การพัฒนาระบบสนับสนุนการตัดสินใจเชิงพื้นที่ผ่านเว็บในการเฝ้าระวังความเสี่ยงต่อการระบาดของโรคไข้เลือดออกเพื่อการป้องกันและควบคุม

นายสุรศักดิ์ สุขสาย

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต
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DEVELOPMENT OF WEB–BASED SPATIAL DECISION SUPPORT SYSTEM TO MONITOR EPIDEMIC RISK OF DENGUE FEVER AND DENGUE HAEMORRHAGIC FEVER FOR PREVENTION AND CONTROL

Surasak Suksai

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Geoinformatics

Suranaree University of Technology

Academic Year 2010

DEVELOPMENT OF WEB-BASED SPATIAL DECISION SUPPORT SYSTEM TO MONITOR EPIDEMIC RISK OF DENGUE FEVER AND DENGUE HAEMORRHAGIC FEVER FOR PREVENTION AND CONTROL

Suranaree University of Technology has approved this thesis submitted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy.

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วัตถุประสงค์ของงานวิจัยคือการพัฒนาแบบจำลองเชิงพื้นที่ในการเฝ้าระวังการระบาดของโรคไข้เลือดออกและพัฒนาระบบสนับสนุนการตัดสินใจเชิงพื้นที่ผ่านเว็บในการเฝ้าระวังความเสี่ยงต่อการระบาดของโรคไข้เลือดออกเพื่อการป้องกันและควบคุม โดยใช้ข้อมูลในปี 2001–2005 ที่สัมพันธ์ต่อการระบาดของโรค ได้แก่ น้ำฝน อุณหภูมิ และค่าความชุกของลูกน้ำยุงลาย (HI CI BI) การวิเคราะห์ข้อมูลดังกล่าว เป็นการวิเคราะห์ในรูปแบบสมการทางด้านสถิติและแบบจำลองด้านภูมิศาสตร์ ผลที่ได้คือ ค่าความน่าจะเป็นของความสัมพันธ์ในการเกิดโรคกับอุณหภูมิ (P_T) ความน่าจะเป็นของความสัมพันธ์กับปริมาณน้ำฝน (P_R) และความสัมพันธ์กับดัชนีชี้วัดปริมาณของยุงลาย ($I_{(\mathrm{HI,CI,BI})}$) ในแต่ละฤดูกาล จากนั้นนำค่าดังกล่าวไปคาดการณ์จำนวนผู้ป่วยที่น่าจะเกิดขึ้น (y) ทำการแปลงผลคาดการณ์จำนวนผู้ป่วยเป็นความน่าจะเป็นหรือโอกาสที่จะเกิดการระบาดของโรคไข้เลือดออก *(P)* ด้วยแบบจำลอง logistic regression เพื่อใช้กับการจัดระดับความเสี่ยงของการเกิดโรคด้วย Delphi technique ผลลัพธ์แบ่งได้เป็น 3 ระดับ คือ พื้นที่เสี่ยงสูง เสี่ยงปานกลาง และเสี่ยงน้อย จากนั้นนำผลระดับความเสี่ยงทั้ง 3 ระดับที่ได้จากแบบจำลองไปตรวจสอบความถูกต้องโดยเทียบกับเหตุการณ์ที่เกิดขึ้นจริงในพื้นที่ที่แบ่งระดับความเสี่ยงไว้ 3 ระดับเหมือนกัน จากการวิเคราะห์ข้อมูลทั้ง 18 ฤดูกาล ในปีดังกล่าวพบว่า 14 ฤดูกาล มีความถูกต้องแม่นยำมากกว่า 60% ซึ่งเป็นการยอมรับสมมติฐาน H_{A0}

ค่า *P* ถูกใช้ร่วมกับจำนวนประชากรและจำนวนผู้ป่วยภายในตำบลในการวิเคราะห์ผลกระทบของพื้นที่ติดกับพื้นที่เสี่ยงสูงซึ่งจะได้ค่า ความสัมพันธ์ความเสี่ยงของพื้นที่ติดกัน คือ ค่า Y_t (NPIC) ทำการตรวจสอบผลลัพธ์โดยใช้ค่าเฉลี่ยเปอร์เซ็นต์ของความคลาดเคลื่อนสมบูรณ์ (MAPE) พบว่าค่าความผิดพลาดอยู่ที่ระดับ 36% หรือค่าความถูกต้อง 64% ซึ่งเป็นการยอมรับสมมติฐานที่ H_{A1}

ข้อมูล GIS ฟังก์ชันการทำงานของแบบจำลองในการจำแนกพื้นที่เสี่ยง การแสดงผลการรายงานและการเลือกใช้มาตรการป้องกันและควบคุมสำหรับแต่ละพื้นที่เสี่ยงได้รับการพัฒนาเป็นระบบสนับสนุนการตัดสินใจเชิงพื้นที่ผ่านเว็บโดยใช้ภาษา PHP เป็นภาษาหลักในการพัฒนาให้สามารถเรียกใช้งานผ่านเว็บเบราว์เซอร์ สามารถส่งต่อความต้องการและแสดงผลได้ในรูปแบบของ

ข้อมูลลักษณะประจำและข้อมูลพื้นที่ความเสี่ยงผ่านอินเทอร์เนตโดยใช้ Mapserver เป็นเครื่องมือ ระบบที่พัฒนายังเอื้อให้ผู้ดูแลระบบสามารถปรับปรุงฐานข้อมูลผ่าน phpMyAdmin และ MySQL ได้ตลอดเวลา ผลของการประเมินความพึงพอใจต่อระบบงานอยู่ ในระดับดีมาก (ค่าเฉลี่ย = 4.0)

สาขาวิชาการรับรู้จากระยะไกล	ลายมือชื่อนักศึกษา ___________________
ปีการศึกษา 2553	ลายมือชื่ออาจารย์ที่ปรึกษา _____________

SURASAK SUKSAI : DEVELOPMENT OF WEB–BASED SPATIAL DECISION SUPPORT SYSTEM TO MONITOR EPIDEMIC RISK OF DENGUE FEVER AND DENGUE HAEMORRHAGIC FEVER FOR PREVENTION AND CONTROL. THESIS ADVISOR : ASST. PROF. SUNYA SARAPIROME, Ph.D. 226 PP.

DF/DHF/ MODELLING/ WEB–BASED SDSS

The purpose of the study is to develop spatial model for monitoring dengue fever and dengue haemorrhagic fever (DF/DHF) epidemic and to develop web-based spatial decision support system (SDSS) to prevent and control it. Data related to the epidemic including rain, temperature, and laval indexes (HI, CI and BI) during 2001–2005 were used for analysis. The results of the analysis through mathematical equations and geographic models are epidemic probabilities related to temperature (P_T), related to rain (P_R), and related to laval indexes ($I_{(\mathrm{HI,CI,BI})}$). They were analyzed seasonally. These results were used in regression analysis for case prediction (y). The predicted cases were further transformed to be probabilities of occurrence *(P)* by logistic regression. Delphi technique was applied to classify the probabilities of occurrence to be 3 levels of risk i.e. high, moderate, and low. They were verified by data of the actual risk classified by conventional method. From 18 seasons of those years, it revealed that 60% of accuracy was achieved and led to the Hypothesis 0 acceptance.

Impacts on adjacent sub-districts connected to high risk sub–districts were analyzed by using input data of *P*, sub–district population, and the number of cases in the sub-districts. This resulted in Y_t (NPIC), the risk related to high risk area adjacency, of those sub–districts. Mean Absolute Percentage Error (MAPE) was employed to check the error which is 36% or 64% of accuracy. This leads to the Hypothesis 1 acceptance.

GIS data, functions of spatial risk models, result display, and report including advising remedial measures for prevention and control in specific sub-districts were developed to be web–based spatial decision support system. PHP is the main programming language used for system development. Web browser is an interface tool for users to request data and processing connecting to the server. The spatial and attribute data as the requests and resulting reports are transmitted through internet using Mapserver as a tool. The system developed enables the system administrator to constantly improve database using phpMyAdmin and MySQL. The satisfaction of users for the system developed was evaluated with very good level (average = 4.0).

School of Remote Sensing — Student's Signature___________________

Academic Year 2010 — Advisor's Signature___________________

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Finally, I wish to extend my appreciation to my beloved family for their everlasting support and enthusiasm throughout my whole life. I dedicate to my father, my mother, and all the teachers who have taught me since my childhood.

Surasak Suksai

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LIST OF ABBREVIATIONS

BI	Breteau Index
CI	Container Index
CGI	Common Gateway Interface
DBMS	Database Management System
DF	Dengue Fever
DFD	Data Flow Diagrams
DGMS	Dialog Management System
DHF	Dengue Haemorrhagic Fever
DI	Density Index
DSS	Decision Support Systems
GIS	Geographic Information System
GPS	Global Positioning Systems
GUI	Graphic User Interface
HI	House Index
HTML	Hypertext Markup Language
HPO	Health Provincial Office
IDW	Inversion Distance Weighting
IR	Interquartile Range
IHR	International Health Regulations
JDBC	Java Database Connectivity

LIST OF ABBREVIATIONS (Continued)

JDBC	Java Database Connectivity
JSP	Java Server Pages
MR	Morbidity Rate
MBMS	Model-Based Management System
MAPE	Mean Absolute Percentage Error
NASA	National Aeronautics and Space Administration
NPIC	Normalized Product of Interactive Correlation
ODPC7	Office of Disease Prevention and Control 7
OPEA	Occurrence Probability of Epidemic in Adjacent Areas of High Risk Areas
PAHO	Pan American Health Organization
PHU	Primary Healthcare Un it
PHP	Hypertext Preprocessor
ppm	Part Per Million
SDSS	Spatial Decision Support Systems
SQL	Structured query language
TM	Thematic Mapper
UOPH	Ubon Ratchathani province of Public Health
WHO	World Health Organization

CHAPTER I

INTRODUCTION

1.1 Introduction

Dengue fever is the most important insecticide viral disease of public health. Today the geographic distribution includes more than 100 countries worldwide. Many of these had not reported dengue for 20 or more years and several have no known history of the disease. The World Health Organization (WHO) estimates that between 50 and 100 million cases of dengue are reported around the world each year and over 2.5 billion people are at risk of infection. Several hundred thousand dengue cases each year result in dengue haemorrhagic fever (DHF), which usually affects children under 15 years of age. The average fatality rate with DHF is 5 percent (Gubler, 1997), although with timely treatment this is reduced to less than 1 percent. It is estimated that as many as 100 million dengue virus infections occur annually in the tropics, with over 10,000 deaths from DHF (Halstead, 1982). Besides a rapid global increase in incidence, there has been an increase in severe cases as well (Monath, 1994). In 1998, Thailand experienced an exceptionally intense epidemic of DHF, 112,488 cases (23.3% increased from 1997) and 415 deaths (64.0% increased) (Chareonsook *et al*., 1999), which was the second largest epidemic outbreak of dengue after 1987. Epidemics occur with a periodicity of between two and four years; these epidemics are of significant concern for the public health authorities.

The Asia–Pacific Dengue Strategic Plan (2007–2015) has been prepared in response to the increasing threat from dengue, which is spreading to new geographical areas and causing high mortality during the early phase of the outbreaks. Among an estimated 2.5 billion people at risk globally, about 1.8 billion (more than 70%) reside in the Asia–Pacific region. The development of this Strategic Plan is also important to meet the requirements of the International Health Regulations (IHR) 2005. The specific objectives of plan are to increase capacity to predict, to detect early and respond to dengue outbreaks, to strengthen capacity to implement effective integrated vector management, to increase health workers' capacity to diagnose and treat patients and improve health–seeking behavior of communities, to increase the capacity of member countries to monitor trends and reduce dengue transmission, and to address programmatic issues and gaps that requires new or improved tools for effective dengue prevention and control.

Annually recorded epidemics in Ubon Ratchathani province, which has been endemic since 1987 and a cumulative total of 35,069 cases and 155 deaths (UOPH, 2006) are displayed in Figure 1.1. During the 1998 outbreak of dengue fever and dengue haemorrhagic fever (DF/DHF), about 35% mortality was reported among children admitted in a hospital, while total 4,905 cases were hospitalized and 25 deaths recorded (UOPH, 2006). This epidemic peaked in August when an *Aedes aegypti* larval House Index of 30.50% was recorded. Since then, regular monitoring of larval density of *Aedes aegypti* and dengue cases has been of interest to study the trends and to prevent any recurrence of an outbreak. In 2003, there were 3,138 DF/DHF cases reported. Morbidity rate was observed at 173.82 per 100,000 people. The DF/DHF incidences were recorded at the village level. Highest numbers of dengue incidence were all recorded in the country with morbidity rate >50/100,000 people. It was found that the highest number of cases occurred during 2001 to 2003 and more likely during March and August. This indicated the seasonal dependence in occurrence of DF/DHF cases, which generally starts just before the rainy season and continues till the end of rainy season as statistical recorded in UOPH during 2000–2003.

The dengue virus is an arbovirus (arthropod–borne virus) transmitted by the mosquito *Aedes aegypti*. Control of the spread of the disease focuses on vector control strategies based mainly on the elimination of potential breeding sites (WHO, 1972). Surveillance for *Aedes aegypti* is important in determining the distribution, population density, major larval habitats, spatial and temporal risk factors related to dengue transmission and levels of insecticide susceptibility or resistance in order to prioritize areas and seasons for vector control (Kalra *et al*., 1997). These data will enable the selection and use of the most appropriate vector control tools, and can be used to monitor their effectiveness. There are several methods available for the detection and monitoring of larval and adult populations (Strickman and Kittayapong, 2002). The selection of appropriate sampling methods depends on surveillance objectives, levels of infestation, and availability of resources. For practical reasons, the most common survey methodologies employ larval sampling procedures rather than egg or adult collections. The basic sampling unit is the house or premise, which is systematically searched for water–holding containers. Containers are examined for the presence of mosquito larvae and pupae (WHO, 1972). Three indices that are commonly used to monitor *Aedes aegypti* infestation levels are House index, Breteau index and Container index. The house index has been most widely used for monitoring infestation levels, but it does not take into account the number of positive containers nor the productivity of those containers (Furlow and Young, 1970). The Breteau index establishes a relationship between positive containers and houses, and is considered to be the most informative, but again there is no reflection of container productivity (Jetten and Focks, 1997).

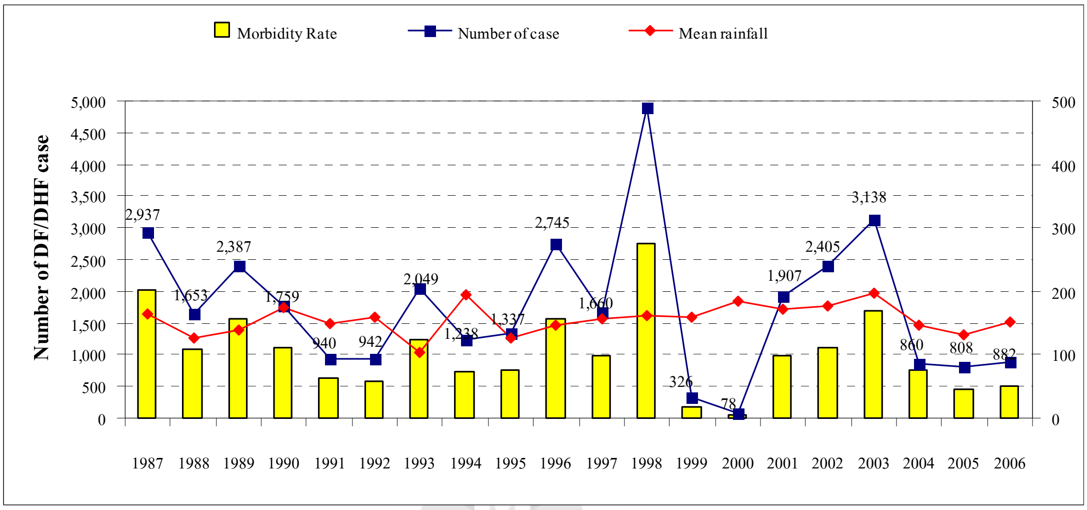


Figure 1.1 The number of DF/DHF cases, morbidity rate and mean rainfall in Ubon Ratchathani (1987–2006), Thailand.

However, seasonal and climatic variations affect the occurrence of epidemics of DHF, as well as long–term trends. High temperature, humidity and rainfall are mostly considered as the main risk factors for DHF outbreaks in epidemic areas (Kettle, 1995). It is well established that climate is an important determinant of the spatial and temporal distribution of vectors and pathogens (Kovats *et al.*, 2001). Mosquito abundance depends on the rate at which insects are produced from their breeding sites, and their survival rates. Higher temperatures speed up the development of adult mosquitoes, which live longest between 25°C and 35°C. At very low and very high temperatures, mosquitoes have shorter lives (Kettle, 1995). The person–biting rate is a measure of the number of times that each person gets bitten each day. This number is dependent on the frequency of mosquitoe–biting per person, the feeding behavior of the mosquitoes, and human behavior. Climatic conditions and temperature in particular, directly influence mosquito development, feeding frequency and longevity, as well as the time in which the parasite develops inside the mosquito. Other environmental factors such as vegetation and breeding sites are indirectly influenced by climate conditions (Martens *et al*., 1995).

At present, Geographic Information System (GIS) has been known primarily as research tools in the field of vector–borne disease; it will become an increasingly important research tool for geographic database construction, data analysis, modeling, and decision support systems. This study approach is to find the models in conjunction with GIS and incidences of viral diseases and to demonstrate that the spatial characteristics combined to GIS modeling is the right way to approach this kind of problem. Therefore GIS is an ideal tool and has been used extensively in many DF/DHF studies (Sithiprasasna and Linthieum, 1997; Bohra, 2001; Gupta *et al*., 2003). In fact, GIS can be integrated with modeling, statistics, and analysis tools to carry out sophisticated tasks. Thus, it can be a useful development to incorporate GIS with decision support systems (DSS) for a specific task. This incorporation is commonly known as spatial decision support systems (SDSS).

In this study the approach focuses on developing a web–based SDSS to predict and manage DF/DHF epidemics. The system developed covers spatial modeling using vector surveillance factor, climatic factor and disease occurrence data.

1.2 Influence of DF/DHF epidemic periods

In the tropical country like Thailand, the epidemic can be classified to be three seasons or periods, namely, pre–high incidence (January to April), high incidence

(May to August) and post–high incidence (September to December). An active/inactive certain period will influence to other periods as discussed in the followings and shown in Figure 1.2.

1) Areas of which DF/DHF spatial model and case occurrence considered to be risk and active in a period will deliver the adverse impact or influence to the next period, for example, the active pre–high incidence period will positively effect to high incidence period as well as active high incidence period will influence to the next post–high incidence period (จิตติ จันทร์แสง และคณะ, 2540).

2) Considering the annually cyclic fluctuation using data of years, each active incidence period will deliver the adverse impact or influence to the same period next year, for example, the active pre–high incidence (January to April) of this year will positively effect to the pre–high incidence (January to April) of the next year. Other active periods perform the same characteristic of influence as shown in Figure 1.2.

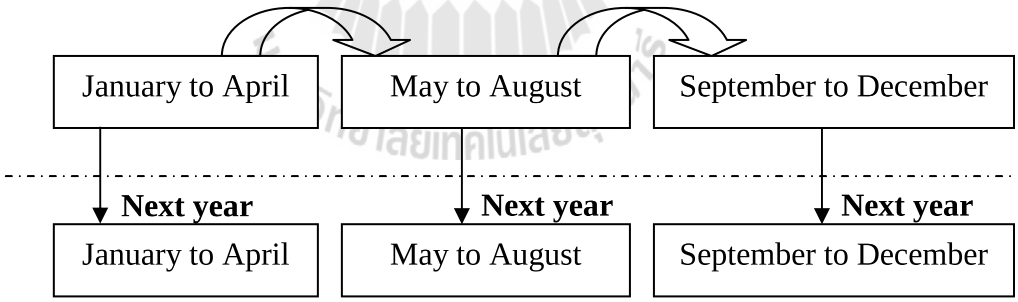


Figure 1.2 Influence/effect of DF/DHF epidemic periods.

1.3 Research objectives

1) To develop surveillance spatial model of DF/DHF epidemics in Ubon Ratchathani province.

2) To develop the web–based SDSS for DF/DHF epidemics for dynamic implementation.

1.4 Research hypothesis

Hypothesis 0

H_{00} = Risk area of DF/DHF from model–based prediction has insignificant correlation (< 60 %) to actual event of epidemics in the study area.

H_{A0} = Risk area DF/DHF from model–based prediction has significant correlation (≥ 60 %) to actual event of epidemics in the study area.

Hypothesis 1

H_{01} = Occurrence probability of epidemic in adjacent areas of high risk areas is less than 50%

H_{A1} = Occurrence probability of epidemic in adjacent areas of high risk areas is equal or more than 50%

If H_{00} is true, then the Hypothesis 0 is rejected. Otherwise it is accepted.

If H_{01} is true, then the Hypothesis 1 is rejected. Otherwise it is accepted.

1.5 Basic assumption and terminology

Traditional code area classification of DF/DHF risk based on epidemic statuses:

Status for code area A: There are cases in every week within at least 4 consecutive weeks.

Status for code area B: There are cases in at least 2 weeks within 4 consecutive weeks.

Status for code area C: Within a week, there is a new case reoccurring in the area.

Status for code area D: There is a new case occurring in the area which has no case within a week before.

Status for code area E: There is a new case occurring in the area which has no case within 4 weeks before.

Status for code area F: There is a new case occurring in the area which has no case within 6 months before.

SDSS (Spatial Decision Support Systems)**:** A customized computer–based information system that utilizes decision rules and models and incorporates spatial data.

House (premises) Index (HI): Presence of houses or premises positive for *Aedes* larvae. The HI is calculated as follows.

$$HI = \frac{\text{Number of houses infected}}{\text{Number of houses inspected}} \text{ x } 100$$

Container Index (CI): Presence of water holding containers positive for *Aedes* vector larvae.

$$CI = \frac{\text{Number of positive containers}}{\text{Number of containers inspected}} \text{ x } 100$$

Breteau Index (BI): Number of *Aedes* positive containers per 100 houses in a specific locality.

$$BI = \frac{\text{Number of positive containers}}{\text{Number of houses inspected}} \text{ X } 100$$

DF/DHF is endemic in Ubon Ratchathani province and the different serotypes are largely distributed of sub–districts, the spatial patterns of epidemic in different locations.

1.6 Study area

1) Ubon Ratchathani province is located in the Northeastern Thailand. It covers an area of 16,112.61 km^2 (Figure 1.3). The province consists of 25 districts and 219 sub–districts.

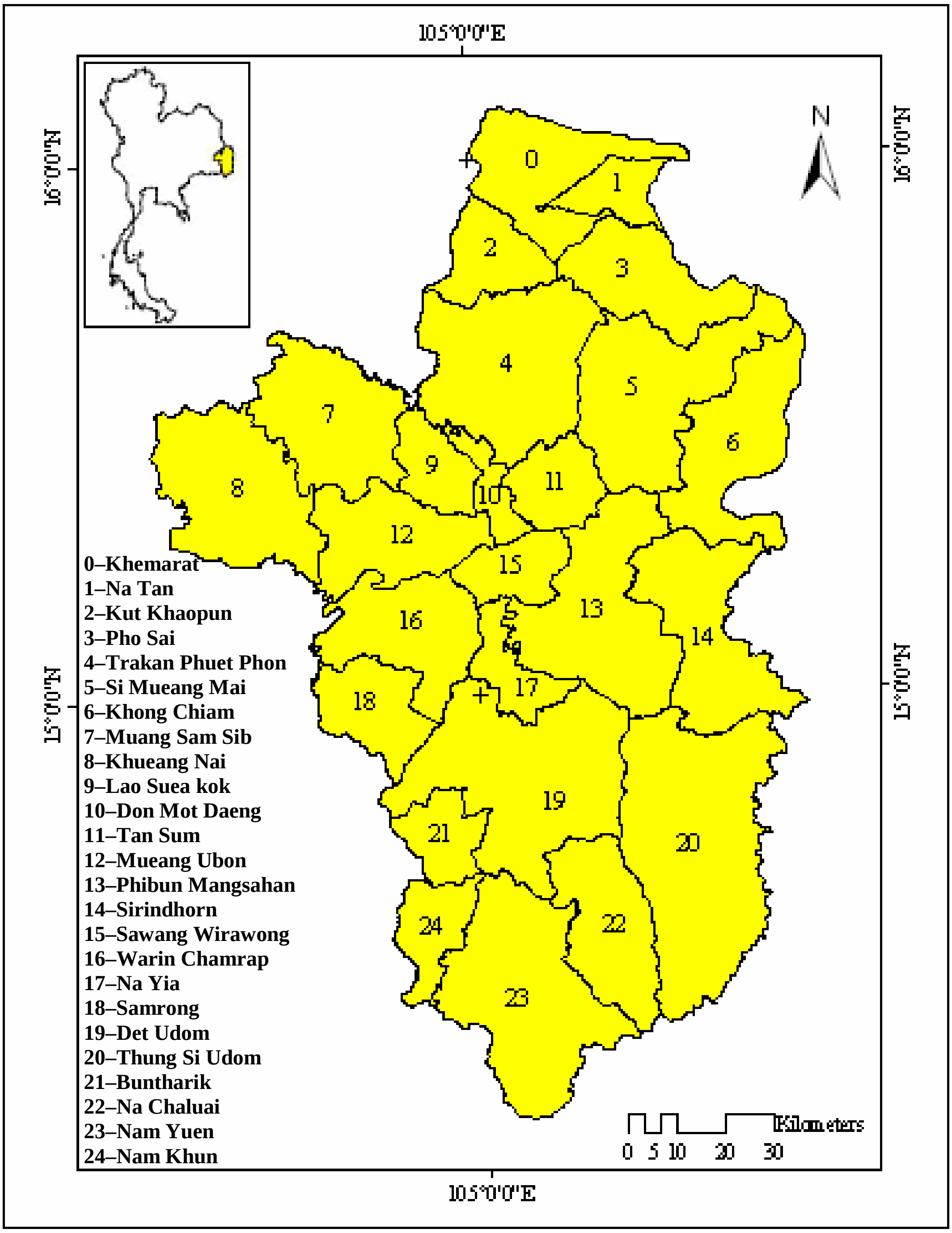


Figure 1.3 Ubon Ratchathani province, the study area.

2) The data of DF/DHF cases of the study area were collected annually by district/sub–district level (2001–2005) from the Provincial Health Office as shown in Table 1.1.

Table 1.1 Annual distribution of DF/DHF cases in districts of Ubon Ratchathani province (2001–2005).

Districts	**Year**									
	2001		**2002**		**2003**		**2004**		**2005**	
	Totals	**MR**	**Totals**	**MR**	**Totals**	**MR**	**Totals**	**MR**	**Totals**	**MR**
Mueang Ubon	**279**	**123.99**	**127**	**56.01**	**313**	**135.99**	**121**	**57.50**	**154**	**72.69**
Khemarat	**113**	**149.70**	**136**	**179.11**	**174**	**226.66**	**46**	**61.91**	**31**	**40.25**
Khueang Nai	**217**	**196.44**	**215**	**194.44**	**100**	**90.82**	**82**	**74.84**	**67**	**61.21**
Si Mueang Mai	**40**	**62.38**	**47**	**72.94**	**208**	**321.06**	**20**	**30.89**	**57**	**87.10**
Det Udom	**194**	**115.55**	**306**	**180.71**	**419**	**245.81**	**118**	**69.67**	**37**	**21.78**
Trakan Phuet Phon	**138**	**115.68**	**170**	**141.71**	**308**	**255.72**	**162**	**135.97**	**68**	**56.78**
Na Yia	**69**	**103.01**	**233**	**345.48**	**137**	**200.79**	**5**	**7.47**	**62**	**91.66**
Khong Chiam	**12**	**38.15**	**7**	**22.08**	**29**	**90.50**	**4**	**12.32**	**3**	**9.18**
Buntharik	**29**	**32.79**	**153**	**171.43**	**111**	**121.98**	**16**	**18.27**	**21**	**23.85**
Phibun Mangsahan	**123**	**92.63**	**165**	**123.41**	**214**	**159.41**	**33**	**25.86**	**54**	**42.40**
Muang Sam Sip	**95**	**113.95**	**47**	**56.21**	**121**	**144.60**	**41**	**49.70**	**30**	**36.25**
Warin Chamrap	**367**	**236.43**	**218**	**139.68**	**349**	**221.00**	**88**	**56.88**	**81**	**51.81**
Kut Khaopun	**11**	**27.87**	**54**	**135.81**	**83**	**208.41**	**2**	**5.04**	**2**	**5.02**
Na chaluai	**12**	**22.47**	**52**	**96.41**	**28**	**51.42**	**20**	**37.43**	**42**	**78.10**
Tan Sum	**1**	**3.18**	**67**	**211.45**	**50**	**157.82**	**5**	**16.13**	**5**	**16.04**
Pho Sai	**31**	**75.84**	**41**	**98.40**	**91**	**216.32**	**11**	**26.29**	**16**	**37.97**
Samrong	**40**	**77.25**	**60**	**114.80**	**50**	**96.30**	**27**	**52.22**	**16**	**30.79**
Don Mot Daeng	**27**	**102.67**	**11**	**41.50**	**61**	**230.41**	**15**	**57.11**	**9**	**34.22**
Sirindhorn	**25**	**54.50**	**133**	**285.91**	**83**	**176.65**	**8**	**16.87**	**19**	**39.46**
Thung Si Udom	**3**	**11.19**	**15**	**55.51**	**18**	**67.03**	**1**	**3.73**	**16**	**59.29**
Na Yia	**9**	**36.85**	**23**	**93.71**	**31**	**125.82**	**1**	**4.02**	**4**	**16.02**
Lao Suea Kok	**7**	**27.78**	**13**	**51.44**	**50**	**197.08**	**15**	**58.47**	**3**	**11.64**
Nam Yuen	**45**	**129.53**	**85**	**242.42**	**50**	**142.07**	**5**	**14.44**	**8**	**23.03**
Sawang Wirawong	**16**	**54.15**	**23**	**77.00**	**25**	**83.46**	**12**	**39.99**	**2**	**6.63**
Na Tan	**4**	**13.62**	**4**	**13.37**	**35**	**116.43**	**2**	**6.58**	**1**	**3.27**
Province	**1,907**	**107.15**	**2,405**	**134.15**	**3,138**	**173.82**	**860**	**48.78**	**808**	**45.53**

* MR–Morbidity Rate: The proportion of patients with a particular disease during a given year per given unit of population.

3) Climate data related to the occurrence of DF/DHF cases are rainfall and temperature during 2001 to 2005. The data achieved from 19 weather stations available in Ubon Ratchathani province are listed in Table 1.2.

Table 1.2 List of the available weather stations.

Station code	Name	Latitude	Longitude
407301	Mueang 1	$15^{o}14'00''$ N	$105^{o}0'00''$ E
407501	Mueang Ubon	$15^{o}15'00''$ N	$104^{o}5'00''$ E
407001	Warin Chamrap	$15^{o}11'00''$ N	$104^{o}53'00''$ E
407002	Det Udom	$14^{o}53'00''$ N	$105^{o}04'00''$ E
407004	Si Mueang Mai	$15^{o}34'00''$ N	$105^{o}20'00''$ E
407005	Muang Sam Sip	$15^{o}30'00''$ N	$104^{o}45'00''$ E
407006	Trakan Phuet Phon	$15^{o}03'00''$ N	$105^{o}37'00''$ E
407007	Khong Chiam	$15^{o}22'00''$ N	$105^{o}28'00''$ E
407008	Khueang Nai	$15^{o}22'00''$ N	$104^{o}35'00''$ E
407009	Phibun Mangsahan	$15^{o}15'00''$ N	$105^{o}14'00''$ E
407012	Nam Yuen	$14^{o}29'00''$ N	$104^{o}59'00''$ E
407013	Buntharik	$14^{o}44'00''$ N	$105^{o}26'00''$ E
407015	Mueang 2	$15^{o}19'00''$ N	$104^{o}47'00''$ E
407016	Khemarat	$16^{o}02'00''$ N	$105^{o}13'00''$ E
407017	Sawang Wirawong	$15^{o}19'00''$ N	$104^{o}47'00''$ E
407018	Thung Si Udom	$15^{o}16'00''$ N	$105^{o}02'00''$ E
407019	Tan Sum	$14^{o}53'00''$ N	$105^{o}08'00''$ E
407020	Kut Khaopun	$15^{o}19'00''$ N	$105^{o}11'00''$ E
407021	Na chaluai	$15^{o}48'00''$ N	$105^{o}00'00''$ E

CHAPTER II

LITERATURE REVIEW

The review was made to cover concepts, theories and related researches in terms of climate effects on DHF, indicators for dengue vectors transmission, applications of GIS to epidemiology, and web–based spatial decision support systems to monitor epidemic risk.

2.1 Climate effects on dengue hemorrhagic fever

Seasonal and climatic variation affects the occurrence of epidemics of DHF, as well as long–term trends. High temperature, humidity, and rainfall are mostly considered as the main risk factors DHF outbreaks in epidemic areas (Kettle, 1995). It is well established that climate is an important determinant of the spatial and temporal distribution of vectors and pathogens (Kovats *et al*., 2001). Climatic conditions and temperature in particular, directly influence mosquito development, feeding frequency and longevity, as well as the time in which the parasite develops inside the mosquito. Other environmental factors such as vegetation and breeding sites are indirectly influenced by climate conditions (Jackson, 1995; Martens *et al*., 1995).

2.1.1 Direct effects of climate

Mosquito abundance depends on the rate at which insects are produced from their breeding sites, and their survival rates. Higher temperatures speed up the development of adult mosquitoes, which live longest between 25°C and 35°C. At very low and very high temperatures, mosquitoes have shorter lives (Chareonsook *et al*, 1999; Kettle, 1995).

2.1.1.1 Temperature: Temperature plays an important role in the life cycle of mosquitoes and in the replication and transmission of diseases such as: population size, maturation period, feeding characteristics, and survival rate of Aedes mosquitoes (Yang *et al*., 2009; Focks *et al*., 2000). Mortality rate of larvae, pupae and adult female mosquitoes as a function of temperature between 10°C and 40°C. At temperature ranging from 15 to 30°C, Aedes mosquitoes experience lower mortality rate (Yang *et al*., 2009). Simultaneously, Aedes mosquitoes experience shorter reproductive cycle at higher temperature of 32°C and increase feeding frequency more than twofold as compared to temperature at 24°C; pupae development period may reduce from four days at 22°C to less than one day as temperature increases to 32–34°C; thus, mosquito population multiplies swiftly as temperature increases (Focks *et al*., 2000). According to a study by Tun–Lin *et al*. (2000) female and male ratio of mosquito offspring could be 4:3 at 30°C. Additionally, the extrinsic incubation period of dengue viruses shortens from 12 days at 30°C to seven days as temperature rises to 32–35°C (Watts *et al*., 1987). At an average temperature of 26ºC, larvae stages can be completed in 5 days. The pupae stage lasts 1 to 2 days. Areas that dry up and are reflooded every few days can produce a hatch with each flooding (Goddard, 2002). The ambient temperature of the transmission for dengue virus is above 20°C, and it can not be transmitted at 16°C.

In areas where seasonal changes in temperature are affected, the transmission of dengue virus always decreases with the approach of cold temperatures, for example, the epidemic of DF/DHF in Australia ceased as the temperatures dropped to 14–15°C at the beginning of winter. Temperature may also effect the maturation of mosquitoes, higher temperature producing smaller females which are forced to take more blood meals to obtain the protein needed for egg production. The temperature and humidity are thought to influence the extrinsic incubation period of the mosquitoes and is an important variable in causing epidemic transmission (Kuno, 1995).

In conclusion, temperature is important because it governs (Patz and Lindsay, 1999; ประคอง พันธ์อุไร และ บุญล้วน พันธุมจินดา, 2520).

1) The rate at which mosquitoes develop into adults.

2) How frequently they blood feed (therefore, acquire parasites).

3) The survival rate of adult mosquitoes.

4) The incubation time of parasites in the mosquito.

2.1.1.2 Precipitation: In addition to the direct influence of temperature on the biology of vectors and parasites, changing precipitation patterns can also have short and long term effects on vector habitats (Githeko *et al*., 2000). High amounts of precipitation result in a greater potential to increase the number of breeding sites. A lack of precipitation is also important. Multi–month drought in early summer was found to be associated with recent severe urban outbreaks of West Nile virus in the United States (Epstein, 2001). Monath and Tsai (1987) agree that outbreaks have been associated with rainfall. The combination of drought and rainfall is probably the key to outbreaks. Rains followed by drought seem to be the correct combination for these outbreaks. Excessive rainfall in January and February (spring season), in combination with drought in July (summer), most often precedes outbreaks (Githeko *et al*., 2000).

Day and Curtis (1989) found similar results. A wet July results in high mosquito abundance in August.

2.1.1.3 Humidity: Humidity is one of the factors which have a direct effect on the survival of mosquitoes. Survival rate might be reduced when hot weather is accompanied by low humidity. But in areas with this type of climate, such as semi–arid parts of Sudan, local species have adapted themselves (Reiter, 2001). Humidity also affects the risk of exposure to vectors. Humidity is an often–overlooked factor in the life cycle of mosquitoes and in the replication and transmission of diseases. Rainfall raises the relative humidity particularly following dry periods, and relative humidity strongly influences mosquito flight and subsequent host–seeking behavior. The most adverse extremes of humidity can completely prevent mosquito host–searching flights. More in–depth research on the effects of humidity needs to be completed before a full understanding can be acquired (Day and Curtis, 1989).

The literatures on effects of temperature and rainfall to DF/DHF vectors can be summarized in Table 2.1.

2.1.2 Other considerations related to climate

2.1.2.1 Migration and urbanization: Drought, flooding or economic factors can cause mass population movements (Oppenshaw and Taylor, 1981). Infected people can introduce DHF to non–endemic areas. Rapid population expansion can cause breakdown in public health services. In addition, extensive water storage and inadequate water disposal can lead to disastrous surges in the number of DHF mosquitoes. Furthermore in large cities and camps, zoophiles species might be encouraged to feed on people due to dense human population and the absence of cattle (Villermé *et al*., 1821). Dengue epidemics in urban areas are due to transmission by

Aedes aegypti and can involve up to 70–80% of the population (Gubler and Trent1993).

Table 2.1 Summary of the literatures on temperature and precipitation (rainfall) effect on DF/DHF vectors.

Temperature	Survival percentage of adults	Author
20°C <	No adult develops	
> 34°C	Adults are eliminated.	Githeko *et al*.(2000)
	Mosquito Life Cycle	
26°C	Larvae stage can be completed in 5 days, the pupae stage lasts 1 to 2 days.	Goddard (2002)
30°C	Feeding will be maximum	Koopman (1991)
	Feeding opportunity becomes 4 times	Boonmaging (2004)
Precipitation (Rainfall)	***Aedes aegypti* density**	**Author**
August	High abundance of mosquito	Day and Curtis (1989)
January and February, drought in July	Most often lead to outbreaks	Githeko *et al.* (2000)
April to October	Many broods are produced.	Hawley (1991)
Between July and October	Maximum feeding	Day and Curtis (1989)

2.1.2.2 Changing human behavior: The lifestyle of people is dependent on the climate. Usually people wear less clothes in warm and humid climates, and prefer to work and rest in open areas. Therefore, they are more exposed to mosquito bites. On the other hand, due to the abundance of insects they might use more bed–nets or other protective methods, which decrease the risk of effective exposure (Oppenshaw and Taylor, 1981).

2.1.2.3 Natural disaster and conflict: Natural disasters such as drought and flood might disrupt the health infrastructures and change human life, and so might create an optimum condition of any types of epidemics (Patz and Lindsay, 1999). Flooding often causes disruption of breeding sites and temporary reduction of vectors. But it never eliminates the vectors, high rainfall is still considered optimal for transmission (Krieger, 2000). The incidence and, in particular, epidemics of dengue have been commonly associated with the rainy season, and the El Niño phenomenon has been incriminated in the increases of certain vector–borne diseases, including dengue (Hales *et al*., 1996; Keating, 2001).

2.2 Indicators for dengue vectors transmission

Surveillance for *Aedes aegypti* is important in determining the distribution, population density, major larvae habitats, spatial and temporal risk factors related to dengue transmission, and levels of insecticide susceptibility or resistance (Focks *et al*., 1995; Focks 2003), in order to prioritize areas and seasons for vector control. These data will enable the selection and use of the most appropriate vector control tools, and can be used to monitor their effectiveness. There are several methods available for the detection and monitoring of larvae and adult populations. The selection of appropriate sampling methods depends on surveillance objectives, levels of infestation, and availability of resources.

2.2.1 *Aedes aegypti* density

2.2.1.1 Factors of DF/DHF

Dengue virus transmission is enhanced by the following factors (Martinique, 2000):

1) Increased vector density: In many tropical countries, seasonal increases in rainfall contribute to an increased density of mosquitoes.

2) Shorter incubation periods in the mosquito: The length of the incubation time in the mosquito, known as the extrinsic incubation period, is inversely associated with the ambient temperature.

3) Increased movement of mosquito vectors and viruses: Air, land and water transportation of mosquitoes or vermin facilitate the dissemination or dengue viruses.

4) Increased density of susceptible human hosts: Crowded conditions probably increase the potential for virus transmission.

2.2.1.2 Factors contributing to the Reemergence of DF and DHF.

The emergence of DHF as a public health problem has largely been a result of human behaviors including (Shaheem and Afeef, 2000):

1) Population growth.

2) Poorly planned urbanization, associated with overcrowding, poor water distribution and poor sanitation.

3) Changing lifestyles, such as increased reliance on plastic containers and tires, standing water can easily collect in these.

4) Modern transportation, with increased movement of viruses, mosquitoes and susceptible humans.

5) Lack of effective mosquito control.

2.2.2 Patterns of dengue virus transmission

Dengue virus transmission follows two general but not mutually exclusive patterns, with different implications for disease risk in both the local population and travelers (Madarieta *et al*., 1999).

2.2.2.1 Epidemic dengue: Epidemic dengue transmission occurs when the dengue virus is introduced into a single virus strain. If susceptible hosts are sufficiently large populations and mosquitoes are present, transmission of dengue is explosive, leading to a recognizable epidemic. The incidence of infection among susceptible individuals often reaches 25 to 50 percent, and can be considerably higher. Herd immunity, changes in weather, and mosquito control efforts can contribute to the termination of the epidemic. Epidemic activity is currently the predominant pattern of dengue virus transmission in smaller island nations, certain areas of South America and Africa and in the areas of Asia where dengue virus transmission has recently reemerged.

2.2.2.2 Hyperendemic dengue: Hyperendemic transmission refers to the continuous circulation of multiple dengue virus in the same area. This requires the year round presence of competent vector mosquitoes and either a large population base or steady movement of individuals into the area to maintain a pool of susceptible individuals. Seasonal variation in virus transmission is common. The incidence of infection also varies from year to year, with increased dengue transmission at intervals of three to four years, but this variation is not as dramatic as in areas where transmission predominantly follows the epidemic pattern. Areas with hyperendemic dengue virus transmission contribute the vast majority of cases of dengue virus infection globally.

2.2.3 Larvae indices

The commonly used larvae indices are as follows (WHO, 1972):

House or premises Index (HI) is the percentage of houses or premises with one or more habitats positive for *Aedes aegypti* or related species. The House index is the most frequently used and understood index. It also involves less labor because, when the first positive container is located in a house, there is no need to proceed further. This index does not take into account the number of positive containers in an infested house. The House index gives an idea of the percentage of houses positive for vector breeding and hence the percentage of the population at risk. If the index is high, transmission occurs easily to neighboring houses, and if the index is low transmission occurs less rapidly.

The Container Index, although not so useful from the epidemiological point of view, is a useful comparative figure especially when evaluation of control measures is being carried out.

The Breteau Index is generally considered the best of the commonly used indices, such as the House or premises Index and the Container Index, since it combines dwellings and containers and is more qualitative and of more epidemiological significance.

The larvae indices were developed (Conner and Monroe, 1923; Breteau, 1954) to monitor the progress of vector eradication efforts and to protect *Ae.aegypti* free zones from re–infestation (Soper, 1967). The house or premises index (HI: % of houses infested with larvae and/or pupae) has been used most widely, but it does not take into account the number of containers with immature mosquitoes nor the production of adults from those containers (Pan American Health Organization, 1994). The container index (CI: % of water holding containers infested with active immatures) only provides information on the proportion of water holding containers that contain > 1 immature mosquito; it does not account for variation in density or adult productivity. The Breteau index (BI: number of positive containers/100 houses) is considered the most informative because it establishes a relationship between positive containers and houses, but it fails to account for adults produced from containers. Since 1971, a variety of alternative indices were proposed (Chan, Chan and Ho, 1971; Bang, Bown and Onwubiko, 1981; Chan, 1985; Tun–Lin, Kay and Barnes, 1995; Tun–Lin *et al.*, 1996), which attempted to account better for adult productivity. In general, many of those indices were discounted because of the high degree of sample variation and, perhaps more important, the severe logistical limitations that they posed (Tun–Lin, Kay and Barnes, 1995).

Establishing epidemiologically significant levels of entomological indices for dengue has been elusive (see Table 2.2). In urban areas in Latin America, a container index (CI) of less than 10 (Conner and Monroe, 1923) or a house index (HI) of < 5 (Soper, 1967) was considered a prophylactic level for yellow–fever transmission. During a yellow fever epidemic in Diourbel, Senegal, transmission occurred only in areas where the World Health Organization density index was > 5 (Brown, 1977). PAHO (Dengue and dengue hemorrhagic fever in the Americas: guidelines for prevention and control, 1994) recognizes three levels of infestation for dengue transmission: low (HI < 0.1%), medium (HI = 0.1–5%), and high (HI > 5%). These estimates were similarly obtained retrospectively. They require empirical verification because results from field studies indicate that there is an inconsistent relationship between larvae indices and virus transmission rates (Focks and Chadee, 1997).

To monitor vector control progress and to determine if prophylactic levels had been achieved, larvae indices were developed (Brown, 1994 and 1997). The initial indices, described in 1923, were the House (or Premises) Index (HI) – the percentage of houses infested with larvae and/or pupae and the Container Index (CI) – the percentage of water holding containers infested with active immatures; 30 years later, the Breteau Index (BI) – the number of positive containers per 100 houses, became a common measure (Brown, 1997). In the late 1960s, the World Health Organization began promoting the world–wide surveillance of *Aedes aegypti* and related species. To facilitate the dissemination of this information on maps, a statistic was developed, the Density Index (DI) and then empirical relationships between it and the larvae indices were derived (Table 2.3).

Table 2.2 Estimates of dengue entomological thresholds.

Index	***Aedes aegypti* density**	Author
Container index < 10%	Safe zone for yellow fever Transmission	Connor and Monroe,1923
House index < 5%	Prophylactic for yellow fever	Soper, 1967
Breteau index < 5	Absence of yellow fever transmission	Brown, 1977
House index > 15%	Dengue hemorrhagic fever Present	Brown, 1977
Pupae per Person 1.05–0.26	Unable to sustain dengue transmission	Focks *et al*., 1995, 2000

Table 2.3 Weight *of Aedes aegypti* density for each criterion index is displayed as Priority of transmission (Brown, 1994; 1997).

Priority of transmission	Container Index	House Index	Breteau Index
1	0–2.99	0–3.99	0–4.99
2	3–5.99	4–7.99	5–9.99
3	6–9.99	8–17.99	10–19.99
4	10–14.99	18–28.99	20–34.99
5	15–20.99	29–37.99	35–49.99
6	21–27.99	38–49.99	50–74.99
7	28–31.99	50–59.99	75–99.99
8	32–40.99	60–76.99	100–199.99
9	> 41	> 71	> 200

In the past 30 years, two countries – Cuba (Armada Gessa and Figueredo Gonzalez, 1986) and Singapore (Chan, 1985) – have instituted successful dengue–control programmes. At both locations control was vertically oriented and incorporated source reduction, space spraying, health education, and law enforcement. There were negative consequences for non–compliance. In response to a serious dengue epidemic in 1981, Cuba reduced the national HI from 35 to 0.2. Since then, maintaining a HI of < 0.01 has prevented dengue (Guzmán *et al.*, 1999). Before control programmes were instituted in Singapore, DHF was most prevalent where HI were > 15 (Brown, 1977). With control, HIs were reduced from 25 to < 5 by 1973 and to < 1 by the mid–1980s. Although dengue transmission persists and has been increasing since 1986, the incidence of dengue in Singapore remains considerably lower than in neighboring countries.

2.3 Applications of GIS to epidemiology

Epidemiologists have traditionally used maps when analyzing associations between location, environment, and disease (Gesler, 1986). GIS is particularly well suited for studying these associations because of its spatial analysis and display capabilities. Recently GIS has been used in the surveillance and monitoring of vector–borne diseases (Richards, 1993) and water–borne diseases (Clarke *et al*., 1991), in environmental health (Cuthe *et al*., 1992), in modeling exposure to electromagnetic fields (Krieger, 2001), in quantifying lead hazards in a neighborhood (Campo, 2003), predicting child pedestrian injuries (Braddock *et al*., 1994), and in the analysis of disease policy and planning (Macintyre, 2002).

In Baltimore county, Maryland, GIS and epidemiologic methods were combined to identify and locate environmental risk factors associated with Lyme disease (Coleman, 1982). Ecologic data such as watershed, land use, soil type, geology, and forest distribution were collected at the residences of Lyme disease patients and compared with data collected at a randomly selected set of addresses. A risk model was generated combining both GIS and logistic regression analysis to locate areas where Lyme disease is most likely to occur.

GIS allows analysis of data generated by global positioning systems (GPS). Combined with data from surveillance and management activities, GIS and GPS provide a powerful tool for the analysis and display of areas of high disease prevalence and the monitoring of ongoing control efforts. The coupling of GIS and GPS enhances the quality of spatial and non–spatial data for analysis and decision making by providing an integrated approach to disease control and surveillance at the local, regional, and/or national level (Alpana and Haja, 2001).

GIS is being used to identify locations of high prevalence and monitor intervention and control programs in areas of Guatemala for on chocerciasis (Coleman, 1987) and in Africa for trypanosomiasis (Diez–Roux, 2000). Spatial and ecologic data are combined with epidemiologic data to enable analysis of variables that play important roles in disease transmission. This integration of data is essential for health policy planning, decision making, and ongoing surveillance efforts. For example, as part of the guinea worm eradication effort, the United Nation's Children's Emergency Fund placed pumps in villages most infected with the disease to ensure access to a safe water supply (Subramanian and Duncan, 2003). GIS enabled researchers to locate high prevalence areas and populations at risk, identify areas in need of resources, and make decisions on resource allocation (Macintyre, 2002). Epidemiologic data showed a marked reduction in prevalence in villages where pumps were introduced.

GIS was used in designing a national surveillance system for the monitoring and control of malaria in Israel (Hurley *et al*., 2003). The system included data on the locations of breeding sites of *Anopheles* mosquitoes, imported malaria cases, and population centers. The GIS–based surveillance system provided means for administrative collaboration and a network to mobilize localities in the case of outbreaks.

In 1985, the National Aeronautics and Space Administration (NASA) established the Global Monitoring and Disease Prediction Program at Ames Research Center in response to the World Health Organization's call for the development of innovative solutions to malaria surveillance and control (McElroy *et al*., 2003). A major aspect of the program was to identify environmental factors that affect the patterns of disease risk and transmission. The overall goal of the program was to develop predictive models of vector population dynamics and disease transmission risk using remotely sensed data and GIS technologies.

Remotely sensed data have been used in many vector disease studies (Krieger *et al.*, 2001). Remote sensing and GIS were used to identify villages at high risk for malaria transmission in the southern area of Chiapas, Mexico. An earth environmental analysis system for responding to fascioliasis on Red River Basin farms in Louisiana was developed by integrating LANDSAT MSS imagery with GIS (Bonner *et al.*, 2003). In Kwara State, Nigeria, a temporal analysis of Landsat Thematic Mapper (TM) satellite data was used to test the significance of the guinea worm eradication program based on changes in agricultural production (Ahearn and Rooy, 1996).

GIS is being used by public health administrators and professionals, including policy makers, statisticians, epidemiologists, regional and district medical officers (Weekly Epidemiological Record, 1999). Some of its applications in public health are mentioned below:

1) Find out geographical distribution and variation of diseases.

2) Analyze spatial and temporal trends.

3) Identify gaps in immunizations.

4) Map populations at risk and stratify risk factors.

5) Document health care needs of a community and assess resource allocations.

6) Forecast epidemics.

7) Monitor diseases and interventions over time.

8) Manage patient care environments, materials, supplies and human resources.

9) Monitor the utilization of health centers.

10) Route health workers, equipments and supplies to service locations.

11) Publish health information using maps on the Internet.

12) Locate the nearest health facility.

Previous studies on application of GIS to epidemiology are limited. Spatial epidemiology covers the analysis of the prevalence and geographical distribution of a disease (Lawson, 2001). Issues such as data sampling, map interpretation and production, geo–statistical analysis and modeling must be taken into consideration within this subject. Studies of spatial epidemiology often require the formulating of a mathematical model to describe the spread symbolically. Mathematical models are formed by summarizing the relationship between influencing factors and geographical distribution of the disease. The model can assist predicting the impact of the outbreak and help implementing an intervention plan. GIS has proven to be one of the most useful tools in public health research. It has been widely used in disease surveillance and monitoring, research hypotheses generation, identification of high–risk area and population at risk, targeting resources and the monitoring of interventions (Gupta *et al*., 2003). GIS provides an effective tool for visualization and spatial analysis of epidemiology data and environmental exposure. Recent studies have shown the increasing use of GIS as an important component in public health and epidemiology (Gupta *et al*., 2003; Pearce, 1996). Lately the applications of GIS to public health and epidemic such as DF/DHF through modeling are increased as shown in Table 2.4.

Table 2.4 Summary of the literatures on studies to identify risk area and epidemic (DF/DHF).

Risk area and epidemic/outbreak (DF/DHF) identification						
Using GIS				Non GIS (disease occurrence)		
Index Model	Regression Models	Logistic Regression Models	Other (statistics)	Host	Agent	Environment
Irizarry *et al*. (2004)	**Nakhapakorn (2005), Alpana (2001)**	**Chansang *et al*. (2002)**	**Muttitanon *et al.* (2003)**	**Chareonsook, Foy, Teeraratkul and Silarug (1999)**	**Kathleen (2000)**	

A GIS is a computer system capable of assembling, storing, analyzing, and displaying geographically referenced information. Therefore GIS is an ideal tool and has been used extensively in many DF/DHF studies (Sithiprasasna and Linthieum, 1997; Bohra, 2001; Gupta *et al*., 2003).

2.4 Web–based spatial decision support systems to monitor epidemic risk

GIS is a complex tool which is applying to many fields of study. Its database and powerful functions are normally used by well–trained people. In addition, GIS is more than just a tool that is used to handle geographic data in digital form, display or create maps. In fact, GIS can be integrated with modeling, statistics, and analysis tools to carry out sophisticated tasks. Thus, it can be a useful development to incorporate GIS with decision support systems (DSS) for a specific task. This incorporation is commonly known as spatial decision support systems (SDSS).

DSS is a special purpose tool that is originated in the 1960s in primarily operation research and management science to address business problems (Marakas, 1999). DSS is an extremely broad concept and its definitions vary depending upon the author's point of view (Power, 1997). Keenan (1997) defined a DSS as being an interactive computer–based system that helps decision–makers utilize data and models to solve unstructured problems. Mitchell (2000) defined a DSS broadly as a computer–based system that aids the process of decision making.

SDSS is a class of computer systems in which the technologies of both GIS and DSS are applied to aid decision makers with problems that have a spatial dimension (Walsh, 1992). A common motivation for making SDSS accessible online is to support group decision–making (Kingston *et al*., 2000; Zhu *et al*., 2001). SDSS is mostly built upon GIS coupled with modeling. There are several strategies and approaches for the coupling of environmental models with a GIS (Nyerges, 1993; Fedra, 1996), which can range from loose to tight coupling. A loose coupling is just the transfer of data between models and GIS, and it is based on two separate systems and generally separate data management. A tight coupling is one with integrated data management, in which GIS and models share the same database. The tightest of couplings is an embedded or integrated system, in which modeling and data are embedded in a single manipulation framework (Crosbie, 1996; Fedra, 1993).

SDSS is a powerful tool. However, one of the issues is how to make the product easy to use and access. Since the emergence of the World Wide Web in the mid–1990s, SDSS research has found a direction (Rinner and Jankowski, 2002). The Internet extends the capabilities of SDSS to a large number of geographically dispersed users at a relatively low cost. Some of the most popular online geo–spatial applications, such as driving directions (Yahoo Maps), combine features of Internet mapping and decision support (Sugumaran *et al*., 2004). Therefore, research into web–based SDSS (Web SDSS) seems a natural consequence. Rinner and Jankowski (2002) described technical foundations and applications of Web SDSS. Sugumaran *et al*. (2004) developed a web–based DSS that prioritizes local watersheds in terms of environmental sensitivity. Regmi (2002) developed a web–based SDSS to incorporate watershed hydrologic and water quality assessment for present and future land–use planning.

Overall, there have been very limited SDSS applications and even less Web SDSS. There is a great need to be researched about how to integrate GIS, the Internet, modeling and databases to create a Web SDSS. Table 2.5 shows some of applications using GIS, web–based and their incorporation technologies in various types of task.

Table 2.5 Summary of the literatures on web–based SDSS tools and applications.

Authors	Web SDSS	Web & GIS technology	Decision task
Kingston *et al*. (2000)	Client– and Server–side	HTML forms Perl CGI scripts, java applet	Planning
Jensen *et al*. (1998)	Server–side	HTML forms Perl CGI scripts to access SAS on server	Agricultural management
Rinner (2003)	Server–side	HTML forms Visual Basic CGI	Land–use allocation
Rinner and Malczewski (2002)	Client–side	Java applet (CommonGIS with extension)	Site selection
Zhu *et al*. (2001)	Client– and Server–side	HTML page, java applets /servlets (JESS, Web map)	Vegetation management
Andrienko (2001)	Client–side	Java applet (Descartes)	Site selection
Bhargava and Tettelbach (1997)	Routing	HTML forms, CGI scripts to access DBMS	Public access to application

In this study the approach focuses on developing a web–based SDSS to predict and manage DF/DHF epidemics. The system developed covers using data vector surveillance factor, climatic factor and disease occurrence data through the concepts and process of MCDA. Those data factors relate to disease occurrence are grouped in terms of agent, host, and environment, which have to be considered simultaneously, as shown in Figure 2.1.

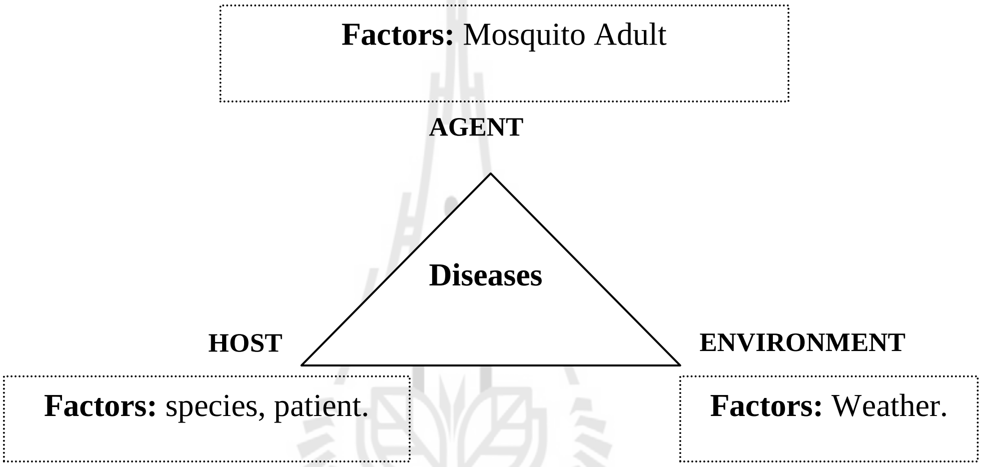


Figure 2.1 The components of disease occurrence (Friedman, 1974).

Both vector surveillance and climatic changes in environmental condition are important determinants of vector–borne disease transmission. Spatial and temporal distributions of these components lead to identifying risk area. In addition, integration the Web–based Spatial Decision Support System (Web–based SDSS) would be particularly useful if it also provides rules on line for decision support regarding the prediction, prevention and control of DF/DHF in the community. Relation of these tools can be set up as shown in Figure 2.2.

