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The association between malaria incidences and air temperature at Kulon Progo District, Yogyakarta Special Province

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ABSTRACT

Malaria is still a public health problem in Indonesia including in Kulon Progo District, Yogyakarta Special Province. Kulon Progo District remains become malaria endemic area, with significant number of malaria cases for more than the last ten years. Previous studies proved that malaria transmission is associated with climatic conditions. However, these conditions have never been investigated in Kulon Progo District. The aim of this ecological study was to investigate the association between the distribution of malaria cases and climatic condition in the Kulon Progo District using spatial-temporal approach. A total of 1439 malaria cases were collected during the period of 2005-2015. Time-trend, bivariate analysis, and spatial analysis were performed. The results showed that air temperature lag 0 (p = 0.0000; r = 0.5225), air temperature lag 1 (p = 0.0009; r = 0.2850), air temperature lag 2 (p = 0.0329; r = 0.1858) related to the incidence of malaria. Spatial analysis and time-trend analysis also showed direct relationship pattern between malaria and air temperature. In conclusion, there is a relationship between malaria cases and air temperature in Kulon Progo District. Spatial analysis approach is important for early alert system, to decrease morbidity and mortality due to malaria.

Keywords:
malaria;
air temperature;
spatial analysis;
Kulon ProgoDistrict;
Yogyakarta;

ABSTRAK

Malaria masih menjadi isu masalah kesehatan masyarakat di Indonesia termasuk di Kabupaten Kulon Progo, Daerah Istimewa Yogyakarta. Kabupaten Kulon Progo masih menjadi daerah endemi malaria dengan jumlah kasus malaria yang signifikan selama 10 tahun terakhir. Penelitian sebelumnya membuktikan bahwa penularan malaria dikaitkan dengan kondisi iklim. Namun demikian kondisi ini belum pernah dikaji di Kabupaten Kulon Progo. Tujuan penelitian ekologi ini adalah mengkaji hubungan antara distribusi kasus malaria dan kondisi iklim di Kabupaten Kulon Progo menggunakan pendekatan spasial-temporal. Sebanyak 1439 kasus malaria diambil selama periode 2005-2015. Kecenderungan waktu kejadian, analisis bivariat, dan analisis spasial dilakukan. Hasil penelitian menunjukkan bahwa suhu udara lag 0 (p = 0,0000; r = 0,5225), suhu udara lag 1 (p = 0,0009; r = 0,2850), suhu udara lag 2 (p = 0,0329; r = 0,1858) berkaitan dengan kejadian malaria. Analisis spasial dan analisis kecenderungan waktu juga menunjukkan pola hubungan langsung antara malaria dan suhu udara. Dapat disimpulkan, ada hubungan antara kasus malaria dan suhu udara di Kabupaten Kulon Progo. Pendekatan analisis spasial penting untuk system peringatan dini, untuk mengurangi morbiditas dan mortalitas akibat malaria.

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INTRODUCTION

Malaria is caused by *Plasmodium, spp.* and transmitted by Anopheles mosquitoes, malaria is the biggest killer disease in densely populated countries, especially in tropical and subtropical countries. Malaria transmission is highly sensitive to climatic conditions in the area, such as air temperature which climatic factors can reduce or increase the vector density.[1,2] It is estimated that 3.2 billion people in 95 countries live in areas with high risk infection malaria, in 2015 there are 214 million new cases of malaria with 438.000 cases of malaria deaths, which is 88% occurred in Africa, 2% in East Mediterranean and 10% occurred in Asia including Indonesia.[3]

Malaria incidence is one of the indicators of the millennium development goals (MDGs), which targeted to stop the spread and reduce the incidence of malaria by 2015 based on the indicator of decreased morbidity and mortality due to malaria. With the expiration of the MDGs by 2015, global commitments such continued through the sustainable development goals (SDGs), which put an end to the AIDS epidemic, tuberculosis, malaria, tropical neglected disease in 2030.[3,4] In Indonesia malaria is a public health problem, which efforts to control malaria in Indonesia is monitored using indicators annual parasite incidence (API) where every case of malaria must be proven by the results of blood examination and all positive cases should be treated with artemisinin-based combination drugs or ACT *(*Artemisinin-based Combination Therapies).[5,6]

