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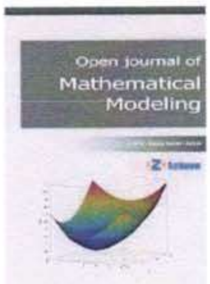

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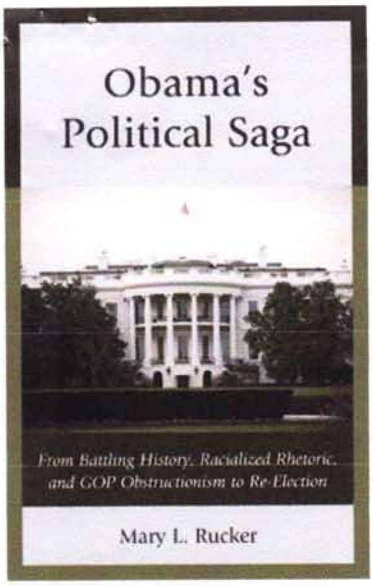

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Early Warning System of Malaria Disease Using Spatial Pattern Analysis

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Abstract - Malaria is a disease that comes back, ranks 10th cause of illness. Malaria also ranks 5th of six infectious diseases were the cause of death in the world. Malaria is the leading cause of death of tropical diseases, every year there are 40% of the world population at risk of suffering from malaria or about 300-500 million cases. It is estimated that each year there are 1-3 million people die caused malaria. Map of geographical distribution of disease is very useful to help implement the intervention plan. The objectives of this study are to describe a case of malaria and developed vulnerability maps the spread of malaria in Tanah Bumbu, South Kalimantan by using spatial pattern analysis. The results showed that the number of malaria cases in the first 6 months is higher than the second 6 months. Furthermore, it can be informed also that the spread of malaria cases are likely to be in the region of northern, central and southern. The highest numbers of cases of malaria in Tanah Bumbu during the past 5 years occurred in January 2012 LISA Based on testing, Sungai Loban District, Angsana, Simpang Empat, Mantewe, and Kuranji is a district that has a spatial relationship with the surrounding districts and form a grouping with numbers high malaria cases.

Keywords - Malaria cases, Moran's I, Local Indicator of Spatial Autocorrelation, Moran's scatter plot, Thematic Maps

1. Introduction

Malaria still dominate public health problem in the world, according to a WHO report in 2009 there were 109 malaria endemic countries, 31 countries are malaria-high burden countries, there are an estimated 3.3 billion or half the world's population is in the malaria prone areas. Every year there are 250 cases with nearly one million deaths. Incidence is highest in sub-Saharan Africa, and also occurs in Asia, Latin America, the Middle East and parts of Europe. Malaria can cause economic losses of an average of 1.3% per year in malaria-endemic areas, consequently threatening the lives of poor communities, fringe people, people who cannot afford the cost of treatment and the people residing in these areas the lack of health care facilities. According to WHO (2010), malaria is becoming one of the causes of student absenteeism in schools and labor in workplaces [1].

Malaria is a disease that comes back (reemerging disease), ranks 10th cause of illness. Malaria also ranks 5th of six infectious diseases were the cause of death in the world. Malaria is the leading cause of death of tropical diseases, every year there are 40% of the world population at risk of suffering from malaria or about 300-500 million cases. It is estimated that each year there are 1-3 million people die from malaria [2].

Malaria is caused by an obligate intracellular protozoan of the genus Plasmodium. In humans, malaria caused by plasmodium malariae, plasmodium vivax, plasmodium ovale and plasmodium falcifarum. Transmission of malaria carried by the female anopheles mosquito, 400 species of Anopheles mosquitoes have been found 67 species that can transmit malaria and 24 of them are found in Indonesia, the common species are Anopheles sundaicus, Anopheles balabacensis, Anopheles minimus, Anopheles barbirostris, Anopheles punctulatus, Anopheles farauti and Anopheles karwari [3].