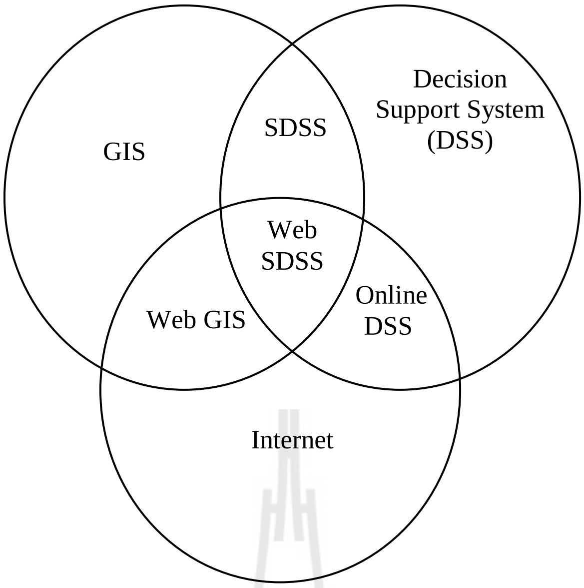


Figure 2.2 GIS, Decision Support System, Internet and their integrations.

CHAPTER III

RESEARCH METHODOLOGY

The research methodology consists of four phases: data collection and transformation, developing spatial DF/DHF prediction models, developing web–based SDSS, and system implementation as shown in Figure 3.1. Research methods are designed to meet the objectives of the research.

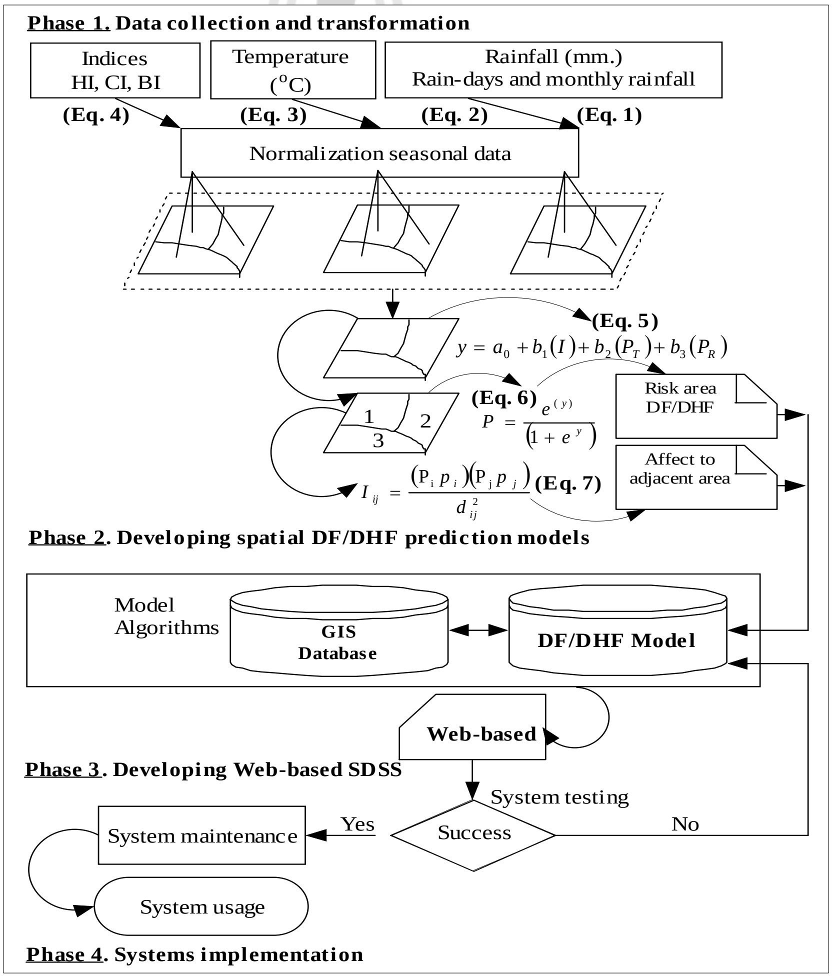


Figure 3.1 Conceptual diagram of the study.

3.1 Data collection and transformation

3.1.1 GIS data layers collection

3.3.1.1 Spatial data

Administrative boundary digital map of scale 1:50,000 from the Regional Environmental Office 10.

3.3.1.2 Non–spatial data

1) Secondary data on HI, CI and BI are calculated each year and reported in districts and sub–district levels by Ubon Ratchathani province of Public Health.

2) Data on DF/DHF cases are recorded yearly for each district and sub–district by the Provincial Health Office.

3) Climate data including monthly rainfall, rainy day and temperature are collected by the Department of Meteorology, Ministry of Information and Communication Technology.

Table 3.1 GIS data layers.

GIS data layer	Feature types	Attribute (non–spatial)	sources
District, sub–district	polygon	DF/DHF case, Population HI, CI and BI	Provincial Health Office
Precipitation	point	station name, annual rainfall	Thai Meteorology Department.
Temperature	point	station name, annual temperature	

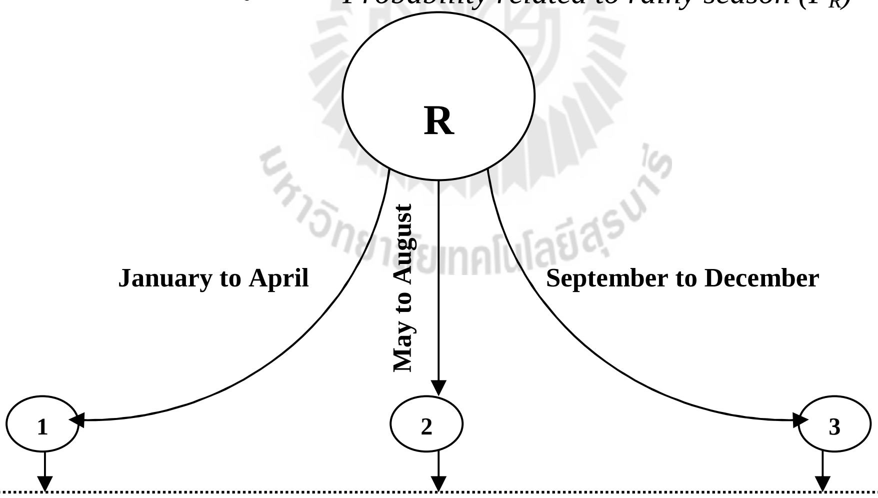
3.1.2 Transformation data

3.1.2.1 GIS precipitation and temperature data: These data prepared in terms of GIS layers were interpolated and then averaged to present for each district/sub–district.

3.1.2.2 Data normalization: In this step is to normalize/standardize data which are R, T, HI, CI, and BI. R is normalized to be probability of case occurrences which are varied when the season, rain–day, and amount of rainfall vary (Figure 3.2 and Equation 1). Decision tree technique is used when R data are taken seasonally. Then, proper probability of bite (Day and Curtis, 1989; Githeko *et al*., 2000; Hawley, 1991) is assigned as shown in Figure 3.2. P_R is further applied in Equation 1.

1) Precipitation

- *Probability related to rainy season (P_R)*



$$P_R = (probability\_of\_bite)[\text{probability of } \textit{Aedes aegypti} \text{ transmission}] \quad \textbf{Eq. 1}$$

(1) $P_R = (0.59)(\text{probability of } \textit{Aedes aegypti} \text{ transmission})$

(2) $P_R = (0.68)(\text{probability of } \textit{Aedes aegypti} \text{ transmission})$

(3) $P_R = (0.42)(\text{probability of } \textit{Aedes aegypti} \text{ transmission})$

Figure 3.2 Transmission probability related to seasons.

$P_{(trans.)}$ is obtained using Mamdani model (Borke and Fisher,1998). In this case, it is the maximum of the product of monthly rainy day and amount of monthly rainfall of each period as illustrated in Equation 2.

Where $P_{(trans.)}$ is *Probability related to Aedes aegypti transmission* and can be expressed as

$$P_{(trans)} = \max\left| x_1 y_1, x_2 y_2, x_3 y_3, ... x_n y_n \right| \qquad \textbf{Eq. 2}$$

n is numerical of month.

x is monthly rainy days.

y is amount of monthly rainfall.

2) Temperature

Probability related to temperature data (P_T)

Decision tree analysis is applied to temperature data as shown in Figure 3.3. Certain probability of bite and w_t are applied to certain season and temperature (Koopman, 1991; Kettle, 1995; Boonmaging, 2004). $\overline{x_t}$ is the average temperature of each season. This probability will be normalized to be between 0 and 1, too.

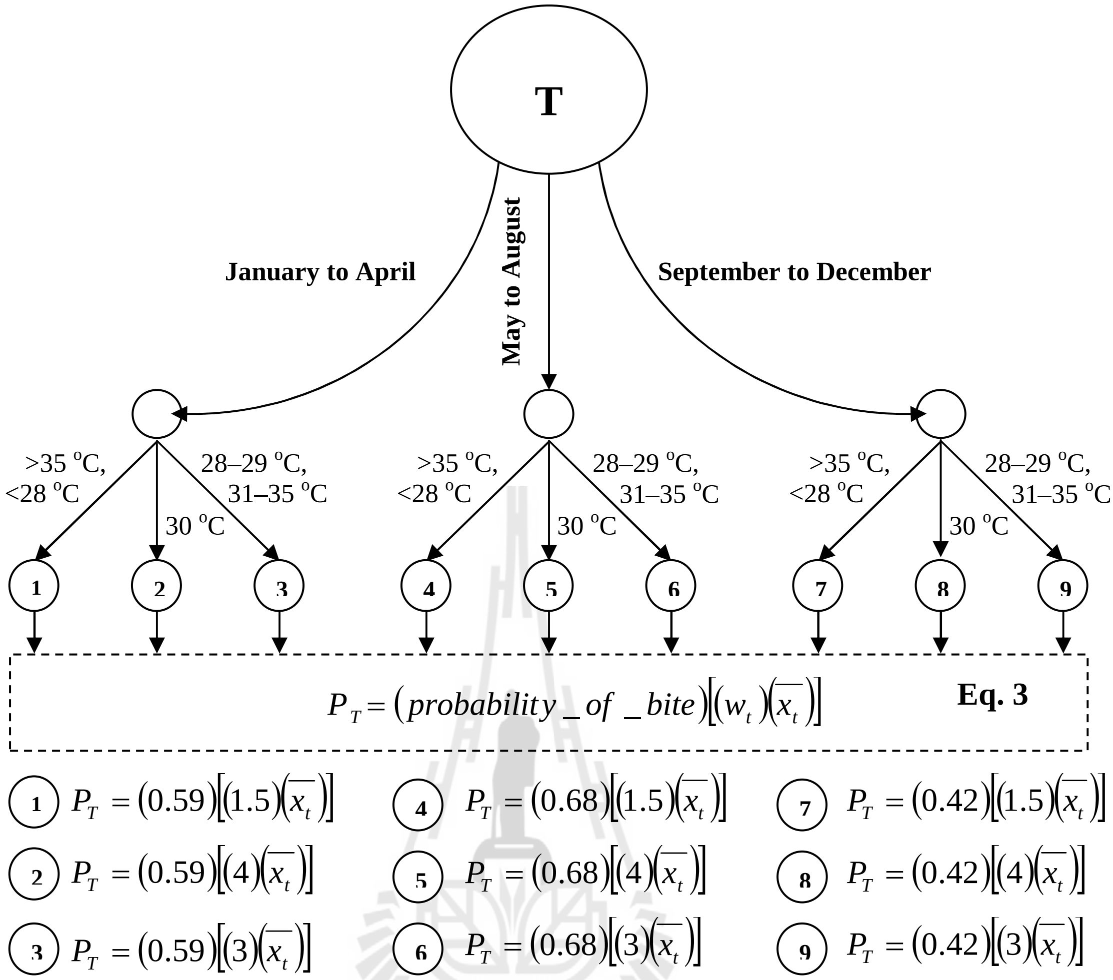


Figure 3.3 Normalization of temperature data.

3) HI, CI, and BI

Index value as normalized HI, CI and BI

The weighted linear combination method is probably the most common method for computing the index value (Saaty, 1980; Banai–kashani, 1989; Malczewski, 2000). It is calculated by summing the weight criterion values and dividing the sum by the total of the weights (Equation 4):

$$I = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i}$$

$$I_{(\mathrm{HI,CI,BI})} = \frac{w_{(\mathrm{HI})}(x_{\mathrm{HI}}) + w_{(\mathrm{CI})}(x_{\mathrm{CI}}) + w_{(\mathrm{BI})}(x_{\mathrm{BI}})}{(w_{(\mathrm{CI})} + w_{(\mathrm{HI})} + w_{(\mathrm{BI})})} \qquad \textbf{Eq. 4}$$

Where $I_{(\mathrm{HI,CI,BI})}$ is the index values of HI, CI and BI, n is the number of criteria, w_i is the weight for criterion i (HI, CI and BI), and x_i is the (mean) value of criterion i.

Weight for this index can be obtained depending on varied HI, CI, and BI (Table 3.2).

Table 3.2 Weight *of Aedes aegypti* density for each criterion index is displayed to show the priority of transmission (Brown, 1994; 1997).

Priority of transmission	**Container Index (CI)**	**House Index (HI)**	**Breteau Index (BI)**
1	0–2.99	0–3.99	0–4.99
2	3–5.99	4–7.99	5–9.99
3	6–9.99	8–17.99	10–19.99
4	10–14.99	18–28.99	20–34.99
5	15–20.99	29–37.99	35–49.99
6	21–27.99	38–49.99	50–74.99
7	28–31.99	50–59.99	75–99.99
8	32–40.99	60–76.99	100–199.99
9	> 41	> 71	> 200

3.2 Developing spatial DF/DHF prediction models

This section provides a detailed description of the different steps and procedures used during the study to formalize the conceptual model. The conceptual model as shown in Figure 3.4 is the overall spatial models methodology.

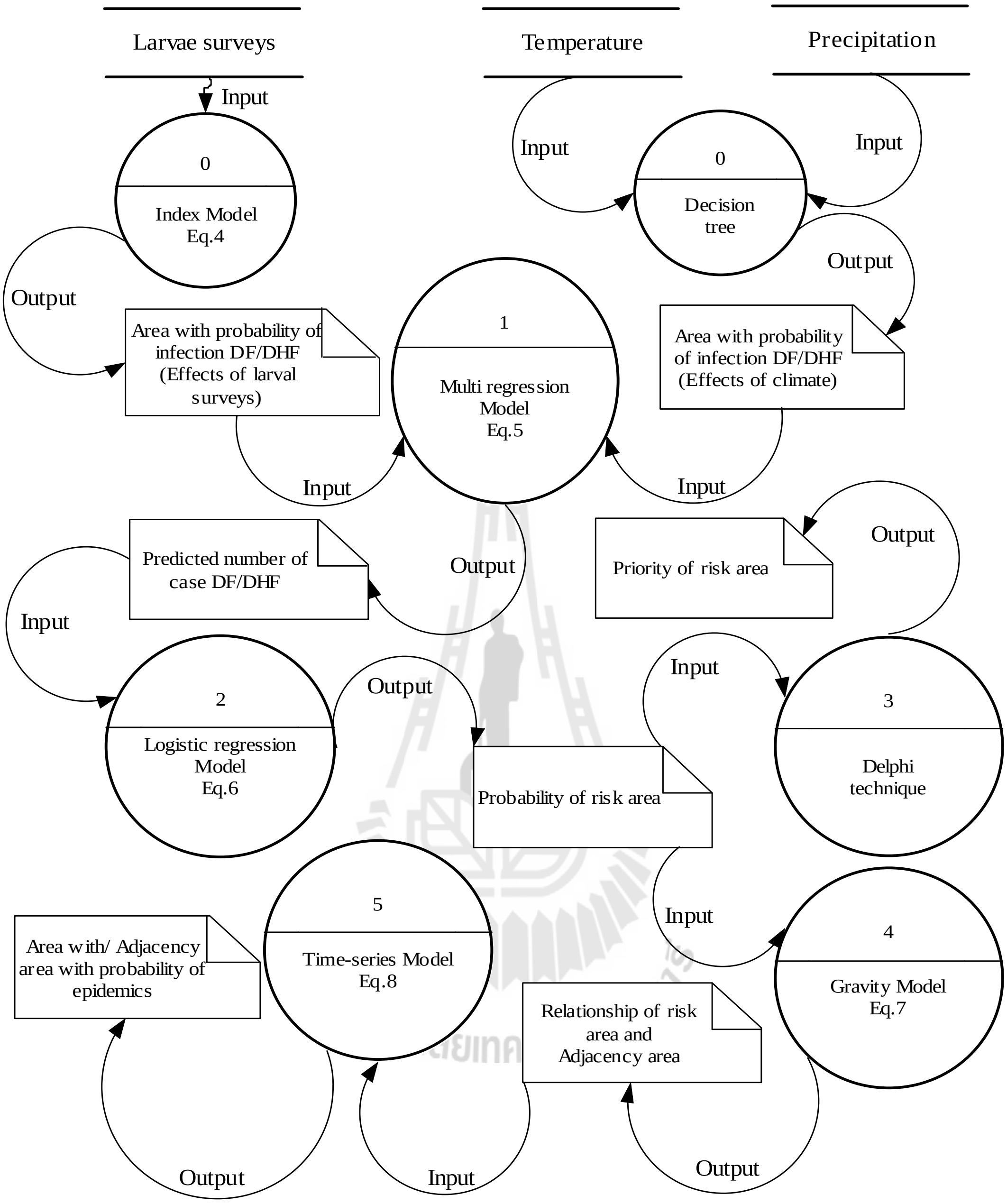


Figure 3.4 Systematic data flow diagram of DF/DHF spatial epidemic model.

3.2.1 Developing spatial model of each module

3.2.1.1 Relationship of DHF incidences and climatic factors using linear regression model. A multiple linear regression model to predict DHF incidence is defined by:

$$y = a_0 + b_1(I) + b_2(P_R) + b_3(P_T)$$ **Eq. 5**

Where y is the predicted number of DF/DHF cases,

I is the index value of HI, CI and BI (from Equation 4)

P_R is the probability of rainfall effect

P_T is the probability of temperature effect

a_0 is the intercept of y–axis

b_1 is the constant for factor indices of larval surveys

b_2 is the constant for rainfall factor

b_3 is the constant for temperature factor

3.2.1.2 Prediction of DF/DHF epidemic using logistic regression model.

Logistic regression is used for DF/DHF study to predict the occurrence of particular events or conditions from known independent variables (Equation 5). Logistic regression attempts to express the probability that an event is present as a function of the independent variable. Logistic regression can be displayed as Equation 6.

$$P = \frac{e^{(y)}}{(1 + e^{y})}$$ **Eq. 6**

Where P is occurrence probability of DF/DHF epidemic (its values are all between 0–1).

y is the predicted number of case DF/DHF (from Equation 5) . If y is ≤ 0, P will be assigned to be 0.

3.2.1.3 Classifying risk level using the Delphi technique.

Results from Equation 6 were classified to be risk level using the Delphi technique as its framework shown in Figure 3.5. The technique is in essence a series or rounds of sequential questionnaires (Appendix A), interspersed by controlled feedback to a group of experts (Linstone and Turoff, 1975). It is useful for situations where individual judgments can be independent and combined in order to address or solve a lack of agreement or incomplete state of knowledge (Delbecq *et al*., 1975). Classification of risk areas can be high risk area, moderate risk area and low risk area.

1) Create tool for surveying data. Prepare and send the first questionnaires, which ask each participant to engage in individual brainstorming so as to generate as many ideas as possible for dealing with the issue.

2) Response to the first questionnaires. Each participant lists his/her ideas in a brief, concise manner and returns the list anonymously to the coordinator. These ideas need not be fully developed. In fact, it is preferable to have each idea expressed in one brief sentence or phrase. No attempt should be made to evaluate or justify these ideas at this point in time.

3) Create and send the second questionnaires. The coordinator prepares and sends the second questionnaires to participants that contain all of the ideas response to the first questionnaires and provides space for participants to refine each idea, to comment on each idea's strengths and weaknesses for addressing the issue, and to identify new ideas.

4) Response to the second questionnaires. Participants anonymously record their responses to the second questionnaires and return them to the coordinator.

5) Consider value Interquartile Range (IR – the statistical medians of the low and high groups). IF maximum number of IR falls in to each class THEN the class ranges are consistent and GO TO step 6, ELSE return to Create and send the third questionnaires.

6) Conclusion of analysis. Classification of risk areas can be high risk area, moderate risk area, and low risk area.

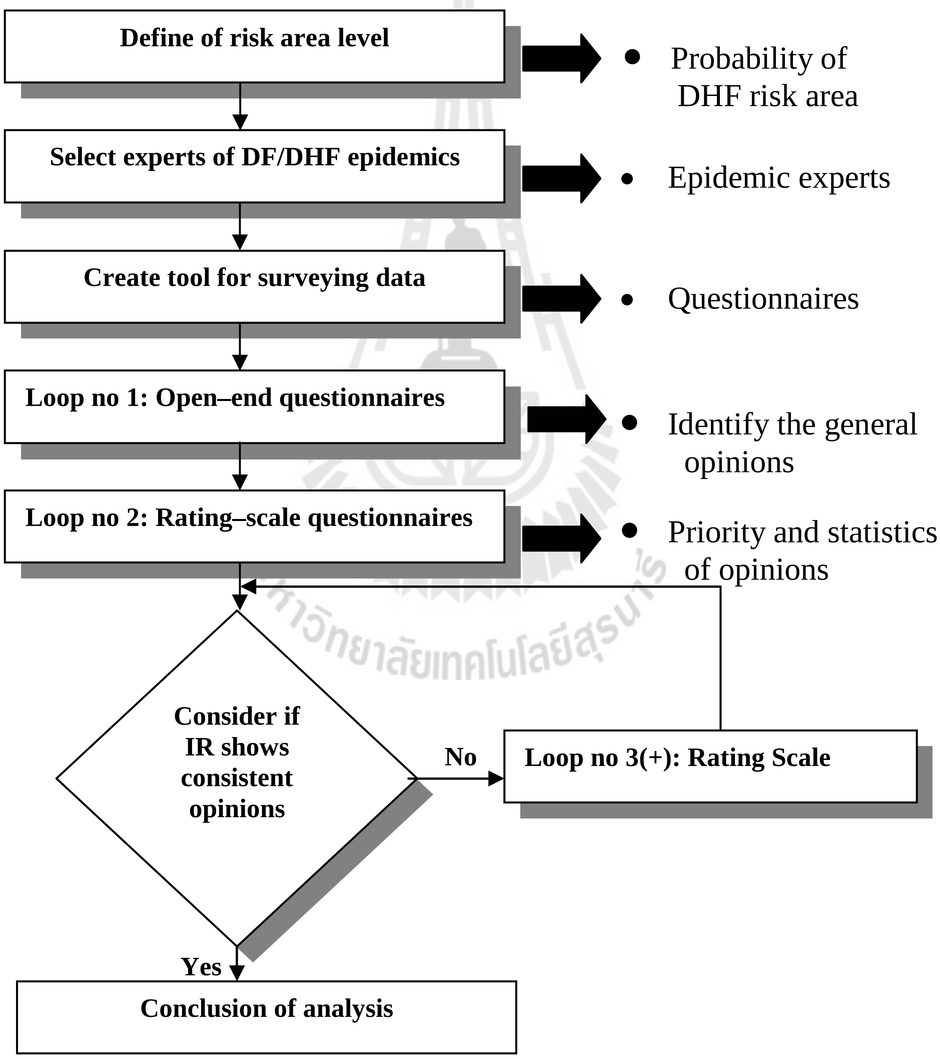


Figure 3.5 Framework of Delphi Technique.

3.2.1.4 Estimating relationship of high risk area and its adjacent areas using the Gravity model.

Newton defined the law of gravitation in the seventeenth century stating that two celestial bodies or planets were subjected to an attraction force that depended positively on the product of their masses and negatively on their distance. The gravity model was applied in many fields e.g. first applied to international trade by Tinbergen (1962) and Pöynöhen (1963), used to explain social flows or migration, in terms of the "gravitational forces of human interaction". It can also be applied to the interaction between the high risk area and its adjacent area as shown Equation 7.

$$I_{ij} = \frac{\left((Pop_i)(P_i)\right)\left((Pop_j)(P_j)\right)}{d_{ij}^2} \qquad \textbf{Eq. 7}$$

Where I_{ij} is the interaction volume from high risk area *i* to its adjacent area *j*,

Pop_i and Pop_j are the populations of area *i* and area *j*, P_i and P_j are occurrence probabilities of DF/DHF epidemic in area *i* and area *j*, d_{ij} is the distance between centroids of area *i* and area *j*.

3.2.1.5 Estimating Normalized Product of Interactive Correlation (NPIC) using the Time–series Forecasting Method.

Time series analysis is a procedure using multiplicative variables to compute values related to forecasting (David *et al*., 1995). The model is designed that all variables are multiplied by each other. For this study, the model/equation applied is below.

$$Y_t = (I_{ij})(r_{ij}) \qquad \textbf{Eq. 8}$$

Where Y_t is the product of interactive correlation.

I_{ij} (from Equation 7) is the interaction volume from *i* to *j*,

(i = high risk area, j = adjacent area), r_{ij} (from Equation 9) is the correlation between the number of DF/DHF cases in high risk area (i) and its adjacent area (j), Y_t will be normalized (linear scale transformation) to be between 0 and 1, which is NPIC.

$$r_{ij} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}} \qquad \textbf{Eq. 9}$$

Where r_{ij} is the correlation between the number of DF/DHF cases in high risk area (i) and its adjacent area (j)

x_i is the number of DHF cases in high risk area i of month.

y_i is the number of DHF cases in adjacent area j of month.

$\bar{x}$ is the average DHF cases in high risk area i, $\bar{y}$ is the average DHF cases in high risk area j of season.

3.2.2 Producing output and verification of predicted DF/DHF risk area for decision support

3.2.2.1 Display results from prediction models as GIS data set.

Results of the models are GIS datasets for two levels of spatial unit i.e. district and sub–district displayed in Figure 3.4. Both spatial and non–spatial data will be reported through web–based SDSS.

3.2.2.2 Modeled risk area verification and hypothesis 0 testing.

This procedure determines how well the risk areas classified by the model fit to the traditional classification (Table 3.3) A, B, C, D, E and F are referred to the basic assumption in 1.5. The statistics of fit for various predicting results and traditional classification with the same period of time can be calculated using *error* *matrix* (Pumplin and Stump, 2001). The percent of error or accuracy obtained can be used for hypothesis 0 testing. For this study, if the accuracy is > = 60% or moderate to strong agreement, the hypothesis 0 will be accepted.

Table 3.3 Traditional classification of risk area DF/DHF.

Code area based on epidemic status					
A	**B**	**C**	**D**	**E**	**F**
High risk area (A+B+C+D)				**Moderate risk area (E)**	**Low risk area (F)**

3.2.2.3 Hypothesis 1 testing

To test the hypothesis 1, only the high risk areas and their adjacent areas are taken into account. The mean of NPIC or E for each high risk area is calculated (Figure 3.6). If the frequency of E of which value is higher than or equal to 0.5, is equal or more than 50% from the total number, then the hypothesis 1 will be accepted.

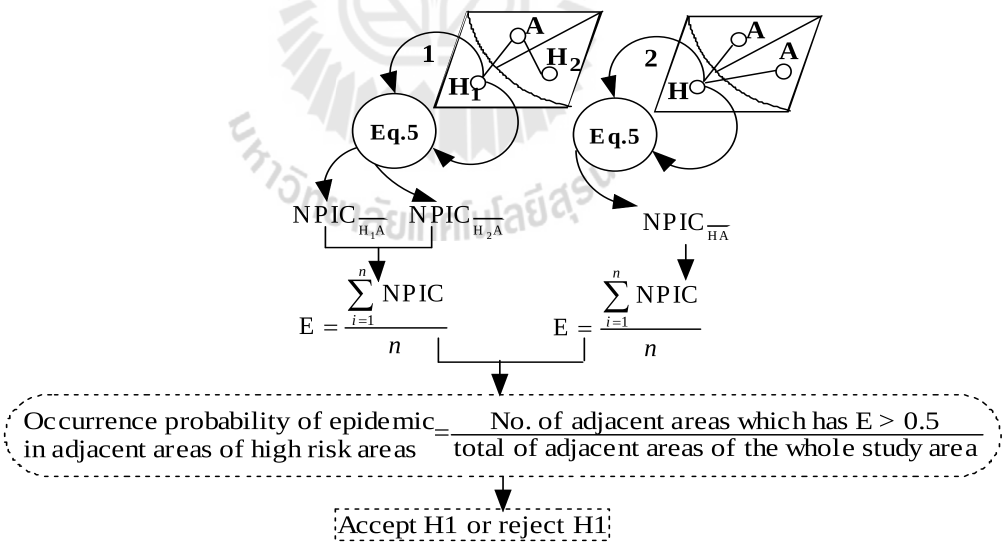


Figure 3.6 The average NPIC of each adjacent area is used for hypothesis 1 testing (H=High risk area, A=Adjacent area).

3.3 Developing Web–Based SDSS

The Web–Based SDSS has two components: Spatial Decision Support System (SDSS) module and Web–based module (see Figure 3.7). The steps to develop the system include designs of the system, software, database and interface.

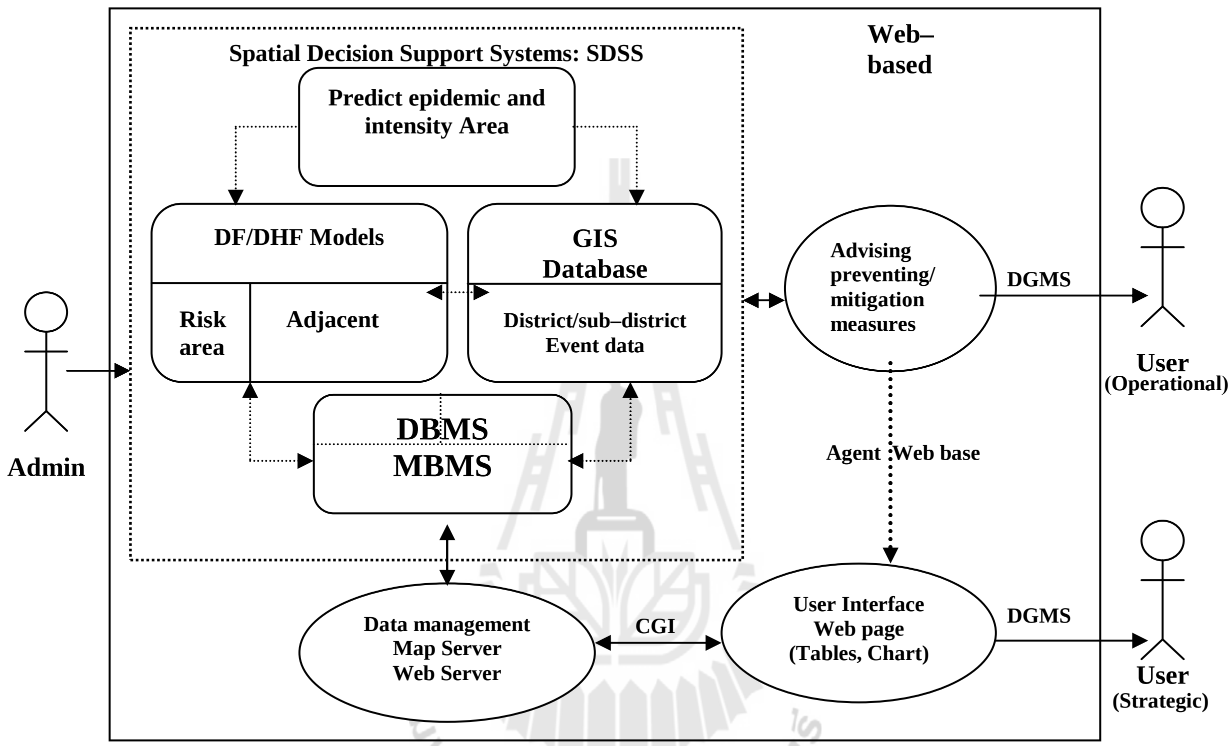


Figure 3.7 Conceptual diagram of Web–based SDSS for predictive DF/DHF epidemic model.

3.3.1 Spatial decision support system (SDSS) module

The SDSS is capable of providing mechanisms for input spatial data that allow representation of the spatial relations and structures, including the analytical techniques and output in a variety of spatial forms. The SDSS is typically composed of Database Management System (DBMS), GIS database, Model–Based Management System (MBMS), Dialog system, User interface, and Model Base DF/DHF (Figure 3.7).

3.3.1.1 Database Management System (DBMS)

Database management system for a SDSS module must support spatial query (searching or selection district, sub–district in polygon). DBMS was used to incorporate with the followings:

1) Database Design and Implementation: The DBMS is the major tool to manage the database in this SDSS. This SDSS uses MySQL web database server as the DBMS. A typical database design and implementation includes application logic, conceptual design, logical design, and application design.

2) Application Logic: Regarding database operation, this SDSS includes two major activities, query and editing data (Figure 3.8). User information management is used in the whole process to identify users and create customized web pages. After login, users can view data through web pages. Users first send a request for data, then the web server queries the database according to the request, the DBMS server queries current database and returns required data to the web server, the web server organizes the data into a formatted web page and returns it to users.

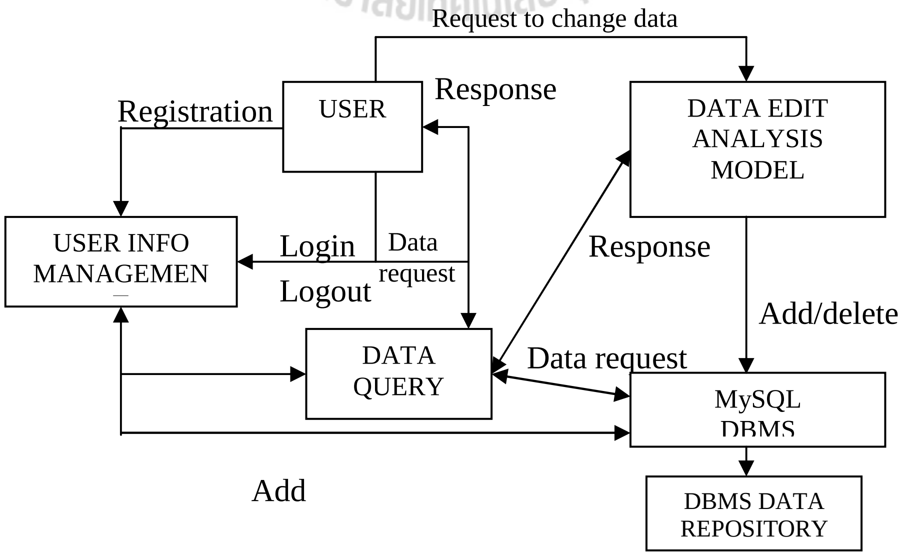


Figure 3.8 Application logic of the SDSS (modified from Sadagopan, 2000).

3) Conceptual Design: Conceptual design defines the abstract model of data organization. The design depends on the objectives of a database and application logic. The entity relationship diagram, or E–R diagram, is usually used in conceptual design to represent the entities and their relationships. This database uses a combined primary key in many entities. The combined key allows a SQL query to filter the records according to one attribute in a combined primary key without linking different tables, which reduces the number of tables and the links between tables. Structured Query Language (SQL) is used to implement the database scheme as shown below.

SQL for Creating Database

```
CREATE TABLE Amphoe      (Code_amp   varchar 2(40)  PRIMARY KEY,
                          Name_thai   varchar       2(80),
                          Name_eng    varchar       2(80));
CREATE TABLE Tambon      (Code_tam  varchar  2(20)  PRIMARY KEY,
                          Code_amp    varchar       2(40),
                          Name_thai   varchar       2(80),
                          Name_eng    varchar       2(80));
CREATE TABLE Village     (Code_village varchar  2(20) PRIMARY KEY,
                          Code_village  varchar     2(20),
                          Name_thai     varchar     2(80));
CREATE TABLE Patient    (Code_village  varchar  2(20)   PRIMARY KEY,
                          Number        Number      (20, 10),
                          Date          date        2(80));
```

CREATE TABLE Larval Surveillance (Code_village varchar 2(20))

PRIMARYKEY,

HI	Number	20,10)
CI	Number	(20,10)
BI	Number	(20,10)
Date	date	2(80));

4) Logical Design: Logical design defines the operational relationships among different entities in a database. The deletion is implemented in a cascade pattern.

5) Application Design: The proposed application model is shown in the following Figure 3.9. The design shows a sample DF/DHF model of the application to provide the information about the factor condition.

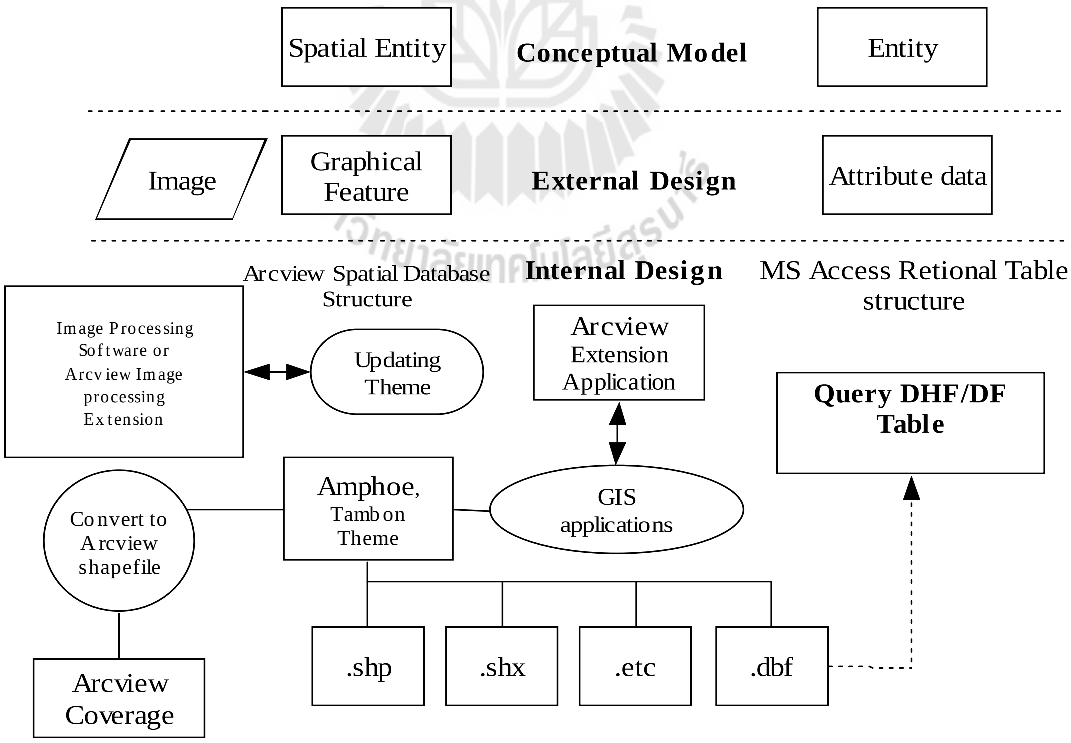


Figure 3.9 The application model. (Modified design from Laurini and Thompson, 1998; Bernhardsen, 1999).

3.3.1.2 GIS Database

The foundation of developing a web–based SDSS is to build a GIS database first. This database can produce a set of factors/resulting maps to help visualize and evaluate the geographic distribution of DF/DHF risk areas in Ubon Ratchathani province. This database has been used to provide mapping products for Ubon Ratchathani province Research and Development Authority and other interested parties.

3.3.1.3 Model–Based Management System (MBMS)

The system contains all needed decision models discussed above. The MBMS creates and manages the model directory, as well as the input, process, and output files for model computations.

3.3.1.4 Dialog Management System (DGMS)

In the Web–based SDSS application, the user interacts with a web interface written with HTML, Java script, and PHP to select the location being analyzed in terms of risk and to provide event information of district and sub–district. The model runs on the web server using the, rainfall, temperature and surveillance index as input. The model outputs can be dynamically displayed as web–based tabular and graphical representations when the user requests a web page.

3.3.1.5 User Interfaces

The visualized user interfaces allow users to generate and submit requests of information and decisions, to browse the contents of retrieved information and the computational results of decision models, to revise inputs of decision procedures and activate what–if analysis, to give feedbacks with respect to system outcomes and performances, to select and execute applications and functions, to login and logout the application systems. This component also provides the usual DSS and DGMS functions to interact with consumers for activating desired application functions, decision procedures, information retrieval and model/knowledge computational processes. It deals with the followings:

1) Graphic User Interface Layout: Using Java applet control, there are three panels as shown in Figure 3.10. The first panel is the applet itself. Line 1 of the applet in Table 3.4 is an example to show the creation of this panel using border layout.

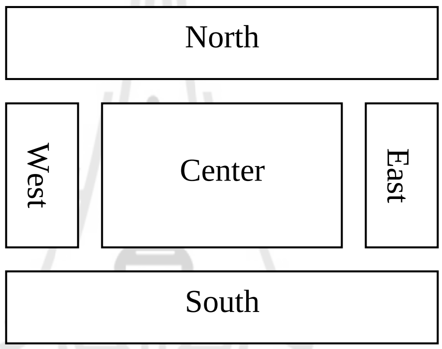


Figure 3.10 Shows the border layout style of Table 3.4.

Table 3.4 Border layout.

```
1   myBorderLayout = new BorderLayout();
2   setLayout(new BorderLayout());
3   add("North", topPanel);
4   add("West", leftPanel);
5   add("Centre", theCanvas);
```

2) Graphic User Interface Design: A GUI control panel has been designed by using the "form menu" provided in Figure 3.11. Control panel functions must meet the requirements of system flow control. These functions include selecting and deselecting data objects and submitting operation requests such as "overlay" or "drawing". A data import function lists the available data objects (files) following with an external database directory path. If users select an item from the list (a data object), its data file will be automatically imported to the system and appear as an icon in the display window. Four buttons ("select data", "deselect data", "overlay", "drawing" and "data import list") are implemented in the interface.

The display window consists of a processing box, an operator's box and a map display box. The processing box displays the data flow described above, and provides a visualization of the GIS analysis.

The map display box displays the geographical contents of selected data objects (data files) when the "drawing" request is given. The map display of geographical data can help users see the data features of operation results.

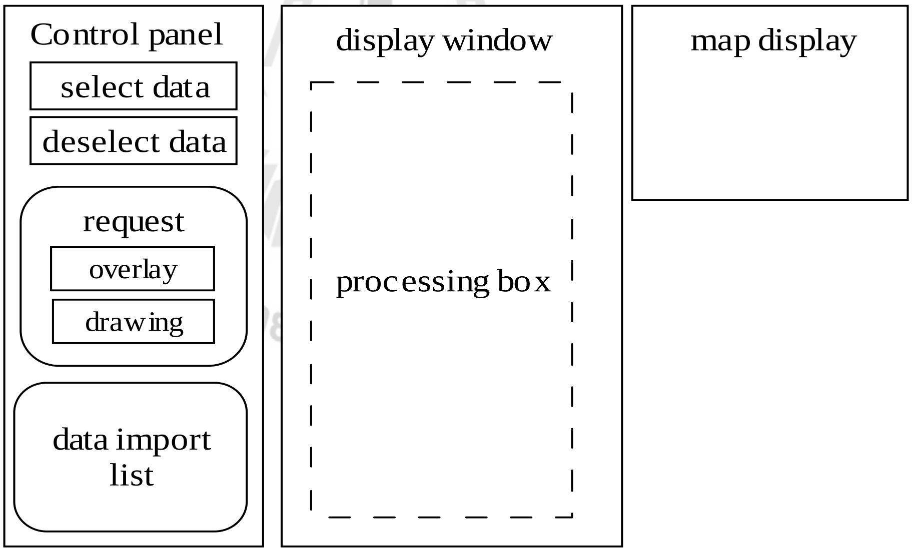


Figure 3.11 The deployment of the graphic user interface.

3) Web Mapping GUI Components: A Web Mapping application normally consists of the following components: Map and/or Layer Control,

Overview/Navigation Map and Functions (buttons): such as Navigation, Query etc. and helpful tool tips Search Options, Query Info. The Map(s) which is the most important thing of a web mapping application can be selectively displayed through GUIs such as Layer choice only, Categorized layer choice using tabs, and Categorized layer choice using a tree.

3.3.1.6 DF/DHF Models

The collection of the DF/DHF models developed using equation 1–9 will be called to use through MBMS.

3.3.2 Web–based module

By integrating components such as databases, GIS, the internet, and modeling, this web–based spatial decision support system is designed to provide data, information and tools to help users in their decision making. In general, the system components are determined by the research objectives. Accordingly, three modules are proposed:

3.3.2.1 A web–based GIS system

This system developed provides graphical display (dynamic mapping) and tabular reports (querying). This module is designed to help users dynamically explore the map by displaying, zooming in/out to any extent, and selecting any combination of information layers. Users can also create and print out customized maps. In addition, users can retrieve various data through queries that might be helpful in their decision making. This web–based GIS pages created uses three major techniques to create dynamic web–pages: JSP/Servlet, JavaScript, and MapServer.

1) JSP/Servlet: Java Server Pages (JSP) and Servlets are the server–side technology for creating dynamic web page on the Java 2 Platform. The basic structure of a JSP/Servlet includes a container and application codes. In this study, JSP and Servlets are also used with Java Database Connectivity (JDBC), Java Beans and session management to create customized web pages.

2) JavaScript: JavaScript is mainly client–side dynamic web page technology. Client–side JavaScript can implement minor operations on client machine, thus the response is fast. The combination of server–side JSP/Servlet and client–side JavaScript can help to create customized web pages to support diverse functionality for user access.

3) MapServer: MapServer is a CGI–based web server. MapServer of this study are displayed in Figure 3.12. More detail structure and relation flow of the MapServer version 4.4.2 are provided in the Figure 3.13. The diagram of Map File structure is shown in Figure 3.14.

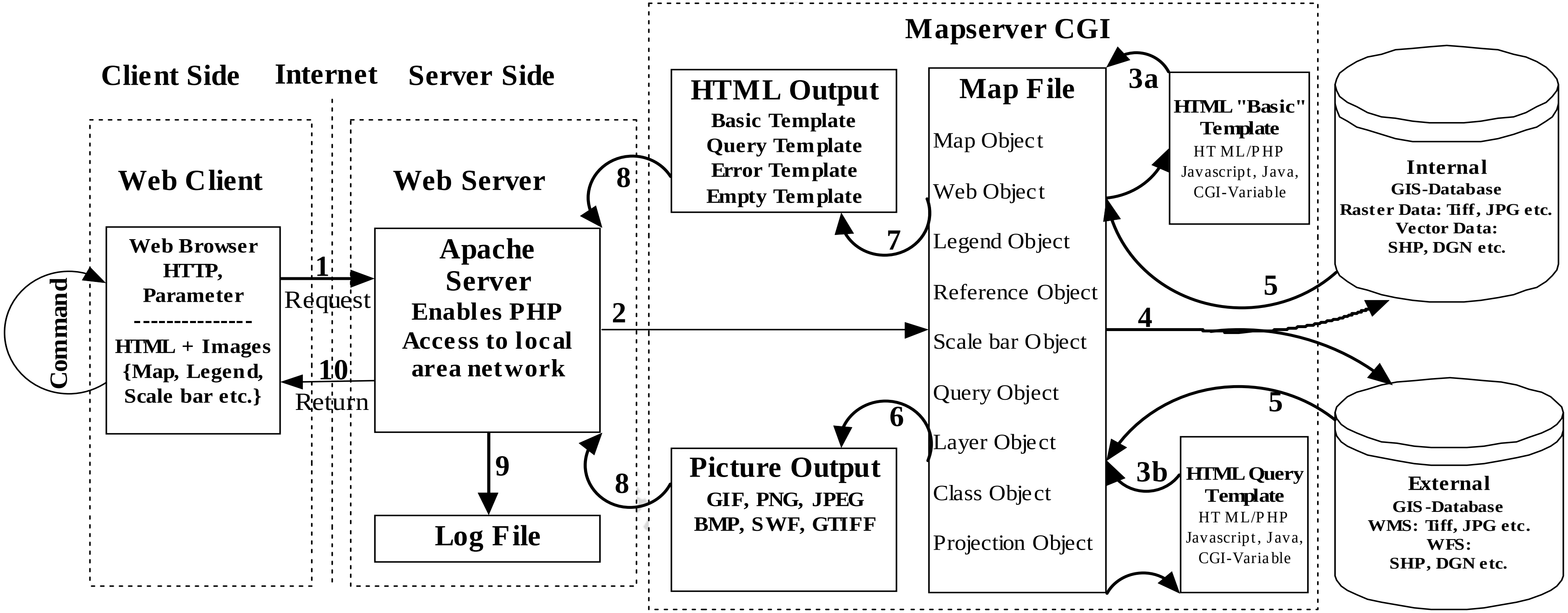


Figure 3.12 The structure and relationships of objects and parameters in MapServer.

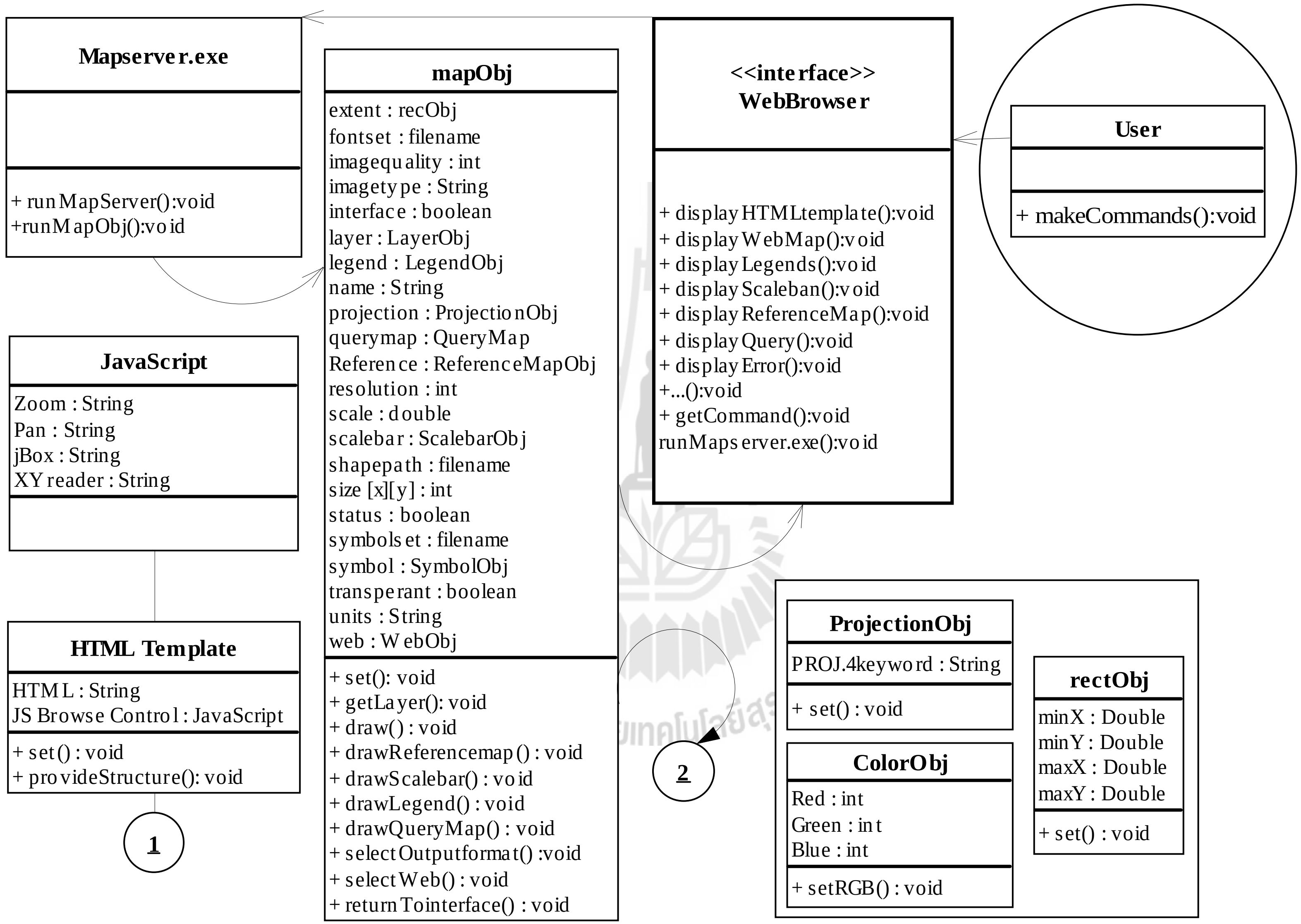


Figure 3.13 More detail structure and relation flow of the MapServer version 4.4.2.

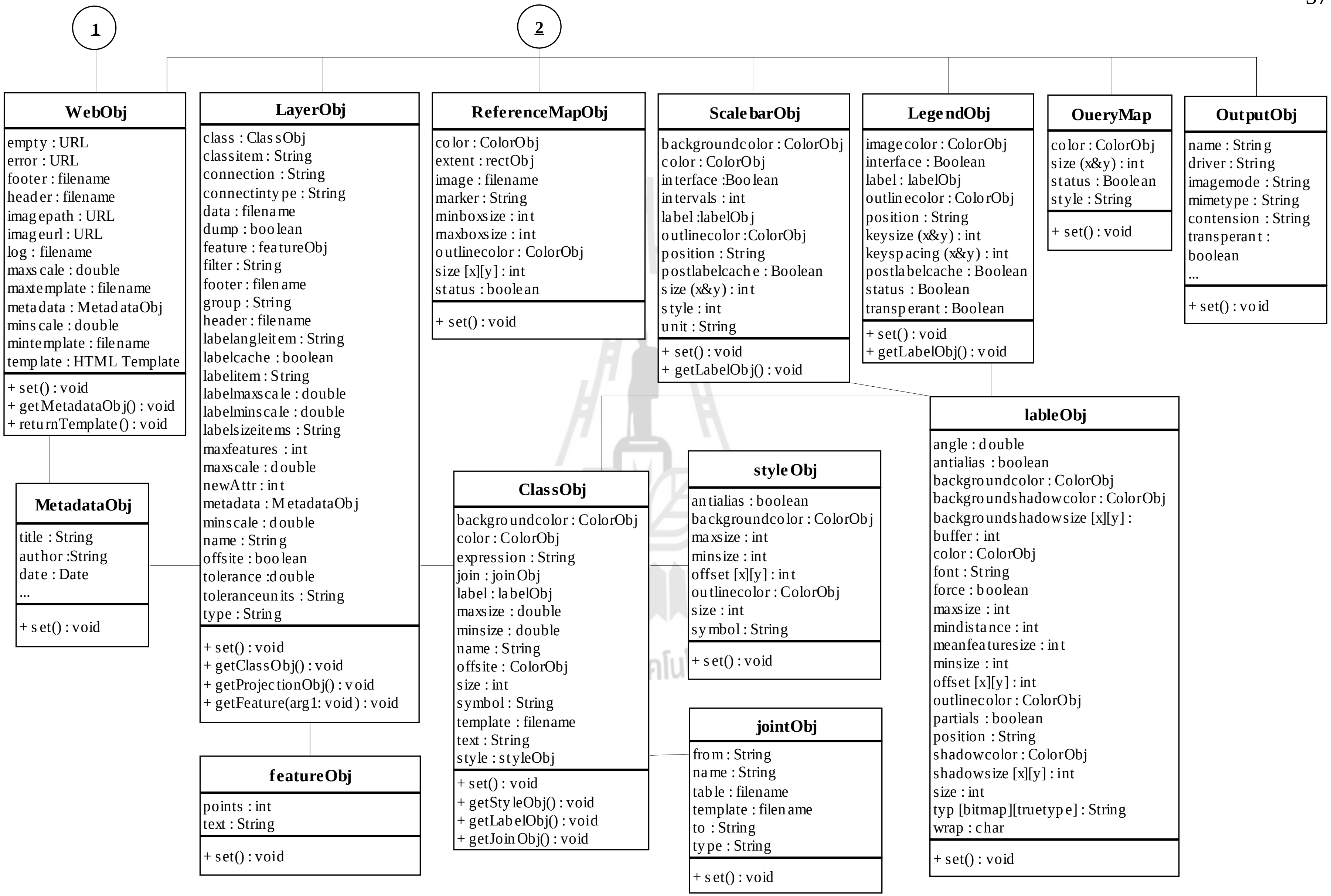


Figure 3.13 (Continued).

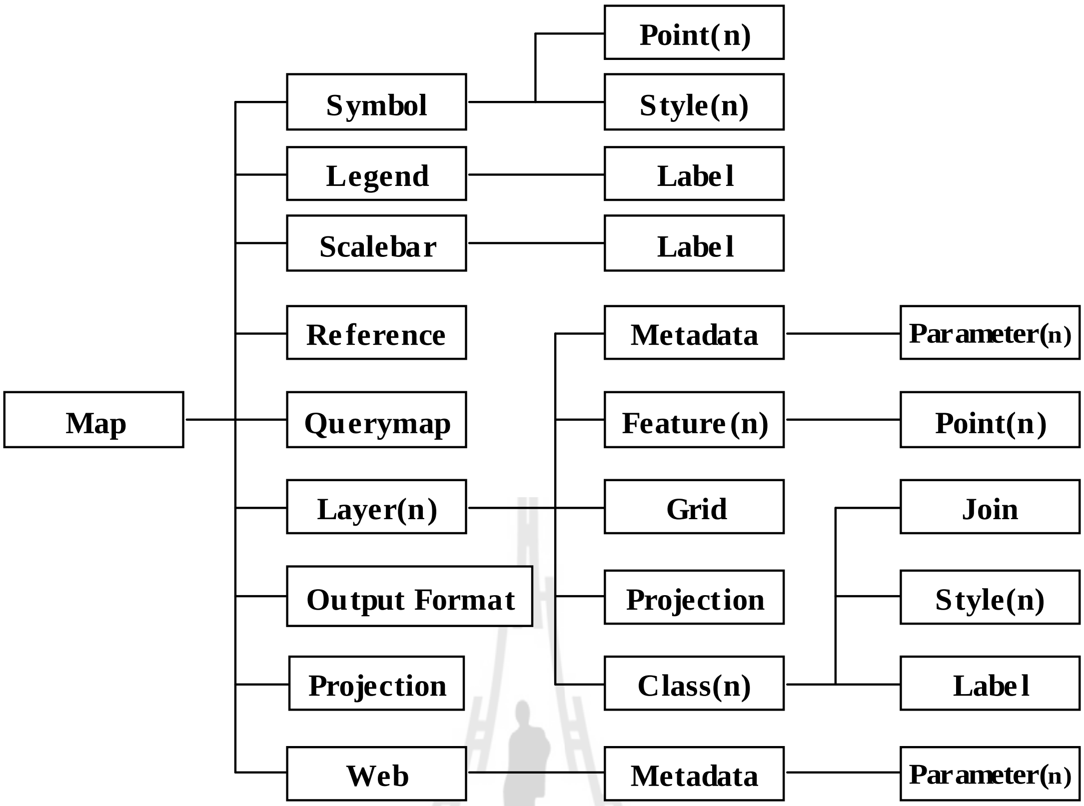


Figure 3.14 Map file structure.

3.3.2.2 A web–based DF/DHF model

The model developed can simulate results based on inputs from users. Risk area DF/DHF maps can be requested from the interface for each of the 219 sub–districts, 25 districts in the Ubon Ratchathani province. Geographic database maps are served using Internet Map Server technology. The user can interactively check the locations/areas of different degree of risk and find out the appropriate strategy to be used as mentioned in the next step.

3.3.2.3 Advising preventing/mitigation measures

The system shows area classified as output to help users understand the results easily. From the output, the system can tell operators "Advising preventing/mitigation measures". This will include certain activities to treat certain kinds of risk present in the area. Those practical activities are referred to the regulated implementation of The Office of Disease Prevention and Control 7, Ubon Ratchathani province (ODPC7, 2006), for instance, using smoke, elimination of water holding containers, warning through public relation and etc. The followings are the suggestion and implementation (ODPC7, 2006) according to different levels of places and degree of the risk.

1) If area is classified to be *high risk area*

a. Household level

Adult mosquitoes should be killed by using of commercially available safe aerosols. Rooms including closets, bathrooms and kitchens should be sprayed (by removing/covering all food items properly) for a few minutes and closing the room for 15–20 minutes. The timing of the spray should coincide with the peak biting time of the *Ae.aegypti* mosquito, e.g. early morning or late afternoon.

- Taking personal protection measures like wearing protective clothing (full sleeved shirts & full pants during day time) and using mosquito nets, preferably insecticide treated ones, while sleeping, even during day time. Using commercially available repellents during day time.
- Using mosquito repellents or burning leaves, coconut shells and husk to kill or repel the mosquitoes.
- Using tight–fitting screens/wire mesh on doors and windows.
- Intensifying efforts to reduce actual or potential larval habitats in and around houses by: covering all water containers in the house to prevent fresh egg laying by the vector. Emptying, drying water tanks, containers, coolers, bird baths, pets, water bowls, plant pots, drip trays at least once each week. Regularly checking for clogged gutters and flat roofs that may have poor drainage.