Yogyakarta Province contributes in malaria burden of disease in Indonesia and the outbreak malaria cases occurred in Kulon Progo District. Kulon Progo District is one of the four districts in Yogyakarta Province, with capital city of Wates situated 30 km west of the city of Yogyakarta with area of 586.28 km^2. Kulon Progo area is mainly, flat surrounded by mountains that are mostly located in the northern region.[7] Malaria is a disease that have not been successfully eliminated in Kulon Progo District, with persistent annual occurrence of the disease. The trend of malaria cases in Kulon Progo District from year 2005-2015 fluctuates with total number of cases reached 1439 cases in the last 11 years compared with the other endemic area in Indonesia.[7]

Climate change can potentially increase malaria cases. Climate change caused temperature increase and will accelerate the growth of the *gonotrophic* cycle in mosquitoes, resulting in higher breeding rate and this rapidly increases, the mosquito population.[1,8] Previous studies, show that air temperature is one explanatory factors in the increase in malaria cases but has not received adequate research focus.[9]

One method that can describe and monitor cases of malaria is the geographic information system (GIS), where spatial analysis can provide graphic information on the spread of malaria in relation with the air temperature in a region. The output of the mapping would assist in determining the spatial distribution, and in designing a control programs pertaining to reducing morbidity and mortality due to malaria through better prediction on future malaria patterns.[10,11]

MATERIALS AND METHODS

Study area

The site selected for the study was Kulon Progo District, one of the four district within the Yogyakarta Special Province that located in west of this province (FIGURE 1). The area of the regency is 586.28 km² with the population was estimated 426,420 in 2020. Kulon Progo District is surrounded by the Menoreh Hills. The greatest part of the population of the district work as farmers.

