GIS APPLICATION FOR IDENTIFYING RISK AREAS OF LEPTOSPIRA INFECTION IN SISAKET PROVINCE

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Thematic Paper
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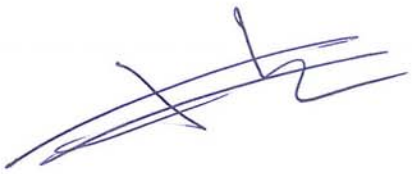

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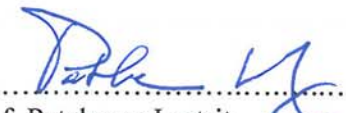

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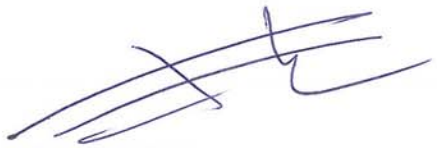

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GIS APPLICATION FOR IDENTIFYING RISK AREAS OF LEPTOSPIRA INFECTION IN SISAKET PROVINCE

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ABSTRACT

This research presents the application of geographic information systems (GIS) to determine the risk level of leptospirosis infection in sub-districts of Sisaket province. The data of geographical risk factors of leptospirosis disease is used for our study taken from four major sources, including Bureau of Epidemiology, Land Development Department, Royal Thai Survey Department, and Thai Meteorological Department. By using the backward elimination technique with multiple logistic regression analysis, the researcher has discovered that there are six significant variables related to the relationship between geographical data and leptospirosis, given as: the utilization of land, physiology of land, the incidence rate of leptospirosis, top soil's pH, the prevalence rate of leptospirosis, and precipitation. All the variables data will be used to create the database and to setup the layers of GIS by defining condition of multiplier overlay of the risk factors.

The analysis of GIS data also provides the on-time report, corrects the situation, and reduces the time delay of 506 Report System. This study suggested that GIS prevents and controls not only the leptospirosis but also the other diseases related to the regional environment.

KEY WORDS: LEPTOSPIROSIS/RISK AREAS/ GEOGRAPHIC INFORMATION SYSTEM (GIS)/DISEASE CONTROL/MULTIPLE LOGISTIC REGRESSION

68 pages

การประยุกต์ใช้ระบบสารสนเทศภูมิศาสตร์เพื่อระบุระดับความเสี่ยงของพื้นที่ต่อการติดเชื้อเลปโตสไปร่าในจังหวัดศรีสะเกษ

GIS APPLICATION FOR IDENTIFYING RISK AREAS OF LEPTOSPIRA INFECTION IN SISAKET PROVINCE

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บทคัดย่อ

การศึกษาครั้งนี้เป็นการวิจัยเพื่อประยุกต์ใช้ระบบสารสนเทศภูมิศาสตร์ในการระบุระดับความเสี่ยงของพื้นที่ต่อการติดเชื้อเลปโตสไปร่า ของตำบลในพื้นที่จังหวัดศรีสะเกษ ข้อมูลที่ใช้เป็นข้อมูลทุติยภูมิของปัจจัยเสี่ยงเชิงพื้นที่ที่เกี่ยวกับการเกิดโรคฉี่หนู ซึ่งรวบรวมมา 4 แหล่งข้อมูล ได้แก่ สำนักระบาดวิทยา กรมพัฒนาที่ดิน กรมแผนที่ทหาร และกรมอุตุนิยมวิทยา ผู้วิจัยได้ทำการศึกษาปัจจัยที่มีผลต่อพื้นที่เสี่ยงในการเกิดโรคเลปโตสไปโรซิส ด้วยการวิเคราะห์ถดถอยพหุลอจิสติค ด้วยเทคนิคการวิเคราะห์แบบขจัดออกทีละตัวแปรในการหาปัจจัยเสี่ยงเชิงพื้นที่ที่มีความสัมพันธ์กับการเกิดโรคเลปโตสไปโรซิส ได้ตัวแปรที่มีความสัมพันธ์กับการเกิดโรคอย่างมีนัยสำคัญทางสถิติ 6 ตัวแปร คือ การใช้ประโยชน์ที่ดิน ความลาดชั้นของพื้นที่ ความถี่ในการเกิดโรค ค่า PH ในดินชั้นบน จำนวนผู้ป่วย และปริมาณน้ำฝน จากนั้นนำตัวแปรมาสร้างชั้นข้อมูล และสร้างฐานข้อมูลด้วย GIS โดยกำหนดเงื่อนไขในการซ้อนทับข้อมูลด้วยวิธีผลคูณของปัจจัยเสี่ยง

ผลการศึกษา พบว่าการประยุกต์ใช้ระบบสารสนเทศภูมิศาสตร์เพื่อระบุระดับความเสี่ยงของพื้นที่ต่อการติดเชื้อเลปโตสไปร่านั้น มีประโยชน์ต่อการป้องกันควบคุมโรค ทำให้สามารถกำหนดนโยบายในการป้องกันควบคุมโรคได้ตรงพื้นที่และทันต่อสถานการณ์การระบาดของโรค และยังสามารถช่วยแก้ปัญหาความล่าช้าของรายงาน 506 ทั้งนี้จากการศึกษายังสามารถนำไปประยุกต์ใช้กับโรคที่มีความเกี่ยวข้องกับสิ่งแวดล้อมได้

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CHAPTER I
INTRODUCTION

1.1 Background and Problem Statement.

Leptospirosis is a communicated pathogen from animals to human (zoonosis) by Leptospira which the pathogen spreads out around the world and high disease prevalence in equator zone, especially for South-east Asia region including Thailand due to the damp temperature condition and the monsoon zone. This is a factor to support prevalence that could survive in environment excellently. In addition, Leptospira is found in all of het zoogdier kinds, especially for rat, cow-buffalo, pig and dog which and retained the major pathogens, since they get a pathogen, perhaps not show a symptom and could defecate urine long as month, year or lifetime. The pathogens contaminate with urine and survive in environment to burrow the human on the soft-tissue or skin wound. Then, when the human gets the pathogens to the body, these pathogens would split to rapidly increase the number of pathogens. Noticeable human and animals could get a pathogen from daily livelihood, especially for house group lived in rainy district, flood, and crowded community. Also when determination a livelihood, animals tend to get a pathogen easily, especially animals used nose or month in eating feed from ground and ground rummaging, such as dog, buffalo, pig, elephant, horse etc.

From monitor data in 2013 found 2,255 patients from 67 provinces, sick rate calculated 3.50 per one hundred thousand population, die rate calculated 0.04 per one hundred thousand population. The proportion male per female 1: 0.23 the most found of age group respectively as age 45-54 (22.04 %) age 35-44 (20.89 %) age 55-64 (17.29 %) Thai nationality 98.5% Myanmar 1.0% Cambodia 0.3% Laos 0.1% and other nationality 0.0% The most of carrier Agriculture 58.0% work as employee 21.1% Student 8.8% (506 Monitor pathogen report, Bureau of Epidemiology, Department of communicable disease control, 2014)

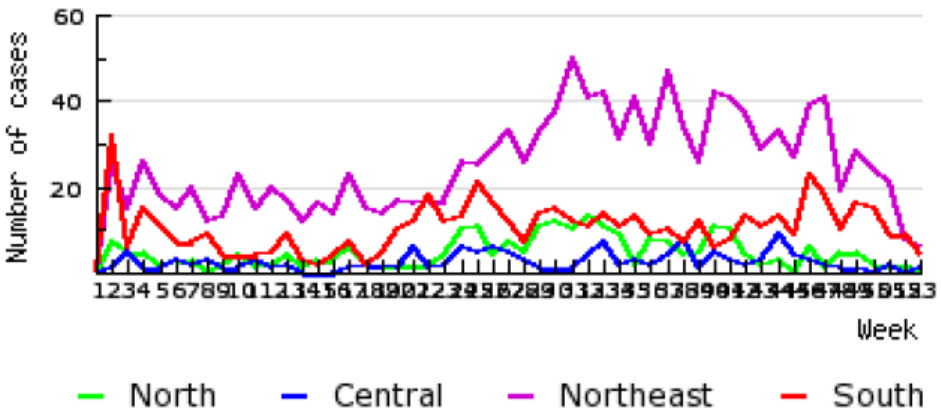

Figure 1.1 Number of Leptospirosis cases by week of onset and region 2014
Source : Bureau of Epidemiology, Department of Disease Control,
Ministry of Public Health

The five top chart of sick rate province per one hundred thousand population are Ranong province (19.16 per one hundred thousand population), Sisaket province (18.38 per one hundred thousand population), Panggna province (15.15 per one hundred thousand population), Kalasin province (12.38 per one hundred thousand population), and Surin province (11.33 per one hundred thousand population). The most of sick rate region are North-east with sick rate of 6.11 per one hundred thousand population, South with sick rate of 6.06 per one hundred thousand population, North with sick rate of 2.08 per one hundred thousand population, Central with sick rate of 0.61 per one hundred thousand population, respectively. (506 Monitor pathogen report, Bureau of Epidemiology, Department of communicable disease control, 2014) Moreover, found Sisaket province has a sick rate in the first rank for 3 year thoroughly.

Central region found the most of age group 35-44 years (31 case), 45-54 years (28 case), 25-34 years (28 case), North-east region found the most of age group 45-54 years (339 case), 35-44 years (296 case), 55-64 years (261 case), North region found the most of age group 55-64 years (56 case), 45-54 years (53 case), 35-44 years (43 case), South region found the most of age group 25-34 years (114 case), 35-44 years (101 case), 15-24 years (87 case) (506 Monitor pathogen report, Bureau of Epidemiology, Department of communicable disease control, 2014)

Currently, the 506 monitor report is used as the form monitor system which has the efficiency for a long time usage. Data from monitor report is a incidence pathogen in area which this report includes a sick rate, die rate, ageny classification, career, sex, date/month/year of sickness, etc. All of data are related to almost personal characteristics. Nevertheless, by reviewing from this research was found Leptospirosis incidence natural and had a factor related with environment which 506 report had no detail in subject of environment. It was a major factor to pathogen incidence, moreover although improvement in correctly and on time reporting of patient by 506 report system but monitor report system follow 506 report was so late and have no clearness to assign the incidence risk area.

Also if the method to take a relation data such as Environment factor was possibility a second part of data which supported monitor system form old 506 report to use this data to monitor and prevent Leptospirosis to be strong. In the present the popular system used in environment study as Geographic Information System (GIS). GIS is a method and equipment to take a Geographic map system for operate whom. It could keep, edit, improve, management, analysis, display, and result the Spatial data report with computer system. By using relation of geography to connect relation data with other data, for explaining situation was occurred in surface of the earth (Autai Suksing, 2004)

Form 506 report limit in lateness with patient report and have no detail about environment to use to consist in risk area assigned and the applying method to use Geographic Information System with several benefit especially Leptospirosis which related with environment directly, so researcher use Geographic Information System in spatial data analysis. For assigning risk level with Leptospira pathogen communicated in Sisaket province and got a detail of spatial data more and more, when this data used to support 506 report for the highest profit and efficiency in monitor, prevent and control Leptospirosis pathogen in Sisaket province.

1.2 Objectives of Research.

The objectives of this study are as follow:

To investigate the Leptospira infection risk areas of the districts of Sisaket province, by using Geography information system (GIS).

1.3 Scope of Research.

The scopes of this research consists of:

1) The case study area of Sisaket province

2) Studying data for Leptospira infectious risk area analysis following:

2.1) 506 report data

2.2) Soil set data

2.3) Rainfall data

2.4) Land benefit data

2.5) Area gradient data

1.4 Expected Outcome.

The expected outcomes of this study include:

1) Using data or information to support with the 506 report to assign measure include strategy plan for monitor, prevent and control Leptospirosis in Sisaket province.

2) Using applying form to use Geography information system for assigning risk level of Leptospira infection risk area in other province including to use applying form with other pathogen which related with environment.

CHAPTER II
LITERATURE REVIEW

In this study was a applying to use Geographic Information System to find Leptospirosis pathogen risk area in Sisaket province. Which the researcher were study and knowledge gathering, concept from textbooks education document and relation research for taking the way in this study following:

2.1 Leptospirosis situation in Sisaket province.

Leptospirosis situation in Sisaket province from monitor report by Bureau of Epidemiology. Department of disease control ministry of public health, found in the year 2012 found patient 4,130 case from 74 province, sick rate calculated as 6.50 per one hundred thousand population, die 60 case die rate calculated as 0.09 per one hundred thousand population. The province in top five of sick rate chart, the first as Ranong province (221.73 per one hundred thousand population) Sisaket province (24.68 per one hundred thousand population) Pangnga province(24.64 per one hundred thousand population) Surin province (23.08 per one hundred thousand population) Leoi province (20.46 per one hundred thousand population) (506 Monitor pathogen report, Bureau of Epidemiology, Department of communicable disease control, 2013) in the year 2013 found patient 3,094 case from 73 province, sick rate calculated as 4.87 per one hundred thousand population, die 29 case die rate calculated as 0.05 per one hundred thousand population. The province in top five of sick rate chart, the first as Pangnga province (27.42 per one hundred thousand population) Sisaket province (21.57 per one hundred thousand population) Leoi province (19.65 per one hundred thousand population) Surin province (16.98 per one hundred thousand population) Ranong province (15.96 per one hundred thousand population) (506 Monitor pathogen report, Bureau of Epidemiology, Department of communicable disease control, 2014). In the year 2014 found patient 2,263 case from 67 province sick rate calculated as 3.51

per one hundred thousand population, die 25 case, die rate calculated as 0.04 per one hundred thousand population. The province in top five of sick rate chart, the first as Ranong province (20.81 per one hundred thousand population) Sisaket province (18.38 per one hundred thousand population) Pangnga province (15.15 per one hundred thousand population) Kalasin province (12.38 per one hundred thousand population) Surin province (11.33 per one hundred thousand population) (506 Monitor pathogen report, Bureau of Epidemiology, Department of communicable disease control, 2014) and found Sisaket province has a sick rate in the first rank in 3 year thoroughly.