Indonesia is one country in the world that still have problems with malaria, cases of death due to severe malaria in Indonesia is still quite high at between 20.9 to 50% [2]. In 1996, malaria cases are found in the Java-Bali as much as 2,341,401 people, the slide positive rate (SPR) 9,215, the annual paracitic index (API) of 0.08 ‰, CFR at the hospital 10-50% [4]. In 2007 in Indonesia there are 396 endemic districts of the existing 495 districts, with an estimated 45% of the population live in areas at risk of contracting malaria. The number of cases in the year 2006 as many as 2 million people and in 2007 it decreased to 1.8 million people [5].

In South Kalimantan in 2006, there are 5 districts into malaria-endemic areas, namely Banjar Regency, Tanah Laut, Tabalong, Tanah Bumbu and Kotabaru [6], in the year 2007 to 2012 API figures in South Kalimantan are respectively 0.6 ‰, 0.8 ‰, 0.98 ‰, 1.51 ‰, 2.8 ‰ and 2.6 ‰ [7]. In 2012, the number of malaria cases without discovery laboratory tests are 181 people with the number of deaths by 14 people. The discovery of cases of malaria by microscopy examination of 17,036 people, with RDT (Rapid diagnostic test) 1,2176 people.

Tanah Bumbu from years 2007-2012 are always found in cases of malaria and malaria tend to have the highest incidence of town/other districts in South Kalimantan. In 2012, the discovery of cases of malaria in Tanah Bumbu amounted to 6,044 cases from a total of 29,212 cases in South Kalimantan.

Geographical distribution maps of disease are very useful for studying the relationship between climate and disease or other health problems and empirically useful to help implement the intervention plan. Information prone area distribution according to place and time required in determining the priority areas of program implementation anticipation and prevention.Therefore, the necessary distribution maps will be able to determine the priority areas of program implementation anticipation and prevention of malaria cases in Tanah Bumbu.

The objectives of this study is to describe a case of malaria in Tanah Bumbu, South Kalimantan and develop vulnerability maps the spread of malaria in Tanah Bumbu, South Kalimantan by using spatial pattern analysis.

2. Theory

2.1. Malaria

Malaria is derived from the Italian language which means bad and the mall area which means the air, or air to be bad because of the disease or often found in areas that have marshes that emit unpleasant odors (rotten), another name of this disease are fever aroma, swamp fever, fever tropical, beach fever, Chagas fever and fever tortoise [3].

Malaria is caused by protozoa of the genus plasmodium, plasmodium consists of falcifarum, plasmodium vivax, Plasmodium malariae and Plasmodium ovale. Of the four types of which often lead to death in humans is of a type plasmodium falcifarum. All types of the plasmodium stage having moved from vector mosquitoes to humans and then back to the mosquito vector, the mosquito vector is Anopheles genus. Sexual cycle occurs in the mosquito Anopheles and asexual cycle occurs in humans [8].

In Indonesia, malaria spreading in almost all areas, the number of malaria cases confirmed by per thousand populations, known as the Annual Parasite Incidence (API) in Java-Bali in 2006 of 0.19 ‰, while outside Java-Bali, a number of clinical malaria per thousand inhabitants, known as Annual Malaria Incidence (AMI) in 2006 was 23.98 ‰ [9].

2.2. Spatial Autocorrelation

Spatial Autocorrelation is a method used to measure the relationship between observations in the variable itself, which is influenced by factors between the observation locations. Measurement of spatial autocorrelation can use Moran's I and Local Indicator of Spatial Autocorrelation (LISA).

2.2.1. Weighting matrix

Weighting matrix (w_{ij}) has size n x n matrix, where each element of the matrix describes the closeness measure between observation i and j. If i to j adjacent areas (both administratively a contiguous area), then the value is 1 and when far apart, is 0 (zero).

