STUDY OF POTENTIAL RISK OF CHIKUNGUNYA FEVER OUTBREAK IN SURATTHANI PROVINCE USING GIS AND STATISTICAL MODELLING

SUCHART AOOCHAY

**A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE
(TECHNOLOGY OF INFORMATION SYSTEM MANAGEMENT)
FACULTY OF GRADUATE STUDIES
MAHIDOL UNIVERSITY
2013**

Thesis
entitled

STUDY OF POTENTIAL RISK OF CHIKUNGUNYA FEVER OUTBREAK IN SURATTHANI PROVINCE USING GIS AND STATISTICAL MODELLING

……………………….…….……..……….
Mr. Suchart Aoochay
Candidate

……………………….…….……..……….
Lect.Waranyu Wongseree, Ph.D.
Major advisor

……………………….…….……..……….
Lect. Supaporn Kiattisin, Ph.D.
Co-advisor

……………………….…….……..……….
Asst.Prof. Bunlur Emaruchi, Ph.D.
Co-advisor

……………………….…….……..……….
Prof. Banchong Mahaisavariya,
M.D., Dip Thai Board of Orthopedics
Dean
Faculty of Graduate Studies
Mahidol University

……………………….…….……..……….
Lect. Supaporn Kiattisin, Ph.D
Program Director
Master of Science Program in
Technology of Information System
Management
Faculty of Engineering
Mahidol University

Thesis
entitled
STUDY OF POTENTIAL RISK OF CHIKUNGUNYA FEVER OUTBREAK IN SURATTHANI PROVINCE USING GIS AND STATISTICAL MODELLING

was submitted to the Faculty of Graduate Studies, Mahidol University
for the degree of Master of Science
(Technology of Information System Management)
on
May 15, 2013

……………….…………..………
Mr. Suchart Aoochay
Candidate

……………….…..………………
Lect. Pichitpong Soontornpipit, Ph.D.
Chair

………………….…..……………..…
Lect. Supaporn Kiattisin, Ph.D.
Member

………………….…..……………….…
Lect. Waranyu Wongseree, Ph.D.
Member

………………….…..……………..…
Asst.Prof. Worasit Choochaiwattana, Ph.D.
Member

………………….…..………………..
Asst.Prof. Bunlur Emaruchi, Ph.D.
Member

………………….…..……………..…
Prof. Banchong Mahaisavariya, M.D., Dip Thai Board of Orthopedics
Dean
Faculty of Graduate Studies
Mahidol University

………………….…..……………..…
Lect. Worawit Israngkul, M.S.
Dean
Faculty of Engineering
Mahidol University

ACKNOWLEDGEMENTS

The success of this paper can be attributed to the extensive support and assistance from my major advisor, Lect. Waranyu Wongseree, Ph.D His encouragement, valuable advice and guidance in this paper.

I would like to thank Lect. Pichitpong Soontornpipit, Ph.D. for his support as my co–advisor, Lect. Supaporn Kiattisin, Ph.D. and Asst.Prof. Bunlur Emaruchi. Ph.D. for advices. Moreover, I would like to acknowledge Meteorological station staff and officer at the town hall Suratthani province for providing the data in this paper.

My thanks also go to all lecturers of Technology Information System Management in Faculty of Engineering, Mahidol University for their valuable advices.

Finally, I am grateful to my family for their entire support. I dedicate to my mother, my father, and all teachers who have taught me since my childhood.

Suchart Aoochay

STUDY OF POTENTIAL RISK OF CHIKUNGUNYA FEVER OUTBREAK IN SURATTHANI PROVINCE USING GIS AND STATISTICAL MODELLING

SUCHART AOOCHAY 5136042 EGTI/M

M.Sc. (TECHNOLOGY OF INFORMATION SYSTEM MANAGEMENT)

THESIS ADVISORY COMMITTEE: WARANYU WONGSENEE, Ph.D., SUPAPORN KIATTISIN, Ph.D., BUNLUR EMARUCHI, Ph.D.

ABSTRACT

This study aims to describe the potential risk areas by using Geographic Information Systems (GIS) to create maps displaying area at risk of Chikungunya Fever (CHIKV) epidemics in Surat thani province and to study the relationship between CHIKV incidences with environmental factors by multiple regression analysis. This research divided the factors into three environmental factors including; total annual rainfall, average annual temperature and average annual air pressure. For studying risk areas by three epidemic factors, the study represents epidemic measures index consisting of classification. The high risk areas included Phanom district, Vibhavadi district, Ban Na San district, Phrasaeng district, Kanchanadit district and Chai Buri district. The spatial autocorrelation of all environmental factors is classified into patterns. The factor of air pressure is the clustering pattern. However, the factor of rainfall and temperature are the random pattern.

In the analysis of the relationship between CHIKV incidence with environmental factors, the Correlation Coefficient is 0.59 ($r = 0.59$). The result from this study, shows potential risk factors and Geographic Information Systems (GIS) can be used to assess the risk for the outbreaks of CHIKV and plan, control and prevent the outbreak of CHIKV. Furthermore, this information can be applied to health care in the future. That can be reduce the spread and disease severity rate of Chikungunya Fever as well as other vector – borne diseases.

KEY WORDS: CHIKUNGUNYA FEVER / SURATTHANI / GIS / STATISTICAL MODELLING

61 pages

การศึกษาความเสี่ยงที่จะเป็นไปได้ในการระบาดของโรคชิคุนกุนยา ในจังหวัดสุราษฎร์ธานี โดยใช้ระบบสารสนเทศทางภูมิศาสตร์ และรูปแบบทางคณิตศาสตร์

STUDY OF POTENTIAL RISK OF CHIKUNGUNYA FEVER OUTBREAK IN SURATTHANI PROVINCE USING GIS AND STATISTICAL MODELLING

สุชาติ อู่ฉาย 5136042 EGTI/M

วท.ม. (เทคโนโลยีการจัดการระบบสนเทศ)

คณะกรรมการที่ปรึกษาวิทยานิพนธ์: วรัญญู วงษ์เสรี, Ph.D., สุภาภรณ์ เกียรติสิน, Ph.D.,
บันลือ เอมะรุจิ, Ph.D.

บทคัดย่อ

การศึกษาครั้งนี้มีวัตถุประสงค์เพื่ออธิบายพื้นที่เสี่ยงที่อาจเกิดขึ้นโดยใช้ระบบสารสนเทศภูมิศาสตร์ เพื่อสร้างแผนที่แสดงพื้นที่ที่มีความเสี่ยงต่อการระบาดของโรคชิคุนกุนยา ในจังหวัดสุราษฎร์ธานีและศึกษาความสัมพันธ์ระหว่างอัตราการเกิดโรคชิคุนกุนยา กับปัจจัยทางด้านสภาพแวดล้อมโดยใช้วิธีการวิเคราะห์การถดถอยพหุคูณในการวิเคราะห์ข้อมูล อย่างไรก็ตาม ในงานวิจัยนี้ได้แบ่งปัจจัยที่เกี่ยวข้องออกเป็นสามปัจจัยประกอบด้วย ปริมาณน้ำฝน อุณหภูมิเฉลี่ยและความกดอากาศเฉลี่ยต่อปี สำหรับการศึกษาปัจจัยเสี่ยงทั้งสามปัจจัยนั้นได้ใช้ดัชนีการวัดการระบาดของโรคด้วยการแบ่งกลุ่มของพื้นที่ ซึ่งพบว่าพื้นที่มีความเสี่ยงสูง คือ อำเภอพนม อำเภอวิภาวดี อำเภอบ้านนาสาร อำเภอพระแสง อำเภอกาญจนดิษฐ์และอำเภอชัยบุรี การศึกษาความสัมพันธ์เชิงพื้นที่ของปัจจัยสภาพภูมิอากาศพบว่า ปัจจัยด้านความกดอากาศมีรูปแบบการกระจายแบบกลุ่ม ส่วนปัจจัยด้านปริมาณน้ำฝนและปัจจัยด้านอุณหภูมิมีรูปแบบการกระจายแบบสุ่ม

ในการวิเคราะห์ความสัมพันธ์ระหว่างการเกิดโรคชิคุนกุนยาที่มีปัจจัยทางด้านสภาพแวดล้อมพบว่า มีค่าสหสัมพันธ์เท่ากับ 0.59 ผลจากการศึกษาในครั้งนี้ พบว่าปัจจัยทางด้านสภาพแวดล้อม และ ระบบสารสนเทศภูมิศาสตร์สามารถนำมาใช้ในการประเมินความเสี่ยงของการแพร่ระบาดของโรคชิคุนกุนยาได้ และนอกจากนี้ยังนำไปสู่การวางแผน ควบคุมและป้องกันการระบาดของโรคชิคุนกุนยาได้ ยิ่งไปกว่านั้นข้อมูลสารสนเทศเหล่านี้ยังสามารถนำไปประยุกต์ใช้เพื่อการดูแลรักษาในอนาคตได้อีกด้วย โดยสามารถ ลดการแพร่ระบาด และอัตราความรุนแรงของโรคชิคุนกุนยา ได้เช่นเดียวกับโรคติดต่อที่นำโดยแมลงอื่นๆ

61 หน้า

CONTENTS

CONTENTS (cont.)

CONTENTS (cont.)

LIST OF TABLES

LIST OF FIGURES

CHAPTER I
INTRODUCTION

1.1 Background and problem statement

Thailand is one of several countries which were reported Chikungunya Fever outbreaks in Asia.Chikungunya Fever is a re-emerging in Thailand which outbreak was recorded in 1960, 1962-1964, 1988, 1991-1993, 1995, 2008 and 2009 (Powers and Logue, 2007)

Chikungunya Fever is a viral disease transmitted by Aedes mosquitoes. The disease presented as fever associated with rash later followed by debilitating joint pains. (Florida Medical Entomology Laboratory, 1999) The probable vector is *Aedes albopictus*, a mosquito species endemic in the current Indian Ocean and *Aedes aegypti*, a mosquito species endemic in Asian. In Asia, Chikungunya virus is transmitted to humans mainly by *Aedes aegypti* and to lesser extent by *Aedes albopitus* through an urban transmission cycle. (WHO, 2009)

Situation of Chikungunya fever in Suratthani province in 2009, Bureau Epidemiology, Suratthani provincial Public health office reported 2,616 CHIKV patients morbidity rate 267.85 per 100,000 people. There are no reported of mortality. Three Districts of patients reporting the most is Phasang district report 580 patients morbidity rate 1,095.24 per 100,000 people, Panom district reports 545 patients morbidity rate 1,863.24 per 100,000 people and Ban Nasan district reports 519 patients morbidity rate 776.79 per 100,000 people, respectively. (Bureau of Epidemiology, 2009). In 2010, Suratthani have been reported 168 CHIKV patients morbidity rate 16.90 per 100,000 people. Although, Chikunkunya fever in Suratthani province is remain in top five of vector – borne diseases and most common in the south region of Thailand.

Geographic Information System (GIS) is the best alternative application to accommodate the solving of the problem with statistical analysis of spatial characteristics of a disease. Otherwise, these applications help to planning and suggestion in control, surveillance and monitoring of CHIKV outbreak in risk area of Suratthani province.

1.2 Objectives

1. To description Chikungunya Fever outbreaks in Suratthani province.
2. To study spatial autocorrelation of environmental factors with Chikungunya Fever in Suratthani province.
3. To develop regression model associated with the disease to the prevention and management control Chikungunya Fever.

1.3 Scope of study

The research areas are districts in Suratthani province that have Chikungunya Fever outbreak continuously during January 2009 – December 2009.

1.4 Expected Result

The information that applied from Geographic Information System (GIS) based information system for supporting decision, preventing and controlling Chikungunya Diseases outbreaks in Suratthani province.

CHARPTER II
LITERATURE REVIEW

The literature review on the concepts and research is consists of six parts: study site, epidemic of Chikungunya Fever, Geographic Information System, interpolation method, spatial autocorrelation method, the regression method and related research.

2.1 Study Site

SuratThani province, the largest province of the South located 685 kilometers from Bangkok is SuratThani the province with a name that literally means "City of the Good People". A former capital of the Srivijaya Empire, the province covers an area of approximately 12,891 square kilometers. SuratThani Province borders the Gulf of Thailand to the north and east, Chumphon Province to the north, Nakhon Si Thammarat and Krabi Provinces to the south, Phang-Nga and Ranong Provinces to the west and Nakhon Si Thammarat Province to the east.

The province is subdivided into 19 districts (Amphoe), which are further subdivided into 131 subdistricts (tambon) and 1028 villages (muban).High plateaus and forested mountains are located to the west of the province, while there are low basins in the center and along the eastern coast Figure 2.1. This topography has created 14 river basins including Tapee, PumDuang, Tha Thong, ThaKrajai, Chaiya, Tha Chang which are the most important basins. All rivers in SuratThani flow east of the province to the Gulf of Thailand.

Climate in Suratthani province is tropical monsoon, receiving influence of the northeast monsoon and southwest monsoon. Temperature are unchangeable until throughout the year. The pre – monsoon months are in March – May, which had highs temperature. The rainy season starts from May to December and heaviest rains occur in October and November.

