Exploring Geospatial Factors Contributing to Malaria Prevalence in Kanchanaburi, Thailand

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Abstract
This investigation is aimed to contribute the concepts and methods of the innovative development and application of Geographical Information System (GIS) and Remote Sensing regarding Malaria prevalence. Kanchanaburi province, Thailand is chosen as study area. The input data are based on the geospatial factors including climatic aspects, physical environment, and statistical record of Malaria cases. Afterwards data preprocessing needs to be carried out. Malaria cases map and information value (i-value) approach will be used in order to identify the relation between physical and social factors, and also statistical analysis will be carried out so as to define the relation of climatic factor. The final output based on those approaches is a Malaria risk map which is classified into three classes including high risk level, moderate risk level and low risk level. This study also develops the model based on i-values which are formed as thematic layers in GIS database and are computed using different map analysis techniques, for example, map crossing.

1. Introduction

The malaria control program in Thailand was successful in decreasing the malaria disease over the past decade. The mortality rate was reduced from 1.38 per 100,000 in 1996 to 1.26 per 100,000 population in 1997 and morbidity rate was increased from 1.78 per 1,000 in 1997 to 2.21 per 1,000 populations in 1998 (MOPH, 1998). The proportion of malaria parasite species of P.falciparum and P.vivax in 1997 was 50.7% and 48.7% respectively, and the rest was P.malariae and mixed infection. P.ovale could not be found in this year. Total cases were 99,679 in 1997, increased to 125,013 in 1998 or by 25.4%. In 1997, Malaria got distributed in bordering provinces the highest number of cases, 85,995 or 86.3% of total malaria cases, were found at Thai-Myanmar border (10 provinces, 58,439 or 58.6%). From 1993 to 1997, foreign cases were discovered between 51,090 to 66,622 and in 1997 API rate was decreased to 14.8%. The provinces of Tak, Mae Hong Sorn, Kanchanaburi, Yala, Trad, Suratthani, Ranong, Krabi and Chanthaburi had the highest local transmitted cases in 1998. Above mentioned provinces had the highest incidence rate showing 82,120 cases or 65.69% of total malaria cases in Thailand, increased from 75,357 or 7.77% of total malaria cases in 1997. From 1994 to 1998 highest numbers of cases were found in Tak province of Thailand, especially Mae Sot district. In 1998 incidences were found to be 61.03 per 1,000 population in total province and 53.85 per 1,000 in this district.

The main vectors were An.minimus and An.dirus to infected P.falciparum type. The transmission of malaria in Thailand occurs in the beginning of the rainy season (May-June) and the second peak in the beginning of the cold season (November-December). However, the problems due to exophillic behavior and parasite resistance to anti-malaria drugs were certainly important obstacles achieving the control of malaria.

2. Objectives

Objectives of the study were to evaluate the use of GIS for the following;

- To characterize malaria risk levels in relation to climatic factor.
- To characterize malaria risk levels in relation to physical factor.

To develop a model based on above knowledge to prepare a malaria-risk map of Kanchanaburi, Thailand

3. Study Area

Kanchanaburi province is a city in the west of Thailand with geographical location at 14° 2' north, 99° 32' east. It covers the area of 19,486 square kilometers, most of which is forested mountains. Northern boundary is connected with Tak, Uthai Thani, and Chainat province, southern part is allied with Ratchaburi and Nakhon Pathom provinces,

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eastern boundary is connected with Suphanburi province, and the western part is allied with Union of Myanmar (Burma).

4. Methodology

The summarized flowchart of the methodology of the study is illustrated as shown in Figure 2 below.

5. Result

5.1 The Seasonal Characteristic of Malaria Disease

The climate pattern of Thailand falls into three seasons. The cold season from October to February, hot season from February to May, and rainy season from May – October (KEOLA, 2001). Observations to the epidemiological characteristics of diseases follow in three seasons. Thus, this study used data from 1999 – 2005, which was provided by provincial health care department in Kanchanaburi. The distribution of malaria disease in seven years 1999 – 2005 is shown in Figure 3. The Figure shows that malaria incidence cases were highest in rainy season (May-September). Every year, the number of cases increases during rainy season. In 1999, the highest numbers of malaria cases were found during rainy season. The malaria distribution in the whole province, having highest incidences in rainy season, has similar characteristic for every year from 1999 to 2005 (Annual Epidemiological Surveillance Report, 2004. Vector Borne Disease Control Center 4.1 Kanchanaburi province).