2.2.2. Moran's I

Coefficient Moran's I is the development of univariate Pearson correlation in the data series. Pearson correlation (ρ) between the variables x and y with a lot of data n is formulated as follows.

And the Pearson correlation equation is the average of the sample variables x and y. measure whether the variables x and y are correlated. Moran's I measure the correlation of the variable e.g. x (and) where $i \neq j$, with a lot of data for n, then the formula of Moran's I is as follows [10].

$$I = \frac{n \sum_{i=1} \sum_{j=1} w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{S_0 \sum_{i=1} (x_i - \bar{x})^2} \quad (1)$$

$\bar{x}$ in equation (1) is the average of the variable x, w_{ij} is an element of the weighting matrix, and S_0 is the weighted sum of the elements of the matrix, where $S_0 = \sum_i \sum_j w_{ij}$. The value of the index I range between -1 and 1. Pattern identification using an index value criterion I, if $I > I_0$, then it has a clustered pattern (cluster), if $I = I_0$, then the pattern is not evenly spread, and $I < I_0$, the pattern of spreading evenly. I_0 is the expectation value of I, which formulated $I_0 = -1/(n-1)$.

Variance Moran's I can be formulated as follows:

$$\mathrm{Var}(I) = \frac{n\{(n^2-3n+3)S_1 - nS_2 + 3S_0^2\}}{(n-1)(n-2)(n-3)S_0^2} - \frac{k\{n(n-1)S_1 - 2nS_2 + 6S_0^2\}}{(n-1)(n-2)(n-3)S_0^2} - \frac{1}{(n-1)^2} \quad (2)$$

With,

$S_1 = \frac{1}{2}\sum_{i\neq j}(w_{ij} + w_{ij})^2 = 2S_0$

$S_2 = \sum_i (w_{i0} + w_{0i})^2$, $w_{i0} = \sum_j w_{ij}$

And $w_{0i} = \sum_i w_{ji}$

Tests on the parameters I can be done as follows.

$H_0: I = 0$ (No spatial auto correlation)

There are two kinds of alternative hypotheses are:

$H_1: I > 0$ (Have a positive auto correlation)

$H_1: I < 0$ (Has a negative auto correlation)

With the test statistic:

$$Z_{count} = \frac{I - I_0}{\sqrt{var\,(I)}} \quad (3)$$

This test will reject the initial hypothesis if the value of Z_{count} lies in the $|Z| > Z_{\alpha/2}$. Positive auto to indicate that the spatial correlation between the location of the observations have a close relationship.

2.2.3. Local Indicator of Spatial Autocorrelation (LISA)

Identification of an autocorrelation coefficient locally to find the spatial correlation in each region, can be used Moran's I. In contrast to Moran's I described in point 2.2.2., which is indicative of global autocorrelation, Moran's I local autocorrelation at LISA indicated. The index is as follows [11].

$$I_i = z_i \sum_i w_{ij} z_j \quad (4)$$

And the equation (4) is the deviation from the average value.

$$z_i = (x_i - \bar{x})/\delta \quad (5)$$

δ is the standard deviation of the values x_i. Expectations I_i can be formulated with $E(I_i) = -w_{i.}/(n-1)$. Higher value of local Moran's, provide information that adjacent regions have almost the same value or form a clustered deployment.

The variance of can be formulated as follows.

$$\mathrm{var}[I_i] = w_{i.}^{(2)} \frac{\left(n - \frac{m_4}{m_2^2}\right)}{(n-1)} - 2w_{i(kh)} \frac{(2m_4/m_2^2 - n)}{(n-1)(n-2)} - \frac{w_{i.}^2}{(n-1)^2} \quad (6)$$

With,

$w_{i.}^{(2)} = \sum_j w_{ij}^2, \quad i \neq j$

$w_{i(kh)} = \sum_{k\neq i}\sum_{h\neq i} w_{ik} w_{ih}$

$w_{i.}^2 = (\sum_j w_{ij})^2$

Tests on the parameters can be done as follows.

