genetically determined and temperature dependent (Ngowo *et al*, 2017).

In addition to the existing drivers of vector-borne diseases, such as seasonal weather variation, socio economic status, vector control programs, environmental changes and drug resistance, climate change and variability are highly likely to influence current vector-borne disease epidemiology. The effects are likely to be expressed in many ways, from short-term epidemics to long-term gradual changes in disease trends (Githeko *et al*, 2000).

The rate of spread of the virus is estimated to increase with the change of seasons which is marked by rainfall and high air temperature (Sintorini, 2007). Climate change, especially the temperature ranges from 23-27°C and humidity 67-82% affects the incidence of dengue (Ridha *et al*, 2019).

In addition to environmental factors (climate), minimal public education regarding the transmission of dengue disease is another important factor that influences the transmission of dengue, especially in today's conditions when the rainy and dry seasons can no longer be predicted. Additionally, as a result of climate change, some viruses spread more readily during seasonal changes in temperature and rainfall. During the transitional season, there is a chance for extreme weather, one of which is heavy rain, to occur. Due to the close relationship between the influence of climate and the transmission of dengue fever, an early warning service for dengue fever is needed based on climate parameters (temperature, humidity, rainfall) in the Banjarnegara area. Therefore, this study aimed to examine

the relationship of climatic factors (air temperature, rainfall and humidity, and wind velocity) to the incidence of dengue and malaria in Banjarnegara Regency in 2010-2019.

## MATERIALS AND METHODS

### Materials

The climatic data (temperature, humidity, wind speed, and rainfall) were obtained from the Central Bureau of Statistics (BPS), Meteorology, Climatology and Geophysics Agency (BMKG) Class III Banjarnegara as the secondary data, while data on dengue and malaria cases during 2010-2019 were obtained from the Banjarnegara District Health Office, either on request or by accessing the online health profile of Banjarnegara Regency.

### Methods

This research is quantitative in nature and is a descriptive study with a research design that used a time trend ecological study to examine the effect of rainfall, humidity, temperature, and wind velocity on the incidence of dengue and malaria 2010-2019 in Banjarnegara Regency. The research location was the entire area of Banjarnegara Regency. Data analyses included univariate analysis, bivariate/correlation analysis (statistics, graphs/ time trend), and continued multiple regression test. The description of temperature and humidity uses the Junghuhn category, namely hot if the temperature is  $>22^{\circ}\text{C}$ , moderate if the temperature is  $17.1-22^{\circ}\text{C}$ , cool if the temperature is  $11.1-17.1^{\circ}\text{C}$  and cold if the temperature is  $6.2-11^{\circ}\text{C}$  (The Student Team, 2012). The description of rainfall in Banjarnegara Regency follows Oldeman's classification (The Student Team, 2012), namely wet months when rainfall is  $>200$  mm, humid months when rainfall is between 100-200 mm, while dry months when rainfall is  $<100$  mm. The wind speed category team uses Beaufort Scale where Calm when wind speed is  $<1$  knot

(1 knots = 0.5 meters/second (m/s) or 1.8-1.9 kilometers/hour (km/h); light air, light breeze, gentle breeze and moderate breeze when wind speeds are 1-3, 3-6, 7-10 and 11-16 knots, respectively.

Univariate analysis was used to provide an overview of the distribution of dengue disease, fluctuations in rainfall, humidity, wind speed and air temperature. The early warning system was obtained from the climate factor prediction model for the dynamics of dengue transmission in Banjarnegara District using multivariate analysis by including several variables that fit the criteria as model candidates ( $p < 0.25$ ).

## RESULTS

Tables 1 and 2 describe climatic factors (air temperature, humidity, rainfall, and wind speed) during 2010-2019. The air temperature and humidity did not vary much; the wind speed did vary starting to increase from 2016 until 2019; rainfall in 2010 was the highest among those 10 years.

The incidence of malaria was relatively decreasing every year, with the highest incidence reaching 843 cases in 2011 and the lowest being 10 in 2017. Meanwhile, dengue cases were relatively fluctuating every year. Dengue cases in Banjarnegara Regency during 2010-2019 were recorded at 2,167 with an average of 17.6 cases per month (Table 2). The lowest number of cases was 48 cases and the highest was 591 cases. The results of the descriptive measurements of climate data in Banjarnegara Regency during 2010-2019 (Table 1), the highest average rainfall of 44,823 mm in 2010 and there was a downward trend yearly. Table 2 describes the wind speed range of 7.9 knots with a minimum and maximum wind speed of 3.2 knots to 13.2 knots. The average air temperature per month is 28.2°C with a humidity of 84.5%.