2.2 Principle of Leptospirosis.

Leptospirosis had been the first patient report in Thailand total 4 case (death 2 case) since1942 with the biggest floods in Bangkok by Dr.Chai Unipan at Sirirath Hospital, after that found Leptospirosis patient report in all of region of nations and found two time in year 1983 which had floods in Bangkok and the end of year 1988 since flood disaster in upper south province.

Since 1996 spreading was occurred in rainy season from July to October continually every year until at the present and situation tend to increase continually until at the present. By beginning patient report total 358 case from 38 province in year 1996, then to increase more and more as 2,334 case from 48 province in year 1997 and 2,230 case from 59 province in year 1998, after that report increase as 6,080 case from 60 province in year 1999 and 13,461 casein year 2000 Patient 85% - 90% ,found in each province of North-east region especially Buriram province, Khonkhan province, Surin province, Chaiyaphum province, Mahasarakham province, Nakhon Rathchasima province, Leoi province, Kalasin province and Roiet province and beginning found patient report increase in North region such as Phare province, Petchabun province etc. In year 1999 and South in year 2000 was appearance spreading of Leptospirosis all the time (Bureau of General Communicable Disease)

2.2.1 Pathogen appearance.

"Leptospirosis was a pathogen commutated with animals to human (Zoonotic Disease)" which symptom of this pathogen from bacteria communicated with several kibd of animals, built several symptom with serovars and quantity of pathogen, Leptospirosis incidence begin since disappear of symptom and non-violent, severe or death. The human who incidence in area where was this pathogen as a endemic disease, the most of patient disappear symptom or appear non-violent.

2.2.2 Cause.

Leptospira infection type brought to incidence had 6 species including infection Leptospira interrogans, Leptospira kirschneri, Leptospira noguchii, Leptospira borgpetersenii, Leptospira santarosai and Leptospira weilii. Found Laptospira infection brought to all pathogen more than 230 kind, shape of infection was a twist stick turn in clockwise and twist had more than 18 twist per each and diameter 0.1 micron length 6-12 micron, by generally tip of 2 side or from one side to bend like a hook and dye in blue faded and move fast by turn around. It could see by darkfield microscope, infection need damp temperature, Oxygen, alkalinity and acidity in middle condition (pH 7.0-7.4) and proper temperature as 28-30º Celsius.

2.2.3 Communicate.

The infection was release with urinate of incidence animals and contaminated follow water, wet soil or plant, vegetable. The infection could burrow into body with bound skin or scratch and tissue of mouth, eyes, nose, besides it could burrow into normal skin which soaking in water long time to tender skin. Human was indirect when step foots in clay, soaking in floods or swimming or direct incidence by touching infection in animal urinate or contamination meat.

The infection was into body by eating foods or water or a nucleus dust from contamination liquid inhale, could find but a little. In the part of communicate from human to human, had a report that communicate by urinate only 1 report. Although found a infection in of patient long as 1-11 month but communication from mother to infant could be fatal in womb, there were 2 case, moreover infant who bring forth would have a symptom as same as adult.

2.2.4 Incubate period.

By average about 10 days or in the phase 4-19 days (perhaps suddenly within 2 days or long to 26 days).

2.2.5 Human symptom.

Human symptom was different depend on kind and quantity of infection, a symptom found frequently such as suddenly fever, severe headache, tremble, muscular pain severe (pain at calf of legs, back muscle and calf) ciliary infection and perhaps have fever several day continuously and alternate with biphasic and Cephalomenigits, palatal exanthema, anemia, spot blood on skin and tissue, liver and kidney failure, jaundice perharps Cephalomenigits, It make feel confuse, rave, dull myocarditis perhaps symptomwith respiratory organ, cough a cold with phlegm perhaps hemoptysis and angina pain.

Atypical pneumonia syndrome was found in Leptospirosis patient Aseptic meningoencephalitis, perhaps incidence from all kind of Leptospira infection but found from Canicola, Icterohaemorrhagiae and Pomona infection.

In Thailand had a survey report, found this pathogen in not have cause patient group 2.2 % to 18.9% survey in year 2534-2536 by Department of medical sciences , found frequently 4.8% , but in children hospital report found frequently to 36.11%.

Although symptom of pathogen was quit several, perhaps symptom prominent of one of organ to destroy irrespective liver, kidney, respiratory organ or circulation system, but from report in Thailand always found symptom as high fever (88.8-100%) headache (66-100%) muscle pain (76-100%) and ciliary infection (74-100%) for jaundice found less than as 37-70% other symptom such as spot blood on skin, cough a cold with blood, hepatomegaly and splenormegaly etc.

The severe of this pathogen depend on kind and quantity of infection such as Icterohaemorrhagiae and Bataviae, often bring to severe symptom (Jaundice, bleeding and kidney failure) more than the other infection kind such as Canicola, Grippotyphosa and Hardjo. Leptospira incidence bring to pathogrn symptom as have no jaundice (anicteric illness) more than as jaundice (icteric disease) which a Icterohaemorrhagiae infection bring to Jaundice symptom, kidney destroyed and

breeding condition and at last sick rate will change to die rate too high and found Jaundice not over 10%.

2.2.6 Animal symptom.

Animals will respond to Laptospira incidence by have a symptom following:

- Severe suddenly symptom (peracute)

To have a fever high temperature about 104 - 107º Fahrenheit (40-42º Celsius) bring to kidney failure and kidney failure in yearling, die rate high to 80%.

- Semi-suddenly symptom (acute or subacute)

To have fever, dull, do not eat feeds, blood clot in eyes tissue, bloods spot on skin, bloods urine, yellow body, yellow eyes, anemia, organ in body such as spleen, kidney, big lymph node, found nephritis condition, pneumonia, colitis, mastitis without heat, swollen, red, stop feed milk suddenly, milk abnormal was a clot, thick yellow or red. In the part of miscarry occurred in period 3 last month of pregnant, had a high die rate of bringing forth. New born yearling in a weak condition, some yearling have a nervous system symptom, due to brain and cephalomeningitis die rate about 5 %.

- Chronic symptom

Animals had an abnormal with organ, low breed rate, complete of reproduce to decrease since spermatogenesis decrease, always miscarry, placenta remain, high die rate in bringing forth, quantity of brood decrease, milk production decrease continuous until terminate of phase, to effect to yearling got milk insufficient, body lose weight, weak and infection easily.

- Subclinical

Always found in animals which they were in good condition and have no other abnormal symptom, but had Leptospira in kidney and repel with urine which was a major focus, for spreading to human and other animals

2.2.7 Treatment.

Treatment method should consist with giving a proper and rapidly antibiotic.Treatment by symptom for recover abnormal and complications with supporting treatment. The method of giving rapidly antibiotic will help to decrease

violence and prevent a pathogen complications, Penicillin was a antibiotic which was the best efficiency in treatment for hun\man who allergic a penicillin will give doxycycline, antibiotic cephalosporins and lincomycin. To have the best action of drug in laboratory, but have no study in patient. Experiment in animals by using doxycycline which had an action of drug in stopping increase of infection (bacteriostatic) more than disinfection and this drug was absorb into other tissue rapidly include kidney, brain and cerebral spinal fluid, the result of culture germs not found drug-resistance and in monkey could reduce finding infection phase in bloods include to prevent incidence in cerebral spinal fluid and in urine. The result in guinea pig was found can prevent incidence in urine and prevent die rate. The severe patient was a patient who examined lately and/or treatment lately (by the most had symptom since 4 days over) and /or was a complication patient such as jaundice patient and high serum creatinine. The severe patient was found fatality rate (CFR) high to 15-40 % , if they had treated in hospital where had a standard (which at least must treatment with peritoneal dialysis) perhaps help to decrease CFR to 5% . Penicillin G was the best efficiency, dose of Penicillin G which inject into vein to use a maximum as 6 millionunit/day. By divided to give 1.5 million unit every 6 hours in phase 7 days, besides found after giving Penicillin G in 3 days, still have a high fever, must consider infection complication or examined right or wrong, if certain in examined result and have no infection complication, should consider to bioavailability of Penicillin G using Ampicillin to inject into vein , using dose 4 grams per day. By divided to give 1 gram every 6 hours continuous 7 day. In the case of sever patient who was allergy Penicillin, perhaps to consider to use Doxycycline to inject into vein, using dose 100 milligrams every 12 hours long 7 days. For Cephalosporins and Lincomycin had the best drug action to disinfection in test tube, but have no study in patient, non-violence patient to immediate patient perhaps select drug following:

-To take Doxycycline 100 milligrams 2 time daily, long 7 dats (in the case of could not separated the patient to incidence leptospirosis or scrub typhus, should select using Doxycycline instead using Penicillin)

-To take Amoxycillin 500 milligrams every 6 hours, long 5-7 days.

-To take Ampicillin 500-750 milligrams every 6 hours, long 5-7 days.

2.2.8 Patient sampling.

Bloods and cerebral spinal fluid ought to keeping before giving antibiotic in the first phase of pathogen within 10 days and should culture germs immediately to have the most chance to separate infection. If It don not culture germs immediately, it should keep bloods 5 milliliter in tube without infection with 1% heparin 0.1 milliliter or 1% Sodium Oxalic 0.5 milliliter. For prevent blood clotting mechanism, should avoid using blood tube with Citrate solution, because found, Citrate was a substance to restrain grow up of infection, should keep in room temperature and send to laboratory within 24 hours and the longest should not over 1 week.

- Serum keeping should vein puncture a suspect patient 2 times less than from 1 week and serum centrifugal immediately for protect erythrocyte broken and send to laboratory immediately. If could not send immediately, to keep in temperature -20º Celsius.

- Urine should keep after appear a symptom more over 1 week and should keep urine water in immediate phase. The method of urine keeping to be careful with contamination and should culture germs immediately, It should dissolve a urine in solution PBS (pH 7.2-7.8), due to no longer of infection to exist in acid urine.

- Sampling keeping from dead person, must keep tissue in kidney, liver and brain and should keep immediately and should culture germs within 4 hours, due to no longer of infection to exist in deteriorate tissue.

2.2.9 Animals sampling.

1. Serum samping

- Vein puncture from vein 5 - 10 milliliter put in test tube which was disinfect and centrifuge serum at least 1 milliliter. In the second part vein puncture from the first time 1 - 2 weeks.

- Writing an name ,animals number in serum tube side correctly and cover tube with plastic cover to tight and binding top of tube with Para film for protect plastic cover lost, to keep serum in freezer of refrigerator (-4º to-20º Celsius)

- Send to freeze in foam box with ice inside.

2. Sampling of pathogen send prove isolate.

- Bloods , bloods and cerebral spinal fluid keeping should keep in animals sick phase and had a fever in first week . By sampling keeping in bottle without infection and had a heparin 15 - 20 international unit (IU), prevent blood coagulation and keep in temperature room until would be culture germs in media.

- Urine , urine keeping in animals sick phase and had a fever in 2 weeks and must be a new urine. By sampling in immediate phase, not over 1 hours. If could not be culture germs immediately, must keep in transport media (contact to requirement at National institute of animal health or Center for research and diagnostic disease animals.) or keep in solution PBS (Phosphate Buffer Saline) or dissolve with saline solution 0.85% which was disinfect steam in rate 1:10 for controlling transform to acid – alkali condition and keep in temperature room until to culture germs infection in media.

- Other organs such as liver, kidney and miscarry yearling, should keep immediately, must be a new and fresh organs and do not freeze absolutely (will soak in vacuum flask for protecting to spoil organs but do not freeze to be hard.

2.2.10 Spread period measure.

During pathogen investigation.

- Set up investigation team /Fast move unit to operate controlling of disease including District public health officer or represent in subject of human, District livestock officer or represent in subject of animals, Sanitarian in occurred area, municipally/Sub-district administrative organization officer in occurred area and officer who were related with community hospital.

- Search for source of infection such as source of water, farm and factory including infection animals, then to solve contamination or do not use temporary.

- To give health education and relation to people about Leptospirosis to understand and be aware of dangerous of pathogen including prevent and control pathogen.

2.2.11 Patient control, Contact tracing and environment measure.

- Separating patient: Be careful to touch bloods and secretion from the patient.

- Infection destroyed: Equipment contamination with urine, must take to disinfect.
- Internment: unnecessary
- Immunity giving for contact tracing: unnecessary

2.2.12 Prevent measure.

- To give health education for people and method of pathogen communicated and avoid swimming, soaking and walking in contaminate water from urine which conducted to pathogen or if necessary, should wear boots.
- Pathogen protect for worker who were in a incidence risk job such as rubber gloves, boots etc.
- Source of water inspection, contaminate sandy soil, if it was a water in release tube, should wash and release contamination water.
- If found infection animals, must separate for protection uncommunicative to other animal or to contaminate in the live area, working area and tourism location etc.
- To control and eliminate in the human live area especially in countryside and live area, working area and tourism location etc.
- To vaccinate protection pathogen for livestock such as cow, buffalo and animals such as dog, It will protect a pathogen but to prevent incidence and not repel infection by urine, vaccine which was used, must have serovars. It was found in this country.
- To vaccinate protection pathogen for worker and occupation who were in a pathogen risk communicated. It was a method to use in Japan, China, Italy, Spain, France and Israel (Bureau of epidemiology, DDC, MPH)

2.3 Leptospirosis incidence relationship factor.

In this study the researcher was review the context and research preceding, could be conclude, the relation factor with Leptospirosis incidence have 2 main factor as personal factor and environment factor.

2.3.1 Person factor.

From document review and the relation research, could be divided the main personal factor which was related with importance person and relation with leptospirosis incidence 2 major part as personal characteristic and risk behavior to incidence a pathogen, detail following:

1. Personal characteristic.

Personal characteristic was a mail factor to leptospirosis incidence such as age, occupation and sex from pathogen monitor of year 2013 – 2014, found the most of Leptospirosis patient was in a age group 25-54 years and found male sex more than female sex and the most of patient was an agriculture (506 Monitor pathogen report, Bureau of Epidemiology, Department of communicable disease control.)