$H_0: I_i = 0$ (No spatial auto correlation)

There are two kinds of alternative hypotheses are:

$H_1: I_i > 0$ (Have a positive auto correlation)

$H_1: I_i < 0$ (Has a negative auto correlation)

With the test statistic:

$$Z_{hitung} = \frac{I_i - I_0}{\sqrt{var\,(I)}} \quad (7)$$

This test will reject the initial hypothesis if the value of Z_{count} lies in the $|Z| > Z_{\alpha/2}$. Positive auto to indicate that the spatial correlation between the location of the observations have a close relationship.

2.3. Moran's scatter plot

Moran's scatter plot is one way to interpret statistical Moran index [11]. Moran's scatter plot is a tool to see the relationship between (the values of standardized observations) with (the average value of neighboring regions which have been standardized.

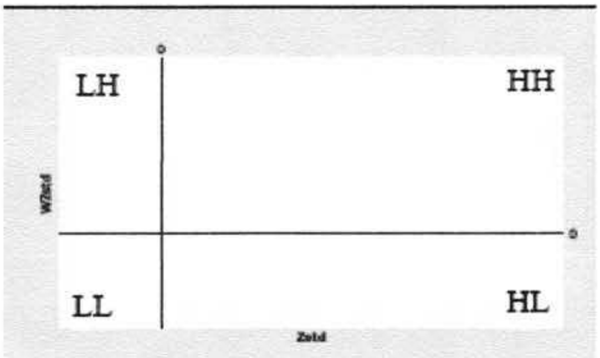

Fig. 1. Plot between Z_{std} with WZ_{std}

Plot between the quadrant I (located in upper right) called the High-High (HH), indicating regions with high observation value surrounded by regions with high observed values. Quadrant II (located at the upper left) is called the Low-High (LH), indicating areas with low observation but surrounded by areas with high observation value. Quadrant III (located at the bottom left) is called Low-Low (LL), indicating areas with low observed values and the surrounded areas also have low observed values. Quadrant IV (located at the bottom right) called the High-Low (HL), indicating areas with high observation value surrounded by regions with low observed values.

Moran's scatter plot that puts a lot of observations in quadrants HH and LL quadrant will tend to have a positive spatial autocorrelation values (clusters). While Moran's scatter plot that puts a lot of observations in HL and LH quadrant will tend to have a negative value of spatial autocorrelation.

2.4. Thematic maps

Thematic map is a picture of part of the earth's surface are equipped with certain information, both above and below the earth's surface that contains a specific theme. These thematic maps usually reflect specific things. Moreover thematic map is a map that provides information on a specific theme, both qualitative and quantitative data. Thematic maps very closely related to the GIS (Geographic Information System) because in general the output of the GIS project is a thematic map. Either in the form of digital and paper maps is still shaped.

There are many ways to display the theme depicted through thematic maps, such as the color, texture, pie chart or bar chart. One example of a thematic map is a map of soil types and land suitability map.

3. Research Methodology

Sources of data used in this study are secondary data of malaria cases occurred in 10 (ten) sub districts in Tanah Bumbu South Kalimantan starting in 2009-2013. It is also used administrative map Tanah Bumbu (Figure 2). Demographic data, including population, population density and population growth rate are obtained from the BPS Tanah Bumbu South Kalimantan.

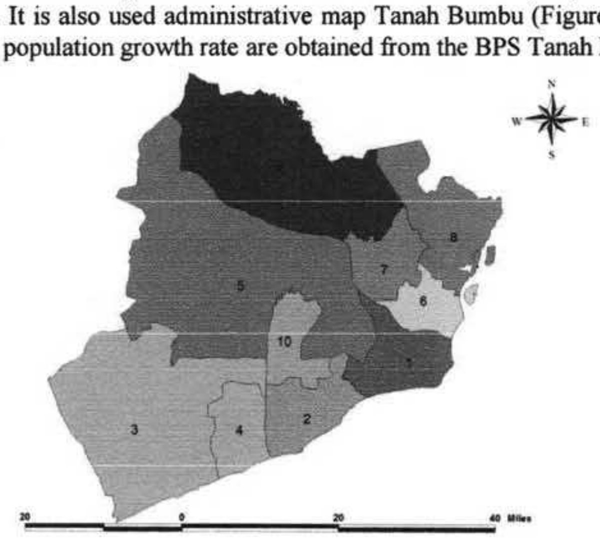

Fig. 2. Administrative Region Tanah Bumbu

Specification:

1.	Kusan Hilir	6.	Batulicin
2.	Sungai Loban	7.	Karang Bintang
3.	Satui	8.	Simpang Empat
4.	Angsana	9.	Mantewe
5.	Kusan Hulu	10.	Kuranji

The steps of the data analysis of this study are to describe the spread of malaria occurrence and create distribution maps with Spatial Pattern Analysis with steps (a). malaria incidences per month and per year in a thematic map, (b). compare the patterns formed from month to month between years, (c). calculate the size of the spatial dependencies (autocorrelation) using Moran's I index and the Local Indicator of Spatial Autocorelation (LISA), (d). Looking expectations index value of Moran's I and Local Indicator of Spatial Autocorelation (LISA), (e). identify the distribution pattern of events based on the index of Moran's I and Local Indicator of Spatial Autocorelation (LISA), (f). calculate the variance of the index of Moran's I and Local Indicator of Spatial Autocorelation (LISA) and (g). examine the spatial dependencies Moran's I index, and Local Indicator of Spatial Autocorelation (LISA).

4. Results

4.1. Picture of Malaria Cases in Tanah Bumbu

Malaria cases in Tanah Bumbu 2009 to 2013 have very diverse characteristics. Picture of malaria cases in Tanah Bumbu districts according to full 2009-2013 period are presented in Table 1.

Table 1. Mean, variance, minimum and maximum cases of malaria in Tanah Bumbu 2009 to 2013

No.	Subdistrict	Mean	Variance	Minimum	Maximum
1.	Kusan Hilir	0.08	0.01	0.00	0.41
2.	River Loban	0.13	0.02	0.00	0.76
3.	Satui	0.33	0.03	0.00	0.73
4.	Angsana	0.33	0.06	0.00	1.05
5.	Kusan Hulu	1.22	0.77	0.05	4.76
6.	Batulicin	0.27	0.08	0.00	1.26
7.	Star coral	1.57	2.46	0.06	6.28
8.	Simpang Empat	0.86	0.41	0.00	2.93
9.	Mantewe	2.85	9.30	0.00	16.63
10.	Kuranji	1.56	0.95	0.00	3.85

4.2. Distribution of Malaria Cases in Tanah Bumbu

Malaria cases in Tanah Bumbu in the period 2009-2013 showed that malaria cases in Tanah Bumbu most occurred in January-June. This period is the period of the rainy season (December to March) and the transition to the dry season (April to June), although there are cases of malaria occur throughout the year in 2011 and 2012 Based on the location of the distribution shows that malaria cases in Tanah Bumbu gathered on Tanah Bumbu northern, central, and south (Fig.3.).