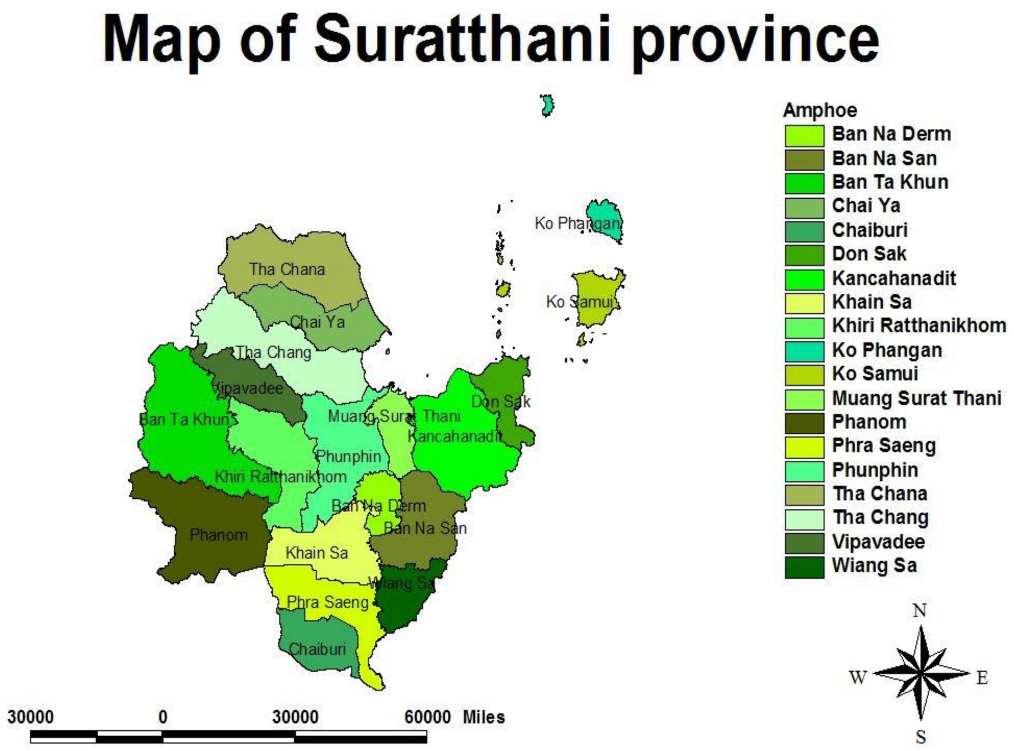

Figure 2.1 Surat Thani Province's Boundary

2.2 Epidemic of Chikungunya Fever

2.2.1 Epidemiology

In the South-East Asia Region, Chikungunya virus contacted in human population by a human-mosquito-human transmission cycle that from the sylvatic. The highest vector density occur in the post monsoon season accentuates the transmission.

WHO South-East Asia Region, outbreaks were reported from India (1963, 1973, 2006 and 2007) Indonesia (1979, 1985, 2001 and 2003-2007), Myanmar (1975 and 1984), Maldives (2006-2007), Sri Lanka (1965 and 2006) and Thailand (1960, 1978, 1988 and 1995-1996). The outbreaks in the Region prior to 2000 were due to the Asian strain.

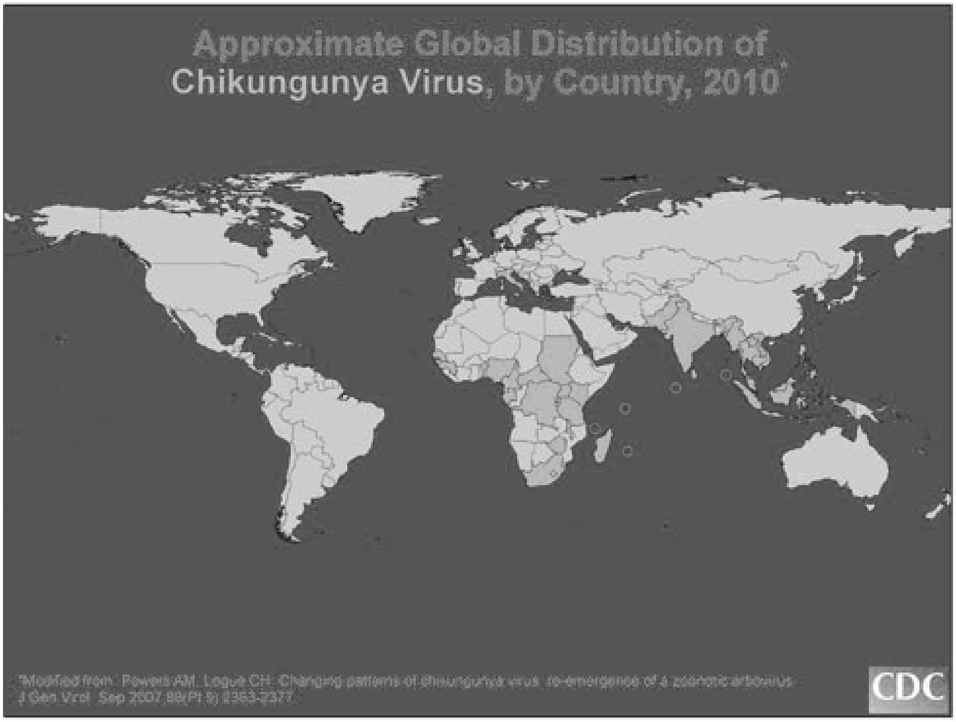

Figure 2.2 Geographical distribution of Chikungunya cases 2010

Source: Centers for Disease Control and Prevention,
http://www.cdc.gov/ncidod/dvbid/chikungunya/CH_GlobalMap.html. (25 Nov 2010)

Chikungunya (pronounced as chiki-en-gun-yah) Fever is caused by virus which is an RNA virus that belongs the *Alphavirus* genus of the Togaviridae, the family that comprises a number of viruses that are mostly transmitted by arthropods. The disease was reported first time in the form of outbreak in Tanzania. The name“Chikungunya” derives from a root verb in the Kimakonde langue meaning “that which bends up or "to become contorted", i.e. and describes the stooped appearance of sufferers with joint pain.

2.2.2 Causative agent

Chikungunya Fever is caused by arbovirus that belongs to the genusalphavirus under the Togaviridae family.It has a single-stranded RNA genome, a 60-70 nanometrediameter capsid and a phospholipids envelope. It is heat labile and sensitive to temperatures above 58 Celsius and also to desiccation. The virus was first isolated in 1952-1953 from both man and mosquitoes during an epidemic of fever that was considered clinically indistinguishable from dengue fever in Tanzania. Three lineages with distinct genotypic and antigenic characteristics have been identified: two phylogenetic groups, east-central-southern and West African groups from Africa; and the other Asian phylogroup.

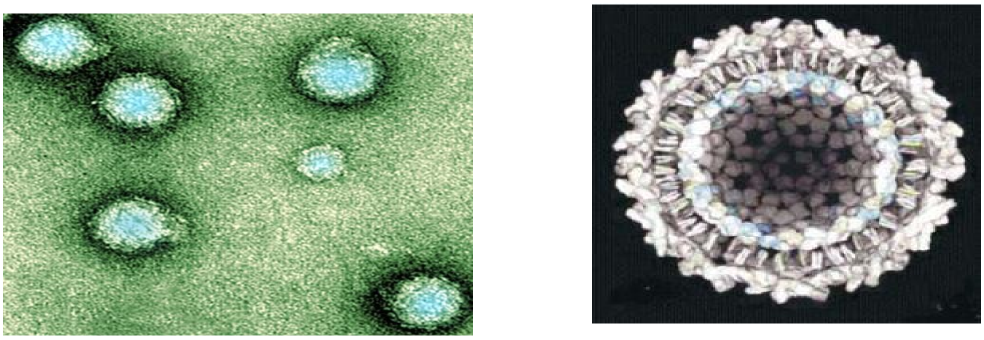

Figure 2.3 Chikungunya virus

Source: Ann M. Powers and Christopher H. Logue. (2007) Changing patterns of chikugunya virus: re-emergences of a zoonotic arbovirus. Journal of General Virology. 88; 2363-2377.

2.2.3 Vector

Chikungunya Fever is primarily transmitted by bites of mosquitoes of the genus *Aedes*. *Aedes aegypti* is the common vector responsible for transmission in urban areas. In rural areas has been implicated of *Aedes albopictus*. Only the female mosquitoes are infective. In Asia, *Aedes aegypti*is believed to be the principal vector responsible for transmission during human outbreaks. Although, in the recently *Aedes alboplictus*, the “Asian Tiger mosquito”, has been increasingly implicated in both urban and rural areas. This vector is far more resilient, able to survive in both rural and urban environments. As well as it has a much wider geographical distribution across the word.

The *Aedes* mosquitoes does not lay its eggs either in the water or on the surface of the water, as most other species do. Instead, A. aegypti lays its eggs above the water on the interior wall of the vessel containing the water so that when the water vessel is refilled, from the water line at which the mosquito laid its eggs to the lip of the vessel, the eggs will have enough time to complete their developmental cycle to adulthood before evaporation depletes the water source. A truly incredible evolutionary adaptation.

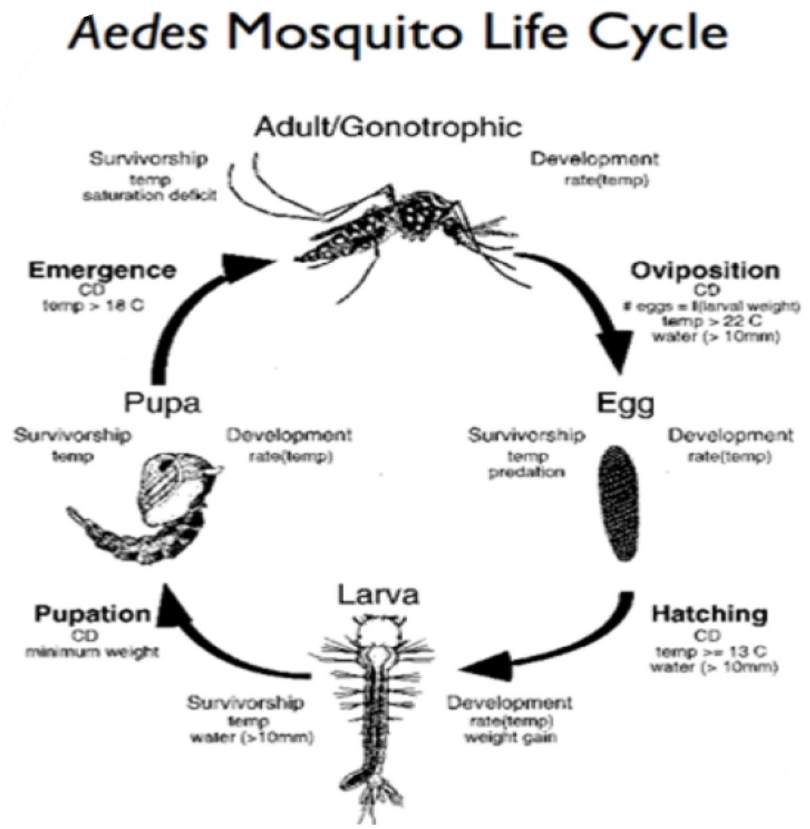

Figure 2.4 *Aedes* mosquito life cycle

Source: Hopp MJ and Foley J. Global-scale Relationships between Climate and the Dengue Fever Vector *Aedes Aegypti*. Climate Change. 2001; 48: 441-463

Environmental factors associated with the spread of mosquitoes, consist to Temperature, Mosquitoes are cold-blooded animals, so the temperature is an important variable in the life of a mosquito. When the environmental temperature is lower. Mosquitoes can be controlled with less physical. The optimum temperature for growth is between 25-27 degrees Celsius, but the growth of mosquitoes may be interrupted when the temperature is below 10 and above 40 degrees Celsius.

Humidity, humidity is an important factor for the spread. Mosquitoes are highly susceptible to drought. In the summer the mosquitoes are usually found in the home with high humidity. Outdoor mosquito to rest under a bush near the ground.

Daytime mosquitoes will rest peacefully in the damp cold. When the outside temperature drops at dusk. Mosquitoes are more active.

Rainfall influence the mosquitoes as well, depending on local conditions is important. If the area is flooded. The amount would be less because of mosquito breeding mosquitoes was carried out to the other. Reduce the spread of mosquitoes while. If the water level lowered as flood it. The spread of mosquitoes will increase.

Light influences mosquitoes in relation to blood feeding. The mosquitoes rest and most often at day in search of food or blood. But some time it will be bite, day and night. Especially for mosquitoes to fly or river water for spawning. Mosquitoes to fly in the morning to find a proper rest, depending on light intensity. And humidity are important.

The *Aedes* mosquitoes breed in domestic settings such as flower vases, water-storage containers, desert coolers, etc. and peri-domestic areas such as construction sites, coconut shells, discarded household junk items (vehicular tyres, plastic and metalcans, etc.). The adult female mosquito rests in cool and shady areas in settings of both domestic and peri-domestic. It bites during day time.

2.2.4 Clinical features

Chikungunya fever occurs in victim of all ages and both sexes. Symptoms of infection generally last for three to seven days after the patient has been bitten by an infected mosquito, the disease manifests itself after an average incubation period of 2-4 days (rage: 3-12 days). Commonest presenting features are: Had Fever (92%) usually association with Arthralgia (87%), Backache (67%) and Headache (62%).

In most session, fever and joint pains are almost universal at onset. The fever varies from grade to high grade, lasting for 24 to 48 hours and rise abruptly in some, reaching 39-40 C, with shaking chills and rigours. Fever is biphasic or saddle-back (fever subsides in two to three days and then come back after one day). Ankle, knee and wrist are the usual joints that are affected but the involvement of the small joints of hand and feet is also not uncommon. Other symptoms often reports was skin rash (40%-50% of case), the infection can result in meningoencephalitis (swelling of the brain), especially in newborns and those with pre-existing medical conditions.

Figure 2.5 Rash with according to the patient

Figure 2.6 Wrists and small joints

Source (**Figure 2.5, 2.6**): Courtesy of Dr. Thongchai Leartwilairatanapong, Narathiwat Provincial Health Office.