- Introducing larvivorous fishes in ornamental water tanks/garden. These small fishes eat mosquito larvae.

b. Community level

People should form groups to supplement and reinforce efforts at household level. The Groups should launch awareness campaigns on Dengue and seek cooperation for prevention of mosquito breeding and protection from mosquito bites. Community activities against larvae and adult mosquitoes can include:

- Cleaning and covering water storage containers.
- Keeping the surroundings clean and improving basic sanitation measures.
- Burning mosquito coils to kill or repel the mosquitoes/burning leaves, coconut shells and husk to repel mosquitoes and eliminating outdoor breeding sites.
- Aiding in screening houses.
- Making available hand aerosols for killing mosquitoes.
- Cleaning weeds and tall grass to reduce available outdoor resting places for adult mosquitoes near houses.

Promoting use of mosquito nets to protect infants and small children from mosquito bites during day time and also insecticide treated nets and curtains to kill mosquitoes attempting to bite through the nets or resting on nets and curtains. Organizing camps for insecticide treatment of community owned mosquito nets/curtains.

- In case water containers cannot be emptied, applying Temephos (1 ppm) on weekly basis in coordination with the Health authorities.

- Mobilizing households to cooperate during spraying/fogging.

c. Institutional level

This level includes places such as hospitals, schools, colleges, other institutions, offices, etc:

- Weekly checking for *Ae.aegypti* larvae habitats especially overhead tanks, ground water storage tanks, air coolers, planters, flower pots, etc
- Ensuring source elimination by covering all water tanks with mosquito proof lids, emptying, drying water containers, coolers, plant pots at least once each week and checking for clogged gutters and flat roofs that may have poor drainage.
- Introducing larvivorous fishes (e.g. mosquitofish) in ornamental water tanks/garden.
- Carrying out indoor space spraying with Pyrethrum 2%. The timing of the spray should coincide with the biting time of the *Ae.aegypti* mosquito, e.g. early morning or late afternoon.
- Continuing for 4 weeks of fogging or Ultra Low Volume spray by using 95%.
- Promoting personal protection measures like wearing protective clothing (full sleeved shirts & full pants during day time), using commercially available repellents during day time as well as mosquito nets, preferably insecticide treated ones, while sleeping, particularly during day time.
- Putting tight–fitting screens/wire mesh on doors / windows.

- Information and management training of key environmental health officers and other key health workers who are involved in surveillance and control work, source reduction, resource management, and health promotion.
- The reduction of mosquito breeding places. (Breteau Index (BI) below 50, Container Index (CI) below 10.)

d. Medical care organization to face Dengue epidemics

- Training all medical and nurse personnel of health centers to get knowledge (Dengue diagnosis is supported by epidemiological, clinical and laboratory criteria**).**
- Educating population and medical care providers (physicians and nurses) in daily activities that promotion and prevention are also an important part of the work they have to do**.**
- Triage of dengue patients according to their signs and symptoms**.** This triage or classification of patients for treatment is to be applied at every level of the Health System, including Primary Care units, emergency departments, wards in hospitals, and also during the home visits by medical service providers and trained health worker. Dengue cases should be actively searched and identified.
- Reordering medical services, resources and rearrange the Emergency Department, giving priority to patients with dengue, having trained personnel to classify febrile cases, at hospitals and Primary Care level, where dengue units must be created with physicians and nurses working 24 hours a day.

e. Emergency Action Committee (EAC)

The EAC will comprise administrators, epidemiologists, entomologists, clinicians and laboratory specialists, school health officers and health educators.

- To take all administrative actions and to coordinate activities aimed at the management of serious cases in all medical care centers and undertake emergency vector control intervention measures.
- To draw urgent plans of action and resource mobilization in respect of medicines, intravenous fluids, blood products, insecticides, equipment and vehicles.
- To liaise with intersectoral committees in order to mobilize resources from non–health sectors, namely Urban Development, Ministry of Education, Ministry of information, Legal Department, Water Supply, Waste Disposal, and information for the elimination of breeding potential of *Aedes aegypti*.
- To interact with the news media and local organizations for dissemination of information related to health education and community participation.

f. Rapid Action Team (RAT)

The RAT at state/provincial levels will comprise epidemiologists, entomologists, and a laboratory specialist at state and local levels (Medical officer, public health officer, non–health staff, and local government staff).

- Undertake urgent epidemiological and entomological investigations.
- Provide required emergency logistical support, e.g. delivery of medical and laboratory supplies to health facilities.

- Provide on–the–spot training in case management for local health staff.
- Supervise the elimination of breeding places and application of vector control measures.
- Carry out health education activities.
- Sample the collection of serum specimens.

2) If the area is classified to be *moderate risk area*

- Continuing for 2 weeks of fogging or Ultra Low Volume spray by using 95%.
- In traducing larvivorous fish in large water bodies or large water containers
- Reducing mosquito breeding places. (Breteau Index (BI) below 50, Container Index (CI) below 10.)
- Promoting personal protection measures like wearing protective clothing (full sleeved shirts & full pants during day time),
- Using commercially available repellents during day time as well as mosquito nets, preferably insecticide treated ones, while sleeping, particularly during day time.

3) If the area is classified to be *low risk area*

- Introducing larvivorous fish in large water bodies or large water containers.
- Reducing mosquito breeding places (Breteau Index (BI) below 50, Container Index (CI) below 10).

- Promoting personal protection measures like wearing protective clothing (full sleeved shirts & full pants during day time).

- Using commercially available repellents during day time as well as mosquito nets, preferably insecticide treated ones, while sleeping, particularly during day time.

4) If the area is classified to be *no risk area*

- Reducing mosquito breeding places (Breteau Index (BI) below 50, Container Index (CI) below 10).

- Promoting personal protection measures like wearing protective clothing (full sleeved shirts & full pants during day time).

- Using commercially available repellents during day time as well as mosquito nets, preferably insecticide treated ones, while sleeping, particularly during day time.

3.4 System implementation

A prototype of the Web–based SDSS outlined above is implemented for a part of the entire decision making process. The system implementation process is shown in Figure 3.15. The effective implementation of the Web–based SDSS will support recording activities and database management for all events in the study area.

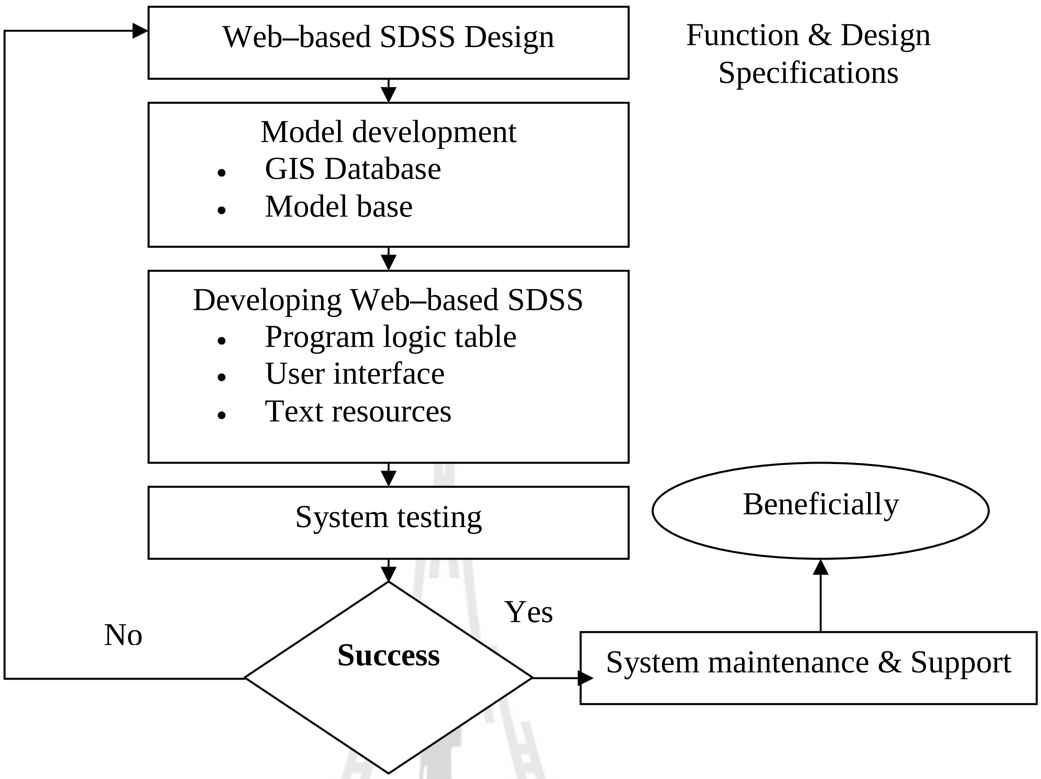


Figure 3.15 System implementation process.

3.4.1 Unit test

This focuses on the smallest unit of software construction. Using the system design specifications, input/output parameters and error–handling mechanism of the application are tested to uncover possible errors in individual units/modules.

1) Positive testing is test cases to the sequence of statements in modules aiming at showing software works. It is also known as "test to pass".

2) Negative testing of this step aimed at showing software does not work. It is also known as "test to fail".

3) Condition testing is a test case of design approach that exercises the logical conditions contained in a program module. A simple condition is a Boolean variable or a relational expression, possibly with one which is NOT operator.

3.4.2 System testing

This is performed when the application development process of the entire system is complete. Acceptance test by users includes functional requirement test, function test, usability test and security test.

APPENDICES

APPENDIX A

QUESTIONNAIRE OF DELPHI

แบบประเมินจัดระดับความเสี่ยง

เป็นแบบประเมินเพื่อสอบความคิดเห็นของผู้ทรงคุณวุฒิ เพื่อจัดระดับความเสี่ยงต่อการเกิดโรคไข้เลือดออกโดยแบ่งเป็น 3 ตอน ดังนี้

ตอนที่ 1 ข้อมูลทั่วไปของผู้ตอบแบบสอบถาม

1.1 ชื่อ–สกุล…………………………………………………..

1.2 ตำแหน่ง…………………………………………………..

1.3 แผนก/หน่วยงาน…………………………………………….

1.4 วันที่ประเมิน(วัน/เดือน/ปี)………………………………..

ตอนที่ 2 ความคิดเห็นเกี่ยวกับรายละเอียดของการพิจารณาจัดลำดับพื้นที่เสี่ยง โดยได้กำหนดคะแนนน้ำหนักของความคิดเห็นตามแบบของ ลิเคอร์ สเกล ดังนี้คือ

5 หมายถึง เห็นด้วยในระดับมากที่สุด

4 หมายถึง เห็นด้วยในระดับมาก

3 หมายถึง เห็นด้วยในระดับปานกลาง

2 หมายถึง เห็นด้วยในระดับน้อย

1 หมายถึง เห็นด้วยในระดับน้อยที่สุด

การแปลผลค่าเฉลี่ย กำหนดดังนี้

4.50 ขึ้นไป หมายถึง ผู้ทรงคุณวุฒิเห็นด้วยในระดับมากที่สุด

3.50 – 4.49 หมายถึง ผู้ทรงคุณวุฒิเห็นด้วยในระดับมาก

2.50 – 3.49 หมายถึง ผู้ทรงคุณวุฒิเห็นด้วยในระดับปานกลาง

1.50 – 2.49 หมายถึง ผู้ทรงคุณวุฒิเห็นด้วยในระดับน้อย

ต่ำกว่า 1.50 หมายถึง ผู้ทรงคุณวุฒิเห็นด้วยในระดับน้อยที่สุด

เกณฑ์	ระดับความเสี่ยง								
ระดับคุณภาพ	เสี่ยงมาก			เสี่ยงปานกลาง			เสี่ยงน้อย		
แบบชุดเกณฑ์	ชุด 3	ชุด 2	ชุด 1	ชุด 3	ชุด 2	ชุด 1	ชุด 3	ชุด 2	ชุด 1
ระดับปริมาณ	0.8–1	0.7–1	0.6–1	0.5–0.79	0.4–0.69	0.3–0.59	0–0.49	0–0.39	0–0.29
ผู้เชี่ยวชาญ									
ผู้เชี่ยวชาญ									
ผู้เชี่ยวชาญ									
ผู้เชี่ยวชาญ									

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APPENDIX B

EXAMPLE OF CALCULATION SEASONAL VARIABLE

Table B.1 Calculated variables of agent sub–districts of Ubon Ratchathani province in three seasons of the year 2001.

Sub-district	January to April						May to August						September to December					
	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E
Khemarat	13.3	59.78	49.47	8.48	0.99	-	18.33	70.83	45.13	67.33	1	-	13.3	39.34	22.38	13.40	0.99	-
Kengnai	14.7	57.12	43.59	12.78	0.99	-	18.6	69.76	17.46	71.22	1	-	15	39.46	29.86	16.71	0.99	-
Tabai	10.87	60.71	21.96	3.09	0.95	-	14.22	69.76	67.94	34.58	1	-	12.12	40.44	29.87	10.37	0.99	-
Maung Dech	17.66	58.71	49.27	20.23	0.99	-	23.71	69.81	11.99	111.0	1	-	16.18	39.40	30.36	19.28	1	-
Trakanphutphon	10.57	60.18	21.77	2.36	0.91	-	12.71	69.36	56.86	23.65	1	-	10.57	39.06	29.63	6.95	0.99	-
Song	9.33	58.41	32.31	-1.15	0	0.43	12.4	69.76	3.49	24.06	1	-	9.33	50.4	28.01	4.41	0.98	-
Khong Chiam	7.5	58.41	42.65	-6.46	0	0.25	7.66	69.97	55.79	-15.4	0	0.3	7.14	36.41	27.90	-0.53	0	0.42
Ponngam	4	55.66	31.69	-14.9	0	0.16	6.6	69.36	55.79	-23.5	0	0.17	8.66	40.32	38.60	2.23	0.90	-
Phibunmangsahan	11	56.81	32.33	3.47	0.96	-	17.81	69.05	16.17	65.44	1	-	11	40.79	30.25	7.87	0.99	-
Muang Sam Sib	8.87	59.33	37.12	-2.69	0	0.53	12.4	69.20	17.46	23.44	1	-	9	42.14	19.32	4.12	0.98	-
Warin Chamrab	17.72	55.71	47.89	20.82	0.99	-	25.71	64.56	25.96	127.1	1	-	19.18	40.38	24.67	26.25	1	-
Khao Pun	7.16	59.73	22.75	-6.67	0	0.11	13.42	66.70	45.13	30.54	1	-	8	39.34	28.93	1.32	0.78	-
Nachaluai	1.66	59.29	42.95	-22.0	0	0.05	1.66	63.24	9.06	-57.4	0	0.1	8.16	50.98	33.61	1.51	0.81	-
Tansum	5.8	60.04	37.37	-10.9	0	0.52	10	69.10	28.57	4.30	0.98	-	5.8	39.94	27.34	-3.43	0	0.53
Phosai	10.14	59.82	25.39	1.11	0.75	-	15.11	71.34	68	41.01	1	-	10.14	41.29	27.89	6.12	0.99	-
Samrong	9.25	58.98	32.73	-1.46	0	0.54	12.66	69.87	27.57	24.76	1	-	7.57	51.87	39.46	-0.13	0	0.55
Don Moddang	9	57.87	37.76	-2.20	0	0.32	15.44	70.68	25.42	46.13	1	-	9	51.91	33.94	3.34	0.96	-
Kanrai	10.5	58.01	26.29	2.25	0.90	-	12.33	68.59	55.79	20.97	0.99	-	10.5	39.53	22.13	7.24	0.99	-
Nakasem	5.5	59.47	31.79	-11.4	0	0.52	9	69.97	9.06	-2.57	0	0.31	5.5	39.31	30.13	-4.26	0	0.25
Na Yea	3.8	58.89	31.69	-15.8	0	0.51	8.62	69.87	9.06	-5.44	0	0.52	6.5	40.28	30.25	-2.05	0	0.58
Hlao Suekok	6.6	56.64	37.22	-8.40	0	0.53	12.5	68.74	25.42	23.90	1	-	8.33	40.32	30.79	1.95	0.87	-
Na Tan	9.5	59.64	35.04	-0.98	0	0.34	14	69.25	45.13	34.26	1	-	9.5	39.31	30.77	4.52	0.98	-
Savang	9.71	60.18	38.16	-0.60	0	0.39	11.5	69.76	28.82	15.70	0.99	-	7.66	40.32	0.50	2.27	0.90	-
Takao	7.71	60.18	43.64	-6.15	0	0.22	9.33	68.54	9.15	0.38	0.59	0.64	8.625	39.43	35.43	2.31	0.91	-

Table B.2 Calculated variables of agent sub–districts of Ubon Ratchathani province in three seasons of the year 2002.

Sub-district	January to April						May to August						September to December					
	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E
Khemarat	15.5	59.38	31.55	13.68	0.99	-	19.33	70.83	24.64	73.93	1	-	13.5	39.34	20.84	13.54	0.99	-
Kengnai	10.62	58.18	27.81	1.17	0.76	-	13	69.97	9.53	27.05	1	-	10.25	41.07	27.80	5.85	0.99	-
Tabai	9.28	60.35	14.02	-1.55	0	0.34	9	69.76	37.10	-7.16	0	0.54	10.25	40.44	27.82	5.85	0.99	-
Maung Dech	18	60.44	31.42	20.20	0.99	-	23	69.61	6.55	104.8	1	-	16.85	51.78	28.27	20.48	0.99	-
Trakanphutphon	12	60.35	13.90	5.66	0.99	-	12.5	70.38	31.04	20.45	0.99	-	9.75	39.06	27.6	4.75	0.99	-
Song	16	59.91	20.62	15.81	0.99	-	19.66	70.43	1.91	79.39	1	-	16	39.78	26.09	18.66	0.99	-
Khong Chiam	9.85	56.02	27.21	-0.54	0	0.54	10	69.10	30.46	1.55	0.82	-	11.14	39.53	25.98	7.95	0.99	-
Ponngam	13	59.11	20.22	7.97	0.99	-	15.72	68.59	30.46	45.96	1	-	14	40.79	35.95	13.50	0.99	-
Phibunmangsahan	16	61.06	20.63	15.66	0.99	-	23.66	68.03	8.83	110.1	1	-	16.88	41.73	28.17	20.48	0.99	-
Muang Sam Sib	9.33	60.0	23.68	-2.15	0	0.58	12.33	68.34	9.53	22.34	1	-	9.33	41.45	17.99	4.58	0.98	-
Warin Chamrab	20	56.94	30.54	26.02	1	-	28.66	69.66	14.17	147.6	1	-	18.5	50.98	22.98	24.50	1	-
Khao Pun	9.85	60.48	14.52	-0.09	0	0.63	12	64.77	24.64	18.90	0.99	-	11.5	39.06	26.94	8.66	0.99	-
Nachaluai	12.25	60.0	27.40	5.30	0.99	-	15.45	65.79	4.95	47.73	1	-	13.75	51.36	31.30	13.40	0.99	-
Tansum	15	61.28	23.84	12.72	0.99	-	24.76	69.46	15.60	117.4	1	-	17.66	50.73	25.46	22.48	1	-
Phosai	10.87	60.53	16.21	2.47	0.92	-	12.66	35.82	37.13	30.43	1	-	10.5	39.37	25.97	6.53	0.99	-
Samrong	12.28	59.47	20.88	5.97	0.99	-	12.28	69.41	15.05	21.01	0.99	-	12.71	40.88	36.74	10.61	0.99	-
Don Moddang	7.714	58.32	24.09	-6.27	0	0.11	7.5	69.15	13.88	-15.76	0	0.57	7.875	39.84	31.61	0.31	0.57	0.43
Kanrai	10.66	57.74	16.78	2.22	0.90	-	15	70.89	30.46	39.71	1	-	10.66	40.69	20.61	7.32	0.99	-
Nakasem	6.75	56.64	20.29	-8.32	0	0.22	9.57	67.32	4.95	1.83	0.86	-	7	39.06	28.06	-1.34	0	0.61
Na Yea	9.14	60.22	20.22	-2.41	0	0.32	9.28	69.61	4.9	-0.99	0	0.39	8.71	40.57	28.17	2.43	0.91	-
Hlao Suekok	7.5	60.18	23.75	-7.05	0	0.14	10.85	69.97	13.88	9.96	0.99	-	5.16	40.32	28.67	-5.42	0	0.52
Na Tan	18.55	59.42	22.36	22.52	1	-	24.84	69.25	24.64	116.9	1	-	16.22	39.31	28.65	18.95	0.999	-
Savang	9	56.64	24.34	-2.67	0	0.12	11.8	69.36	15.7	17.19	0.99	-	9	39.06	0.47	5.16	0.99	-
Takao	4.33	60.62	27.84	-15.8	0	0.53	5.6	69.36	4.99	-29.42	0	0.36	5.62	39.91	32.99	-4.74	0	0.32

Table B.3 Calculated variables of agent sub–districts of Ubon Ratchathani province in three seasons of the year 2003.

Sub-district	January to April						May to August						September to December					
	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E
Khemarat	17.33	61.68	31.68	17.65	0.99	-	22.66	69.97	24.64	101.4	1	-	17.45	41.08	20.84	22.68	1	-
Kengnai	16.83	59.02	27.93	17.00	0.99	-	22	68.85	9.54	98.02	1	-	15.45	39.85	27.80	17.84	0.99	-
Tabai	11.88	56.99	14.13	5.37	0.99	-	13.5	67.32	37.10	30.12	1	-	11.89	40.32	27.82	9.98	0.99	-
Maung Dech	22.27	58.85	31.56	31.14	1	-	28.33	69.15	6.55	147.1	1	-	21.36	40.01	28.27	30.85	1	-
Trakanphutphon	11.5	60.18	14.01	3.95	0.98	-	11.5	69.76	31.05	14.56	0.99	-	10.71	39.31	27.60	7.39	0.99	-
Song	7.14	57.48	20.73	-7.90	0	0.34	7.14	69.36	1.91	-16.24	0	0.58	8.88	39.34	26.08	3.43	0.96	-
Khong Chiam	16	56.33	27.33	15.17	0.99	-	21	68.34	30.47	88.44	1	-	15.20	40.13	25.98	17.39	0.99	-
Ponngam	16.44	59.51	20.34	16.59	0.99	-	20.33	67.42	30.46	83.54	1	-	16.89	40.35	35.95	20.53	1	-
Phibunmangsahan	19.63	60.88	20.75	24.87	1	-	23.66	67.83	8.83	111.2	1	-	20.00	40.48	28.16	27.86	1	-
Muang Sam Sib	18	59.07	23.81	20.47	1	-	19.33	65.43	9.54	78.34	1	-	17.33	40.57	17.99	22.58	1	-
Warin Chamrab	21.81	56.94	30.67	30.25	1	-	26.33	67.57	14.18	131.4	1	-	18.89	40.48	22.98	25.71	1	-
Khao Pun	10.57	59.29	14.64	1.54	0.82	-	13.1	64.00	24.64	29.11	1	-	10.57	39.82	26.94	7.12	0.99	-
Nachaluai	10.8	59.91	27.52	0.89	0.70	-	11.71	67.57	4.95	19.30	1	-	8.14	50.74	31.30	1.60	0.83	-
Tansum	10	59.82	23.96	-0.90	0	0.57	13	69.0	15.60	27.83	1	-	9.00	51.20	25.46	3.84	0.97	-
Phosai	20.1	55.53	16.32	27.17	1	-	24.07	72.01	37.13	110.5	1	-	22.43	52.00	25.97	33.44	1	-
Samrong	11	60.53	21.00	1.94	0.87	-	17.5	68.34	15.06	62.85	1	-	11.00	39.97	36.74	7.49	0.99	-
Don Moddang	13.66	59.64	24.22	8.84	0.99	-	17.18	71.04	13.89	59.76	1	-	11.88	40.95	31.61	9.73	0.99	-
Kanrai	8.57	57.96	16.89	-3.82	0	0.24	11.8	70.27	30.47	16.80	0.99	-	9.43	40.16	20.61	4.98	0.99	-
Nakasem	5.33	59.11	20.40	-12.8	0	0.52	7.66	68.54	4.95	-12.26	0	0.62	5.29	40.32	28.06	-4.60	0.009	0.32
Na Yea	19	59.82	20.34	23.35	1	-	19.33	70.78	4.95	77.31	1	-	15.00	40.19	28.17	16.82	0.99	-
Hlao Suekok	10.83	58.41	23.87	1.50	0.81	-	15.18	68.34	13.89	45.04	1	-	10.33	40.32	28.67	6.50	0.99	-
Na Tan	10.14	59.42	22.48	-0.33	0	0.57	14.42	68.23	24.64	38.23	1	-	9.00	40.04	28.65	3.56	0.97	-
Savang	15.37	58.41	24.47	13.52	0.99	-	15.25	69.36	15.74	45.11	1	-	14.00	39.56	0.47	16.25	0.99	-
Takao	8.285	59.69	27.96	-5.80	0	0.31	10	68.79	5.00	5.70	0.99	-	8.29	52.04	32.99	1.83	0.86	-

Table B.4 Calculated variables of agent sub–districts of Ubon Ratchathani province in three seasons of the year 2004.

Sub-district	January to April						May to August						September to December					
	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E
Khemarat	15.29	61.82	31.58	11.49	0.99	-	15.29	68.09	24.64	42.02	1	-	13.75	39.91	20.84	14.26	0.99	-
Kengnai	15.38	57.22	27.83	12.70	0.99	-	16.27	68.80	9.54	51.67	1	-	15.38	40.32	27.81	17.36	0.99	-
Tabai	4.67	59.65	14.03	-14.6	0	0.32	4.00	69.77	37.10	-47.51	0	0.42	4.50	40.45	27.83	-6.63	0	0.59
Maung Dech	19.58	58.90	31.46	23.29	1	-	26.57	70.48	6.55	131.2	1	-	19.44	40.23	28.28	26.31	1	-
Trakanphutphon	3.00	56.64	13.91	-18.6	0	0.34	4.80	67.32	31.05	-39.77	0	0.36	5.88	40.32	27.60	-3.58	0	0.33
Song	6.50	56.46	20.64	-10.0	0	0.43	7.14	69.72	1.91	-18.04	0	0.41	6.14	39.66	26.09	-2.89	0	0.27
Khong Chiam	5.25	57.66	27.24	-14.2	0	0.25	6.60	68.19	30.47	-26.00	0	0.48	5.67	40.95	25.99	-3.92	0	0.42
Ponngam	9.13	59.96	20.24	-3.46	0	0.52	14.38	69.05	30.46	33.86	1	-	9.13	41.17	35.96	3.02	0.95	-
Phibunmangsahan	14.13	60.05	20.65	9.77	0.99	-	13.30	68.19	8.83	28.96	1	-	14.13	51.79	28.17	14.68	0.99	-
Muang Sam Sib	11.38	58.14	23.71	2.38	0.91	-	11.38	66.15	9.54	14.53	0.99	-	8.50	40.32	18.00	2.88	0.94	-
Warin Chamrab	23.27	58.59	30.58	33.22	1	-	22.67	66.35	14.18	101.0	1	-	19.11	40.48	22.98	25.94	1	-
Khao Pun	4.00	58.94	14.54	-16.3	0	0.27	4.67	67.07	24.64	-39.79	0	0.47	4.33	39.25	26.94	-6.95	0	0.47
Nachaluai	11.56	59.74	27.43	2.28	0.90	-	17.09	63.24	4.95	60.19	1	-	11.56	50.74	31.30	8.78	0.99	-
Tansum	6.00	57.79	23.87	-11.8	0	0.58	6.00	68.95	15.60	-28.67	0	0.58	5.67	51.91	25.46	-3.79	0	0.27
Phosai	5.50	57.75	16.22	-12.4	0	0.27	4.67	35.70	37.13	-33.06	0	0.38	5.50	51.11	25.98	-4.20	0	0.34
Samrong	10.33	59.43	20.90	-0.25	0	0.44	10.33	35.75	15.06	13.97	0.99	-	10.33	39.75	36.75	5.61	0.99	-
Don Moddang	14.00	60.40	24.12	9.03	0.99	-	17.33	69.05	13.89	59.16	1	-	16.50	40.23	31.61	19.58	0.99	-
Kanrai	5.33	57.17	16.80	-12.8	0	0.21	5.20	35.88	30.47	-28.01	0	0.35	4.40	39.12	20.61	-6.36	0	0.58
Nakasem	7.29	58.41	20.31	-8.16	0	0.34	8.14	67.32	4.95	-10.10	0	0.41	7.14	39.06	28.07	-0.83	0	0.61
Na Yea	4.67	58.14	20.24	-15.0	0	0.13	3.75	35.75	4.95	-35.44	0	0.42	4.50	39.75	28.17	-6.66	0	0.26
Hlao Suekok	13.33	56.64	23.77	7.77	0.99	-	19.78	69.97	13.89	77.81	1	-	12.86	40.32	28.68	11.75	0.99	-
Na Tan	10.00	59.43	22.38	-1.29	0	0.43	8.50	35.80	24.64	-1.62	0	0.35	8.43	39.60	28.66	1.97	0.87	-
Savang	8.71	60.18	24.37	-5.01	0	0.55	13.30	35.70	15.74	36.82	1	-	9.29	50.90	0.48	5.92	0.99	-
Takao	3.75	59.52	27.87	-18.4	0	0.32	3.75	70.23	5.00	-44.85	0	0.43	3.75	40.01	33.00	-8.65	0	0.25

Table B.5 Calculated variables of agent sub–districts of Ubon Ratchathani province in three seasons of the year 2005.

Sub-district	January to April						May to August						September to December					
	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E
Khemarat	14.8	31.0	31.56	16.82	0.99	-	14.60	69.62	24.64	40.16	1	-	9.75	51.24	20.85	6.48	0.99	-
Kengnai	13.8	56.2	27.81	11.27	0.99	-	16.67	68.60	9.54	57.58	1	-	13.78	39.53	27.82	15.05	0.99	-
Tabai	11.1	58.4	14.01	4.63	0.99	-	11.13	69.36	37.10	12.41	0.99	-	11.00	39.06	27.84	8.92	0.99	-
Maung Dech	14.4	59.0	31.43	12.51	0.99	-	15.09	68.85	6.55	45.56	1	-	13.44	39.82	28.29	14.31	0.99	-
Trakanphutphon	6.7	58.4	13.89	-7.21	0	0.24	6.67	69.56	31.05	-21.64	0	0.33	7.00	40.32	27.61	0.12	0.52	0.54
Song	5.8	58.5	20.61	-9.85	0	0.27	14.00	68.80	1.91	37.50	1	-	9.00	51.24	26.10	4.67	0.99	-
Khong Chiam	8.8	56.6	27.21	-1.89	0	0.32	11.60	68.85	30.47	16.73	0.99	-	11.33	39.94	25.99	9.72	0.99	-
Ponngam	10.0	57.9	20.22	1.39	0.80	-	10.00	68.85	30.46	4.36	0.98	-	9.00	40.26	35.97	4.28	0.98	-
Phibunmangsahan	10.3	59.6	20.63	2.05	0.88	-	10.33	69.21	8.83	8.51	0.99	-	10.33	39.06	28.18	7.44	0.99	-
Muang Sam Sib	9.3	56.6	23.68	-0.38	0	0.43	10.89	67.93	9.54	13.10	0.99	-	9.14	39.75	18.00	5.12	0.99	-
Warin Chamrab	9.9	56.8	30.55	0.69	0.66	0.63	13.10	66.76	14.18	30.15	1	-	9.88	40.26	22.99	6.59	0.99	-
Khao Pun	9.6	58.4	14.52	0.62	0.65	0.59	14.40	67.83	24.64	39.10	1	-	10.25	37.64	26.95	7.28	0.99	-
Nachaluai	12.0	60.6	27.40	6.02	0.99	-	16.91	69.67	4.95	59.52	1	-	12.00	51.20	31.31	11.13	0.99	-
Tansum	9.6	56.8	23.84	0.36	0.58	0.56	14.82	67.73	15.60	43.06	1	-	8.14	51.66	25.47	2.80	0.94	-
Phosai	10.6	59.4	16.20	3.00	0.95	-	10.60	35.80	37.13	17.51	0.99	-	10.25	39.06	25.99	7.32	0.99	-
Samrong	10.5	58.5	20.88	2.62	0.93	-	9.33	69.05	15.06	0.34	0.58	0.54	9.00	39.34	36.76	4.25	0.98	-
Don Moddang	7.5	60.6	24.09	-5.77	0	0.51	13.33	69.51	13.88	31.23	1	-	11.00	39.12	31.62	8.81	0.99	-
Kanrai	13.1	73.0	16.77	8.03	0.99	-	13.14	69.97	30.47	28.35	1	-	13.14	40.32	20.62	13.87	0.99	-
Nakasem	12.5	58.4	20.28	7.97	0.99	-	14.91	67.32	4.95	44.70	1	-	12.50	39.06	28.08	12.22	0.99	-
Na Yea	5.8	59.3	20.22	-10.0	0	0.24	8.00	69.31	4.95	-9.25	0	0.52	4.75	39.38	28.18	-4.87	0	0.57
Hlao Suekok	8.0	59.1	23.75	-4.24	0	0.33	11.00	68.54	13.88	13.46	0.99	-	5.25	40.32	28.69	-3.78	0	0.53
Na Tan	10.5	58.1	22.36	2.59	0.93	-	10.60	69.05	24.64	9.39	0.99	-	9.67	39.69	28.67	5.96	0.99	-
Savang	12.0	58.4	24.35	6.44	0.99	-	10.88	69.36	15.74	12.12	0.99	-	10.67	39.06	0.48	9.00	0.99	-
Takao	5.3	59.3	27.84	-11.7	0	0.17	7.50	69.67	5.00	-13.22	0	0.51	5.75	41.11	33.01	-2.80	0	0.58

Table B.6 Calculated variables of agent sub–districts of Ubon Ratchathani province in three seasons of the year 2001–2005.

Sub-district	January to April						May to August						September to December					
	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E
Khemarat	15.23	54.73	31.81	16.83	0.99	-	18.04	69.87	24.65	107.4	1	-	13.55	42.18	20.85	17.68	0.99	-
Kengnai	14.26	57.55	28.05	14.19	0.99	-	17.31	69.20	9.54	103.6	1	-	13.97	40.05	27.82	18.17	0.99	-
Tabai	9.57	59.22	14.21	2.59	0.93	-	10.37	69.20	37.11	46.97	1	-	9.95	40.14	27.84	9.31	0.99	-
Maung Dech	18.39	59.19	31.69	24.68	1	-	23.34	69.58	6.55	150.4	1	-	17.46	42.25	28.29	25.86	1	-
Trakanphutphon	8.75	59.15	14.09	0.42	0.60	0.58	9.64	69.28	31.05	41.94	1	-	8.78	39.61	27.61	6.73	0.99	-
Song	8.96	58.14	20.84	0.58	0.64	0.61	12.07	69.62	1.91	63.82	1	-	9.87	44.09	26.10	9.26	0.99	-
Khong Chiam	9.49	57.01	27.45	1.62	0.83	-	11.37	68.89	30.47	55.54	1	-	10.10	39.39	25.99	9.73	0.99	-
Ponngam	10.51	58.44	20.44	4.71	0.99	-	13.41	68.66	30.47	71.32	1	-	11.54	40.58	35.97	12.32	0.99	-
Phibunmangsahan	14.22	59.68	20.85	14.37	0.99	-	17.76	68.46	8.84	107.3	1	-	14.47	42.77	28.18	19.27	0.99	-
Muang Sam Sib	11.38	58.62	23.92	6.73	0.99	-	13.27	67.41	9.54	72.84	1	-	10.66	40.85	18.01	11.46	0.99	-
Warin Chamrab	18.54	57.00	30.80	25.41	1	-	23.30	66.98	14.18	149.9	1	-	17.11	42.52	22.99	25.41	1	-
Khao Pun	8.24	59.37	14.72	-0.99	0	0.52	11.52	66.08	24.65	58.06	1	-	8.93	39.02	26.95	7.10	0.99	-
Nachaluai	9.65	59.91	27.64	1.68	0.84	-	12.57	65.90	4.95	68.35	1	-	10.72	51.00	31.31	10.89	0.99	-
Tansum	9.29	59.14	24.07	1.08	0.74	-	13.72	68.85	15.60	75.28	1	-	9.26	49.09	25.47	7.99	0.99	-
Phosai	11.44	58.61	16.41	7.47	0.99	-	13.42	50.14	37.13	75.79	1	-	11.76	44.57	25.99	13.45	0.99	-
Samrong	10.67	59.38	21.10	4.97	0.99	-	12.42	62.49	15.06	67.08	1	-	10.12	42.37	36.76	9.17	0.99	-
Don Moddang	10.38	59.37	24.33	3.93	0.98	-	14.16	69.89	13.89	78.59	1	-	11.25	42.41	31.62	11.96	0.99	-
Kanrai	9.64	60.79	16.98	2.37	0.91	-	11.50	63.12	30.47	58.05	1	-	9.63	39.97	20.62	9.02	0.99	-
Nakasem	7.47	58.41	20.50	-3.37	0	0.23	9.86	68.10	4.95	46.81	1	-	7.49	39.36	28.08	3.84	0.97	-
Na Yea	8.47	59.27	20.44	-0.82	0	0.51	9.80	63.07	4.95	47.72	1	-	7.89	40.04	28.18	4.74	0.99	-
Hlao Suekok	9.25	58.20	23.98	1.12	0.75	-	13.86	69.12	13.89	76.52	1	-	8.39	40.32	28.69	5.81	0.99	-
Na Tan	11.74	59.21	22.59	7.71	0.99	-	14.47	62.32	24.65	81.94	1	-	10.56	39.59	28.67	10.60	0.99	-
Savang	10.96	58.76	24.58	5.54	0.99	-	12.55	62.71	15.74	67.88	1	-	10.12	41.78	0.48	11.33	0.99	-
Takao	5.87	59.85	28.09	-8.41	0	0.12	7.24	69.32	5.00	26.20	1	-	6.41	42.50	33.01	1.20	0.76	-

APPENDIX C

RISK AREA COMPARISON BASED ON TRADITIONAL CLASSIFICATION AND DF/DHF PREDICTED MODELS

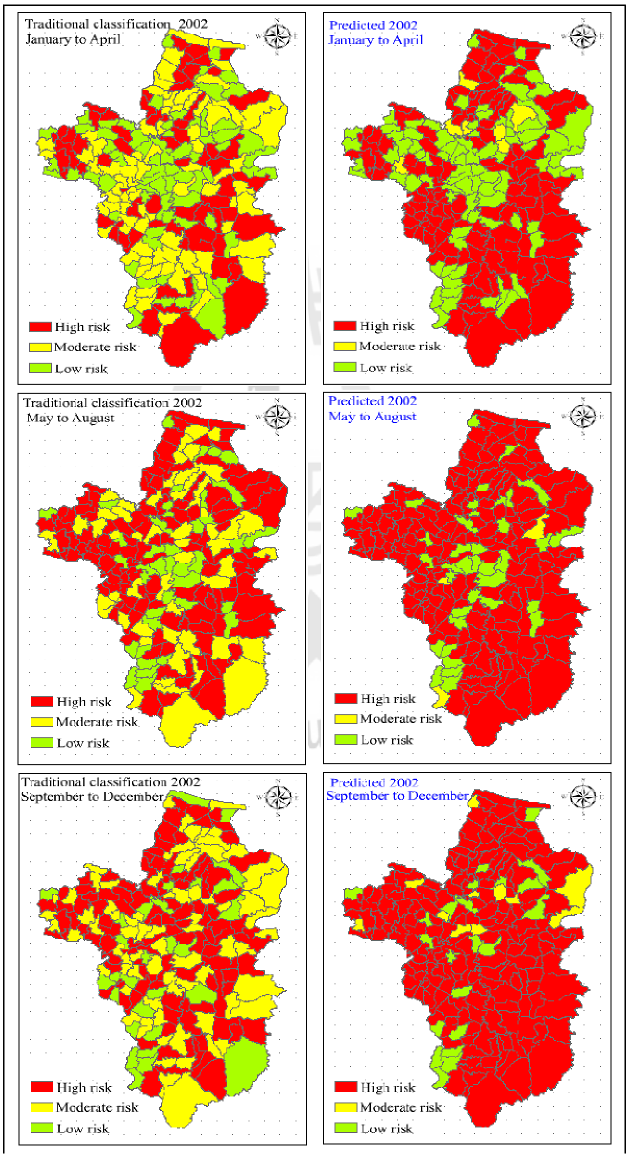


Figure C.1 Risk area comparisons based on traditional classification and predicted model of the year 2002.

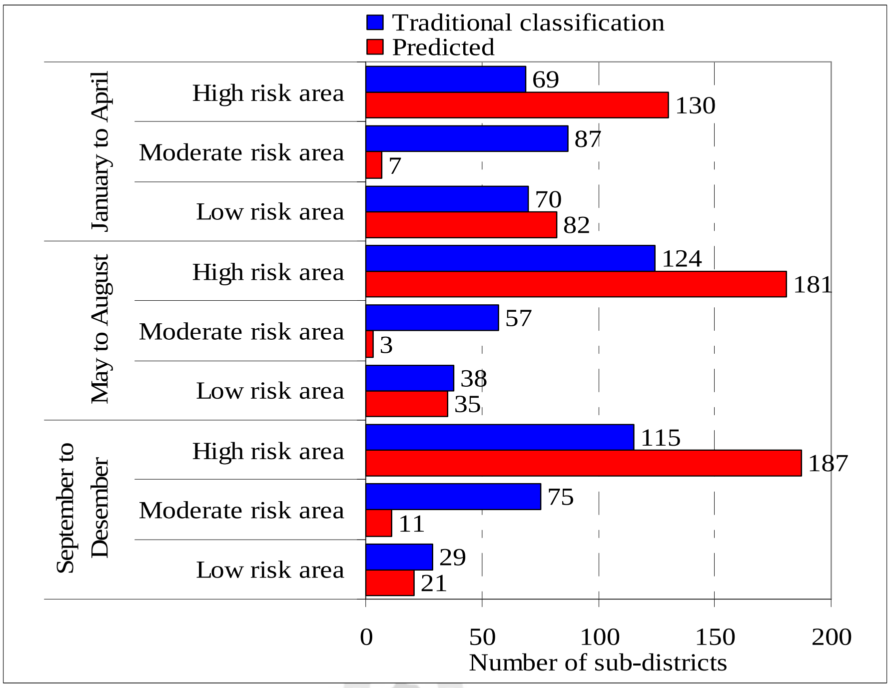


Figure C.2 Graphs comparisons of areas based on traditional classification and predicted model of the year 2002.

Table C.1 Error matrix of the classes of risk area based on traditional classification and predicted model of January to April of the year 2002.

	Area	Traditional classification of risk area DF/DHF: High risk area	Moderate risk area	Low risk area	Row totals	Commission error
Predicted	**High risk area**	69	61	0	130	46.92 %
	Moderate risk area	0	7	0	7	0
	Low risk area	0	12	70	82	85.36 %
	Column totals	69	80	70	219	
	Omission error	0	91.25 %	0		
	Overall accuracy			66.67%		

Table C.2 Error matrix of the classes of risk area based on traditional classification and predicted model of May to August of the year 2002.

	Area	Traditional classification of risk area DF/DHF High risk area	 Moderate risk area	 Low risk area	Row totals	Commission error
Predicted	**High risk area**	124	54	3	181	31.49 %
	Moderate risk area	0	3	0	3	0
	Low risk area	0	0	11	11	0
	Column totals	124	75	29	219	
	Omission error	0	72 %	10.34 %		
	Overall accuracy			73.97 %		

Table C.3 Error matrix of the classes of risk area based on traditional classification and predicted model of September to December of the year 2002.

	Area	Traditional classification of risk area DF/DHF High risk area	 Moderate risk area	 Low risk area	Row totals	Commission error
Predicted	**High risk area**	115	64	8	187	38.5 %
	Moderate risk area	0	11	0	11	0
	Low risk area	0	0	21	21	0
	Column totals	115	75	29	219	
	Omission error	0	85.33 %	27.58 %		
	Overall accuracy			67.12 %		

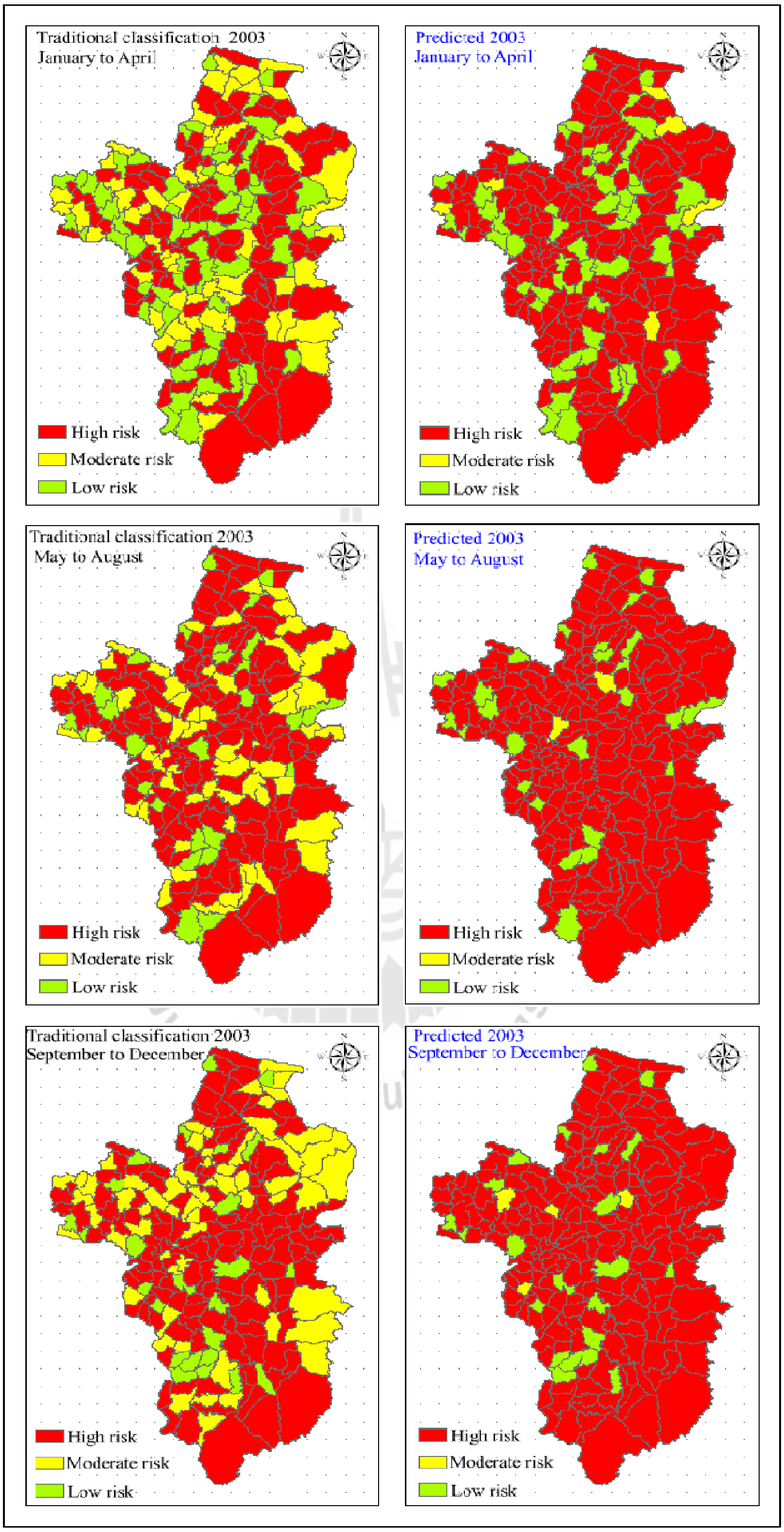


Figure C.3 Risk area comparisons based on traditional classification and predicted model of the year 2003.

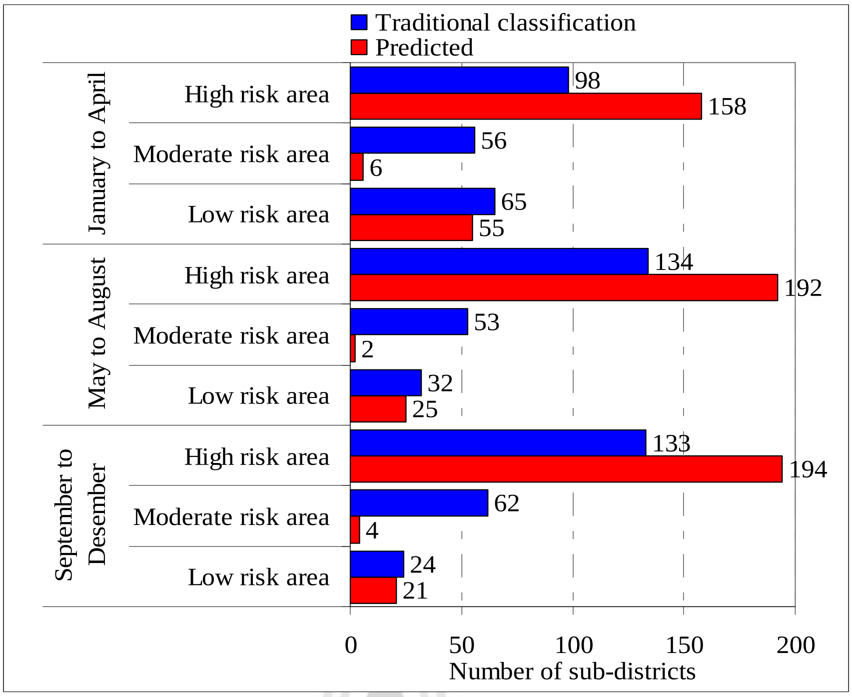


Figure C.4 Graphs comparisons of areas based on traditional classification and predicted model of the year 2003.

Table C.4 Error matrix of the classes of risk area based on traditional classification and predicted model of January to April of the year 2003.

	Area	Traditional classification of risk area DF/DHF				
		High risk area	**Moderate risk area**	**Low risk area**	**Row totals**	**Commission error**
Predicted	**High risk area**	98	50	10	158	37.97 %
	Moderate risk area	0	6	0	6	0
	Low risk area	0	0	55	55	0
	Column totals	98	56	65	219	
	Omission error	0	89.28 %	15.38 %		
	Overall accuracy	72.60 %				

Table C.5 Error matrix of the classes of risk area based on traditional classification and predicted model of May to August of the year 2003.

	Area	Traditional classification of risk area DF/DHF			Row totals	Commission error
		High risk area	**Moderate risk area**	**Low risk area**		
Predicted	**High risk area**	134	51	7	192	30.2 %
	Moderate risk area	0	2	0	2	0
	Low risk area	0	0	25	25	0
	Column totals	134	53	32	219	
	Omission error	0	96.22 %	21.87 %		
	Overall accuracy			73.52 %		

Table C.6 Error matrix of the classes of risk area based on traditional classification and predicted model of September to December of the year 2003.

	Area	Traditional classification of risk area DF/DHF			Row totals	Commission error
		High risk area	**Moderate risk area**	**Low risk area**		
Predicted	**High risk area**	133	59	2	194	31.44 %
	Moderate risk area	0	3	1	3	33.33 %
	Low risk area	0	0	21	21	0
	Column totals	133	62	24	219	
	Omission error	0	95.16 %	12.50 %		
	Overall accuracy			71.69 %		

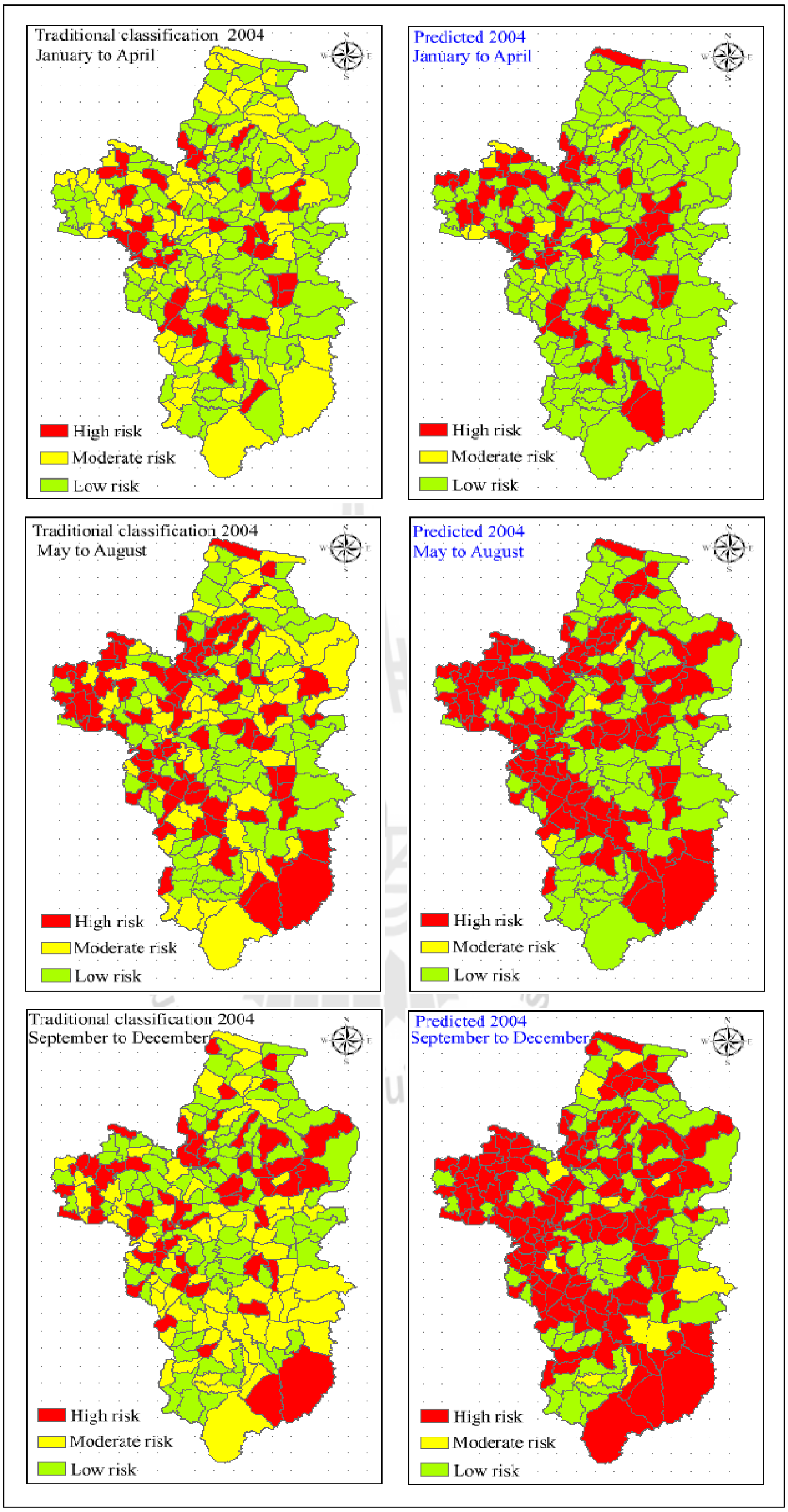


Figure C.5 Risk area comparisons based on traditional classification and predicted model of the year 2004.

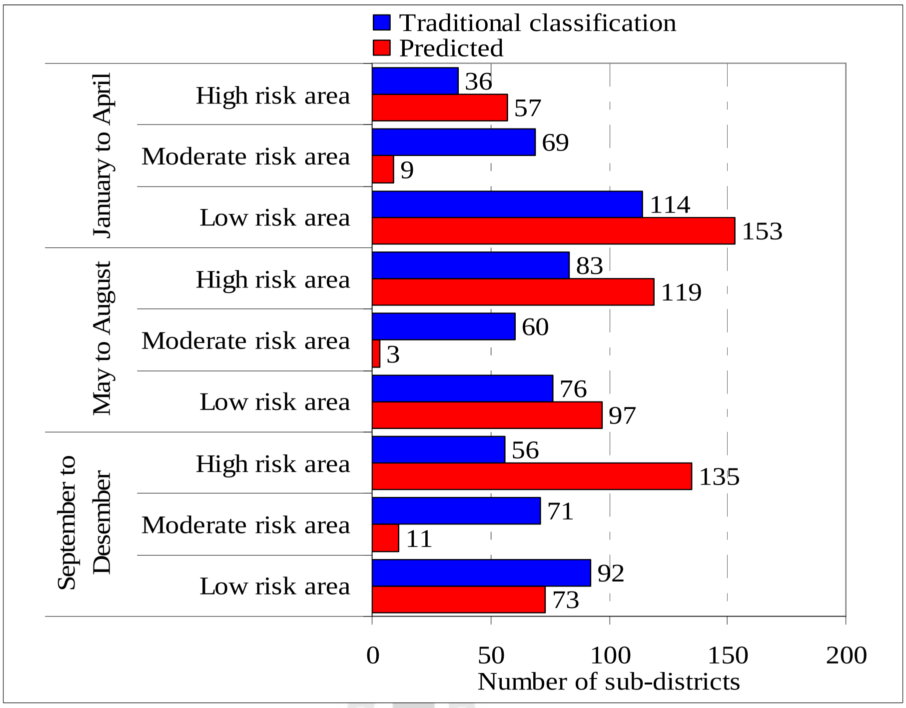


Figure C.6 Graphs comparisons of areas based on traditional classification and predicted model of the year 2004.

Table C.7 Error matrix of the classes of risk area based on traditional classification and predicted model of January to April of the year 2004.

	Area	Traditional classification of risk area DF/DHF: High risk area	Moderate risk area	Low risk area	Row totals	Commission error
Predicted	**High risk area**	36	21	0	57	36.84 %
	Moderate risk area	0	9	0	9	0
	Low risk area	0	39	114	153	25.49 %
	Column totals	36	69	114	219	
	Omission error	0	86.95 %	0		
	Overall accuracy			72.60%		

Table C.8 Error matrix of the classes of risk area based on traditional classification and predicted model of May to August of the year 2004.

	Area	Traditional classification of risk area DF/DHF				
		High risk area	Moderate risk area	Low risk area	Row totals	Commission error
Predicted	High risk area	83	36	0	119	32.77 %
	Moderate risk area	0	3	0	3	0
	Low risk area	0	21	76	97	21.64 %
	Column totals	83	60	76	219	
	Omission error	0	95 %	0		
	Overall accuracy			73.97 %		

Table C.9 Error matrix of the classes of risk area based on traditional classification and predicted model of September to December of the year 2004.

	Area	Traditional classification of risk area DF/DHF				
		High risk area	Moderate risk area	Low risk area	Row totals	Commission error
Predicted	High risk area	56	60	19	135	58.51 %
	Moderate risk area	0	11	0	11	0
	Low risk area	0	0	73	21	0
	Column totals	56	71	92	219	
	Omission error	0	84.5 %	20.65 %		
	Overall accuracy			63.92 %		

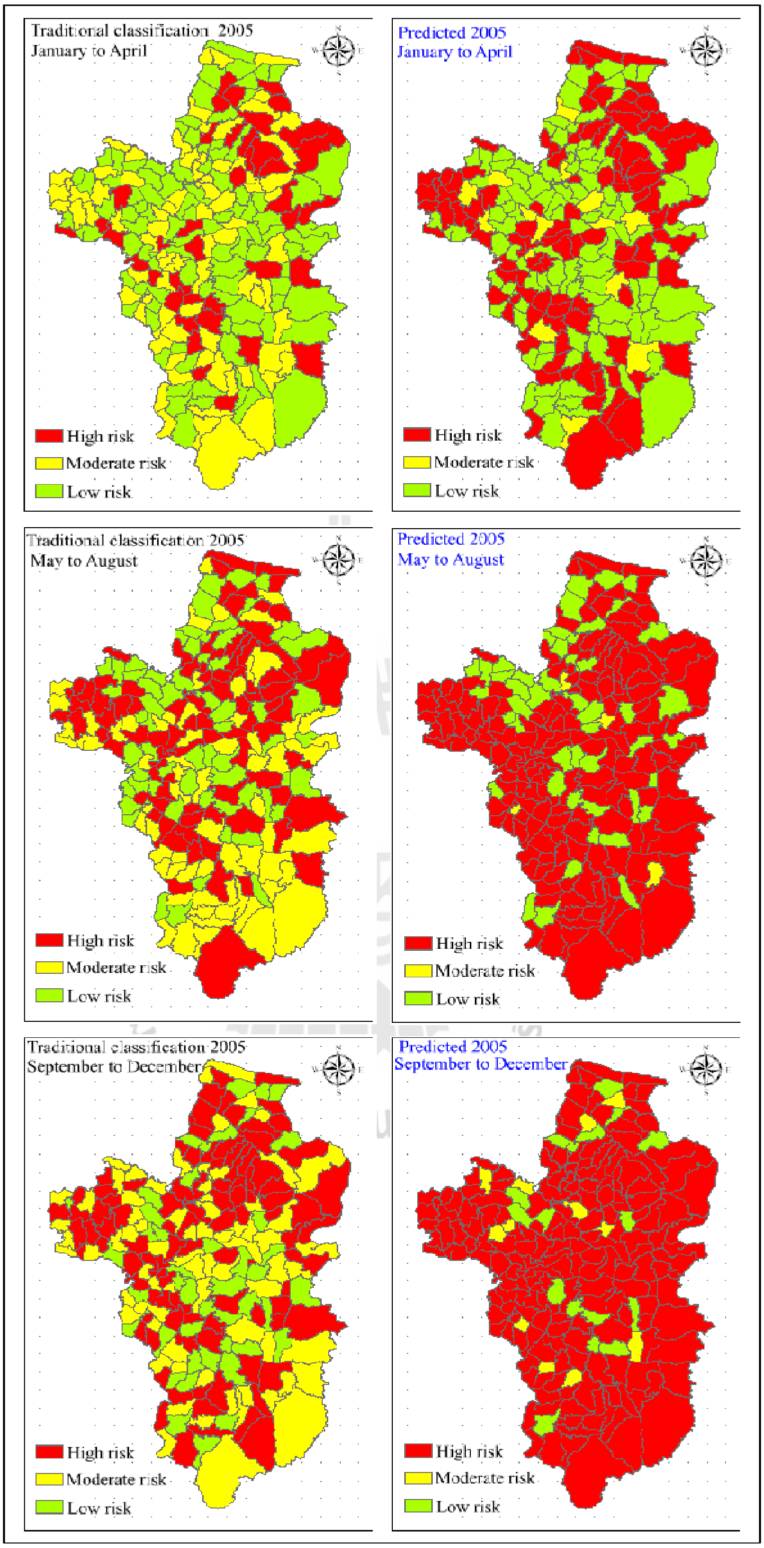


Figure C.7 Risk area comparisons based on traditional classification and predicted model of the year 2005.