Fig 1 shows that humidity is related to the incidence of dengue and malaria during the ten years (2010-2019). The humidity in Banjarnegara Regency was at the average of 84.5% in one month with a minimum of 71.3% and a maximum of 91.3%. Fig 2 shows the effect of air temperature on the

Table 1  
Climate parameters and mosquito-borne diseases in Banjarnegara Regency 2010-2019

Variable	Year									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Dengue, number of cases	445	100	147	134	141	197	591	48	89	275
Malaria, number of cases	807	843	592	407	287	176	222	89	25	10
Temperature, degree Celsius	22.2-28.4	21.3-27.6	20.5-28.0	20.9-28.6	21.5-27.9	21.9-29.3	21.4-28.2	20.8-27.2	20.3-27.5	22.3-27.3
Humidity, percent	85.86	84.62	86.70	85.3	86.20	82.68	84.78	84.23	82.80	81.60
Rainfall, millimeter/year	6,179	3,866	3,886	3,730	3,738	3,623	5,542	4,923	3,029	5,767
Wind velocity, knots	6	5.14	6	4	6.17	10	11	10.17	11	11

Sources: <https://banjarnegarakab.bps.go.id/subject/151/iklim.html#subjekViewTab3>; <https://dinkesbna.banjarnegarakab.go.id/>

Table 2  
 Descriptive statistics of dengue, malaria and climate (temperature, humidity, rainfall, and wind velocity) in  
 Banjarnegara Regency, 2010-2019

Variable	Mean	Median	Standard deviation	Variance	Minimum	Maximum
Dengue cases	17.6	11.0	20.11	404.242	0	108
Malaria cases	29.9	18.0	33.61	1,129.811	0	160
Temperature (°C)	28.2	28.2	1.25	1.568	23.5	31.6
Humidity (%)	84.5	84.8	3.64	13.321	71.3	91.3
Rainfall (mm/year)	328.1	343.5	206.38	42,592.511	0	797
Wind velocity (knot)	7.9	7.9	2.73	7.427	3.2	13.2