In the part of occupation to have a Leptospirosis incidence risk, found human group to work with touching soil, clay, water and animals were a occupation group found in result the most of education and could be conclude as occupation which were in a Leptospirosis incidence risk (WDIC, 1999)

2. Leptospirosis incidence risk behavior.

Behavior research about communication of leptospiropsis pathogen in the past time, by using epidemiology concept was used to pose a question and create research almost all. Especially define risk behavior which was emphases in behavior with touching water, animal and eating foods which was from the result of logical in behavior theory. From the report was risk behavior conducted to incidence, so that relation behavior about touching water and wade into water and clay which was a livelihood of farmer, moreover include other behavior, then said that the research preceding was try to search risk behavior more than prove a behavior was a real risk behavior and the mainly, form of adumbrate research and have no experiment including have no the result of laboratory to use together, also It was found data and information insufficient such as wade in water and clay behavior, fisher, touching animals behavior and eating activities etc.

2.3.2 Environment factor.

From document context review and related research, found the most of study not appear the result clearly. The most of data was from medical history talking

and notice environment in patient live area or in spreading pathogen area which was the environment point. It was the main factor for pathogen spreading such as geography property, rainfall quantity and animals which were live in infection area, detail following:

1. Geography property.

Although Leptospirosis pathogen, found in all of the world but the most finding in worm and humid district nations and countryside. In developed nations were found Leptospirosis incidence less than and It was related with recreation activities of human. Nevertheless data from this pathogen antibody in population in urban area high to 30% as well as patient report in urban area, then to set up a notice with Leptospirosis situation in urban area, perhaps It will be a problem which was ignore (Albert KO, 1999).

The study of Kuriakose M. and council, 1997 which was making in urn\ban area Kolenchery in a middle of Kerela which have a area as lake and some portion as an upland which used small canal or well which was built by human and irrigation set up, found Leptospirosis incidence in this area perhaps related with physical property of area, damp soil condition, irrigation set up in summer season and agriculture period in each year include rodent animals in area (Kuriakose M., et al., 1997).

However leptospira incidence risk of urban people, could be occur as same as countryside. The different factor were occupation in livelihood daily and environment etc.

Leptospirosis was a pathogen which spread all of region of Thailand but the most Leptospira incidence was found in North-east region, also in the other region study were found less than. Which in study of Leptospirosis in North-east region of Waraluk Tongkanakul and Darika Khingnate, 1997, reviewed all of data since spread beginning and have a notice in other province which was a high of spreading area and the most of North-east region in a middle district was a shallow lake. In the part of other province not find spreading in area where was near Khong river and have a high however not found the relation study or the study of consideration with the topography in other area.

2. Water quantity in area.

Due to Leptospira infection had an water as a main factor to exist, also to assign a hypothesis about water in the study of leptospirosis spreading which have a several context in hypothesis setting such as conclude of children medical history taking with Leptospirosis. In the year of more patient was a flood in Bangkok and perimeter (Sujittra Nimmannit and council, 1985) from the pathogen investigation in the spreading phase in Nakhon Ratchasima in year 1996 , found data was assigned in this year have the severest flood in 15 year which have more rainfall quantity and wetland (Pongsakron Pokpeamdee and council, 1996) from noticed Leptospirosis spreading in urban area was possibility relate with flood condition which water conduct to infection or carrier from suburb to urban area. Spreading in urban area had to always incidence in suburb formerly (Anan Knoksilp, 2000)

From other study report, found attempt to connect to show pathogen spreading with was related with flood condition in area, to support in this subject was having several a patient report in rainy season or flood period in area, which this period the people had to touch water all the time. When was found some report have a different conclude, by the conclude from this study was assigned a pathogen spreading not have a relation with flood or rainfall quantity in area. Since in spreading area in the year 1997, have no flood condition in a long time and rainfall quantity more less than the year preceding, the portion of not spreading pathogen area, not found rainfall quantity less than the year preceding (Waraluk Tongkanakul and Darika Khingnate, 1997)

3. Community environment.

The study relation with community environment property of Waraluk Tongkanakul and council, 2000. The environment survey would have an effect by Leptospirosis in North-east region countryside population. In the year 1998 to study compare in sampling as 2 group by sampling as a patient who the doctor examined was Leptospirosis and compare group as neighbor in near area with patient. Due to environment condition of sampling not different, also the result of study were have a data of different behavior subject more than different of environment data which have an effect with pathogen spreading. In this study was summarized, in the patient group had a behavior with walking on rough footpath, have hole, well and wetland. In

the other way when compare with travel by car on the same road, in conclude could not measure an environment have an effect to spread of pathogen clearly.

From education document review and research preceding, found leptospirosis is a communicated pathogen from animals to human (zoonosis) and complex of infection and pathogen spreading property, also It was found a factor which related with several incidence of pathogen factor, by the main factor 2 context were personal factor and environment factor which the importance personal factor such as general personal characteristic and Leptospirosis incidence risk behavior such as soaking in water longer than 6 hours over in a next day, steping and walking in a clay, touching urine or infection meat directly, rice grow – pull up and harvest etc.

2.4 Geographic Information System.

2.4.1 Meaning.

Geographic Information System (GIS) was the method and instrument to take a graphic map system to work with Spatial data base system, could use in keeping, edit, improvement, search, management, analysis, display and spatial data report with computer system. By relationship from geography to connect relationship with the other data. For explaining the occur or phenomena in the surface of earth.(Authai Suksing, 2004)

Object data or Phenomena were occurred to relate in direct or indirect with the one position which relation with the surface of earth, by the period of time to assigned and gathering whole data instead with sign or symbol together with detail data of each object into category, called Spatial data which perhaps was a data form in map sheet or digital map data.

GIS, Geographic Information System was a instrument used to Spatial Context analysis, by the other property in study area was arranged in the platform which was related to connect with together and depend on type and detail of this data, for the best of result by the requirement. Data in GIS system consist as 2 part following:

1. Graphic or Spatial Data, could be divided property of graphic as 3 types following:

1.1 Point feature used reference with position of the other things in a map.

1.2 Line feature used reference as a set of series spot, by used instead line property.

1.3 Polygon feature was a close shape and used instead property of area.

2. Non graphic or attribute was a other property of feature.

2.4.2 GIS Data Analysis.

Data analysis in Geographic Information System (GIS) was the main of bring to Geographic Information System different from the other programs which was only management or only create data base. In the Geographic Information System will use a detail of data both of Spatial data and Non-spatial data in the method of analysis.

Spatial data analysis in Geographic Information System was a one of chance which open to GIS Analyst, they could find relation of Spatial Relationship of old data for creation new data by other condition in Geographic Information System data analysis that, to conduct the method and the other procedure to apply in transform of data and could mix with the other data in the method of data analysis. For convenient, fast and correction of the best result.

Detail of data in Geographic Information System could answer which was related with station or location such as Where in the part of GIS Data Analysis, it will answer as “Why was at here”. Geographic Information System could explain in number form and include a picture, it will make to convenient in Model analysis. Expectation analysis both of map form and information data but the success factor of GIS was not success with itself. GIS was not working in everything correctly, but GIS must use personnel or staff in GIS. It was a major to assist reduce failure in loading raw data to database and thoroughness of input data such as scale of GIS map could not answer the question with itself that this is proper area or not, but it must use a

professor or personnel or staff in each part to answer the each form of data analysis and to answer by principle of education more or less somehow.

2.4.3 Geography information system analysis method.

Geography information system was different from the other information system. Geography information system could operate and Spatial data analysis. In the data analysis perhaps use Spatial data and non-spatial data in data base of GIS for sending the answer to refer on geography coordinate system but when the other information system. Though It will analysis data in statistic or the other data, but could not define geography coordinate system. The result of data analysis with GIS system could display in spatial data or data explaining and overall image to connect the relation of data and could explain clearly to appear the occurred or require answer to decision in the best way.

Geography information system could get the result in map by using geography coordinate system by finding average value and standard deviation and relation with spatial data. Geography information system could take statistic to use with GIS system together and display in map form, the method of analysis was complicated and could apply to use properly. Geography information system could be divided the main of data analysis form as 3 form following:

1. Analysis of the spatial data.

1.1 Geography coordinate system transforms, scale was change from geography coordinate system to one of system.

1.2 connection many sheet of maps together or adhere per sheet in same subject but have many sheet of map or adhere many sheet of map together. In the part of Edge -matching was the method adjust detail position of second sheet over by continuously , but to adhere incongruity, It was necessary to adjust for map continuously

1.3 Area calculate, circumference and distance. The area calculate in data base system and could measure circumference, length of line and distance of line. By program Geography information system will automatic calculate after make a Topology or perhaps will inquire with program by using the instrument or command in program for describe distance or area.

2. Analysis of non-spatial data.

In data processor with Geography coordinate system. We will edit data, check correction and non-spatial data analysis which this method as same as the old data analysis by using database system and statistic such as

2.1 Attribute editing function could call for check and change information or data, could add or reduce data include table connection and contribute many tables to 1 table.

2.2 Attribute query function was search data in database related with condition by user to pose a question and ask by using the other method.

2.3 Attribute statistic function calculate statistic value from data in table which was calculated statistic value to new data table and could use in query and provide complete report.

3. Integrated analysis of the spatial and non-spatial data.

Non-spatial data analysis with spatial data will make this information system have a high efficiency and geography information system will use with the other applying program which operation of geography information system completely such as Data retrieval, Classification and Measurement in the this method was participated both of spatial data and non-spatial data, had a detail following:

3.1 Retrieval.

Data search about search selection, edit and the result of data not modify in the other form such as Standard query language-SQL. It was a standard to use in database connection and using in the part of GIS. Search the way to select from database which have many levels. Using the Boolean logic must use principle of operation in non-spatial data and spatial data. Searching data could select the requirement area and show the result after search data from table. Non-spatial data in each record or the result of asking from the map which was selected in database. Searching complex type was using method Boolean logic participate with Overlay data .

3.2 Classification.

The method of arrange in the same things property group, after divided a new group we will join a map which have a detail in the portion as same as 1

map, called Generalization or Map Dissolve. The method of dividing data group will use the most of non-spatial data .

Soil map set consideration could create soil map set from data layer which have several areas and dividing by property. In generally could make Reclassify, Dissolve and Merge.

1) Reclassify was a new group by non-spatial data in one data or countribution.

2) Dissolve was a subtract district between area in the same type by remove arc line between of 2 polygon in the same group or non-spatial data to arrange in the same group.

3) Merge was a contribution a area data together in the large area, by using password or new value respectively of district line connection and set new ID every polygon.

4) Measurement , by generally the measurement must relate with spatial data but in display the result of measurement could keep in new database or a new group.

2.4.4 Overlay Function.

Overlay Function was the one of the method which have a major and general geography information system basically. The principle was taking data from the several data source for using in Decision Making. By the generally overlay function in the map used point x and y and new non-spatial data which created. After making overlay in geography information system which overlay function will use both of arithmetic or logic.

The form of overlay function such as Buffer, Clip, Merge, Dissolve, Eliminate, Erase, Identity, Intersect, Union, 2 Theme-Near and improvement data have a detail following:

1. Finding distance with Buffer

This method was finding distance from geography features which was assigned by making a Buffer to only analysis area 1 Theme and build the surround area with Graphic Features of 1 theme. It was selecting some portion, if it do not select to make a buffer and theme. The result was new theme which have a length of area

from select position as same as sixe of buffer which was assigned and have an unit as meter.

2. Edge of data district cutting by Clip

This method was cutting map data out of theme, the aim was Theme to be clipped with map or cutting area such as province area which requirement to use as district in Theme to clip.

3. Finding overlay area with Union

This method was a mathematic function which was born from interesting area of object more than 2 area, by gathering maps total 2 area to join together, by making a new map set.

4. Finding overlay area with Intersect

The method was a overlay of data between theme 2 theme by out-theme , it will be in map extent of 2 theme ,data total not over 2 theme, in the order that in-theme were both of point and line.

5. Finding overlay area with Identity

The method was a overlay of spatial data 2 theme by hold district of map from origin in-theme mainly and It will keep property of data in 2 theme together, Data from origin in-theme were point, line, polygon and multi-point, but identity-theme will be only specific เฉพาะ polygon theme.

6. Map data connection with Map jointand Merge

This method was gathering Graphic Features from several themes into one theme as Map joint, it could operate all of point, line and polygon for connecting map which have same coordinate geography or join into on map.

7. District data gathering with Dissolve

The function to gather area data (polygon) which have property or attribute as same as join together, for reducing a coincidence of theme to decrease which keep district line of area which have a same value in one or several fields out off.

8. Elimination and gathering data with Eliminate

The command to gather polygon which was select , by search query or select direct with polygon beside distance snap tolerance which was assigned, by delete the longest line of polygon which was selected. By the most of data delete from

classify to used lane, in the part of noise or the less part out off , then gathering into the most of area.

9. Data delete by Erase Cover

Data delete from map as Graphic feature from the first map in-theme, by using second map was a the erase-theme which have overlay area were polygon, line, point or multi-point similar as clip ,but erase cover was a remain external data of erase-theme.

10. Distance between data of 2 theme with Near

The command to use in distance calculate from each feature in 1 theme to feature the nearest in the other theme, distance will record in field.

11. Data adjusting portion to Update

This method was instead area in one theme by the other theme, by overlay between in-theme and update-theme (specific area data) out-theme consist to field all of 2 theme.

2.5 Related research.

Watcharapong Sangnil (2006) who was study the applying to use geography information system (GIS) in work of hemorrhagic monitor in the area of Detchudom Ubolratchatani province. It was studying spreading and hemorrhagic incidence risk area analysis. To conduct geography information system (GIS) help in keep data, data analysis and display the result of data analysis. The method of data analysis was taking geography information system (GIS) to help in data management, keeping data and data analysis in Spatial datawhich was gathering and making into category or divided data Layer and connection with Attribute data to relate data, by district of record in each table to refer relationship and hemorrhagic incidence risk area analysis. From the result of area analysis in Detchudom district. It had several sub-district to have a hemorrhagic incidence risk especially in Detchudom sub-district and Somsaaad sub-district which perhaps since the thickness of population factor and several live areas to effect to hemorrhagic incidence risk area.