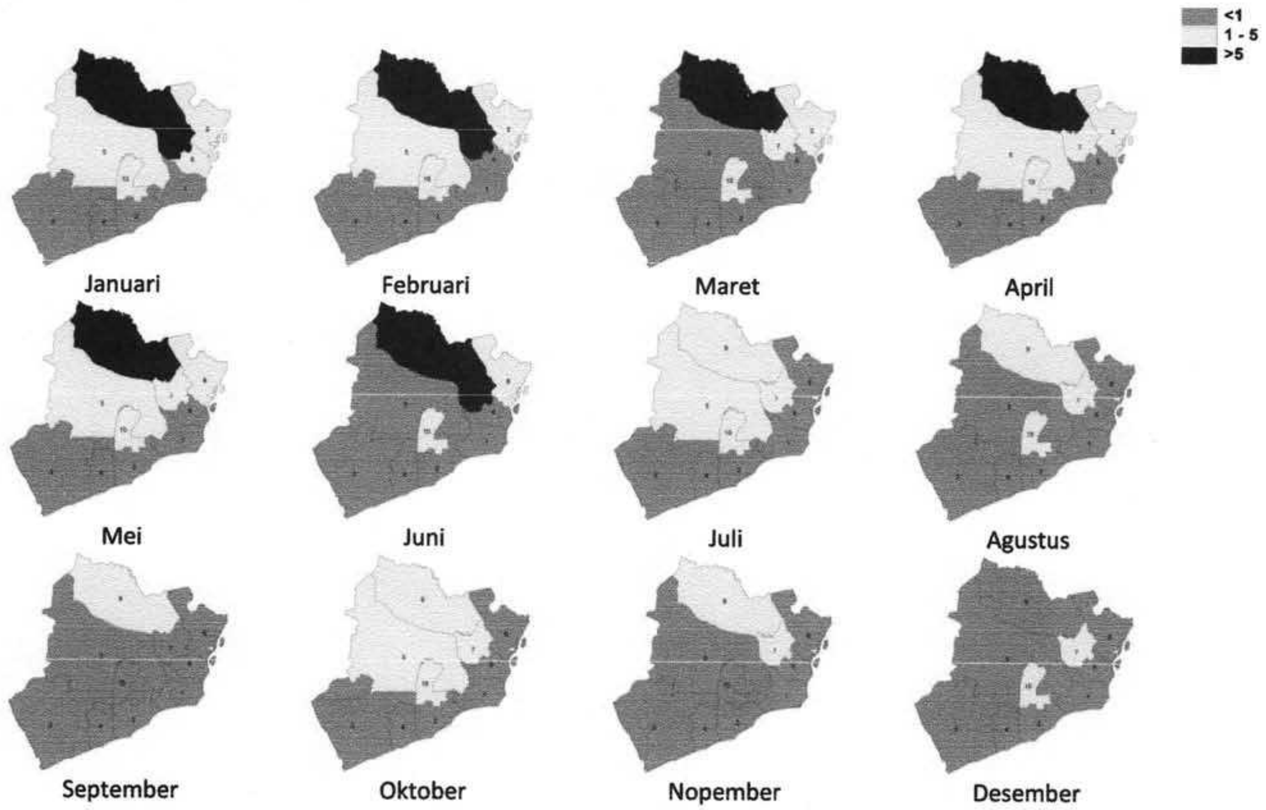

Fig. 3. Distribution of malaria cases in every district Tanah Bumbu between months in 2012

Identification of distribution patterns of malaria incidence in 2009 and the total malaria cases from years 2009 to 2013 can be seen in table 2 and 3 below:

Table 2. Moran's index *(I)*, E*(I)*, Var*(I)*, and Zhitung Year 2009

Month	*I*	E*(I)*	Var*(I)*	Z*(I)*
January	0.1140	-0.1111	0.0495	1.0119
February	0.0906	-0.1111	0.0495	0.9067
March	0.0476	-0.1111	0.0495	0.7134
April	-0.0265	-0.1111	0.0495	0.3803
May	-0.0256	-0.1111	0.0495	0.3844
June	0.0491	-0.1111	0.0495	0.7201
July	0.0330	-0.1111	0.0495	0.6478
August	-0.1170	-0.1111	0.0495	-0.0265
September	0.0440	-0.1111	0.0495	0.6972
October	0.0835	-0.1111	0.0495	0.8748
November	0.0809	-0.1111	0.0495	0.8631
December	0.1028	-0.1111	0.0495	0.9615