°C: degrees Celsius; mm: millimeter

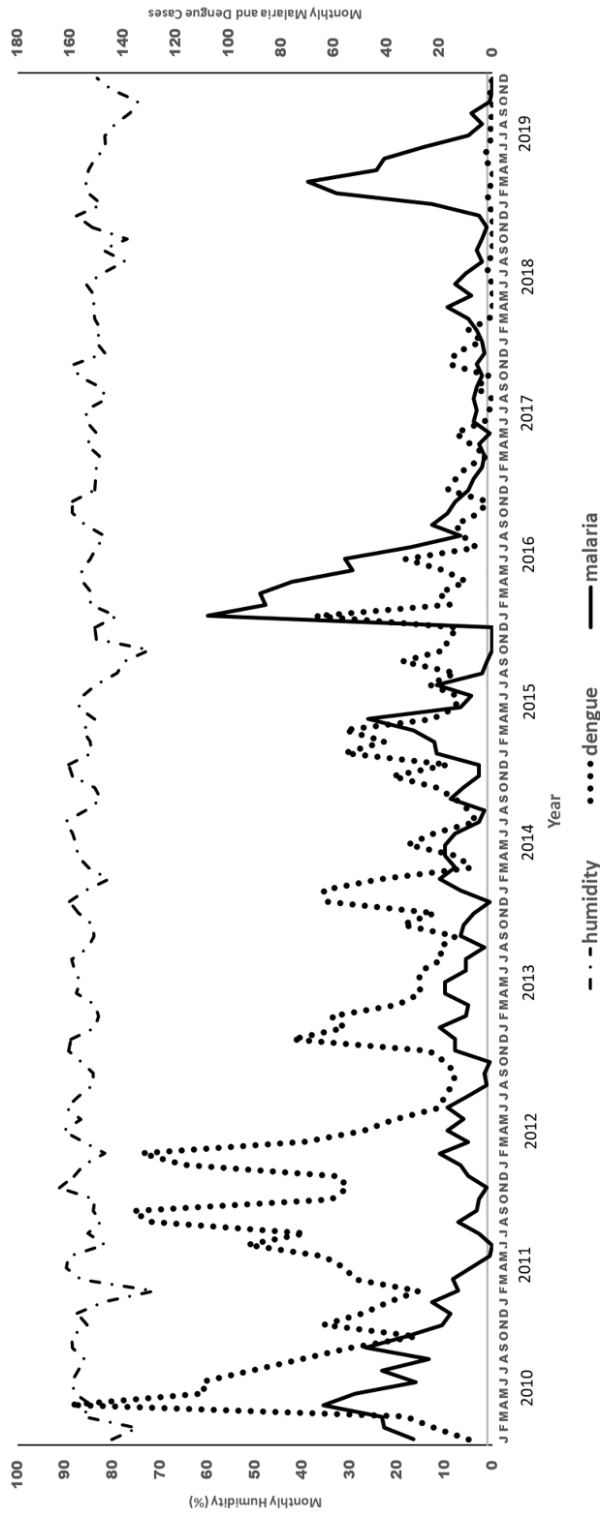


Fig 1 - Malaria and dengue cases with humidity in Banjarnegara, 2010 – 2019

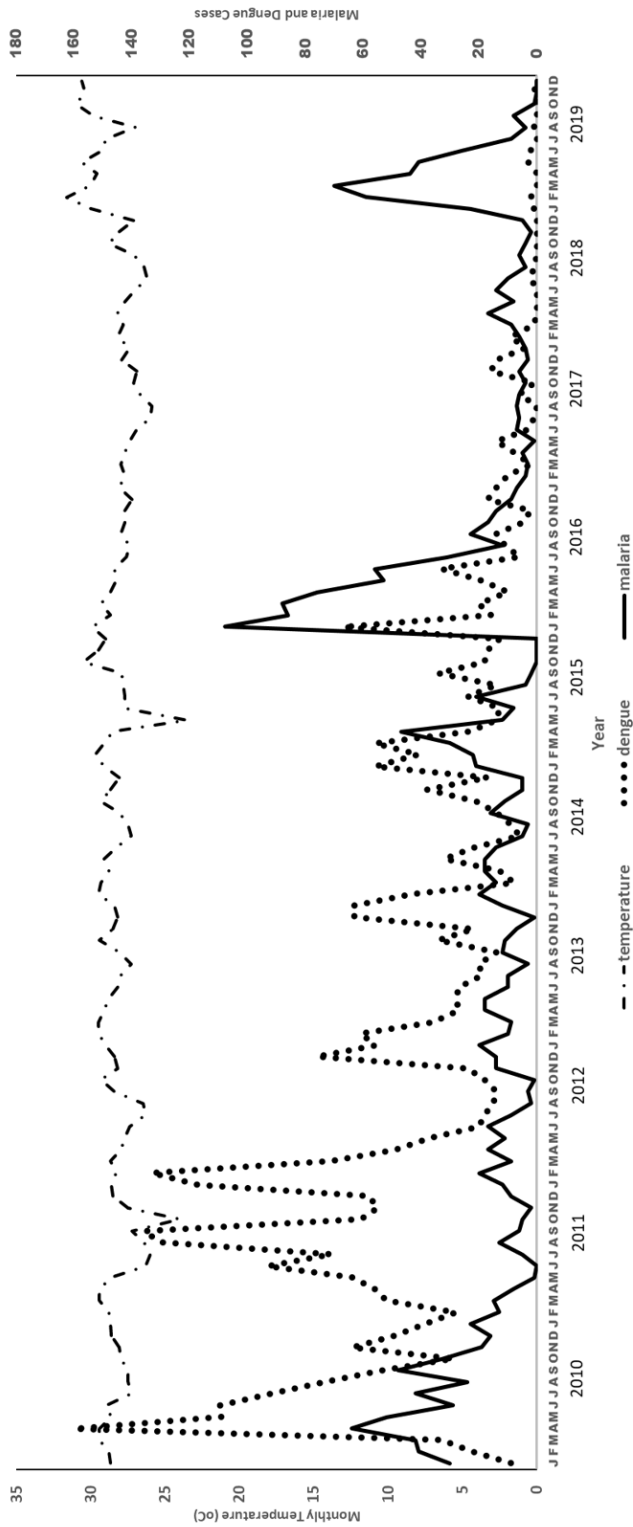


Fig 2 - Malaria and dengue cases with temperature in Banjarnegara 2010 – 2019

incidence of malaria and dengue in Banjarnegara District during 2010-2019. The range of air temperatures during 2010-2019 was between 23.3-29.3°C. The dengue incidence is inversely proportional to air temperature, at some points the increase in dengue incidence is associated with an increase in air temperature and vice versa.