Sombat Aumoung (2007) who was study the applying to use geography information system (GIS) to manage an avian influenza in Thailand, by gathering data in the part of avian influenza spreading since July 2004 until November 2005, found examine total 1,748 point, by observe in the year 2004 in July– December total 1,560 point and year 2005 in January – November total 188 point respectively, which the most of month was October 2004, by observe total 748 point which in this period to examine found avian influenza in all of nations area which relate with this period in Thailand had quit a cold temperature, by expectation an avian influenza infection could grow up and breed the best. A basic data of physical of area and a basic population data, economy, social and simulation connection using in expectation tend to a avian influenza incidence from study of FAO in applying program of geography information system. It was a result of analysis and expectation tend to a avian influenza incidence from Model of FAO which was a Logistic regression. For finding a major factor with incidence and expectation tend to avian influenza risk level in each area to connect and show the result with the other spatial data which relate from experiment to take a data position of incidence and the result of avian influenza risk data analysis to overlay, found the area was related and not related, said that in the area where had the result of data analysis from FAO, assigned high risk, but in some area not found avian influenza incidence but in some area had the result to relate in the same direction.

Yupayong Paha (2008) who was study the applying to use (GIS) for design geography information system in epidemiology of Leptospirosis. For applying to use geography information system in monitor Leptpspirosis incidence risk area and support to decision in management in the area of Autumpronpisai district and Phosuwan district, Srisaket province and gathering the factor of Leptospirosis spreading as 8 factor were Benefit of land, distance of river, distance of water resource, the thickness of population in year 2008, distance from patient incidence point as1 square-kilometer in year 2004 – 2007 2547-2550 , by assign weight of number and Overlay data of each factor and evaluation efficiency of system by Black Box Testing. The result of study was found the age group of patient as 24 – 60 years 75.36% they were a working age and male patient 68.84% the most of patient were a farmer 93.03% education level were in primary level 66.67% the most of sub-district

risk area was Khan loeang sub-district with area 9.66 square-kilometer , the result was efficiency in the excellent level and average at 8.99.

Wantana Klangburam (2009) who was study the applying to use (GIS) to indentify risk level area of Leptospira incidence of sub-district in Khonkhen province. Using data was a secondary of frisk area actor which relate with Leptospirosis incidence which was from The office of diseases prevention and control 6 Khon khen province, The office of livestock Khon khen province, The office of environment 10 Khon khen province and Veterinary research and development center (Upper Northeastern region) Khon khen province.Using multiple logistic regression analysis with technique eliminate variable type in finding spatial data factor of Leptospirosis incidence relation. The variable was related with incidence of pathogen in a major statistic as benefit of land and reaction variable between area where was incidence of pathogen and ground surface water resource, design of variable layer to 2 or 3 layer and build database with GIS. By create data layer were 6 simulation and overlay with multiply result by risk factor .Using utility program of GIS to select the best proper simulation by using Kappa statistic in analysis to find relation between risk level of sub-district From GIS with 506 report, the result of study was found the highest all of sub-district total 70 sub-districts from total 199 sub-districts, cover area 4,032.3 Kilometers and found the highest of district with leptospira incidence. The most of district were spread in Moung district, Kranoun district and Nong reah district.

CHAPTER III
RESEARCH METHODOLOGY

3.1 Populations and Samples.

3.1.1 Populations.

Population in our case study is the group of leptospirosis patients in Sisaket province which the population data is taken from Bureau of Epidemiology, Department of communicable disease control, since 2004 – 2014.

3.1.2 Samples.

The size of samples is determined by of Taro Yamane method (Yamane, 1970: 580-581). It is was conducted by assigning a confidence level of 95% having error level of 0.04. The formula is given as:

$$n = \frac{N}{1 + Ne^2} \quad \text{..... (3.1)}$$

Where,

n = Sample size;

N = Population size;

e = Level of precision;

From Eg.(3.1), we could calculate the sample size from the given population size of 4,528 people as follows.

$$n = \frac{4{,}528}{1 + \left(4{,}528 \times (0.04)^2\right)} \text{.....} \quad \text{(3.2)}$$

$$n \approx 550 .$$

3.1.3 The study area.

The study area is Sisaket province.

Geography: Sisaket province is located in the northeastern region at 14-15 degrees north latitude and 104-105 degrees east longitude. It is located 120 meters above sea level. There is an area of 8,929.06 square kilometers. It is far from Bangkok to the northeast on highway no. 24 at a distance of 576 kilometers. It's environment is mainly plain areas in the north and central part of the province. The South is the slope and undulating. The neighboring provinces of Sisaket province are given as:

North Border is with Roi Et province and Yasothon provinces;

South Border is with Cambodia;

West Border is with Surin province;

East Border is with Ubon Ratchathani province.

(Source: Sisaket Provincial Office)

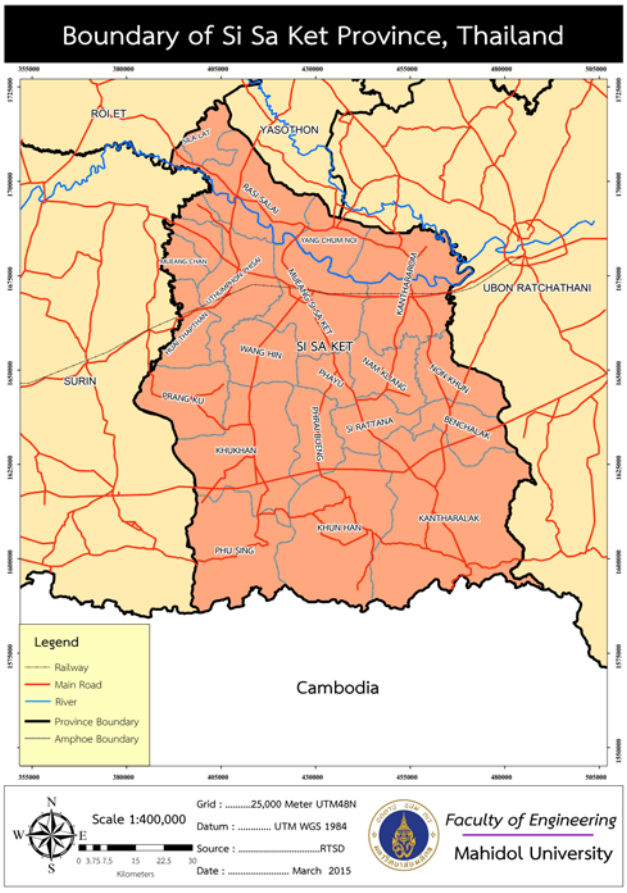

Figure 3.1 Sisaket Boundary Map

Climate: Generally, the climate is very hot in summer and very cold in winter. There are heavy rains in the rainy season in September, especially for the

center and southern part of the province. There are less and rarely consistent rainfall in the northern area of the province. Or the average results in one year, it will be rain around 100 day with the average rainfall of 1200-1400 mm per year. The temperature ranges from 10 to 40 degrees Celsius with the average around 26-28 degrees Celsius. The average relative humidity is 66-73 percent.

Administrative Boundaries: Sisaket province is divided into 22 districts, 206 sub-districts as follows:

Table 3.1 Number of sub-districts.

No.	Districts	No. of sub-districts.
1	Mueang Sisaket	18 sub-districts
2	Yang Chum Noi	7 sub-districts
3	Kanthararom	16 sub-districts
4	Kantharalak	20 sub-districts
5	Khukhan	22 sub-districts
6	Phrai Bueng	6 sub-districts
7	Prang Ku	10 sub-districts
8	Khun Han	12 sub-districts
9	Rasi Salai	13 sub-districts
10	Uthumphon Phisai	19 sub-districts
11	Bueng Bun	2 sub-districts
12	Huai Thap Than	6 sub-districts
13	Non Khun	5 sub-districts
14	Si Rattana	7 sub-districts
15	Nam Kliang	6 sub-districts
16	Wang Hin	8 sub-districts
17	Phu Sing	7 sub-districts
18	Mueang Chan	3 sub-districts
19	Benchalak	5 sub-districts
20	Phayu	5 sub-districts
21	Pho Si Suwan	5 sub-districts
22	Sila Lat	4 sub-districts

3.2 Research Model.

This research is a descriptive study in order to determine the risk of infection of leptospirosis in each sub-district in Sisaket province by geographic information system (GIS).

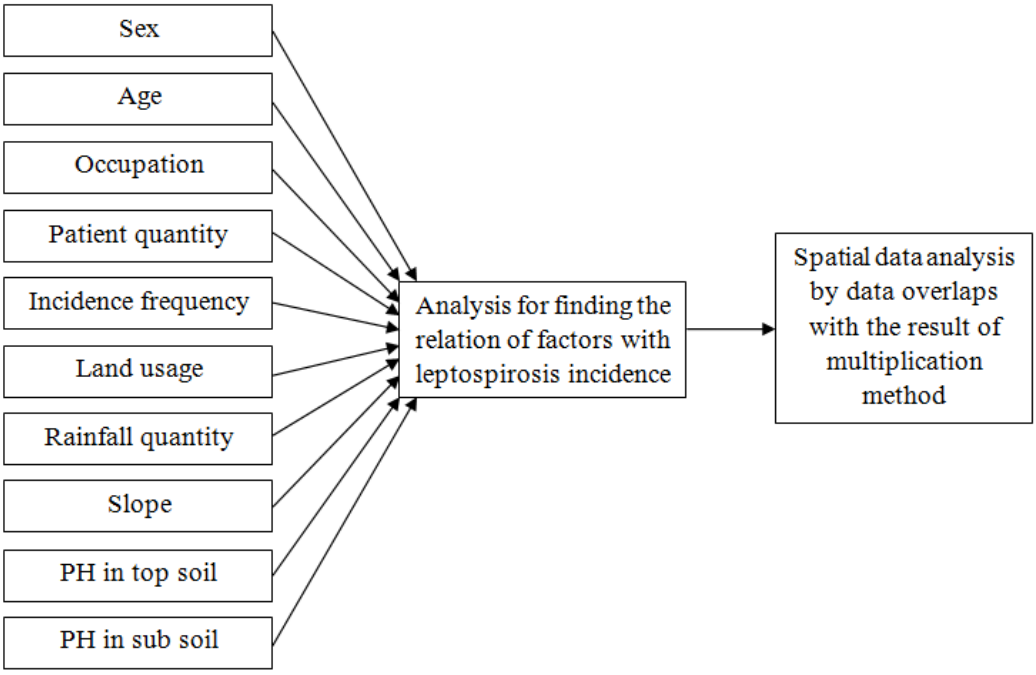

Figure 3.2 Research Frame work.

As the conceptual framework of this research, it consists of the variables used in this research as follows:

1.) Independent Variables

1.1 Gender: It refers to the gender of patients in each sub-district, according to the 506 report.

1.2 Age: It refers to age of patients in each sub-district, according to the 506 report.

1.3 Occupation: It refers to occupation of patients in each sub-district, according to the 506 report.

1.4 Slope: It refers to steepness of the study areas. The higher the slope is, the higher the steepness will be.

1.5 PH value in the topsoil: It refers to the value of acid-alkali level in the top layer, which is resulted as infection of leptospirosis.

1.6 PH value in the subsoil: It refers to the value of acid-alkali level in the lower layer, which is resulted as infection of leptospirosis.

1.7 The frequency of the disease: It refers to the disease frequency of leptospirosis in the study area.

1.8 Rainfall: It refers to the rainfall level in the study area.

1.9 Land usage: It refers to the usage of land, such as agriculture, construction of residential buildings, etc.

1.10 Number of patients in the area: It refers to the number of patients in the study area of Sisaket province.

2.) Dependent Variables: These depend on the independent variables effect the disease in the studied area.

For the risk level determination of leptospirosis incidence area in each district of Sisaket province, there are 5 step for finding as follows:

1. Data gathering: By the education document reviewed and research preceeding, from spatial factor review of leptospirosis incidence, it take to create data level into the spatial analysis with 7 factors including the personal data property of 3 factor.

2. Data level creation: It is a base creation of spatial data and the risk data level by risk factor that is used to create data level from the relation evaluation between risk factor and leptospirosis incidence factor analysis. The multiple logistic regression analysis of factor is to assign the condition of data level generated by Geography information system (GIS). Which is equipment to create the data level.

3. Data analysis with overlap data by result of data level multiply in each factor and used result of analysis to arrange risk level of leptospirosis incidence area with assigning period of point risk level , it could divided as 5 level as the highest, high, immediate, low and lowest.

4. Inspection relate of data from this study and 506 report data.

5. Study reporting with risk level of leptospirosis incidence area plan of district in Sisaket province.

3.3 Research Instruments.

3.3.1 Computer with CPU Core i5 3.5 GHz, DDR3 Ram 4 GB, and Harddisk 1 TB.

3.3.2 SPSS 17.0

3.3.3 ArcGIS 10.0

3.4 Data Collection.

For the data in this study, there are 2 parts of data, given as: Spatial data which refer to data of geography passion (Geo-referenced) from ground and Non-spatial data which refers to the data of each characteristic in this area (Attributes).

Table 3.2 Source of information for the research.

Information	Source	Year of collection
- Patient information from the 506 report	Bureau of Epidemiology, Department of Disease Control	2004 – 2014
- Information of Land Usage	Land Development Department	2011
- Soil Information	Land Development Department	2011
- Average Rainfall in a period of 30 years	Thai Meteorological Department	1972- 2012
- Slope Information	Royal Thai Survey Department (L7017)	2011

3.5 Data Analysis

In this study, the analysis methods can be classified into 2 parts, given as the leptospirosis incidence risk analysis and the spatial data analysis. The details of data analysis methods can be summarized as follows:

3.5.1 Leptospirosis incidence risk analysis.

The method of analysis to find relation between leptospirosis incidence and spatial data factor for finding variable to create data level in Spatial analysis method (Spatial Analysis). In this step to find this relation by using multiple logistic regression analysis with analysis technique as Backward Elimination.

