Advanced Geomatics

http://publish.mersin.edu.tr/index.php/geomatics/index

e-ISSN: 2791-8637

A Correlation Study for Determination Risk Area of Dengue Fever and Dengue Hemorrhagic Fever: a Case Study of Sisaket Province, Thailand

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Keywords
Geographic information system,
Dengue fever,
Dengue Hemorrhagic fever,
Risk zone map,
Correlation.

Abstract

This study has purpose on analyzing risk zone area in Sisaket province, Thailand, by using the subdistrict-level (Tumbon) data in sick ratio, average temperature, maximum temperature, minimum temperature, relative humidity, precipitation, population density, and housing density. The meteorological data are acquired from POWER, NASA. The data is stored in points, griding by 30 minutes of latitude and longitude, going through the inverse distance weighting tool to interpolate the meteorological data into each Tumbon. The physical socio data are from government authority, are population from each Tumbon by monthly and housing amount from each Tumbon by yearly. The authority of meteorological data in Thailand officially only has the weather measuring stations in the middle of the province. The surrounding province also do not have sufficient station to interpolate the weather data, as well as the southern of the province is Thai-Cambodia border area with no station or data, leaving the vast area in the south has no data. Statistic yearly results show that average maximum and minimum temperature are significantly positive correlated with sick ratio while average relative humidity and precipitation are significantly negative correlated. Meanwhile, monthly results show that average temperature and average maximum temperature are significantly negative correlated with sick ratio while average minimum temperature, relative humidity and precipitation are significantly positive correlated. In both yearly and monthly results, population density and housing density are not significantly correlate with the sick ratio, as well as the average temperature in the yearly result.

1. INTRODUCTION

Nowadays, many diseases are obvious problems for public health. To prevent the spread, from food, water, air, and vector borne, we need to find the originated source or location of spreading. Especially, the transmitter in tropical and subtropical zone since high temperature and humidity are suited habitat for various type of insects. Many of insects transmit deceases such as Malaria and Chikungunya, damaging in lives and medical funds that lead to economical loss in many countries, including Thailand.

Sisaket province is a province in Thailand, locating about 600 km. afar from the Bangkok, country's capital. The province is geographically involved with the mountain line in the southern area of the province, which is the natural Thai-Cambodian border line. The overall landscape of the province is a wide low plain with scattering of streams. Mun river flows through the province from the northeast to the southwest. Recently, rising of Dengue fever (DF) and dengue hemorrhagic fever (DHF) incidence cases had been reported. The number of cases is raised and dropped every 1 – 2 or 3 years. People in the province are quite insufficient on

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Cite this;

Chantapoh, N. & Hong, S. & Soytong, P. (2022). A Correlation Study for Determination Risk Area of Dengue Fever and Dengue Hemorrhagic Fever: a Case Study of Sisaket Province, Thailand. Advanced Geomatics, 2(2), 57-64.

Received: 25/08/2022; Accepted: 25/09/2022

funds and times to spend on medical diagnosis, also there are unregistered population such as foreigners and labors.

Dengue fever (DF) and dengue hemorrhagic fever (DHF) are vector-borne diseases which Aedes Aegypti transmit the Dengue virus. DF/DHF cases was first detected in 1779 in Asia, Africa, and North America. Thailand had first case of DF/DHF in 1949 and a widespread epidemic in 1958 in Bangkok and Thonburi area. Since 1958, the trend of infection increases and has many forms such as every other year, 2 years then stop for 1 or every 2 years. Most of patients are 0-14 years old, with most fatal symptoms in 5-9 years old. DF/DHF cases could be found along the year, yet the highest months are in rainy season (May-August) The effects of DF/DHF could lead to radical complications. Some patients are suffered from failure of circulatory system, shocking from leaking of plasma. Without correct medical treatment, the patient might be death in 12-24 hours.

By many factors, these diseases could spread through increasing crowding rate, mosquito's habitats and lacking healthcare and sanitation. The spreading rate increase in rainy season, from the middle of April to August and the highest point is in July. By the way, in November, the rate drop. Dengue fever is a re-emerging disease and a worldwide problem. To control the disease is to control the transmitter (Vector control), by find hot spots, interrelationship between land use and land cover factors and provide preventive measures. Geographic Information System (GIS) can be applied to analyze and to estimate the breeding ground, assisting in public healthcare planning.