2.2.5 Prevention and control

Chikungunya fever is pending vaccine development for the prevention of Chikungunya. Treatment is therefore purely symptomatic. The outbreaks of Chikungunya fever consist of Chikungunya virus, risked patient or environment and vector. Prevented and controlled method can be done through anti-adult and anti-larva control of mosquito such as dengue fever prevented and controlled method which is the proper method before epidemic occurs.

WHO assigns four main methods of prevention and control vector-bound are

- Environmental management (most effective)
- Chemical control
- Biological control
- Integrated control.

2.2.5.1 Environmental Management

Environmental management is the most effective means of vector control. It is done with the objective of preventing or reducing the breeding of *Aedes* mosquitoes and human-vector contact.

Environmental management strategies focus on the destruction, modification, disposal or recycling of containers and natural larval habitats that produce most adult *Aedes* mosquitoes in each community.

These practices are best conducted concurrently with health education lesson and campaigns that encourage the community to participate actively in the execution of container management behavior (e.g. regular household sanitation or clean-up campaigns).

Methods for environmental management

Three environmental management methods prevent, control and reduce human-vector contact:

Improvement of water supply and storage: To control urban *Aedes* mosquitoes, the supply of water must be reliable and regular to reduce or eliminate the need for water storage containers. If water storage containers must be used, they should be well covered. Screen covers allow collection of rainwater but prevent adult mosquitoes from escaping.

Solid waste management: Reducing, reusing and recycling plastic containers and tyres otherwise left to lay dormant and collect water reduces potential larval habitats.

Modification of man-made larval habitats: Any man-made objects (bamboo fences, tyres, containers, buckets, roof gutters and outdoor sinks etc.) that retain water should always be covered or inverted.

2.2.5.2 Chemical Control

Chemicals or insecticides are widely used to control *Aedes* mosquitoes. DDT was used from the 1940s till early 1960s when resistance to DDT emerged. Currently, there are three methods of applying chemical control:

Larvicide application - used to treat household containers holding drinking water. These larvicides have extremely low toxicity and are safe for human consumption.

Perifocal treatment - uses sprayers to apply insecticides to larval habitats and surrounding areas. This not only destroys larval infestations but also kills adult mosquitoes. However, it should only be used around non-drinking water.

Space spraying - usually used in dengue outbreak emergencies. Microscopic vapours of insecticides are sprayed into to air to kill adult mosquitoes. This insecticide mist can be applied using portable machines, vehicle mounted generators or even helicopters and aircraft. An aerial spraying from an aircraft is mostly used to treat a large area fast and may be the most cost effective despite the high initial cost.

Chemical control technic: The indiscriminate use of insecticides should be discouraged. During low *Aedes* season, routine environmental management methods should be employed together with larvicide application.

Safety precautions for chemical control: Insecticides are toxic and safety precautions need to be observed. Reading instructions on pesticide labels, using safety gloves and masks, thorough washing of body and work clothes should all be performed.

Insecticide susceptibility monitoring: *Aedes* have developed resistance to some insecticides, as chemicals have been widely used to control mosquitoes over the past 40 years. Baseline data on insecticide susceptibility should be obtained before control methods are started and to continue monitoring susceptibility levels regularly.

Personal protection: Bed nets or curtains are effective against night-feeding mosquitoes. They are also useful for bedridden individuals and infants. Insect repellents and clothing impregnated with permethrin are also useful protection measures

2.2.5.3 Biological control

Fish that eat mosquito lava and the biocide, H-14 (BTI), are frequently utilized for the biological control of *Aedes* mosquito populations. Their advantages are that they are chemical free and specifically target mosquitoes. BTI is to be environmentally safe when used near drinking water.

2.2.5.4 Integrated control

Integrated control combines all the above methods into an effective and economical prevention and control plans against the *Aedes* mosquitoes.

2.3 The epidemiological measures

Epidemiologists study the occurrence of disease or other health-related conditions or events in defined populations. Viewed as the study of the distribution and societal determinants of the health status of populations, epidemiology is the basic-science foundation of public health.

Epidemiological measures of disease is the measures of disease occurrence are central to all epidemiological activity. Such measures can be formulated in a variety of ways:

1. absolute numbers and numbers related to size of the population
2. incidence and prevalence

Measures of prevalence describe what proportion of the population has the disease in question at one specific point in time. Prevalence is the total number of individuals who have a characteristic or disease at a particular point in time divided by the number who are at risk of having that characteristic or disease at that designated point in time. Prevalence depends on both the number of people who have had the disease or characteristic in the past and the duration of the disease or characteristic. Measures of incidence, on the other hand, describe the frequency of occurrence of new cases during a time period. Incidence is the number of new cases of a disease in a defined population within a specified time-period divided by the number who are at risk of having that disease or characteristic at that designated time-period.

The relevant measure of disease occurrence is incidence. Measures of prevalence may be relevant in connection with the planning of health services or in assessing the need for medical care in a population.

The temporally defined indices of epidemiological characteristics to improve health risks identifications. Bruno Galli and Francisco Chiaravalloti Neto (2007) study to apply the temporal-spatial model to asses high-risk areas for the occurrence of dengue fever based on three risk measures in geographic space - frequency, duration and intensity to identify high-risk areas.

Frequency index (α) can be defined as the probability of number of weeks with one or more CHIKV case occurred during the entire epidemic period.

Duration index (β) can be defined as the mean number of weeks per epidemic wave when cases successively occur, which mean time of disease occurrence marked before and after by no report cases of CHIKV.

Intensity index (Υ) can be defined as the mean incidence of cumulative CHIKV cases occurring in consecutive weeks per epidemic wave that had persisted for more than two weeks.

2.4 The regression method

Regression analysis is a statistical tool for investigation of relationships between environmental factors and patient. Statistical approach to forecasting change in a patient on the basis of change in any environment factors. Known also as curve fitting or line fitting because a regression analysis equation can be used in fitting a curve or line to factors points. Regression formula defined as

$$\gamma = \alpha + b_1 x_1 + b_2 x_2 + b_3 x_3$$

γ is the value of the patient. α (Alpha) is the constant or intercept. b_1 is the slope (Beta coefficient) for x_1 that first environmental factors. b_2 is the slope (Beta coefficient) for x_2 that second environmental factors that is explaining the variance in γ . b_3 is the slope (Beta coefficient) for x_3 that third environmental factors that is explaining the variance in γ . R^2 referred to the proportion of the variance in the values of the patient (γ) explained by all the environmental factors. (x_s) in the equation together; sometimes this is reported as adjusted R^2, when a correction has been made to reflect the number of factors in the equation. F Whether the equation as a whole is statistically significant in explaining γ .

2.5 Geographic Information System

Geographic Information System (GIS) is an integrated system for capturing, storing, checking, analyzing and displaying data which are geographically referenced to the earth. In a more generic sense, GIS is a tool which manipulate, storing, analyzing, retrieve and display information. Spatial and attribute data related and join to information, which used the result for decision support.

GIS is a rapidly growing technological field that incorporates graphical feature with tabular data in order to assess real-word problem. GIS field began used to discovery that maps could be programmed using simple code, stored in a computer allowing for future modification when necessary.

The key word of technology Geography mean that the data is spatial, in other words, data that is in some way referenced to locations on the earth. This data is usually data known as attribute data. Attribute data generally defined as additional information which can then be tried to spatial data.

GIS operates on many levels. The most basic level which used by GIS is as computer cartography (i.e. mapping). The power in GIS is more than that, GIS is through using spatial and statistical methods to analyze attribute and geographic information. The summary of final result of analysis can be derivative information, interpolated information or prioritized information, spatial correlation.

2.6 Interpolation methods

Interpolation predicts values for cells in a raster from a limited number of sample data point. These methods can be used to predict unknown values for any geographic point data: elevation, rainfall, chemical concentrations, noise levels and so on. The represent on the left shows a point dataset of known rainfall-level values, the right shows a raster interpolated from these point. Figure 2.7 Unknown values are predicted with a mathematical formula that uses the values of nearby known points

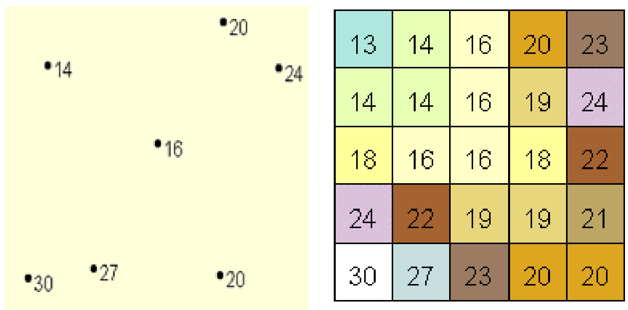

Figure 2.7 Raster interpolated from these points

Source: Understand raster interpolation,
http://resources.esri.com/help/9.3/arcgisengine/java/Gp_ToolRef/geoprocessing_with_3d_analyst/understanding_raster_interpolation.htm. (25 Nov 2010)

The ascription that makes interpolation a viable option is that spatially distributed objects are spatially correlated. Such as, if it is raining on one side of the area, we can predict with a high level of confidence that it is also raining on the other side of area adjacent.

From previous analogy, it is easy to represent the values of points close to sampled points are more likely to be similar than those that are far away. The typical use for point interpolation is to establish an elevation surface from a set of sample measurement.

2.6.1 Inverse Distance Weighted (IDW)

IDW interpolation determines cell values using a linear-weighted combination set of sample point. The weigh assigned is a function of the distance of an input point from the output cell location. The greater the distance, the less influence the cell has on the output value. In the figure 6 represent of five measured points (neighbors) will be used when predicting a value for the location without a measurement, the yellow point.

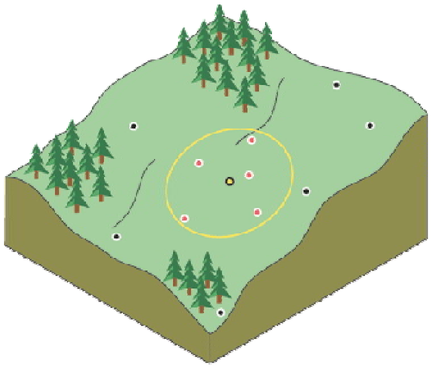

Figure 2.8 The five measured points to used predicting a value of yellow point
Source: The search neighborhood, http://resources.arcgis.com/en/help/main/10.1/index.html#/How_inverse_distance_weiweigh_interpolation_works/00310000002m000000/. (25 Nov 2010)

2.7 Spatial Autocorrelation

Spatial autocorrelation statistics measure and analyze the degree of dependency among observations in a geographic space. Observations made at different locations may not be independent. For example, measurements made at nearby locations may be closer in value than measurements made at locations farther apart. This phenomenon is called spatial autocorrelation. Spatial Autocorrelation is measures the relationship among values of a variable according to the spatial arrangement of the values.

A measure of the degree to which a set of spatial features and their associated data values tend to be clustered together in space (positive spatial autocorrelation) or dispersed (negative spatial autocorrelation).

2.7.1 Moran's I

Moran's I applied to area with continuous variables associated with them and compare the value of the variable at any one location with the value at all other location. Moran's I is defined as

$$I = \left(\frac{N}{\sum_i \sum_j \omega_{ij}} \right) \left(\frac{\sum_i \sum_j \omega_{ij} (X_i - \overline{X})(X_j - \overline{X})}{\sum_i (X_i - \overline{X})^2} \right)$$

Where N the number of spatial units is indexed by i and j ; X is the study area; $\overline{X}$ is the mean of X ; and ω_{ij} is an element of a matrix of spatial weights.

Result of Moran's I calculates is index value, z score and p – value. The Moran's I Index value near + 1.0 indicates clustering while an index value near -1.0 indicates dispersion. The z score and p – value show the statistical significance of that index.

2.7.2 Getis-Ord General G

Getis-Ord General G is a multiplicative measure of overall spatial association of values which fall within a critical distance of each other. It can separate clusters of high values from clusters of low value. Getis-Ord General G define as

$$G(d) = \frac{\sum \sum \omega_{ij}(d) x_i x_j}{\sum \sum x_i x_j}, i \neq j$$

Where x_i the value of factors at location i , x_j is the value factors at location j if j is within d of i, and $\omega_{ij}(d)$ is the spatial weight. The weight is based on some weight distance is 1 and 0 for i and j

Result of Getis-Ord General G calculates is the value of the General G index, associated z score and p-value evaluating the significance of that index. A high $G(d)$ value shows a clustering of high value, and a low $G(d)$ value shows a clustering of low values.

2.7.3 The local indication of spatial association (LISA)

The local indication of spatial association (LISA) identifies clusters of features with value similar. That was adopted as the identified significant clusters. The definition of the LISA index is given by:

$$I(i) = \frac{(x_i - \bar{x})}{\delta} \times \sum_{j=1}^{n} \omega_{ij} \times \frac{(x_i - \bar{x})}{\delta}$$

Where $I(i)$ is the I region's LISA, ω_{ij} is the proximity of the i area to the j area, x_i is the j area's factors value, x_j is the j area's factors index value, $\bar{x}$ is the factors index's mean value, δ is x_i's standard deviation and n is the total number of assessed area.

Result of the local indication of spatial association (LISA) calculated is a local Moran's I value, z score, p – value and a code representing the cluster type for each feature. The z score and p – value show the statistical significance of the calculated index value. The positive value for $I(i)$ indicates that the feature is surrounded by feature with similar values that is a part of a cluster. The other side, $I(i)$ indicates is negative value that the feature is surrounded by feature with dissimilar value and this is an outlier. The COType field varying between a statistically significant (0.05 level) cluster of high values (HH), cluster of low values (LL), outlier in which a high value is surround primarily by low values (HL) and outlier in which a low value is surrounded primarily by high values (LH) (Jennifer Lentz, 2009).