The variables used in this study are the dependent variables, which are vulnerable area of the leptospirosis infection, and initial variable, which are consisted of seven area factor variables: Number of patients in the area, frequency of disease in the area, usage of land, rainfall, slope, acid-alkali value within the topsoil, and acid-alkali value within the lower soil. Three personal factor variables are gender, age, and occupation.

When making analysis of all variables to find the relationship between risk factors and leptospirosis in each sub-district by using multiple logistic regression by backward elimination, it is found that there six risk factors of leptospirosis infection given as: land usage, slope, frequency of disease, and PH value within area, number of patients in the area and rainfall. Experts can identify each factor as in Table 3.2

Table 3.3 Initial Variables Details.

Initial variables	Possible variables	Weighing risks
Slope value	1 – 18 degrees	5
	19 – 36 degrees	4
	37 – 54 degrees	3
	55 – 72 degrees	2
	73 – 90 degrees	1
Land usage	Farming area	5
	Gardening area	4
	Community area	3
	National Forest	2
	Other areas	1
PH value in the topsoil	6.8 – 7.7	5
	5.8 – 6.7	4
	4.8 – 5.7	3

Table 3.3 Initial Variables Details (Cont.)

Initial variables	Possible variables	Weighing the risks
	3.8 – 4.7	2
	2.8 – 3.7	1
Frequency of disease	9 years and up	5
	7 – 8 years	4
	5 – 6 years	3
	3 – 4 years	2
	1 – 2 years	1
number of local patients	113 – 140 people/sub-district	5
	85 – 112 people/ sub-district	4
	57 – 84 people/ sub-district	3
	29 – 56 people/ sub-district	2
	1 – 28 people/ sub-district	1
Rainfall	1,601 - 1,800	5
	1,401 – 1,600	4
	1,201 – 1,400	3
	1,001 – 1,200	2
	800 – 1,000	1

3.5.2 Geographical Analysis.

Geographical analysis is an application of GIS analysis as a tool to analyze area that is the risk of disease. The geographic factors related to leptospirosis, are taken from multiple logistic regression. Then, making geographic analysis to find the risk level of leptospirosis in each area by multiplying information of all factors and report by using risk level of each area. To define the risk level of each of the areas divided into five levels as follows:

5 means very high risk;

4 means high risk;

3 means medium risk;

2 means low risk;

1 means very low risk;

Source: Pornpen Supatawuttinan (1988 refer from Land Development Department, 1992, FAO, 1983 and Sys and party, 1993)

When making analysis of derived factors to find the relationship between risk factors, it found six risk factors of leptospirosis infection: land usage, slope, frequency of disease, and acid-alkali value within area, number of patients in the area and rainfall. Then, making geographic analysis to find the risk level of leptospirosis in each area by multiplying information of all factors and report by using risk level of each area. To define the risk level of each of the areas divided according to each area into 5 levels as Table 3.3

Table 3.4 Display the value of variables based on dependent variable.

Dependent variables	Score range	Value of dependent variables
very high risk	85 – 105	5
high risk	64 – 84	4
medium risk	43 – 63	3
low risk	22 – 42	2
very low risk	1 – 21	1

3.6 Research Schedule.

Table 3.5 Research Schedule.

NO	Task\Month	Jan		Feb		Mar		Apr		May		Jun		Jul	
1	Data study and Leptospirosis risk area finding	■	■	■	■	■	■								
2	Data gathering.			■	■	■									
3	Principle of data analysis.					■	■	■							

Table 3.5 Research Schedule. (Cont.)

NO	Task\Month	Jan		Feb		Mar	Apr	May		Jun		Jul	
4	Risk level method of leptospirosis incidence area.												
5	The process of analysis.												
6	The process of conclude.												
7	Schedule of research												

CHAPTER IV
RESULTS AND DISCUSSION

This study is to identify the risk level of leptospirosis in a sub-district of Sisaket province by using GIS to analyze the risk area. It consists of the general information of the sample group, the general information of the geographic factor, the relationship between the risk factors and the leptospirosis, the application of GIS for identifying the risk area of leptospirosis infection, and the consistency of information study the 506 report. The discussion is as follows:

4.1 General information of the sample group.

General information from the sample group of this study consists of 451males (82 percent) and 99 females (18 percent). The age of the sample group are: between 24 years or lower at 11.6 percent, 25 – 34 years old at 19.6 percent, 35 – 44 years old at 28.9 percent, 45 – 54 years old at 15.1 percent and 55 – 64 years old at 24.7 percent respectively. The sample group are: 69.6 percent farmers, 0.2 percent government officers, 0.9 percent contractors, 0.2 percent students, 2.5 percent soldiers, 0.2 percent others and 25.5 percent unknown. The details as in Table 4.1:

Table 4.1 General information of the sample group.

Factor	Items	Amount (550)	%
Gender	Male	451	82
	Female	99	18
	Total	**550**	**100**
Age	24 years or below	64	11.6
	25 – 34 years	108	19.6

Table 4.1 General information of the sample group. (Cont.)

Factor	Items	Amount (550)	%
	35 – 44 years	159	28.9
	45 – 54 years	83	15.1
	55 – 64 years	136	24.7
	Total	**550**	**100**
Occupation	Farmers	383	69.6
	Government officers	1	0.2
	Contractors	5	0.9
	Housemaids	1	0.2
	Students	14	2.5
	Soldier	1	0.2
	Others	5	0.9
	Unknown	140	25.5
	Total	**550**	**100**
Number of patients	1 – 28 people/sub-district	235	42.7
	29 – 56 people/sub-district	127	23.1
	57 – 84 people/sub-district	76	13.8
	85 – 112 people/sub-district	86	15.6
	113 – 140 people/sub-district	26	4.7
	Total	**550**	**100**
Frequency of disease	1 – 2 years	6	1.1
	3 – 4 years	21	3.8
	5 – 6 years	58	10.5
	7 – 8 years	122	22.2
	9 years and up	343	62.4
	Total	**550**	**100**

4.1.1 Gender.

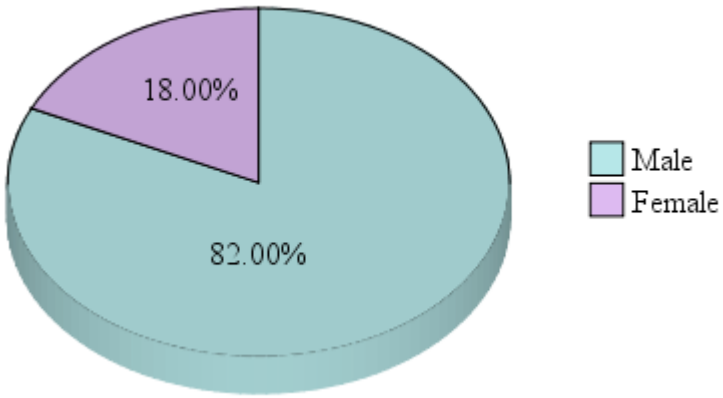

Figure 4.1 Gender of the sample group.

As show in Figure 4.1, it displays all genders of the total sample group of 550 people: 18% female and 82% male.

4.1.2 Age.

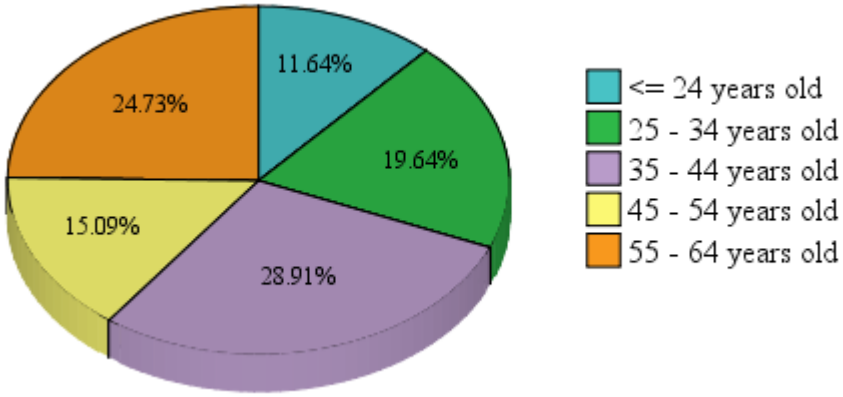

Figure 4.2 Age of the sample group.

As show in Figure 4.2, it displays all ages of the total sample group of 550 people: less than or equal to 24 years as 11.64%, between 25 – 34 years as 19.64%, between 35 – 44 years as 28.91%, between 45 – 54 years as 15.09%, and between 55 – 64 years as 27.73%.

4.1.3 Occupation.

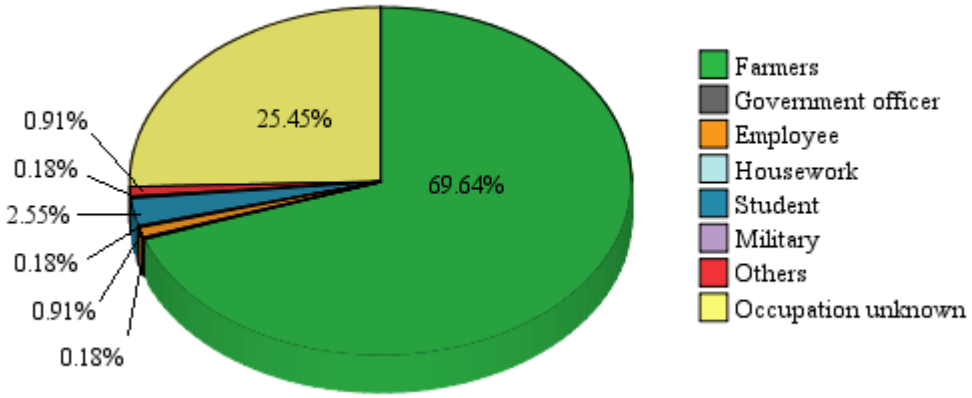

Figure 4.3 Occupation of the sample group.

As show in Figure 4.3, it displays all occupation of the total sample group of 550 people: 69.64% farmers, 0.18% government officers, 0.91% contractors, 0.18% housemaids, 2.55% students ,0.18% soldiers, 0.91% others, 25.45% unknown.

4.1.4 Number of patients.

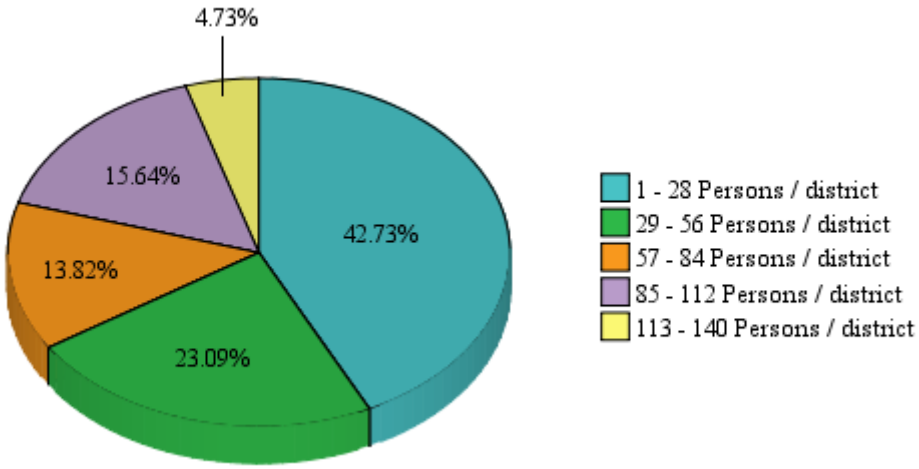

Figure 4.4 Number of patients per district.

As show in Figure 4.4, it Displays all patients of each district of the total sample group of 550 people per district: 1 – 25 people at 42.73%, 29 – 56 people at 23.09%, 57 – 84 people at 13.82%, 85 – 112 people at 15.64%, 113 – 140 people at 4.73%.

4.1.5 Frequency of disease.

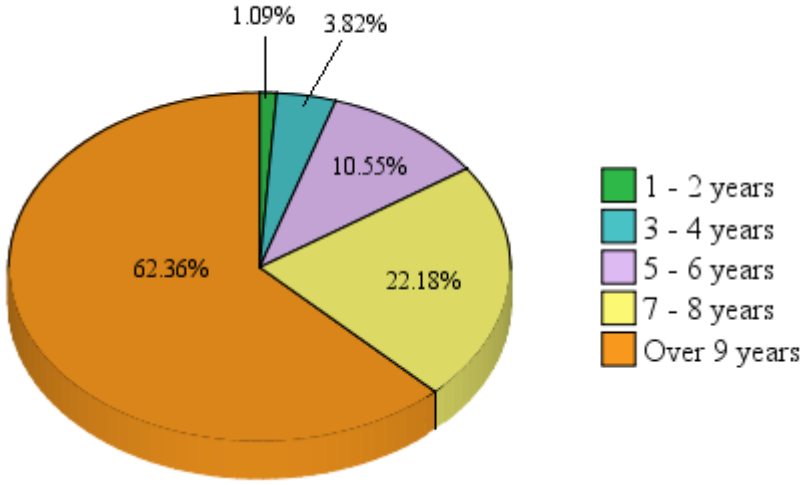

Figure 4.5 Frequency of disease.

As show in Figure 4.5, it displays the frequency of disease in each sub-district of the total sample group of 550 people, frequency of the disease 1 – 2 years at 1.09%, 3- 4 years at 3.82%, 5 -6 years at 10.55%, 7 – 8 years at 22.18%, and more than 9 years at 62.36%.

4.2 General Information of geographic factors in the study area.

General information of geographic factors in this study consists of land usage, which is the national forest area at 10.4%, gardening at 36.7%, farming at 49.6% and others at 3.3%. Rainfall within the area is 1,201 – 1,300 mm or 97.8%. The slope of the area is 74 ° – 90 ° or 63.27%. The PH value in the topsoil of the most area is 5.8 – 67 or 98.18% and the PH value in the subsoil is quite the same. The details are as in table 4.2:

Table 4.2 General Information of Geographic Factors of the Study area.