The time-series graph of rainfall (Fig 3) with the incidence of malaria shows that the relationship between the incidence of malaria and rainfall in Banjarnegara Regency tends to be directly proportional, namely the incidence of malaria increases when rainfall also increases and vice versa. Meanwhile, the incidence of dengue tends to increase after the rainfall decreases.

Fig 4 shows the relationship between wind speed and the incidence of malaria per month; wind speed has an inverse relationship with the incidence of malaria. The incidence of malaria increases when the wind speed is low and vice versa. The correlation test (Table 3) showed that air temperature and rainfall correlated with dengue incidence while humidity and wind speed correlated with malaria incidence ( $p < 0.05$ ). Table 4 shows the statistical data generated by the regression model. It can be seen that the value of the correlation coefficient (R) is 0.345, meaning that the relationship between temperature and dengue incidence is of low positive correlation (Hinkle *et al* 2003). The analysis results show a coefficient of determination ( $R^2$ ) was 0.119, which means temperature has a proportion of influence on the incidence of dengue by 11.9%, while the remaining 88.1% is influenced by other variables that are not in the linear regression model. As for the incidence of malaria, the wind velocity variable obtained a correlation coefficient value of (R) 0.535, which means that the relationship between the variable wind speed and the incidence of malaria was of moderate positive correlation (Hinkle *et al* 2003). Based on Table 4, the value of the coefficient of determination ( $R^2$ ) on the incidence of malaria is 0.286, this indicates that the variable wind speed has an effect of 28.6% on the incidence of malaria while the remaining 71.4% is influenced by other variables not tested in this study.