2.8 Related Research

Philippe Renault et al. (2007) study an epidemic of Chikungunya fever broke out in the Comoro Islands in January - May 2005. In April, cases were also reported in Mayotte and Mauritius. On Réunion Island, the first cases were reported at the end of April. Surveillance of this epidemic required an adaptive system, which at first was based on active and retrospective case detection around the cases reported, then relied on a sentinel network when the incidence increased. Emerging and severe forms of infection were investigated. Death certificates were monitored. By April 2006, the surveillance estimate was 244,000 cases of Chikungunya virus infection, including 123 severe cases and 41 of maternoneonatal transmission, with an overall attack rate of 35%. Chikungunya infection was mentioned on 203 death certificates and significant mortality was observed. This epidemic highlighted the need for a mutual strategy of providing information on arboviral diseases and their prevention and control between countries in the southwestern Indian Ocean.

WutjanunMuttitanon et al. (2004) study outbreak of dengue fever by survey environmental factors modulate the distribution of dengue fever (DF), such as climate, density of vector and human populations in urban areas and distribution of herd immunity. In order to identify geographical variables involved in the spread of a DHF process, a Geographic Information System (GIS) has been built to create links between geo-referenced data including medical records and socioeconomic and environmental data. Applied to a retrospective analytical study of DHF epidemics in Nakhon Pathom province (1997-2001), the GIS allowed a mapping of spatial variations of DHF incidence, the recognition of different temporal incidence patterns and the quantification of the dispersal of outbreaks among defined spatial units. The analysis showed that the diffusion process of these epidemics was of a contagious type as the distance between epidemic areas (sub-districts) was significantly lower than the average distance between every sub-district. This result indicates that these epidemics were likely to be due to the spread of a new or rare virus serotype, from its emergence location in the province to areas with a sufficient density of vectors and a similar limited immune protection against this serotype.

Tzai-Hung Wen et al. (2006) study of the purpose of mapping is to find out the spatial clustering of uneven events and identify spatial risk areas, which could lead to potential environmental hazards or epidemics. Meanwhile, more hypotheses could be generated through mapping process for further investigations. This paper proposed a novel spatial–temporal approach to focusing on: (1) how often these uneven cases occur, (2) how long these cases persist and (3) how significant cases occur in consecutive periods across the study area. The proposed model was applied to the dengue fever epidemic in Taiwan in 2002 as a case study, which was the worst epidemic in the last 60 years. This approach provides procedures to identify spatial health risk levels with temporal characteristics and assists in generating hypothesis that will be investigated in further detail.

Tzai-Hung Wena et al. (2009) study aimed to examine whether spatial–temporal patterns of dengue can be used to identify areas at risk of dengue hemorrhagic fever (DHF). Methods: Three indices areprobability of case occurrence, mean duration per wave, and transmissions, Intensity were used to differentiate eight local spatial–temporal patterns of dengue during the 2002 epidemic in Kaohsiung, Taiwan. DHF densities (DHF cases/km2 per 100 dengue cases) in each spatial temporal typed area were compared.Results: Areas with three high indices correlated with the highest DHF density: (1) high transmission intensity only; (2) long duration of wave only, and (3) high transmission intensity plus long duration of wave. However, cumulative incidences of dengue cases were not correlated with DHF densities. Conclusion: Three spatial–temporal indices of dengue could provide useful information to identify areasat high risk of DHF.

SumithPathinrana, Masato Kawabata and RohithaGoonatilake (2009) study the increasing incidence of dengue fever has become a priority issue for Sri Lanka. This study examines the association between weekly rainfall patterns and dengue outbreak between 2000 and 2004. Method of this study develops to quantitatively assess the relationship between rainfall and dengue outbreaks and then evaluation the suitability of the model for predicting dengue outbreaks. A power regression model was constructed using rainfall and dengue incidence data. The Inverse Distance Weighted (IDW) interpolation and Geographic information system (GIS) techniques were used in mapping the spatial distribution of dengue risk surface. The ability to predict dengue outbreaks and mapping the spatial patterns facilitates dengue surveillance and monitoring.

V.M. Chakkaravarthy, S. Vincent and T. Ambrose study aimed to provide detailed picture and baseline data about recent outbreak of chikungunya virus in public health sectors. The data were collected from the Director of Medical Science (DMS) department of economic and statiss in Chennai. The present invertigation Chikungunya outbreak in different districts of Tamil Nada was plotted in Geographic Information Systems (GIS) software and rainfall was correlated to forecast with recently outbreak. The method was used Smoothing method that adapted to filter the data. Chikungunya outbreak was high at 8 districts; 1 district were not recorded, the very low prevalence in 2 districts and in the rest of 19 districts, chikungunya fever case were moderately recorded in Tamil Nada.

Pornpop Saengthong (2000) was studied the factors affecting the accuracy of quantitative forecasting. Seven forecasting method was studied, namely: regression analysis with dummy variables, regression analysis with trigonometric variables, regression analysis with dummy variables and autocorrelated errors, decomposition method, Census II method, Holt-Winters exponential smoothing method and Box-Jenkins method. Fifteen monthly series used, from 1987 to 1997. Each time series from 1987 to 1995 was formed into five time series with the sizes of 3, 4, 5, 7, and 9 years. While, time series from 1996 to 1997 were kept to investigate the accuracy of forecasting methods with short term, medium term and long term forecasting period. They found that in short term forecasting, additive Holt-Winters exponential smoothing method was suitable for 3 and 4 year time series size. Multiplicative decomposition method was suitable for 5 and 7 year time series sizes. For 9 year time series size, there were 3 suitable methods which were multiplicative regression analysis with dummy variables and autocorrelated errors, multiplicative Census II method and multiplicative Holt-Winters exponential smoothing method. In the medium term forecasting, multiplicative Holt-Winters exponential smoothing method and multiplicative Census II method were suitable for time series sizes of 3 and 4 years, respectively. For 5 year time series size, there were 2 suitable methods which were multiplicative Census II method and multiplicative Holt-Winters exponential smoothing method. Also, for 7 and 9 year time series sizes, multiplicative decomposition method was suitable. In the long term forecasting, for

4, 5, 7 and 9 year time series sizes, the suitable methods were additive regression analysis with dummy variables and autocorrelated errors.

Jukkit Kittinapakul (2000) was compared seasonal data analysis by Box-Jenkins and Holt-Winters Exponential Smoothing methods by using rainfall per month in Chiangmai collected from the Climatology Division Office, Department of Meteorology, Chiangmai from January 1987 to December 1999. There are two ways in analyzing the data; one is using all the data collected, and another is the data collected within 12 years from January 1987 to December 1998 to achieve the forecast model. Considering the MSE, the study revealed that Holt-Winters exponential smoothing method is found more efficient than Box-Jenkins method in both the additive and the multiplicative models. When using all the data collected, the additive model of Holt-Winters exponential smoothing method showed the least MSE (3299.987). In case of 12-year data, the additive model of Holt-Winters exponential smoothing method displayed the least MSE (3399.017). However when the two models were used to forecast the monthly expected to have next year rainfall, it revealed that the multiplicative model of Holt-Winters exponential smoothing method showed the least MSE (4519.56).

CHAPTER III
MATERIALS AND METHODOLOGY

Researcher reviewed the risk area of Chikungunya Fever map making and found that Chikungunya Fever is an emerging vector-borne disease. Chikungunya Fever outbreaks typically result in huge number of cases but deaths are rarely encountered. Outbreaks are most likely to occur in post-monsoon period when the vector density is higher than regular season. Chikungunya Fever can spread to adjacent areas.

Disease mapping can be used to locate of area explosion of Chikungunya Fever, where can be defined as areas at risk of Chikungunya Fever. Researcher used environment factors to examine the relationship between the areas adjacent for early prevention and control. The scope of this research has a flow chart as in Figure 3.1.

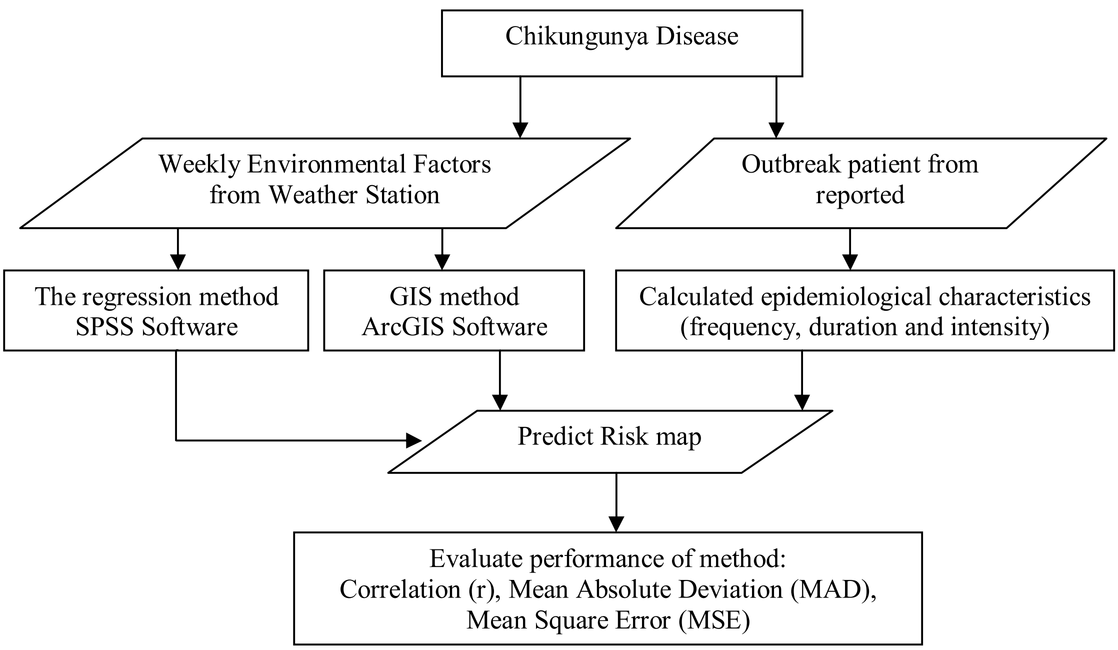

Figure 3.1 Flow chart of research methodology

3.1 Data collection and analysis

The researcher selected Study site of outbreak Chikungunya Fever in Suratthani province that obtain information of epidemic factors. This research using tool of GIS by applying it with ArcGIS software and SPSS software used to analysis relations between factors with patient.

3.1.1Chikungunya Fever factor

Study epidemic factors of Chikungunya Fever in the study site Consists of environment factors. Rainfall is important factors that influence transmission dynamics vector-bond disease. (V.M. Chakkaravarthy et al., 2011). Therefore the researcher used rainfall as factors for study. In addition used temperature and air pressure. Weather stations were collected rainfall measure from the Thai Meteorological Department (Annual data processing sub-division, 2009)

3.1.2 Chikungunya Fever incidence

Chikungunya Fever patient data outbreak in Suratthani province. Patient that diagnostics from physician who had symptom of infect, fever and joint pains in January 2009 – December 2009 were obtained from the record report 506 (Bureau of Epidemiology, 2009). The data collected base on registration address of patient in report.

3.1.3 Mapping spatial distributions

In creating the dataset for model development by use weekly patient compared with the environmental factors in same weekly. The sum of rainfall, the average of temperature and air pressure are compute and mapping in outbreak area as predictor. Risk area is analyzed through GIS statics for the result of prediction.

3.2 Methodology

This study, ArcGIS software is used as a tool in the development of the local indication of spatial model of spatial autocorrelation method GIS and SPSS software is used as a tool in the development of regression model. The model was developed by using the dataset of patient and environmental factors.

3.2.1 The regression method

The multiple regression analysis is a statistical tool for investigation of relationships between environmental factors and patient. Statistical approach to forecasting change in a patient on the basis of change in any environment factors.

3.2.2 The temporal – spatial model

This study of disease can be described identify high risk area (Bruno Galli and Francisco Chiaravalloti Neto, 2007) study to apply the temporal-spatial model to asses high-risk areas for the occurrence of dengue fever based on three risk measures in geographic space - frequency, duration and intensity to identify high-risk areas.

3.2.3 The interpolation method

This study, researcher use the Inverse Distance Weighted model (IDW) for determines cell values of environmental factors level. That at all values can be estimated by point of many weather stations on the map that keep the dataset.

3.2.4 The Spatial Autocorrelation method of GIS

In this study we choose spatial autocorrelation statistics measure and analyze the degree of dependency among observations in the study site. Spatial autocorrelation statistics compare the spatial weights to the covariance relationship at pairs of site. Indices of spatial autocorrelation, model of this the researcher use Moran's I, Getis-Ord General G and the local indication of spatial of association (LISA).

3.3 Evaluation of model performance

This study evaluation of model performance using comparison of results that obtained from calculated model and measured data with statistical methods. The Mean Square Error (MSE) is a statistical method that shows the value MSE the low value shows how forecasts are very accurate and the Mean Absolute Deviation (MAD) is a statistical method to shows difference value between actual data and predict data. The equation that shown the calculation following.

$$MSE = \frac{\sum (A-F)^2}{n}$$

$$MAD = \frac{\sum |A-F|}{n}$$

Where A = actual value

F = predicted value

n = number of data

3.4 Material

The research has classified materials used in this project into two categories. The details are as following:

3.4.1 Software Development

1) Operation system: Microsoft Windows XP

2) GIS application software: ArcView GIS 3.3

3) Microsoft office 2007 for student

4) Statistical Package for the Social Sciences (SPSS)

3.4.2 Hardware

1) Laptop Computer: CPU 1.6 GHz, RAM 2.50 GB, Hard disk 250 GB, Graphics memory 358 MB and other components

2) Printer

CHAPTER IV
RESULTS AND DISCUSSION

The result of study of potential risk of Chickungunya fever outbreak in Suratthani province using GIS and statistical modelling. The study was conducted in the outbreak Chikungunya Fever in Suratthani province that obtain information of epidemic factors.

