ANALYTICAL HIERARCHY PROCESS MODELING FOR MALARIA RISK ZONATION IN KANCHANABURI, THAILAND

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ABSTRACT

Vector-borne diseases are the most dreaded worldwide health problems causing a constant and serious risk to a large of the world's population. Although many campaigns against it have been conducted throughout the country, Malaria is still the major health problem of Thailand. Kanchanaburi province was selected as a case study. AHP technique is analytical hierarchy process modeling. The combination of AHP method with GIS is a new trend and a powerful combination to monitor the public health and control issues. AHP has been introduced and applied in assessing the risk of Malaria in this study. The final output is a Malaria risk map. Spatial modeling included several factors and information. Socio-economic factors is very useful for Malaria prevention. Finally, the model can be applied as a monitoring and early warning system to enhance the awareness and preparedness of this disease.

1. INTRODUCTION

Malaria epidemic is one of the complex spatial problems around the world. In order to evaluate the spatial decision capability in handling such problems, Kanchanaburi province, Thailand is chosen as a case study. Three factors related parameters such as average yearly rainfall (1998 - 2007), land use types such as agriculture, water bodies, forest, built-up, miscellaneous, and elevation were considered in the Malaria risk zonation. From an analytical point of view, the main difficulty is the assignment of weight to the different spatial datalayers. All layers were classified into three classes. The climatic factor is average yearly rainfall (1998 - 2007) and the physical factors are agriculture, forest, urban and built-up, water bodies, miscellaneous, and elevation data.

2. KANCHANABURI PROVINCE

Kanchanaburi province is adopted as the study area. It is an important city in the west of Thailand. 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, eastern boundary is connected with Suphanburi province, and the western part is allied with Union of Myanmar (Burma).

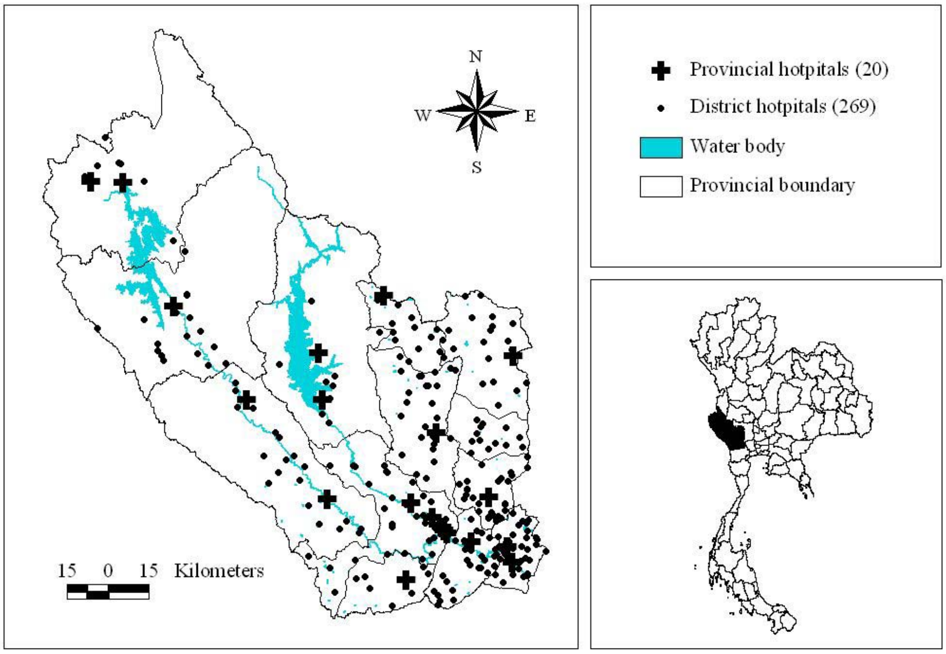

Figure 1. Location of hospitals and water bodies in Kanchanaburi, Thailand.

3. THE ANALYTICAL HIERARCHY PROCESS (AHP)

The Analytic Hierarchy Process (AHP) method is one of the more widely used Multicriteria approach, developed by Saaty (1980). This method based on the concept of pair-wise comparisons to create a ratio matrix and estimate a ranking or weighting of each of the criteria. It takes the pair-wise comparisons as input and produces the relative weights as output. This comparative analysis is a multiple-criteria evaluation, where the alternative products are ranked at the end of the evaluation (Ong et al., 2001). Saaty claims that the AHP serves as a framework for people to structure their own problems and provide judgments based on knowledge, reasons or feelings to derive a set of priorities considered as an optimal solution to a decision problem (Saaty, 1994).