Comparison of the predicted value of dengue cases with the number

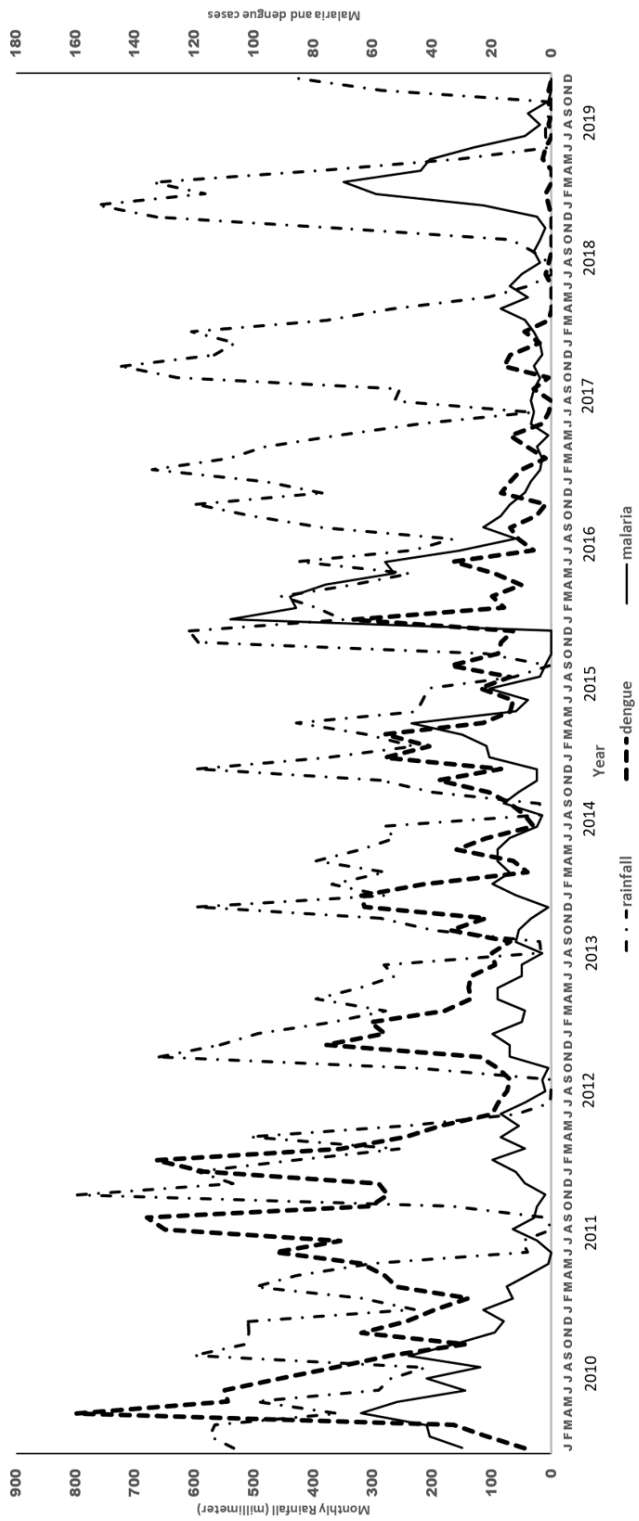


Fig 3 - Malaria and dengue cases with rainfall in Banjarnegara 2010 – 2019

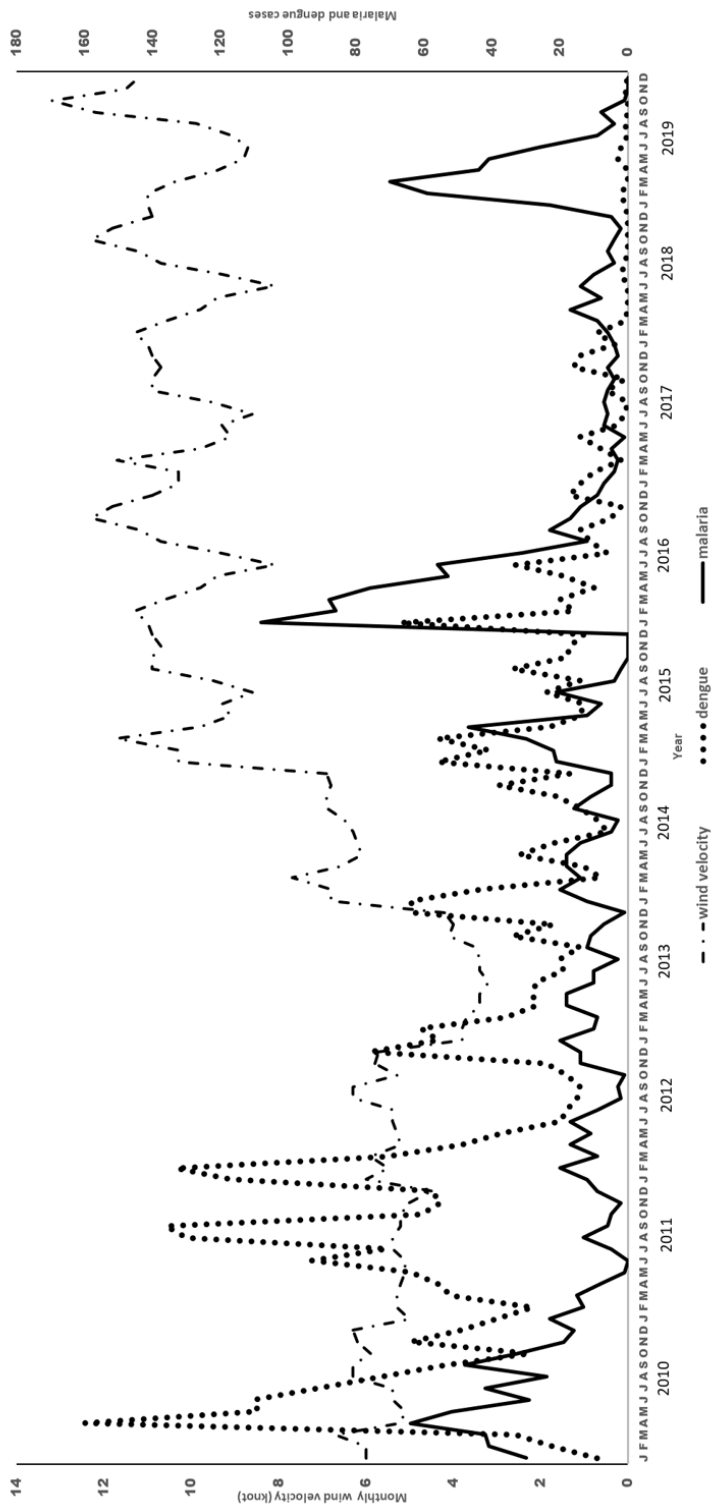


Fig 4 - Malaria and dengue cases with wind velocity in Banjarnegara 2010 – 2019

Table 3

Correlation test of climate with the cases of dengue and malaria in Banjarnegara 2010-2019

Variable	Dengue cases		Malaria cases	
	Pearson correlation coefficient	<i>p</i> -value	Pearson correlation coefficient	<i>p</i> -value
Temperature	0.319	<i>p</i> <0.001	-0.011	0.902
Humidity	0.050	0.588	0.188	0.039
Rainfall	0.213	0.019	0.068	0.459
Wind velocity	0.074	0.425	-5.35	<0.001

Note: Calculation was made based on 120 data (*n* = 120) of temperature, humidity, rainfall, and wind velocity per month during 2010-2019.