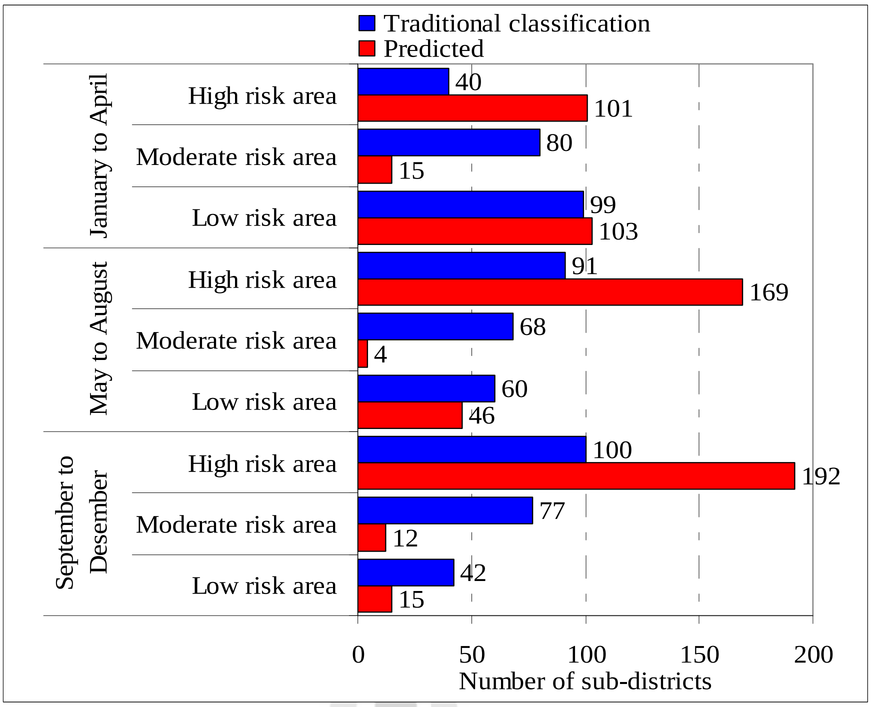


Figure C.8 Graphs comparisons of areas based on traditional classification and predicted model of the year 2005.

Table C.10 Error matrix of the classes of risk area based on traditional classification and predicted model of January to April of the year 2005.

		Traditional classification of risk area DF/DHF				
	Area	**High risk area**	**Moderate risk area**	**Low risk area**	**Row totals**	**Commission error**
Predicted	**High risk area**	40	61	0	101	60.39 %
	Moderate risk area	0	15	0	15	0
	Low risk area	0	4	99	103	0
	Column totals	40	80	99	219	
	Omission error	0	81.25 %	0		
	Overall accuracy			70.32 %		

Table C.11 Error matrix of the classes of risk area based on traditional classification and predicted model of May to August of the year 2005.

	Area	Traditional classification of risk area DF/DHF: High risk area	Moderate risk area	Low risk area	Row totals	Commission error
Predicted	**High risk area**	91	64	14	169	46.15 %
	Moderate risk area	0	4	0	4	0
	Low risk area	0	0	46	46	0
	Column totals	91	68	60	219	
	Omission error	0	94.11 %	23.33 %		
	Overall accuracy			64.38 %		

Table C.12 Error matrix of the classes of risk area based on traditional classification and predicted model of September to December of the year 2005.

	Area	Traditional classification of risk area DF/DHF: High risk area	Moderate risk area	Low risk area	Row totals	Commission error
Predicted	**High risk area**	100	65	27	192	49.47 %
	Moderate risk area	0	12	0	12	0
	Low risk area	0	0	15	15	0
	Column totals	100	77	42	219	
	Omission error	0	84.41 %	64.28 %		
	Overall accuracy			57.59 %		

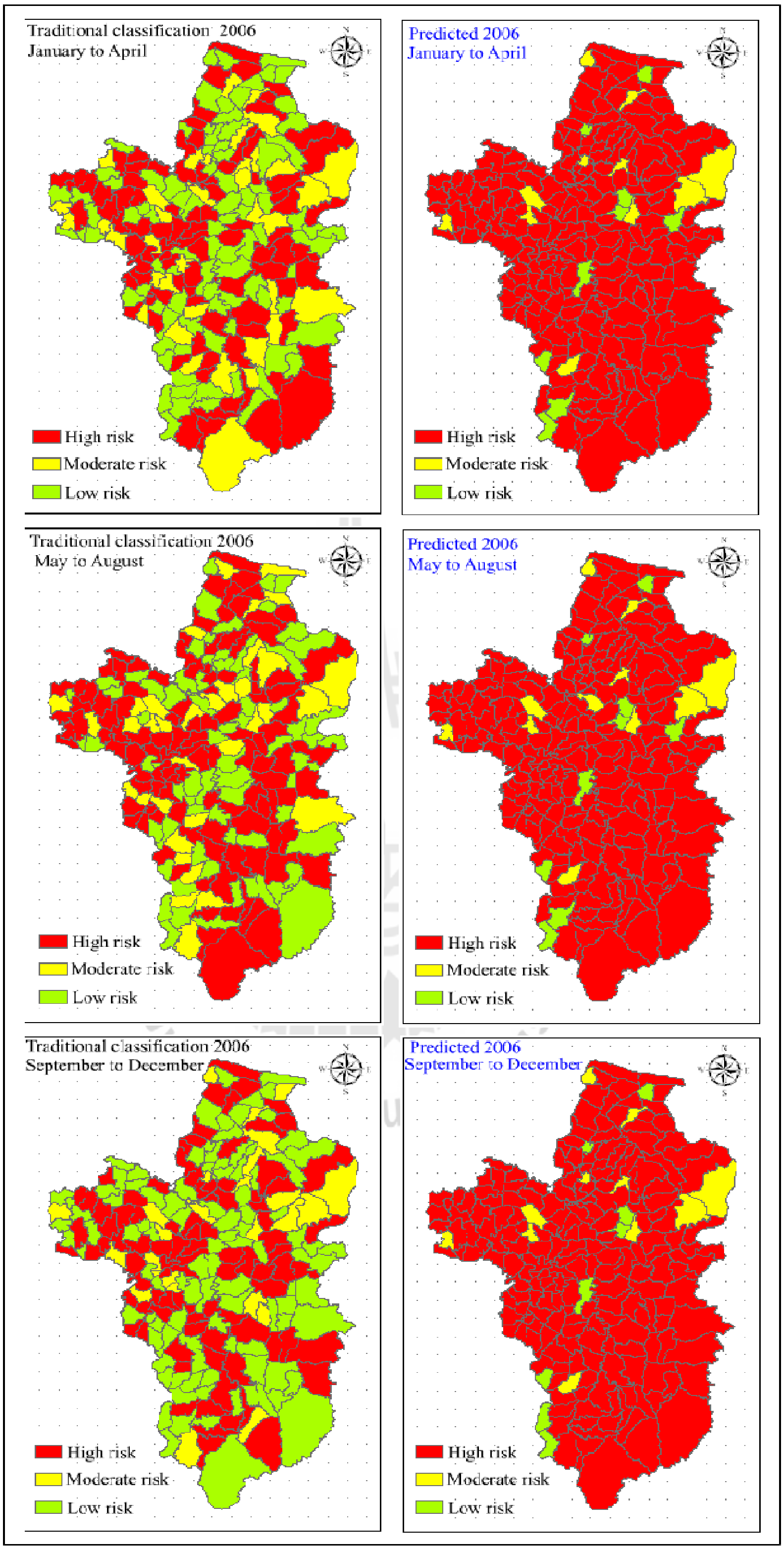


Figure C.9 Risk area comparisons based on traditional classification and predicted model of the year 2006.

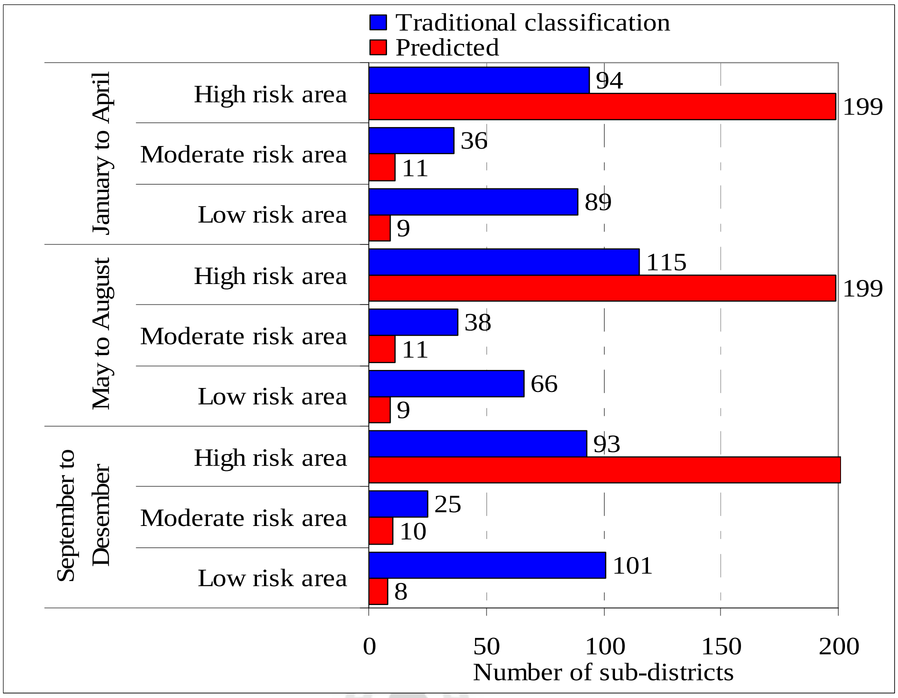


Figure C.10 Graphs comparisons of areas based on traditional classification and predicted model of the year 2006.

Table C.13 Error matrix of the classes of risk area based on traditional classification and predicted model of January to April of the year 2006.

		Traditional classification of risk area DF/DHF				
	Area	**High risk area**	**Moderate risk area**	**Low risk area**	**Row totals**	**Commission error**
Predicted	**High risk area**	94	27	78	199	88.23 %
	Moderate risk area	0	9	2	11	18.18%
	Low risk area	0	0	9	9	0
	Column totals	94	36	89	219	
	Omission error	0	75 %	89.88 %		
	Overall accuracy			51.14 %		

Table C.14 Error matrix of the classes of risk area based on traditional classification and predicted model of May to August of the year 2006.

	Area	Traditional classification of risk area DF/DHF			Row totals	Commission error
		High risk area	Moderate risk area	Low risk area		
Predicted	High risk area	114	30	55	199	42.71 %
	Moderate risk area	1	8	2	11	0
	Low risk area	0	0	9	9	0
	Column totals	115	38	66	219	
	Omission error	0.86 %	78.94 %	96.96 %		
	Overall accuracy			59.82 %		

Table C.15 Error matrix of the classes of risk area based on traditional classification and predicted model of September to December of the year 2006.

	Area	Traditional classification of risk area DF/DHF			Row totals	Commission error
		High risk area	Moderate risk area	Low risk area		
Predicted	High risk area	93	18	90	201	48.75 %
	Moderate risk area	0	7	3	10	0
	Low risk area	0	0	8	8	0
	Column totals	93	25	101	219	
	Omission error	0	72 %	92.07 %		
	Overall accuracy			49.32 %		

APPENDIX D

OCCURRENCE PROBABILITY OF EPIDEMIC IN ADJACENT AREAS

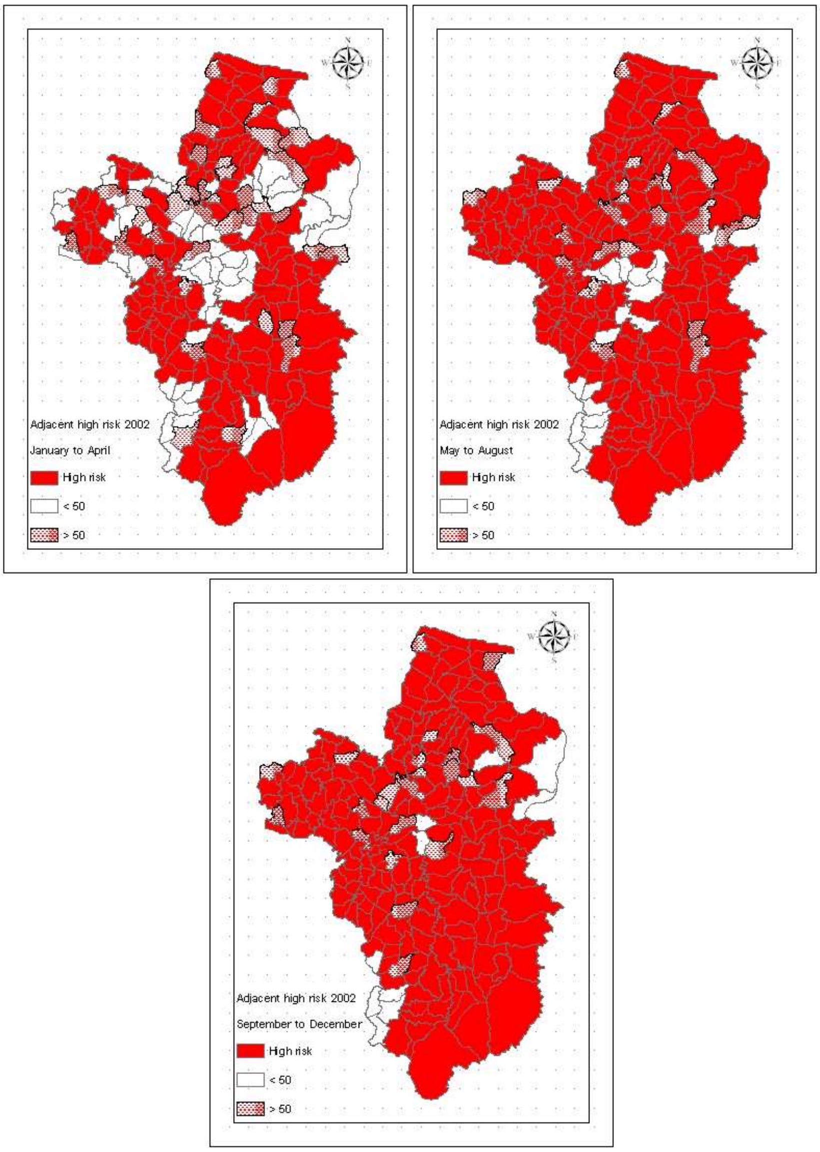


Figure D.1 High risk areas and adjacent areas with NPIC or E more than 0.50 and less than 0.50 in three seasons of the year 2002.

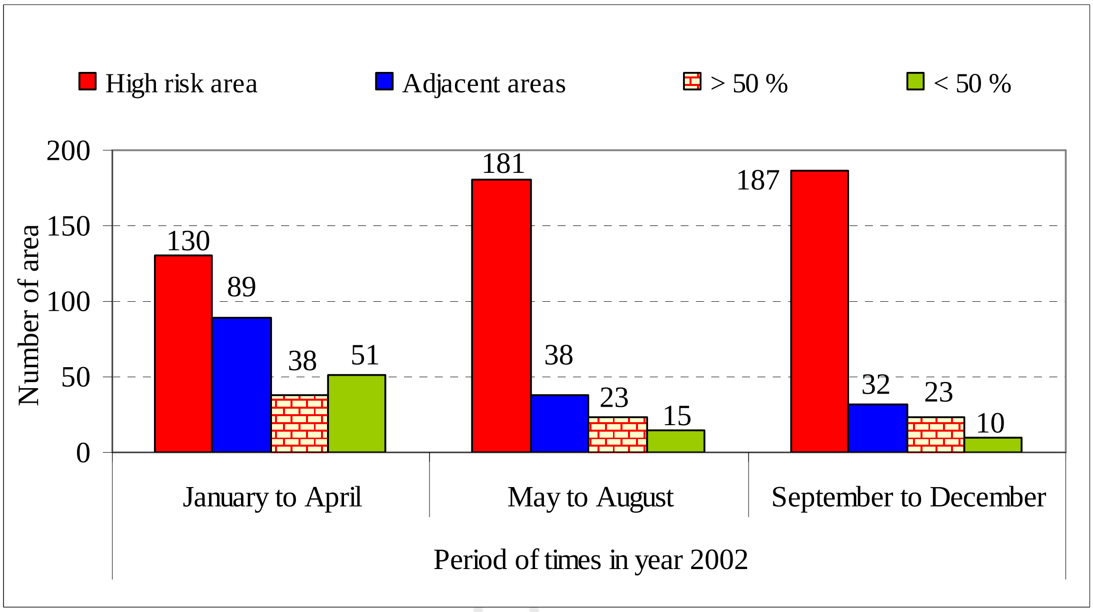


Figure D.2 Graphs comparison of epidemic effect in adjacent areas of high risk areas between periods of time in 2002.

Table D.1 Epidemic effect in adjacent areas of high risk areas in 2002.

Period of times in year 2002	**High risk area**	**Adjacent areas (Moderate risk area and Low risk area)**	**Occurrence probability of epidemic in adjacent areas of high risk areas**	
			> 50 %	**< 50 %**
January to April	130	89	38	51
May to August	181	38	23	15
September to December	187	32	23	10

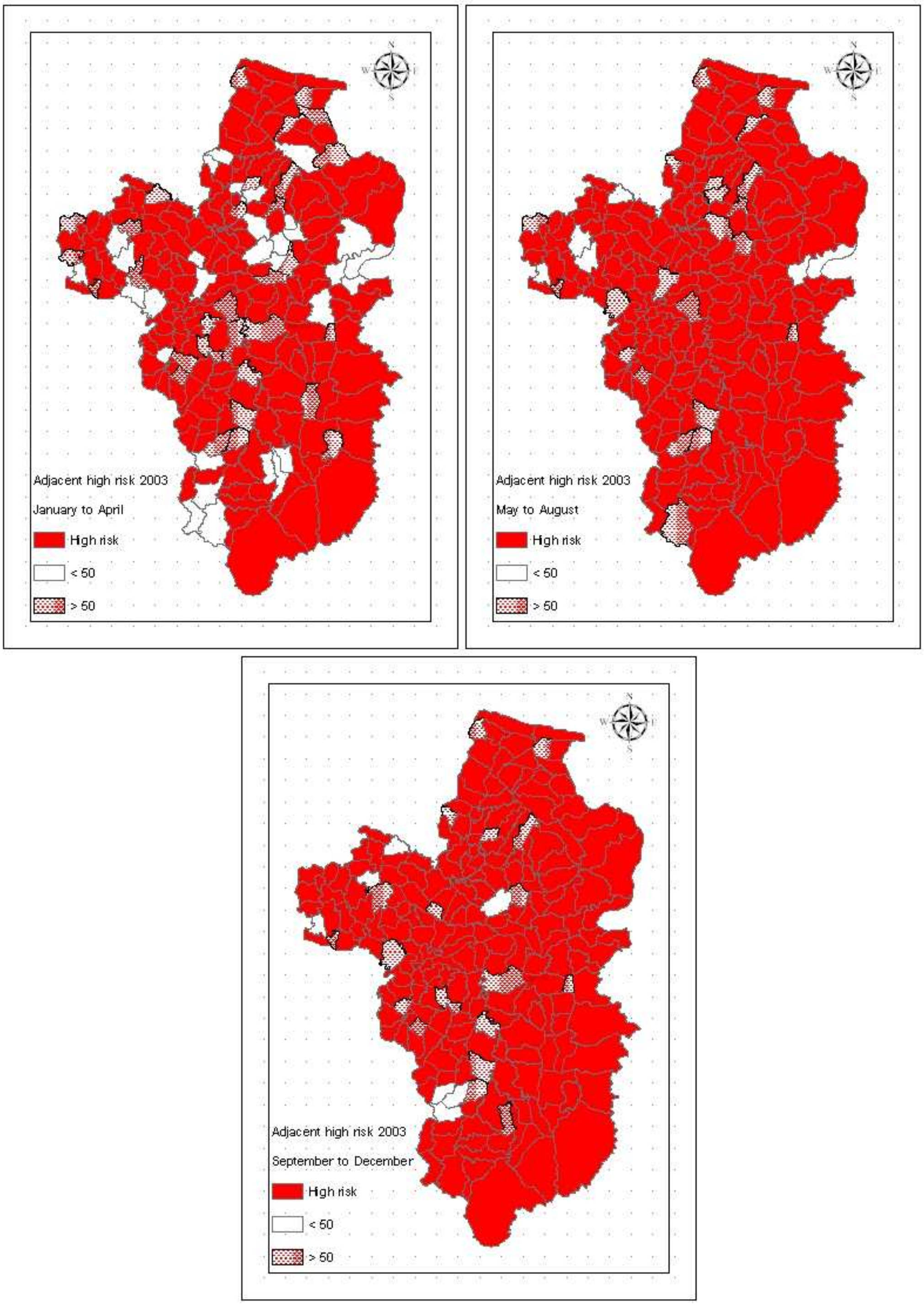


Figure D.3 High risk areas and adjacent areas with NPIC or E more than 0.50 and less than 0.50 in three seasons of the year 2003.

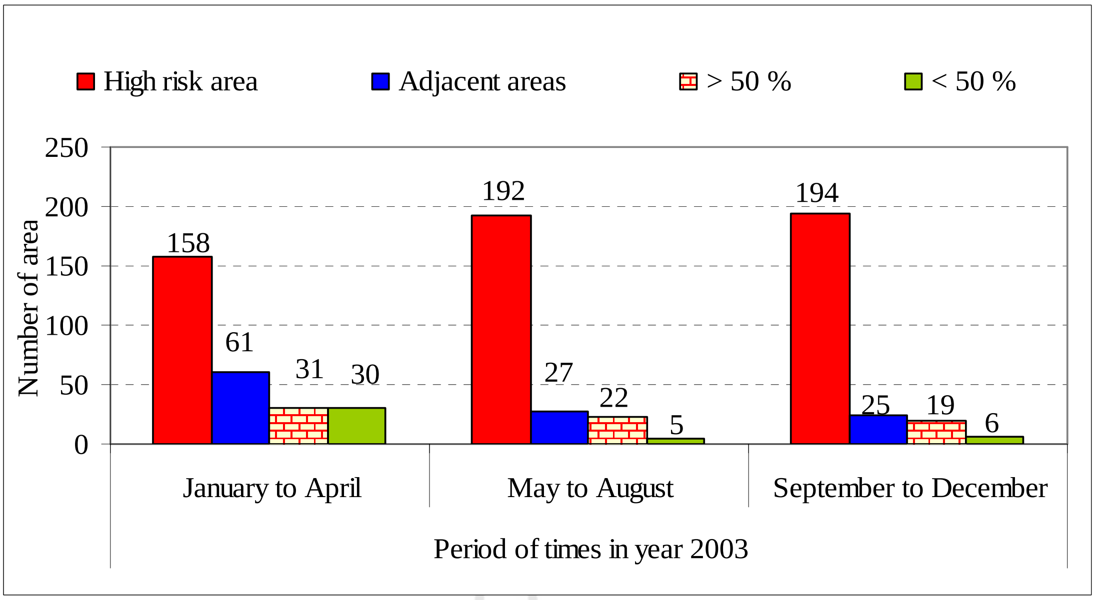


Figure D.4 Graphs comparison of epidemic effect in adjacent areas of high risk areas between periods of time in 2003.

Table D.2 Epidemic effect in adjacent areas of high risk areas in 2003.

Period of times in year 2003	**High risk area**	**Adjacent areas (Moderate risk area and Low risk area)**	**Occurrence probability of epidemic in adjacent areas of high risk areas**	
			> 50 %	**< 50 %**
January to April	158	61	31	30
May to August	192	27	22	5
September to December	194	25	19	6

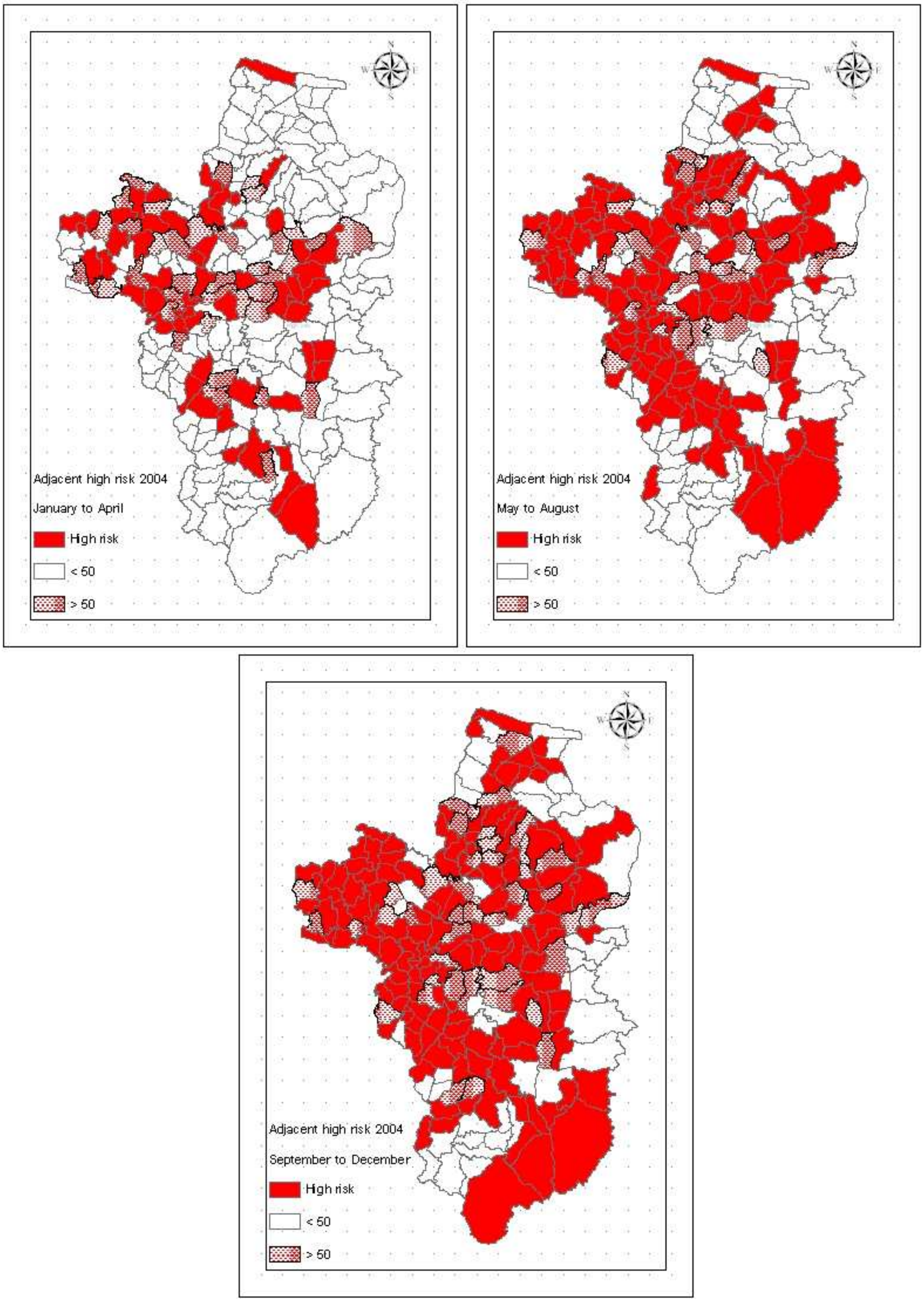


Figure D.5 High risk areas and adjacent areas with NPIC or E more than 0.50 and less than 0.50 in three seasons of the year 2004.

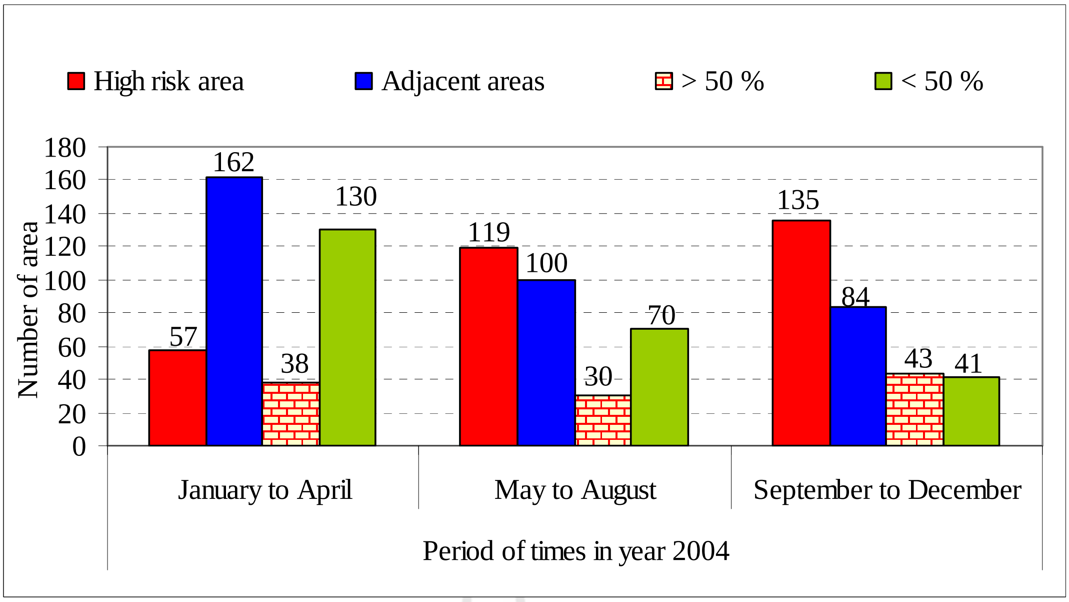


Figure D.6 Graphs comparison of epidemic effect in adjacent areas of high risk areas between periods of time in 2004.

Table D.3 Epidemic effect in adjacent areas of high risk areas in 2004.

Period of times in year 2005	High risk area	Adjacent areas (Moderate risk area and Low risk area)	Occurrence probability of epidemic in adjacent areas of high risk areas	
			> 50 %	< 50 %
January to April	57	162	38	130
May to August	119	100	30	70
September to December	135	84	43	41

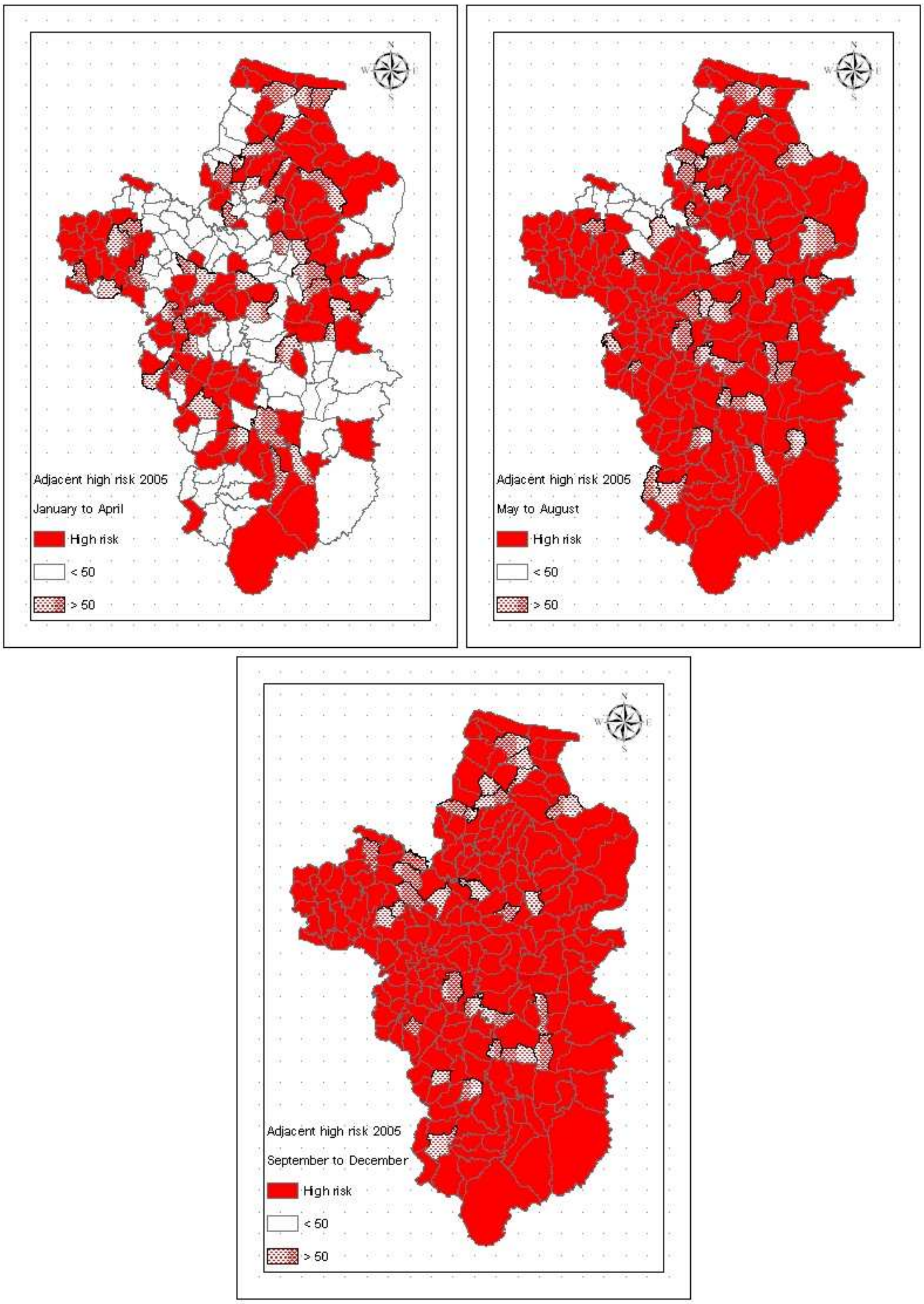


Figure D.7 High risk areas and adjacent areas with NPIC or E more than 0.50 and less than 0.50 in three seasons of the year 2005.

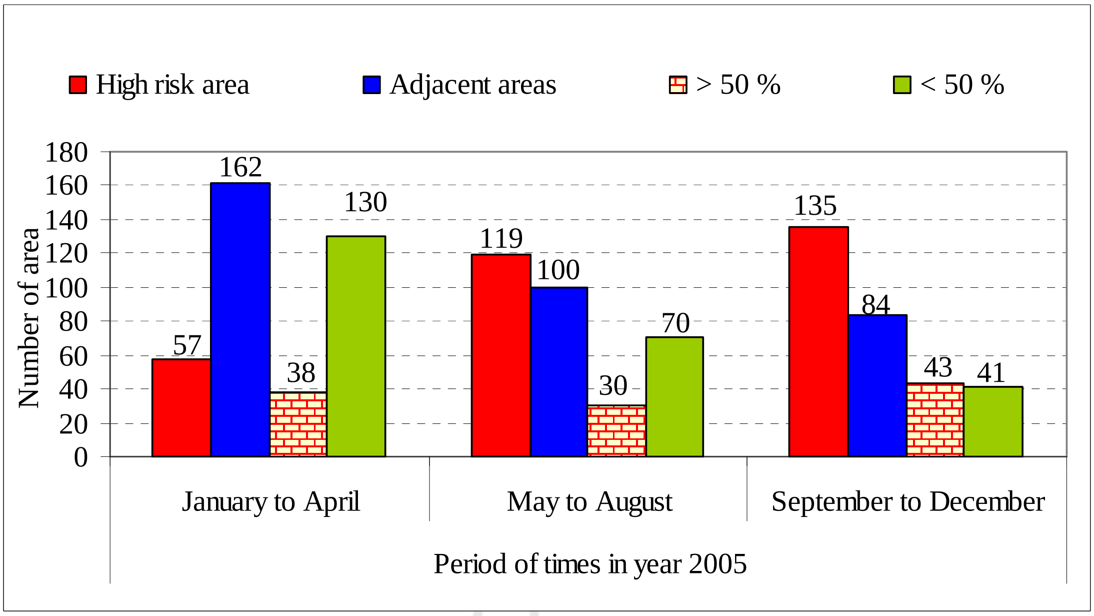


Figure D.8 Graphs comparison of epidemic effect in adjacent areas of high risk areas between periods of time in 2005.

Table D.4 Epidemic effect in adjacent areas of high risk areas in 2005.

Period of times in year 2005	High risk area	Adjacent areas (Moderate risk area and Low risk area)	Occurrence probability of epidemic in adjacent areas of high risk areas	
			> 50 %	< 50 %
January to April	101	118	42	76
May to August	169	50	38	12
September to December	192	27	27	0

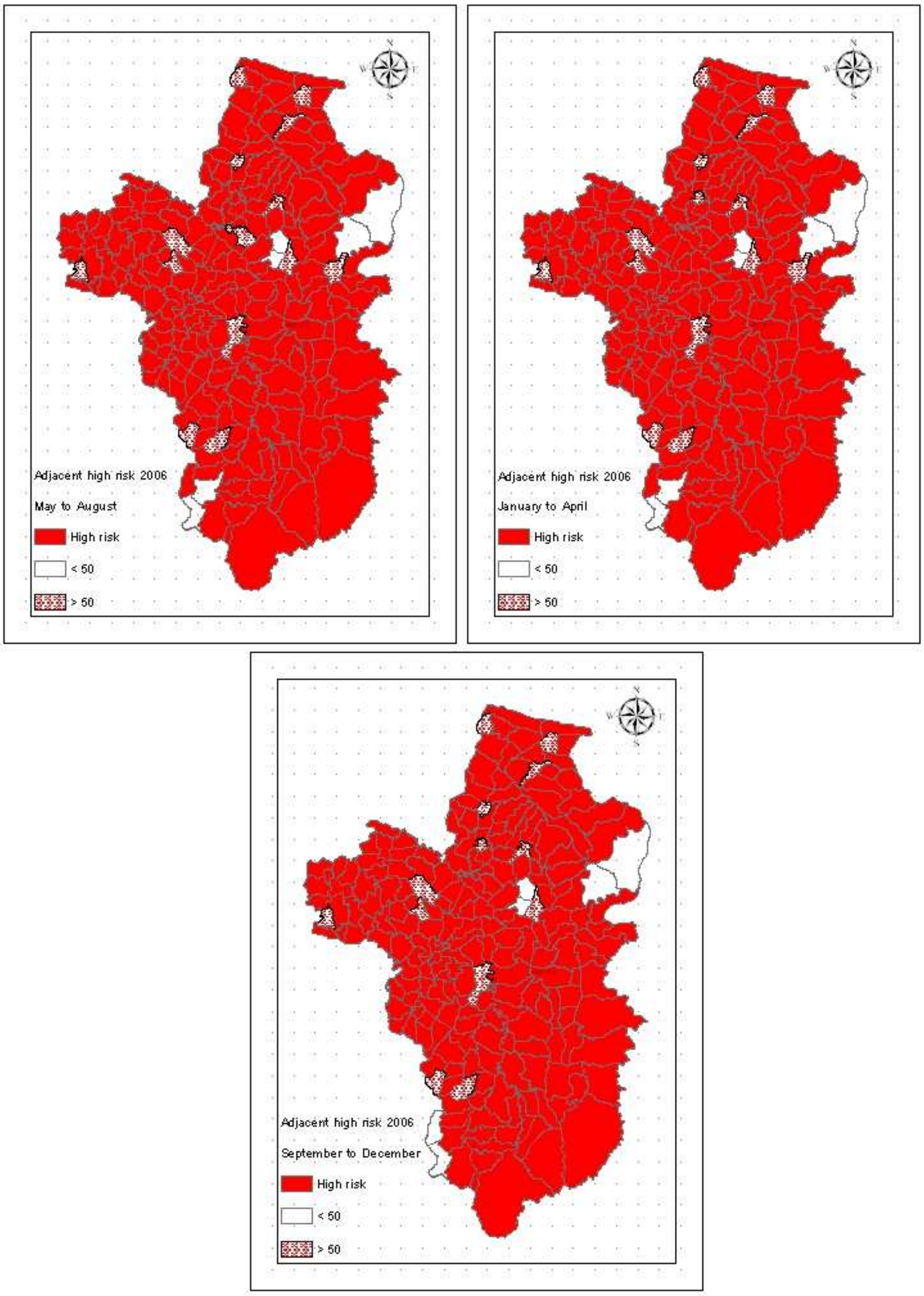


Figure D.9 High risk areas and adjacent areas with NPIC or E more than 0.50 and less than 0.50 in three seasons of the year 2006.

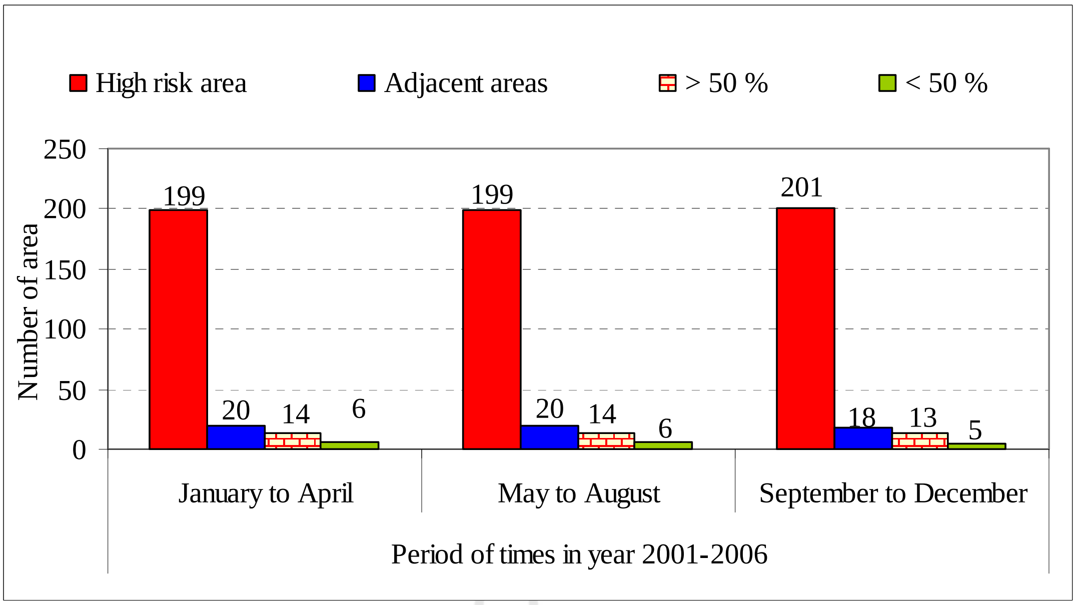


Figure D.10 Graphs comparison of epidemic effect in adjacent areas of high risk areas between periods of time in 2006.

Table D.5 Epidemic effect in adjacent areas of high risk areas in 2006.

Period of times in year 2001-2006	**High risk area**	**Adjacent areas (Moderate risk area and Low risk area)**	**Occurrence probability of epidemic in adjacent areas of high risk areas**	
			> 50 %	**< 50 %**
January to April	199	20	14	6
May to August	199	20	14	6
September to December	201	18	13	5

APPENDIX E

EXAMPLE OF PHP SOURCE CODE

This example of PHP source code is for login of users.

```
<?session_start();

include('include/filemaster.php');

$username = $HTTP_POST_VARS["username"];

$userpassword = $HTTP_POST_VARS["userpassword"];

?> <head><meta http-equiv="Content-Type" content="text/html; charset=windows-

874" />

<title><?=$titlepage?></title><link href="css/Styles.css" rel="stylesheet"

type="text/css" />

<script language="javascript" src="js/checkobj.js"></script>

</head><body><table width="750" border="0" cellspacing="0" cellpadding="0"

align="center" height="100%"> <tr> <td valign="top" height="1px">

<? include("comtop.php");?></td></tr> <tr> <td valign="top" class="pattern">

<table width="100%" border="0" cellspacing="0" cellpadding="0">

<tr><td><br /><? if(!$_SESSION['R36_UID'] &&

!$HTTP_SESSION_VARS['nologin'])

{

?>

<form action="login_process.php" method="post" name="formlogin"

onSubmit="return chkvalLogin(this);">
```

```
<input name="action" type="hidden" value="login" />
<table width="40%" border="0" align="center" cellpadding="5" cellspacing="1"
bgcolor="#6394bd">
 <tr><td colspan="2"><div align="center"><strong><img src="images/doctor.gif"
width="16" height="16" align="absmiddle"><span class="headtable">เข้าสู่ระบบ
</span></strong></div></td>
</tr><tr><td width="32%" bgcolor="#98B9D3"><div align="right"
class="topic">Username :  </div></td><td width="68%"
bgcolor="#FFFFFF"><input type="text" name="username" size="20"
class="textbox"></td>
</tr><tr>
<td bgcolor="#98B9D3"><div align="right"  class="topic">Password
:  </div></td>
<td bgcolor="#FFFFFF"><input type="password" name="userpassword" size="20"
class="textbox"></td></tr>
<tr><td colspan="2" bgcolor="#FFFFFF"><div align="center">
<input type="submit" name="login" value="ตกลง" class="Submit">
  
<input type="reset"name="clear" value="ยกเลิก" class="Submit">
</div></td></tr>
<tr><td colspan="2" bgcolor="#98B9D3"><div align="center"><img
src="images/warning2.gif" width="16" height="16" align="absmiddle"> <a href="#"
onClick="m =
```

```
window.open('popup_forgetpassword.php','popup_forgetpassword','width=400,height
=200,location=0,scrollbars=1');m.focus();" >ลืมรหัสผ่าน</a> <img
src="images/warning2.gif" width="16" height="16" align="absmiddle"></div></td>
</tr><tr>
<td colspan="2" bgcolor="#98B9D3"><div align="center"><img
src="images/warning2.gif" width="16" height="16" align="absmiddle"> <a
href="nologin_process.php?action=nologin">เข้าสู่ระบบโดยไม่ต้อง Login </a> <img
src="images/warning2.gif" width="16" height="16" align="absmiddle"></div></td>
</tr></table>
</form><?}else if($_SESSION['R36_UID']){
if($_SESSION['R36_UID'] && $_SESSION['R36_LEVEL']=='00'){
?><form action="<?=$_SERVER['PHP_SELF'];?>" method="post"
name="formlogin">
<input name="action" type="hidden" value="" />
<table width="100%" border="0" cellspacing="0" cellpadding="2">
<tr><td width="43%" valign="top"><table width="65%" border="0" align="center"
cellpadding="5" cellspacing="1" bgcolor="#6394bd">
 <tr> <td height="15"></td>
 </tr> <tr> <td bgcolor="#FFFFFF"><img src="images/user1_find.gif" border="0"
/> <a href="search_user.php">ค้นหาผู้ใช้ระบบ</a></td>
</tr><tr><td bgcolor="#FFFFFF"><img src="images/user1_add.gif" border="0"
/> <a href="add_user.php">เพิ่มผู้ใช้ระบบ</a></td>
```

```
</tr> <tr> <td bgcolor="#FFFFFF"><img src="images/edit16x16.gif" border="0"
/> <a href="edit_template.php">ปรับแต่งข้อความต้อนรับ</a></td>
</tr><tr><td height="15"></td></tr>
</table></td><td width="57%"><table width="65%" border="0" align="left"
cellpadding="5" cellspacing="1" bgcolor="#6394bd">
<?$recuser=$DB->FETCHARRAY($DB->QUERY("SELECT
userfirstname,usersurname,usermail,username FROM n_user WHERE
uid='".$_SESSION['R36_UID']."'"));
$userfirstname=$recuser['userfirstname'];
$usersurname=$recuser['usersurname'];
$usermail=$recuser['usermail'];
$username=$recuser['username'];
?><tr><td colspan="2"><div align="center"><strong><span class="headtable">ยินดี
ต้อนรับ<BR />คุณ  <?=$userfirstname?>
<?=$usersurname?></span></strong></div></td>
</tr><tr>
<td width="34%" bgcolor="#98B9D3"><div align="right" class="topic">Username
:  </div></td>
<td width="66%" bgcolor="#FFFFFF"><?=$username?></td>
</tr> <tr><td bgcolor="#98B9D3"><div align="right"  class="topic">ชื่อ
:  </div></td>
<td bgcolor="#FFFFFF"><?=$userfirstname?></td>
```

```
</tr><tr><td bgcolor="#98B9D3"><div align="right"  class="topic">นามสกุล
:  </div></td>
<td bgcolor="#FFFFFF"><?=$usersurname?></td>
</tr><tr><td bgcolor="#98B9D3"><div align="right"  class="topic">อีเมล์
:  </div></td>
<td bgcolor="#FFFFFF"><?=$usermail?></td>
</tr><tr><td colspan="2" bgcolor="#FFFFFF"><div align="center"><img
src="images/data_edit.gif" border="0" /> <a href="edit_user.php">แก้ไขข้อมูลส่วนตัว
</a><br /><img src="images/lock2.gif" border="0"> <a href="destroy.php">ออกจาก
ระบบ</a></div></td></tr></table>
</td></tr></table></form><?
}else{?>
<form action="<?=$_SERVER['PHP_SELF'];?>" method="post"
name="formlogin">
<input name="action" type="hidden" value="" />
<table width="40%" border="0" align="center" cellpadding="5" cellspacing="1"
bgcolor="#6394bd">
<?$recuser=$DB->FETCHARRAY($DB->QUERY("SELECT
userfirstname,usersurname,usermail,username,userhospital FROM n_user WHERE
uid='".$_SESSION['R36_UID']."'"));
$userfirstname=$recuser['userfirstname'];
$usersurname=$recuser['usersurname'];
$usermail=$recuser['usermail'];
```

```
$username=$recuser['username'];
$userhospital=$recuser['userhospital'];
if($userhospital!=''){
$rechospital=$DB->FETCHARRAY($DB->QUERY("SELECT hospital_name
FROM n_hospital WHERE hospital_code='".$userhospital."'"));
$userhospitalname=$rechospital['hospital_name'];
}else{$userhospitalname="-";
}?><tr><td colspan="2"><div align="center"><strong><span class="headtable">ยินดี
ต้อนรับ<BR />คุณ <?=$userfirstname?>
<?=$usersurname?></span></strong></div></td>
</tr><tr><td width="34%" bgcolor="#98B9D3"><div align="right"
class="topic">Username :  </div></td>
<td width="66%" bgcolor="#FFFFFF"><?=$username?></td>
</tr><tr><td bgcolor="#98B9D3"><div align="right"  class="topic">ชื่อ
:  </div></td>
<td bgcolor="#FFFFFF"><?=$userfirstname?></td>
</tr><tr><td bgcolor="#98B9D3"><div align="right"  class="topic">นามสกุล
:  </div></td>
<td bgcolor="#FFFFFF"><?=$usersurname?></td>
</tr><tr><td bgcolor="#98B9D3"><div align="right"  class="topic">อีเมล์
:  </div></td>
<td bgcolor="#FFFFFF"><?=$usermail?></td>
</tr><tr>
```

```
<td bgcolor="#98B9D3"><div align="right"  class="topic">สถานพยาบาล
:  </div></td>
<td bgcolor="#FFFFFF"><?=$userhospitalname?></td>
</tr><tr><td colspan="2" bgcolor="#FFFFFF"><div align="center"><img
src="images/data_edit.gif" border="0" /> <a href="edit_user.php">แก้ไขข้อมูลส่วนตัว
</a><br /><img src="images/lock2.gif" border="0"> <a href="destroy.php">ออกจาก
ระบบ</a></div></td></tr></table></form><?}
}else if($HTTP_SESSION_VARS['nologin']=='nologin'){
?><form action="<?=$_SERVER['PHP_SELF'];?>" method="post"
name="formlogin"><table width="40%" border="0" align="center" cellpadding="5"
cellspacing="1" bgcolor="#6394bd"><tr>
<td colspan="2" bgcolor="#98B9D3"><div align="center"><img
src="images/warning2.gif" width="16" height="16" align="absmiddle"> <a
href="destroy.php">Login </a> <img src="images/warning2.gif" width="16"
height="16" align="absmiddle"></div></td>
</tr></table></form><?
}?><br /></td>
</tr> <? $rectemplate = $DB->FETCHARRAY($DB->QUERY("select * from
n_template"));?><tr><td>
<?=$rectemplate[template];?></td>
</tr></table></td></tr><tr><td height="1"><? include("combottom.php");?></td>
</tr></table>
</body></html>
```

APPENDIX F

EXAMPLE OF MEASURES AND CASE DATA IN WEB-BASED DF/DHF

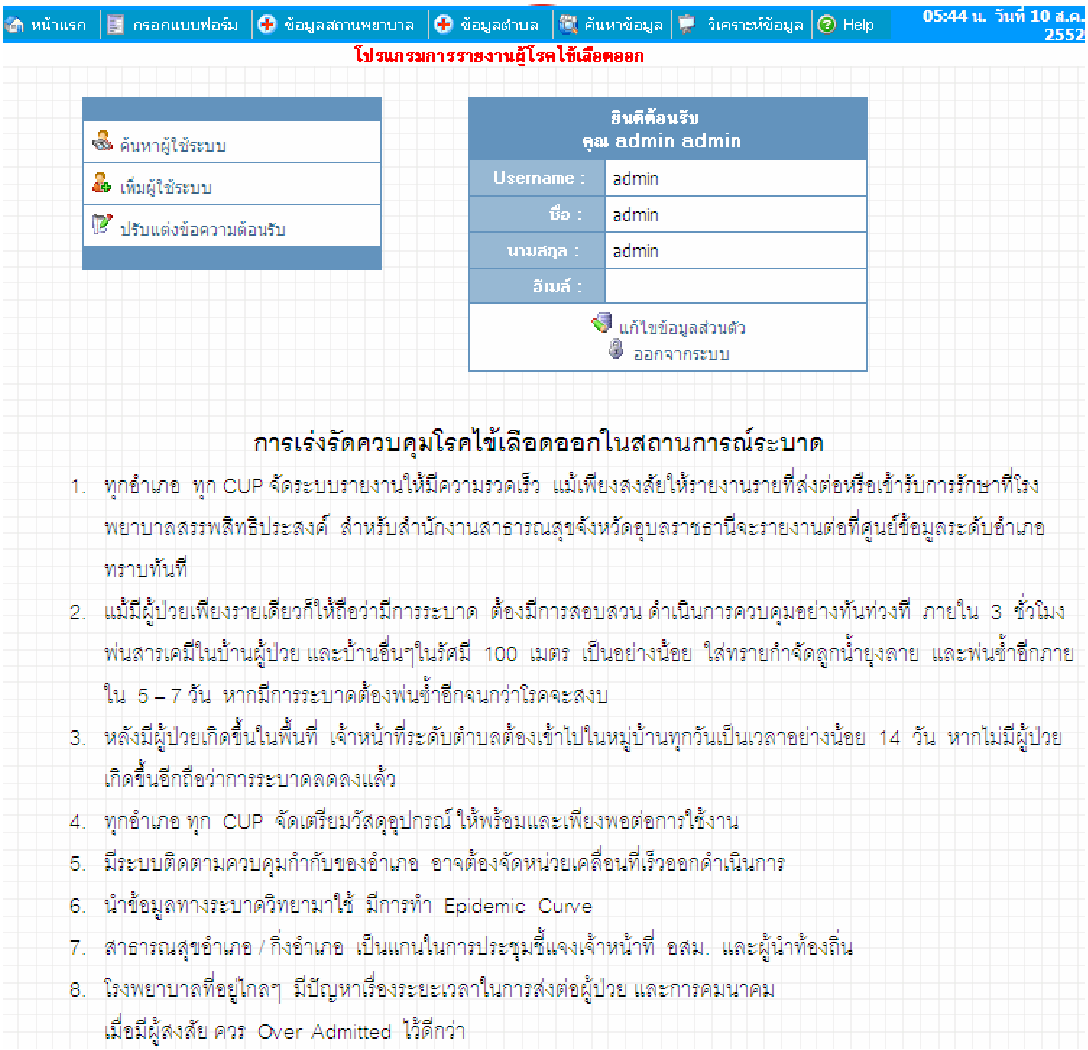
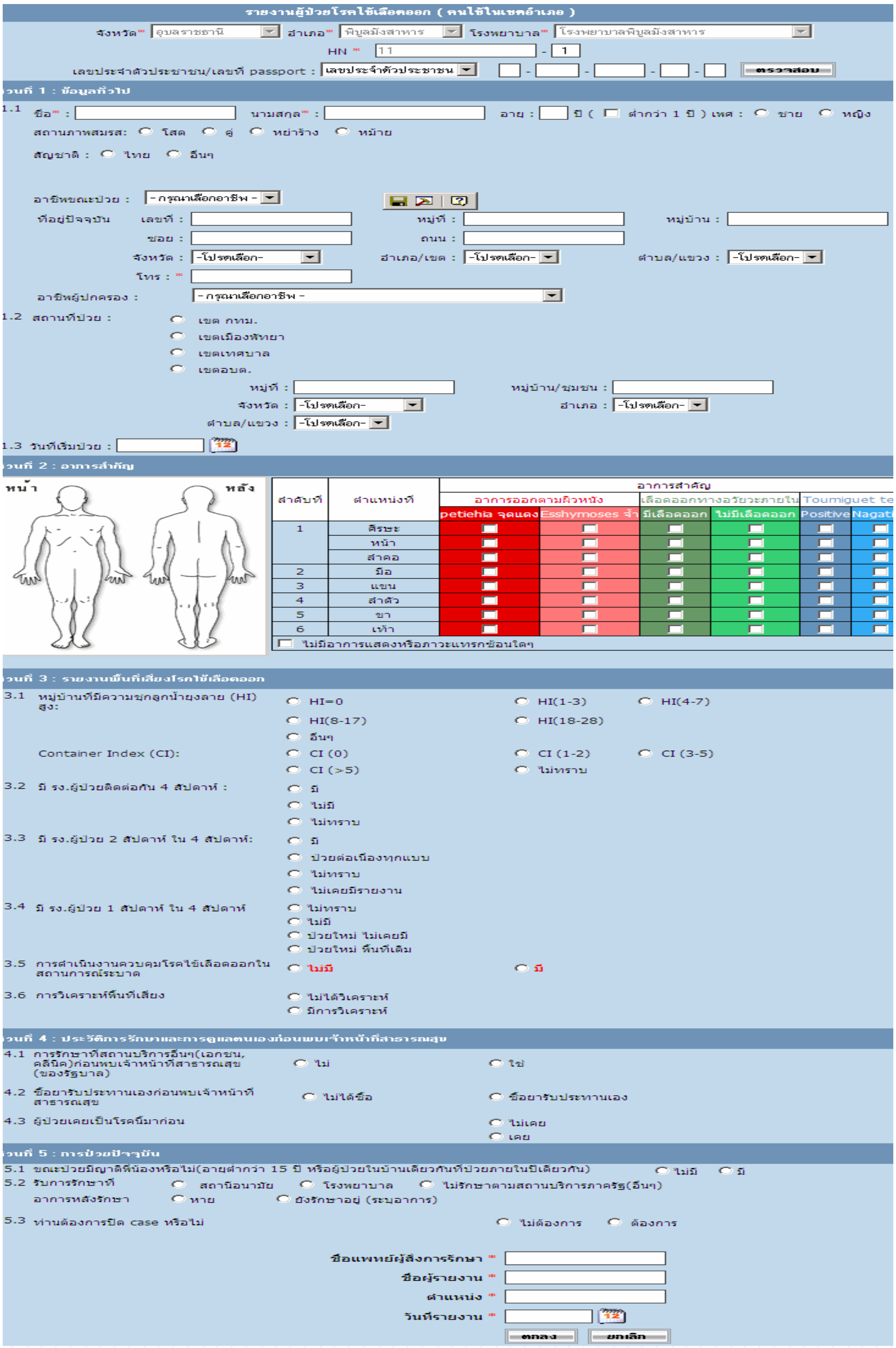


Figure F.1 Measures for dynamic implementation of web–based DF/DHF



รายงานผู้ป่วยโรคไข้เลือดออก (คนไข้ในเขตอำเภอ)

จังหวัด* อุบลราชธานี อำเภอ* พิบูลมังสาหาร โรงพยาบาล* โรงพยาบาลพิบูลมังสาหาร

HN * 11 - 1

เลขประจำตัวประชาชน/เลขที่ passport : เลขประจำตัวประชาชน - - - - ตรวจสอบ

วนที่ 1 : ข้อมูลทั่วไป

1.1 ชื่อ* : นามสกุล* : อายุ : ปี (ต่ำกว่า 1 ปี) เพศ : ชาย หญิง

สถานภาพสมรส: โสด คู่ หย่าร้าง หม้าย

สัญชาติ : ไทย อื่นๆ

อาชีพขณะป่วย : - กรุณาเลือกอาชีพ -

ที่อยู่ปัจจุบัน เลขที่ : หมู่ที่ : หมู่บ้าน :

ซอย : ถนน :

จังหวัด : -โปรดเลือก- อำเภอ/เขต : -โปรดเลือก- ตำบล/แขวง : -โปรดเลือก-

โทร : *

อาชีพผู้ปกครอง : - กรุณาเลือกอาชีพ -

1.2 สถานที่ป่วย : เขต กทม. / เขตเมืองพัทยา / เขตเทศบาล / เขตอบต.