Table 3. Total Incidence of Malaria

Month	2009	2010	2011	2012	2013
January	0.58	0.85	0.58	**2.03**	0.35
February	0.59	0.69	0.84	1.47	0.86
March	0.64	0.50	0.89	1.47	0.77
April	0.61	0.53	0.88	1.52	0.80
May	1.75	0.57	1.22	1.47	0.54
June	0.62	0.44	1.50	1.28	0.41
July	0.55	0.16	1.16	0.62	0.32
August	0.58	0.48	0.86	0.65	0.26
September	0.32	0.40	0.65	0.35	0.19
October	0.27	1.13	0.70	0.68	0.24
November	0.26	1.41	1.58	0.58	0.33
December	0.46	1.18	1.93	0.70	0.15

From Table 3, the pattern of spread of malaria incidence in January 2012 can be described in the following scatter plot Morans:

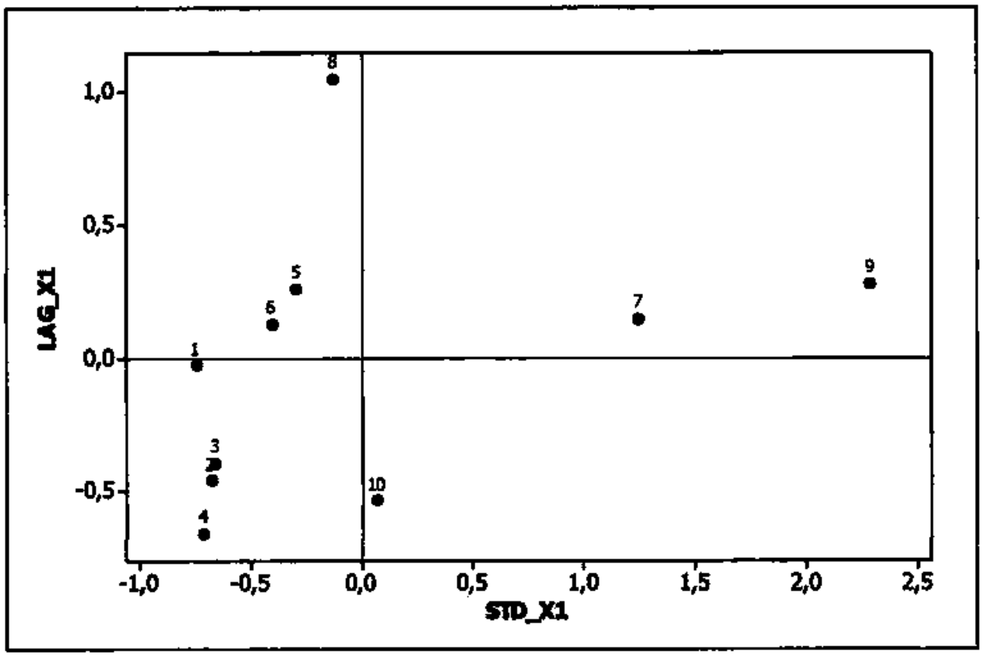

Fig. 4. *Moran's scatterplot* incidence of Malaria in January 2012

Testing LISA gives mixed results according to the sub district. Sungai Loban District, Angsana, Simpang Empat, Mantewe, and Kuranji are a district that has a spatial relationship with the surrounding districts (Table 4).

Table 4. Value *I* and *the p-value* on the LISA Month January 2012

Subdistrict	*I*	*P-Value*
Kusan Hilir	0.1285	0.3540
River Loban	0.2574	0.0500[a]
Satui	0.1986	0.1600[c]
Angsana	0.2954	0.0460[a]
Kusan Hulu	-0.1237	0.2940
Batulicin	0.0055	0.4640
Star coral	0.1265	0.2980
Simpang Empat	-0.1574	0.0260[a]
Mantewe	0.1090	0.1160[b]
Kuranji	-0.0386	0.1260[b]

[a]significant at $\alpha = 5\%$,
[b]significant at $\alpha = 15\%$,
[c]significant at $\alpha = 20\%$

5. Discussion

Malaria cases in Tanah Bumbu 2009 to 2013 have very diverse characteristics. The highest average is 2,85 cases of malaria lies in the District of the District Mantewe then followed by Karang Bintang, Kuranji, Kusan Hulu and Simpang Empat, while the lowest average of 0.08 which is located in Kusan Hilir. The highest diversity is at 9.30 which are also in Mantewe while the lowest diversity is equal to 0.01 which is also located in the sub district Kusan Hilir.