Table 4

Linear regression analysis test of rainfall, wind velocity, temperature, and humidity on the incidence of malaria and dengue in Banjarnegara Regency, 2010-2019

Variable	Temperature	Humidity	Rainfall	Wind velocity
Dengue incidence				
Correlation coefficient (R)	0.345	-	-	-
Coefficient of determination ( $R^2$ )	0.119	-	-	-
<i>p</i> -value	0.002	0.127	0.350	0.410
Malaria incidence				
Correlation coefficient (R)	-	-	-	0.535
Coefficient of determination ( $R^2$ )	-	-	-	0.286
<i>p</i> -value	0.784	0.378	0.073	<0.001

of existing cases based on temperature conditions in Banjarnegara Regency with a determination rate of  $R^2 = 11.9\%$  from 2010-2019 shows that there is a fairly wide range, the difference in the number of cases is quite large and the trend is different (Fig 5) especially in January, February, March, November, and December. Meanwhile, for the predictive value of malaria incidence, there is a wide range for almost all months except September and October.

## DISCUSSION

The temperatures in Banjarnegara Regency from 2010-2019 were generally  $>22^\circ\text{C}$  (classified as hot weather). As for the rainfall in Banjarnegara Regency, wet months occur in November-March because rainfall reaches  $>200$  mm while July-August experience dry months because rainfall  $<100$  mm. Humid months occasionally occur but tend to be in October. The wind speed is in the gentle breeze category, where the wind causes leaves and twigs to move continuously and can wave small flags. This wind category is not related to the incidence of dengue but is related to the incidence of malaria in Banjarnegara District.

The rainfall pattern during 2010-2019 in Banjarnegara Regency tends to be the same, the rainy season occurs at the beginning of October while July-September is in the dry season. The lowest rainfall throughout the 2010-2019 period occurred in July 2018, which was 0 mm, while the highest occurred in December 2011 with 796.50 mm rainfall. The highest humidity reached 91.30% in December 2011 and was the most extreme humidity that ever happened in Banjarnegara Regency since 2004.

The number of dengue cases when adjusted for the dominant rainfall conditions occurred in the wet months as many as 1,843 cases (87%), followed by the dry months with as many as 181 cases (9%) and the dry months with as many as 88 cases (4%). Not much different from the case of malaria, dengue is also more dominant in the wet months with as many as 2,836 cases (79%) in dry months 608 cases (17%) and humid months 148 cases (4%).