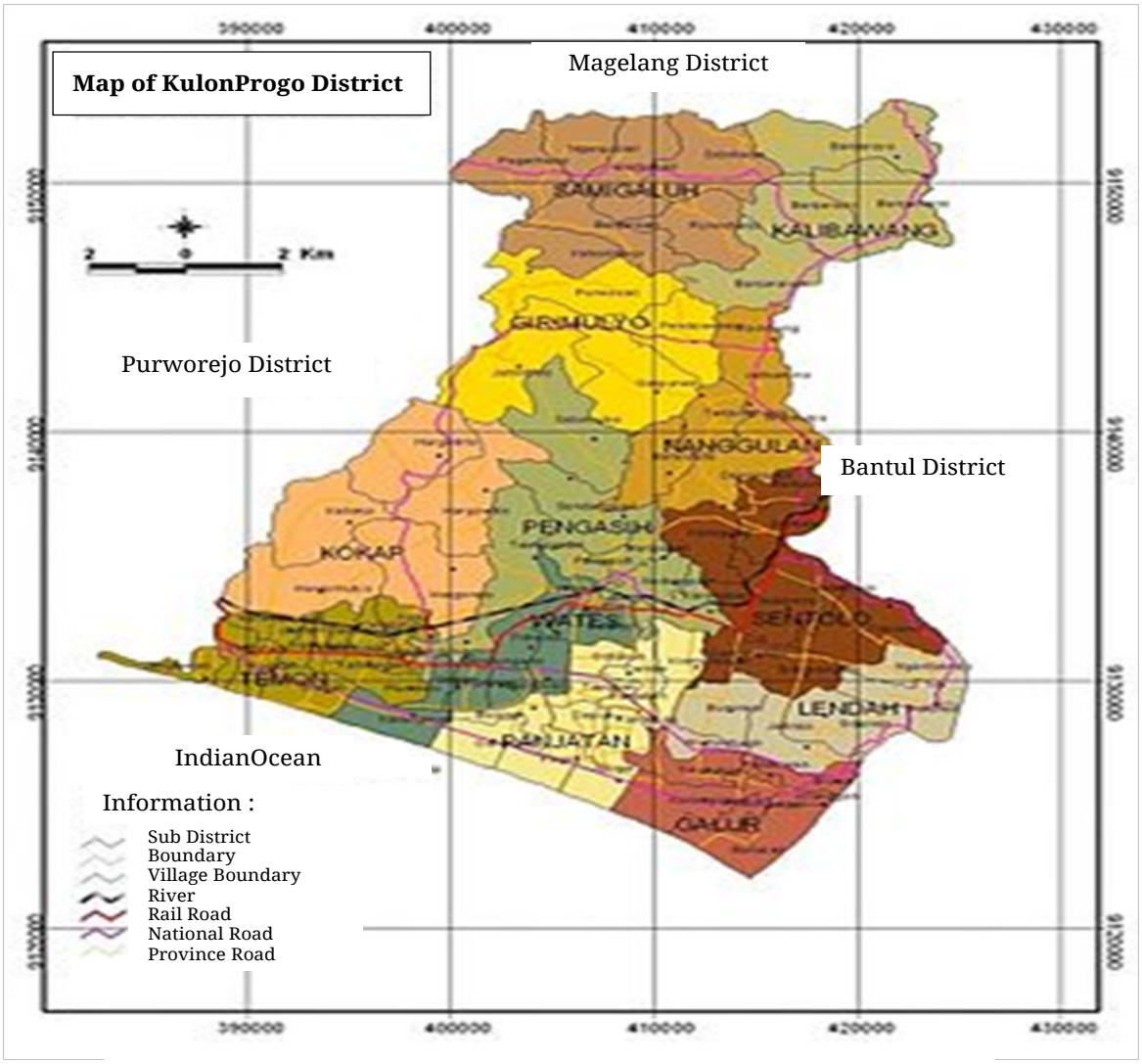


FIGURE 1. Map of Kulon Progo District, Yogyakarta Special

Data collection and management

This was an ecological study using spatial-temporal approach. The data of malaria cases in period of 2005-2015 were obtained from the Kulon Progo District Health Office.[12] A total 1439 data of malaria cases were collected during this period. Climatic conditions data in Kulon Progo District per month and per day in period of 2005-2015 included air temperature and weather were obtained from Meteorological, Climatological and Geophysical Agency in Yogyakarta Special Province, Department of Public Work Housing and Energy Mineral Resources in Yogyakarta Special Province and the Serayu Opak River Basin Agency in Yogyakarta Special Province.[7]

In this study, the Kokap Weather Station with an altitude 400 masl was used as the benchmark station. In this station the data of weather was available from 2005 to 2015. The air temperature data were also collected from other weather station includedStation of Galur (100 masl), Station of Girimulyo (500 masl), Station of Kalibawang (550 masl), Station of Lendah (100 masl), Station of Nanggulan (520 masl), Station of Panjatan (100 masl), Station of Pengasih (350 masl), Station of Samigaluh (350 masl), Station of Sentolo (100 masl), Station of Temon (100 masl), and Station of Wates (100 masl).

The air temperature data were classified into three groups i.e. low temperature (20°C-23°C), moderate temperature (23°C-26°C) and high temperature (26°C-29°C). Furthermore,the distribution of malaria cases were classified into four criteria based on its endemicity i.e. malaria-free (zero case), high case incidence (API>5 ‰), moderate case incidence (API 1-<5 ‰) and low case incidence (API <1 ‰). The different endemicity of malaria in each district was presented in different colors. The relationship between air temperature and malaria cases was presented by overlay.[6]

Ethical approval

Protocol of the study has been approved by the Medical and Health Reseacrh Ethic Committee, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada, Yogyakarta.

Data analysis

Time-trend analysis was used to evaluate the relationship between malaria cases with air temperature in Kulon Progo District.[12] Spearman correlation test was used to evaluate the relationship between air temperatures during the same month (lag 0) to three months earlier (lag 3) with malaria cases.[13] Spatial analysis using the Mock method was used to evaluate the relationship between air temperatures with distribution of malaria cases.[14]

RESULTS

The average air temperature in Kulon Progo District during 2005 and 2015 was 26.61 ± 0.84 ^{o}C. The air temperature minimum was 25.2°C recorded in February 2008, February 2009, June 2013, while the air temperature maximum was 28.6°C recorded in September 2009. Positive correlation between the air temperature with malaria cases was observed. The increase of air temperature would increase malaria cases. The highest correlation between air temperature and the distribution of malaria cases was observed in the same month (lag 0) with r value of 0.523. No significant significantly correlation was observed in lag 3 (p=0.136) (TABLE 1).

TABLE1. Correlation between air temperature (lag 0-lag3) with malaria cases in Kulon Progo District Year 2005-2015

Parameter	Air temperature			
	lag 0	lag 1	lag 2	lag 3
p	0.000	0.001	0.033	0.136
r	0.523	0.285	0.186	0.130

Time-trend analysis of the air temperature and malaria cases by year during the last 11 years showed the increase of air temperature cause the increase of malaria cases distribution (FIGURE 2). The spatial analysis concerning relationship between air temperature and malaria cases during the 11 years of the movement showed that malaria cases spread in all districts (FIGURE 3).