5.2 Rainfall as an Influence from Physical Environmental on Malaria Incidences

The cause of malaria incidence is related with the rainfall. The table 1 demonstrates that in the rainy season, rainfall and humidity are high and as well as number of malaria cases. Table 1 shows that in September rainfall, humidity is highest than in other months and in June malaria incidence were highest than other months.

5.3 Land Covers Types over Malaria Epidemic Area (Kanchanaburi Province)

Physical environmental factors were analyzed in order to identify the area and percentage of land cover types within 1, 2, and 5 km. buffer over malaria risk area using the locations of each village (768 villages). It can be conclude that malaria incidence case was the highest in agricultural area, approximately 6204.4 km^2 (61% of total area) and mostly the types of agriculture are sugarcane area, transplanted paddy field, cassava area, corn area. The rest of the area is forest area around 11697.0 km^2 (32% of total area), urban and build up area, and water body, respectively.

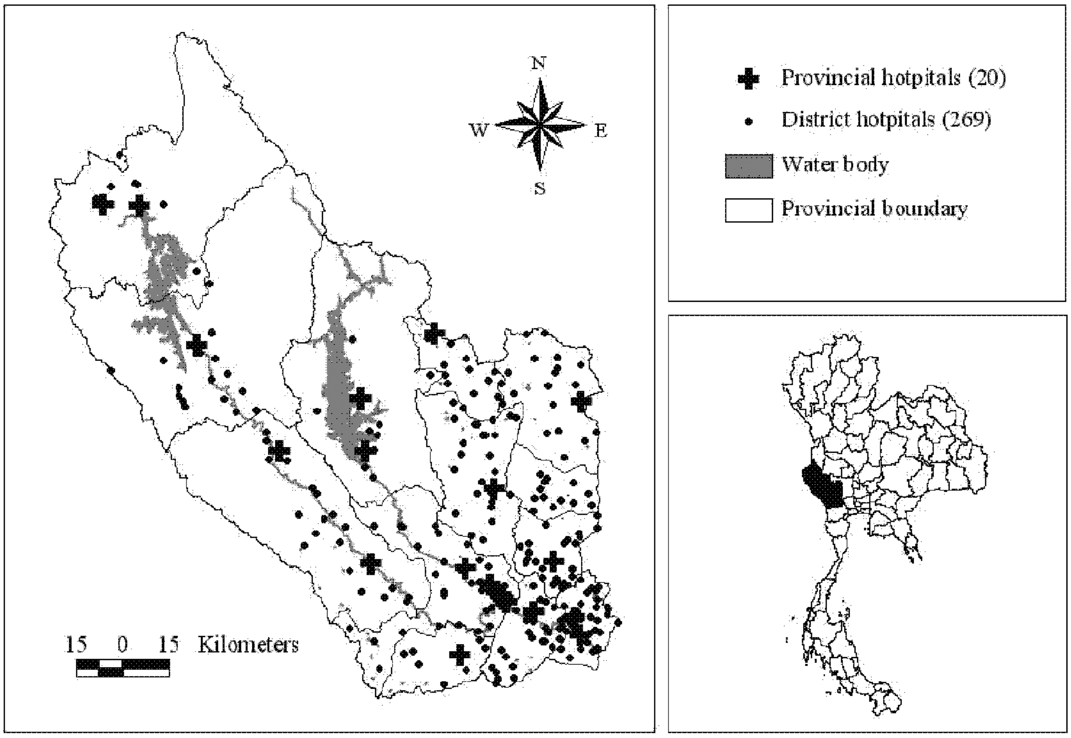

Figure 1: Location of hospitals and water bodies in Kanchanaburi, Thailand (Study area)