Although many organizations by public and government have increasingly focused on the disease's prevention. Yet is not applied by agencies, GIS could assist in decision, planning and solving the problems by managing, storing, and analyzing information of spatial, medical, and public health as well.

GIS is a systematic tool that gather, adapt, and display spatial data as well as their attributes. In public healthcare, GIS could be used to display epidemics and estimate the diseases factors. The system could display the information in various forms such as maps, 3D models and statistic table. Spatial information shows the locations of events on earth's surface in layers form by overlaying information. The relation between human and biological environment integrates the knowledges in diseases prevention. GIS helps increasing the efficiency of preventive process and cover the correct areas, deescalating the infection and death rates. The benefits from applying GIS and statistical analysis to study about the diseases can be presented to relevant agencies such as provincial public health center and hospitals.

2. Method

The patient's data from public health agency of Sisaket province, Thailand. from 2010 – 2019 The data stored in spreadsheet with headers consisting of age, gender, DF or DHF, defined date, Amphoe (district), Tumbon (subdistrict), and result of treatment (recover/dead). The data is acquired from Sisaket's public health office, ministry of public health. Population and housing data is acquired from department of provincial administration (DOPA), Ministry of Interior. Meteorological data (temperature, relative humidity, precipitation) is acquired from prediction of worldwide energy resources project (POWER), National Aeronautics and Space Administration (NASA). The used tools are ArcMap 10.5 (Hotspots Analysis (Getis-Ord Gi*), Inverse Distance Weight (IDW), Zonal Statistics as Table), JASP 0.15 (Pearson's correlation analysis), and Microsoft Excel.

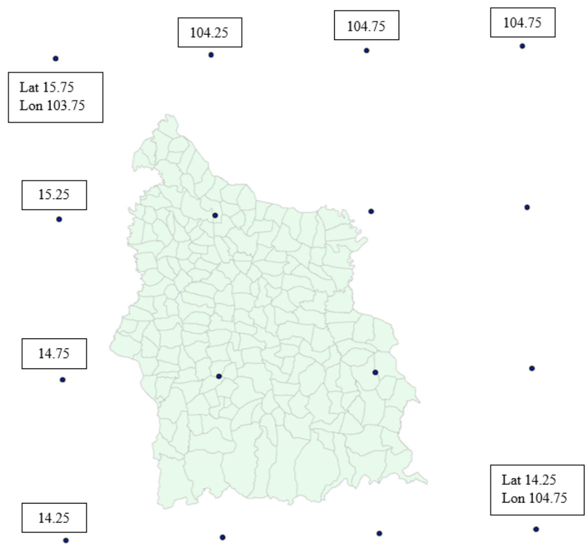

Figure 1. Meteorological Data's Coordinates

2.1. DF/DHF in Sisaket, 2010 – 2019.

Dengue Fever (DF) and Dengue Hemorrhagic Fever (DHF) are found in Thailand and other south-east-Asia countries, being a radical problem for public health service and medical treatment due to the massive number of patients annually. The patients might be shocked and rapidly die if right treatment have not been given.

DF/DHF cause by Dengue Virus, which has ribonucleic acid as its genetic material, or called RNA Virus. The virus is in Flaviviridae family with 5 serotypes. All serotypes have some similar antigens that lead to occur cross reaction and protection in a short period. This mean if the patient was infected by a type of the virus, the body will produce permanent immunity in that type of virus' serotype and other 3 types will be partial immune about 6 – 12 months.

DF/DHF's transmitter is Aedes Aegypti mosquito. In the daytime, female Aedes take a blood meal from an infected person. The virus in the blood spread into mosquito's stomach, implanted on cells of the stomach's wall. When the number of the virus grow, it transmits to the mosquito's saliva and the next bitten person consequently. After been bitten for 5 – 8 days, the patient starts to express the symptoms

The DF/DHF data is classified into 2 forms for separate results: yearly correlation, monthly correlation. Yearly data is the summarized number of DF/DHF incidence cases through each year in the province, and monthly data is summarized number of the disease's incidence cases through each month from studied years.