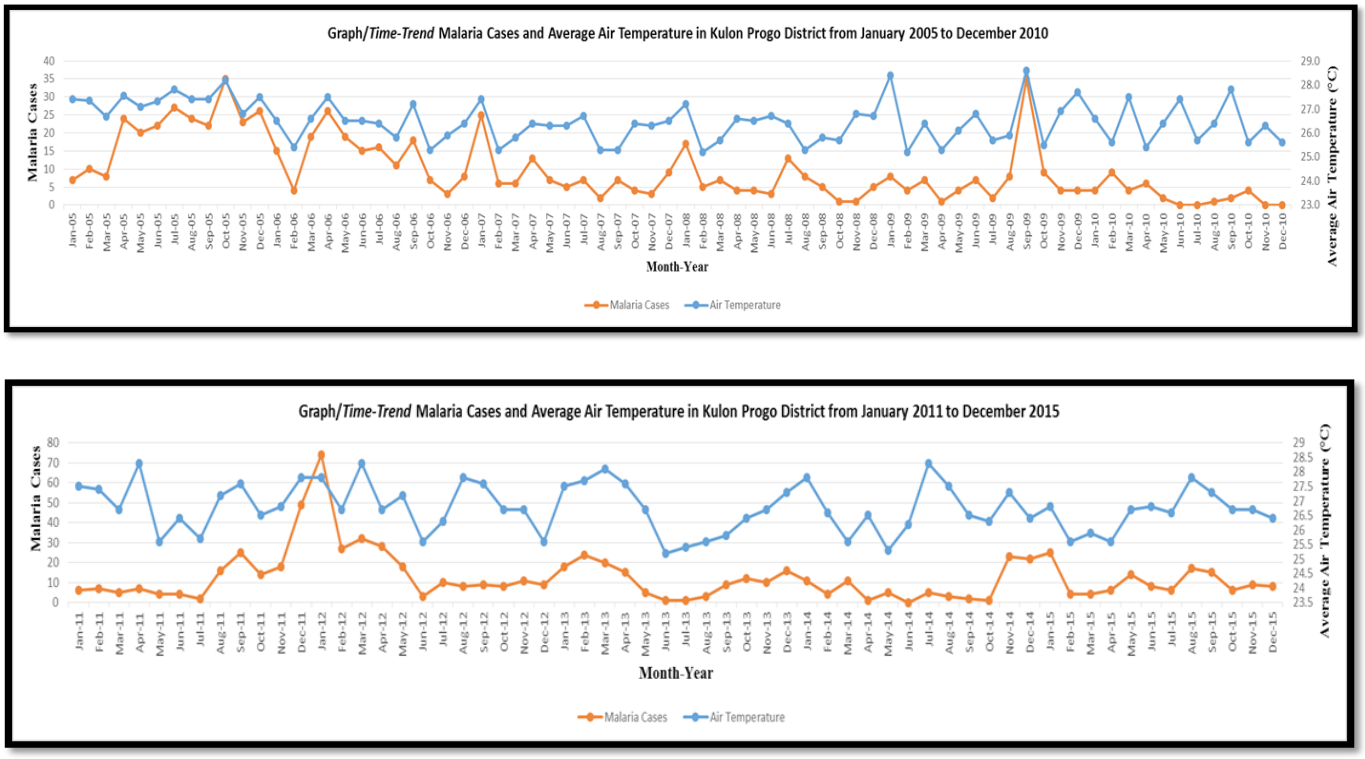
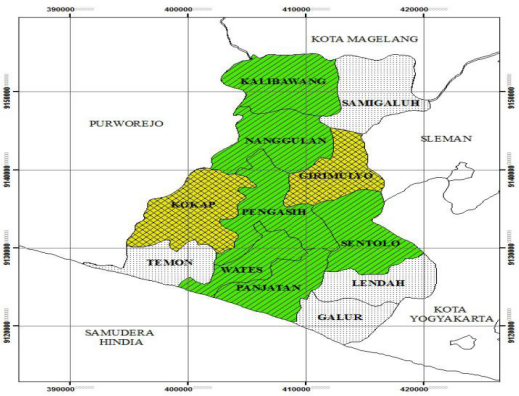
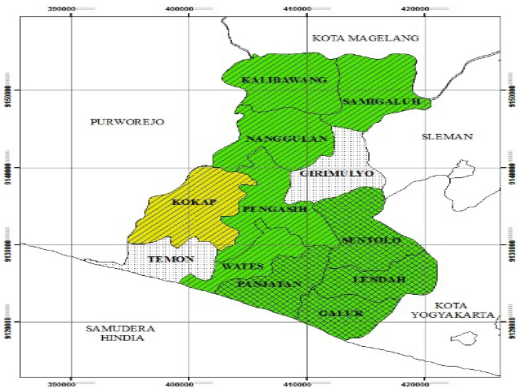


FIGURE 2. Time-trend malaria cases and average air temperature in Kulon Progo District from January 2005 to December 2015.