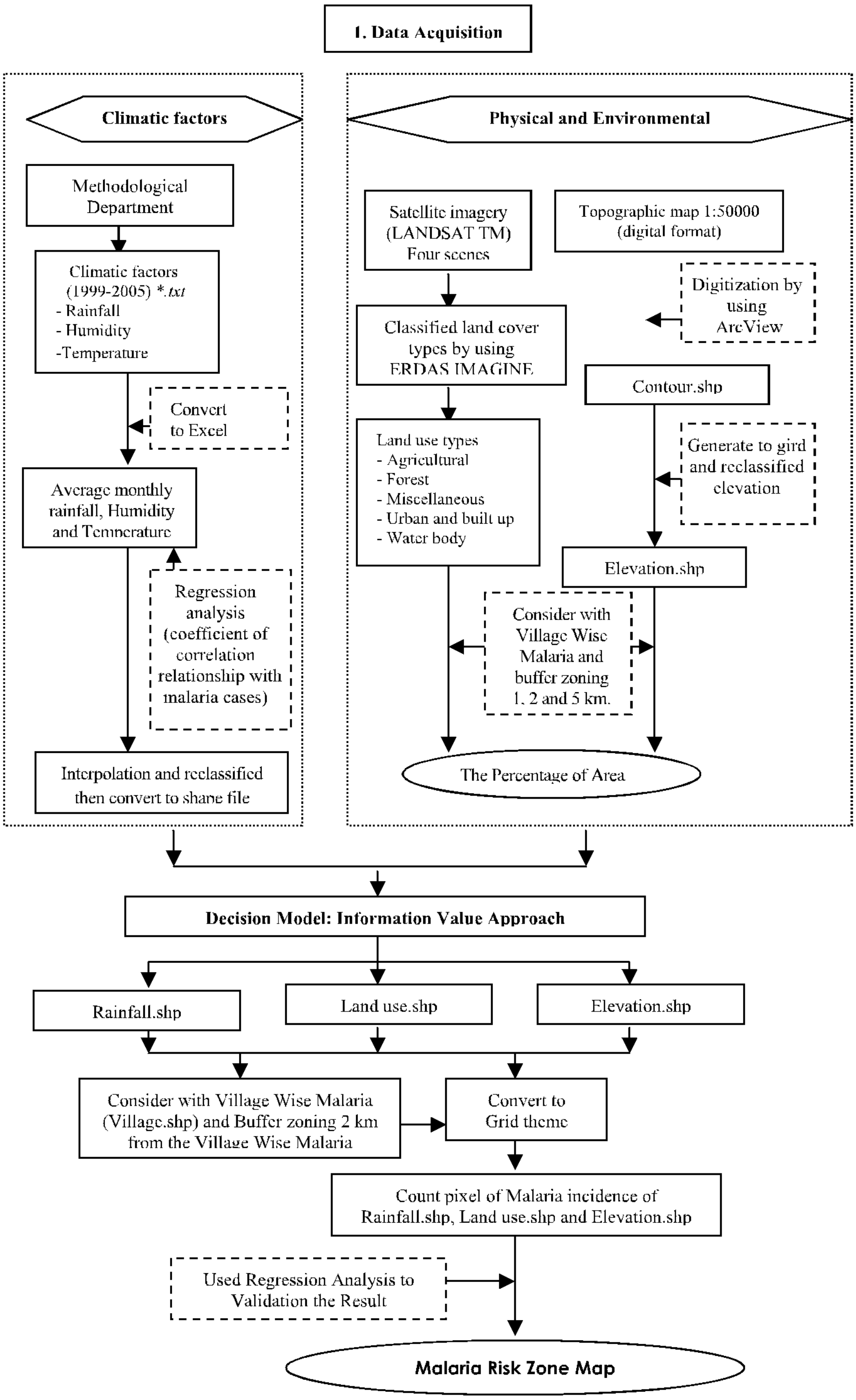

Figure 2: The methodology

Elevation data were derived by used spatial analysis tools and information value approach so as to create elevation area over 13 districts. The results show the malaria risk maps classified into three categories including low, moderate and high dependent to elevation levels.

The highest malaria risk area was covered under elevation area between 100 to 300 meters and the elevation area between 300 to 500 meters is the second, the third is elevation area between 500 to 700 meters, and then residue are elevation area between 700 to 900 meters and 900 to 1100 meters.