หมู่ที่ : หมู่บ้าน/ชุมชน :

จังหวัด : -โปรดเลือก- อำเภอ : -โปรดเลือก-

ตำบล/แขวง : -โปรดเลือก-

1.3 วันที่เริ่มป่วย :

วนที่ 2 : อาการสำคัญ

หน้า หลัง

ลำดับที่	ตำแหน่งที่	อาการสำคัญ					
		อาการออกตามผิวหนัง		เลือดออกทางอวัยวะภายใน		Toumiguet te	
		petiehia จุดแดง	Esshymoses จ้ำ	มีเลือดออก	ไม่มีเลือดออก	Positive	Nagati
1	ศีรษะ						
	หน้า						
	ลำคอ						
2	มือ						
3	แขน						
4	ลำตัว						
5	ขา						
6	เท้า						

ไม่มีอาการแสดงหรือภาวะแทรกซ้อนใดๆ

วนที่ 3 : รายงานพื้นที่เสี่ยงโรคไข้เลือดออก

3.1 หมู่บ้านที่มีความชุกลูกน้ำยุงลาย (HI) สูง: HI=0 / HI(1-3) / HI(4-7) / HI(8-17) / HI(18-28) / อื่นๆ

Container Index (CI): CI (0) / CI (1-2) / CI (3-5) / CI (>5) / ไม่ทราบ

3.2 มี รง.ผู้ป่วยติดต่อกัน 4 สัปดาห์ : มี / ไม่มี / ไม่ทราบ

3.3 มี รง.ผู้ป่วย 2 สัปดาห์ ใน 4 สัปดาห์: มี / ป่วยต่อเนื่องทุกแบบ / ไม่ทราบ / ไม่เคยมีรายงาน

3.4 มี รง.ผู้ป่วย 1 สัปดาห์ ใน 4 สัปดาห์ ไม่ทราบ / ไม่มี / ป่วยใหม่ ไม่เคยมี / ป่วยใหม่ พื้นที่เดิม

3.5 การดำเนินงานควบคุมโรคไข้เลือดออกในสถานการณ์ระบาด ไม่มี / มี

3.6 การวิเคราะห์พื้นที่เสี่ยง ไม่ได้วิเคราะห์ / มีการวิเคราะห์

วนที่ 4 : ประวัติการรักษาและการดูแลตนเองก่อนพบเจ้าหน้าที่สาธารณสุข

4.1 การรักษาที่สถานบริการอื่นๆ(เอกชน, คลินิค)ก่อนพบเจ้าหน้าที่สาธารณสุข (ของรัฐบาล) ไม่ / ใช่

4.2 ซื้อยารับประทานเองก่อนพบเจ้าหน้าที่สาธารณสุข ไม่ได้ซื้อ / ซื้อยารับประทานเอง

4.3 ผู้ป่วยเคยเป็นโรคนี้มาก่อน ไม่เคย / เคย

วนที่ 5 : การป่วยปัจจุบัน

5.1 ขณะป่วยมีญาติพี่น้องหรือไม่(อายุต่ำกว่า 15 ปี หรือผู้ป่วยในบ้านเดียวกันที่ป่วยภายในปีเดียวกัน) ไม่มี / มี

5.2 รับการรักษาที่ สถานีอนามัย / โรงพยาบาล / ไม่รักษาตามสถานบริการภาครัฐ(อื่นๆ)

อาการหลังรักษา หาย / ยังรักษาอยู่ (ระบุอาการ)

5.3 ท่านต้องการปิด case หรือไม่ ไม่ต้องการ / ต้องการ

ชื่อแพทย์ผู้สั่งการรักษา *

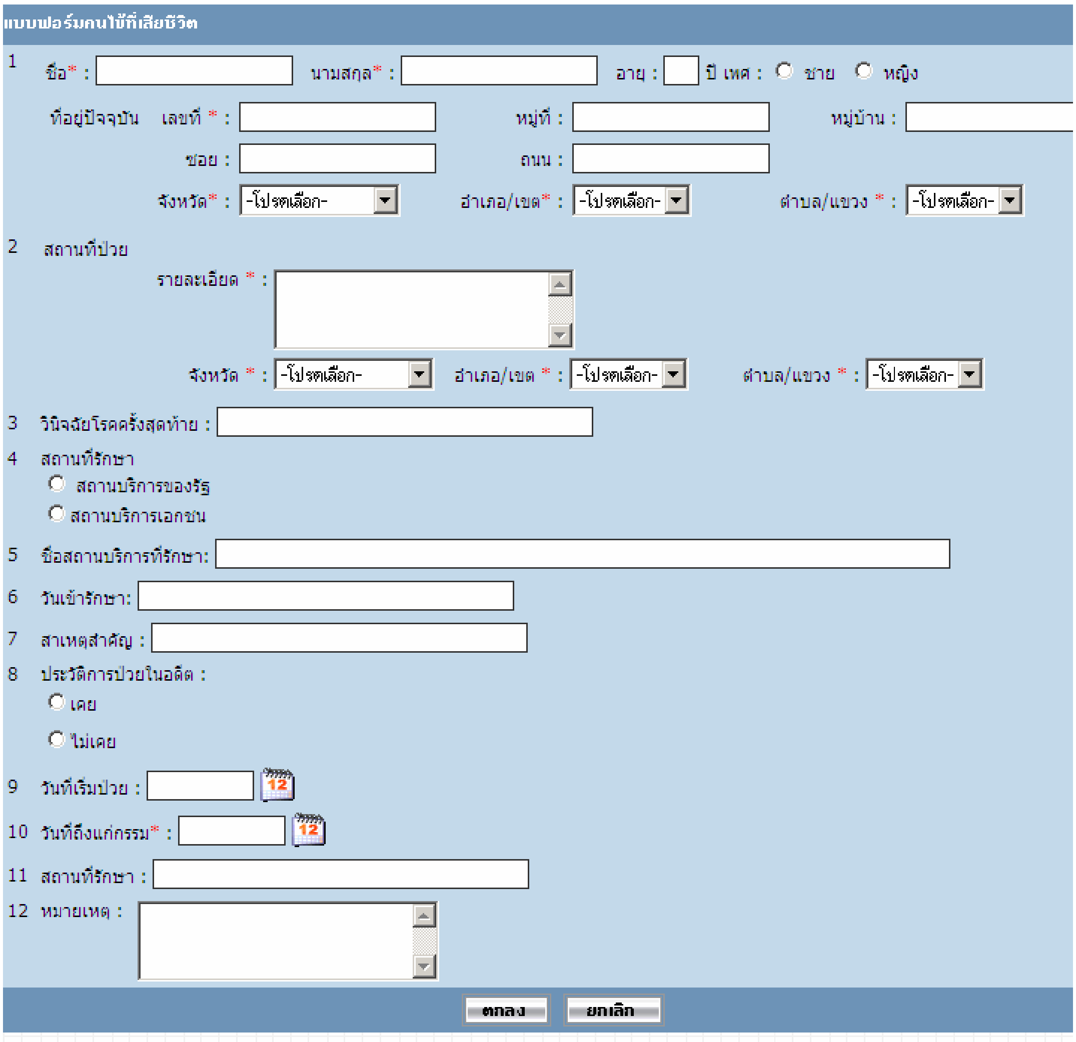
ชื่อผู้รายงาน *

ตำแหน่ง *

วันที่รายงาน *

ตกลง ยกเลิก

Figure F.2 Form for adding case



แบบฟอร์มคนไข้ที่เสียชีวิต

1 ชื่อ* : นามสกุล* : อายุ : ปี เพศ : ชาย หญิง

ที่อยู่ปัจจุบัน เลขที่ * : หมู่ที่ : หมู่บ้าน :

ซอย : ถนน :

จังหวัด* : -โปรดเลือก- อำเภอ/เขต* : -โปรดเลือก- ตำบล/แขวง * : -โปรดเลือก-

2 สถานที่ป่วย

รายละเอียด * :

จังหวัด * : -โปรดเลือก- อำเภอ/เขต * : -โปรดเลือก- ตำบล/แขวง * : -โปรดเลือก-

3 วินิจฉัยโรคครั้งสุดท้าย :

4 สถานที่รักษา

สถานบริการของรัฐ

สถานบริการเอกชน

5 ชื่อสถานบริการที่รักษา:

6 วันเข้ารักษา:

7 สาเหตุสำคัญ :

8 ประวัติการป่วยในอดีต :

เคย

ไม่เคย

9 วันที่เริ่มป่วย :

10 วันที่ถึงแก่กรรม* :

11 สถานที่รักษา :

12 หมายเหตุ :

ตกลง ยกเลิก

Figure F.3 Form for adding dead case.

ข้อมูล	ไตรมาส (N=4)		
	1	2	3
ผู้ป่วย(คน)	0	4	0
สัญชาติ			
• ไทย	0 (0.00)	4 (100.00)	0 (0.00)
• จีน/ฮ่องกง/ไต้หวัน	0 (0.00)	0 (0.00)	0 (0.00)
• พม่า	0 (0.00)	0 (0.00)	0 (0.00)
• มาเลเซีย	0 (0.00)	0 (0.00)	0 (0.00)
• กัมพูชา	0 (0.00)	0 (0.00)	0 (0.00)
• ลาว	0 (0.00)	0 (0.00)	0 (0.00)
• เวียดนาม	0 (0.00)	0 (0.00)	0 (0.00)
• ยุโรป	0 (0.00)	0 (0.00)	0 (0.00)
• อเมริกา	0 (0.00)	0 (0.00)	0 (0.00)
• ไม่ทราบสัญชาติ	0 (0.00)	0 (0.00)	0 (0.00)
• อื่นๆ	0 (0.00)	0 (0.00)	0 (0.00)
• ไม่ระบุ	0 (0.00)	0 (0.00)	0 (0.00)
อาชีพขณะป่วย			
• นักเรียน นักศึกษา	0 (0.00)	3 (75.00)	0 (0.00)
• ในปกครอง	0 (0.00)	0 (0.00)	0 (0.00)
• เกษตร ทำนา ทำสวน	0 (0.00)	0 (0.00)	0 (0.00)
• ข้าราชการ	0 (0.00)	0 (0.00)	0 (0.00)
• กรรมกร	0 (0.00)	0 (0.00)	0 (0.00)
• รับจ้าง	0 (0.00)	0 (0.00)	0 (0.00)
• ค้าขาย	0 (0.00)	0 (0.00)	0 (0.00)
• งานบ้าน	0 (0.00)	0 (0.00)	0 (0.00)
• ทหาร ตำรวจ	0 (0.00)	0 (0.00)	0 (0.00)
• ประมง	0 (0.00)	0 (0.00)	0 (0.00)
• ครู	0 (0.00)	0 (0.00)	0 (0.00)
• เลี้ยงสัตว์ / จับสุนัข	0 (0.00)	0 (0.00)	0 (0.00)
• นักบวช / ภิกษุสามเณร	0 (0.00)	0 (0.00)	0 (0.00)
• ผู้ขับขี่จักรยาน / จักรยานยนต์ส่งของ	0 (0.00)	0 (0.00)	0 (0.00)
• จนท.ระดับชุมชน/หมู่บ้าน	0 (0.00)	0 (0.00)	0 (0.00)
• อาสาสมัครสาธารณสุข	0 (0.00)	0 (0.00)	0 (0.00)
• เจ้าหน้าที่สาธารณสุข	0 (0.00)	0 (0.00)	0 (0.00)
• ไปรษณีย์	0 (0.00)	0 (0.00)	0 (0.00)
• ป่าไม้	0 (0.00)	0 (0.00)	0 (0.00)
• ห่อค้าซื้อขายแลกเปลี่ยนสินค้าในหมู่บ้าน	0 (0.00)	0 (0.00)	0 (0.00)
• อื่นๆ	0 (0.00)	0 (0.00)	0 (0.00)
• ไม่ระบุ	0 (0.00)	1 (25.00)	0 (0.00)
อาชีพผู้ปกครอง			
• เกษตร ทำนา ทำสวน	0 (0.00)	1 (25.00)	0 (0.00)
• ข้าราชการ	0 (0.00)	2 (50.00)	0 (0.00)
• กรรมกร	0 (0.00)	0 (0.00)	0 (0.00)
• รับจ้าง	0 (0.00)	0 (0.00)	0 (0.00)
• ค้าขาย	0 (0.00)	0 (0.00)	0 (0.00)
• งานบ้าน	0 (0.00)	0 (0.00)	0 (0.00)
• ทหาร ตำรวจ	0 (0.00)	0 (0.00)	0 (0.00)

Figure F.4 Report cases of group status

หน้าแรก | กรอกแบบฟอร์ม | ข้อมูลสถานพยาบาล | ข้อมูลตำบล | ค้นหาข้อมูล | วิเคราะห์ข้อมูล | Help 05:36 น. วันที่

โปรแกรมการรายงานผู้โรคไข้เลือดออก

ปัจจัยที่เกี่ยวข้องกับการรายงานผลผู้ป่วยโรคไข้เลือดออก

รูปแบบเขตความรับผิดชอบ รูปแบบเดิม (12 เขต) ข้อมูลรายเขต ทั้งหมด

จังหวัด ทั้งหมด อำเภอ ทั้งหมด

โรงพยาบาล ทั้งหมด ปี ทั้งหมด

ตาราง จำนวนของผู้ป่วยโรคไข้เลือดออก แจกแจงตามความชุกลูกน้ำยุงลายและ มี รง.ผู้ป่วยติดต่อกัน 4 สัปดาห์

ความชุกลูกน้ำยุงลาย (HI)	มี รง.ผู้ป่วยติดต่อกัน 4 สัปดาห์				
	มีรายงาน	ไม่มีรายงาน	ไม่ทราบ	ไม่ระบุ	รวม
HI=0	2 (66.7)	0 (0.0)	1 (33.3)	0 (0.0)	3 (100.0)
HI(1-3)	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)
HI(4-7)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (100.0)
HI(8-17)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (100.0)
HI(18-28)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (100.0)
HI (29-37)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (100.0)
HI (38-49)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (100.0)
HI (50-59)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (100.0)
HI (60-70)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (100.0)
HI (71-80)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (100.0)
HI (81-90)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (100.0)
HI (91-100)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (100.0)
HI (101-110)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (100.0)
HI (111-120)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (100.0)
HI (121-130)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (100.0)
HI (131-140)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (100.0)
HI (141-150)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (100.0)
ไม่ทราบ	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (100.0)
ไม่ระบุ	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (100.0)
รวม	3	0	1	0	4

Figure F.5 Report of HI and case

ส่วนที่ 2 : ตำแหน่งและที่พักขณะป่วยเป็นโรค

ตารางที่ 2 จำนวนและร้อยละของผู้ป่วยหรือสงสัยว่าป่วยโรคไข้เลือดออก แจกแจงตามสถานที่พักขณะเป็นโรค และอาการที่สำคัญ

ผู้ป่วย	จำนวน(N= 4)	ร้อยละ
สถานที่ป่วยเป็นโรค		
เขต กทม.	0	0.00
เขตเมืองพัทยา	0	0.00
เขตเทศบาล	0	0.00
นคร	0	-
เมือง	0	-
ตำบล	0	-
ไม่ระบุ	0	-
เขต อบต.	4	100.00
ในชุมชน / ตลาด	1	-
ชนบท	3	-
ไม่ระบุ	0	-
ไม่ระบุ	0	0.00
อาการสำคัญ (n= 9)		
อาการออกตามผิวหนัง		
petiehia จุดแดง	4	44.44
Esshymoses จ้ำ	1	11.11
เลือดออกทางอวัยวะภายใน		
มีเลือดออก	2	22.22
ไม่มีเลือดออก	0	0.00
Toumiguet test		
Positive	2	22.22
Nagative	0	0.00
ไม่มีอาการแสดงหรือภาวะแทรกซ้อนใดๆ	0	0.00
ตำแหน่งที่แสดงอาการ(n= 10)		
ศีรษะ	4	40.00
หน้า	2	20.00
ลำคอ	2	20.00
มือ	0	0.00
แขน	1	10.00
ลำตัว	1	10.00
ขา	0	0.00
เท้า	0	0.00

พิมพ์รายงาน

ส่วนที่ 1 : ข้อมูลทั่วไป
ส่วนที่ 3 : รายงานพื้นที่เสี่ยงโรคไข้เลือดออก
ส่วนที่ 4 : ประวัติการรักษาและการดูแลตนเองก่อนพบเจ้าหน้าที่สาธารณสุข
ส่วนที่ 5 : การป่วยปัจจุบัน

Figure F.6 Case data display according to places to live when sick.

ตาราง จำนวนและร้อยละของผู้ป่วยโรคไข้เลือดออก แจกแจงตามรายเดือน (ต่อ)

ข้อมูล	เดือน (N=4)											
	ม.ค.	ก.พ.	มี.ค.	เม.ย.	พ.ค.	มิ.ย.	ก.ค.	ส.ค.	ก.ย.	ต.ค.	พ.ย.	ธ.ค
ผู้ป่วย(คน)	0	0	0	1	3	0	0	0	0	0	0	0
ผู้ป่วยติดต่อกัน 4 สัปดาห์												
• มี	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	2 (66.67)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0
• ไม่มี	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0
• ไม่ทราบ	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (33.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0
• ไม่ระบุ	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0
การวิเคราะห์พื้นที่เสี่ยง	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0
มีการดำเนินรณรงค์หรือกิจกรรมเพื่อการป้องกัน	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0
ขณะป่วยมีญาติพี่น้องหรือไม่(อายุต่ำกว่า 15 ปี หรือผู้ป่วยในบ้านเดียวกันที่ป่วยภายในปีเดียวกัน)												
• ในบ้านมีเด็กอายุต่ำกว่า 15 ปี	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	1 (33.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0
• ในบ้านมีเด็กอายุต่ำกว่า 15 ปี และผู้ป่วยในบ้านเดียวกันที่ป่วยภายในปีเดียวกัน	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (33.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0
• ไม่ระบุ	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0
อาการหลังการรักษา												
• หาย	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0
• ยังรักษาอยู่	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0
• ไม่ระบุ	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	2 (66.67)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0
สถานที่รักษา												
• สถานีอนามัย	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	1 (33.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0
• โรงพยาบาล	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0
• ไม่รักษาตามสถานบริการภาครัฐ(อื่นๆ)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	2 (66.67)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0
การรักษาขั้นต้น												
• ไม่ได้ทำ	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0
• ให้น้ำเกลือ	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	3 (50.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0
• ให้น้ำเกลือ/ยาลดไข้	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	2 (33.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0
• ยาลดไข้/เช็ดตัว	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (16.67)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0
อาการหลังรักษา												
• หาย	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	3 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0
• ยังรักษาอยู่	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.0

Figure F.7 Report of monthly case data

APPENDIX G

EXAMPLE OF UNIT TESTING

To pass condition and branch condition, the test case number 1 was performed.

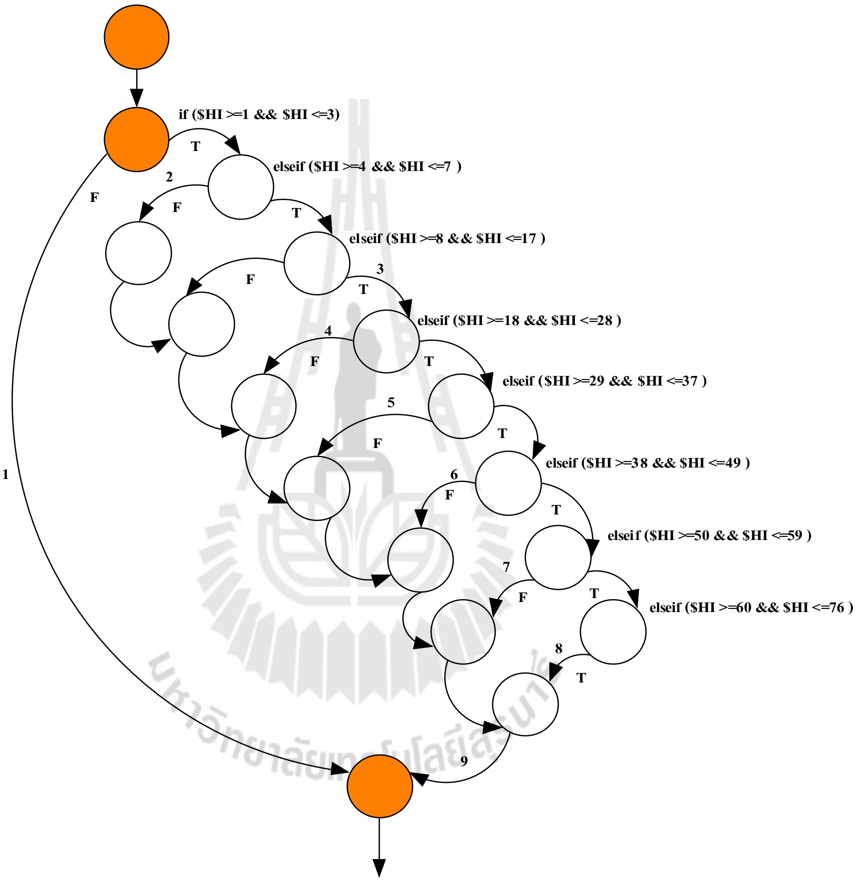


Figure G.1 Control flow of condition testing number 1.

Test case number 1, 1 in 9 passed is 11 % branch condition coverage.

Table G.1 Report of the test case 1.

Test Case	Check House Index (HI)	Check	
		number	justified
1	1 =< HI <=3	6	6

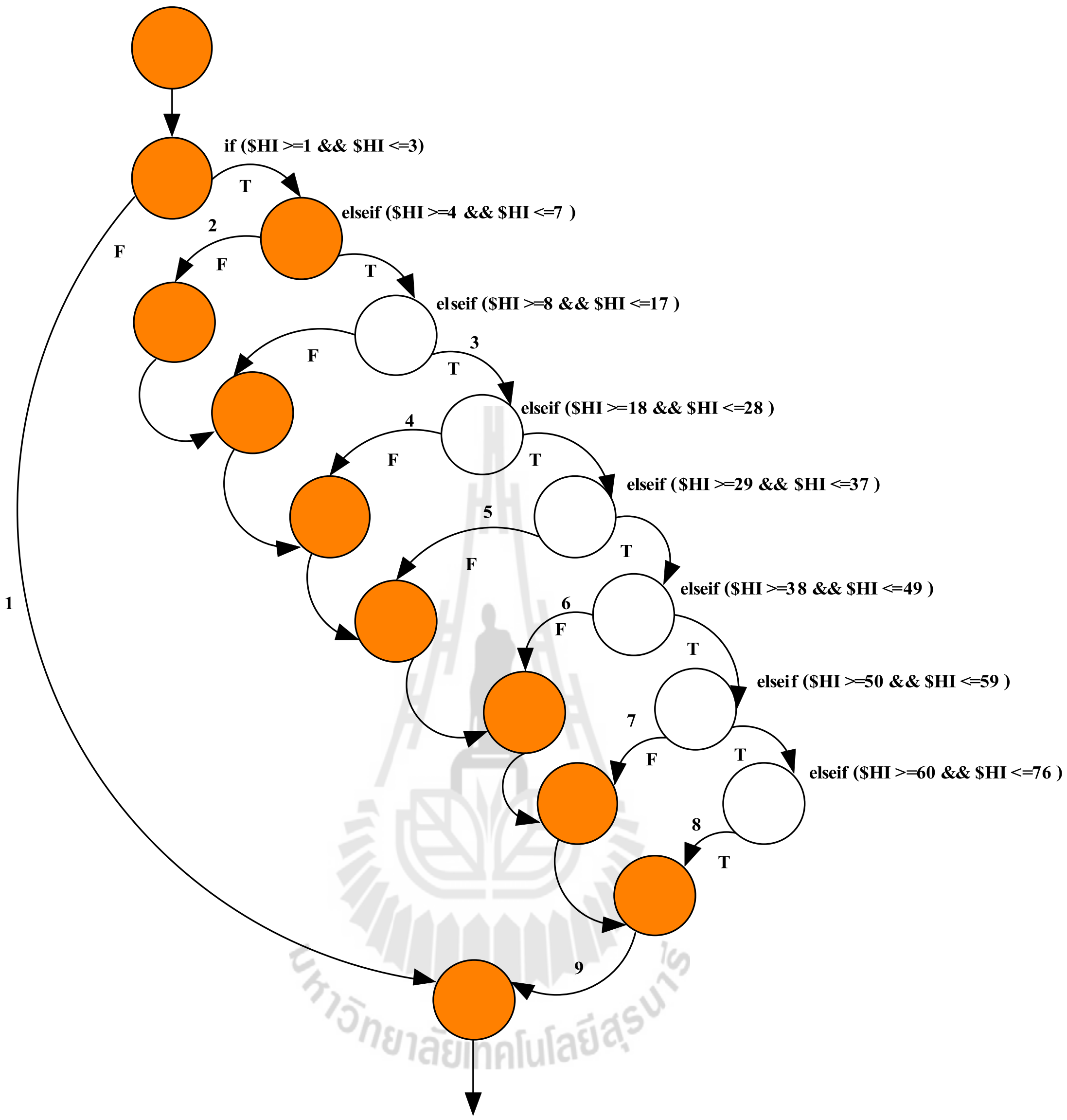


Figure G.2 Control flow of condition testing number 2.

Test case number 2, 2 in 9 passed, is 22 % branch condition coverage.

Table G.2 Report of the test case 2.

Test Case	Check House Index (HI)	Check	
		number	justified
1	1 =< HI <=3	6	6
2	4 =< HI <=7	8	8

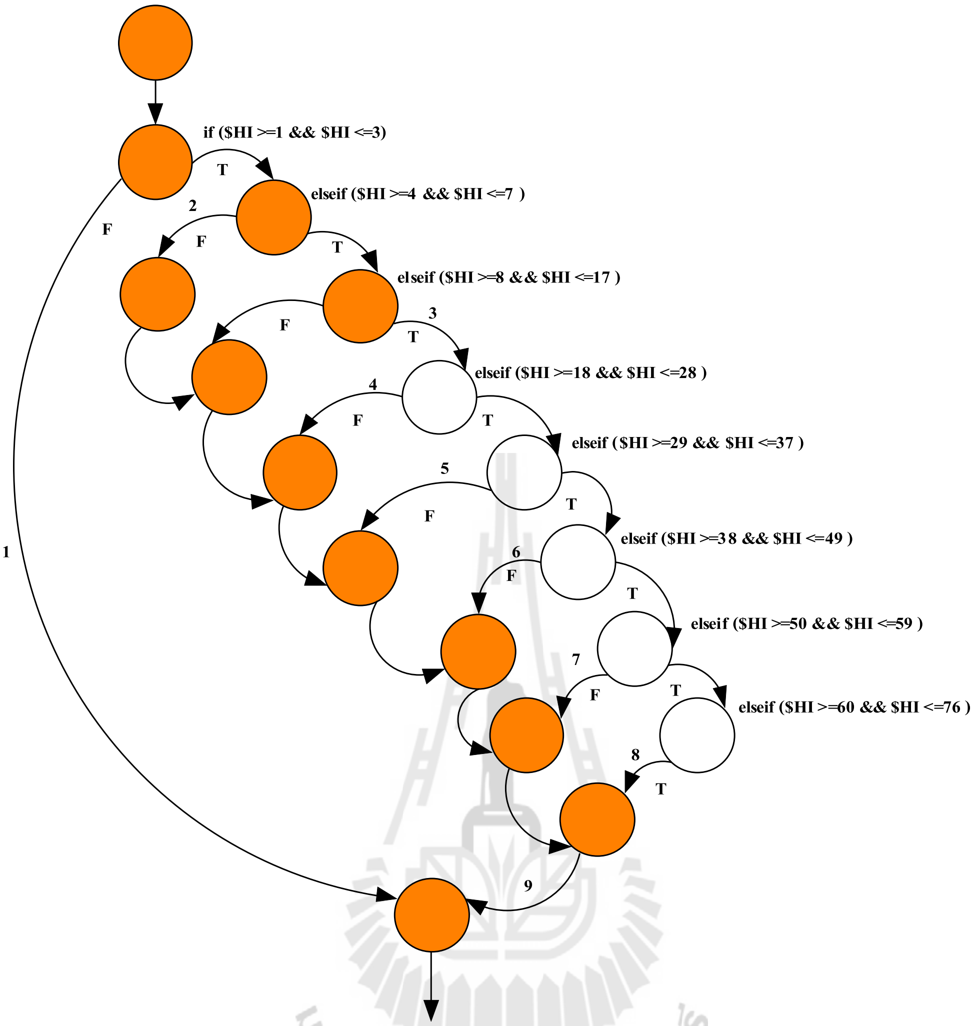


Figure G.3 Control flow of condition testing number 3.

Test case number 3, the case 1, 2, and 3 in 9 passed, is 33 % branch condition coverage.

Table G.3 Report of the test case 3.

Test Case	Check House Index (HI)	Check	
		number	justified
1	1 =< HI <=3	6	6
2	4 =< HI <=7	8	8
3	8 =< HI <=17	20	20

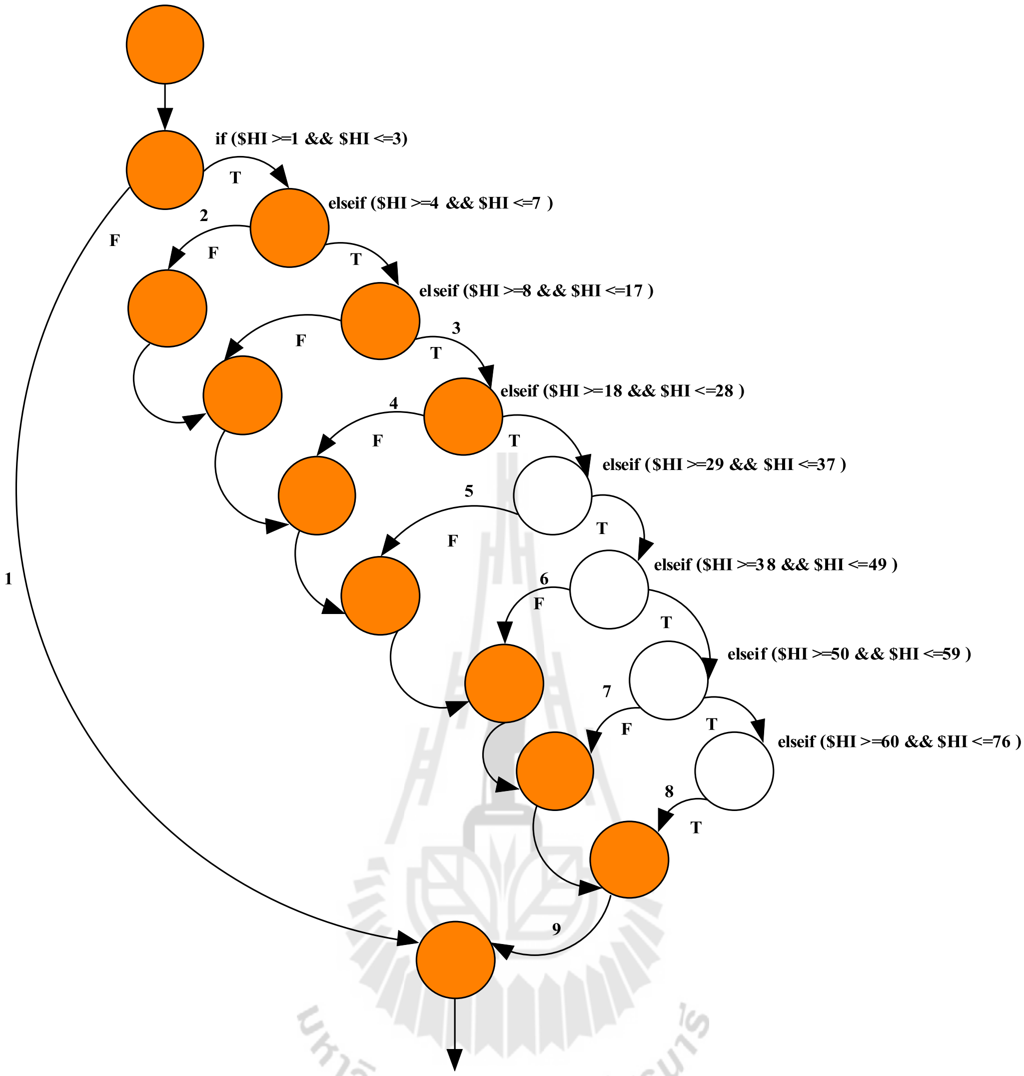


Figure G.4 Control flow of condition testing number 4.

Test case number 4, the case 1, 2, 3, and 4 in 9 passed, is 44 % branch condition coverage.

Table G.4 Report of the test case 4.

Test Case	Check House Index (HI)	Check	
		number	justified
1	1 =< HI <=3	6	6
2	4 =< HI <=7	8	8
3	8 =< HI <=17	20	20
4	18 =< HI <=29	24	24

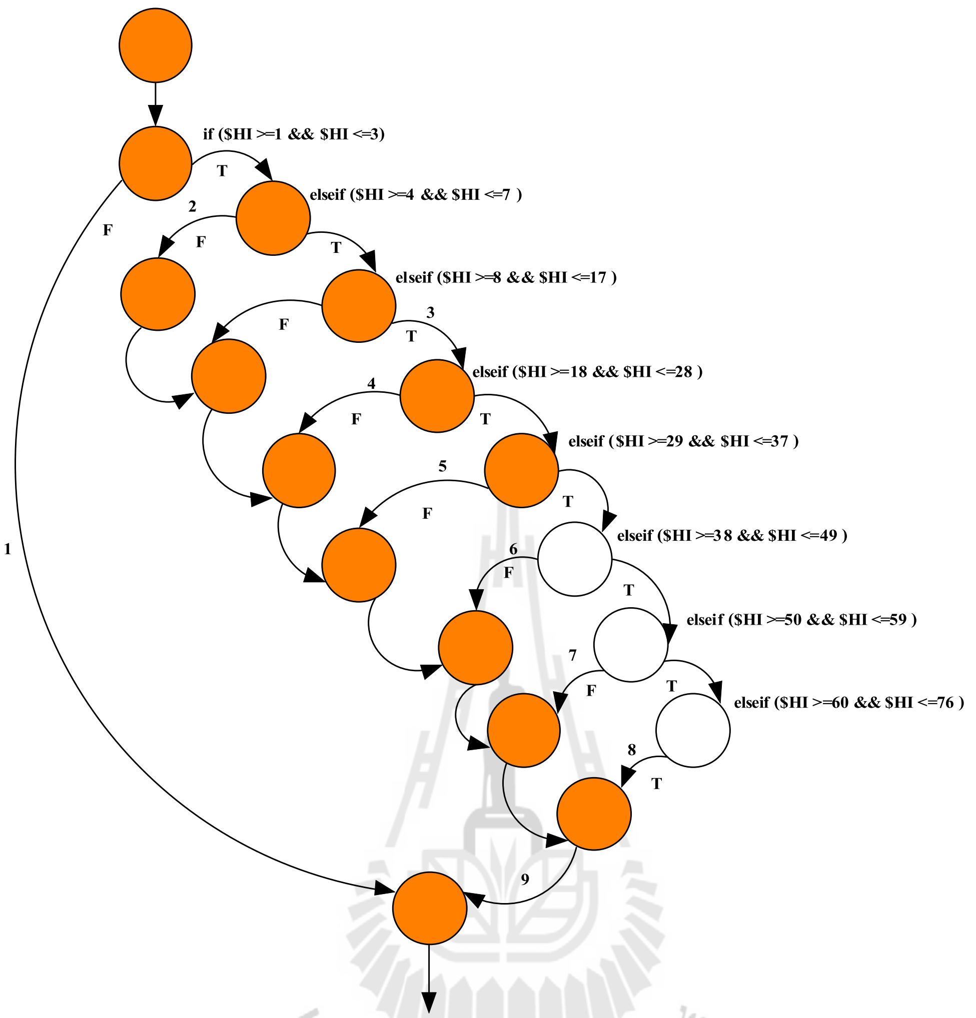


Figure G.5 Control flow of condition testing number 5.

Test case number 5, the case 1, 2, 3, 4 and 5 in 9 passed, is 55 % branch condition coverage.

Table G.5 Report of the test case 5.

Test Case	Check House Index (HI)	Check number	Check justified
1	1 =< HI <=3	6	6
2	4 =< HI <=7	8	8
3	8 =< HI <=17	20	20
4	18 =< HI <=29	24	24
5	29 =< HI <=37	18	18

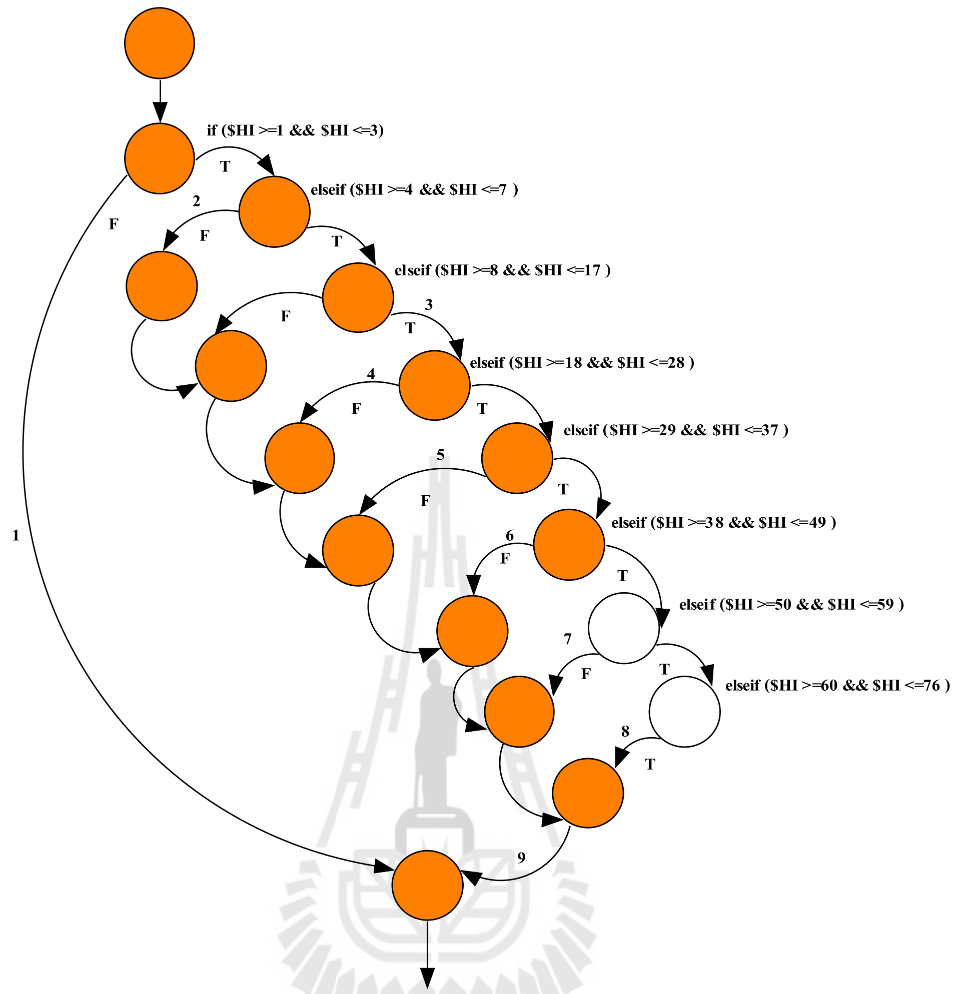


Figure G.6 Control flow of condition testing number 6.

Test case number 6, the case 1, 2, 3, 4, 5 and 6 in 9 passed, is 66 % branch condition coverage.

Table G.6 Report of the test case 6.

Test Case	Check House Index (HI)	Check	
		number	justified
1	1 =< HI <=3	6	6
2	4 =< HI <=7	8	8
3	8 =< HI <=17	20	20
4	18 =< HI <=29	24	24
5	29 =< HI <=37	18	18
6	38 =< HI <=49	24	24

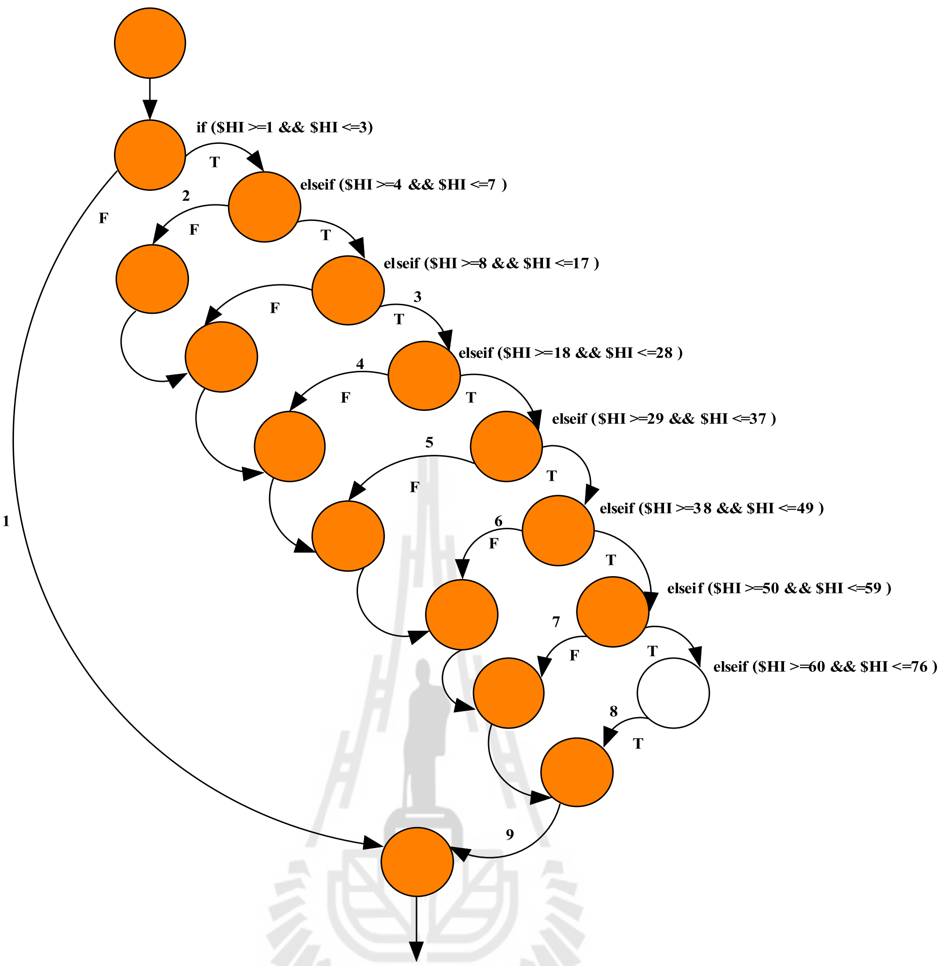


Figure G.7 Control flow of condition testing number 7.

Test case number 7, the case 1, 2, 3, 4, 5, 6 and 7 in 9 passed, is 77 % branch condition coverage.

Table G.7 Report of the test case 7.

Test Case	Check House Index (HI)	Check	
		number	justified
1	1 =< HI <=3	6	6
2	4 =< HI <=7	8	8
3	8 =< HI <=17	20	20
4	18 =< HI <=29	24	24
5	29 =< HI <=37	18	18
6	38 =< HI <=49	24	24
7	50 =< HI <=59	20	20

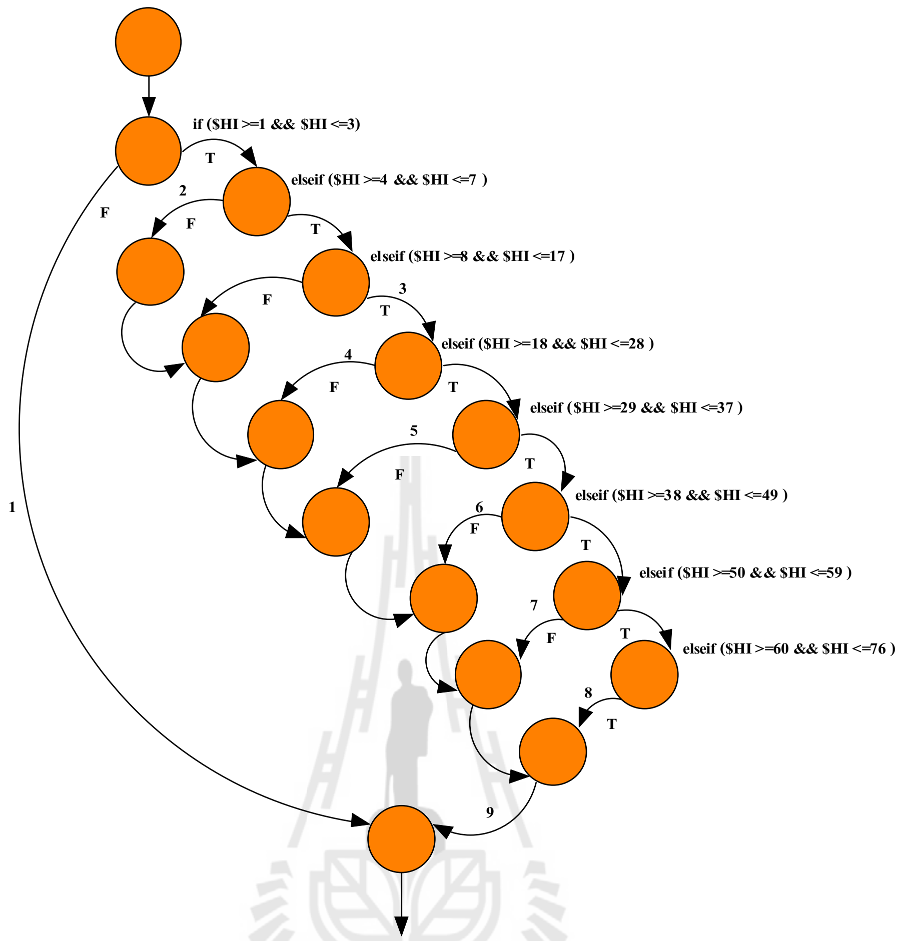


Figure G.8 Control flow of condition testing number 8.

Test case number 8, the case 1,2,3,4,5,6,7 and 8 in 9 passed, is 88 % branch condition coverage.

Table G.8 Report of the test case 8.

Test Case	Check House Index (HI)	Check number	Check justified
1	1 =< HI <=3	6	6
2	4 =< HI <=7	8	8
3	8 =< HI <=17	20	20
4	18 =< HI <=29	24	24
5	29 =< HI <=37	18	18
6	38 =< HI <=49	24	24
7	50 =< HI <=59	20	20
8	60 =< HI <=76	34	34

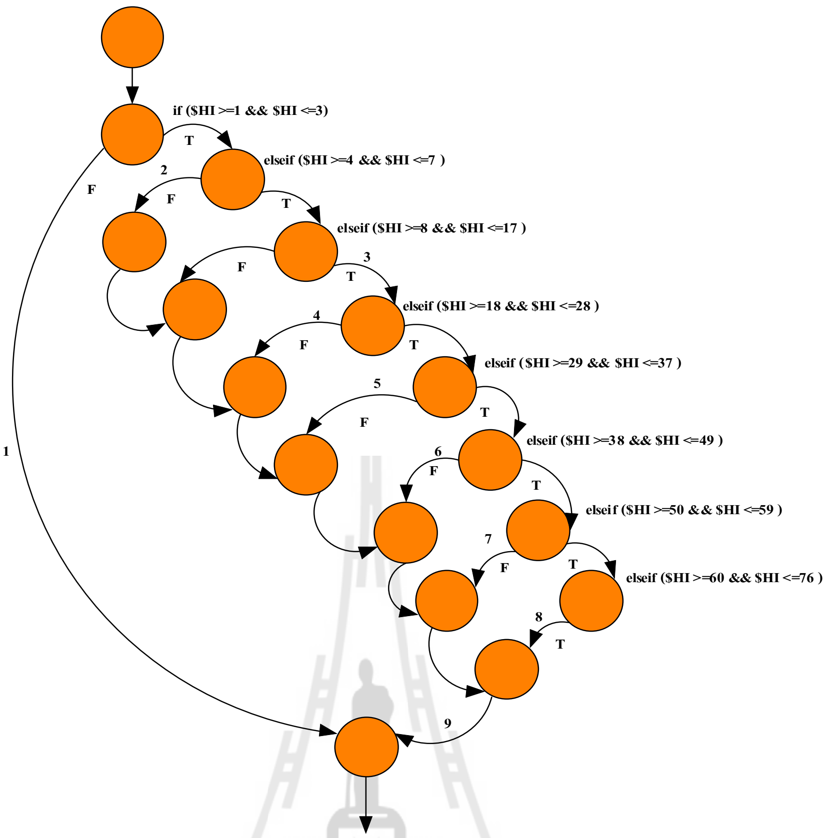


Figure G.9 Control flow of condition testing number 9.

Test case number 9, the case 1, 2, 3, 4, 5, 6, 7, 8 and 9 in 9 passed, is 100 % branch condition coverage.

Table G.9 Report of the test case 9.

Test Case	Check House Index (HI)	Check	
		number	justified
1	1 =< HI <=3	6	6
2	4 =< HI <=7	8	8
3	8 =< HI <=17	20	20
4	18 =< HI <=29	24	24
5	29 =< HI <=37	18	18
6	38 =< HI <=49	24	24
7	50 =< HI <=59	20	20
8	60 =< HI <=76	34	34
9	76 < HI	10	10

APPENDIX H

QUESTIONNAIRE

แบบสอบถามการประเมินการใช้ระบบงาน

ข้อชี้แจง แบบประเมินนี้เป็นส่วนหนึ่งของการศึกษาวิจัย เรื่อง

DEVELOPMENT OF WEB-BASED SPATIAL DECISION SUPPORT SYSTEM TO MONITOR EPIDEMIC RISK OF DENGUE FEVER AND DENGUE HAEMORRHAGIC FEVER FOR PREVENTION AND CONTROL

การพัฒนาระบบสนับสนุนการตัดสินใจเชิงพื้นที่ผ่านเว็บในการเฝ้าระวังความเสี่ยงต่อการระบาดของโรคไข้เลือดออกเพื่อการป้องกันและควบคุม

จึงใคร่ขอความกรุณาในการตอบแบบสอบถามข้างล่างนี้ ซึ่งแบบสอบถามนี้แบ่งได้เป็น 3 ส่วนหลักดังนี้

ส่วนที่ 1 ข้อมูลทั่วไปของผู้ตอบแบบสอบถาม

1.1 ชื่อ-สกุล…………………………………………………..

1.2 ตำแหน่ง…………………………………………………..

1.3 แผนก/หน่วยงาน………………………………………….

1.4 วันที่ประเมิน(วัน/เดือน/ปี)………………………………..