The dataset of model development used weekly patient and the environmental factors that are 52 weeks. The input weather station and district area. The output is risk area from shape file data of district whereas outbreak. Therefore we need construct dataset by the reference of weekly rainfall to create dataset in forecast risk area.

Disease mapping locate of area explosion of Chikungunya Fever, as areas at risk of Chikungunya Fever. To describe the areas adjacent for outbreak Chikungunya Fever in Suratthani province.

4.1 Chikungunya Fever risk area

In this section, the study was conducted in the district of Suratthani province Figure 4.1 whereas the outbreak of Chikugunya fever cased in 2009.The patient data was identify high risk area using model based on three factors that are epidemic measures obtain frequency, duration and intensity. The Table 4.1 show below represent the measure of the indices in from standardization score and aggregate of epidemic indices. The aggregate of three indices can be classification by standard deviation method of ARCGIS program that shown in Figure 4.2.

Figure 4.1 GIS Surat Thani province divided by district

Table 4.1 display result of standardize score

No	District	Frequency index (α)	Duration index (β)	Intensity index (ϒ)	Total
1.	MueangSuratThani	0.66	-0.17	0.11	0.61
2.	Kanchanadit	0.66	0.23	1.03	1.92
3.	Don Sak	0.49	-0.29	0.78	0.98
4.	KoSamui	0.05	0.79	0.04	0.89
5.	KoPha-ngan	-2.36	-1.76	-1.31	-5.43
6.	Chaiya	0.38	-0.03	-0.01	0.34
7.	Tha Chana	-0.66	-1.24	-0.83	-2.74
8.	Khiri Rat Nikhom	0.22	1.99	-0.96	1.24
9.	Ban Ta Khun	0.82	-0.05	-0.18	0.59
10.	Phanom	1.15	0.64	1.69	3.49
11.	Tha Chang	0.38	0.46	-0.54	0.30
12.	Ban Na San	0.66	0.23	1.63	2.52
13.	Ban Na Doem	-1.92	-1.69	-1.33	-4.94
14.	Khian Sa	-0.55	-0.85	-1.21	-2.61
15.	Wiang Sa	-1.75	-1.50	-1.30	-4.56
16.	Phrasaeng	0.49	0.10	1.45	2.04
17.	Phunphin	0.38	0.46	-0.50	0.35
18.	Chai Buri	0.05	1.74	0.08	1.87
19.	Vibhavadi	0.82	0.94	1.36	3.12

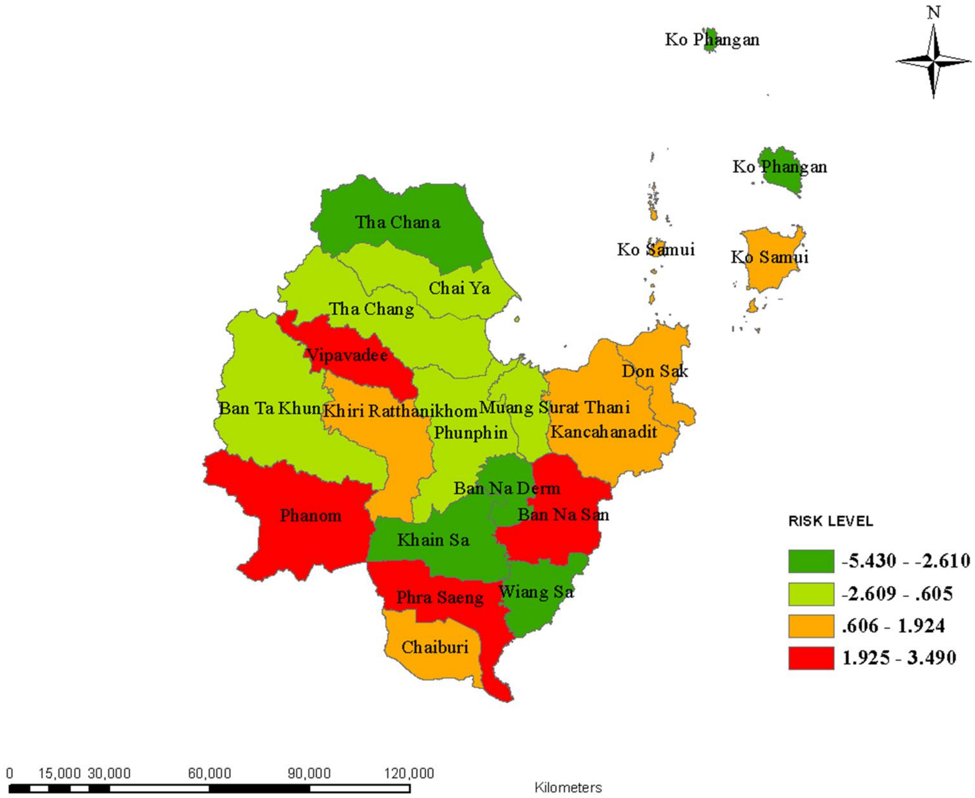

Figure 4.2 GIS province map showing difference level of intensity in Suratthani province

Figure 4.2 shown GIS the level of intensity from classify four level. The results showed the four level of risk area. The district had highest risk including Phanom, Vibhavadi, Ban Na San, Phasaeng, Kanchanadit and Chai Buri. The district had high risk including Khiri Rat Nikhom, Don Sak, Ko Samui, Mueang Surat Thani, Ban Ta Khun, Phunphin, Chaiya and Tha Chang. The district had moderate risk including Khain Sa and Tha Chana. The district low risk including Wieng Sa, Ban Na Doem and Ko Pha-ngan.

4.2 Statistical modelling

In this section, the researcher study relation between disease outbreaks and environmental factors. In this paper, a statistical modelling has been study relation either environmental factors or patient of Chikungunya fever in the meaning of other available data to forecast the probability from the model. The weekly average of patient and average of temperature, total of rainfall and average of air pressure data had been plotted.

Data collection, the weekly (52 weeks) average of patient and average of temperature, total of rainfall and average of air pressure data and patient data for all district sites. The dataset have been analyst using correlation models by SPSS programing. Table 4.2

Table 4.2 The correlation statistic of three environmental factors and patient.

		Patient	Rainfall	temperature	Air pressure
Patient	Pearson Correlation	1.00	0.254	-0.335*	.0425**
	Sig. (2 – tailed)		0.069	0.015	0.002
Rainfall	Pearson Correlation	0.254	1.00	-0.153	-0.120
	Sig. (2 – tailed)	0.069		0.277	0.397
Temperature	Pearson Correlation	-0.335*	-0.153	1.00	-0.046
	Sig. (2 – tailed)	0.015	0.277		0.744
Air pressure	Pearson Correlation	0.425**	-0.120	-0.046	1.00
	Sig. (2 – tailed)	0.002	0.397	0.744	

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.2 shown the compute the correlation between three environment factors and patient, which result of Pearson correlation is 0.425 (p = 0.002) of Air pressure, Temperature is -0.335 (p=0.015) and Rainfall is 0.254 (p=0.069). The correlation between environmental factors data and patient data in Surat Thani province found the air pressure had strong correlation of the quantities involved in the same direction. On the other hand, the temperature had strong correlation of the quantities involved as well but in the opposite direction. For the rainfall had low correlation of the quantities involved.

Table 4.3 The regression analysis to predict by taking environmental factors into the equation.

Variable	b	SE_b	β	T	P-value
Temperature	-42.596	18.378	-0.274	-2.318	0.025
Air pressure	45.506	12.052	0.444	3.776	<0.001
Rainfall	1.883	0.845	0.265	2.230	0.030
Constant = -44995.87 ; SE_{est} = ±85.021 R = 0.590 ; R^2 = 0.348 ; F = 8.542 ; p-value < 0.001					

From Table 4.3 shown multiple linear regression analysis was used to develop a model for predicting. The regression analysis of environmental factors had correlate with value 0.590, correlation of significant $p < 0.001$, coefficient of determination is 34.8 percent and the standard error of the prediction was ±85.021.

The result found the air pressure could predict the patients as most had coefficient significant p = 0.001. The regression coefficients of raw score and standardized regression coefficients was 45.506 and 0.444. Minor rainfall could predict the patients had coefficient significant p = 0.03. The regression coefficients of raw score and standardized regression coefficients was 1.883 and 0.265.

Forecast formula is patient = -44995.87- 42.596Temperature + 45.506Air pressure + 1.883 rainfall

4.3 Spatial analysis

4.3.1 Interpolation method

In this section, the researcher use the rainfall, temperature and air pressure in the outbreak year for the development. The point of each district refer to weather station in Surat thani province that data points are used to infer values over a margin between the points to create a continuous rainfall. Figure 5 shown the interpolated of rainfall in 19 districts areas of Surat thani province.

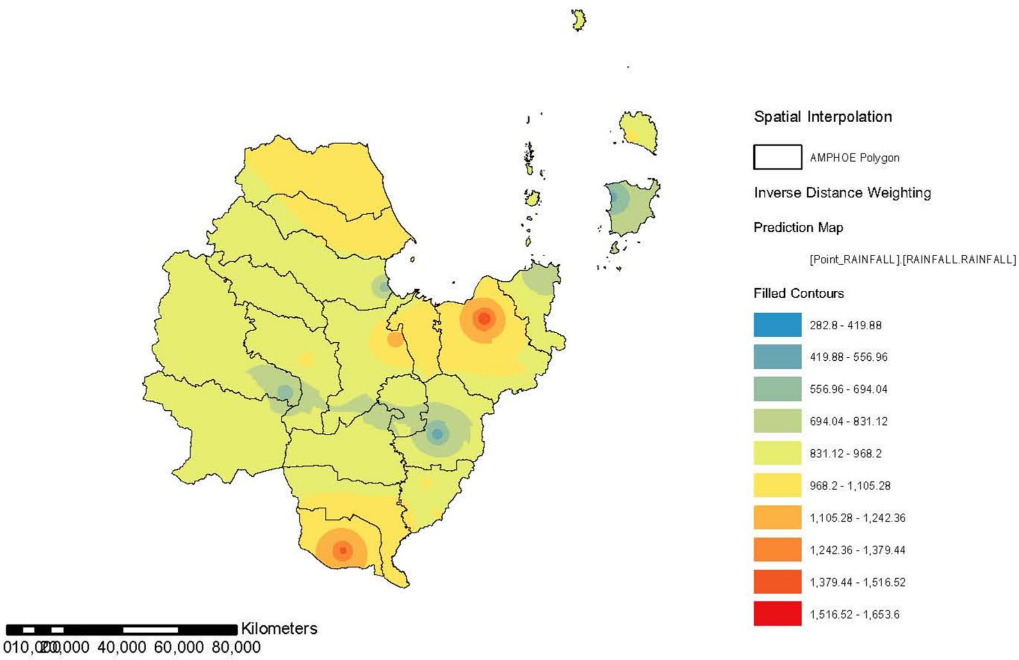

Figure 4.3 GIS the Rainfall interpolation using method Inverse distance weighting.

From the Figure 4.3 show GIS the rainfall interpolation found the most rainfall in Surat Thani province had moderate of total rainfall (831.12-968.2). The district in the middle of map that rainfall in the low level. The hardest rainfall found in the district in the province boundaries.

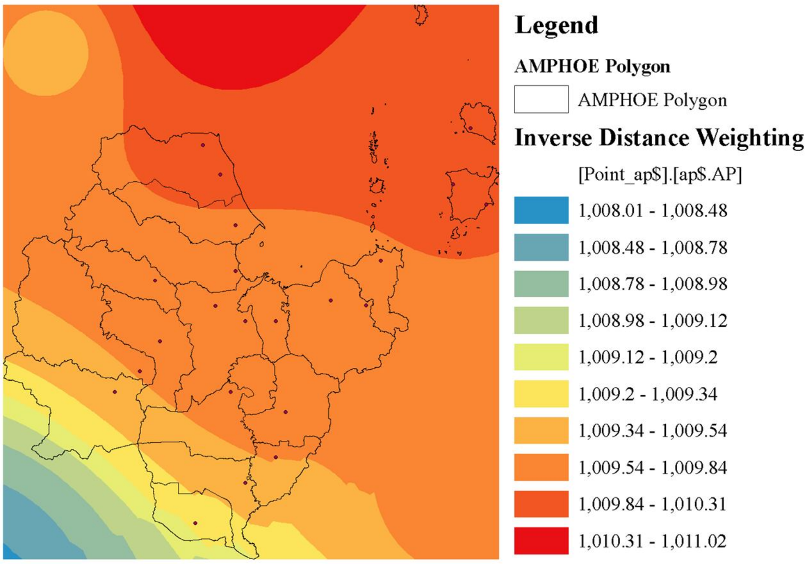

Figure 4.4 GIS the Air pressure interpolation using method Inverse distance weighting

From the Figure 4.4 represent of GIS the air pressure interpolation that found the air pressure had an influence from Gulf of Thailand. The value was high from the district that has boundary near the sea and decrease value steadily.