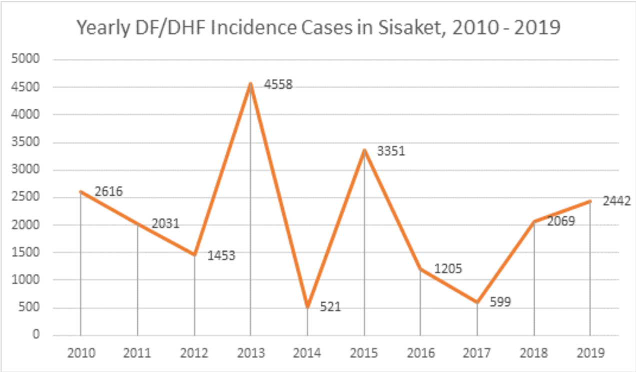

Figure 2. Yearly DF/DHF Incidence Cases in Sisaket, 2010 – 2019

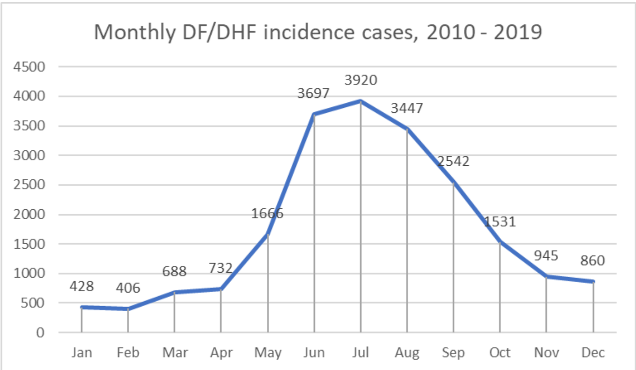

Figure 3. Monthly DF/DHF Incidence Cases in Sisaket, 2010 – 2019

2.2. Correlation Analysis

Correlation (Pearson's) tells if variables are positively related (they move in the same direction) or negatively correlated (they move in opposing directions).

$$r = \frac{\mathbf{n}(\sum \mathbf{xy}) - (\sum \mathbf{x})(\sum \mathbf{y})}{\sqrt{(n\sum x^2 - (\sum \mathbf{x})^2)(n\sum y^2 - (\sum \mathbf{y})^2)}}$$

r = r value (how much the data correlated, 1 is the highest)
x = variable 1 value (variables)
y = variable 2 value (sick ratio)

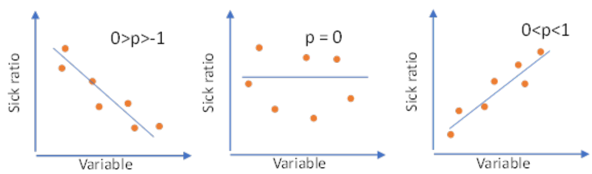

Figure 4. Definition of Correlation Analysis

Insert variables: sick ratio, average temperature, maximum temperature (average), minimum temperature (average), relative humidity (average), precipitation amount (total/average), housing density.

2.2.1. Rating of variables' values

Rating by define the effect of each variable, 1 is for the lowest effect and 4 is for the highest effect. Find the mean value of entire data ($\bar{x}$) and its Standard Deviation (S.D.)

Table 1. Variables' values rating definition

Rating	Observed Value
4	More than $\bar{x}$ + 1 S.D.
3	Between $\bar{x}$ and less than $\bar{x}$ + 1 S.D.
2	Less than $\bar{x}$ but more than $\bar{x}$ - 1 S.D.
1	Less than $\bar{x}$ - 1 S.D.