Factor	Items	Amount (550)	%
Land used	National Forest	57	10.4

Table 4.2 General Information of Geographic Factors of the Study area. (Cont.)

Factor	Items	Amount (550)	% (100)
	Gardening area	202	36.7
	Farming area	273	49.6
	Community and other areas	18	3.3
	Total	**550**	**100**
Rainfall	1,001 – 1,200 mm	2	0.4
	1,201 – 1,300 mm	538	97.8
	1,301 – 1,400 mm	10	1.8
	Total	**550**	**100**
Slope value	1 – 18	91	16.5
	19 – 36	56	10.2
	37 – 54	41	7.5
	55 – 72	14	2.5
	73 – 90	348	63.3
	Total	**550**	**100**
PH value in the topsoil.	4.8 – 5.7	10	1.8
	5.8 – 6.7	540	98.2
	Total	**550**	**100**
PH value in the subsoil.	4.8 – 5.7	279	50.7
	5.8 – 6.7	271	49.3
	Total	**550**	**100**

4.2.1 Land used.

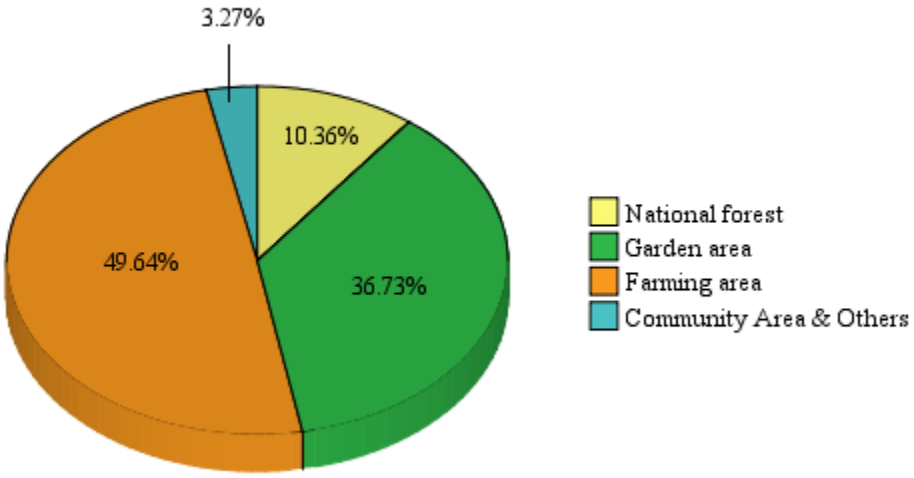

Figure 4.6 Land used.

As show in Figure 4.6, it displays the land usage in the nation forest, as follows: gardening is with 10.36%, farming is with 49.64%, community and other are with 3.27%.

4.2.2 Rainfall.

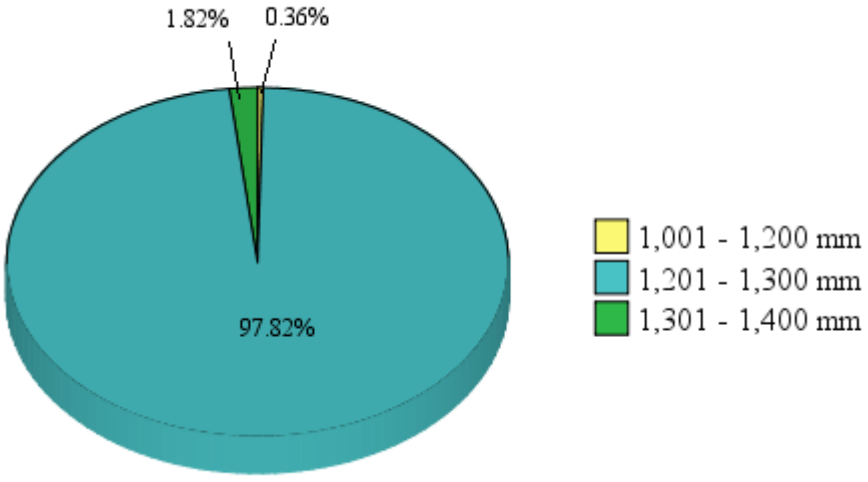

Figure 4.7 Rainfall.

As show in Figure 4.7, it displays the rainfall. There are rainfall in most area at 1,201 – 1,300 mm which is 97.82% of total areas, the rainfall level of 1,301 –

1,400 mm which is 1.82% of total areas, and the level of 1,001 – 1,200 mm which is 0.36% of total areas.

4.2.3 Slope.

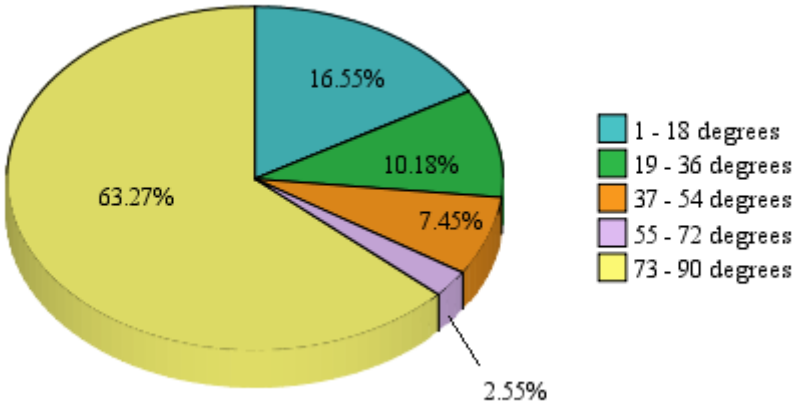

Figure 4.8 Slope.

As show in Figure 4.8, it displays the slope value of all areas are 73 – 90 ° at 63.27%, 1 – 18 ° at 16.55%, 19 – 36 ° at 10.18%, 37 – 54 ° at 7.45%, and 55 - 72 ° at 2.55%.

4.2.4 PH value in the topsoil.

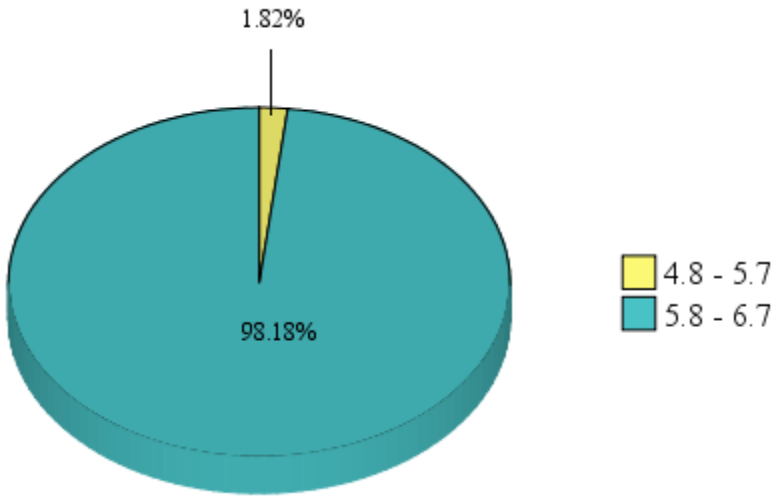

Figure 4.9 PH value in the topsoil.

As show in Figure 4.9, it displays PH value in the topsoil of most areas are 5.8 – 6.7 at 98.18% and 4.8 – 57 at 1.82%.

4.2.5 PH value in the subsoil.

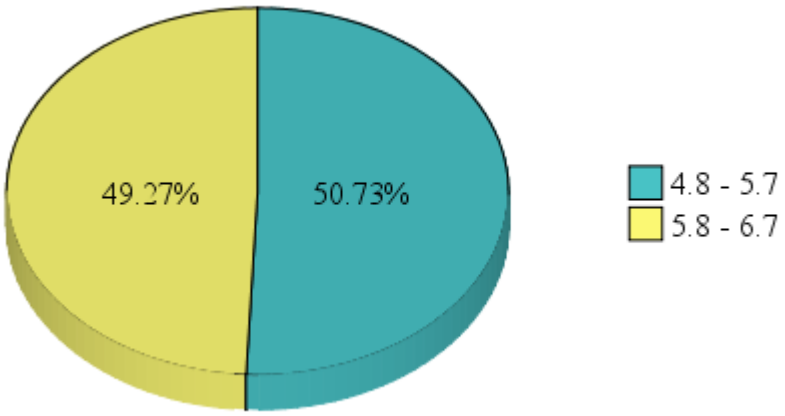

Figure 4.10 PH value in the subsoil.

As show in Figure 4.10, it displays PH value in the subsoil are 5.8 – 6.7 at 49.27% and 4.8 – 5.7 at 50.73%.

4.3 Information display by Arc GIS application.

4.3.1 Analysis of Risk Areas from Land Use.

The analysis of the risk area from land usage, the researcher found that farming area has the highest risk for the disease. The second one is gardening area, community area, forest area, and other respectively as show in Table 4.3 and Figure 4.11.

Table 4.3 Risk level according to land usage.

Land usage	Risk Level
Farming area	5 = Very high risk
Gardening area	4 = High risk
Community area	3 = Medium risk
Forest area	2 = Low risk
Other areas	1 = Lowest risk

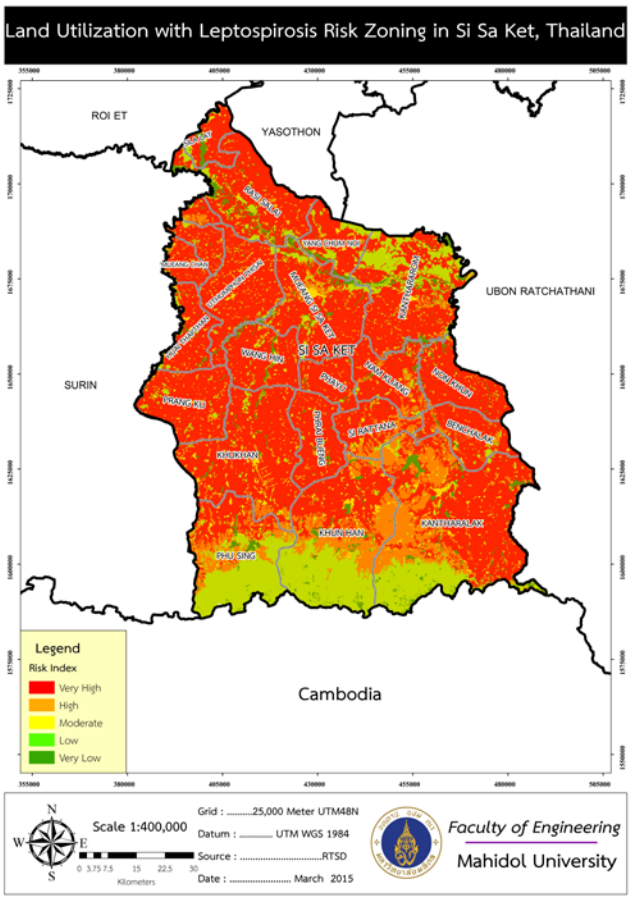

Figure 4.11 Land Usage Map.

4.3.2 Analysis of Risk Areas from Slope

The analysis of the risk area from slope, the researcher has studied and reviewed the related researches and interviews from the experts. It is found that the slope area at 1 - 18° has the highest risk of disease, following by 19 - 36°, 37 - 54°, 55 - 72° and 73 - 90°, respectively, as show in Table 4.4 and Figure 4.12

Table 4.4 Risk level according to slope.

Slope value	Risk Level
1 – 18 degrees	5 = Very high risk
19 – 36 degrees	4 = High risk
37 – 54 degrees	3 = Medium risk
55 – 72 degrees	2 = Low risk
73 – 90 degrees	1 = Lowest risk

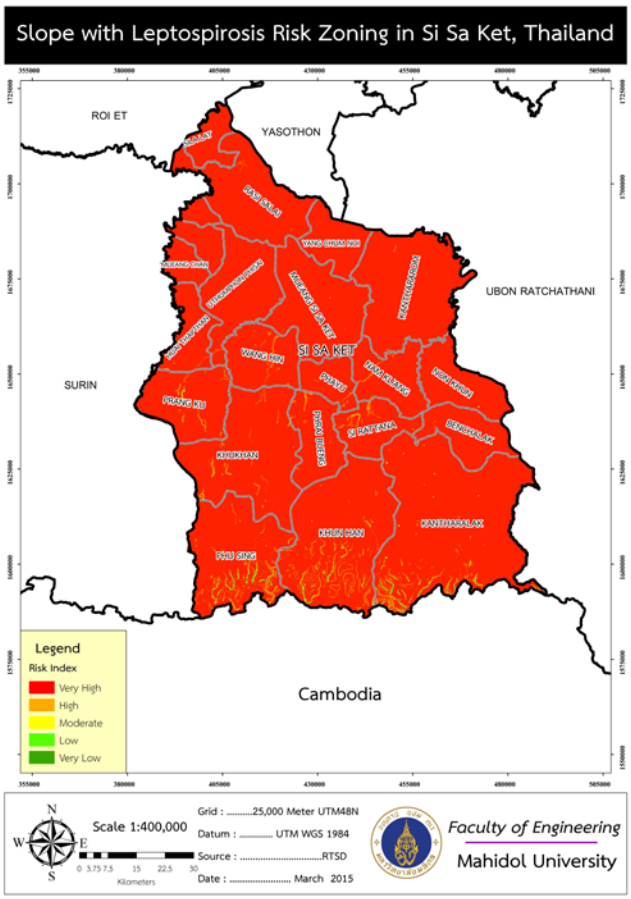

Figure 4.12 Frequency of disease map.

4.3.3 Frequency of disease.

The analysis of the risk area from the frequency of disease, the researcher found that the frequency of disease is higher in accordance with the risk level as show in Table 4.5 and Figure 4.13.

Table 4.5 Risk level according to frequency of disease.