AHP procedure is terminated at the attribute level, and the attribute weights are assigned to the attribute map layers and processed in the GIS environment. This approach is referred to as spatial AHP (Banai-Kashani, 1989; Eastman et al., 1993; Siddiqui et al., 1996; Malczewski, 1999; Ong et. al., 2001). Today the AHP has gained wide popularity and acceptance throughout the world.

Since the AHP is a multi-attribute approach to decision making, it helps the project managers to deal with the human resource substitution problem that involves a large number of alternatives and criteria. It is commonly agreed that there are a great number of factors involved in the human resource substitution process (Proctor, 1999). For this proposed method, the relationship among selection factors will be specified through weighting. The hierarchical structure of the new method allows project managers to compare different selection factors more efficiently, even when a large number of factors are involved.

3.1 Application of AHP to Malaria epidemic risk zonation

The AHP implementation has been performed with the help of Excel and ArcView. The result is an integration of Analytic Hierarchy Process (AHP) and Health problem. AHP estimates the weighting of each criteria based on the importance of criteria. If the criteria are broken down into a number of sub-criteria, the pair-wise comparisons are repeated for each level of the hierarchy (Proctor, 1999). Different criteria have different levels of importance. It is necessary to incorporate some form of criteria weighting to take care of their relative important.

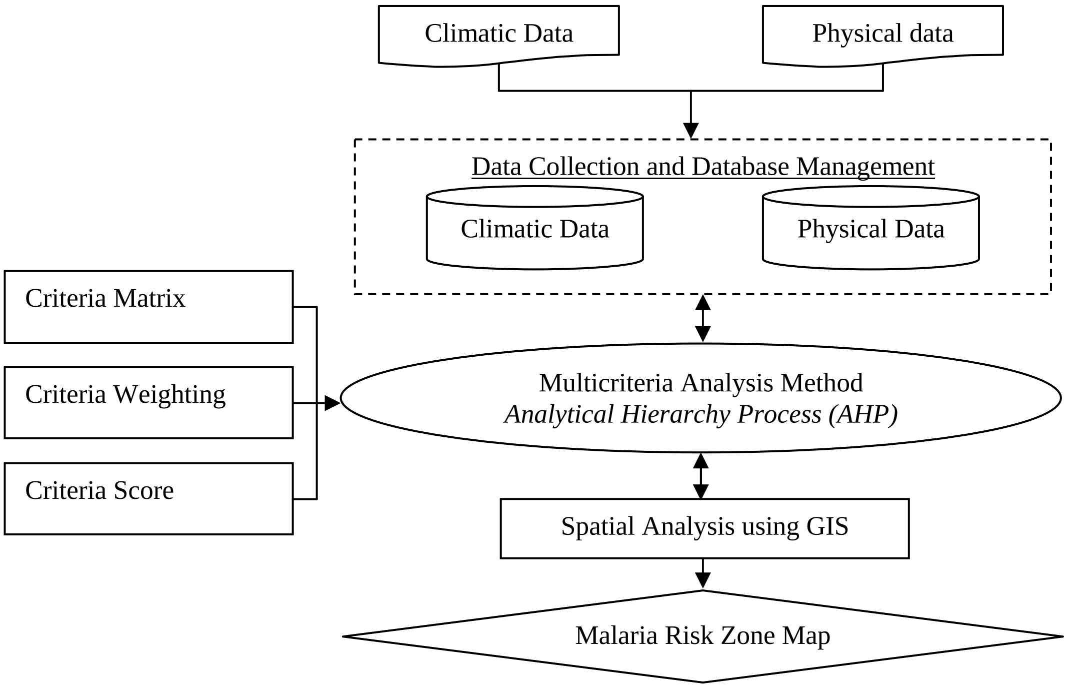

Figure 2. Methodology.

3.1.1 Criteria weight matrix

Criteria weighting is done by using Analytical Hierarchy Process (AHP) developed by Saaty (1980). Table 1 comparisons have been made with each factor against all other factors. The elevation has the highest value (3.29), land use has 1.82, and rainfall has 1.00. The final of result is an estimation of relative weights of alternatives considering all criteria and sub criteria defined by analysis. The weights of themes and features are displayed in Table 1.

Table 1. Thematic map and feature weights.