3. Results

Land cover maps of the years 1990, 2000, 2006, 2012, 2018 were processed in accordance with the study area using GIS software according to CORINE Land Classes (Artificial surfaces, agricultural areas, forest and semi natural areas, wetlands and water bodies) given Table 2. The areal changes of study area were analyzed. The results of these analyses were given in Fig. 4-8 as land cover map and Table 3-7 as areal and percent.

$$Class\ Interval = \frac{\mathrm{Data}_{max} - Data_{min}}{\mathrm{Amount\ of\ class}}$$

Table 2. Pearson's yearly correlation

Variable	r value	p value	n
Population	-0.015	0.503	
Avg. Temp.	0.006	0.795	
Max Temp.	0.169	< .001	
Min Temp	0.131	< .001	2060
Humidity	-0.229	< .001	
Precipitation	-0.11	< .001	
Housing	0.022	0.321	

Table 3. Pearson's monthly correlation

Variable	r value	p value	n
Population	-0.015	0.45	
Avg. Temp.	-0.088	< .001	
Max Temp.	-0.416	< .001	
Min Temp.	0.515	< .001	2472
Humidity	0.561	< .001	
Precipitation	0.658	< .001	

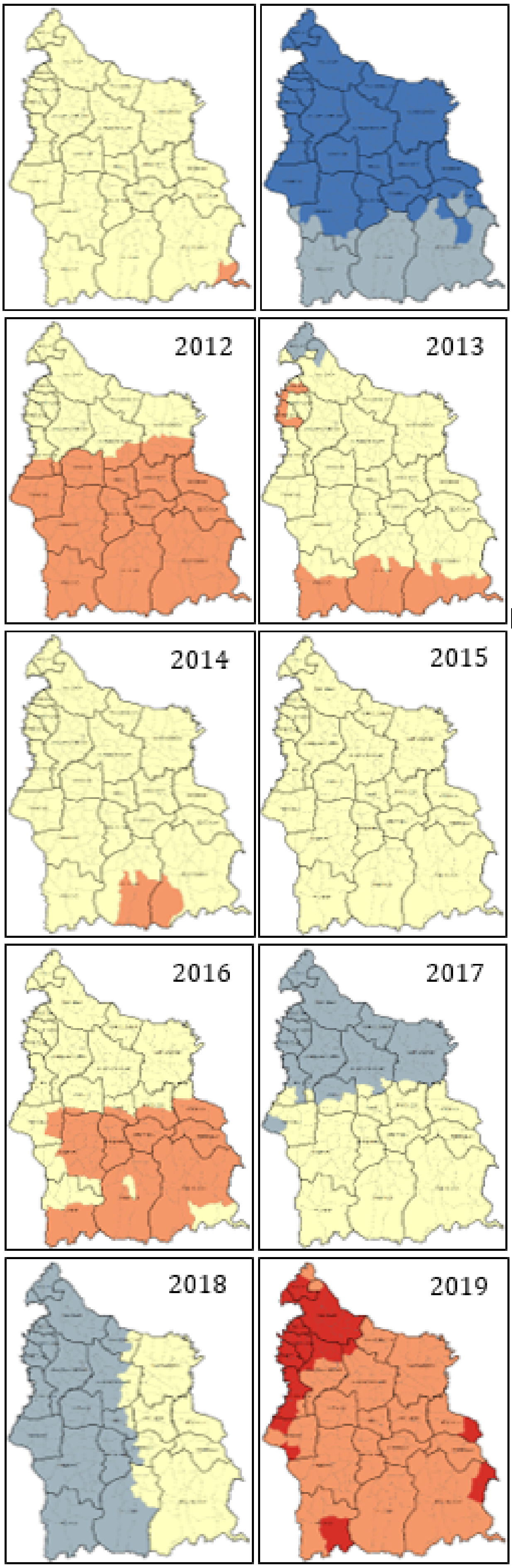

Figure 5. Risk zone maps of 2010, 2019, Sisaket Province, Thailand

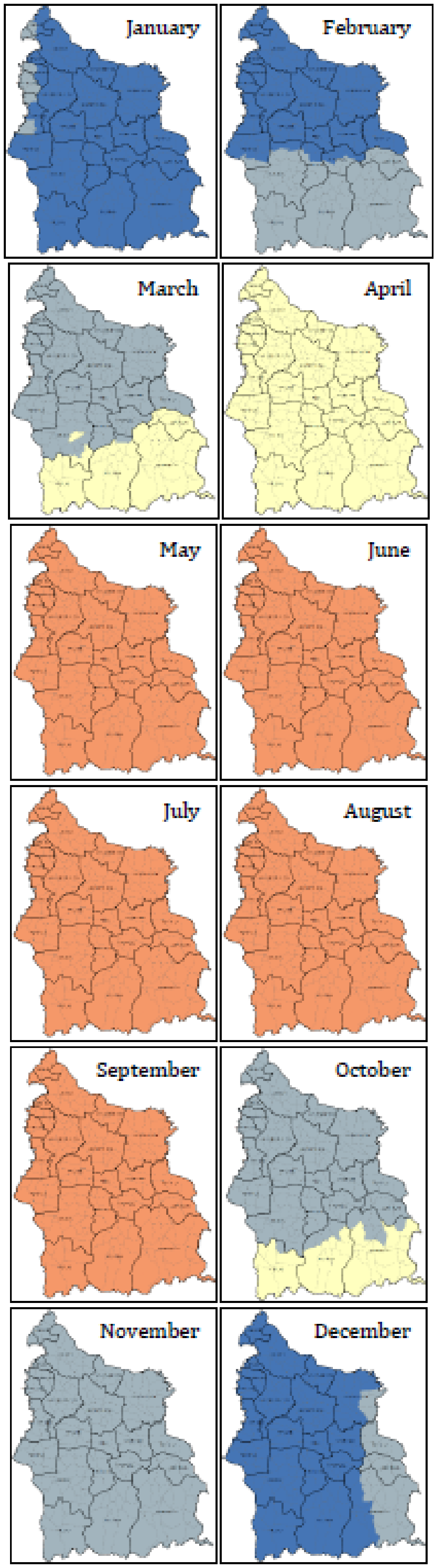

Figure 6. Risk zone maps of January - December, Sisaket Province, Thailand
Maps Legend

- High risk zone (Score 3.4 - 4)
- Moderate-high risk zone (Score 2.8 – 3.4)
- Moderate risk zone (Score 2.2 – 3.8)
- Moderate risk zone (Score 1.6 – 2.2)
- Low risk zone (Score 1.0 – 1.6)

Results are fully displayed in risk zone maps by years 2010 – 2019 and by months from studied years. The example figures (figure 3 and figure 4) show the comparison between the years and months with the highest sick ratio with the lowest.