Frequency of disease	Risk Level
9 years and up	5 = Very high risk
7 – 8 years	4 = High risk
5 – 6 years	3 = Medium risk
3 – 4 years	2 = Low risk
1 – 2 years	1 = Lowest risk

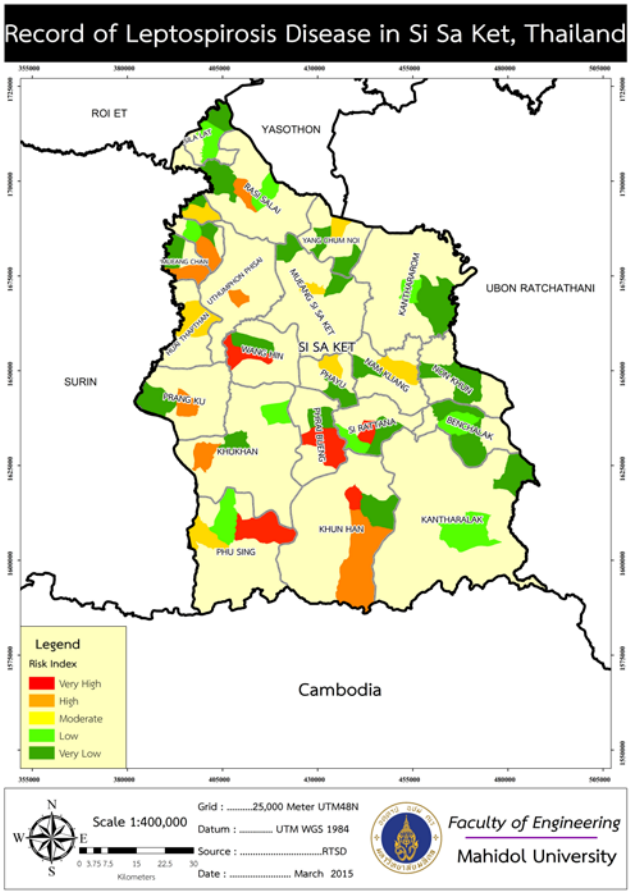

Figure 4.13 Frequency of disease map.

4.3.4 PH value in the topsoil.

The analysis of the risk area from PH value in the topsoil, the researcher found that PH value in the top soil at 6.8 - 7.7 is the highest risk area, then follows by 5.8 - 6.7, 4.8 - 5.7, 3.8 - 4.7 and 2.8 - 3.7 respectively as show in Table 4.6 and Figure 4.14.

Table 4.6 Risk level according to the PH value in the topsoil**.**

PH value in the topsoil	Risk Level
6.8 – 7.7	5 = Very high risk
5.8 – 6.7	4 = High risk
4.8 – 5.7	3 = Medium risk
3.8 – 4.7	2 = Low risk
2.8 – 3.7	1 = Lowest risk

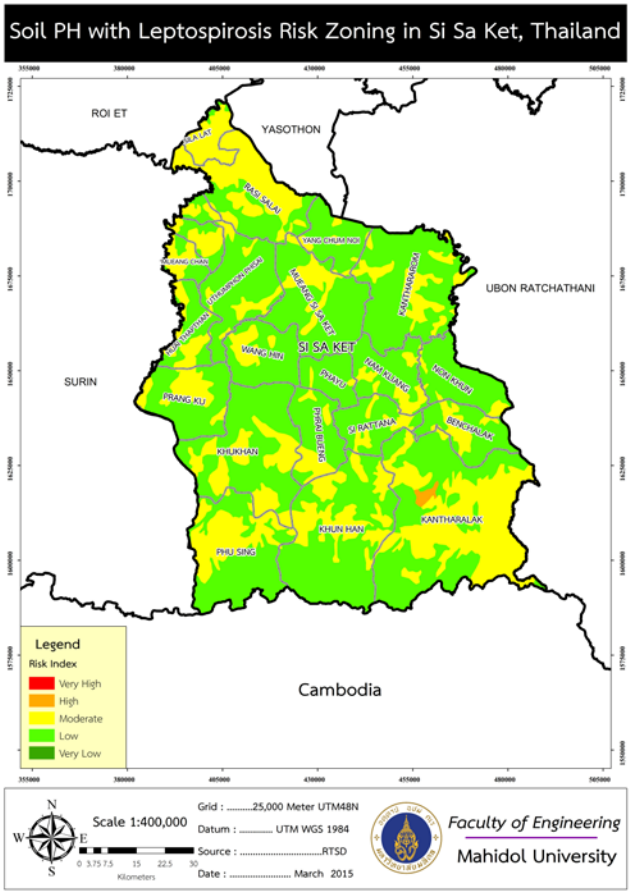

Figure 4.14 PH value in the topsoil.

4.3.5 Number of patients.

The analysis of the risk area from the number of patients in the area, the researcher found that higher number of patients is higher in accordance with risk level as show in Table 4.7 and Figure 4.15.

Table 4.7 Risk level according to the number of patients in the area.

Number of local patients	Risk Level
113 – 140 people/sub-district	5 = Very high risk
85 – 112 people/ sub-district	4 = High risk
57 – 84 people/ sub-district	3 = Medium risk
29 – 56 people/ sub-district	2 = Low risk
1 – 28 people/ sub-district	1 = Lowest risk

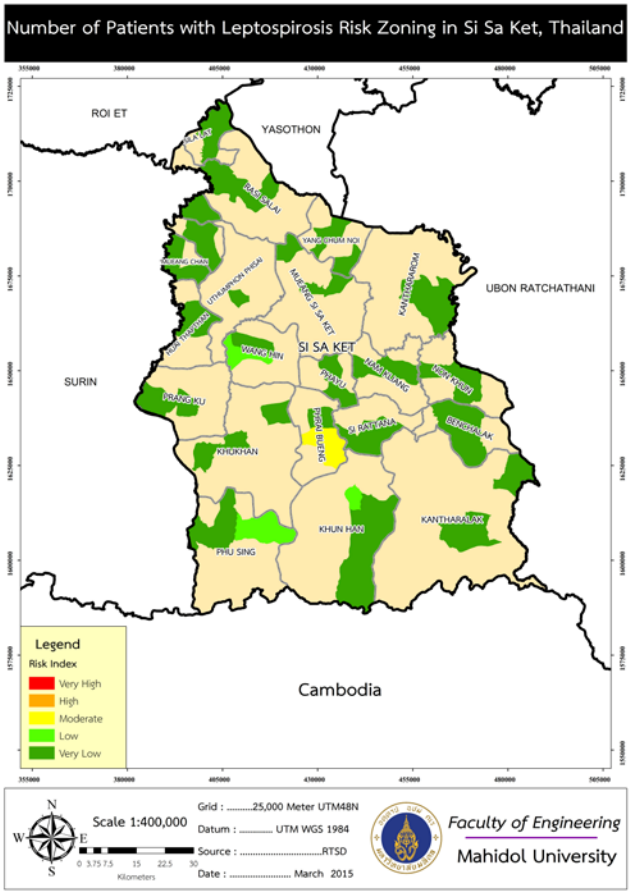

Figure 4.15 Number of patients.

4.3.6 Rainfall

The analysis of the risk area from the rainfall, the researcher found that rainfall is higher in accordance with risk level as show in Table 4.8 and Figure 4.16.

Table 4.8 Risk level according to rainfall.

Rainfall	Risk Level
1,401 – 1,600 mm	5 = Very high risk
1,201 – 1,400 mm	4 = High risk
1,101 – 1,200 mm	3 = Medium risk
801 – 1,000 mm	2 = Low risk
601 – 800 mm	1 = Lowest risk

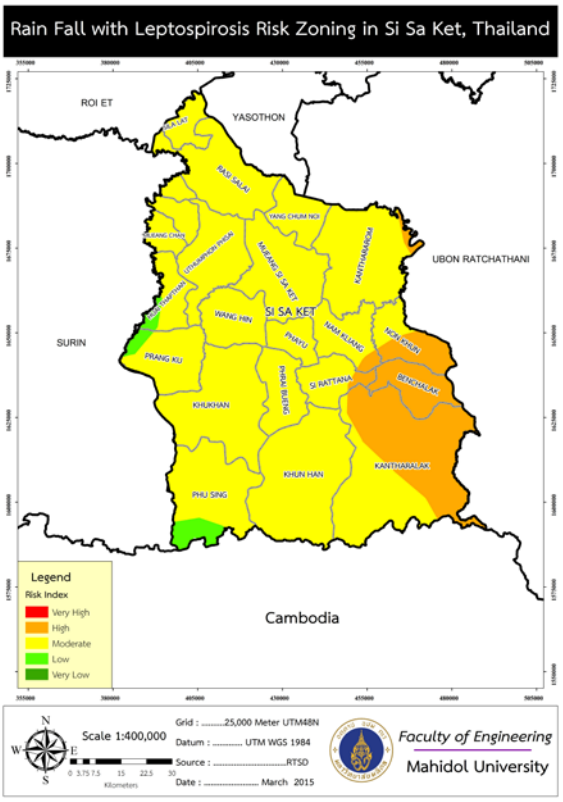

Figure 4.16 Rainfall map.

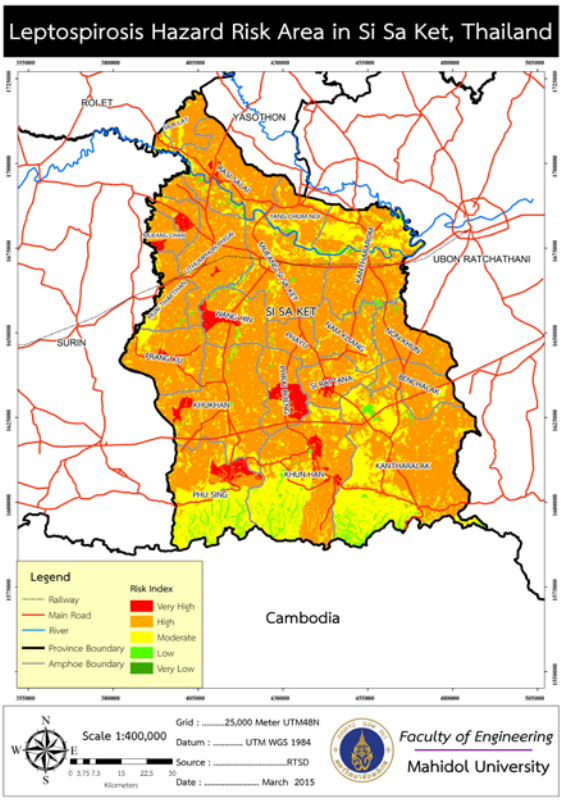

Figure 4.17 Result map.

4.4 Descriptive Analysis.

The analysis is to find the relationship between geographic risk factor and leptospirosis by using the information overlay for the geographical analysis as follows:

4.4.1 Multiple Logistic Regression Analysis.

When bringing all the variables in this study to analyze by using multiple logistic regression method to find the relationship of leptospirosis in the study area, the result of the analysis found six variables, which cause the disease: land usage, slope, frequency of the disease, PH value in the topsoil, number of patients, and rainfall respectively. From the Table, it shows that these factors is significantly related to the leptospirosis infection in the risk area. The multiple correlation coefficient is .953 and can predict the leptospirosis risk area at 91% of population with standard deviation equals to ±.36. With the multiple logistic regression method for finding the relationship of leptospirosis in the area, the analysis results are given as six variables concerning the disease, such as land usage, slope, frequency of the disease, PH value in the topsoil, number of patients, and rainfall respectively.

Table 4.9 Results of multiple logistic regression analysis.

Factor	b	Std. Error	Beta	t	p-value
Land usage	.036	.001	.617	29.891	.000
Slope value	-.055	.001	-.761	-46.793	.000
Frequency of disease	1.135	.049	.326	22.995	.000
PH value in the topsoil.	.471	.022	.402	21.546	.000
Number of patients	.725	.047	.231	15.415	.000
Rainfall	.429	.104	.059	4.119	.000

From Table 4.9, to consider the regression coefficient of the predictors, it is found that the slope can be significantly predicted the leptospirosis infection area with the value of .01. The raw score and standard regression coefficients are given as .055 and .761. Next is the land usage that can predicts the leptospirosis infection area

maximally and significantly at .01. It has regression coefficients in form of raw score and standard regression coefficients at 0.36 and .617.For the rainfall that can predicts the leptospirosis infection area significantly at .01. It has regression coefficients in form of raw score and standard regression coefficients at .429 and .59.

The equation for the prediction of leptospirosis infection in the risk area is given as:

$$MS' = 8.938 + .036LU - .055SL + 1.135RC + .471PHUP + .725NP + .429RF,\ldots..(4.1)$$

where, LU = Land Usage;
SL = Slope;
RC = Frequency of disease;
PHUP = PH value in the topsoil;
NP = Number of patients;
RF = Rainfall.

4.5 Discussion of Findings.

4.5.1 Discussion of the study results.

To consider the analysis results of the risk of leptospirosis infection from this study, there are 38 very high-risk sub-districts, covering the area of 270.80 square kilometers. It can be considered as 3.03% of all areas. The very high-risk district are mostly distributed in Bang Khun Han and Sri Rattana sub-districts. It is in accordance with the 506 report 2010 which found higher leptospirosis in these 3 district, therefore it could say that all 38 sub-districts are areas which need to be very careful and to prevent toxic disease because there is higher risk to be infected by leptospirosis.

Because the data obtained from the comparison with the 506 is not a comparison to the benchmark, but as compared to the alternative to support research that is the same with existing surveillance systems. Thus, consideration had to extend to include parts that are important in disease surveillance. This difference is likely to be taken into consideration when the data were analyzed using GIS. To find an area

with a very high degree of risk. However, the 506 report identified such areas with a moderate level of risk. The significance of the differences in risk factors depends on the data used to analyze the Geographical information that has changed less than from the 506 reports. Although it has improved over the years, it still has problems with the completeness and the accuracy of information. In addition, the log report also based on the doctor's diagnosis that the initial diagnosis might diagnose with other diseases then change the diagnosis later. These limitations may cause patients to the 506 report to delay. Thus, the number of cases in the 506 report may be less than the actual number. Therefore, it is evident that the benefits derived from the application of GIS to identify the level of risk of leptospirosis has covered more than 506 reports. One option is to put the data from the analysis of the application of GIS to use as a supplement to the surveillance system from 506 report according to a more comprehensive and strong surveillance system.