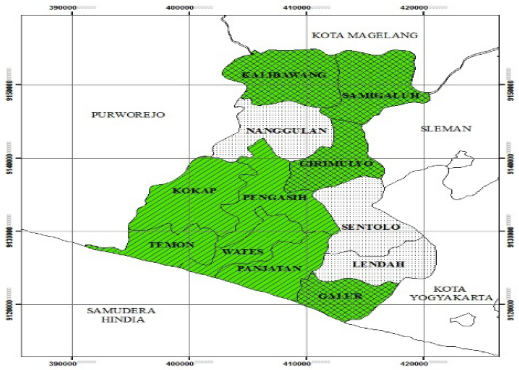


Year 2005



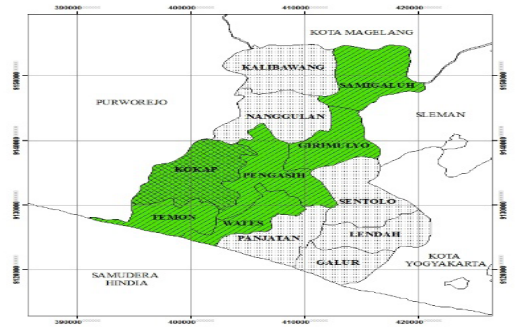
Year 2006

Year 2007



Year 2008

Year 2009



Year 2010

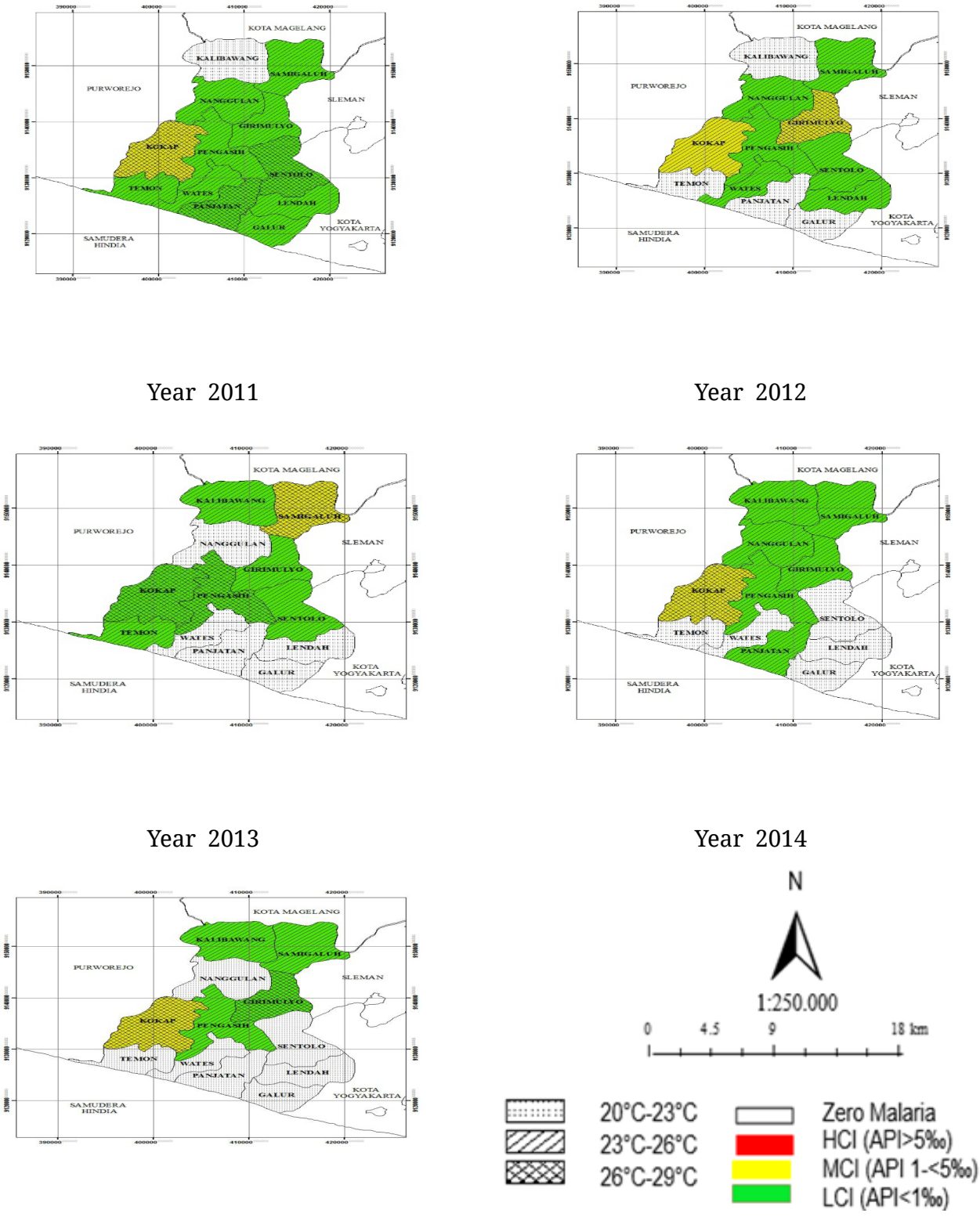


FIGURE 3. Air temperature mapping based on criteria malaria endemicity in Kulon Progo District from 2005-2015

DISCUSSION

Malaria cases in Kulon Progo District in period 2005 to 2015 were fluctuating. The lowest malaria cases was reported in January 2012 as much as 74 cases, while the highest malaria cases was reported in 2005 as much as 248 cases. The highest average air temperature per month for the last 11 years occurred in January. The malaria cases distribution was dominant in Sub-Districts located in the Menoreh Hills where the topography elevation between 500-900 masl and the average temperature of 28-30°C. This condition is compatible for breeding place of Anopheles mosquitoes as vector of malaria.[7]

Mosquitoes are a group of Arthropoda in the class of insects that its metabolism can be influenced by the air temperature in an area. Based on time trends and spatial analysis in several years, this study showed that the air temperature could be influenced by several factors, such as air humidity, rainfall, etc.[15] Furthermore, the air temperature was associated with the malaria cases distribution. This results is in line with previous studies which reported that there was a relationship between air temperature and malaria cases.[9,16,17]

The positive correlation between the air temperature and malaria cases was observed in this study. The increase of the air temperature would increase the malaria cases distribution. The correlation value would increase if the air temperature in the same monthlag 0 ($p = 0.0000$; $r=0.5225$). This correlation could be classified moderate. January was the month with the highest malaria cases and the highest air temperature. Meanwhile, the results of the spatial analysis between air temperature and malarias cases showed those areas with MCI and LCI endemicity conditions had temperature between 23-29°C.