ส่วนที่ 2 แบบการประเมินระบบงานแบ่งออกได้ทั้งหมด 4 ด้านดังนี้

2.1 การประเมินด้านความสามารถทำงานตามความต้องการของผู้ใช้ระบบเว็บ

2.2 การประเมินด้านความสามารถในการทำงานของระบบเว็บ(Web-Based)

2.3 การประเมินด้านรูปแบบการนำเสนอเว็บ(Web-Based)

2.4 การประเมินด้านความปลอดภัยของระบบเว็บ(Web-Based)

ซึ่งจะแบ่งเกณฑ์การให้คะแนนเป็น 5 ระดับตามความพึงพอใจต่อระบบงานได้แก่

5 = พึงพอใจมากที่สุด

4 = พึงพอใจมาก

3 = พึงพอใจปานกลาง

2 = พึงพอใจน้อย

1 = พึงพอใจน้อยที่สุด

ส่วนที่ 3 ข้อคิดเห็นเพิ่มเติมและข้อเสนอแนะ

2.1 การประเมินด้านความสามารถทำงานตามความต้องการของผู้ใช้ระบบ Web-Based

ข้อชี้แจง โปรดแสดงความคิดเห็นของท่านลงในช่องว่างโดยใช้เครื่องหมาย (/) ลงในช่องว่างให้ตรงกับความคิดเห็นของท่านมากที่สุด

ข้อ	เกณฑ์การประเมิน	คะแนน				
		5	4	3	2	1
1	ระบบสามารถช่วยในเรื่องการเก็บข้อมูลนำเสนอข้อมูล และแสดงผล ง่ายต่อการนำไปใช้งาน					
2	ระบบสามารถทำให้การจัดด้านควบคุมโรคได้รวดเร็ว และมีประสิทธิภาพมากขึ้น					
3	สารสนเทศที่ได้นำไปใช้ประโยชน์เพื่อการปฏิบัติ					
4	สารสนเทศที่ได้นำไปใช้ประโยชน์เพื่อการบริหาร					

2.2 การประเมินด้านความสามารถในการทำงานของระบบ Web-Based

<u>ข้อชี้แจง</u> โปรดแสดงความคิดเห็นของท่านลงในช่องว่างโดยใช้เครื่องหมาย (/) ลงในช่องว่างให้ตรงกับความคิดเห็นของท่านมากที่สุด

ข้อ	เกณฑ์การประเมิน	คะแนน				
		5	4	3	2	1
5	ความถูกต้องของการจัดเก็บข้อมูลแต่ละประเภท					
6	ความถูกต้องของการปรับปรุงแก้ไขข้อมูล					
7	ความถูกต้องของการค้นหาข้อข้อมูล					
8	ความถูกต้องของการแสดงผลซ้อนทับข้อมูลในแต่ชั้นข้อมูล					
9	ความถูกต้องของการแสดงของข้อมูลที่ต้องการ					
10	ความถูกต้องของการประมวลผล และคำนวณค่าร้อยละของความครอบคลุมการสำรวจ HI, CI					
11	ความถูกต้องของระบบช่วยเหลือในการให้คำแนะนำการใช้ระบบ Web Mapping					
12	ความถูกต้องในการรายงานผลผ่านระบบ Printer					
13	ความถูกต้องของโปรแกรมที่มีข้อความเตือนหรือความผิดพลาด เมื่อผู้ใช้ไม่ป้อน ข้อมูลตามที่กำหนด					
14	ข้อมูลแสดงผลได้ตามคำสั่งที่เลือกผ่านปุ่มคำสั่ง					
15	ความสามารถในการแสดงผลหลังการปรับแก้ข้อมูลของผู้ใช้งาน					

2.3 การประเมินด้านรูปแบบการนำเสนอ Web-Based

ข้อชี้แจง โปรดแสดงความคิดเห็นของท่านลงในช่องว่างโดยใช้เครื่องหมาย (/) ลงในช่องว่างให้ตรงกับความคิดเห็นของท่านมากที่สุด

ข้อ	เกณฑ์การประเมิน	คะแนน				
		5	4	3	2	1
16	ความยากง่ายในการเรียนรู้การใช้งานระบบ Web Mapping					
17	สามารถใช้งานระบบ Web Mapping ได้ความสะดวก					
18	การใช้สัญลักษณ์และรูปภาพ ในการสื่อความหมายในระบบงานเหมาะสมและเข้าใจง่าย					
19	ปุ่มและคำอธิบายมีความง่ายต่อความเข้าใจ					
20	การจัดวางหน้าจอ (Layout) ช่วยให้อ่านง่าย และสบายตา					
21	ข้อความที่แสดงบนจอภาพในการสื่อความหมายมีความชัดเจนและเข้าใจง่าย					
22	การใช้สีสันของตัวอักษรที่เหมาะสม สวยงาม					

2.4 การประเมินด้านความปลอดภัยของระบบ Web-Based

ข้อชี้แจง โปรดแสดงความคิดเห็นของท่านลงในช่องว่างโดยใช้เครื่องหมาย (/) ลงในช่องว่างให้ตรงกับความคิดเห็นของท่านมากที่สุด

ข้อ	เกณฑ์การประเมิน	คะแนน				
		5	4	3	2	1
23	การตรวจสอบสิทธิในการปรับปรุงระบบงาน					
24	การ Login รหัสผ่านของผู้ดูแลระบบในการเข้าไปปรับปรุงแก้ไขข้อมูล					
25	ความปลอดภัยของระบบโดยรวม					

ส่วนที่ 3 ข้อคิดเห็นเพิ่มเติมและข้อเสนอแนะ

……………………………………………………………………………………………………

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ขอขอบพระคุณทุกท่านเป็นอย่างสูงที่กรุณาให้ความร่วมมือตอบแบบสอบถาม ขอบคุณครับ

APPENDIX I

USER MANUAL

I.1 บทนำ

การพัฒนาระบบสนับสนุนการตัดสินใจเชิงพื้นที่ผ่านเว็บในการเฝ้าระวังความเสี่ยงต่อการระบาดของโรคไข้เลือดออกเพื่อการป้องกันและควบคุม ในจังหวัดอุบลราชธานี โดยการนำข้อมูลเชิงพื้นที่เผยแพร่ให้ผู้ใช้ผ่านทางระบบอินเตอร์เน็ตได้ ซึ่งผู้พัฒนาได้เลือกใช้โปรแกรม Minnesota Map Server เป็นแม่ข่ายแผนที่ เนื่องจาก Minnesota Map Server เป็นซอฟท์แวร์รหัสเปิด (Open Source) จึงมีการพัฒนาให้สามารถสนับสนุนการใช้งานได้หลากหลายภาษา เช่น PHP, Python, Perl, Ruby, Java และ C# เป็นต้น โดยสามารถอ่านละเอียดเกี่ยวกับโปรแกรมเพิ่มเติมได้ที่ http://mapserver.gis.umn.edu/

I.2 การติดตั้งแม่ข่ายแผนที่ (Map Server)

1. Download ชุดแม่ข่ายแผนที่สำเร็จรูป MS4W (Map Server for window) จากเว็บไซต์ http://www.maptools.org/dl/ms4w

2. Unzip ไฟล์ mapserver–4.4.2–win32–php4.3.11 โดยเลือก Root Directory ที่จะทำการติดตั้ง mapserver server ใน Directory C:\AppServ\www\cgi-bin จะได้ โฟล์ดเดอร์ต่างๆดังภาพที่ I.1

3. ทำการทดสอบการทำงานของ MapServer โดยพิมพ์ URL บน Web Browser ดังนี้

http:// localhost/cgi–bin/mapserv.exe? หากผลที่ได้เป็นดังนี้ " No query information to decode. QUERY_STRING is set, but empty. " เสร็จสิ้นการติดตั้งชุดโปรแกรม MapServer

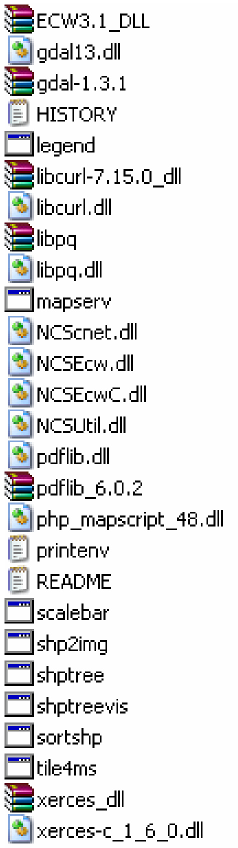
I.2 การติดตั้ง Web Server

ในการพัฒนานี้ใช้ชุดติดตั้งของ Appserv Open Project – 2.4.5 สำหรับ วินโดวส์ ซึ่งประกอบไปด้วย

- Apache Web Server
- PHP Script Language
- MySQL Database
- phpMyAdmin Database Manager

สามารถศึกษาคู่มือการติดตั้งได้ที่เว็บดังกล่าวนี้

http://www.AppServNetwork.com



ภาพที่ I.1 MapServer file

I.3 การติดตั้งชุด Web files

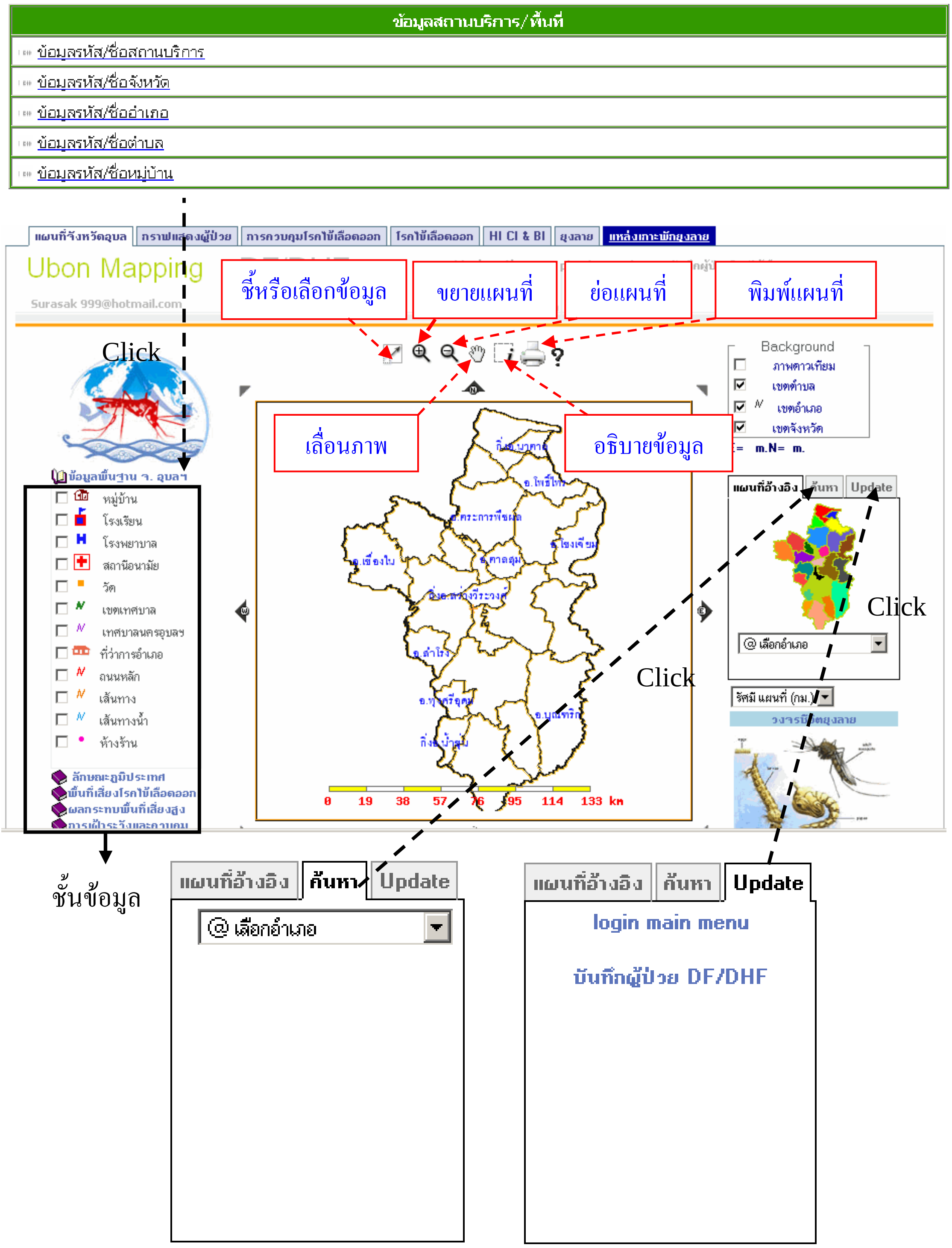
ทำการสร้างโฟล์ดเดอร์ provis ไปไว้ในโพล์ดเดอร์สำหรับเผยแพร่เว็บในที่นี้คือ

C:\AppServ\www\ provis

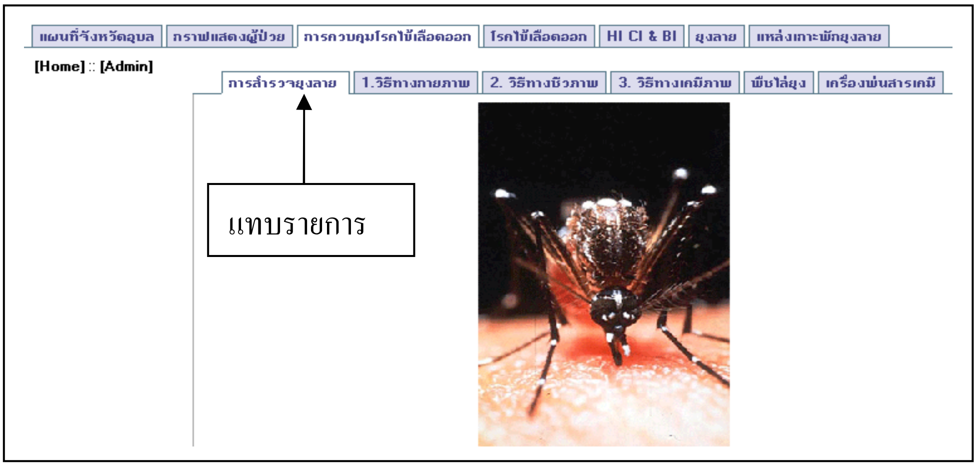
I.4 การสร้าง Map files

ในการสร้าง Mapfile ซึ่งจะใช้เป็นตัว configuration ของ Minnesota Map Server เพื่อกำหนดรูปแบบการทำงานและรายละเอียดต่างๆของข้อมูลเชิงพื้นที่ เช่น การบอกแหล่งข้อมูลเชิงพื้นที่ การแสดงผลข้อมูลเชิงพื้นที่ เป็นต้น โดยสามารถอ่านละเอียดเกี่ยวกับการเขียน Map file เพิ่มเติมได้ที่ http://mapserver.gis.umn.edu/

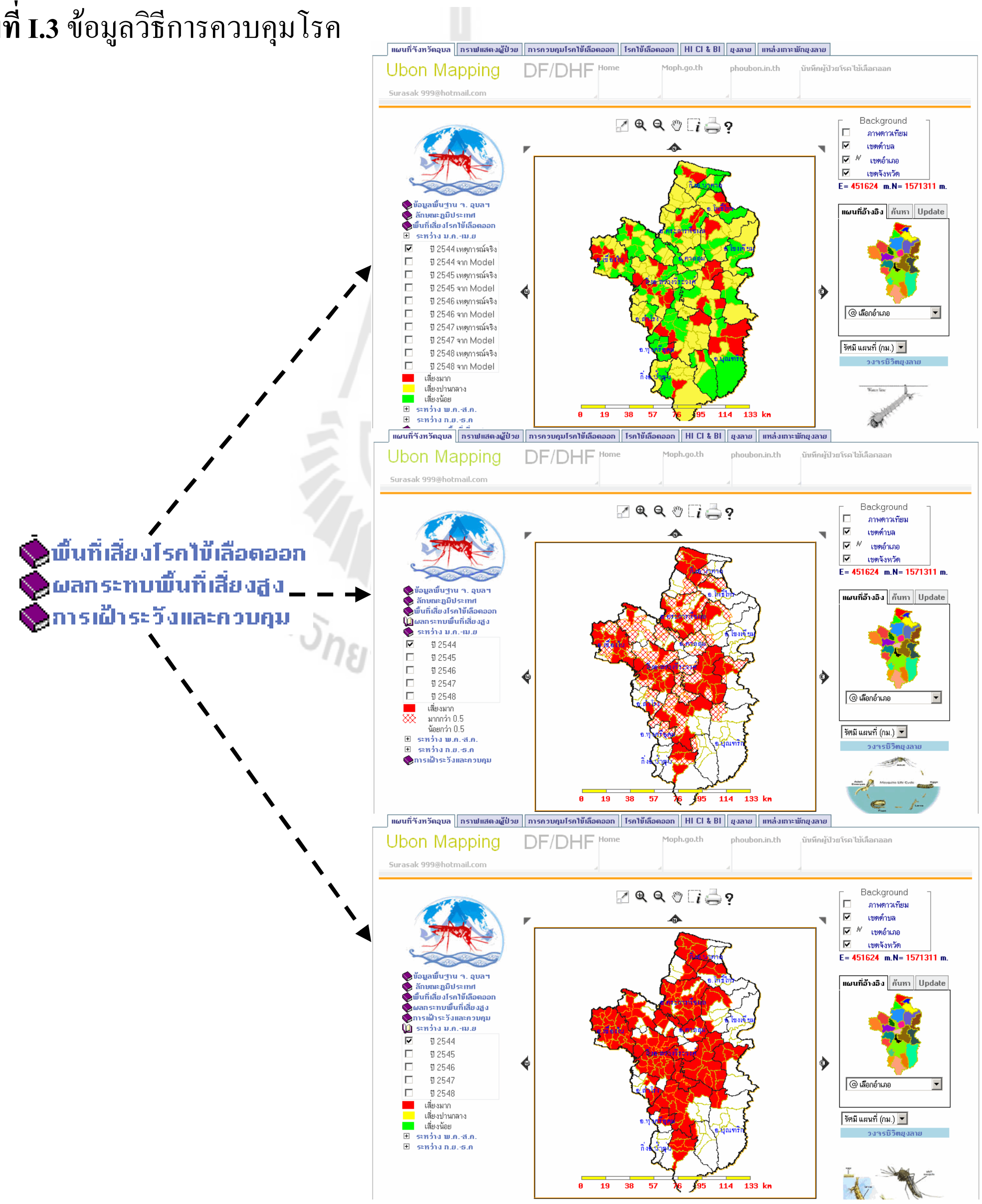
I.5 การเข้าใช้เว็บ



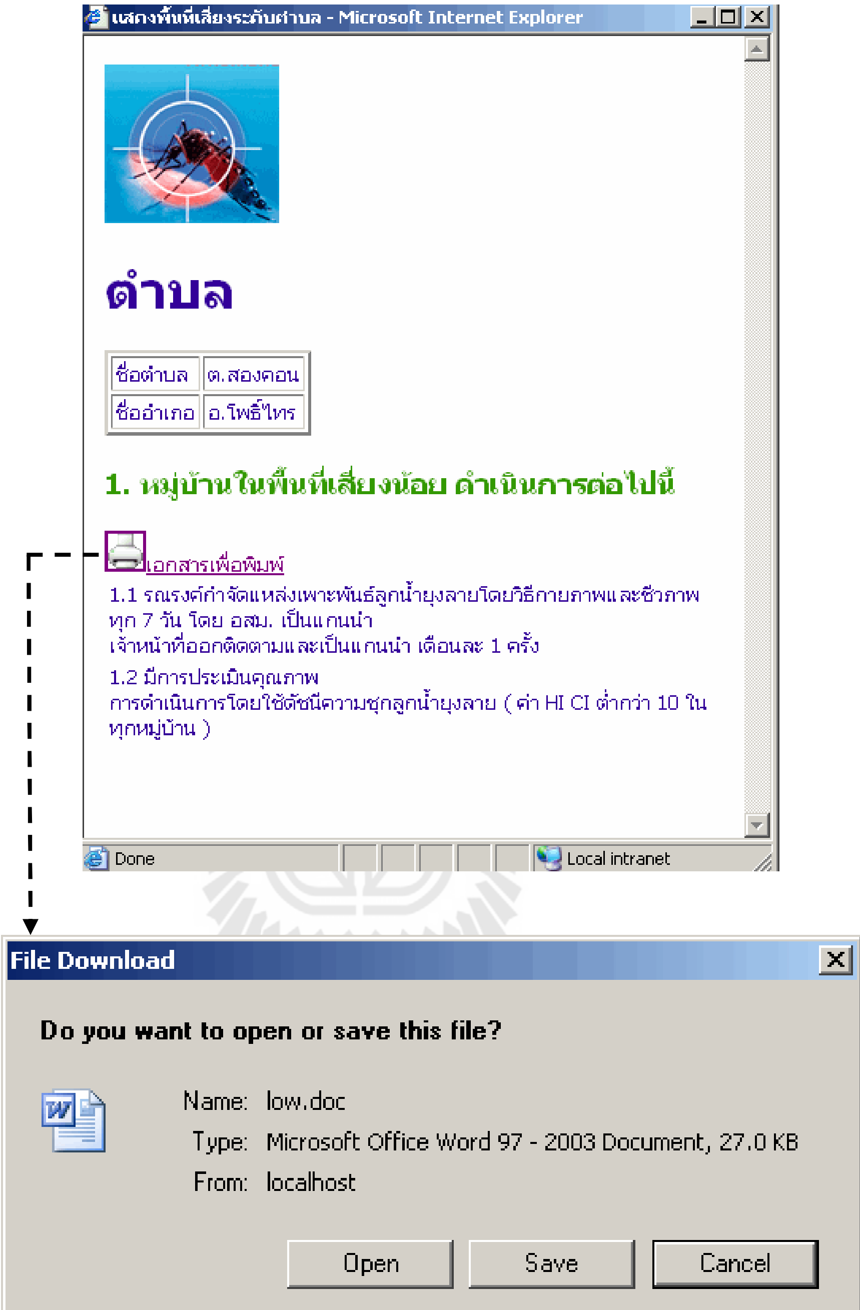
ภาพที่ I.2 รายการเมนูหน้าหลัก



ภาพที่ I.3 ข้อมูลวิธีการควบคุมโรค

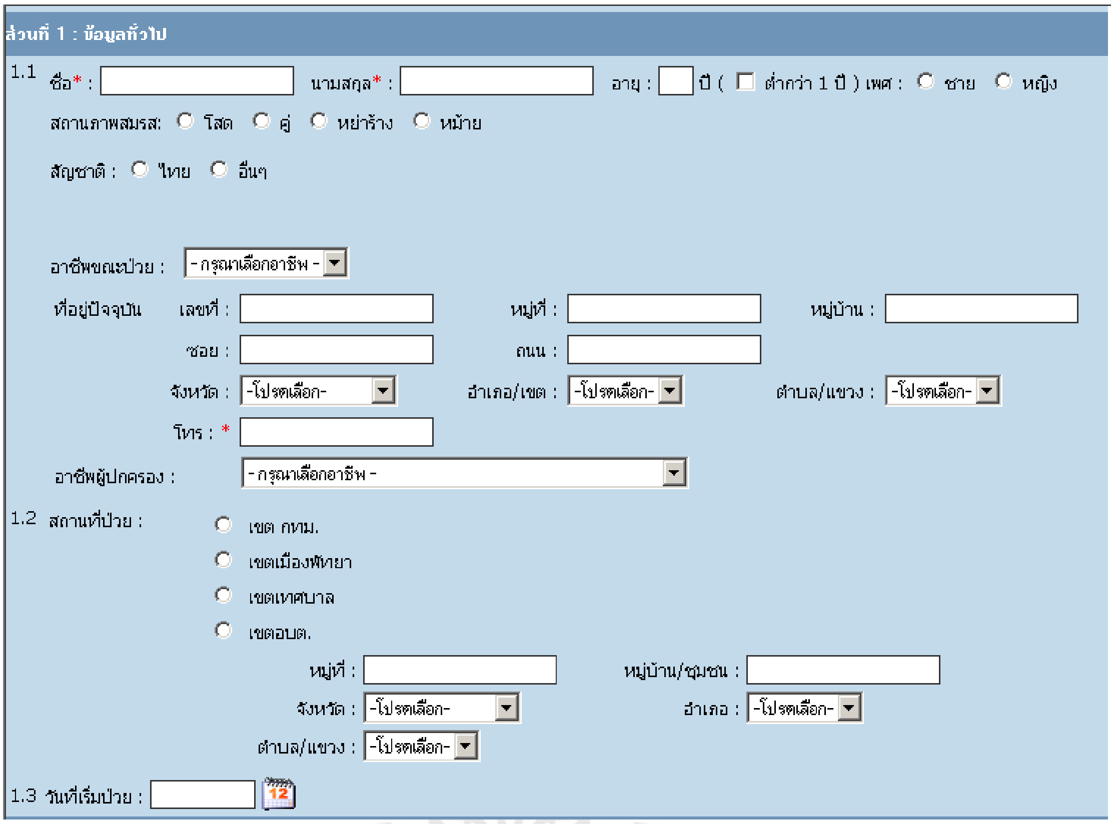


ภาพที่ I.4 แสดงผลการวิเคราะห์จากแบบจำลองและเหตุการณ์จริง



ภาพที่ I.5 ตัวอย่างการดำเนินการตามพื้นที่เสี่ยงน้อย

ผลจากการใช้เครื่องมือคลิกที่ปุ่มอธิบายข้อมูลแล้วคลิกเลือกที่แผนที่พื้นที่เสี่ยงน้อย



ส่วนที่ 1 : ข้อมูลทั่วไป

1.1 ชื่อ* : ______ นามสกุล* : ______ อายุ : ___ ปี (☐ ต่ำกว่า 1 ปี) เพศ : ○ ชาย ○ หญิง

สถานภาพสมรส: ○ โสด ○ คู่ ○ หย่าร้าง ○ หม้าย

สัญชาติ : ○ ไทย ○ อื่นๆ

อาชีพขณะป่วย : - กรุณาเลือกอาชีพ -

ที่อยู่ปัจจุบัน เลขที่ : ______ หมู่ที่ : ______ หมู่บ้าน : ______

ซอย : ______ ถนน : ______

จังหวัด : -โปรดเลือก- อำเภอ/เขต : -โปรดเลือก- ตำบล/แขวง : -โปรดเลือก-

โทร : * ______

อาชีพผู้ปกครอง : - กรุณาเลือกอาชีพ -

1.2 สถานที่ป่วย : ○ เขต กทม. ○ เขตเมืองพัทยา ○ เขตเทศบาล ○ เขตอบต.

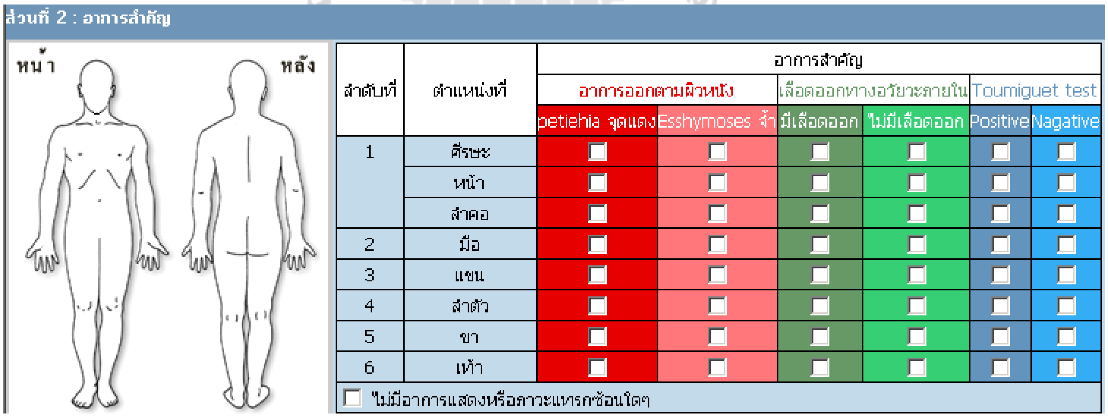
หมู่ที่ : ______ หมู่บ้าน/ชุมชน : ______

จังหวัด : -โปรดเลือก- อำเภอ : -โปรดเลือก-

ตำบล/แขวง : -โปรดเลือก-

1.3 วันที่เริ่มป่วย : ______

ภาพที่ I.6 ฟอร์มข้อมูลทั่วไปของผู้ป่วย

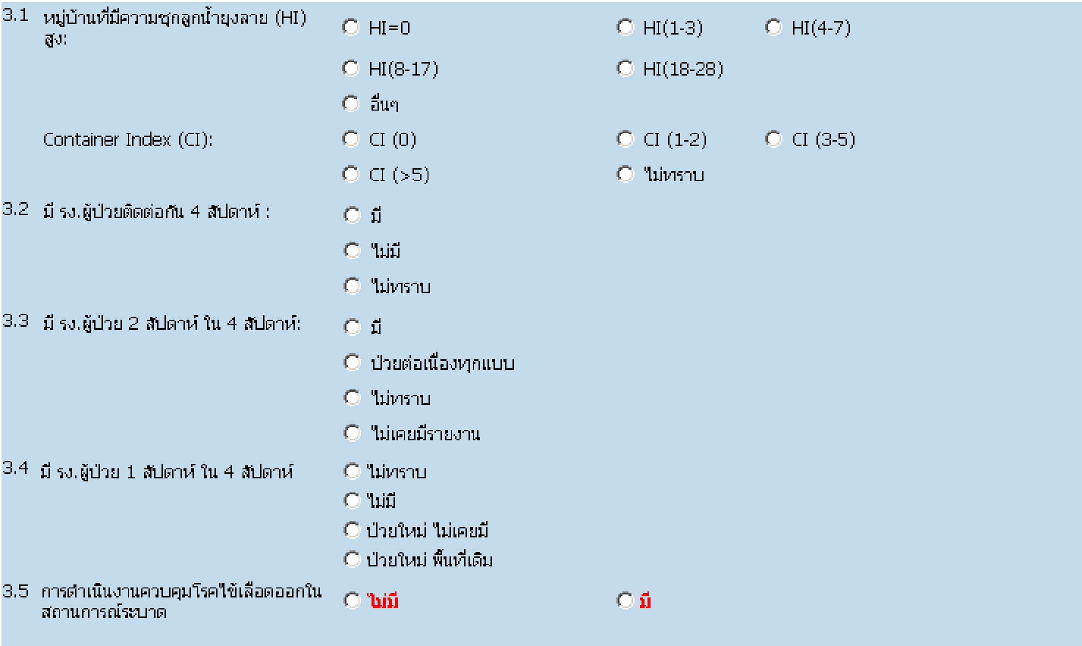


ส่วนที่ 2 : อาการสำคัญ

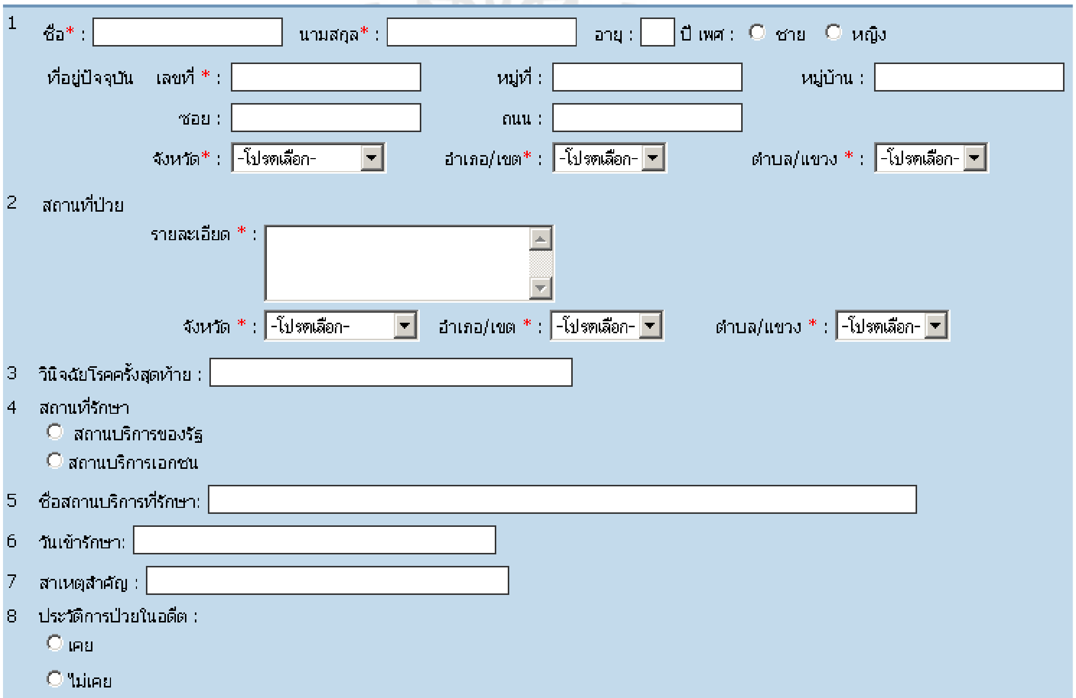
ลำดับที่	ตำแหน่งที่	อาการสำคัญ					
		อาการออกตามผิวหนัง		เลือดออกทางอวัยวะภายใน		Toumiguet test	
		petiehia จุดแดง	Esshymoses จ้ำ	มีเลือดออก	ไม่มีเลือดออก	Positive	Nagative
1	ศีรษะ	☐	☐	☐	☐	☐	☐
	หน้า	☐	☐	☐	☐	☐	☐
	ลำคอ	☐	☐	☐	☐	☐	☐
2	มือ	☐	☐	☐	☐	☐	☐
3	แขน	☐	☐	☐	☐	☐	☐
4	ลำตัว	☐	☐	☐	☐	☐	☐
5	ขา	☐	☐	☐	☐	☐	☐
6	เท้า	☐	☐	☐	☐	☐	☐

☐ ไม่มีอาการแสดงหรือภาวะแทรกซ้อนใดๆ

ภาพที่ I.7 ฟอร์มอาการสำคัญของโรค

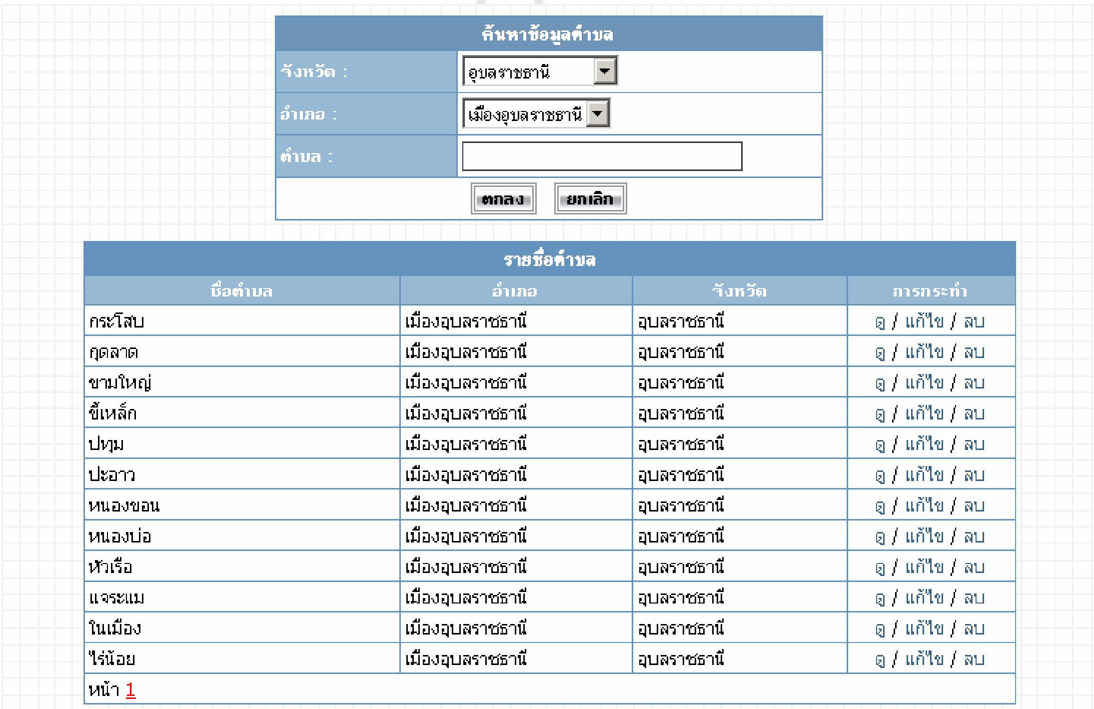


ภาพที่ I.8 ฟอร์มวิเคราะห์พื้นที่เสี่ยงต่อการระบาด

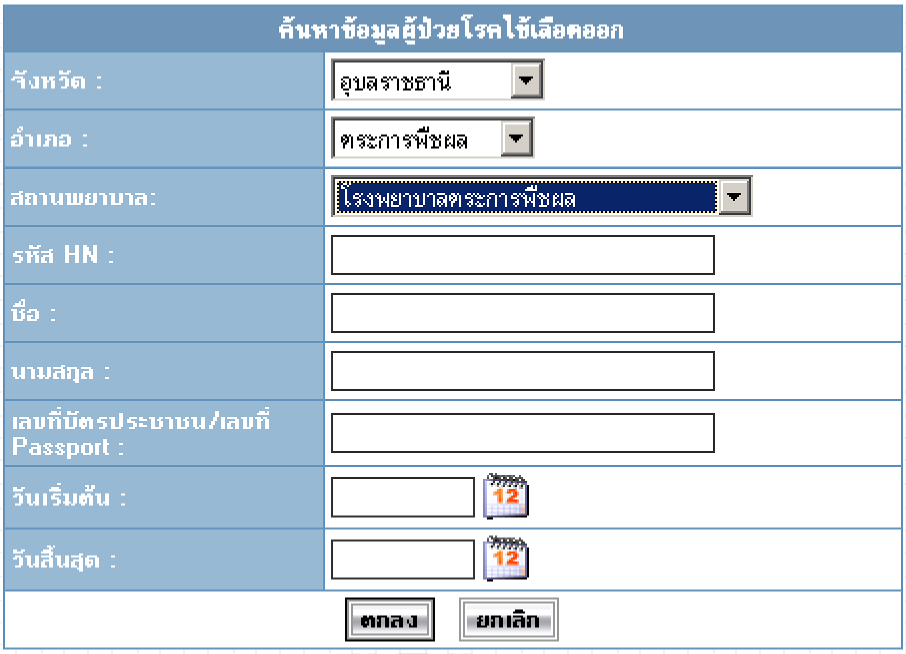


ภาพที่ I.9 ฟอร์มทะเบียนการเสียชีวิต

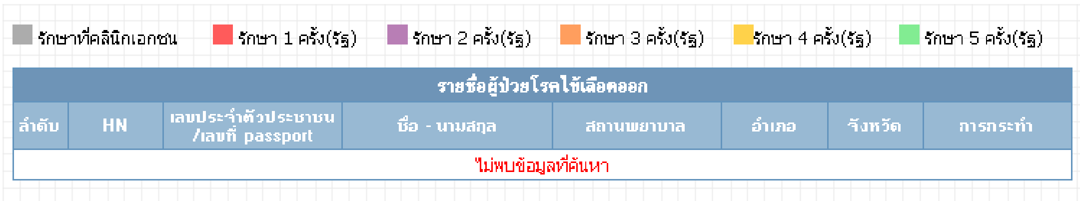
ภาพที่ I.10 ค้นหาข้อมูลสถานพยาบาล



ภาพที่ I.11 ค้นหาข้อมูลตำบล



ภาพที่ I.12 ค้นหาผู้ป่วยโรค DF/DHF



ภาพที่ I.13 แสดงผลการรักษา

ส่วนที่ 1 : ข้อมูลทั่วไป

ตารางที่ 1 จำนวนและร้อยละของผู้ป่วยโรคไข้เลือดออก แจกแจงตามข้อมูลทั่วไป หน้าที่ 1

ข้อมูลทั่วไป	จำนวน(N= 4)	ร้อยละ
เพศ		
ชาย	3	75.00
หญิง	1	25.00
ไม่ระบุ	0	0.00
อายุ		
ต่ำกว่า 1 ปี	1	25.00
1-5 ปี	1	25.00
6-10 ปี	0	0.00
11-15 ปี	1	25.00
16-25 ปี	0	0.00
26-35 ปี	1	25.00
36-45 ปี	0	0.00
46-55 ปี	0	0.00
56-65ปี	0	0.00
66 ปีขึ้นไป	0	0.00
ไม่ระบุ	0	0.00
($\bar{X}$= 12.00, **SD**= 14.09, **Min**= 0.00, **Max**= 35.00)		

ภาพที่ I.14 ข้อมูลทั่วไปของผู้ป่วย

ส่วนที่ 2 : ตำแหน่งและที่พักขณะป่วยเป็นโรค

ตารางที่ 2 จำนวนและร้อยละของผู้ป่วยหรือสงสัยว่าป่วยโรคไข้เลือดออก แจกแจงตามสถานที่พักขณะเป็นโรค และอาการที่สำคัญ

ผู้ป่วย	จำนวน(N= 4)	ร้อยละ
สถานที่ป่วยเป็นโรค		
เขต กทม.	0	0.00
เขตเมืองพัทยา	0	0.00
เขตเทศบาล	0	0.00
นคร	0	-
เมือง	0	-
ตำบล	0	-
ไม่ระบุ	0	-
เขต อบต.	4	100.00
ในชุมชน / ตลาด	1	-
ชนบท	3	-
ไม่ระบุ	0	-
ไม่ระบุ	0	0.00
อาการสำคัญ (n= 9)		
อาการออกตามผิวหนัง		
petiehia จุดแดง	4	44.44
Esshymoses จ้ำ	1	11.11
เลือดออกทางอวัยวะภายใน		
มีเลือดออก	2	22.22
ไม่มีเลือดออก	0	0.00

ภาพที่ I.15 อาการสำคัญของโรค

ส่วนที่ 3 : รายงานพื้นที่เสี่ยงโรคไข้เลือดออก

ตารางที่ 3 จำนวนและร้อยละของรายงานผู้ป่วยหรือสงสัยว่าเป็นโรคไข้เลือดออกแจกแจงตามหมู่บ้านที่มีความชุกลูกน้ำยุงลาย (HI) สูง

หน้าที่ 1

พื้นที่เสี่ยงโรคไข้เลือดออก	จำนวน(N= 4)	ร้อยละ
หมู่บ้านที่มีความชุกลูกน้ำยุงลาย (HI) สูง		
HI=0	3	75.00
HI(1-3)	1	25.00
HI(4-7)	0	0.00
HI(8-17)	0	0.00
HI(18-28)	0	0.00
อื่นๆ		
HI (29-37)	0	0.00
HI (38-49)	0	0.00
HI (50-59)	0	0.00
HI (60-70)	0	0.00
HI (71-80)	0	0.00
HI (81-90)	0	0.00
HI (91-100)	0	0.00
HI (101-110)	0	0.00
HI (111-120)	0	0.00
HI (121-130)	0	0.00
HI (131-140)	0	0.00
HI (141-150)	0	0.00
ไม่ทราบ	0	0.00
ไม่ระบุ	0	0.00

ภาพที่ I.16 แสดงผลค่า HI

ส่วนที่ 4 : ประวัติการรักษาและการดูแลตนเองก่อนพบเจ้าหน้าที่สาธารณสุข

ตารางที่ 4 จำนวนและร้อยละของผู้ป่วย หรือสงสัยว่าเป็นโรคไข้เลือดออก แจกแจงตามการดูแลตนเองและประวัติการได้รับการรักษา

การดูแลตนเองและประวัติการได้รับการรักษา	จำนวน(N= 4)	ร้อยละ
การรักษาที่สถานบริการอื่นๆ		
ไม่	3	75.00
ใช่	1	25.00
ไม่ระบุ	0	0.00
สถานบริการอื่นๆที่ไปรักษา (n= 1)		
คลีนิค	0	0.00
โรงพยาบาลเอกชน	0	0.00
อื่นๆ	0	0.00
ไม่ระบุ	1	100.00
ซื้อยารับประทานเองก่อนพบเจ้าหน้าที่สาธารณสุข		
ไม่ได้ซื้อ	2	50.00
ซื้อยารับประทานเอง	2	50.00
ไม่ระบุ	0	0.00
ชนิดยาที่ใช้ (n= 2)		
ยาลดไข้ paracetamol	1	50.00
ยาแก้อักเสบ	0	0.00
อื่นๆ	0	0.00
ไม่ระบุ	1	50.00
ผู้ป่วยเคยเป็นโรคนี้มาก่อน		
ไม่เคย	1	25.00
เคย	1	25.00

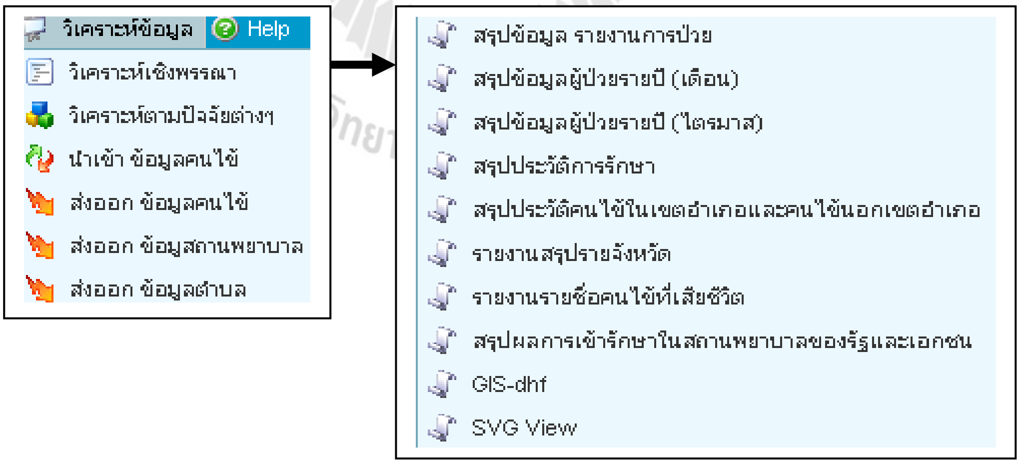
ภาพที่ I.17 แสดงผลการรักษา

ส่วนที่ 5 : รายงานผู้ป่วยตามสภาพแวดล้อม (Host)

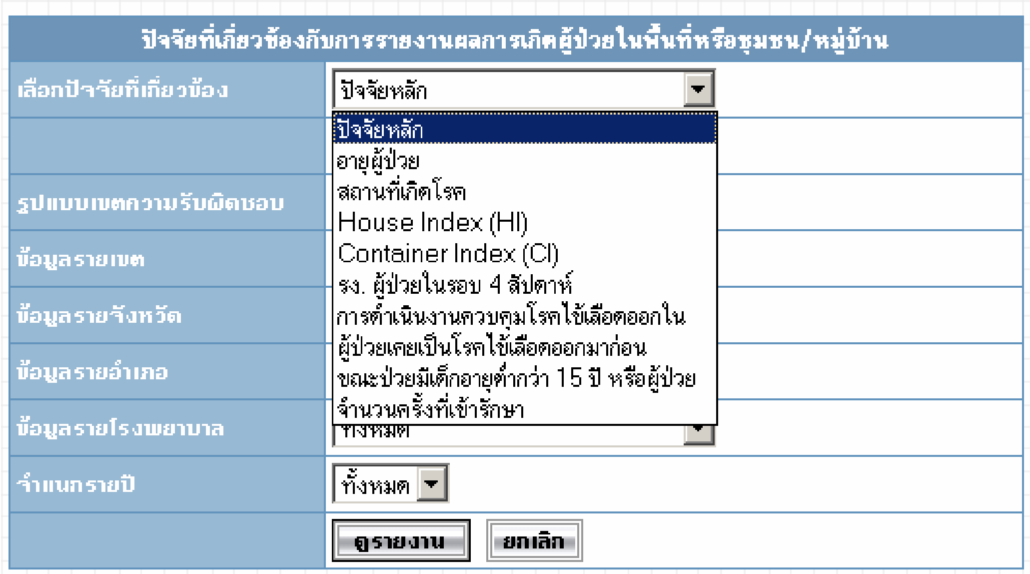
ตารางที่ 5 จำนวนและร้อยละของผู้ป่วยโรคไข้เลือดออก แจกแจงตามสภาพแวดล้อม (Host) หน้าที่ 1

จำนวนผู้ป่วย	จำนวน(N= 4)	ร้อยละ
ญาติพี่น้องที่อาศัยอยู่บ้านเดียวกันขณะป่วยเป็นโรคไข้เลือดออก		
ขณะป่วยมีญาติพี่น้องหรือไม่(อายุต่ำกว่า 15 ปี หรือผู้ป่วยในบ้านเดียวกันที่ป่วยภายในปีเดียวกัน)		
ไม่มี	1	25.00
มี	3	75.00
ไม่ระบุ	0	0.00
ในบ้านขณะป่วยมีญาติดังนี้ (n= 3)		
ในบ้านมีเด็กอายุต่ำกว่า 15 ปี	2	66.67
ในบ้านมีเด็กอายุต่ำกว่า 15 ปี และผู้ป่วยในบ้านเดียวกันที่ป่วยภายในปีเดียวกัน	1	33.33
ไม่ระบุ	0	0.00
ในปีเดียวกันบ้านข้างเคียงมีผู้ป่วยด้วยไข้เลือดออก (คน) (n= 3)		
ไม่มี	0	0.00
มี	0	0.00
ไม่ระบุ	3	100.00
ผู้ป่วยบ้านข้างเคียง (n= 0)		
เด็กอายุต่ำกว่า 15 ปีป่วย	0	0.00
เด็กอายุมากกว่า 15 ปีป่วย	0	0.00
มีผู้ป่วยในครอบครัวเดียวกันมากกว่า 1 คน	0	0.00
มีคนป่วยแล้วมีผู้เสียชีวิต	0	0.00
มีผู้ป่วยที่ยังรักษาอยู่	0	0.00
มีผู้ป่วยแต่รักษาหายแล้ว	0	0.00
อื่นๆ	0	0.00
ไม่ระบุ	0	0.00

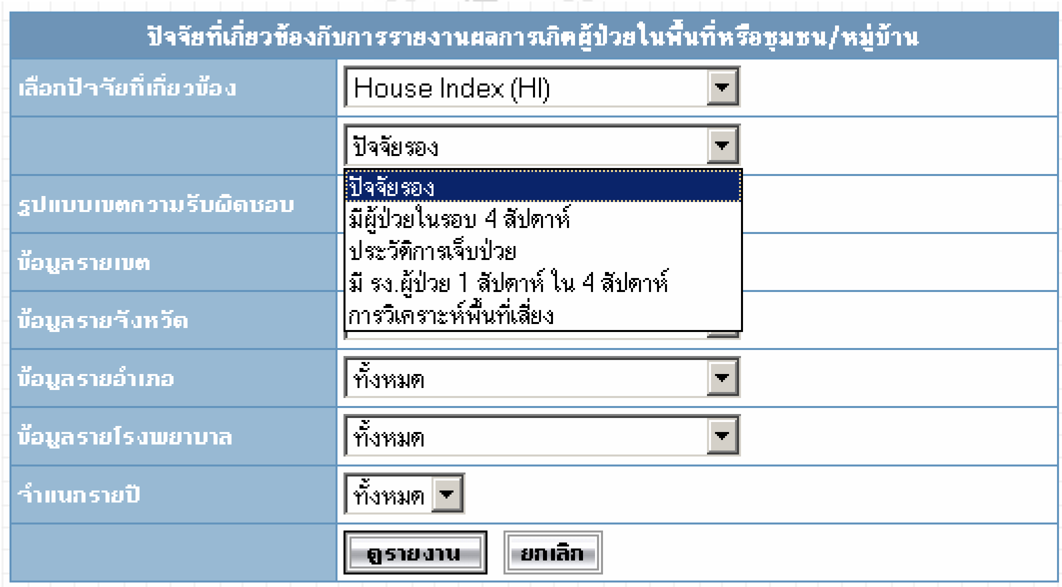
ภาพที่ I.18 รายงานผู้ป่วยตามสภาพแวดล้อม



ภาพที่ I.19 เมนูการวิเคราะห์รายงานผล



ภาพที่ I.20 ค้นหาผู้ป่วยแยกตามปัจจัยหลัก



ภาพที่ I.21 ค้นหาผู้ป่วยแยกตามปัจจัยรอง

CURRCULUM VITAE

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CHAPTER IV

RESULTS AND DISCUSSION

This chapter will focus on the results of the research methodology and is divided into five elements: 1) results of transformation data, 2) results of spatial DF/DHF prediction models, 3) prove to accept hypothesis 0, 4) occurrence probability of epidemic in adjacent areas of high risk areas, 5) prove to accept hypothesis 1.

4.1 Results of transformation data

4.1.1 Precipitation and temperature data

Seasonal precipitation and temperature data of the years 2001–2005 and their average from 19 weather stations available in Ubon Ratchathani province (Figure 4.1) and the surroundings were interpolated using Inversion Distance Weighting (IDW). The seasonal interpolated values of each sub–district were in form of raster and averaged to represent at sub–district centroids. The values of those years were input into equations.

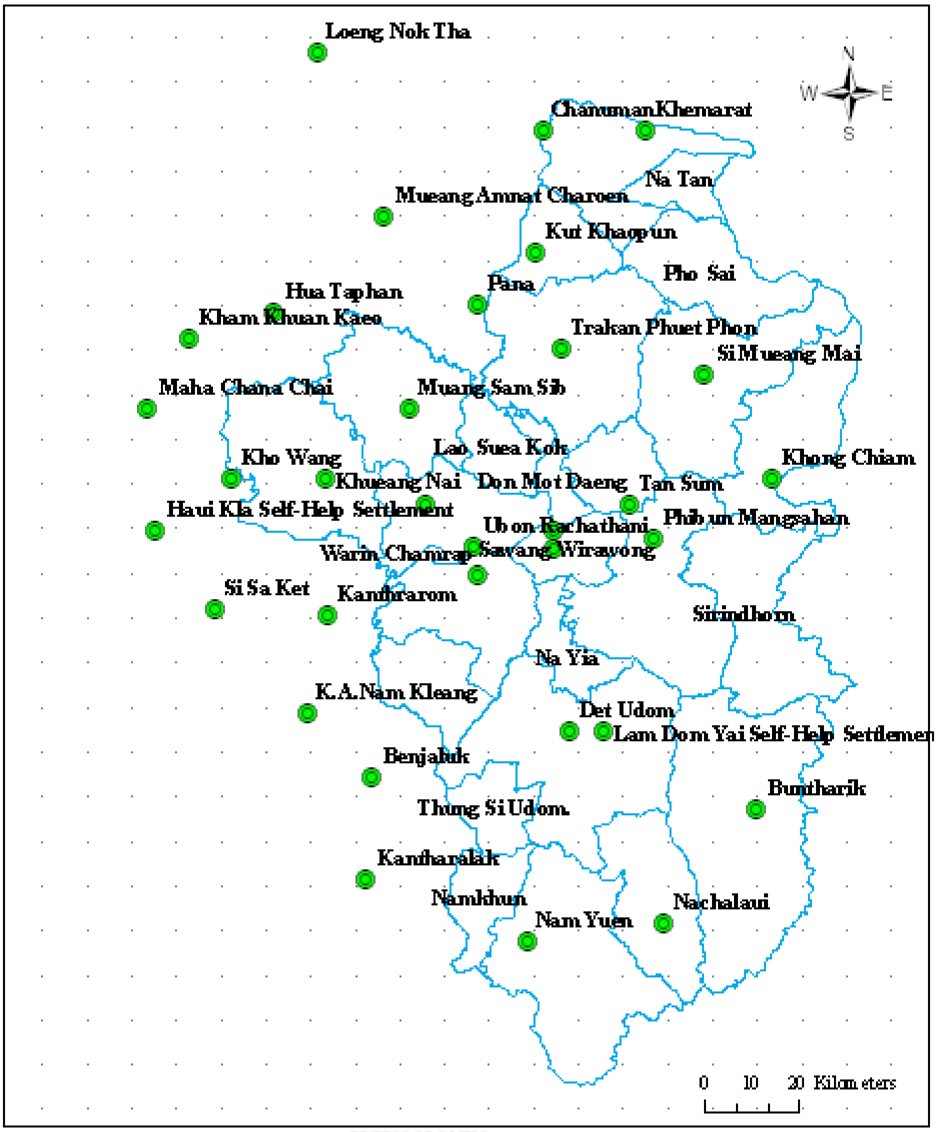


Figure 4.1 Weather stations in and surrounding Ubon Ratchathani province.

4.1.2 Results of model variable calculation

According to equations number 1–9 (in Chapter III), seasonal variables of each sub–district of each year during 2001–2005 and their 5 year average values were calculated and shown as example in Table 4.1–4.6. These variables include the index values of HI, CI and BI ($I_{(HI,CI,BI)}$), probability related to temperature data (P_T), probability related to rainy season (P_R), predicted number of cases (y), epidemic probability of DF/DHF (P), and the NPIC–Product of interactive correlation ($Y_{(t)}$).

Among twelve sub–districts of Mueang district, during January to April of the year 2001, Rainoi sub–district showed the highest predicted number of cases (6 cases) with 0.99 probability of epidemic while the least calculated number of case was at Khilek sub–district (–15.4). According to the NPIC, the spread of DF/DHF from the highest risk at Rainoi sub–district (P = 0.99) was more likely to be at Khamyai sub–district (NPIC = 0.59) (see Figure 4.2), which would be influenced in the following season (May to August of the year), in case there was poor program of transmission control.

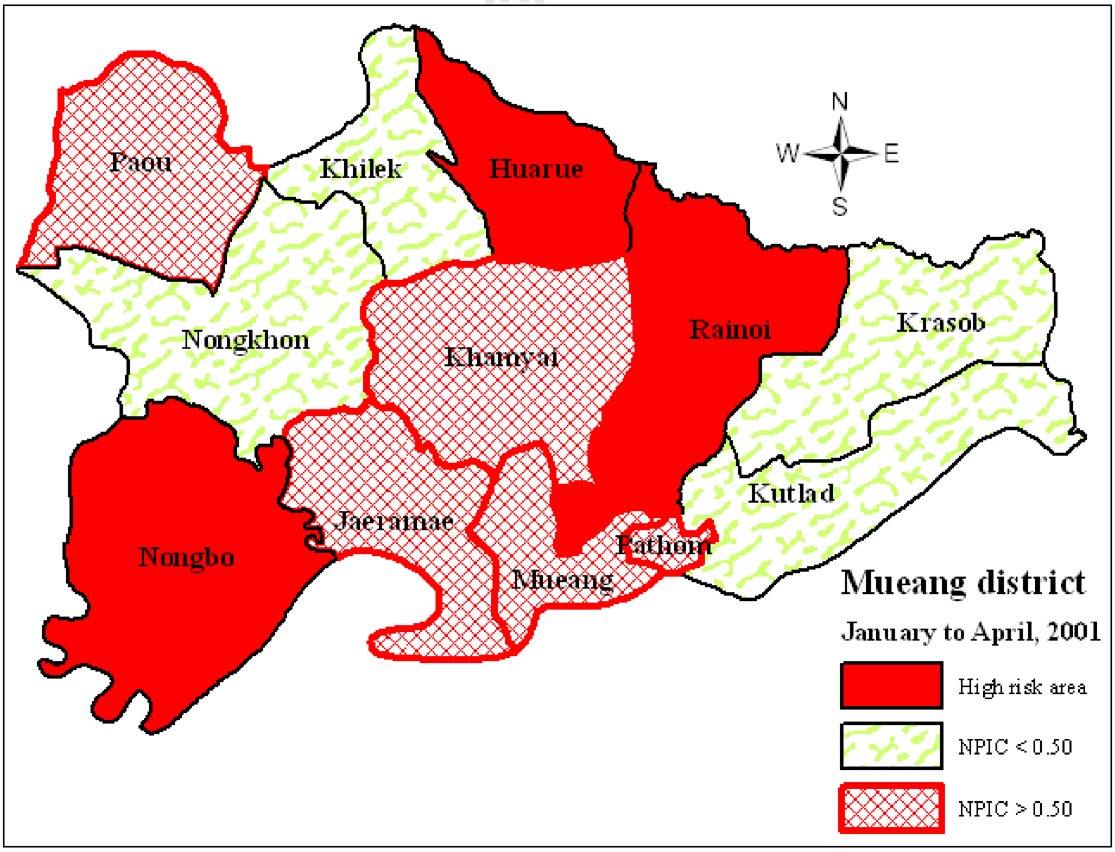


Figure 4.2 NPIC of Mueang district between January to April, 2001.

From the model result during May to August 2001, Mueang and Nongbo sub–districts were apparent to have more cases (116 and 98 cases respectively). There were

6 sub–districts showing high probability epidemic. Kutlad, Paou, and Nongkhon sub–districts showed no potential or probability. However, NPIC of Paou, Jaeramae, and Nongkhon sub–districts showed as high value as 0.55, 0.53, and 0.52 respectively. They express the chance of DF/DHF spreading from high risk neighbor sub–districts (Figure 4.3). Khamyai sub–districts with 29 cases and more chance of spreading were influenced from the former season. This period of a year is a high epidemic season. If any sub–districts have poor surveillance and controlling measures, the spread can be enormously increased over time due to adding effect influenced by characteristics of this season and the former seasons.

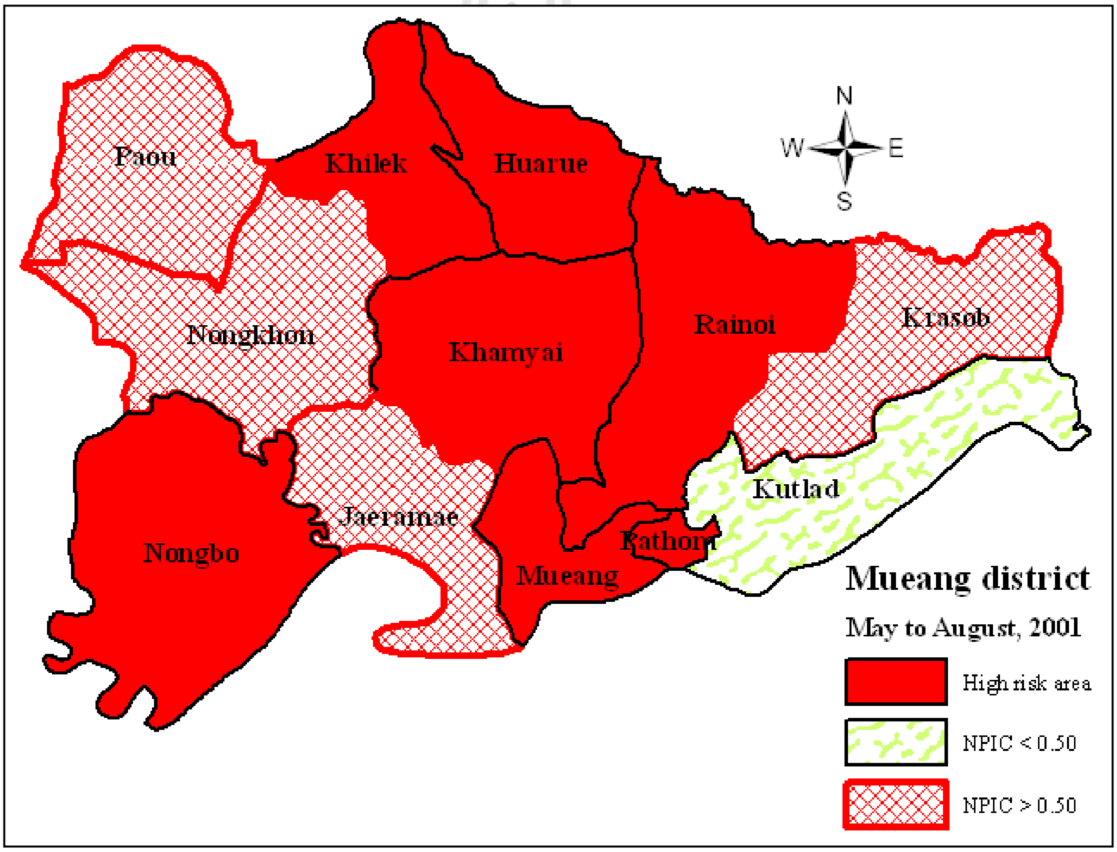


Figure 4.3 NPIC of Mueang district between May to August, 2001.

Considering the period of September to December 2001, the Mueang sub–district showed the highest number of cases predicted which is as high as 22 cases.

The second highest was Rainoi sub–district with 21 cases. The least number of cases appeared as Khilek sub–district (2 cases). Mueang sub–district showed highest number of cases during this season because of rapid outbreak, lack of good controlling measures, man power and community participation. It is very interesting to note that some districts e.g. Nongkhon and Kutlad did not show any cases during pre–high and high seasons but 11 and 5 cases respectively in this period. The cases like these can cause much intensive for every sub–districts and continue effecting to the same season in the following years and to the following seasons as an example in year 2002 and 2003 (Table 4.1).

Considering the year 2002, in January to April (Table 4.2) there is highly probable occurrence to 7 cases in Rainoi sub–districts. The high risk areas increased from 4 to 7 sub–districts in May to August because it was in the high season period. However, in September to December, in different sub–districts the number of cases could be reduced to no case or increased depending on how active and effective mosquito controlling programs. This resulted in 1 sub–district falling into moderate risk area (Krasob sub–district) and 2 sub–districts falling into low risk area (Jaeramae, Khilek sub–districts). However, Jaeramae, Krasob, and Khilek sub–districts experienced the influence from neighboring high risk areas as 0.52, 0.51, and 0.32, respectively, other seasons of the year 2003–2005 and average year 2001–2005 of the Mueang sub–district showed in Table 4.3–4.6. The rests of sub–districts of Ubon Ratchthani provine are shown in the Appendix B.

Table 4.1 Calculated variables of sub–districts of District Mueang Ubon in three seasons of the year 2001.

Sub-district	January to April						May to August						September to December					
	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E
Mueang	9.87	60.2	39.71	-0.24	0	0.51	24.38	68.9	13.66	116.4	1	-	16.81	40.32	27.25	20.88	1	-
Krasob	5.60	60.4	32.88	-11.3	0	0.23	9.33	69.3	25.42	-0.7	0	0.51	9.12	39.31	27.39	3.89	0.98	-
Kutlad	5.00	60.7	41.62	-13.3	0	0.17	8.37	67.9	25.42	-7.8	0	0.44	9.44	39.06	29.38	4.48	0.98	-
Khamyai	7.85	58.4	32.68	-5.09	0	0.59	13.00	65.2	20.27	29.0	1	-	10.66	50.73	27.13	7.41	0.99	-
Jaeramae	7.87	57.9	40.18	-5.30	0	0.52	11.62	69.3	25.42	16.9	0.5	0.53	14.40	49.39	25.12	15.75	0.99	-
Pathom	9.12	58.4	37.27	-1.91	0	0.56	11.00	70.3	25.55	11.9	0.99	-	10.66	39.31	27.41	7.29	0.99	-
Rainoi	12.13	60.5	42.60	5.56	0.99	-	14.75	69.3	25.52	41.1	1	-	17.22	50.73	27.39	21.85	1	-
Nongkhon	7.85	58.4	32.83	-5.09	0	0.32	9.33	67.3	17.46	0.3	0	0.52	12.12	39.43	24.59	10.67	0.99	-
Nongbo	11.66	57.5	31.79	5.17	0.99	-	22.00	68.2	25.42	97.5	1	-	13.66	39.56	27.39	13.91	0.99	-
Huarue	10.75	58.8	37.27	2.35	0.91	-	10.75	68.3	17.46	10.9	1	-	10.33	40.57	27.66	6.55	0.99	-
Khilek	4.00	57.3	37.27	-15.4	0	0.45	6.00	69.7	17.46	-26.2	0	0.46	8.33	50.73	27.39	2.24	0.90	-
Paou	7.875	57.34	27.35	-4.68	0	0.52	13.5	69.7	14.76	31.9	0	0.55	10.00	50.90	30.16	5.76	0.99	-

Table 4.2 Calculated variables of sub–districts of District Mueang Ubon in three seasons of the year 2002.