Table 4. Correlation between yearly sick ratio and risk score

Year	Sick Ratio	Average Risk Score	r score	p value
2010	179.82	2.6210		
2011	139.86	1.7005		
2012	99.63	2.7474		
2013	311.76	2.5663		
2014	35.56	2.4568		
2015	228.15	2.6981	0.213	0.554
2016	81.95	2.6843		
2017	40.69	2.1679		
2018	140.46	2.1174		
2019	165.8	3.3073		

Table 5. Correlation between monthly sick ratio and risk score

Month	Sick Ratio	Average Risk Score	r score	p value
Jan	28.2	1.5508		
Feb	27.98	1.5076		
Mar	46.97	2.1720		
Apr	50.14	2.4219		
May	112.64	3.3879		
Jun	252.43	3.1727		
Jul	266.21	3.0612	0.799	0.002
Aug	231.39	3.2425		
Sep	168.43	3.2425		
Oct	100.39	2.1813		
Nov	61.29	2.1204		
Dec	53.96	1.3356		

4. DISCUSSION

The study of correlation and estimate risk area of DF/DHF by gathering data from agencies, has purpose for find relationship between factors and produce risk zone maps of Sisaket province. The studied data is 10-year long (2010 – 2019), is the DF/DHF incidence cases, had defined the factor that might cause the diseases. There are 6 variables involve in the study which are population density, average temperature, average maximum temperature, average minimum temperature, precipitation amount, and housing density (in monthly analysis used average precipitation instead of total amount and have no monthly housing density). For Tumbon (subdistrict) level, the meteorological data might not have wide range and much difference. The estimation from geoinformatics tools is not exactly accurate, unless the data are physically acquired from local area.