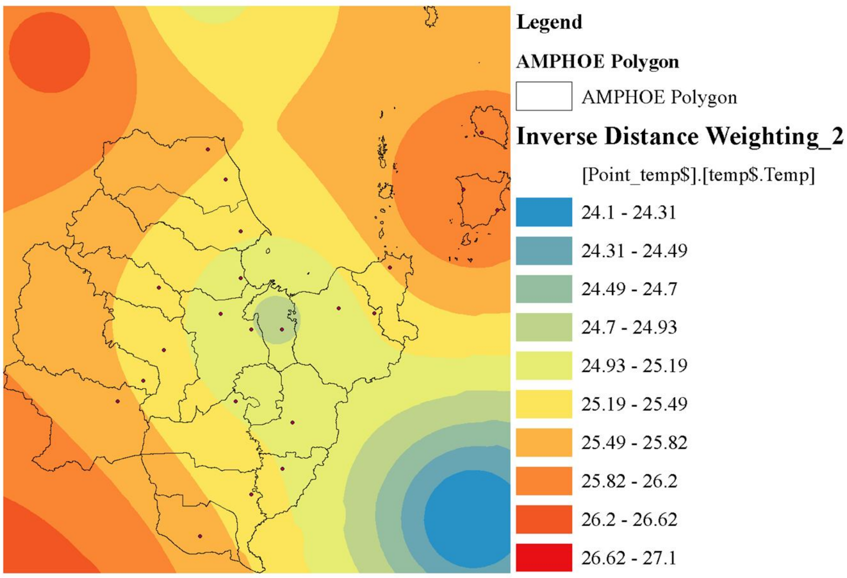

Figure 4.5 GIS the temperature interpolation using method Inverse distance weighting

From the Figure 4.5 represent of GIS the temperature interpolation that found the most of temperature in Surat Thani province in the rage 24 – 26 degree Celsius.

4.3.2 Spatial autocorrelation method

4.3.2.1 Moran's I

In this section, we used environmental factors data from weather station mapping into district's area.

Table 4.4 display result Moran's I method analysis.

Environmental factors	Moran's I		
	Index	Z – score	P - value
Temperature	0.615	3.209	0.001
Rainfall	-0.247	-1.038	0.299
Air pressure	0.410	2.263	0.023

The table 4.4 analyst environmental factors, temperature and air pressure clustered but rainfall found that not clustered. From the result found the factor of environmental clustered pattern in each area were temperature and air pressure (p-value 0.001 and 0.023). The other hand, rainfall result was random chance pattern.

4.3.2.2 Getis – Ord General G

This spatial tool calculates the High/Low clustering analysis. We used data of environmental factors in area each district represent in Table 4.5.

Table 4.5 display result of Getis – Ord General G clustering analysis

Environmental factors	Getis – Ord General G		
	Index	Z – score	P - value
Temperature	0.000003	-0.061	0.950
Rainfall	0.000010	1.234	0.217
Air pressure	0.000006	0.612	0.540

Table 4.5 shown the environmental factors clustering analysis using Getis – Ord General G method found the environmental factors had the random pattern. The pattern of temperature, rainfall and air pressure were not appear to be significantly different than random.

4.3.2.3 Cluster & Outlier Analysis (Anselin's Local Moran's I – LISA)

This tool identifies clusters of features with rainfall and air pressure value similar in magnitude and identifies spatial outlier that shown summary of method in Figure 4.6.

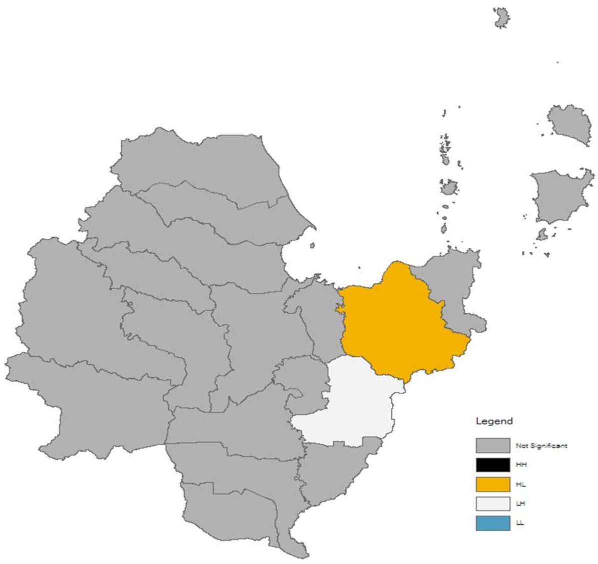

Figure 4.6 GIS shown the cluster/outlier analysis rainfall value

From Figure 4.6 is shown the result of COType field cluster of high rainfall values HL is Kanchanadit and outlier in which a low rainfall value is surrounded primarily by high rainfall value LH is Ban Na San.

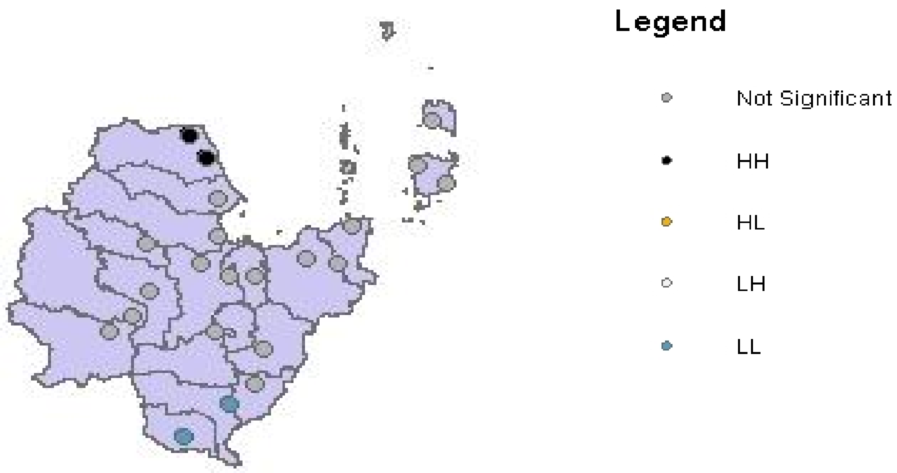

Figure 4.7 GIS shown the cluster/outlier analysis Air pressure value

From Figure 4.7 is shown the result of COType field cluster of high air pressure values HH is Tha Chana and outlier in which a high air pressure value is surrounded primarily by low air pressure value LL is Chai Buri and Pha Sang.

4.3.3 Evaluation

This section. The researcher used evaluate of model performance handle by comparison of results that obtained from calculated model and measured data with statistical methods. The Mean Absolute Deviation (MAD) and Mean Square Error (MSE) is a statistical method that shows the value MAD the low value shows how forecasts are very accurate. Found the MAD value is 70.12 and MSE value is 119486.49 that is the evaluation is low accuracy. The result of predict with environmental factors is shown in the Figure 4.8.

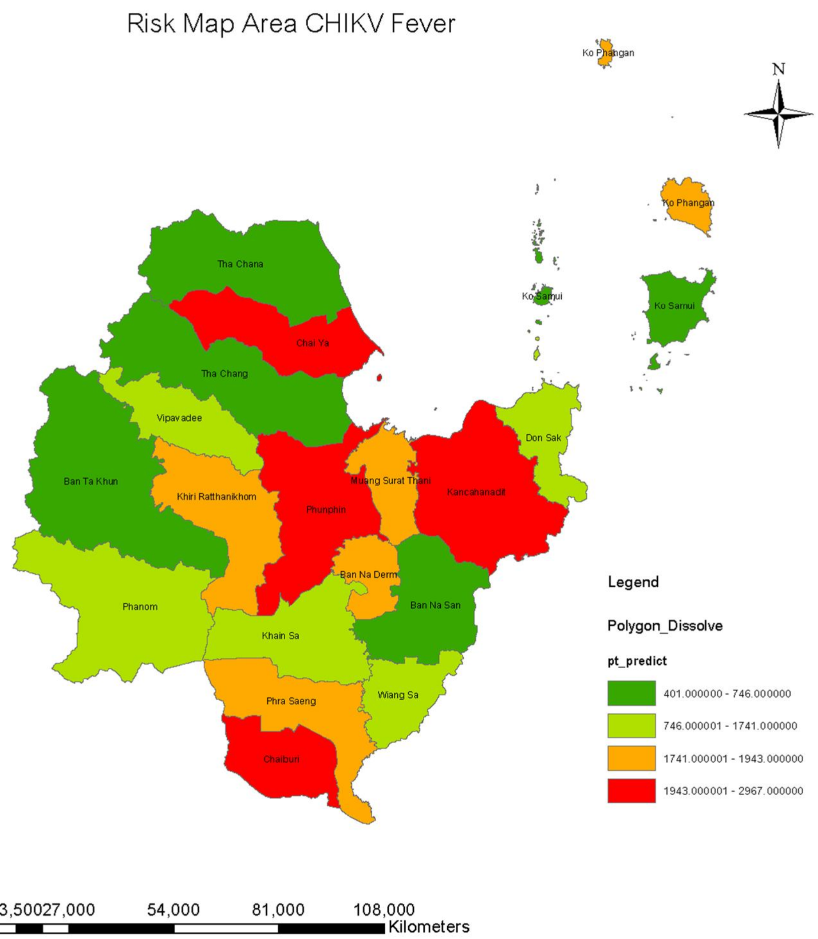

Figure 4.8 The result of predict risk area with environmental factors

Figure 4.8 shown GIS the risk area predict using the environmental factors. The results showed the four level of risk area. The district had highest risk including Kanchanadit, Phunphin, Chaiya, and Chai Buri. The district had high risk including Khiri Rat Nikhom, Phasaeng, Mueang Surat Thani, Ban Na Doem, and Ko Pha-ngan. The district had moderate risk including Phanom, Khain Sa, Vibhavadi, Don Sak and Wieng Sa. The district low risk including Ban Na San, Tha Chang, Ban Ta Khun, Ko Samui, and Tha Chana.

The conclude of this study, the risk area of each method could be represent in Figure 4.9 that comparison between epidemic measure consist; Frequency index, Duration index and Intensity index and the regression model using three factors of environmental factors from weather stations in Surat Thani province.

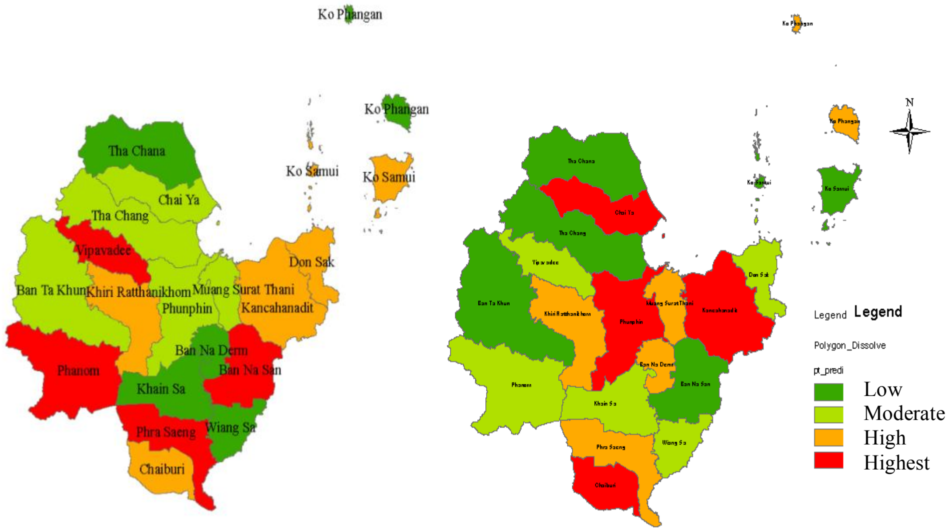

Figure 4.9 Comparison between risk area from epidemic measure method (Left) and environmental factors (Right).

The GIS risk area between each method found the risk area had difference area which environmental factors inconsistent epidemic measure. The risk area mapping with environmental factors shown the risk area by environmental in each area. The epidemic measure mapping the risk area by patients in area. However, the risk area of both method shown the spreading Chikungunya Fever in Surat Thani province. Tha Chana and Kriri Rat Nikhom as same as low risk area. Each area change from high as low risk area may be because address the patient form report or current address. We should study both method in use to supporting determine, preventing and controlling Chikungunya Fever outbreaks in Surat Thani province.

4.4 Discussion

From tryout of all method, it found that the risk area of Chikungunya fever in Suratthani province based on three factors that are epidemic measures obtain frequency, duration and intensity(Wen et al. 2006). The six district high risk area were Phanom, Viphavadi, Phasang, Chaiburi, Kanchanadit and Bannasan.

Furthermore, it shows thatChikungunya fever was outbreaks during the rainy season when the peaks of vector density (Gilles Pialoux et al. 2007) (Narong Nitapattana,et al. 2007) as to the rainfall is the only one of many factorss that influence transmission dynamics (V.M Chakkaravarthy,et.al.2011). The researcher use environmental factors that found the relationship was statistically supports by regression model created in this study presented that there is strong statistical association ($r = 0.590$) ($p < 0.05$) between Chikungunya fever case and rainfall, temperature, air pressure. The result of this method study was similar the study dengue risk map using the spatial distribution of dengue incidence, rainfall and risk population category (SumithPathirana, et. Al. 2009) that study indicated was a strong statistical association. The environmental factors collected from weather station in Suratthani province can be interpolate by IDW method found the Air pressure is clustering pattern from Moran'I method ($P < 0.05$).

The spatial autocorrelation of this factors shown the district in Suratthni province that there are random pattern of spreading Chikugunya fever case. The Anselin's Local Moran's I – LISA method presents field cluster of high rainfall values HH is Kanchanadit and outlier in which a low rainfall value is surrounded primarily by high rainfall value LH is Ban Na San and Air pressure found field cluster of high air pressure values HH is Tha Chana and outlier in which a high air pressure value is surrounded primarily by low air pressure value LL is Chai Buri and Pha Sang. The Geographical information systems (GIS) explored the potential to analyze the spatial factorss involve Chikungunya fever epidemic (N.R. Bergquist. 2001).

However, the result of this experiment that present the factors of disease cannot explain in the one side of epidemic model. The study of epidemic in the outbreak and transmission of vector – borne disease have an obvious relationship with environment conditions, human economic activities, public medical accommodation and other factorss(Wenhua Zeng et al . 2006). This study of rainfall factors could be reply to risk area to preventing and control outbreak of Chikungunya fever. The GIS used in the surveillance and monitoring of Chikungunya fever outbreak in Surathani province. This experiment that if all the necessary epidemiological factorss are in area, a fever such as Chikungunya can re- emerge and become a public health concern.