Sub-district	January to April						May to August						September to December					
	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E
Mueang	13	59.7	25.33	7.48	0.99	-	17	68.4	7.46	58.64	1	-	18.5	40.2	25.37	24.23	1	-
Krasob	7.2	58.4	20.98	-7.40	0	0.54	7.3	69.3	13.88	-17.1	0	0.55	7.5	40.8	25.50	-0.03	0	0.51
Kutlad	8.25	60.5	26.55	-5.32	0	0.15	11.6	68.9	13.88	16.49	0.99	-	8.6	40.3	27.36	2.30	0.90	-
Khamyai	14.5	58.4	20.85	11.99	0.99	-	19.6	69.3	11.07	78.57	1	-	12	40.8	25.27	9.90	0.99	-
Jaeramae	6	58.4	25.64	-10.96	0	0.52	5.3	69.9	13.88	-32.7	0	0.56	5.7	40.5	23.39	-3.81	0	0.52
Pathom	9.14	58.4	23.78	-2.46	0	0.53	10.3	69.3	13.95	6.39	0.99	-	9.5	40.5	25.53	4.52	0.98	-
Rainoi	12.5	58.4	27.18	6.32	0.99	-	16.0	68.1	13.93	50.91	1	-	13.3	39.0	25.51	12.81	0.99	-
Nongkhon	10.5	60.7	20.95	1.22	0.77	-	11.8	69.7	9.53	17.83	0.99	-	10.3	40.4	22.90	6.40	0.99	-
Nongbo	9.4	58.4	20.29	-1.43	0	0.48	9.6	69.3	13.88	0.92	0.71	-	10	40.8	25.50	5.47	0.99	-
Huarue	12.5	58.4	21.16	6.66	0.99	-	17.3	68.9	9.53	60.83	1	-	12.5	40.3	25.76	10.97	0.99	-
Khilek	7.7	58.9	23.78	-6.23	0	0.34	6.5	68.5	9.537	-22.2	0	0.47	6.2	39.8	25.51	-2.91	0	0.32
Paou	11.4	60.1	17.45	3.88	0.97	-	15.8	68.1	8.06	50.06	1	-	10.5	39.3	28.09	6.37	0.99	-

Table 4.3 Calculated variables of sub–districts of District Mueang Ubon in three seasons of the year 2003.

Sub-district	January to April						May to August						September to December					
	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E
Mueang	17.3	58.8	25.45	18.57	0.99	-	23.38	68.49	7.46	109	1	-	16.6	39.84	25.37	20.57	1	-
Krasob	14.5	58.41	21.09	11.49	0.99	-	18.87	69.36	13.88	73.3	1	-	13.1	39.06	25.50	12.87	0.99	-
Kutlad	11	58.41	26.67	1.68	0.84	-	12	69.97	13.88	20.	0.99	-	10	39.43	27.35	5.83	0.99	-
Khamyai	18.2	58.94	20.97	21.3	0.99	-	19.3	69.76	11.07	77.01	1	-	16.4	40.32	25.26	20.18	1	-
Jaeramae	11	58.76	25.75	1.72	0.85	-	12.4	69.97	13.88	23.09	1	-	10	39.56	23.39	6.07	0.99	-
Pathom	13	58.76	23.90	7.21	0.99	-	14.7	67.32	13.95	41.5	1	-	11.6	40.32	25.52	9.62	0.99	-
Rainoi	8.25	59.29	27.30	-5.78	0	0.51	9.37	69.76	13.93	-0.23	0	0.53	8.14	39.06	25.50	1.84	0.86	-
Nongkhon	12.14	59.11	21.06	5.14	0.99	-	12.1	69.36	9.53	21.3	0.99	-	11	40.32	22.90	8.31	0.99	-
Nongbo	6	58.41	20.40	-11.0	0	0.45	5.3	69.36	13.88	-31.3	0	0.49	6	40.82	25.50	-2.86	0	0.46
Huarue	11.44	60.53	23.90	2.8	0.94	-	13.1	68.95	9.536	29.1	1	-	12.12	40.32	25.76	10.62	0.99	-
Khilek	13	60.18	21.99	7.2	0.99	-	13.7	69.56	5.87	34.6	1	-	13.3	40.32	24.25	13.37	0.99	-
Paou	14.4	60.18	17.56	11.3	0.99	-	16.27	69.36	8.06	53.7	1	-	14.1	40.572	28.08	14.84	1	-

Table 4.4 Calculated variables of sub–districts of District Mueang Ubon in three seasons of the year 2004.

Sub-district	January to April						May to August						September to December					
	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E
Mueang	18.8	58.45	25.35	21.90	1	-	19.3	70.58	7.46	75.14	1	-	14	39.28	25.38	14.4	0.99	-
Krasob	3.3	56.64	20.99	-18.51	0	0.52	5.6	69.36	13.88	-31.1	0	0.58	5	40.32	25.50	-5.3	0	0.54
Kutlad	9.85	56.99	26.57	-1.80	0	0.46	9.3	67.32	13.88	-2.2	0	0.47	11.1	40.32	27.36	8.05	0.99	-
Khamyai	10.87	71.50	20.87	-0.32	0	0.51	12	69.36	11.07	18.2	0.99	-	10.7	41.58	25.27	7.2	0.99	-
Jaeramae	10.37	58.41	25.66	-0.51	0	0.48	11.8	69.36	13.88	16.3	0.99	-	9	50.4	23.39	3.6	0.97	-
Pathom	11.75	60.18	23.80	3.11	0.95	-	14	67.32	13.95	33.8	1	-	7.7	40.32	25.53	0.6	0.65	
Rainoi	13	60.18	27.20	6.08	0.99	-	13.8	67.32	13.93	32.8	1	-	10.1	40.32	25.51	6.0	0.99	-
Nongkhon	14.85	56.64	20.96	12.10	0.99	-	16.6	69.36	9.53	54.0	1	-	12.8	39.06	22.90	12.0	0.99	-
Nongbo	11.42	58.41	20.30	2.84	0.94	-	16	69.36	13.88	48.7	1	-	11.4	39.06	25.50	8.7	0.99	-
Huarue	8	56.64	21.80	-6.19	0	0.34	9.8	35.7	9.41	11.2	0.99	-	8	50.4	25.76	1.3	0.78	-
Khilek	5.33	58.41	23.80	-13.71	0	0.32	4.4	69.36	9.53	-40.2	0	0.33	3.8	50.4	25.51	-7.9	0	0.32
Paou	5.8	56.64	17.47	-11.59	0	0.24	6.4	67.32	8.06	-24.0	0	0.31	4.6	39.06	28.09	-6.2	0	0.26

Table 4.5 Calculated variables of sub–districts of District Mueang Ubon in three seasons of the year 2005.

Sub-district	January to April						May to August						September to December					
	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E	I	P_T	P_R	y	P	E
Mueang	21.2	58.41	25.33	30.83	1	-	26.4	70.58	7.46	132.9	1	-	15.2	50.4	25.38	18.54	0.99	-
Krasob	12.2	56.64	20.97	7.49	0.99	-	15.7	67.72	13.88	50.2	1	-	11.5	39.06	25.51	10.09	0.99	-
Kutlad	12.3	59.16	26.55	7.23	0.99	-	14.2	67.32	13.88	38.5	1	-	9.5	50.4	27.37	5.72	0.99	-
Khamyai	16.2	56.64	20.84	18.12	0.99	-	16.0	69.36	11.06	52.8	1	-	11.7	36.54	25.28	10.55	0.99	-
Jaeramae	16.5	58.41	25.63	18.33	0.99	-	18.3	35.7	13.88	79.1	1	-	13.6	50.4	23.40	14.88	0.99	-
Pathom	12.8	56.64	23.77	9.01	0.99	-	15.3	67.32	13.95	47.0	1	-	10.6	39.06	25.54	8.25	0.99	-
Rainoi	9.7	58.41	27.17	0.32	0.58	0.54	13.5	69.36	13.93	32.5	1	-	7.7	40.32	25.52	1.75	0.85	-
Nongkhon	9.1	58.41	20.94	-0.91	0	0.45	10.1	67.32	9.53	7.3	0.99	-	8	40.32	22.91	2.46	0.92	-
Nongbo	9.1	58.41	20.28	-0.99	0	0.48	12.8	69.36	13.88	27.1	1	0.51	9.1	50.4	25.51	4.99	0.99	-
Huarue	9.6	57.34	22.67	0.45	0	0.57	11.8	69.36	9.53	20.3	1	-	9.2	39.06	25.77	5.01	0.99	-
Khilek	8.8	58.41	23.77	-1.94	0	0.23	9	69.36	9.53	-1.8	0	0.56	8.2	50.4	25.51	2.91	0.94	-
Paou	9.2	60.18	17.44	-0.74	0	0.34	12.2	67.32	8.06	23.9	1	-	7	50.4	28.10	0.18	0.54	0.58

Table 4.6 Calculated variables of sub–districts of District Mueang Ubon in three seasons of the average year 2001–2005.

Sub-district	January to April						May to August						September to December					
	I	P_T	P_R	*y*	*P*	E	I	P_T	P_R	*y*	*P*	E	I	P_T	P_R	*y*	*P*	E
Mueang	16.04	59.12	25.56	18.91	0.99	-	22.11	69.41	7.46	140.9	1	-	16.24	42.02	25.38	23.35	1	-
Krasob	8.57	58.09	21.19	-0.45	0	0.51	11.38	69.03	13.88	57.4	1	-	9.25	39.71	25.51	7.89	0.99	-
Kutlad	9.29	59.16	26.79	0.89	0.70	-	11.11	68.29	13.88	55.4	1	-	9.74	41.90	27.37	8.88	0.99	-
Khamyai	13.54	60.78	21.07	12.41	0.99	-	16.01	68.62	11.07	93.6	1	-	12.30	42	25.28	14.67	0.99	-
Jaeramae	10.35	58.38	25.87	3.86	0.97	-	11.89	62.87	13.88	63.0	1	-	10.54	46.06	23.40	10.92	0.99	-
Pathom	11.17	58.48	24.01	6.19	0.99	-	13.07	68.34	13.95	70.6	1	-	10.05	39.91	25.54	9.67	0.99	-
Rainoi	11.13	59.36	27.42	5.70	0.99	-	13.51	68.78	13.93	73.9	1	-	11.31	41.89	25.52	12.46	0.99	-
Nongkhon	10.91	58.65	21.16	5.69	0.99	-	11.99	68.62	9.538	62.6	1	-	10.85	39.91	22.91	11.58	0.99	-
Nongbo	9.52	58.23	20.50	2.11	0.89	-	13.16	69.13	13.88	71.0	1	-	10.04	42.13	25.518	9.65	0.99	-
Huarue	10.47	58.33	22.79	4.43	0.98	-	12.58	62.26	9.50	68.9	1	-	10.43	42.14	25.77	10.50	0.99	-
Khilek	7.78	58.65	23.56	-2.81	0	0.52	7.94	69.31	8.89	31.2	1	-	7.97	46.33	25.27	5.14	0.99	-
Paou	9.75	58.90	17.65	2.84	0.94	-	12.86	68.38	8.06	69.6	1	-	9.25	44.04	28.10	7.78	0.99	-

4.2 Results of spatial DF/DHF prediction models

The multiple linear regression model operating on 6 data sets of the year 2001–2006 and their average is used to evaluate the correlation among DF/DHF incidence rate, environmental variable (precipitation and temperature), and entomological surveillance data (HI, CI and BI). The seasonal regression equations were derived as shown in Table 4.7. The best predictors of DF/DHF incidence are breteau index, house index, container index, precipitation, and temperature.

Table 4.7 Multiple linear regression equation of season.

Season	Multiple linear regression equation of season	Coefficient of Determination (R^2)
January to April	$y = -15.87 + 2.66I - 0.125P_T - 0.01768P_R$	0.70
May to August	$y = -49.41 + 7.73I - 0.273P_T - 0.00051P_R$	0.72
September to December	$y = -14.77 + 2.21I + 0.008P_T - 0.0018P_R$	0.65

With 95% confidence, the most fit equation is May–August season whose Coefficient of Determination (R^2) = 0.72.

The spatial DF/DHF prediction model finally resulted in the seasonal epidemic probability or risk of DF/DHF of each sub–district of those years. To compare the risk with the traditional classification, it was classified into 3 classes i.e. high risk, moderate risk, and low risk using Delphi's technique (Table 4.8).

Table 4.8 Rank of risk level based on epidemic probability using the Delphi technique

Low risk	Moderate risk	High risk
0–0.39	0.4–0.69	0.7–1.0

The comparisons were shown as maps, histograms, and tables of error matrix of every season of sub–districts in the studying time period (Appendix C), as an example of the year 2001 in Figures 4.4–4.5 and their error matrix (Tables 4.9–4.11).

In the period of January to April of years 2001–2005, the spatial DF/DHF prediction model displayed high risk, moderate risk, and low risk different from the traditional classification. This could be because of being in pre–high period and different intensity of the mosquito control operation in sub–districts. Lower intensive program control could result in high probability of DF/DHF epidemic in the following high incidence period. As shown in Figure 4.6, it is the trend of effects in different year according to seasons and types of risk areas. If the preventing and controlling program was not effective in time of pre–high incidence period, it could cause strong effect and resulted in over and rapid spread of DF/DHF cases in rainy season which is the high incidence period.

An example of low efficient operation could be focused at NaiMueang sub–district of Mueang District, as the actual data recorded this area was classified to be very repetitive high risk area and this also reflected as high risk area as the results of the model (see Table 4.1 and Figure 4.2). During January to April of 2001, 10 cases occurred and epidemic resulted in 120 cases later. The main problem is because of the sub–district being subject to many organization responsibilities and lack of adequate coordination among them including no cooperate epidemic control planning for the area and the surroundings.

At the same period of time, an example of highly efficient sub–district was Pathom which has been taken care by the sub–district Primary Healthcare Unit (PHU). There were 12 people working in the unit, which were sufficient for the epidemic control operation. The unit got the award in aspect of effective epidemic prevention and control supported by the district community.

During May to August of years studied, the model results show that the number of high risk areas becomes many in both pre–epidemic and post–epidemic season. It indicates that the relative density of mosquito, HI, CI, and BI become high. This could be because of lacking of resources and poor management practices to eliminate mosquito lavas. However, there is a minor chance that high risk areas can be found in post–epidemic period (September–December) as many as found in the epidemic period (May–August), for example in year 2006.

Generally, the period of September to December would display less number of high risk areas than other period. This depends on the continuation of standard DF/DHF mosquito control policies. It also reflects the quality control programs performed by the organization. Another reason is, after the high epidemic period, the HI, CI and BI will be reduced.

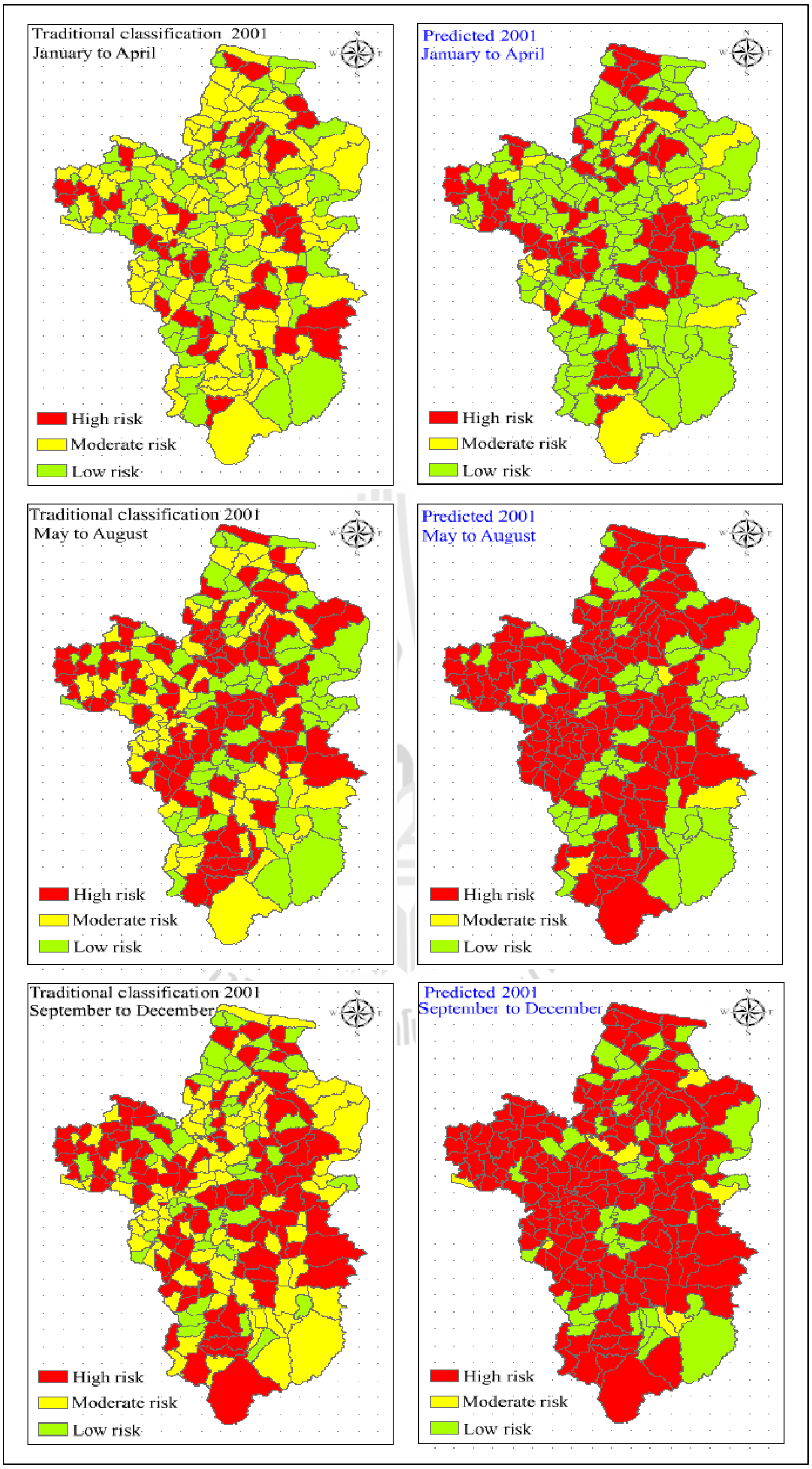


Figure 4.4 Risk area comparisons based on traditional classification and predicted model of the year 2001.

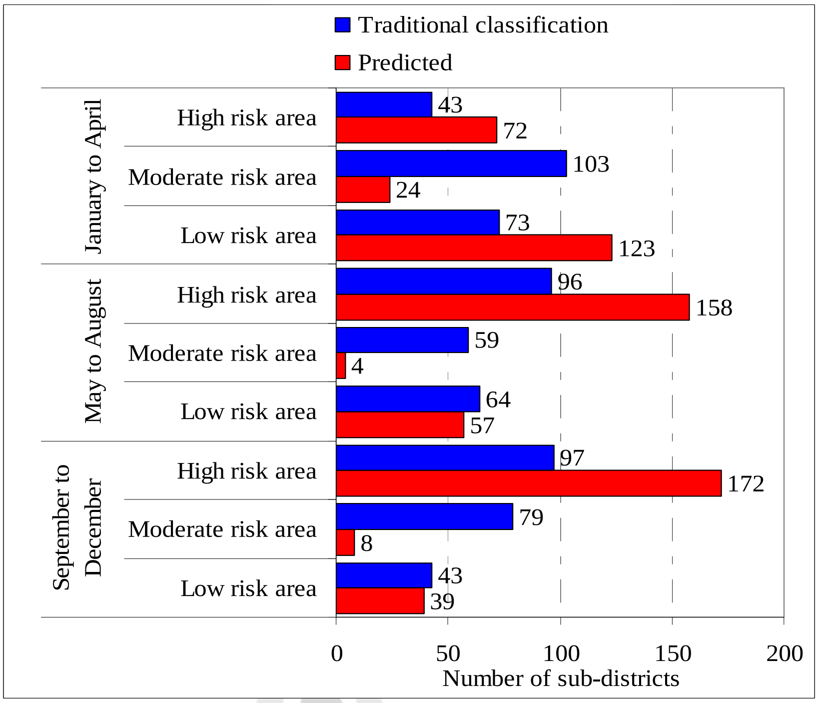


Figure 4.5 Graphs comparisons of area based on traditional classification and predicted risk area in year 2001.

Table 4.9 Error matrix of the classes of risk area based on traditional classification and predicted model of January to April of the year 2001.

		Traditional classification of risk area DF/DHF				
	Area	**High risk area**	**Moderate risk area**	**Low risk area**	**Row totals**	**Commission error**
Predicted	**High risk area**	43	29	0	72	41 %
	Moderate risk area	0	24	0	24	0
	Low risk area	0	50	73	123	59 %
	Column totals	43	103	73	219	
	Omission error	0	76.69 %	0		
	Overall accuracy			63.92%		

Table 4.10 Error matrix of the classes of risk area based on traditional classification and predicted model of May to August of the year 2001.

	Area	Traditional classification of risk area DF/DHF				
		High risk area	**Moderate risk area**	**Low risk area**	**Row totals**	**Commission error**
Predicted	**High risk area**	96	55	7	158	39 %
	Moderate risk area	0	4	0	4	0
	Low risk area	0	0	57	57	0
	Column totals	96	59	64	219	
	Omission error	0	93.22 %	10.93 %		
	Overall accuracy	71.68 %				

Table 4.11 Error matrix of the classes of risk area based on traditional classification and predicted model of September to December of the year 2001.

	Area	Traditional classification of risk area DF/DHF				
		High risk area	**Moderate risk area**	**Low risk area**	**Row totals**	**Commission error**
Predicted	**High risk area**	97	71	4	172	43 %
	Moderate risk area	0	8	0	8	0
	Low risk area	0	0	39	39	0
	Column totals	97	79	43	219	
	Omission error	0	89.87 %	9.30 %		
	Overall accuracy	65.75 %				

Table 4.12 Comparison percentage of overall accuracy resulted from predicted models in year 2001–2006.

Time period / **Year**	**January to April**	**May to August**	**September to December**
2001	63.92%	71.68%	65.75%
2002	66.67%	73.97%	67.12%
2003	72.60%	73.52%	71.69%
2004	72.60%	73.97%	63.92%
2005	70.32%	64.38%	57.59%
2006	51.14%	59.82%	49.32%

From Table 4.12, it shows that, almost all of each season during 2001–2005, overall accuracies of the risk area comparison between predicted and traditional results are above 60%. Only accuracies of the last season in 2005 and seasons in 2006 are between 49.32–59.82%. It can be explained that there were increasing number of epidemic cases in Ubon Ratchathani during 2001–2003. According to the epidemic circle which always occurs in every 3 years, the Health Provincial Office (HPO) therefore strengthened the controlling program in year 2006. This resulted in reducing the intensity of epidemic of the areas. For example, at Dech Udom district the actual cases were reduced from 32 of January to April and 61 of May to August 2005 to be 13 and 23 of the same seasons in the year 2006. As shown in the Figure 4.6, the detail comparison can be discussed as follows:

For moderate and low risk areas only the season of May to August show obviously different trending from 2005 to 2006. The trending of the rests (seasons and years) goes along with each other well.

The low risk areas show obvious difference in terms of the number of areas. The number of low risk areas of the predicted one is somewhat smaller. The predicted moderate risk areas show obviously smaller number than of the traditional one, while for the high risk areas the predicted one show obviously bigger number of the areas in each season.

Considering the high risk areas, it is found out that the number of risk areas of the first season influenced to increasing number of the second season which in turn did the same to the third season. Please notice that even though the number of risk areas of the second and the third seasons are almost the same, it shows significant influence because the second season is the peak of the epidemic and normally has tendency to have more cases than the third season.

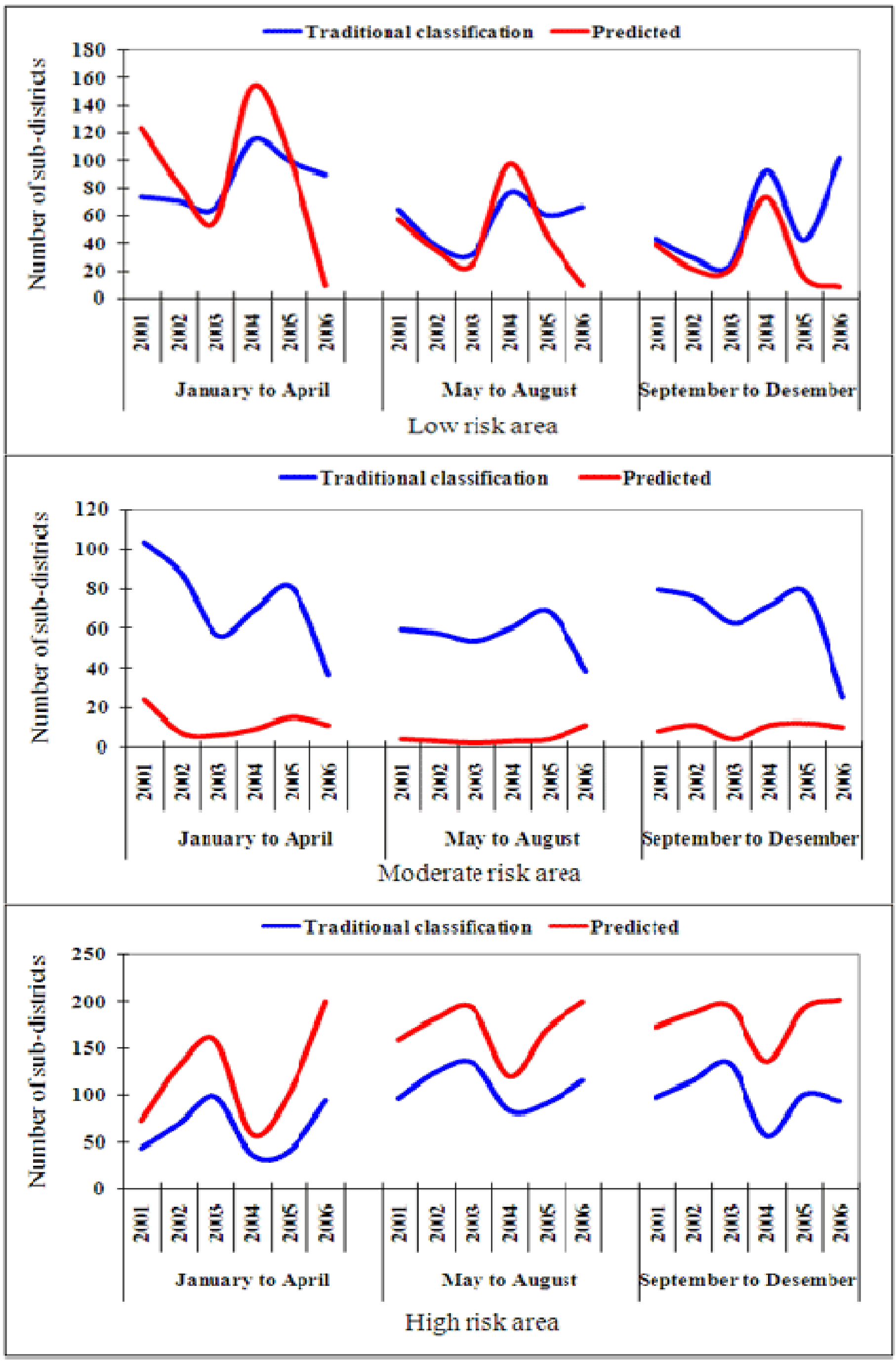


Figure 4.6 Graphs showing trends of high risk area, moderate risk area and low risk area resulted from prediction models and traditional classification of each season in year 2001–2006.

From the graphs of high and moderate risk areas of both traditional and predicted, they show quite high relation but obviously different number of sub–districts. When the high and moderate areas are grouped together, it shows more correlation between the traditional and the predicted one, particularly in the second and the third seasons of the years (Figure 4.7).

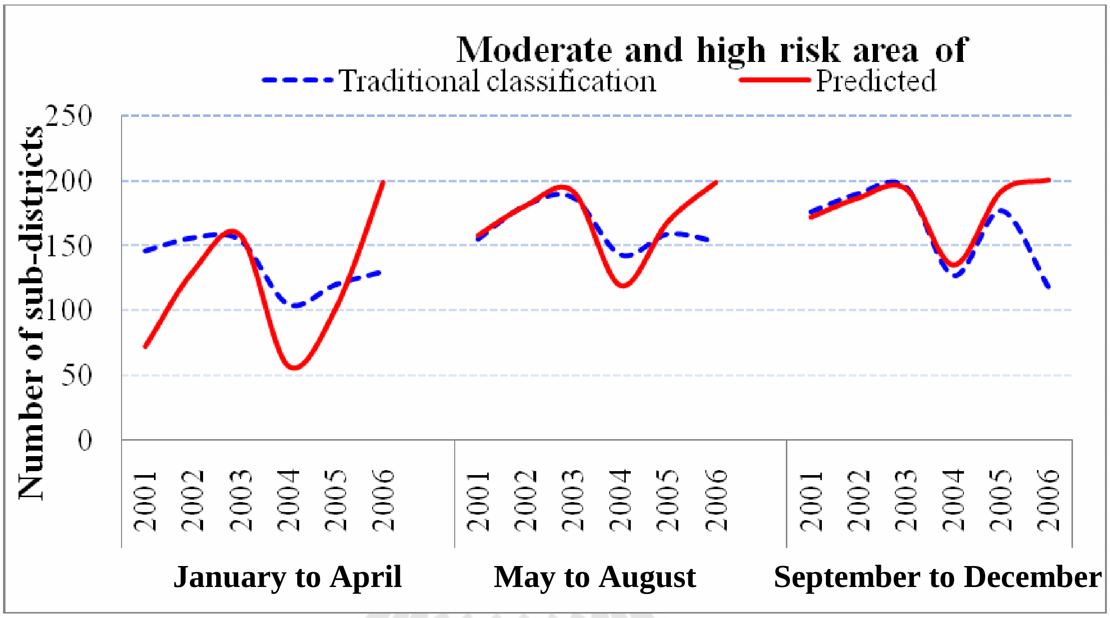


Figure 4.7 Comparison of trending between high and moderate areas of traditional and predicted results of each season during 2001–2006.

4.3 Prove to accept hypothesis 0

From Table 4.13, 14 from 18 seasons during 2001–2006 the overall accuracies appear to be higher than 60%. Therefore, the Hypothesis H_{00}, which is that "Risk area of DF/DHF from model–based prediction has insignificant correlation to actual event of epidemics in the study area", is rejected. Then, the Hypothesis H_{A0}, which is that "Risk area DF/DHF from model–based prediction has significant correlation to actual event of epidemics in the study area", is accepted. Only the last season of the year

2005 and seasons of the year 2006 show low correlation. The reason for this is explained above already.

4.4 Occurrence probability of epidemic in adjacent areas of high risk areas

The probability of epidemic in adjacent areas of high risk areas were calculated correspondingly to epidemic probability of DF/DHF in terms of time and space. Three seasons a year from 2001–2006 were modeled. The spatial unit of analysis is sub–district. A sub–district can be an adjacent area of more than one high risk areas. Then, an NPIC or average of NPICs (E) of any adjacent district was used as the indicator of how high risk area effecting to it. Adjacent areas with E higher than 0.5 were considered as the areas influenced. The parameter used to indicate the degree of effect is occurrence probability of epidemics in adjacent areas (OPEA). OPEA is equal to the number of adjacent areas which has E > 0.5 divided by the total adjacent areas of the whole study area. Maps and graphs showing high risk and effected areas and their numbers of the year 2001 are displayed as an example in Figures 4.8–4.9 and Table 4.13. The rests are shown in the Appendix D.

In each season of the year 2001–2006, the frequency of adjacent sub–districts, whose E > 0.5, equal or more than 50% from the total number of adjacent sub–districts were estimated. From total 18 seasons, there are 14 seasons that their OPEAs with E > 0.5 are equal or higher than 50% as shown in Table 4.14.

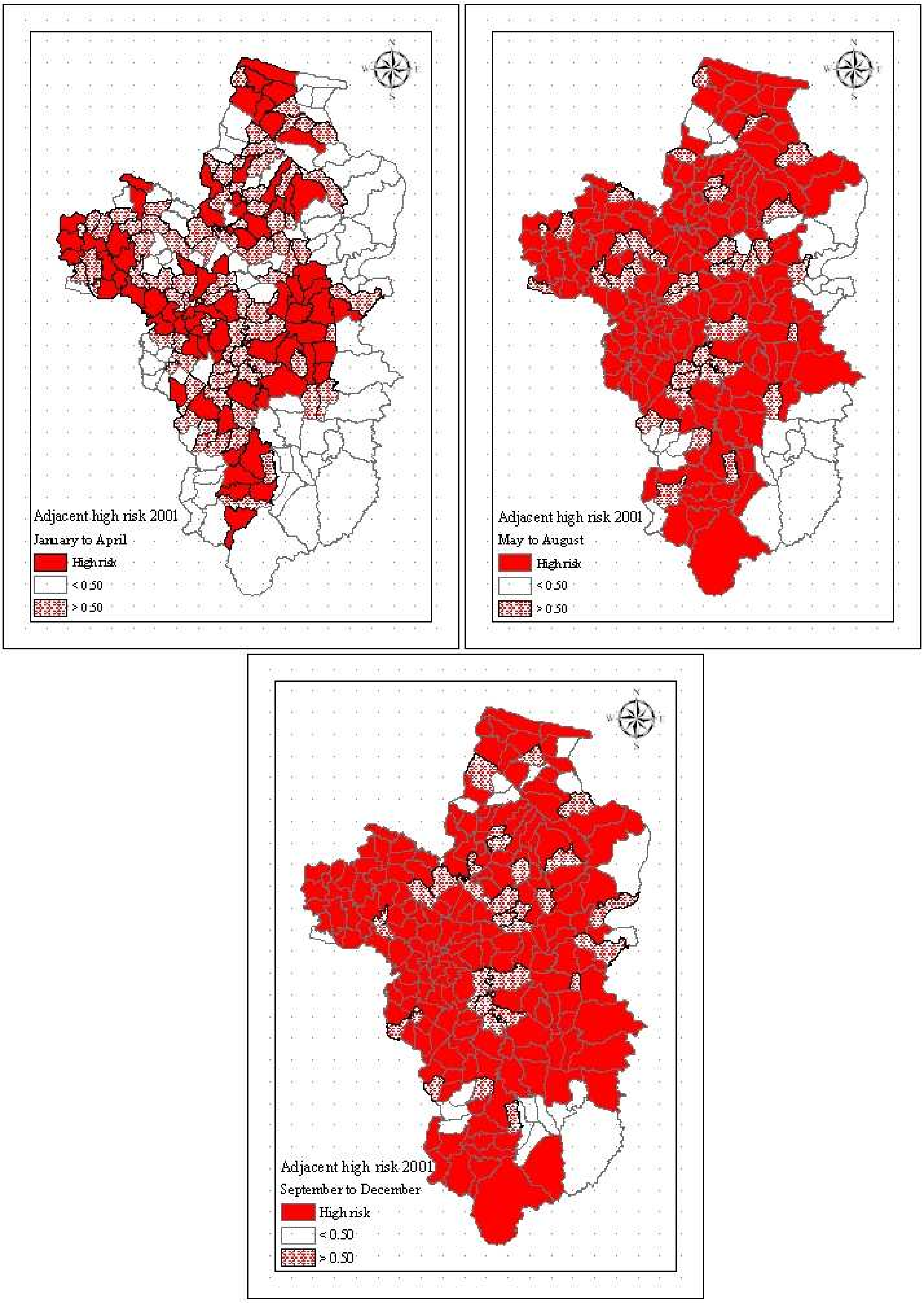


Figure 4.8 High risk areas and adjacent areas with NPIC or E more than 0.50 and less than 0.50 in three seasons of the year 2001.

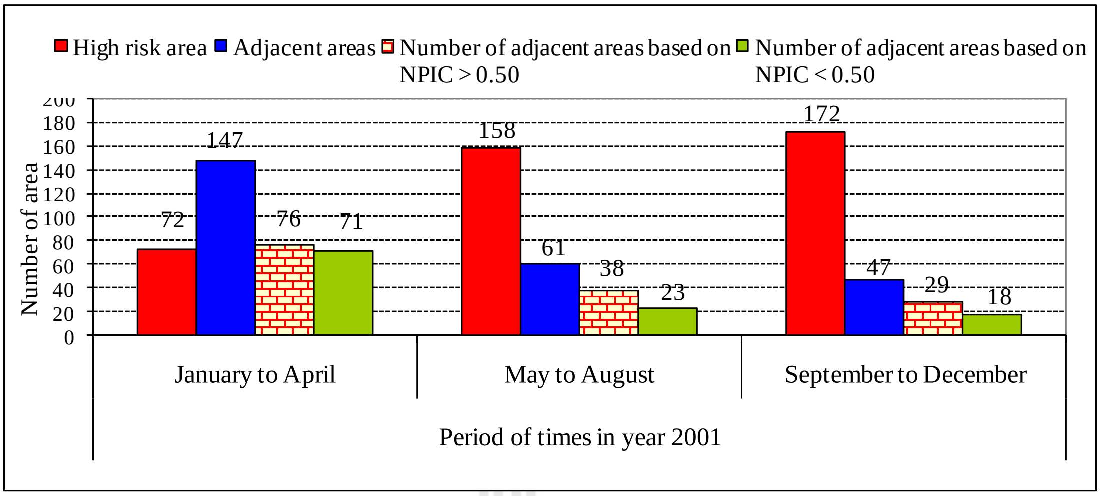


Figure 4.9 Graphs comparison epidemic effect in adjacent areas of high risk areas between periods of times in year 2001.

Table 4.13 Effect epidemic in adjacent areas of high risk areas in year 2001.

Period of times in year 2001	**High risk area**	**Adjacent areas (Moderate risk area and Low risk area)**	**Number of adjacent areas based on E**		**Occurrence probability of epidemic in adjacent areas of high risk areas (OPEA) (%)**
			>0.5	**<0.5**	
January to April	72	147	76	71	52
May to August	158	61	38	23	62
September to December	172	47	29	18	62

- E = *average of NPIC of each adjacent area.*
- OPEA = *No. of adjacent areas which has E > 0.5 / total adjacent areas of the whole study area*

Table 4.14 Epidemic effect from high risk areas to adjacent areas based on seasons during 2001–2006.

Period of times in year 2001		High risk area	Adjacent areas (Moderate risk area and Low risk area)	Number of adjacent areas based on E		OPEA (%)	Seasonal total adjacent areas (E>0.5)	Seasonal total adjacent areas	Total OPEA (E>0.5) (%)
				>0.5	<0.5				
January to April	2001	72	147	76	71	52	232	597	39
	2002	130	89	38	51	43			
	2003	158	61	31	30	51			
	2004	57	162	32	130	23			
	2005	101	118	42	76	36			
	2006	199	20	14	6	70			
May to August	2001	158	61	38	23	62	165	296	56
	2002	181	38	23	15	61			
	2003	192	27	22	5	81			
	2004	119	100	30	70	30			
	2005	169	50	38	12	76			
	2006	199	20	14	6	70			
September to December	2001	172	47	29	18	62	153	233	66
	2002	187	32	22	10	72			
	2003	194	25	19	6	76			
	2004	135	84	43	41	51			
	2005	192	27	27	0	100			
	2006	201	18	13	5	72			

Among 18 seasons, only the January–April season of the year 2002, 2004 and 2005 and May–August season of the year 2004 show that probability of epidemic effect from high risk areas to adjacent areas appear to be less than 50%.

Considering season by season of the 2001–2006 data, it reveals that adjacent area with E > 0.5 in January–April season can be as low as 40%, while they are higher to 56% and 66% in May–August and September–December seasons, respectively. This is consistent to the epidemic theory that the first season is pre–epidemic season and the third or post–epidemic season can carry higher potential epidemic degree in terms of higher number of districts and NPIC than the second season which is regarded as the outbreak season when the event occurs. This is confirmed in the Figure 4.10. Moreover, the result of the study can provide spatial data in terms of which sub–districts have higher risk effecting from the high risk area(s) connecting to it. This could help in increasing efficiency in directing measures spatially and properly.

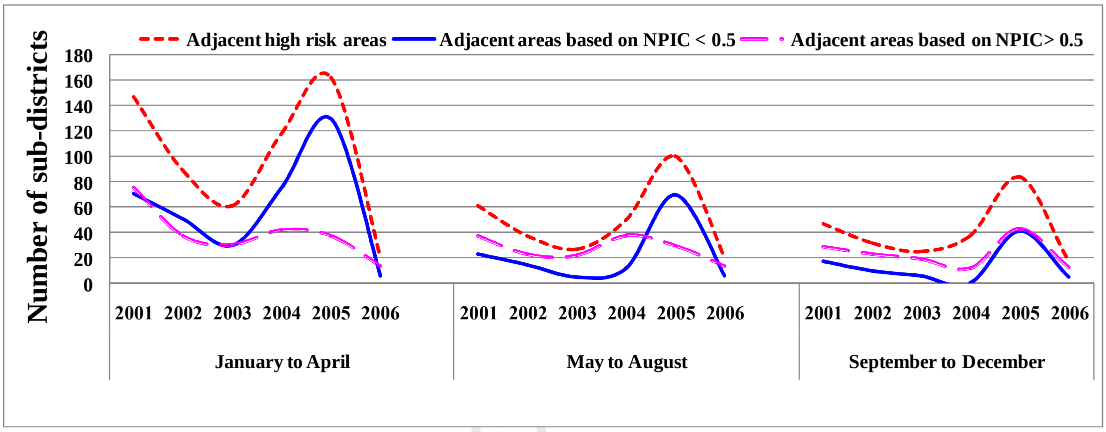


Figure 4.10 Seasonal trending of epidemic effect in adjacent areas of high risk areas between periods of times in year 2001–2006.

4.5 Prove to accept hypothesis 1

As mentioned above, it means that 14 from total 18 seasons play role of supporting acceptance of Hypothesis H_{A1}. This means that the hypothesis is met in the degree of 77.78% (or 100(14/18)). However, to state that the Hypothesis H_{A1} is acceptable, statistic value such as Mean Absolute Percentage Error (MAPE) is used to provide more accurate result of hypothesis acceptance.

The hypothesis will be accepted if the MAPE is less than 50%. The less the MAPE is the better for hypothesis is accepted (Ahlburg, 1992). The MAPE can be calculated according to the following equation:

$$MAPE = \frac{\sum \left(|Y_0 - Y_c| / Y_0 \right) * 100}{N} \quad \textbf{Eq. 10}$$

Where

Y_0 = the expected value–Occurrence probability of epidemic in adjacent areas of high risk areas (OPEA) which has to be equal or higher than 50%.

Y_c = the modeled value–The OPEA obtained from the model.

N = the number of seasons

The detail of calculation is tabulated in Table 4.15 and the result of MAPE of this study is 36% or the accuracy of hypothesis to be accepted is 64%.

Table 4.15 The MAPE estimation of seasonal data during 2001–2006.

N	Y_0	Y_c	$Y_0 - Y_c$	$(\lvert Y_0 - Y_c \rvert / Y_0)$	$\frac{\sum(\lvert Y_0 - Y_c \rvert / Y_0) * 100}{N}$
1	0.5	0.52	–0.02	0.04	
2	0.5	0.43	0.07	0.14	
3	0.5	0.51	–0.01	0.02	
4	0.5	0.23	0.27	0.54	
5	0.5	0.36	0.14	0.28	
6	0.5	0.70	–0.20	0.40	
7	0.5	0.62	–0.12	0.24	
8	0.5	0.61	–0.11	0.22	
9	0.5	0.81	–0.31	0.62	
10	0.5	0.30	0.20	0.40	36
11	0.5	0.76	–0.26	0.52	
12	0.5	0.70	–0.20	0.40	
13	0.5	0.62	–0.12	0.24	
14	0.5	0.72	–0.22	0.44	
15	0.5	0.76	–0.26	0.52	
16	0.5	0.51	–0.01	0.02	
17	0.5	1.00	–0.50	1.00	
18	0.5	0.72	–0.22	0.44	

CHAPTER V

RESULTS OF WEB–BASED SDSS DEVELOPMENT

The Web–Based SDSS for DF/DHF epidemics was developed for dynamic implementation. The system was designed into four parts as: 1) system and software designs, 2) database design, 3) interface design, and 4) results of implementation systems.

5.1 Systems and software designs

These designs include ones of the system and its architecture, and software.

5.1.1 System design

This design is a holistic design for the new system in logical and physical parts shown in form of Data Flow Diagrams (DFD). The DFD of web–based SDSS was studied and analyzed into 2 parts of Level 0.

1) Context Diagram level 0

The context diagram of Web–Based SDSS explains relationship of users and the system in terms of data request and data management as shown in Figure 5.1. The administrator group includes a system administrator and operators who can manage GIS and DF/DHF databases.

2) Data Flow Diagram level 0

The DFD of this level shows relationship of main processes of different types of users. These processes cover authority verification, data management, and data report as shown in Figure 5.2. They are described as follows:

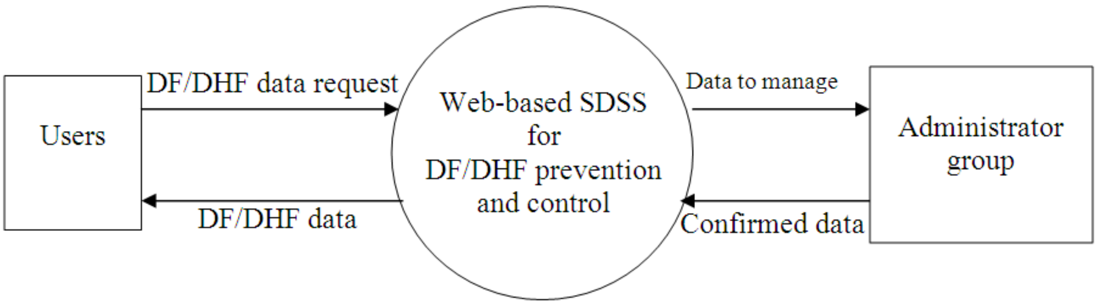


Figure 5.1 The context diagram of Web–Based SDSS system.

Process 1: Authority verification process

The authority verification process to differentiate administrator from general users is performed by checking name and password from users. The administrator group can manage GIS data in the system described in process 2, and DF/DHF data as in process 3. All users can display report described in process 4.

Process 2: GIS data management process

This process can add, update, delete, save, and search all GIS data of the system.

Process 3: DF/DHF data management process

The process can add, update, delete, save, and search to types of data as shown in Figure 5.3.

Process 4: Display report process

In this process, users can select forms for assessment or viewing GIS database and results from DF/DHF model.

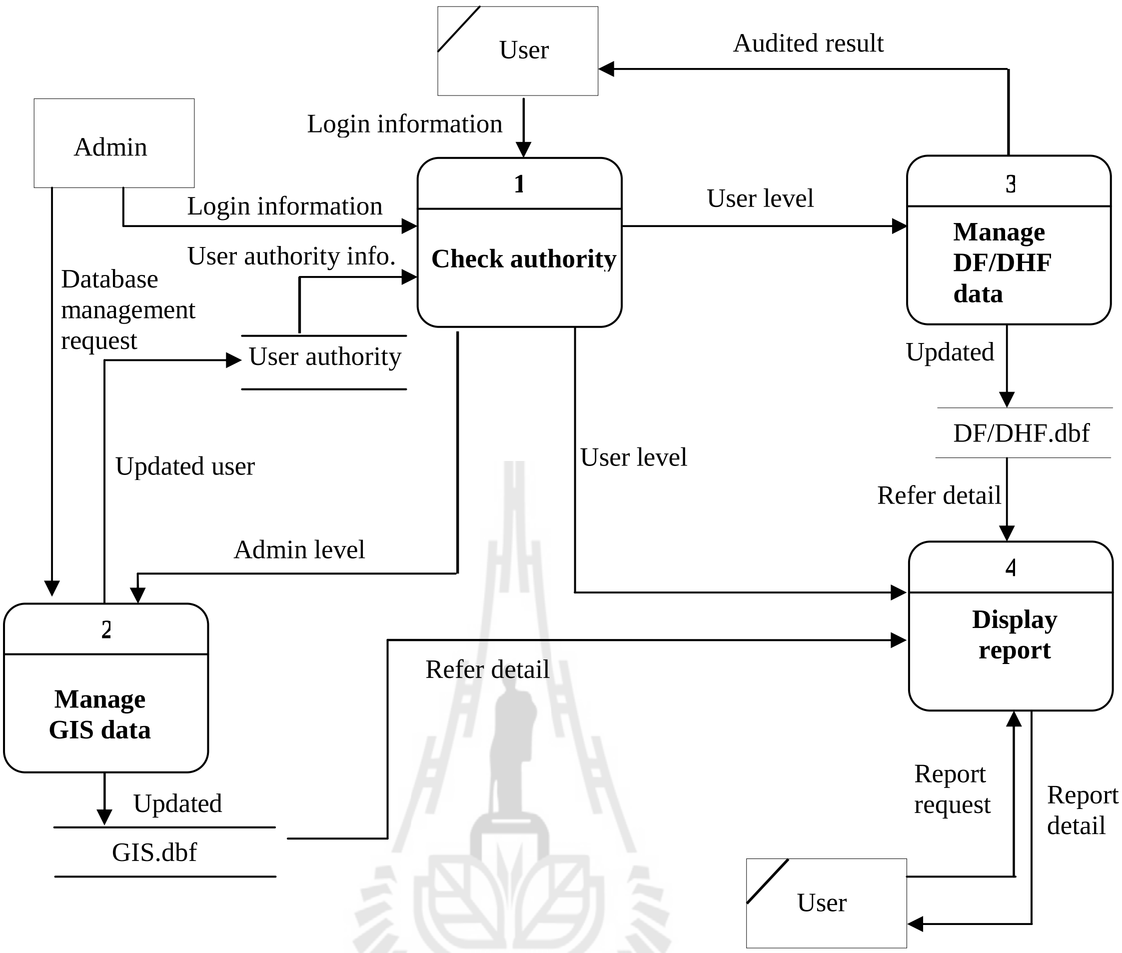


Figure 5.2 Data Flow Diagram Level 0 of system

Figure 5.3 The form of DF/DHF data main page.

5.1.2 Software design

This section discusses about the tool selection of this project. PHP (see example codes in Appendix E) was chosen as a web development program. The reason for selecting PHP is: it is open source, it can runs on many internet server such as Apache, Netscape/iPlanet, Microsoft IIS etc., it provides easy–to–learn syntax and massive library of contributed extension such as JpGraph which is Object–Oriented Graph creating library. Any developer, who has good coding experience and completely in touch with the PHP, will encounter no problem. The system also includes Javascript language to create more efficiency web browsing interface on the web browser.

5.1.3 System architecture design

In web service (Figure 5.4), Apache HTTP Server 1.3.34 is used as web server to support PHP Script Language 4.4.1 to generate the webpage dynamically. The database uses MySQL 5.0.16 and phpMyAdmin 2.5.7 for the web interface for the database.

In the prototype setup, the server runs in a Microsoft windows 2003 Server Operating System environment. In order to run MapServer version 4.4.2, all open source packages specified are required.

MapServer web application requires a configuration file known as a 'mapfile'. A mapfile is a text formatted file detailing the file paths of the data and all the map layers including map projections, legends, scale ratio, etc. Each layer has a specific name and is characterized by a set of attributes such as line color, symbols, etc.

After the web services were set up and ran properly, the user can manage the database by the web interface provided by phpMyAdmin MySQL without much modification.

The user is not required to install specific software to access the data. The requirement is a java–enabled browser which is relatively commonplace nowadays. The server end consists of a web server which can process Java Server Pages (JSP) and Java Servlets.

For designing web–based GIS applications, it is always based on the same model called client/server. The clients are those who connect with the Web and are the end–users of the data. The servers are storage unit of information and also process the requests from the clients and return the corresponding information to them. Client–side and server–side applications are two general solutions providing geospatial data to end–users without requiring them to have complicated or mapserver software on their own machines.

In client–side processing, the client's web browser is enhanced to support GIS functionality (by means of Java applets, plug–ins, applications, etc.), which requires time for downloading and installation. In server–side applications (using PHP), the client's web browser is only used to generate server requests and display the results while the central server does the processing.

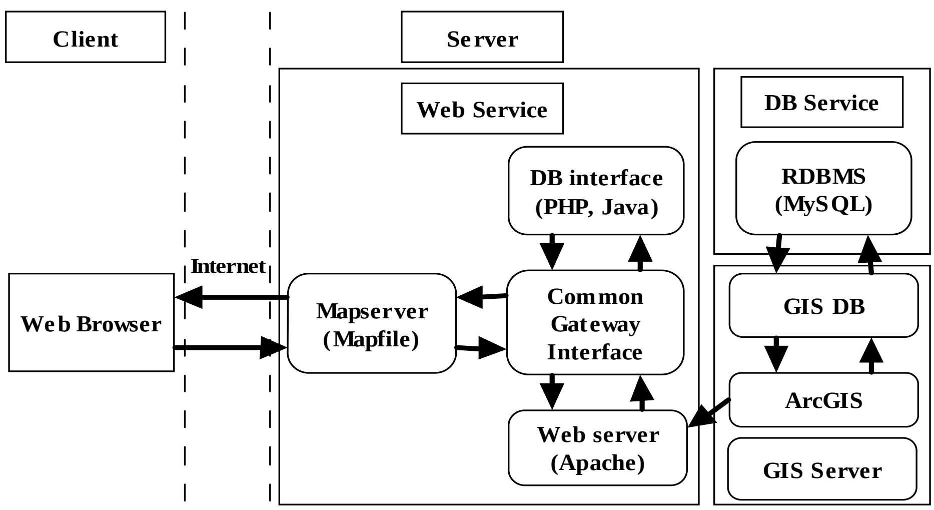


Figure 5.4 Components and information flow within the prototype system.

5.2 Database design

Relational database was designed for the system using MySQL as the DBMS. The relationship of entities and their attributes were designed and expressed as the ER diagram shown in Figure 5.5 as an example. Examples of data dictionary design of the relational database are shown in Tables 5.1–5.8.

Table 5.1 District.

Fields	Type	Length	Key	Definition
Code_dis	varchar	10	PK	Code of district
Name_thai	varchar	40		Thai name
Name_eng	varchar	40		

Table 5.2 Sub−district.

Fields	Type	Length	Key	Definition
Code_sub	varchar	10	PK	Code of sub–district
Code_ dis	varchar	10	Foreign key	Code of district
Name_thai	varchar	40		Thai name
Name_eng	varchar	40		

Table 5.3 Village.

Fields	Type	Length	Key	Definition
Code_sub	varchar	10	Foreign key	Code of sub–district
Code_village	varchar	10	PK	Code of village
Name_village	varchar	40		Thai name

Table 5.4 PCU (Primary Health Care Unit).

Fields	**Type**	**Length**	**Key**	**Definition**
Pcu_id	varchar	10	PK	Code of PCU
Pcu_name	varchar	30		Name of PCU

Table 5.5 Administrator.

Fields	**Type**	**Length**	**Key**	**Definition**
Username	varchar	10		
Password	varchar	30		

Table 5.6 Laval.

Fields	**Type**	**Length**	**Key**	**Definition**
Code_village	varchar	10	PK	Code of village
Date_L	varchar	30		Date to survey
BI	varchar	30		
CI	varchar	30		
HI	varchar	30		

Table 5.7 Patient.

Fields	Type	Length	Key	Definition
Code_village	varchar	10	PK	Code of village
Pcu_id	varchar	10	Foreign key	Code of PCU
Date_b	varchar	30		Birth day
Name	varchar	30		
sex	varchar	5		
Marie	varchar	10		
Address	varchar	50		
Occupat	varchar	30		Occupation
Sign	varchar	50		
Date_sick	varchar	30		
Date_define	varchar	30		
Date_dead	varchar	30		

Table 5.8 Climate.

Fields	Type	Length	Key	Definition
Code_sub	varchar	10	PK	Code of sub–district
Date_C	varchar	30		Date to survey
rainfall	varchar	30		
temperature	varchar	30		

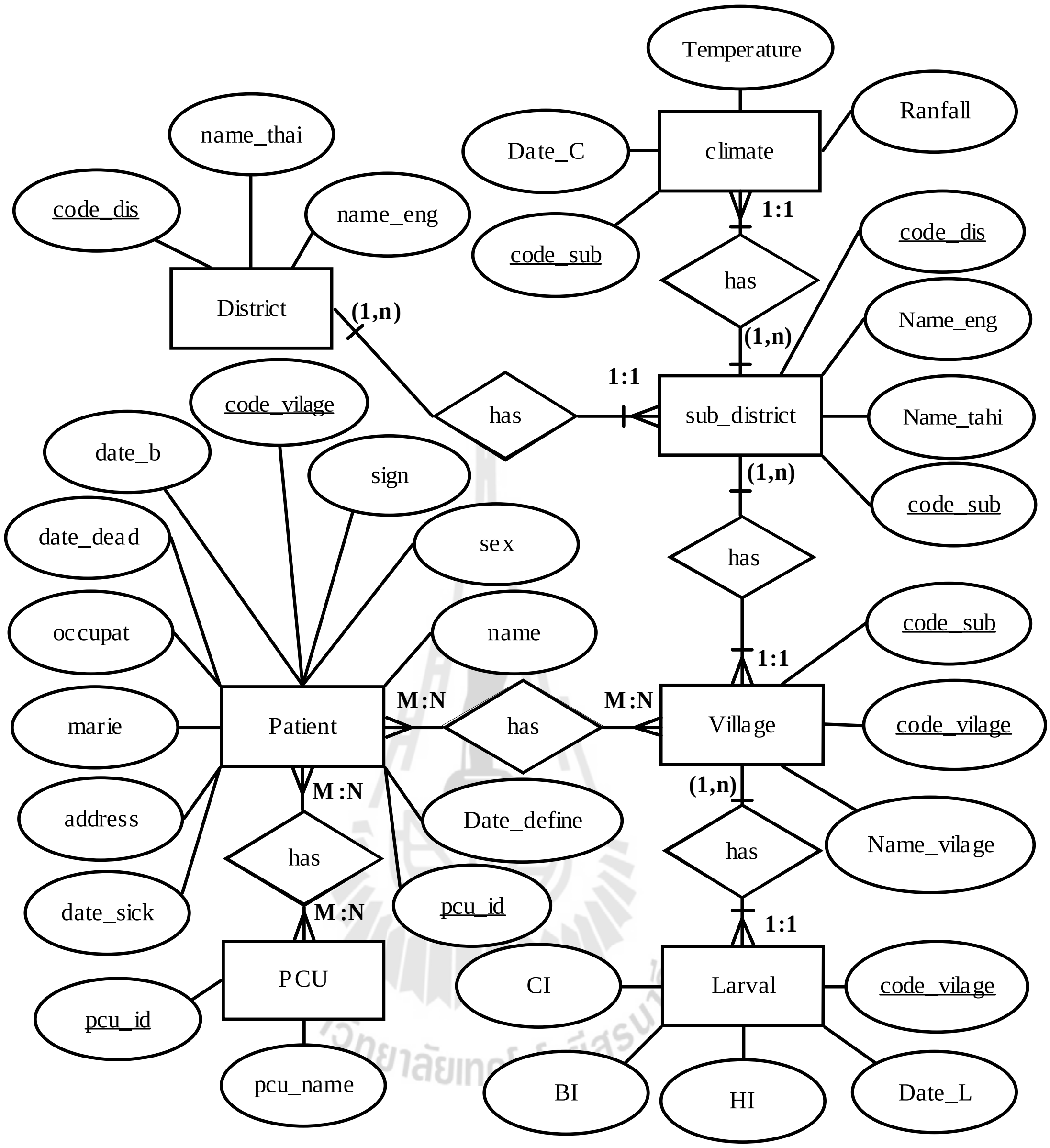


Figure 5.5 Entity relationship diagram (E–R) of the database in the SDSS.

Finally, following the design, the GIS database was developed for the model implementation. GIS layers are, for example, sub–district, meteorological stations, interpolated seasonal climate (rain and temperature). Population, seasonal larval indexes (BI, HI, and CI) and DF/DHF cases are attributes of sub–district.

5.3 SDSS interface design and construction

The interface design is the process of defining how the users will interact with the system and the nature of the inputs and outputs that the system accepts and produces. The system is composed of interfaces developed for connecting user requests, display returning results, and providing services as advice for further spatial implementation on DF/DHF prevention and control (Figure 5.6). The user interface design was divided into two parts: 1) for general user interface and 2) for administrator.

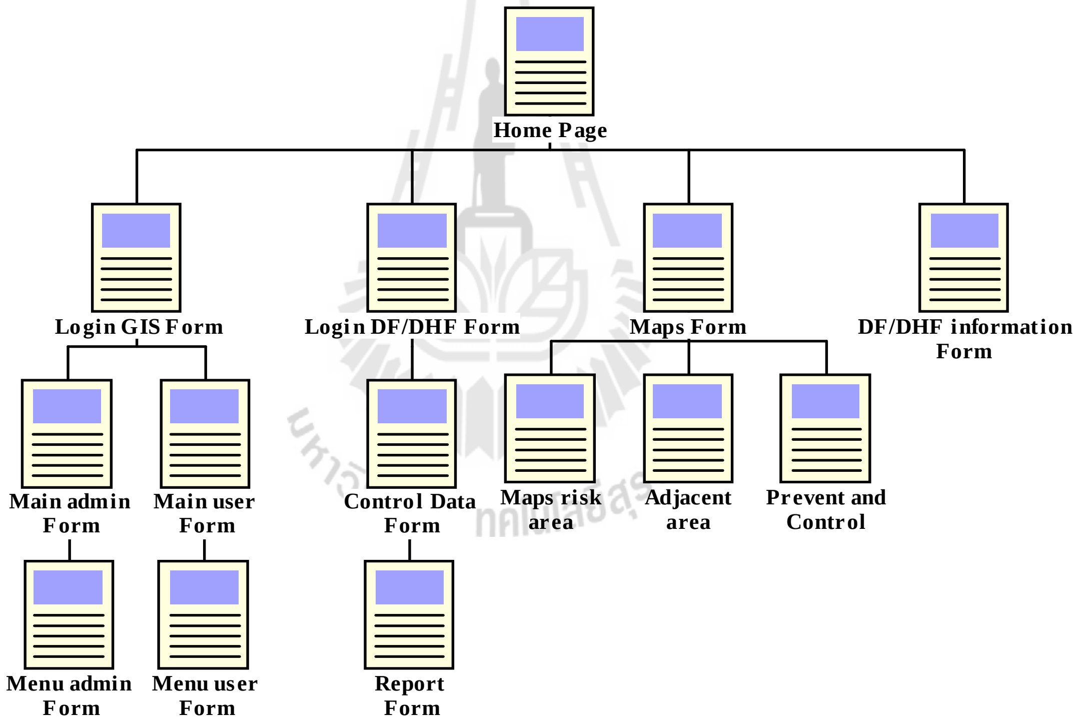


Figure 5.6 Interface structure diagrams of Web–Based forms of the system.