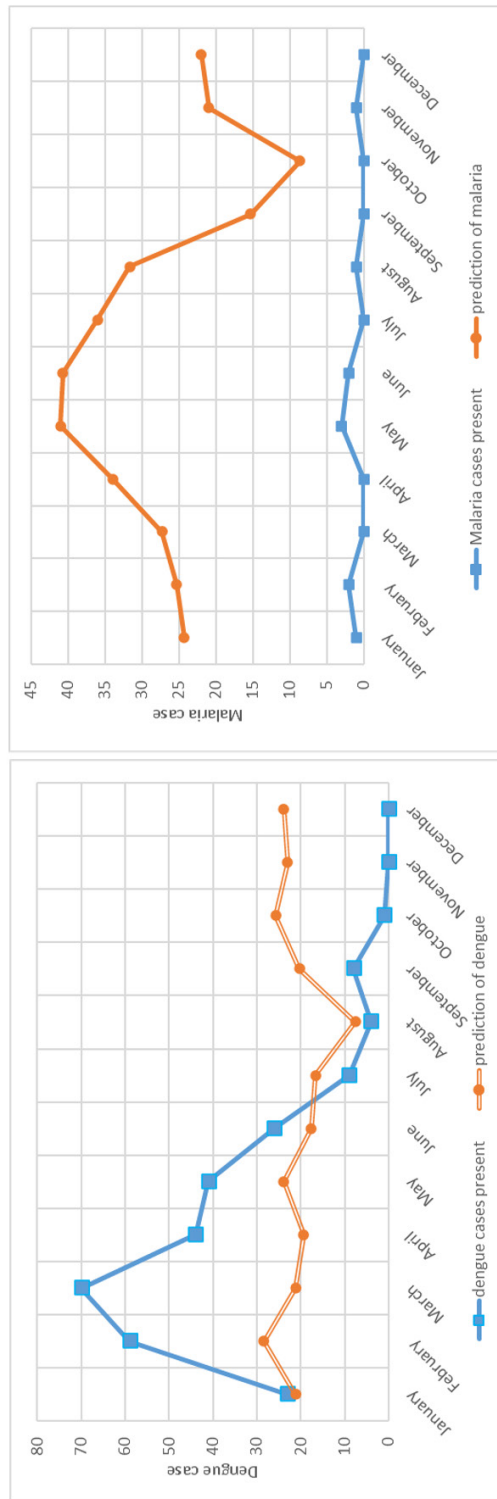


Fig 5 - Simulation of dengue and malaria prediction with cases present in Banjarnegara District in 2010-2019.

Climate change is a change in average climatic conditions, for example, a longer dry season than usual. Climate change caused an increase in the earth's surface temperature by 0.74°C in the 20th century and an increase in world sea temperature by 1.8 mm per year since 1961 (Townroe and Callaghan, 2014).

The existence of climate change, which is characterized by changes in temperature, precipitation, humidity, wind, and dust affects the balance of disease between the host, disease agent, and spread. If there is an imbalance between the factors in this triangle, there will be infectious diseases that are transmitted through the role of vectors, water, food, air, and others. The occurrence of this infectious disease will affect human health (Burgos and Ear, 2015).

During the 2010-2019 period, the air temperature in Banjarnegara Regency ranged from 20.3-29.3°C. This temperature range is the average optimum temperature for mosquito growth, which is 25-30°C (Delatte *et al*, 2009). If the temperatures are greater than 35°C, mosquitoes' physiological process is slow (Dewi and Sembiring, 2011). Temperature will affect the development of the virus in the mosquito body, the rate of biting, rest, and mating behavior, and the spread, and duration of the gonotrophic cycle (Erniasyih *et al*, 2021). The gonotrophic cycle is a cycle of maturation of eggs in the female mosquito's body from the mosquito sucking blood until the eggs are released. Increasing temperatures can potentially accelerate the breeding of *Aedes* mosquitoes. *Aedes aegypti* mosquitoes respond to increased temperature by reducing egg production and changing oviposition patterns (Erniasyih *et al*, 2021). At a temperature of 25°C and 80% relative humidity, the number of female mosquitoes that survived doubled and produced 40% more eggs when compared to conditions of 35°C and 80% relative humidity (Delatte *et al*, 2009). Mosquitoes can survive at low temperatures (10°C), but their metabolism decreases or even stops when the temperature drops below the critical temperature of 4.5°C (Lee *et al*, 2017).

The number of natural mosquito breeding places outside, such as cans, and used bottles, will increase as rainfall increases. Rainfall can affect the life of mosquitoes in two ways, namely: causing an increase in the relative humidity of the air and increasing the breeding ground. Every 1 mm of rainfall increases the density of one mosquito, but if the rainfall in a week reaches 140 mm, the larvae will drift away and die (Lahdji and Putra, 2017).

An increase in the incidence of dengue occurs in the rainy season; a 10°C increase in temperature, 17% of dengue cases increases while a 100 mm of rainfall increases, 11% of dengue cases increases (Lee *et al*, 2017). Moderate rainfall can cause waterlogging and increase humidity, thereby supporting the growth and reproduction of mosquitoes, but excessive rainfall can damage mosquito breeding sites and eliminate their eggs (Lahdji and Putra, 2017).

The vectors for dengue transmission is *Ae. aegypti* and *Ae. albopictus* mosquitoes. The characteristics of the infectious vector determine the distribution and timing of infection. The habitat of the Aedes mosquito is generally an area with a tropical climate, high rainfall, and hot and humid temperatures. *Aedes* mosquitoes like puddles or water reservoirs such as sewers, vases or plant pots, pet drinking places, swimming pools, or trash cans as breeding places. The characteristics and behavior of these vectors can explain the tendency of an increase in cases of dengue in the rainy season along with the emergence of breeding sites. In addition to influencing the number of cases, the characteristics and behavior of the Aedes mosquito are also the basis of efforts to control dengue disease through environmental interventions and individual and community behavior. These control efforts include the 3M (referring to Menguras, Menutup, and Mengubur in Indonesian), the government initiative as a solution to prevent dengue fever, comprising draining, closing, and burying objects that support the life cycle of a mosquito (Ministry of Health Indonesia, 2021).