CHAPTER V
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This paper aims to description Chikungunya Fever outbreaks in Suratthani province, study correlation of environmental factors with Chikungunya Fever in Suratthani province and design a model to support the management of decision making prevention and control Chikungunya Fever. We using patient and environments data during January 2009 – December 2009 as data set in module. This paper is divided into two parts, the first part, we using patient data to identify high risk area using model based on three factor that are epidemic measures obtain frequency, duration and intensity. Second part, the prediction technique and statistical theories are being computed to analyze data set. The method of interpolation using the inverse distance weighted (IDW) method to calculate the data set from 18 weather station in Surathani province. Prediction map represent rainfall, temperature and air pressure of Suratthani province. The result of each study to descript and represent the risk map of Chikugunya Fever.

The risk map of Chikungunya Fever represent by epidemic measures index consists of classification groups of the high risk areas included Phanom district, Vibhavadi district, Ban Na San district, Phrasaeng district, Kanchanadit district and Chai Buri district after that had risk subordinated Kriri Rat Nikhom district, Don Sak district, KoSamui district, Muang Surat Thani district, Ban Ta Khun district, Phunphin district, Chaiya district, Tha Chang district and low risk areas are Khian Sa district, Tha Chana district, Wiang Sa district, Ban Na Doem district and Kopha-ngan district.

The spatial autocorrelation of all environmental factors shown the district in Surat thani province that there are clustering pattern of air pressure moreover found that random pattern. The Anselin's Local Moran's I – LISA method presents field cluster of high rainfall values HH is Kanchanadit and outlier in which a low rainfall value is surrounded primarily by high rainfall value LH is Ban Na San and Air pressure found field cluster of high air pressure values HH is Tha Chana and outlier in which a high air pressure value is surrounded primarily by low air pressure value LL is Chai Buri and Pha Sang.

The correlation between environmental factors and patient is giving strong correlation of the quantities involved (r = 0.59). The appropriated method and model to prediction number of Chikungunya Fever patients are summarized as patient

= (-44995.87) – (42.596) Temperature + (45.506) Air pressure + (1.883) rainfall.

After deriving at model of the prediction, the numbers of Chikungunya Fever patients were forecasted. (Based on people had registered address in district, Suratthani province)

The risk map of Chikungunya Fever patients from model estimated to random pattern spreading of Chikungunya Fever cases in each method. Besides, the environmental factors represent of potencial risk of Chikungunya Fever in Suratthani province. There is the indication the Chikungunya Fever spreading of cases over outbreak increased high during the rainy season. This research results risk areas map of Chikungunya Fever patients even with the current advanced technology. Hence, the Health Office at Suratthani province should exhaustively monitoring the situation to prevent the disease from spreading or outbreak of cases, active controlling and including health promotion in Suratthani prvince. That should be conducted to reduce the spreading of cases and intensity rate of Chikungunya Fever as well as other vector – borne disease.

5.2 Recommendation and Future Work

The following recommendations were development model to control and prevention of vector- borne disease.

1. The risk map of Chikungunya Fever should be applied with planning to prevent and control disease more effectively. Moreover, it may be used in planning the Health Development at Provincial and District levels.

2. In model development, it should receive more weather station of environmental factors to improve the efficiency of interpolation method.

3. The predict model may be useful for short period of time such as 52 week in one year of outbreak disease. Hence, the model must be modified constantly to sustain with augmentative data.

4. There should be the predicting method in subordinate health areas such as predicting numbers of subdistrict or predicting in Public Health Centre so the predict data could be used to develop healthy program or solve problems more effectively.

Furthermore, the following future works were recommendations for the next research are below:

1. The study of the other prediction method and more potentials factors of epidemiology in Chikugunya Fever disease for accurately model.

2. For information, we have it in Ministry of Public Health's the surveillance of the disease system in each service receivers. Wherefore, if we set that information apply to forecast for the future by using the statistical methods of correlation analysis analyzed the model to forecast future values, which ought to be a guideline implementation for the executive's decision in plan to be considered such as the number of staff required, the budget and more material in each level to handle the profit of the organize.

3. The experiment results ought to be used to further researches.

REFERENCES

Ahlbom A. & Norell, S. (1990) *Introduction to modern epidemiology*. Epidemiology Resources Inc.

Alpana Bohra and Dr.Haja Andrianasolo. (2001) *Application of GIS in Modeling of Dengue Risk base on Socio-Culture Data: Case of Jalor*, Rajasthan India.paper presented at the 22nd Asian Conference on remote sensing.

Annelise Tan, XavierDeparis,et.al. (2004) *Dengue Spatial and Temporal Patterns, French Guiana, 2001*. Emerging Infectious Diseases.www.cdc.gov/eid vol.10 No.4; 615-621.

Ann M. Powers and Christopher H. Logue. (2007) *Changing patterns of chikugunya virus: re-emergences of a zoonotic arbovirus.* Journal of General Virology. 88;2363-2377. USA.

Annual Data Processing Sub – division, (2009) *Climatic data, Bangkok: Climatology, Thai Meteorological Department*, Ministry of Transport and Communications.

Bruno Galli, Francisco Chiaravalloti Neto. (2008) *Temporal – spatial risk model to identify areas at high-risk for occurrence of dengue fever*. Rev Saude Publica 2008; 42(4).

Chang, Kang-t sung. (2002) *Introduction to Geographic Information Systems*. New Delhi: Tat a McGraw-Hill Publishing Company Limit ed.

Chen Chee Dhang, Seleena Benjamin, et. al. (2005) *Dengue vector surveillance in urban residential and settlement areas in Selangor*, Malaysia. Tropical Biomedicine 22(1); 39-43.

Chin, J. Editor. (2000) *Chikungunya. In : Control of Communicable Diseases Manual.* 17th Edition, American Public Health Association, Washington, D.C.

F. Benjamin Zhan, Yongmei Lu, Alberto Giordano, J. Hanford. (2005) *Geographic Information System (GIS) as a Tool for Disease Surveillance and Environment Health Research*. IEEE; 1465 – 1470. USA.

Gilles Pialoux, Bernard-Alex Gauzere, Stephane Jaureguiberry, Michel Strobel. (2007) *Chikungunya, an epidemic arbovirosis*. Lancet Infect Dis Vol. 7. P 319 – 327.

Heymann, D.L. Editor. (2004) *Chikungunya. In : Control of Communicable Diseases Manual*. 18th Edition, American Public Health Association, Washington, D.C.

Hopp MJ and Foley J. (2001) *Global-scale Relationships between Climate and the Dengue Fever Vector Aedes Aegypti*. Climate Change. 48: 441-463.

Kanchana Nakhapakorn and Supet jitrajohnkool. (2006) *Temporal and Spatial Autocorrelation Statistics of Dengue Fever*. Denge Buletin; 177 – 183.

Kang – tsung Chang. (2006) *Introduction to Geographic Information Systems*, 3rd Edition. Singapore: McGraw-Hill.

Keith C. Clarke, Ph.D., Sara L. McLafferty, Ph.D., Barbara J. Tempalski. (1996) *On Epidemiology and Geographic Information Systems: A Review and Discussion of Future Directions*. USA. Emerging Infectious Diseases; Vol 2 (2) : P 85 - 92

Mammen P. Mammen Jr.,Chusak Pimgate,et.al. (2008) *Spatial and Temporal Clustering of Dengue Virus Transmission in Thai village*.Plos medicine;1605-1616.

N.R. Bergquist. (2001) *Vector – borne parasitic diseases: new trends in data collection and risk assessment*. Acta Tropica 79. P 13 – 20.

Philippe Renault et al. (2007) *A Major Epidemic of Chikungunya Virus Infection on Réunion Island, France, 2005–2006*. Am. J. Trop. Med. Hyg., 77(4), 2007, pp. 727–731.

R. Beagiehote, R. Bonita. Basic epidemiology. (1993) *Geneva Warld "Health Organization*. p. 2.

R.S. Sharma, M.K. Showkath Ali, G.P.S Dhillon. (2008) *Epidemiological and entomological aspects of an outbreak of chikungya in Lakshadweep Islands*, India, during 2007. Dengue Bulletin, Vol. 32. P 178 – 185.

SK Lam, KB Chua, PS Hooi, MA Rahimah, S Kumari, M Tharmaratnam, SK Chuah, DW Smith, IA Sampson. (2001) *Chikungunya Infection – An Emerging*

Disease in Malasia. Southeast Asian J Trop Med Public Health, Vol. 32(3). P 447 – 451.

Sumith Pathirana, Masato Kawabata, and Rohitha Goonatilake. (2009) *Study of potential risk of dengue disease outbreak in Sri Lanka using GIS and statistical modelling.* Journal of Rural and Tropical Public Health Vol. 8. P 8 – 17.

The search neighborhood. (2010). Retrieved November 25, 2010, Web site: http://resources.arcgis.com/en/help/main/10.1/index.html#/How_inverse_distance_weiweigh_interpolation_works/00310000002m000000/.

Tzai-Hung Wen, Neal H. Lin, et. al. (2006) *Spatial mapping of temporal risk characteristics to improve environmental health risk identification: A case study of a dengue epidemic in Taiwan*. Science of the Environment 367;631-640.

Tzai-Hung Wena et al. (2009) *Spatial–temporal patterns of dengue in areas at risk of dengue emorrhagic fever in Kaohsiung, Taiwan, 2002*. International Journal of Infectious Diseases 14 (2010) e334–e343.

Tzai-Hung Wen, Neal H. Lin, et.al. (2010) *Spatial- temporal patterns of dengue in areas at risk of dengue hemorrhagic fever in Kaohsiung Taiwan 2002*.International Journal of Infectious Diseases 14; e334-e343.

Understand raster interpolation. (2010). Retrieved November 25, 2010, Web site: http://resources.esri.com/help/9.3/arcgisengine/java/Gp_ToolRef/geoprocessing_with_3d_analyst/understanding_raster_interpolation.htm.

V.M. Chakkaravarthy, S. Vincent, and T. Ambrose. (2011) *Novel Approach of Geographic Information Systems on Recent Outbreak of Chikungunya in Tamil Nadu, India.* Journal of Environmental Science and Technology. P 387 – 394.

Wenhua Zeng, Xia CUI, Xiangnam LIU, Haishan CUI, Ping WANG. (2006) *Remote Sensing and GIS for Identifying and Monitoring the Environmental Factors Associated withVector-borne Disease: An Overview*.IEEE. P 1439 – 1442.

WHO. (1997) *Chapter 5 Vector surveillance and control. In Dengue haemorrhagic fever – Diagnosis, treatment, prevention and control. Second Edition*, WHO, UK.

Wutjanun Muttitanon et al. (2004) *Spatial and Temporal Dynamics of Dengue Haemorrhagic Fever Epidemics, Nakhon Pathom Province, Thailand, 1997-2001*. Dengue Bulletin – Vol 28, 2004.

Wutjanun Muttitanon, Pongpan Kongthong, et.al. (2004) *Spatial and temporal dynamics of dengue haemorrhagic fever epidemics, Nakhon Pathon Province, Thailand, 1997 – 2001.* Dengue Bulletin – Vol 28; 35-43.

กระทรวงสาธารณสุข. (2552) ***ชิคุนกุนยา.*** ค้นเมื่อ 30 พฤศจิกายน 2552, จาก http://chikungunya.org

กรมควบคุมโรค. (2552) กระทรวงสาธารณสุข ค้นเมื่อ 30 พฤศจิกายน 2552, จาก *http:// www.ddc.moph.go.th*

กองกีฏวิทยาทางแพทย์. (2533) ***การทบทวนเทคโนโลยีและรูปแบบการควบคุมยุงลายพาหะนำไข้เลือดออกในประเทศไทย พ.ศ. 2501-2532***. กรมวิทยาศาสตร์การแพทย์, กระทรวงสาธารณสุข, 64 หน้า.

กองโรคติดต่อทั่วไป. (2535) ***โรคไข้เลือดออก.*** ใน : งานควบคุมโรคติดต่อทั่วไป. พิมพ์ครั้งที่1. กรุงเทพฯ. : ชุมนุมสหกรณ์การเกษตรแห่งประเทศไทย.

จักรกฤษ กิตตินภากุล. (2543) ***การเปรียบเทียบการวิเคราะห์ข้อมูลตามฤดูกาลโดยวิธีบ๊อกและเจนกินส์ และวิธีปรับให้เรียบเอ็กซ์โปเนนเชียลแบบโฮลท์และวินเตอร์***. การค้นคว้าแบบอิสระวิทยาศาสตรมหาบัณฑิต. มหาวิทยาลัยเชียงใหม่ เชียงใหม่.

ไพบูลย์ โล่ห์สุนทร. (2552) ***ระบาดวิทยา*** พิมพ์ครั้งที่7 กรุงเทพฯ: สำนักพิมพ์จุฬาลงกรณ์มหาวิทยาลัย

พรภพ แสงทอง. (2543) ***ปัจจัยที่มีผลต่อความถูกต้องของการพยากรณ์เชิงปริมาณ.*** วิทยานิพนธ์ปริญญาโท. มหาวิทยาลัยเกษตรศาสตร์, กรุงเทพฯ.

มหาวิทยาลัยสุโขทัยธรรมาธิราช.(2533) ***เอกสารการสอนชุดวิชาวิทยาการระบาดและการ"ควบคุมโรค" หน่วยที่ 1-7***. กรุงเทพมหานคร : สำนักพิมพ์มหาวิทยาลัยสุโขทัยธรรมาธิราช.