Subdistrict Mantewe, Simpang Empat, Batulicin, Kusan Hulu, Karang Bintang, Kuranji and Satui are most endemic districts based on the records of malaria cases in the Department of Health Tanah Bumbu. Subdistrict Mantewe is a district with the average of the highest incidence of malaria cases, including less densely populated but its territory bordering areas always have a case of malaria is on the northern border with Kotabaru District, the southern borders with Banjar District, the eastern borders with Subdistrict Karang Bintang, on the western border with the Sub district Kusan Hulu.

Malaria cases in Tanah Bumbu in the period 2009-2013 showed that malaria cases in Tanah Bumbu most occurred in January-June. This period is the period of the rainy season (December to March) and the transition to the dry season (April to June); although there are cases of malaria occur throughout the year in 2011 and 2012. Based on the location of the distribution shows that malaria cases in Tanah Bumbu gathered on Tanah Bumbu northern, central and southern. In contrast, in the month of July to December of malaria cases tend to be low because these months are the dry season (June to September) and the transition to the rainy season (October to December).

From the years 2009-2013, most malaria cases are in January of 2012 that occurred in District Kusan Hulu, Batulicin, Karang Bintang, Simpang Empat and Mantewe, while the smallest number of malaria cases in the 2009-2013 periods occurred in December of 2013.

Based on Table 1 note that in January and August has a distribution pattern of malaria incidence are clustered. That is, the number of malaria incidence in the nearly equal among districts. As for the other ten months of dispersion patterns are quite varied among districts. Based on Table 1 can also be concluded that there is no spatial autocorrelation in 2009 in every month both for $\alpha = 5\%$, $\alpha = 10\%$, $\alpha = 15\%$, and $\alpha = 20\%$ because Z_{count} value smaller than the value of the Z_{table} on $\alpha = 20\%$. Based on Table 3 note, the incident occurred in January 2012 as the Sports subsequent discussion focused on the Month in January 2012.

Scatter observation points in Figure 4 is a district that is spread by the influence of the neighboring districts, where the X axis is the number of malaria cases that have been standardized and the Y axis is the number of malaria cases in neighboring districts that have been standardized. Quadrant I is a situation where the number of incidents of malaria in sub-districts and the number of observed high incidence of malaria in the district around too high. Sub district located in Quadrant II is a district with a low number of malaria incidences, but the surrounding sub districts have a number of high malaria incidence.

Based on Figure 4 in mind that the District Kusan Hilir (1), Sungai Loban (2), Satui (3), and Angsana (4) in January 2012 includes districts in quadrant III. That is, the four sub-districts have a number of low malaria incidence is between sub-districts with a low number of malaria cases. While Kuranji (10) in January 2012 is the number of districts with high malaria incidence is between districts with a low number of malaria cases. Quadrant I and III indicates a positive autocorrelation while quadrants II and IV indicate negative autocorrelation.

Testing LISA gives mixed results according to the subdistrict Sungai Loban, Angsana, Simpang Empat, Mantewe, and Kuranji is a sub district that has a spatial relationship with the surrounding sub districts.

6. Conclusion

Sub district Sungai Loban, Angsana, Simpang Empat, Mantewe, and Kuranji is a sub district that has a spatial relationship with the surrounding sub districts and forms a grouping with a high number of malaria cases, so it is necessary early warning in cases of malaria in sub-districts.

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