This study it is found that there are six variables associated with the leptospirosis disease, given as land usage, slope, frequency of the disease, PH value in the topsoil, number of patients, and rainfall. It found that the risk factors on the slope and land usage have higher risk of leptospirosis infection more than other factors. From the study of the geographical, relationships of risk factors and the leptospirosis disease found that this study will support workers in the area to be clearer in their operations in order to plan the operation within the area more effective. However, this study focus on the issue of Geographical risk factors, which realized that the leptospirosis disease has several elements, both natural and related environment that are mainly geographic related issues. However, there are other important factors, which are important such as risk behavior of people within the area and reservoir. Therefore, using the result of this study alongside with other study would maximize the benefits of surveillance, prevention and control.

4.5.2 GIS Application Discussion.

Currently, statistics is suitable and widely used in the analysis of environment. It is the analysis by using GIS to analyze information. For the idea of using variables to make analysis in this study, although the researcher had chosen to apply GIS to analyze information, which are mainly geographical information, the

researcher also brought in personal variables such as age, occupations, and gender of most population within the area to make the analysis. It is generally acknowledge in health science that any diseases caused by many factors; therefore bringing other variables, which are not geographic variables, would make the study more complete.

For the geographical analysis in this study conducted by using overlay multiplier of risk factors, because after literature review it was found that most study which are similar to this study conducted by using overlay multiplier of risk factors, and the result of the study were in accordance with information and acceptable. Therefore, the researcher also chose overlay multiplier of risk factors as a method for this study. When making verification of information from the study from the 506 report and found that information are in accordance, thus using overlay multiplier of risk factors might be suitable for this study. Nevertheless, there are many methods of overlay, such as adding, subtract, division, logic, etc. If conduct the overlay by various method, it would be possible to fine the most suitable one. However, there are limitation of study time. The researcher chose to use overlay multiplier as mention. Thus, if there are other studies, which look similar with this study, it is possible to try other overlay methods to find the most suitable one.

4.5.3 Statistics Discussion.

In the medical and public health care, there are many factors to explain the relationship of diseases. Thus, it is important to choose a statistical data analysis to describe the relationship of those factors to the disease. This is indicate the level of risk of leptospirosis infection. The data used in the study is geographical information. Therefore, the appropriate and common statistical analysis used for this type of analysis is geographical analysis by applying geographic information system to identify the risk level of the area, because geographical information is very detailed. Thus, if all variables that are relevant to the analysis, it will cause problems in the process of overlaying the information because of too many details. It may has a problem about computer processing capacity. As an alternative to the other choices for the analysis, thus in this study the researcher chose only the variables that are associated with the disease and brought to the geographical analysis in order to avoid such the limitation. From the literature review, all variables used in this study were

associated with the leptospirosis disease. However, there is no statistical confirmation for these variables. In addition, there is no analysis by using multiple geographical variables before. In order to control other variables in this study, the researcher chose multiple logistic regression in the selection of variables that correlated with the leptospirosis disease in Sisaket province significantly to use in the geographical analysis. Besides having, access to the variables that were associated statistically, the limitation of processing large amounts of information by GIS software were reduced by this method.

For the multiple logistic regression in this study, there are many variables considering by geographical variables and personal analysis. From the literature review, it found that all of the variables used in the study were critical to the leptospirosis disease. Therefore, a technique used to analyze the individual variables are backward elimination in order to evaluate the model in this study. The researcher will consider for the selection of those variables within the model together with computer application analysis. Because some of the variables, although the results are not statistically significant related, but if the variables are very important, they cannot be cut off. They will have to be the variable of the study anyway. Therefore, the appropriate method that will used in the final analysis is to eliminate variables from the model, one variable at a time.

The advantage of this study is a model derived from the study that is to identify the level of risk of leptospirosis infection would be stored in the GIS system. Therefore, when data is changed, it is possible to modify new data to analyzed data in accordance with the current situation. In addition, the analysis of the relationships between risk factors and disease is to remove only the factor that correlated to geographical analysis in order to reduce the factors that used in the process of overlay and reduce the problem of information overload. It found that the geographical analysis by overlay only the risk factors that are associated with the disease could determine the risk level, which is close to all of the factors used in data overlay. The conclusions drawn from this study offer as an alternative to use the data for the further study.

CHAPTER V
CONCLUSION AND RECOMMENDATIONS

This research is to determine the risks of leptospirosis infection for each sub-district of Sisaket province by using geographic information system (GIS). The conclusion and suggestion are as follows.

5.1 Conclusions.

This research proposes the use of geographic information system (GIS) to determine the risk level of leptospirosis infection in Sisaket province. The data used in this study are the geographical risk factors associated with the leptospirosis disease totally seven variable, given as: the number of patients in the area, frequency of the disease, land usage, rainfall, slope, PH value in the topsoil, and PH value in the subsoil. In addition, from the literature review, it is found that personal factors variables are critical to the disease in the area as well. Therefore, in this study, such variables are also used together with the geographical analysis as well. There are three personal variables, given as: age, gender, and occupation variables including initial variables for this study totally 10 variables. The selection of the variables to use for the geographical analysis to find the relationship of risk factors for the leptospirosis disease by using multiple logistic regression method. There are factors that associated with the disease significantly, given as: Land usage, slope, frequency of the disease, PH value in the topsoil, number of patients, and rainfall.

The risk level of the analysis can be classified by 5 levels, given as: Very high risk, high risk, medium risk, low risk, and very low risk. By modified the score and score range of the geographical risk factors in order to find the suitable model. Such the suitable derived from the accordance of information from the study and from the 506 report by the geographical analysis that defined the risk score for the geographical risk factor to analyze as follows: very high risk equals 5, high risk equals

4, medium risk equals 3, low risk equals 2 and very low risk equals 1. It found that most sub-district at 67.62% were very high-risk areas as the following details:

Very high-risk area: there are 38 sub-districts, covering 270.80 square kilometers or 3.03% of the total area. The most of areas include Phrai Bueng, Phu Sing, and Wang Hin. Ten districts are not very high-risk area, given as Benchalak, Bueng Bun, Kantharalak, Kanthararom, Sila Lat, Mueang, Nam Kliang, Non Khun, Phayu, and Yang Chum Noi.

High-risk area: There are 196 sub-districts, covering 6,038.03 square kilometers or 67.62 of the total area. The most of area include Kantharalak, Khukhan. and Khun Han.

Medium-risk area: There are 193 sub-districts, covering 2,352.69 square kilometers or 26.35 of the total area. The most of area include Kantharalak, Phu Sing, and Khun Han.

Low-risk area: There are 167 sub-districts, covering 267.25 square kilometers or 2.99% of the total area. The most of area include Kantharalank, Phu Sing, and Khun Han.

Very low-risk area: There are 22 sub-districts, covering 0.29 square kilometers or 0.003% of the total area. The most of area include Benchalak, Bueng Bun, Khukhan, Pho Si Suwan, Sila Lat, Mueang Chan, Mueang, Non Khun, Phayu, Si Rattana, Uthumphon Phisai, and Yang Chum Noi.

Because the data obtain from the study when compare with the 506 report is not the comparison to the benchmark, but as an alternative to support the research in accordance with the existence surveillance system and by the strategic reason, all information has changed little over the data from the 506 report. The area divided between the different levels of risk and the study result from the 506 report, considered as an interest area in details.

5.2 Research limitations

Because this study is the application of geographic information system (GIS) in the area of geographical analysis, the most important step is to determine the pattern in the area of data analysis. In each study should define format to make data

analysis in many models for comparison. For the data-layer creation is an important step in the area of geographical analysis, particularly to define the criteria used to generate the appropriate data layer, which is important to make more accurate study. During bringing the data layer for analysis with overlay method condition for the creation of the data layer is inappropriate, when bring the data layer to analyze by using overlay method, it would make the interpretation of the result deviate from the actual value. It can be determined by checking the consistency of the data. Therefore, for the creation of data layer should study the information beforehand and consult with the experts who crate data layer every time for the accuracy. There are several ways to overlay data. It requires the mathematical process, such as: adding, subtracting, multiplying, and logic. Therefore, researchers have to consider the purpose of the study by themselves. It is not necessary to overlay data by using multiplier for every case.

5.3 Recommendations for Future Research.

- Density variable of reservoir animal should bring into the analysis with other risk factors, because the variable is critical to disease. After the leptospirosis infection found in the urine of reservoir animal, it can survive for 1 year. Therefore, the large number of reservoir animals have a change to release the infection to the environment, rather than small number of the reservoir animals.

- It is possible to use this study as a guideline for the other disease case study, related to the environment, such as dengue fever, malaria, and bird flu.

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APPENDIX

The results of analysis by SPSS.

```
REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT TOTAL_NEW
  /METHOD=BACKWARD SEX agey OCCUPAT Patient Year_num Landuse Rain
slope PH1  .
```

Variables Entered/Removed(b)

Model	Variables Entered	Variables Removed	Method
1	PH1, agey, Landuse, Rain, SEX, OCCUPAT, slope, Year_num, Patient(a)	.	Enter
2	.	agey	Backward (criterion: Probability of F-to-remove >= .100).
3	.	OCCUPAT	Backward (criterion: Probability of F-to-remove >= .100).
4	.	SEX	Backward (criterion: Probability of F-to-remove >= .100).

a All requested variables entered.
b Dependent Variable: TOTAL_NEW

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.953(a)	.908	.907	.692
2	.953(b)	.908	.907	.691
3	.953(c)	.908	.907	.691
4	.953(d)	.908	.907	.690

a Predictors: (Constant), PH1, agey, Landuse, Rain, SEX, OCCUPAT, slope, Year_num, Patient
b Predictors: (Constant), PH1, Landuse, Rain, SEX, OCCUPAT, slope, Year_num, Patient
c Predictors: (Constant), PH1, Landuse, Rain, SEX, slope, Year_num, Patient
d Predictors: (Constant), PH1, Landuse, Rain, slope, Year_num, Patient

ANOVA(e)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2555.259	9	283.918	592.790	.000(a)
	Residual	258.634	540	.479		
	Total	2813.893	549			
2	Regression	2555.251	8	319.406	668.102	.000(b)
	Residual	258.641	541	.478		
	Total	2813.893	549			
3	Regression	2555.152	7	365.022	764.634	.000(c)
	Residual	258.740	542	.477		
	Total	2813.893	549			
4	Regression	2555.000	6	425.833	893.139	.000(d)
	Residual	258.893	543	.477		
	Total	2813.893	549			

a Predictors: (Constant), PH1, agey, Landuse, Rain, SEX, OCCUPAT, slope, Year_num, Patient
b Predictors: (Constant), PH1, Landuse, Rain, SEX, OCCUPAT, slope, Year_num, Patient
c Predictors: (Constant), PH1, Landuse, Rain, SEX, slope, Year_num, Patient
d Predictors: (Constant), PH1, Landuse, Rain, slope, Year_num, Patient
e Dependent Variable: TOTAL_NEW

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta	B	Std. Error
1	(Constant)	8.891	.390		22.826	.000
	SEX	.041	.078	.007	.527	.598
	agey	.000	.002	.002	.127	.899
	OCCUPAT	-.003	.007	-.006	-.436	.663
	Landuse	.036	.001	.617	29.672	.000
	PH1	.470	.022	.401	21.379	.000
	Patient	.726	.047	.232	15.385	.000
	Rain	.429	.105	.058	4.086	.000
	slope	-.055	.001	-.761	-46.635	.000
	Year_num	1.135	.050	.326	22.878	.000
2	(Constant)	8.901	.381		23.336	.000
	SEX	.042	.077	.007	.549	.583
	agey					
	OCCUPAT	-.003	.007	-.006	-.455	.649
	Landuse	.036	.001	.617	29.785	.000
	PH1	.470	.022	.401	21.442	.000
	Patient	.726	.047	.232	15.404	.000
	Rain	.428	.105	.058	4.089	.000
	slope	-.055	.001	-.761	-46.715	.000
	Year_num	1.135	.050	.326	22.905	.000
3	(Constant)	8.882	.379		23.447	.000
	SEX	.044	.077	.007	.566	.572
	agey					
	OCCUPAT					
	Landuse	.036	.001	.616	29.833	.000
	PH1	.471	.022	.402	21.539	.000

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta	B	Std. Error
	Patient	.726	.047	.232	15.416	.000
	Rain	.432	.104	.059	4.137	.000
	slope	-.055	.001	-.761	-46.766	.000
	Year_num	1.133	.049	.325	22.934	.000
4	(Constant)	8.938	.365		24.476	.000
	SEX					
	agey					
	OCCUPAT					
	Landuse	.036	.001	.617	29.891	.000
	PH1	.471	.022	.402	21.546	.000
	Patient	.725	.047	.231	15.415	.000
	Rain	.429	.104	.059	4.119	.000
	slope	-.055	.001	-.761	-46.793	.000
	Year_num	1.135	.049	.326	22.995	.000

a Dependent Variable: TOTAL_NEW

Excluded Variables(d)

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
		Tolerance	Tolerance	Tolerance	Tolerance	Tolerance
2	agey	.002(a)	.127	.899	.005	.953
	OCCUPAT					
	SEX					
3	agey	.002(b)	.182	.855	.008	.967
	OCCUPAT	-.006(b)	-.455	.649	-.020	.983
	SEX					
4	agey	.003(c)	.256	.798	.011	.985
	OCCUPAT	-.006(c)	-.475	.635	-.020	.985
	SEX	.007(c)	.566	.572	.024	.994

a Predictors in the Model: (Constant), PH1, Landuse, Rain, SEX, OCCUPAT, slope, Year_num, Patient
b Predictors in the Model: (Constant), PH1, Landuse, Rain, SEX, slope, Year_num, Patient
c Predictors in the Model: (Constant), PH1, Landuse, Rain, slope, Year_num, Patient
d Dependent Variable: TOTAL_NEW

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