For statistical analysis results, yearly analyzing gave average maximum and minimum temperature 16.9% and 13.1% significantly positive correlate ($p<0.001$), as well as average relative humidity and precipitation 22.9% and 11% significantly negative correlate. Meanwhile, monthly analyzing gives average temperature and maximum temperature significantly negative correlate with 8.8% and 41.6%, while average minimum temperature, relative humidity and precipitation are significantly positive correlate with 51.5%, 56.1%, and 65.8%. ($p<0.001$). The results obviously show that monthly study provide stronger statistical correlations more than annually study. Moreover, the average risk scores show that the monthly study also provide more correlation than yearly study (79.9% and 21.3%, monthly and yearly).

5. CONCLUSION

The yearly correlation results in positive with maximum and minimum temperature and negative with relative humidity and precipitation, which all factor's trends are rising each year. Positive correlation r values are 16.9% and 13.1% and negative correlation r values are 22.9% and 11%. This phenomenon could lead to decrease of DF/DHF sick rate.

The monthly correlation show that maximum temperature and minimum temperature are respectively negative and positive correlated. This could lead to find the suitable temperature range for DF/DHF incidence. Moreover, the relative humidity and precipitation are both strongly positive correlated, summarizing that seasonal meteorological data are suited for study the correlation with the diseases. The most affected variables are precipitation, relative humidity, minimum temperature, and maximum temperature (negative correlated) respectively. These factors are more than 40% correlated with the sick ratio.

The monthly risk zone maps (which provide significant correlation with sick ratio) show that through the year, DF/DHF are riskier in the southern part of the studied area, Sisaket province. PHU SING, KHUN HAN, and KANTHARALAK Amphoes are the 3 Amphoes located in the south of the province, northern to the Thai-Cambodian border with a vast area of mountain forest. The study of correlation in monthly summarization provides more correlative results than yearly study. The office of provincial public health should consider in providing more density measurements in prevention and healthcare facilities.

Further study finds that at 32□ - 34□ C Ades could be grown up to adults in only a day which can seriously cause DF/DHF pandemic. People who live in 30□ C environment could be 4 times riskier to be infected by DF/DHF Sisaket also has many non-register populations which are tourists and migrators since it is located near the border.

Recommendation

1. Meteorological study should be expanded to larger area, regional or country. Across province provide not obvious difference.
2. Land use and land cover are good choices to find long-term correlation.
3. House Index (HI) and Container Index (CI) of mosquitos' larva would provide much more accurate relationship, but also considered to be very high detailed data.
4. Further study about the diseases should be done in monthly or seasons would provide more statistical precision.
5. Authorities should public provide the epidemic information to raise awareness of locals.

Acknowledgement

I would like to express my appreciation to my thesis advisor; Dr. Phattraporn Soytong, professor of Burapha University and SHU Hong, professor at Wuhan university, who always provides me advice for this research to achieve the goal of research project. Moreover, thank you to all professors from Geo-Informatics and Space Technology Development Agency (GISTDA), especially to Mr. Thanaphat Thanaratkiettikun and Dr. Pramet Kaewmesri, for training me in techniques in geoinformatics.

I am particularly grateful for the assistance given by Sisaket provincial public health doctor; Mr. Pichet Peudkhuntod, as well as Ms. Kanyarat Lhaosatienkit, Public Health Technical Officer, professional level for providing information and data to accomplish this research.

I would like to thank Dr. Wittawin Chantapoh; a local physician in Sisaket and a beloved brother, for inspiring me to form up this thesis by his concern. Also, the Kukan hospital relevant staffs who assisted me. Also, without assistance and supports from miss Varittha Soponsuk, chief of Thai-student in Wuhan university and vice chief of Thai-student in Hubei, this thesis would have not been achieved.

Furthermore, I am extremely grateful to Royal Thai survey department that recognized the importance of education and supported. With all my gratitude to every related staff, I would serve the best for our corps.

Finally, this research could not have been accomplished without the support of Sirindhorn Center of Geoinformatics (SCGI) master program batch 3, great advisors, colleagues, and friends.

Author contributions

Nutchanon Chantapoh: Conceptualization, Methodology, Software, Field study, Writing-Original draft preparation, Field study Visualization, Investigation, Writing-Reviewing and Editing. **Shu Hong:** Principal advisor and Thesis' examiner member. **Phattraporn Soytong:** Co-advisor.

Conflicts of interest

The authors declare no conflicts of interest.

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