The incidence of malaria during the last ten years has decreased, especially since 2016. The factor of increasing malaria cases is not only directly influenced by climate, but also by the intensity of vector bites. High

humidity causes mosquitoes to become more active and bite more often, thereby increasing malaria transmission. Low humidity shortens the lifespan of mosquitoes, although it does not affect parasites. Moisture affects the survival and sucking habits of mosquitoes. Low humidity will shorten the life of mosquitoes, on the contrary, high humidity will prolong their lives. At higher humidity, mosquitoes will become more active and bite more often (Monintja *et al*, 2021; Suwito *et al*, 2010)

The wind velocity is correlated with the incidence of malaria. The incidence of malaria occurs when the wind velocity ranges from 15-22 km/h (8.1-11.9 knots) with the highest incidence of malaria cases occurring at wind velocity of 20.63 km/h (11.1 knots) (Wahistina *et al*, 2018). Wind velocity greatly affects the flight distance of *Anopheles* mosquitoes. If the wind velocity ranges from 11-14 meters per second or 22-28 knots can inhibit mosquito flying activity (Masrizal and Sari, 2016). Direct wind speed will affect evaporation and temperature (convection) (Susanto, 2013).

Humidity is one of the climatic variables that correlate with the incidence of malaria. Low humidity shortens the survival of the *Anopheles* mosquito. On the other hand, high humidity will prolong the life of mosquitoes. At high humidity mosquitoes are more active and bite often offering a greater chance for malaria transmission. The mosquito's respiratory system uses an open trachea and spiracles so that when humidity is low there will be evaporation of water in the mosquito's body resulting in dryness of mosquito body fluids (WHO, 1975). The humidity of 60% is the lowest limit to allow mosquito breeding (Monintja *et al*, 2021). At higher humidity, mosquitoes become active and bite more often, thereby increasing malaria transmission (Rejeki *et al*, 2018). Air humidity correlates with *Anopheles* mosquito density per person per night (Suwito *et al*, 2010).

Using the results of multivariate analysis, the model predicted the dynamics of dengue and malaria transmission in Banjarnegara Regency based on climate factors. The dynamics of dengue transmission could be determined by temperature while that of malaria could be determined by wind velocity.

The different trends in Fig 5 are due to the fact that the simulation model obtained is only influenced by one predictor: temperature for dengue and wind velocity for malaria. Some research results reveal that the incidence of dengue and malaria can be influenced in addition to climate factors, *ie*, the environment, human behavior, vectors, and health services (Faruk *et al*, 2022; Sutarto and Cania, 2017). The latest document, Indonesia Climate Change Sectoral Roadmap (Health Sector), authored by Mintzer *et al* (2010) identifies social, economic and environmental factors that influence the distribution of malaria; they are (1) global climate change, (2) changes in land use, (3) drug and vector resistance, (4) population mobility, (5) socio-economic changes, (6) conditions of health services, (7) political and war situations, and (8) economic crisis and poverty.

The temperature and wind velocity can serve as an early warning system for health professionals, as the number of DHF and malaria cases can be determined from the outset. If high number of dengue and malaria cases are obtained through a climate element prediction model, health workers will have time to prepare health service facilities and improve education to the public to prevent wider transmission of dengue and malaria. Active surveillance needs to be carried out to monitor the spread of cases, distribution and vector density, main larval habitats and risk factors based on time and place related to the spread of dengue and malaria. The Health Service and Community Health Centers (*Puskesmas*) also need to increase community empowerment activities by carrying out the 3M (draining, closing, and burying) together with the elimination of mosquito larvae either chemically or biologically, the use of mosquito repellent and insecticide-treated net (ITN) especially when entering the wet month. The Health Office and the Meteorology, Climatology and Geophysics Agency (BMKG) of Banjar Negara Regency need to collaborate in an effort to plan, implement and formulate dengue and malaria control policies. It also requires active participation from the community in carrying out the eradication of mosquito nests and optimizing self-protection measures, especially when conditions in the area are wet.

In conclusion, in all seasons there are differences in climate elements that affect the incidence of malaria and dengue in Banjarnegara District. The climate elements that influence the incidence of malaria are wind speed and humidity, while for dengue, the climate elements that influence are temperature and rainfall. Climatic factors only 11.9% influence the incidence of dengue while 28.6% on malaria.

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### CONFLICT OF INTEREST DISCLOSURE

The authors report no conflict of interest in this research.

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