Theme	Weight	Feature	Weight
Elevation	3.29	700-900	7.36
		500-700	4.10
		300-500	2.05
		900-1100	1.62
		100-300	1.00
Land use	1.82	Urban	3.06
		Water bodies	2.28
		Forest	2.28
		Agriculture	2.00
		Miscellaneous	1.00
Rainfall	1.00	1500-2000	3.62
		900-1500	1.10
		400-900	1.00

In this study, a consistency ratio of 0.09 is obtained which is less than 0.10, the ratio indicate a reasonable level of consistency in the pair-wise comparisons. This risk classes were ranked as low, moderate, and high respectively with score as following Table 2.

Table 2. Definition of Malaria incidence.

Risk classes	AHP Value
Low	6.11 – 14.73
Moderate	14.73 – 23.36
High	23.36 – 31.98

3.2 Mapping and ranging of Malaria risk zone

Three factors were identified as being relevant to the risk zone: elevation, land use, and rainfall. Map of risk zone are multiplied by respective map weight and put in the GIS spatial modeling. The output generated is a final map having values ranging from 6.11 to 31.98. Three-risk level were identified, AHP scores obtained from equal interval technique of a data set at each range of 8.62 were used as the cut-off level. The zonation map of Malaria incidence is further classified into three classes, as low, moderate, and high.

Finally the zonation map of Malaria incidence with using Analytical Hierarchy Process (AHP) method was derived as Figure 3. We calculated influence of climatic and physical environment factors score that is synthesized the total weights of each data was correspondingly computed. And the problem condition in the whole area is visualized. Due to this method, we could find the quantitative value of Malaria incidence problem area clearly. The result has shown a map in Figure 3.

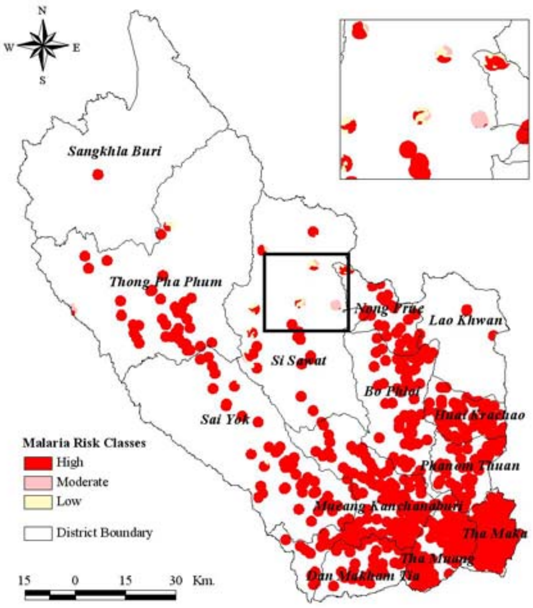

Figure 3. Risk zones of Malaria incidence using AHP base on villages affected by Malaria incidence within 2 km radius.

Table 3. Intensity of Malaria incidence by using AHP modeling.

Risk class	Area having Malaria (km^2)	No. of cases	Case density (case*1000 / area (km^2)
High	4410.77	521	118.12
Moderate	25.48	2	78.49
Low	49.60	1	20.16
Total	4485.85	524	216.77

Malaria cases had a relationship with climatic factor (rainfall) and physical environment factors such as agriculture, urban built-up, forest, and water bodies. Accuracy was calculated by calculating the intensity of cases incidences and pixels falling in the predicted influence of Malaria risk zone. The results obtained are summarised in the following Table (Table 3). For risk zone, the intensity of Malaria incidence (case*1000/area affected by Malaria) in each risk zone was calculated and grouping by risk zone classes. Higher area per case incidence indicated a high risk. From the table, it can be seen that under risk classes of high in AHP the area per case incidence was high risk zone (118.12) and had a highest number of cases (521 cases). Therefore, moderate of risk zone had a number of case 2 cases, the intensity of case was 78.49 and low of risk zone had a number of cases only 1 case, the intensity of case was lowest (20.16).

4. DISCUSSION AND CONCLUSION

Integration of AHP in GIS has helped us to be more precise in defining risk areas of Malaria in decision-making and authorities can respond faster to situations before cases occur. Further investigation needs to be centred on more in socio-economic factors such as income, gender, age group, education, occupation. The developed AHP was used to investigate all potential location for Malaria incidence. The methodology is very effective as we can see that 521 cases fall within high risk areas. Low risk areas have shown only one case. There is ascope to improve the pairwise comparison and also include more factors.

The application of the methodology shows that it works efficiently for investigating of risk zonation. Moreover, the methodology is highly flexible regarding the number, types, and expert decision criteria to rank all factors. However, the development of the criteria is based on expert preferences. Furthermore, this method still provided a valuable tool for preventing Malaria in remote areas.

5. ACKNOWLEDGEMENT

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