Air temperature can affect physiological activities of living beings. However, living organism will maintain body heat in order to maintain its metabolisms. Mosquitoes are cold-blooded animals so that their metabolism and life cycle depends on the ambient air temperature. Temperature less than 16°C and over 32°C will disrupt mosquito metabolism.[1,8]

The optimum air temperature for mosquitoes is 23-27°C. Temperature tolerance for each mosquito species is not the same. However, almost all mosquitoes species can not survive in extreme environmental temperatures with changes between 5°-6°C that affect the adaptation process. Air temperature affects the sporogonic cycle or the extrinsic incubation period. The higher air temperature will shorten the sporogonic cycle time with air temperatures at a daily average of 27°C.[1,8] The water temperatures can also affect the breeding of Anopheles mosquito larvae. Larvae generally live in warm places. This is one of the factors causing more Anopheles mosquitoes in the tropics area. Mosquito eggs that hatch also depend on the temperature of the air which causes high water temperatures so that the eggs hatch faster.[8]

Studies conducted in Bangladesh and Sukabumi showed that malaria prediction models can be developed to monitor the malaria increase. The weather data can be used as an early warning system to plan anticipatory activities continued transmission so that it does not become an outbreak. Climate condition related to risk factors for disease, it is necessary to plan activities prevention of related diseases with season. This results can be used for policy implementation of malaria control programs. An increase of malaria cases starting in October and more significantly at the beginning of the year. Therefore, malaria control programs can be implemented before October.[18-20]

CONCLUSIONS

Thereisa correlation between the air temperature and malaria cases in Kulon Progo District. The implementation of malaria control programs must pay attention to weather patterns and the approaches with the spatial analysis GIS as a comprehensive early warning system of malaria control program.

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