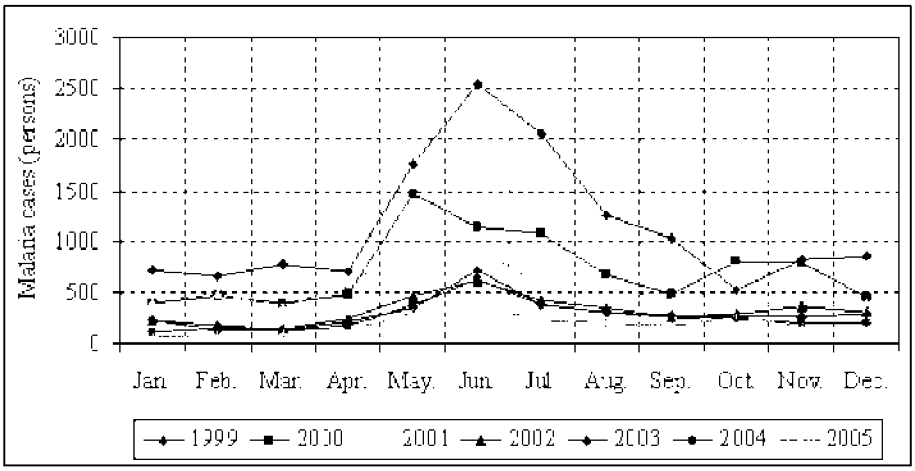

Figure 3: The distribution of malaria disease in the period of 1999 – 2005

Table 1: Location of malaria incidence

Month	Rainfall (mm.)	Temperature (°C)	Humidity (%)	Malaria cases
Jan	5.3	25.9	69.3	313
Feb	12.4	27.4	65.2	314
Mar	41.5	29.3	63.6	292
Apr	87.3	30.4	66.6	371
May	134.7	28.7	77.5	805
Jun	102.1	28.0	78.7	995
July	132.6	27.9	79.1	733
Aug	105.4	27.6	79.4	527
Sep	139.4	27.5	81.6	416
Oct	127.9	27.2	81.4	401
Nov	24.8	26.1	75.6	436
Dec	4.4	24.8	70.3	375

Table 2: Location of malaria incidence

Location and situation	Type		
	Rainfall (mm)	Elevation (m)	Land use
Low	-	500-700 700-900 900-1100	-
Moderate	1500-2000	300-500	wetland, bare land, Water body (river, reservoir)
High	400-900 900-1500	100-300	Agricultural area Forest area Urban and built up area

5.4 Model Development: Information Value Approach

In this study, parameter values required to calculate information value are obtained by crossing malaria map with a certain parameter map. Map crossing results in a cross table showing the number of pixels per class occupied by malaria and total number of pixels in each class. The remaining values, necessary to calculate information value, area obtained from these values, actually can represent in term of information value process, therefore:

i-value = log (classden/mapden)

Where,

classden = nmclass/nclass

mapden = sum (nmclass)/sum (nclass) = nmmap/nmap

In which,

nmclass = number of pixels with malaria in a class

nclass = number of pixels in the class

nmmap = total number of malaria pixels in the map (thematic layer)

nmap = total number of pixels in the map

The malaria risk area has been classified into three classes such as low, moderate, and high. The three factors that appear in all of these classes are rainfall, land use, and elevation.

5.4.1 Location of malaria incidence

Malaria incidents were analyzed with climate and physical factors rainfall, elevation, and land use. Table 2 shows some of the important findings. It can be concluded that climatic and physical environmental factors are very important and malaria occurrence depends on physical environmental change such as elevation, water body, forest, agriculture, and climatic change such as rainfall, humidity, temperature.