5.3.1 The general user (Client) interface

Client interface is a PHP document with a frame layout (see Figures 5.7). The general user interface design was divided into two parts: 1) the Web–Based SDSS application tools for user and 2) the Web–Based DF/DHF model for prevent and control.

1) The Web–Based SDSS application tool for user

The left frame (Figures 5.7) is a javascript which provides the control and navigational capabilities. The center frame is a static display of the map as the user interacts with the javascript and map file (Figures 5.8). Figure 5.9 shows various capabilities of the javascript including zooming and map layer selection.

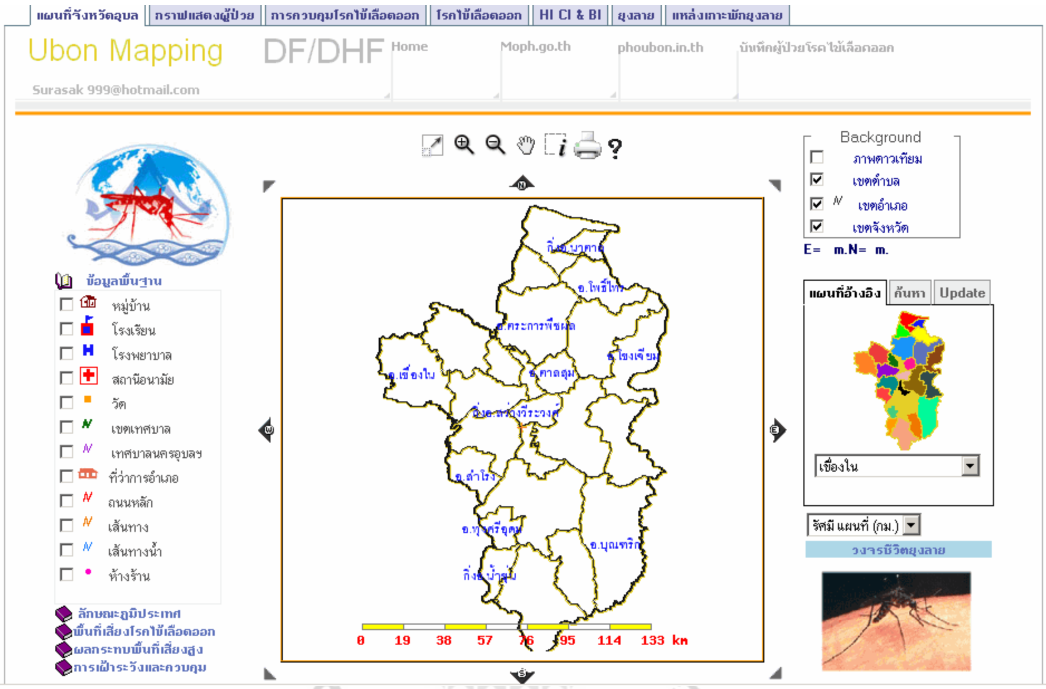
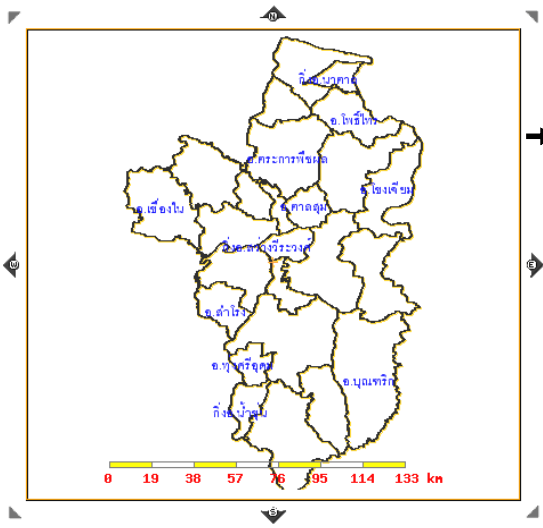


Figure 5.7 Client interface of main map.




```
PROJECTION
   "proj=utm"
   "zone=48"
   "a=6377276.345"
   "b=6356075.413140239"
   "towgs84=209,818,290,0,0,0,0"
   "units=m"
   "no_defs"
END
```

Figure 5.8 A static display of the map and example map file.

It is located in the center of the webpage, and is the main component to show the geographic information and link non–geographic information of DF/DHF data of sub–districts.

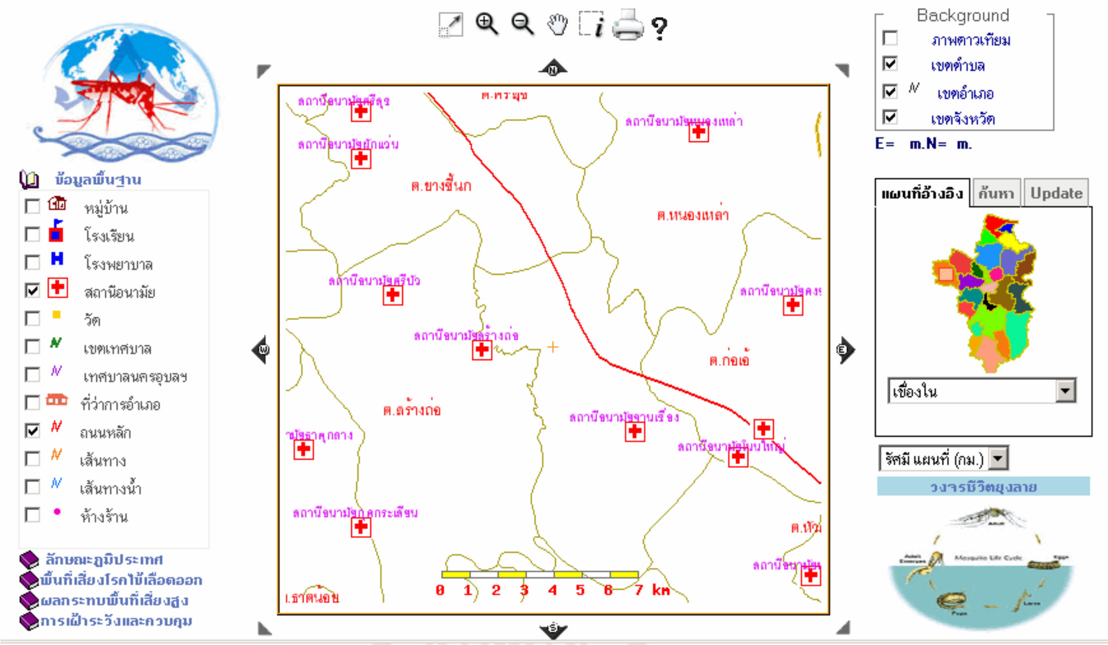


Figure 5.9 A zoom–in showing of the map area on primary health care, road layers.

The dynamic map (interactive map) was developed by coding (java script and map file) based on the basic functions required for web–mapping application. The codes were developed for basic required functions of the map (Show Legend or Layer List, Zoom In, Zoom Out, Full Extent, Previous Extent, Panning Map Display Area and Identifying Features) (Figure 5.10). This module was designed and developed to help users dynamically explore the map by displaying, zooming in/out to any extent, and selecting any combination of information layers. Users can also create and print out customized maps. In addition, users can retrieve various data through queries that might be helpful in their decision making. The followings are detail of parts in the application tools for user.

Zoom to Center – Pan the view so that the spot clicked is centered.

Zoom In – Magnify the view as if seen from a closer distance.

Zoom Out – Reduce the view as if seen from farther away.

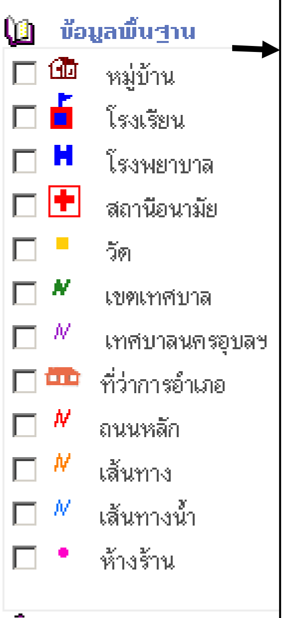
Zoom to Fit – Zoom so that the component fits within the current window.

Info Tool – Show data fields for object.

Print the map layout.

Figure 5.10 Mapping functions.

Layer display choice: Any base maps can be selected to display. Users can turn them off and on by ticking check boxes (Figure 5.11).



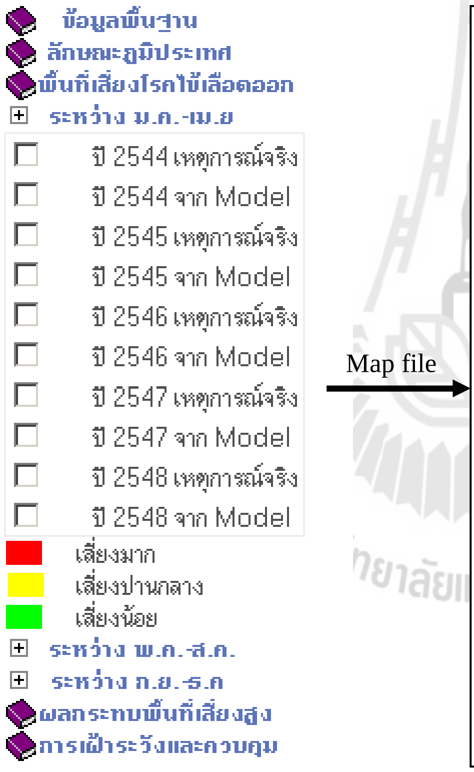

```
myMap.layers[myMap.layers.length] = new Layer('mooban', ' หมู่บ้าน',
'f1', false, '<?= $path_cgi_mapserver?>?mode=legend&map=<?=
$path_root?><?= $path_project?>/<?= $mapfile?>&layers=mooban',
null);
myMap.layers[myMap.layers.length] = new Layer('school', ' โรงเรียน',
'f1', false, '<?= $path_cgi_mapserver?>?mode=legend&map=<?=
$path_root?><?= $path_project?>/<?= $mapfile?>&layers=school',
null);
myMap.layers[myMap.layers.length] = new Layer('pcu', ' โรงพยาบาล',
'f1', false, '<?= $path_cgi_mapserver?>?mode=legend&map=<?=
$path_root?><?= $path_project?>/<?= $mapfile?>&layers=pcu',
null);
myMap.layers[myMap.layers.length] = new Layer('pcu1', ' สถานีอนามัย',
'f1', false, '<?= $path_cgi_mapserver?>?mode=legend&map=<?=
$path_root?><?= $path_project?>/<?= $mapfile?>&layers=pcu1',
null);
myMap.layers[myMap.layers.length] = new Layer('temple', ' วัด', 'f1',
false, '<?= $path_cgi_mapserver?>?mode=legend&map=<?=
$path_root?><?= $path_project?>/<?= $mapfile?>&layers=temple',
null);
```

Figure 5.11 Layer choices and their coding.

In the interface, *categorized layers* can be accessed using choice tabs as shown in Figure 5.12.

Figure 5.12 Layer choice using tabs.

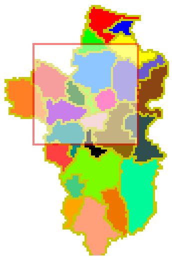
Categorized layer choice can be a tree style. It is suitable if there are more maps and lots of layers (Figure 5.13).




```
LAYER
 NAME "jan44m"
 TYPE Polygon
 STATUS Off
 DATA "predict"
 LABELITEM "TAM_NAM_T"
 LABELMINSCALE 500
 LABELMAXSCALE 420000
 CLASSITEM 'P144'
 CLASS
 EXPRESSION "1"
 COLOR 255 0 0
 OUTLINECOLOR 200 200 0
 LABEL
 COLOR 255 255 255
 ENCODING TIS–620
 font enu
 SIZE 14
 TYPE truetype
 POSITION CC
 BUFFER 5
 MINFEATURESIZE 20
 END
 TEMPLATE
```

Figure 5.13 Layer choices using a tree and its coding.

Overview map or reference map is a small outline map of the whole province, which automatically shows the location of the actual map at the present zoom level (Figure 5.14).



```
MAP
NAME 'REFERENCE'
STATUS ON
Size 150 150
Fontset "fonts/fonts.list" # Set Fontype
SYMBOLSET "symbols/symbol.sym" # Set symbol type
EXTENT 433159.03125 1571310.5 568705.75
1779499.875 UNITS METERS
SHAPEPATH "data"        #Set Path of Data
IMAGECOLOR 255 255 255
SYMBOL
NAME 'star'
TYPE VECTOR
FILLED true
END
```

Figure 5.14 Overview map.

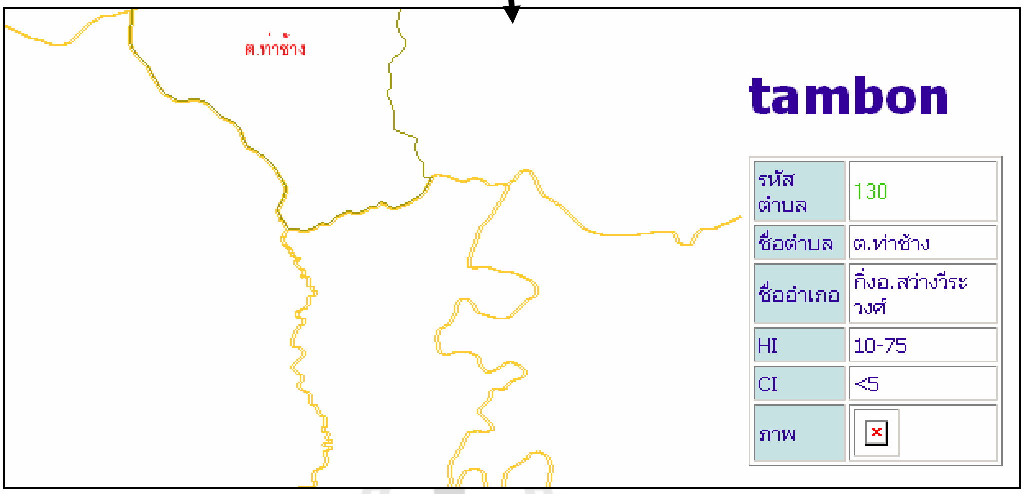
Scale bar of map is a map element used to graphically represent the scale of a map (Figure 5.15).


```
SCALEBAR                                             # Start of scale bar object
IMAGECOLOR 0 0 255                                   # color background
LABEL                                                # Start of label object
COLOR 255 0 0
SIZE medium                # since not TrueType, only relative size can be used
END
STYLE 0                                              #ประเภทเส้น or 0
SIZE 300 5                                           # Width and height in pixels
COLOR 255 255 0                                      # First scale bar interval color
OUTLINECOLOR 110 110 110
UNITS kiloMETERS
INTERVALS 7
TRANSPARENT TRUE
STATUS embed
POSITION lc
END                                                  # End of label object
```

Figure 5.15 Scale bar of map.

Query the .dbf is interrogations of a database. Spatial queries in a web–mapping context usually mean presentation of database information belonging to one or more selected map features. As long as the database is a .DBF file associated with shape files, this type of querying is pretty straightforward with MapServer. Query object of map file to tell MapServer where to put the query map (Figure 5.16).

```
QUERY
  TEMPLATE "../main/template/ sub–districtTemplate.htm"
END
```



Figures 5.16 Example of query the *.dbf*.

2) The Web–Based DF/DHF model for prevention and control.

Seasonal risk areas of DF/DHF in unit of sub–districts based on several sources can be requested to display, namely based on actual event (Figure 5.17), from the model (Figure 5.18), from probability of epidemic in adjacent areas of high risk areas (OPEA) (Figure 5.19), for prevention and control (Figure 5.20). Figures 5.21–5.23 express suggestion and implementation according to different levels of places and degree of the risk. Data sources and case data related to these risk areas in the system for dynamic implementation are provided in Appendix F.

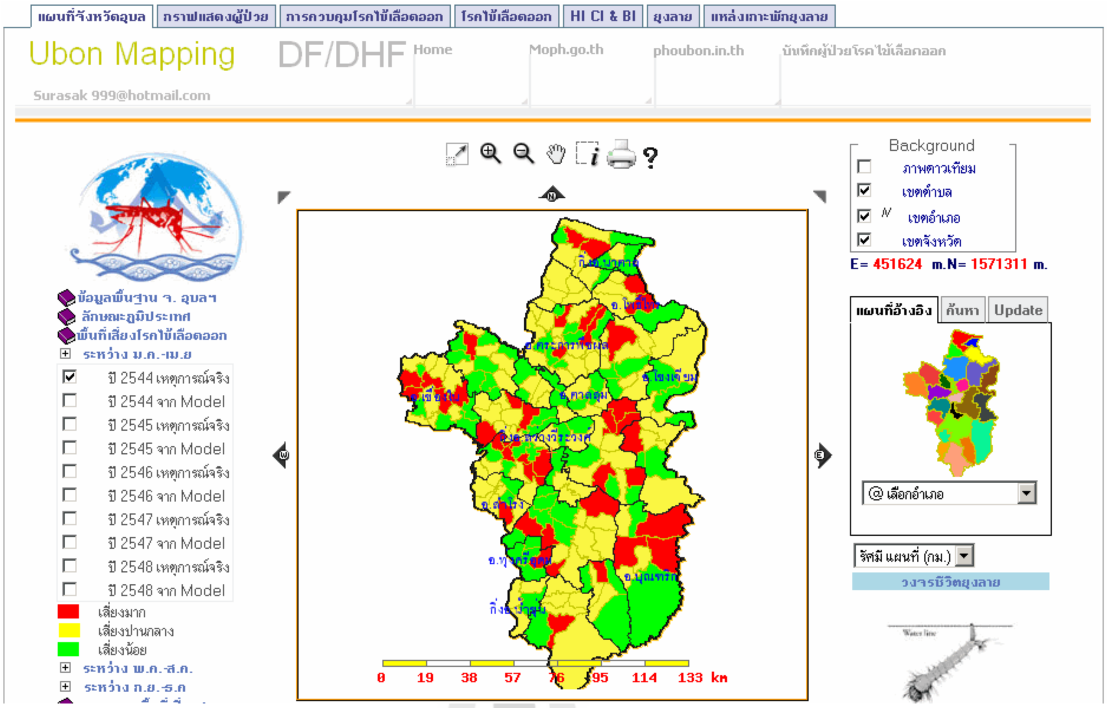


Figure 5.17 Risk areas from actual event during Jan–Apr 2001.

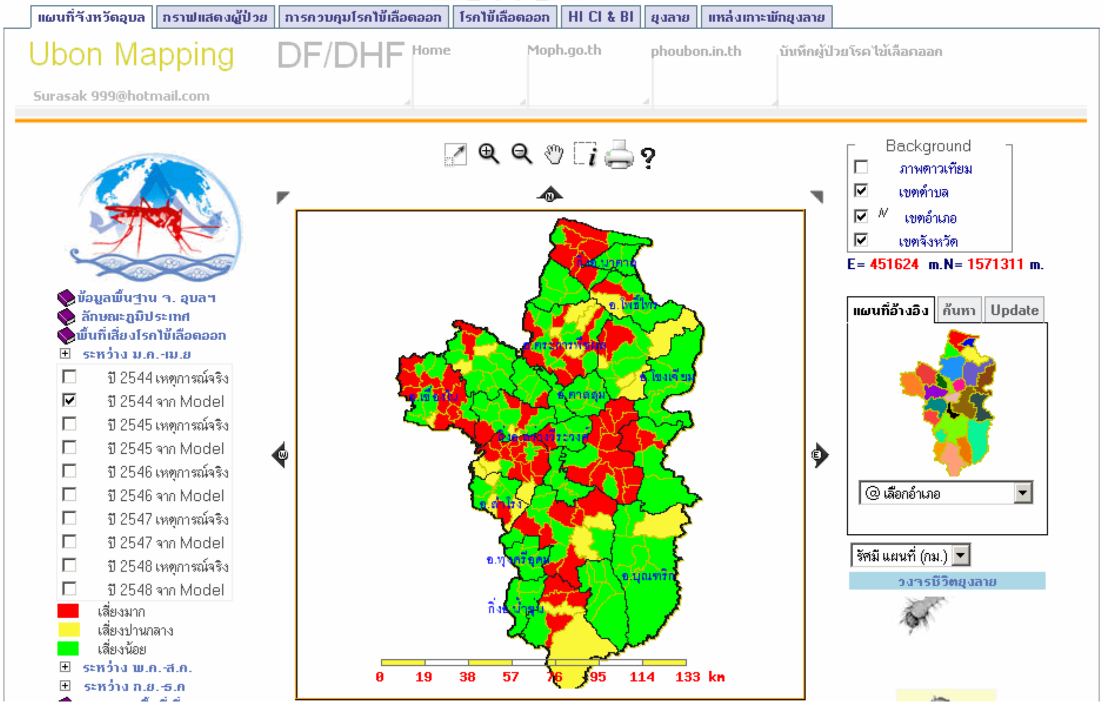


Figure 5.18 Risk areas from the model during Jan–Apr 2001.

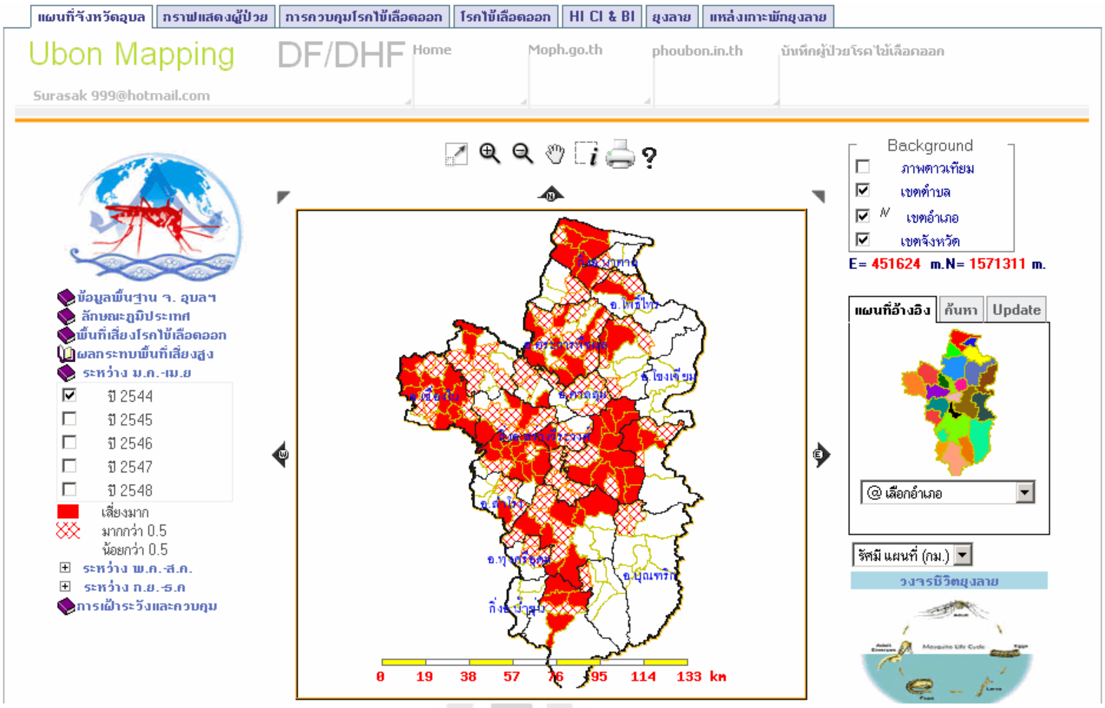


Figure 5.19 Occurrence probability of epidemic in adjacent areas of high risk areas (OPEA) during Jan–Apr 2001.

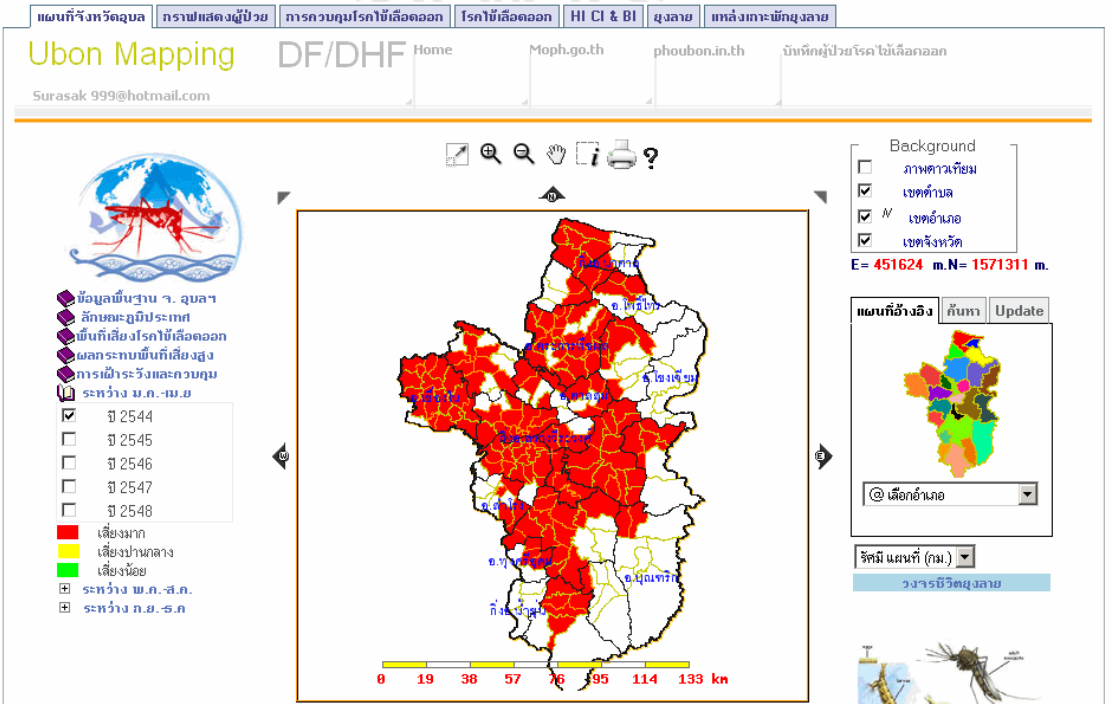


Figure 5.20 Risk areas for prevention and control during Jan–Apr 2001.

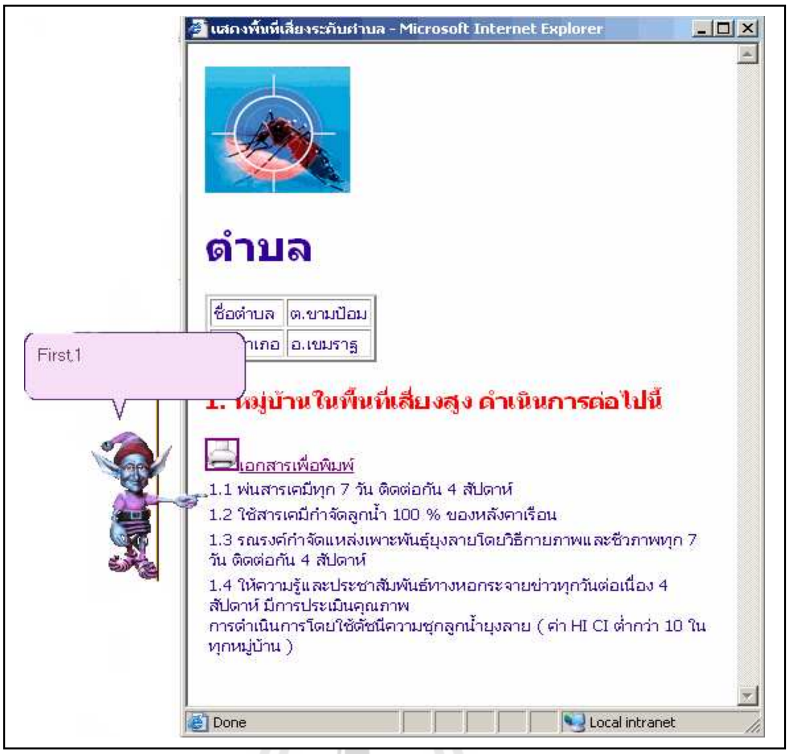


Figure 5.21 Suggestion and implementation for high risk areas.

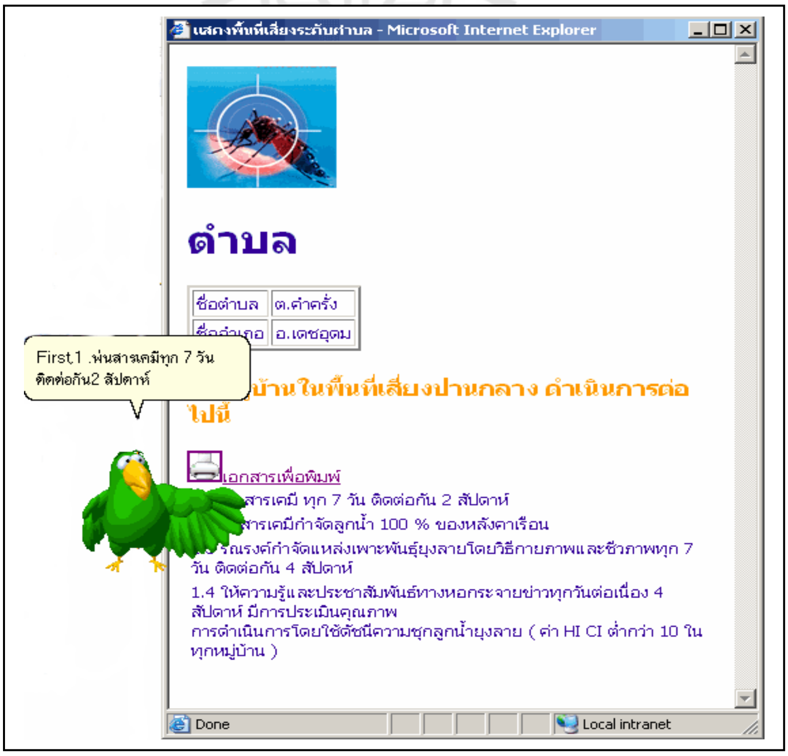


Figure 5.22 Suggestion and implementation for moderate risk area.

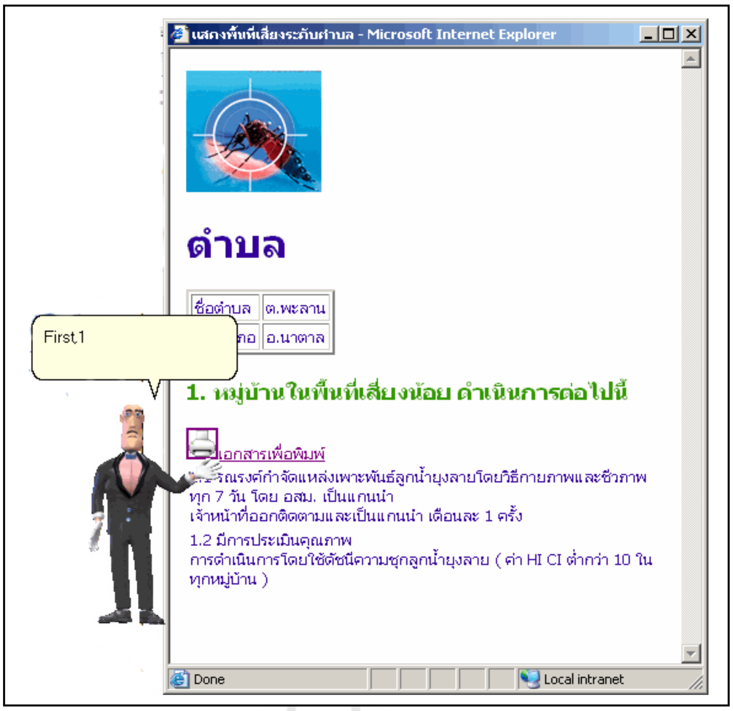


Figure 5.23 Suggestion and implementation for low risk area.

5.3.2 The SDSS for user strategic

The tool was developed for users to be able to vary indexes and environmental conditions of any sub–district to observe the risk predicted by the model referred to a certain season. The tool can be accessed by selecting a season (pre–high incidence: January to April, or high incidence: May to August, or post–high incidence: September to December) and sub–district name as shown in Figure 5.24 (pre–high incidence is selected as an example). Once a sub–district is searched, the name of sub–district required and corresponding district are shown. Further click at those names, the basic data of the sub–district according to research years and the tool will be shown as displayed in Figure 5.24.

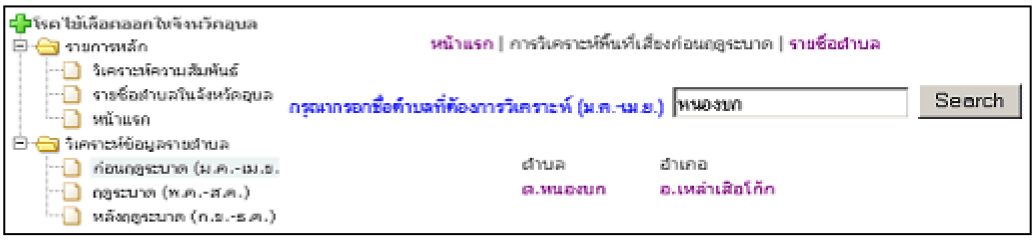


Figure 5.24 Main menu of the system for risk analysis of a sub–district.

By dragging and dropping the red pointers of each factor, the risk rating will be calculated using model from a certain season selected (pre–high incidence: January to April as an example in this case) and displayed in a risk rating meter from 0–5 as shown in Figure 5.25. Color zones of the meter indicates risk levels as green color for low risk, yellow color for moderate risk, and red color for high risk.

The purpose of the tool development is actually for decision support. According to being the high risk area by prediction of a given sub–district and season, the effected seasons in the near future can be theoretically speculated. Then, the possible indexes and environmental conditions can be reasonably varied referred to the basic data to obtain low risk rating. The indexes obtained can be used as a target for implementation as a prevention and control policy of a specific season and year. The result can be printed by clicking at the printer icon.

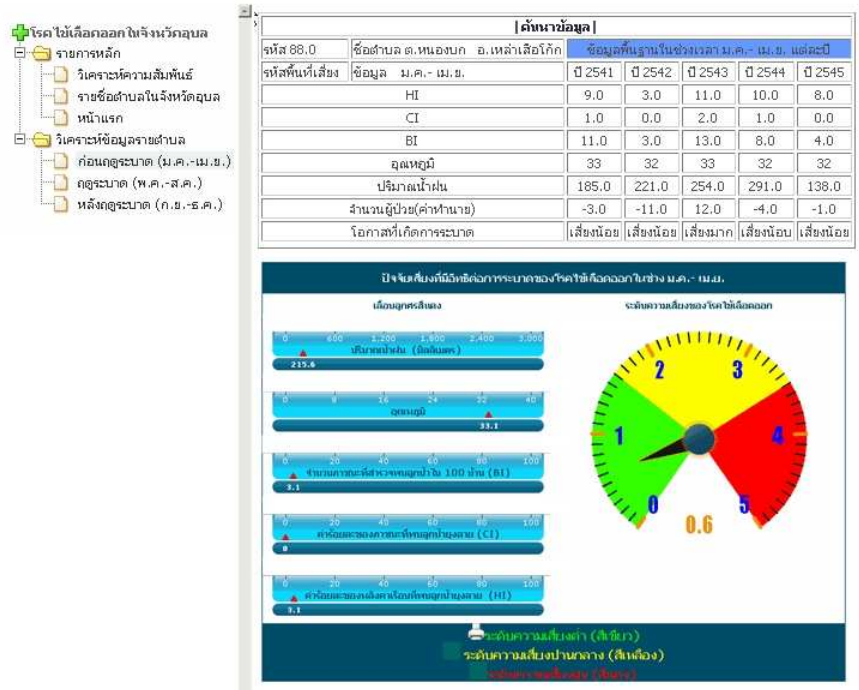


Figure 5.25 Risk rating meter showing indexes and environmental conditions influencing the risk level of DF/DHF occurrence.

5.3.3 The administrator interface

The system was designed using DBMSs which are the MySQL and Microsoft access 2003 for managing GIS database in forms of non–spatial and spatial data. The system was developed to provide interfaces for system administrator and authorized users to be able to manage and use DF/DHF database according to their rights. The system developed also contains codes for database manipulation and model operation functions. Moreover, the system was designed to allow administrator to back up data and to generate reports from all contents as hard copy.

Figure 5.26 Login form of an administrator.

An administrator can access the system by enter username and password (Figure 5.26). The system will then verify this information with the user database. If it is positive, the system will return different page according to group of users. For example the page shown in Figure 5.27 is the main menu of the back–end system for the system administrator. In the page, there are tabs for the administrator to select group of data for viewing and manipulating.

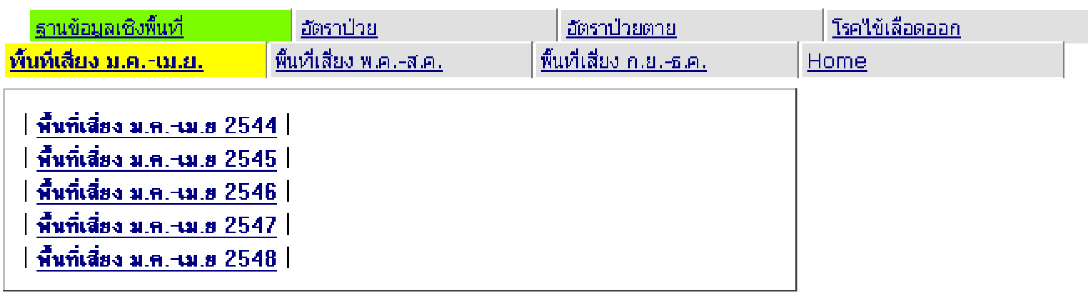


Figure 5.27 Main menu of the system for an administrator.

An administrator can add, delete and edit DF/DHF and GIS databases. The back–end system is composed of database, its manipulate functions (add, update, delete, save, and search), and spatial DF/DHF models' operation functions. Seasonal risk areas from the list can be viewed as an example in Figure 5.28.

แสดงข้อมูลพื้นที่เสี่ยงตำบล (ม.ค.-เม.ย.) ปี 2544

admin login | หน้าแรก | ข้อมูลอำเภอ |ข้อมูลหมู่บ้าน |ค้นหาข้อมูลตำบล | admin

ลำดับที่	รหัสตำบล	ชื่อตำบล	ชื่ออำเภอ	รหัสพื้นที่เสี่ยง	ช่วงเดือน	ค่า HI	ค่า CI	ค่า BI	ค่า T	ค่า PR	ค่า Y	โอกาสแพร่ระบาด
1	1.0	ต.หนองสิม	อ.เขมราฐ	1.0	1.0	22.0	223.0	33.0	34.0	44.0	323.0	1

Figure 5.28 A record of sub–district data during January–April.

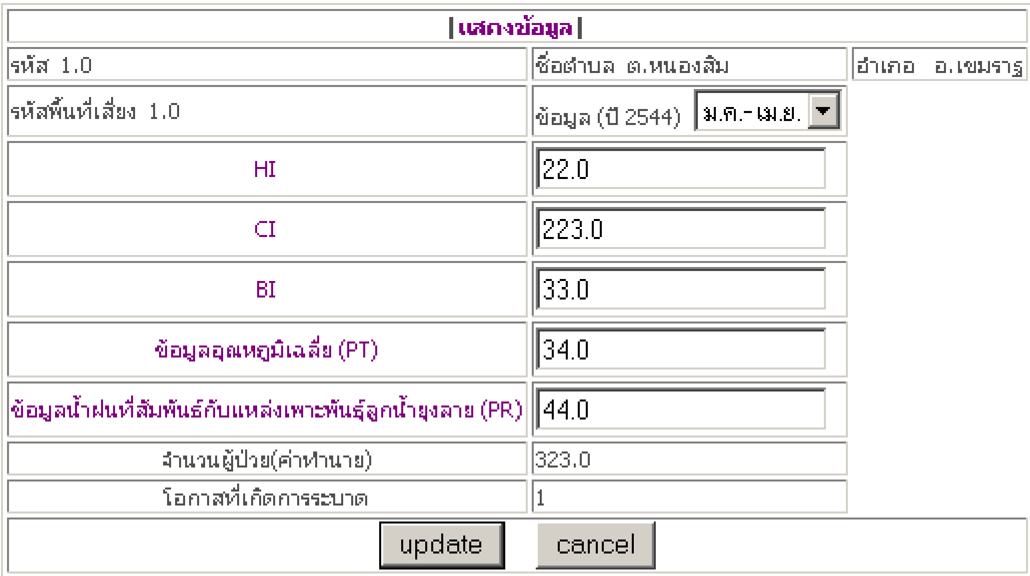


Figure 5.29 Page of spatial DF/DHF model operation on a sub–district.

The following Figure 5.29 can further display data of any sub–districts by clicking at the record (as shown in Figure 5.28). The model operation can be activated by clicking the update button and the result returns in another page as shown in Figure 5.30.

Figure 5.30 Report prediction of DHF epidemic.

When the page of the model operation is updated, all data belong to the sub–district are gathered and the model is performed to analyze. The model results provide information that, during January–April 2001, Nhongsim sub–district of Khemarat district is determined to be low risk area.

5.4 Results of system implementation

The unit testing (statement, condition, and estimation) for the model was done for debugging error. The system testing was done for system performance. The result of testing can be summarized as follows:

5.4.1 Results of unit test

1) *Statement testing* was operated herein as an example of the coding for a part of the estimation of the probability related to temperature data (P_T).

```
echo "ช่วงเดือน=",$month,"<br>";
if ($month=="1" AND $T < 28 )
{$ST=$T;
echo "   มกราคม–เมษายน  PT=0.59*1.5*อุณหภูมิเฉลี่ย=
",$PT=0.59*1.5*$ST,"<br>";}
elseif ($month=="1"  AND $T >=28 && $T <=29 )
{$ST=$T;
echo "   มกราคม–เมษายน  PT=0.59*3*อุณหภูมิเฉลี่ย=
",$PT=0.59*3*$ST,"<br>";}
elseif ($month=="1"  AND $T >=31 && $T <=35 )
{$ST=$T;
echo "   มกราคม–เมษายน  PT=0.59*3*อุณหภูมิเฉลี่ย=–
```

```
",$PT=0.59*3*$ST,"<br>";}
elseif ($month=="1"  AND $T>35)
{$ST=$T;
echo "   มกราคม-เมษายน  PT=0.59*1.5*อุณหภูมิเฉลี่ย=17
",$PT=0.59*1.5*$ST,"<br>";}
elseif ($month=="1" AND $T=30)
{$ST=$T;
echo "   มกราคม-เมษายน  PT=0.59*4*อุณหภูมิเฉลี่ย=
",$PT=0.59*4*$ST,"<br>";}
if ($month=="2"  AND $T < 28 )
{$ST=$T;
echo "   พฤษภาคม-สิงหาคม  PT=0.68*1.5*อุณหภูมิเฉลี่ย=25
",$PT=0.68*1.5*$ST,"<br>";}
elseif ($month=="2" AND $T >=28 && $T <=29 )
{$ST=$T;
echo "   พฤษภาคม-สิงหาคม  PT=0.68*3*อุณหภูมิเฉลี่ย=29
",$PT=0.68*3*$ST,"<br>";}
elseif ($month=="2" AND $T >=31 && $T <=35 )
{$ST=$T;
echo "  พฤษภาคม-สิงหาคม  PT=0.68*3*อุณหภูมิเฉลี่ย=33
",$PT=0.68*3*$ST,"<br>";}
elseif ($month=="2" AND $T>35)
{$ST=$T;
```

```
echo "   พฤษภาคม–สิงหาคม  PT=0.68*1.5*อุณหภูมิเฉลี่ย=
",$PT=0.68*1.5*$ST,"<br>";}
elseif ($month=="2" AND $T=30)
{$ST=$T;
echo "   พฤษภาคม–สิงหาคม  PT=0.68*4*อุณหภูมิเฉลี่ย=
",$PT=0.68*4*$ST,"<br>";}
if ($month=="3" AND $T < 28 )
{$ST=$T;
echo "   กันยายน–ธันวาคม  PT=0.42*1.5*อุณหภูมิเฉลี่ย=
",$PT=0.42*1.5*$ST,"<br>";}
elseif ($month=="3" AND $T >=28 && $T <=29 )
{$ST=$T;
echo "   กันยายน–ธันวาคม  PT=0.42*3*อุณหภูมิเฉลี่ย=
",$PT=0.42*3*$ST,"<br>";}
elseif ($month=="3" AND $T >=31 && $T <=35 )
{$ST=$T;
echo "   กันยายน–ธันวาคม  PT=0.42*3*อุณหภูมิเฉลี่ย=
",$PT=0.42*3*$ST,"<br>";}
elseif ($month=="3" AND $T>35)
{$ST=$T;
echo "   กันยายน–ธันวาคม  PT=0.42*1.5*อุณหภูมิเฉลี่ย=
",$PT=0.42*1.5*$ST,"<br>";}
elseif ($month=="3" AND $T=30)
```

```
59 {$ST=$T;
60 echo "   กันยายน–ธันวาคม  PT=0.42*4*อุณหภูมิเฉลี่ย=
61 ",$PT=0.42*4*$ST,"<br>";}
62 $SW=$WHI+$WCI+$WBI;
63 $SWX=($HI*$WHI)+($CI*$WCI)+($BI*$WBI);
64 $index=$SWX/$SW;
```

The result of statement testing shown in Table 5.9 states that, from 3 testing with varying input, all 64 statements were selectively checked depending on the conditions chosen by input values. For 5 input values of each test, all statements were operated for 20 checking loops. All loops returned correct answers.

Table 5.9 Report of statement testing.

No testing	**Input**	**Executed Statement**	**Check**	
			Number	**Justified**
1	1,10,4,20,34	1,2,3,4,5,6,7,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,3334,35,36, 37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53, 54,55,56,57,58,59,60,61,62,63,64	20	20
2	2,2,3,12,33	1,2,3,4,5,6,7,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,3334,35,36, 37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53, 54,55,56,57,58,59,60,61,62,63,64	20	20
3	3,14,6,24,32	1,2,3,4,5,6,7,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,3334,35,36, 37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53, 54,55,56,57,58,59,60,61,62,63,64	20	20

2) *Condition testing* expressed herein is an example for a part of codes (shown below) for choosing priority of transmission from specific HI values (see Table 3.2).

```
if ($HI >=1 && $HI <=3)
{$WHI=1;}
elseif ($HI >=4 && $HI <=7 )
{$WHI=2;}
elseif ($HI >=8 && $HI <=17 )
{$WHI=3;}
elseif ($HI >=18 && $HI <=28 )
{$WHI=4;}
elseif ($HI >=29 && $HI <=37 )
{$WHI=5;}
elseif ($HI >=38 && $HI <=49 )
{$WHI=6;}
elseif ($HI >=50 && $HI <=59 )
{$WHI=7;}
elseif ($HI >=60 && $HI <=76 )
{$WHI=8;}
else
{$WHI=9;}
```

This test can be set up as a control flow displayed in Figure 5.31. Input with known answer is used for condition testing. The flow has 9 branches and 8 conditions due to the number of priority of transmission. Details were reported in Appendix G.

3) *Estimation testing* was operated by comparing results from the model estimation such as laval indexes, predicted number of cases, epidemic probability of DF/DHF, NPIC etc. to the ones from manual estimations. The comparison of testing results shows 100 % accuracy of the model estimations.

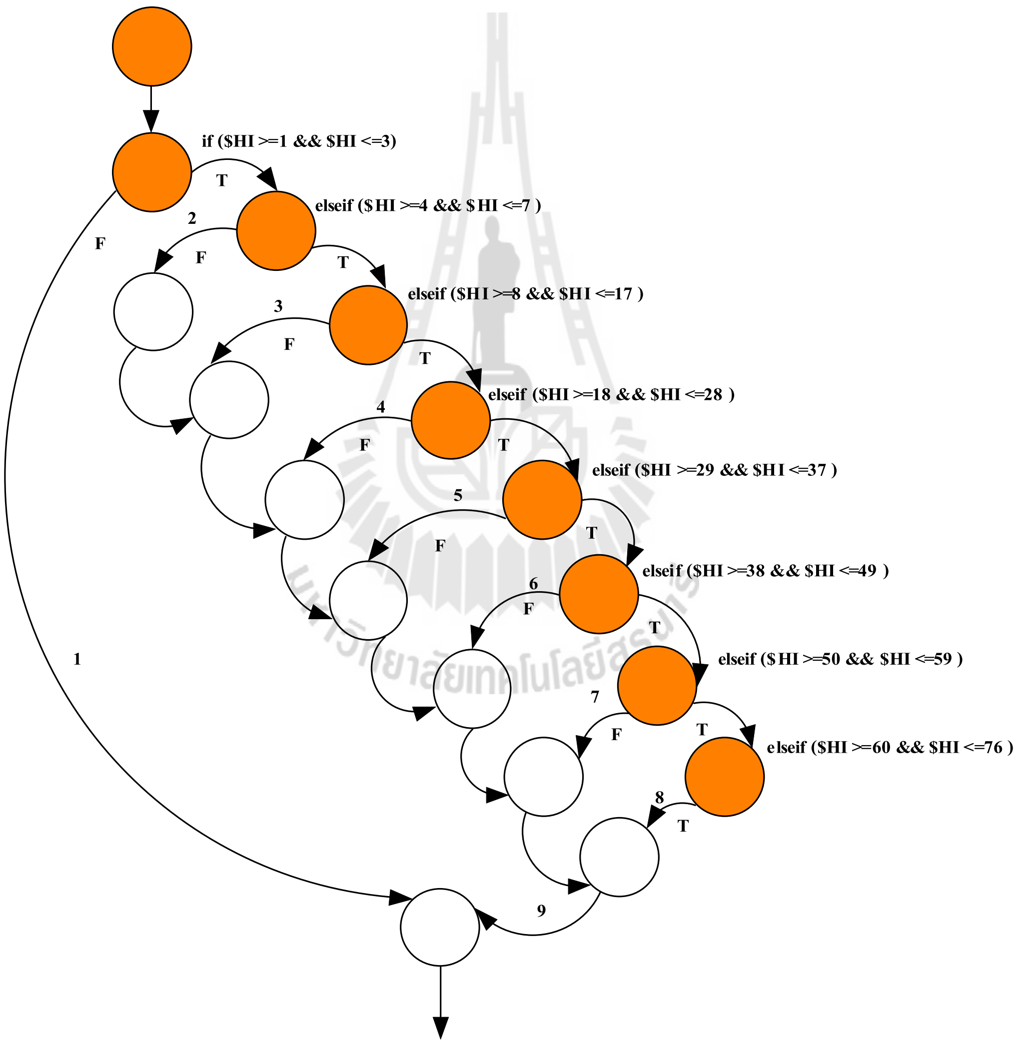


Figure 5.31 Control flow of condition testing.

5.4.2 Results of the system testing

The purpose of the system testing is to evaluate the degree of system acceptance by users. The questionnaires of 4 testing (see Appendix H) were assigned to 50 officers who were working for the District Office of the Public Health. The questionnaires were adapted from Lewis (1995). Each question is a statement required an answer with one rating from five–point scale (1 to 5). The five–point scale to evaluate covers poor, acceptable, good, very good, and excellent. The translation standard used is as follows:

Average point 1.00–1.50 means "Poor"

Average point > 1.50–2.50 means "Acceptable"

Average point > 2.50–3.50 means "Good"

Average point > 3.50–4.50 means "Very good"

Average point > 4.50–5.00 means "Excellent"

The questionnaires used were as follows: 1) Functional requirement test, 2) Usability test, 3) Function test, and 4) Security test. The distributions of average scores on questions of each test are shown in Table 5.10–5.13.

Table 5.10 Functional requirements test.

ID	**Assessment**	$\bar{x}$	**Usability Level**
1	Available storage data and display reports of the system	4.18	Very good
2	The easiness to be used for the disease control in views of overall organization	4.04	Very good
3	The information provided for practice level	4.38	Very good
4	The information provided for administration level	4.32	Very good

Result from the Table 5.10, the average point of overall system satisfaction is 4.2 and its usability level is "Very good".

Table 5.11 Usability test.

ID	Assessment	$\bar{x}$	Usability Level
5	Completeness of data in database	3.96	Very good
6	Completeness of update and edit	4.0	Very good
7	Completeness of search	4.02	Very good
8	Completeness of represented GIS layers	3.90	Very good
9	Requirement corresponding capability of the system	3.98	Very good
10	Accuracy of statistic calculation of HI and CI	4.7	Excellent
11	Completeness in help menu	4.12	good
12	Completeness in report and printing	4.42	good
13	Providing clear error messages and problem resolution	3.34	good
14	The design of buttons covering context and positions	3.86	Very good
15	Information and friendliness provided for all levels of users	3.94	Very good

Result from the Table 5.11, the average point of overall system satisfaction is 3.8 and its usability level is "Very good".

Table 5.12 Functions test.

ID	Assessment	$\bar{x}$	Usability Level
16	Easiness to learn and use this website.	3.98	Very good
17	Comfort in using this website.	4.04	Very good
18	The symbols and pictures provided in the website are clear and easy to understand.	4.0	Very good
19	The information (such as online help, on–page messages, and other documentation) provided by website is easy to understand.	3.9	Very good
20	The overall screen layout and window design of the system is appropriate and easy.	4.14	Very good
21	Terminology used in this website is clear.	4.0	Very good
22	The interface (such as color, font) of this website is pleasant.	4.2	Very good

Result from the Table 5.12, the average point of overall system satisfaction is 4.07 and its usability level is "Very good".

Table 5.13 Security test.

ID	Assessment	$\bar{x}$	Usability Level
23	Authority verification of all levels of users	4.0	Very good
24	Ability to log on to the website	3.92	Very good
25	The overall security of the system	3.90	Very good

Result from the Table 5.13, the average point of overall system satisfaction is 3.94 and its usability level is "Very good".

Conclusively, the overall reliability and capabilities of system testing is 4.0 and its usability level is "Very good".

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

The objectives of this study are to develop spatial model of DF/DHF epidemic surveillance in Ubon Ratchathani province and to develop the web-based SDSS for DF/DHF epidemic prediction and advising dynamic implementation. The procedure and results obtained from the study which are updated with time through web-based service will help in establishing preventive measures applied on sensitive areas according to risk priority at proper time. This chapter covers conclusive contexts in 1) prediction of DF/DHF epidemic of sub-districts in the study area, 2) relationship of high risk areas and adjacent areas, 3) the web–based SDSS for DF/DHF epidemics and 4) recommendations for further study.

6.1 Prediction of DF/DHF epidemic of sub–districts

Steps of epidemic DF/DHF model developed can be listed and concluded as follows.

1) Larval indices (HI, CI, BI) and climatic data during 2001–2005 of each sub-district in the study area were used as input into the model developed.
2) Normalized HI, CI and BI, seasonal normalized and interpolated rainfall, rainy day, and average temperature data were prepared in terms of effects of larvae indices (using linear weighted transformation) and climatic data (such as probability related to temperature (P_T), probability related to rainy season (P_R)).

3) They were input into the regression model of DF/DHF epidemics and resulted in predicted number (*y*) of DF/DHF cases, which were further transformed to be probability (*P*) using logistic regression.
4) *P* of each sub-district was ordinal classified to be low, medium, high using Delphi technique and compare to the conventional method (Table 3.3).
5) According to the accuracy obtained from the comparison, Hypothesis 0 was accepted. However, only the last season of the year 2005 and seasons of the year 2006 show low correlation. The reason for this is explained in Chapter IV.
6) Consistent to the epidemic theory, the model can be used to predict the epidemic influence to the next season (Figure 1.2) and to the same season/period next year as mentioned in Chapter I (1.2).
7) Resulting risk maps of DF/DHF of each sub-district based on seasons are useful information for planners in short and long terms allocating extra resources within health budgets for epidemic prevention and control activities.

6.2 Relationship of high risk areas and adjacent area

In order to evaluate the effect from the high risk sub–districts to surrounding sub–districts, the gravity model was applied.

1) Probability (*P*) from logistic regression and populations during 2001–2005 of each sub–district including distance between centroids of high risk areas and adjacent areas were prepared.
2) They were input into the gravity model to estimate the relationship and resulted in interaction volume (I_{ij}) of high risk area (*i*) and its adjacent areas (*j*).

3) Number of DF/DHF cases in high risk areas and adjacent areas expressed their correlation. They were used to assess the correlation coefficient (r_{ij}).
4) I_{ij} and r_{ij} of high risk areas and adjacent areas were input into the time-series forecasting method and resulted in the product of interactive correlation (Y_t). They were normalized to be in terms of the Normalized Product of Interactive Correlation (NPIC), which were further averaged (as E) for each adjacent area (Table 4.10).
5) Error obtained from the MAPE (explained in 4.2) was 36% or the accuracy is 64%. The error is less than 50%. Therefore, Hypothesis 1 can be accepted.
6) Resulting risk maps of epidemic effect from high risk areas to adjacent areas based on seasons could help in development of network team of disease surveillance. This will increase efficiency in directing measures spatially and properly.

6.3 The Web–Based SDSS for DF/DHF epidemics

This research presents a design and implementation of a system on open source software environment (*MapServerPHP*) such as Minnesota MapServer, PHP Map Script, and MySQL to linking spatial data to work on the internet.

First of all, sub–district data (i.e. political administrative boundary) were transformed to be GIS data layer using GIS software. The seasonal GIS data with attributes of HI, CI, BI, and climatic data have been presented on the website. These data were processed and obtained resulting maps in GIS format.

The web–based SDSS for DF/DHF epidemics were developed using *MapServerPHP*. This is a program for managing GIS data to present on website.

The step was input each layer, such as administrative boundaries, villages, etc.;

categorized layer choice using PHP Map Script (Figure 5.11) with map file (Figure 5.13-5.16); linked GIS database and other database managers based on MySQL.

This web–based SDSS shows maps with HTML viewer available in *MapServerPHP* because it would downloads files faster.

In addition, the website provides tools such as zoom in, zoom out, pan, identifies, find, etc. as shown in Figure 5.10, using JAVA language for development.

After analysis the website shows which sub-district falls into either high or medium or low risk to DF/DHF (Figure 5.21–5.23) including E or average NPIC of the adjacent areas (Figure 5.19).

The web–based SDSS developed also provides advising guideline for administrators and health officers to make decision, plan, set up policy, and implement to prevent and control DF/DHF (Figure 5.20).

This web site was user-friendly designed and developed.

6.4 Recommendations for further study

Making a good prediction and accurate epidemic forecasting models would markedly improve epidemic prevention and control capabilities. However, to achieve better results in applying the models, the limitation provided as the followings should be aware and improved for further study.

1) These predictions from the models respond well in high incidence period (May to August) but not cover epidemic from flood event.
2) Accuracy of climatic data due to limited meteorological stations can affect estimation accuracies of probability related to temperature (P_T) and rainy season (P_R).

3) The number of sub–district health officers involved in the operation to prevent and control DF/DHF can affect estimation accuracies of *Index values* (HI, CI and BI) of each season, which in turn affect the prediction accuracy of the model.

4) The better result could be expected, if *Index value* estimation (Equation 4) could include serological of mosquito**.**

5) If humidity factor, which influences the seasonal transmission of dengue virus, is added as input data, the better result could be expected (Reiter, 2001).

6) Research design in epidemiology which regards villages as spatial units for modeling is expected to provide more accuracy on the influence of infection in space and time due to long term original recording of cases in villages.

7) The model herein will not respond well to a high-populated area such as a big urban area with rapid growth. The higher accuracy can be expected if such an area could be study separately.

8) Additional variables such as land-use zones, population density and growth, crowding and poverty, disease control programs, etc. should be incorporated into the forecasting model.

9) To be successful and avoiding conflict of policy, the start of system implementation should be applied to a small area where cases are continuously and repetitively occurred.