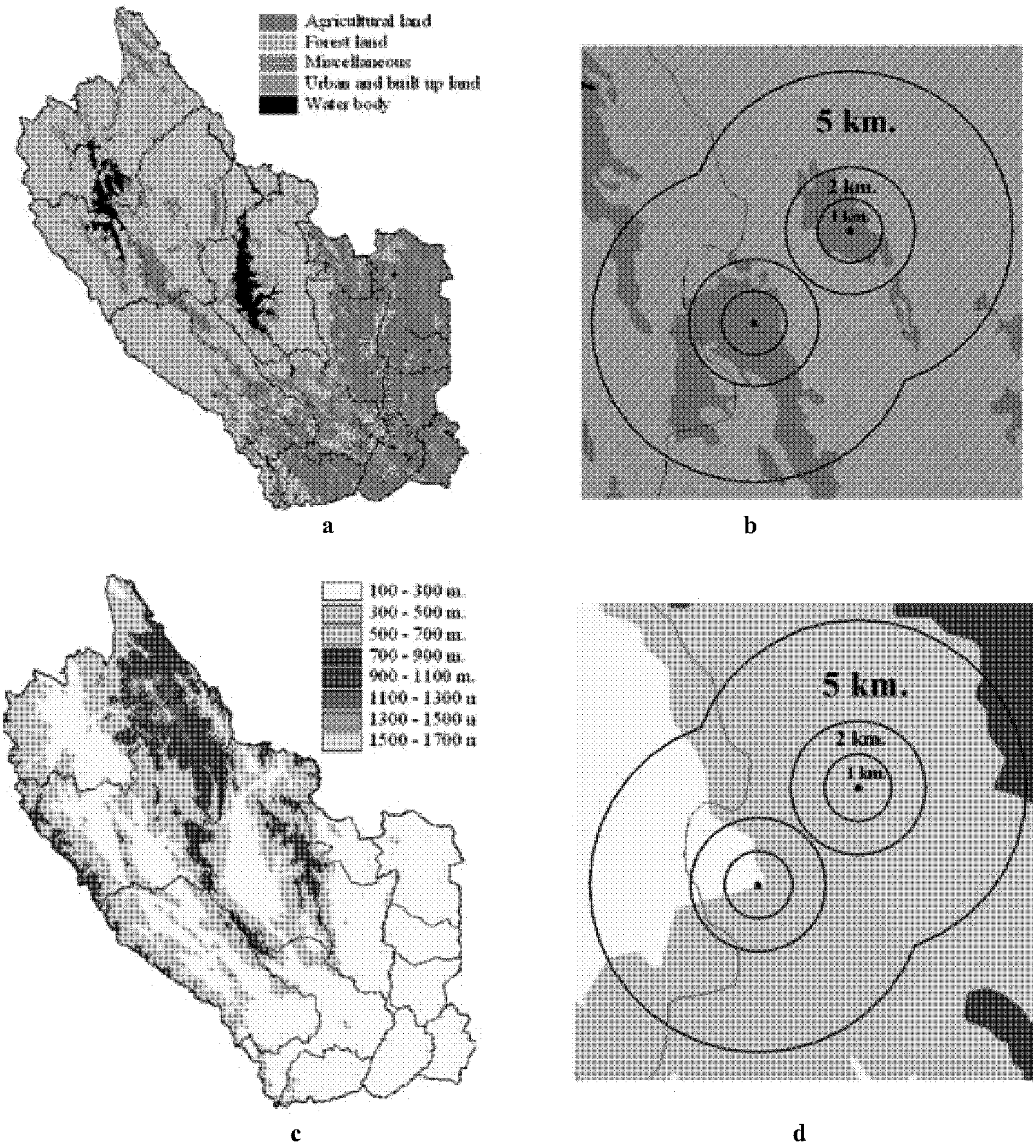

Figure 4: (a.) and (b.) are the land use types and buffering of 1, 2, and 5 km., (c.) and (d.) are the elevation classification and buffering of 1, 2, and 5 km.

From the results it can be concluded that the highest malaria risk zone covered 508 villages (96.95%), moderate malaria risk zone was composed of 13 villages (2.48%) and low malaria risk zone comprised 3 villages (0.57%). In conclusion, the total village's Malaria affected was 524 villages. Based on the information value approach weights were assigned to prepare the malaria risk map as show in Figure5. Table 3 show the weight and score to rank different layers. These weighted layers were combined in GIS to finding develop the malaria risk map (Figure5).

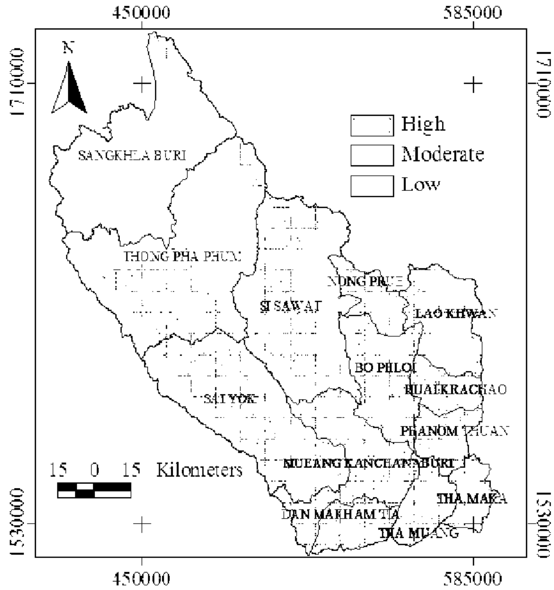

Figure5: Malaria risk map of Kanchanaburi province

6. Conclusion

Recently the planning for monitoring and controlling malaria epidemics has become critical issue. In the present study, malaria risk zonation maps were carried out by statistically establishing the relationship of various physical environment factors using remotely sensed data and GIS. To identify the statistical correlations between malaria cases and climatic factors, the information value method, was applied. The malaria risk maps obtained from the study are able to support public health officers in space and time so as to control and predict malaria spread over extensive areas. Moreover, the risk maps can be beneficial for public warning and awareness.

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