สำนักงานสาธารณสุขจังหวัดสุราษฎร์ธานี. (2552) ***รายงานสรุปผลผู้ป่วยโรคชิคุนกุนยา ปี2552***. (เอกสารอัดสำเนา)

สำนักระบาดวิทยา กรมควบคุมโรค กระทรวงสาธารณสุข . (2552) ***ชิคุนกุนยา.*** ค้นเมื่อ 28 พฤศจิกายน 2552, จาก *http://203.157.15.4/.*

สำนักระบาดวิทยา กรมควบคุมโรค กระทรวงสาธารณสุข . (2552) ค้นเมื่อ 20 พฤศจิกายน 2552, จาก*http://epid.moph.go.th*

สมชาย สุพันธุ์วณิช.(2529) **หลักระบาดวิทยา**. กรุงเทพมหานคร : สำนักพิมพ์ศูนย์ส่งเสริมวิชาการ.

ศุภกิจ เฉลิมกิตติชัย. (2006) **การประยุกต์ใช้ระบบสารสนเทศภูมิศาสตร์บนเว็ปไซต์ เพื่อควบคุมภาวะการเกิดโรคไข้เลือดออกของประชากร กรณีศึกษาเขตพื้นที่อำเภอมะขาม จังหวัดจันทบุรี.**

APPENDICES

APPENDIX A
THE RESULT OF EPIDEMIC INDEX

1. The table of epidemic index

No	District	Frequency index (α)	Duration index (β)	Intensity (ϒ)
1.	MueangSuratThani	0.66	3.00	39.00
2.	Kanchanadit	0.66	3.42	62.85
3.	Don Sak	0.63	2.87	56.25
4.	KoSamui	0.55	4.00	37.20
5.	KoPha-ngan	0.11	1.33	2.00
6.	Chaiya	0.61	3.14	35.85
7.	Tha Chana	0.42	1.87	14.37
8.	Khiri Rat Nikhom	0.58	5.26	11.00
9.	Ban Ta Khun	0.69	3.12	31.25
10.	Phanom	0.75	3.85	80.00
11.	Tha Chang	0.61	3.66	22.00
12.	Ban Na San	0.66	3.42	78.28
13.	Ban Na Doem	0.19	1.40	1.60
14.	Khian Sa	0.44	2.28	4.71
15.	Wiang Sa	0.22	1.60	2.20
16.	Phrasaeng	0.63	3.28	73.57
17.	Phunphin	0.61	3.66	23.16
18.	Chai Buri	0.55	5.00	38.00
19.	Vibhavadi	0.69	4.16	71.33

2. Suratthani province map

This section is illustrated the maps of frequency and duration index, which are related to the outbreaks of Chikungunya in Suratthani province. There are shown in Figure A.1 and Figure A.2.

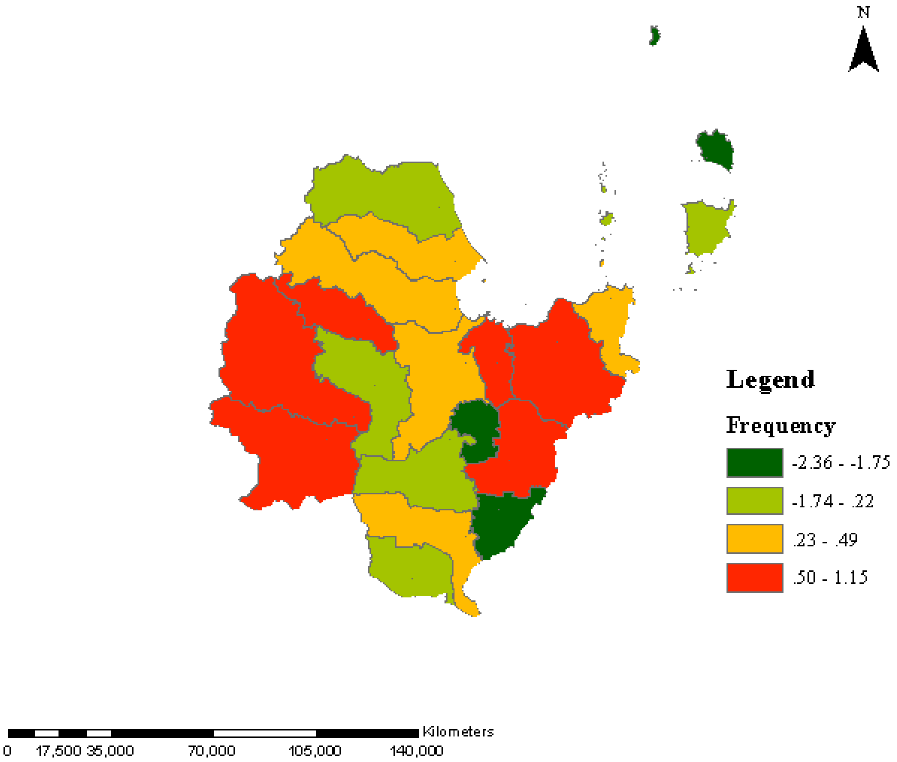

Figure A.1 The level of frequency index in Suratthani province.

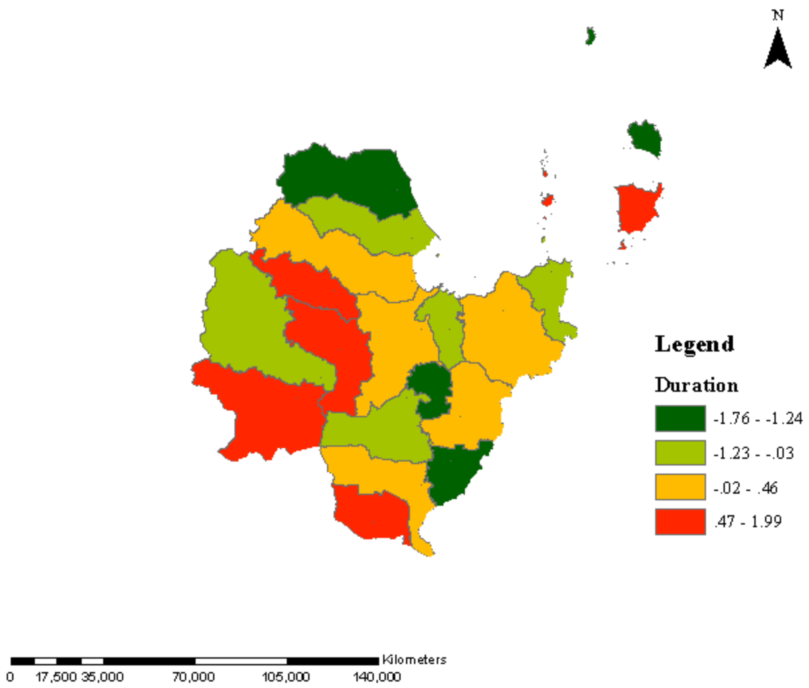

Figure A.2 The level of Duration index in Suratthani province.

Moreover, the period of morbidity rate of Chikungunya in 1 January 2009 to 8 January 2010 and the number of patient are shown in Figure A.3 and A.4. However, the spreading of patient is shown in Figure A.5.

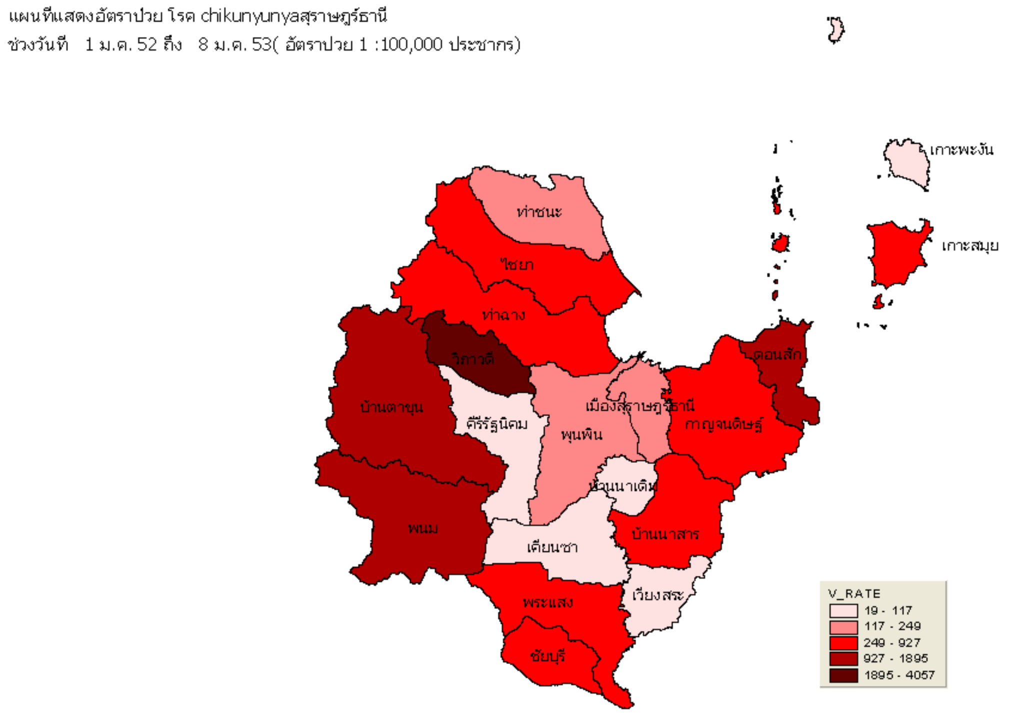

Figure A.3 The Morbidity rate of Chikungunya in 1 January 2009 to 8 January 2010.

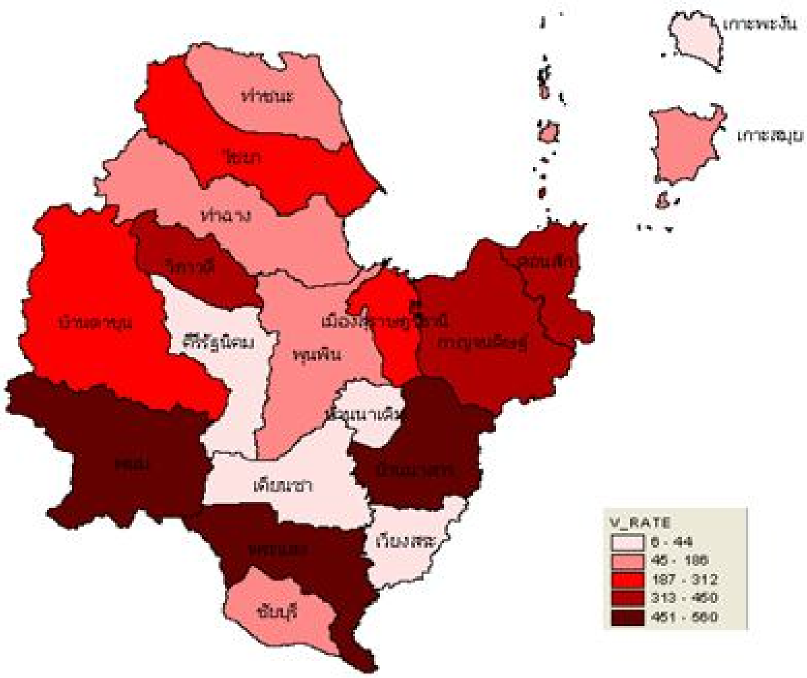

Figure A.4 The number of Chikungunya patient.

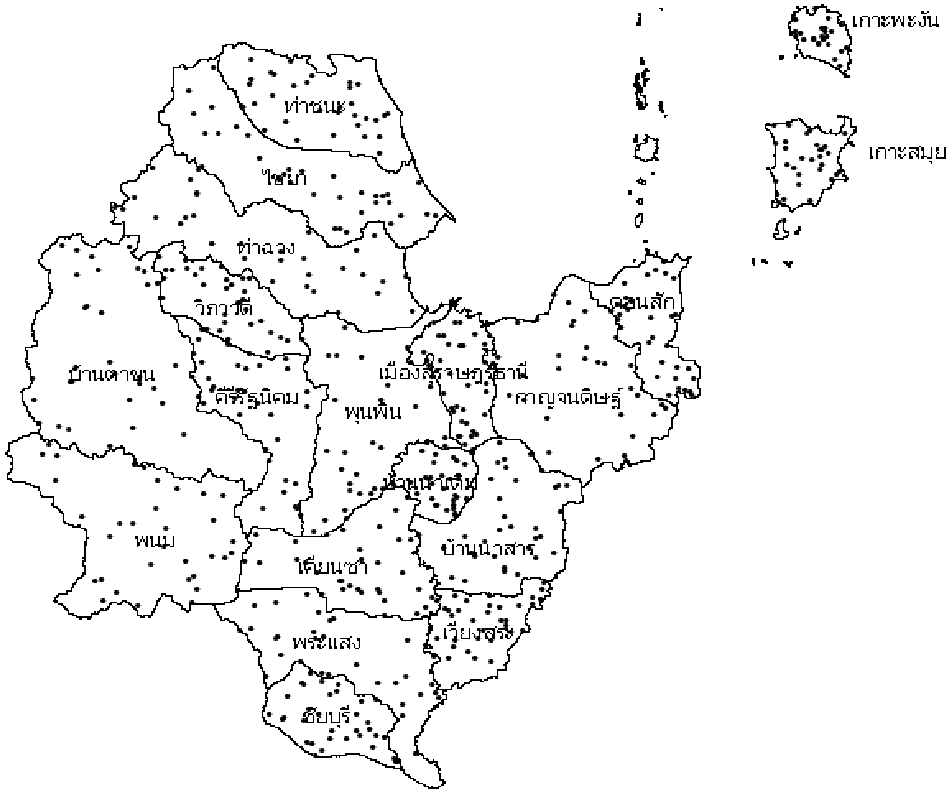

Figure A.5 The spreading of patient.

APPENDIX B
Global Morn's I

In this section, we used rainfall data from weather station mapping into Amphoe's area.

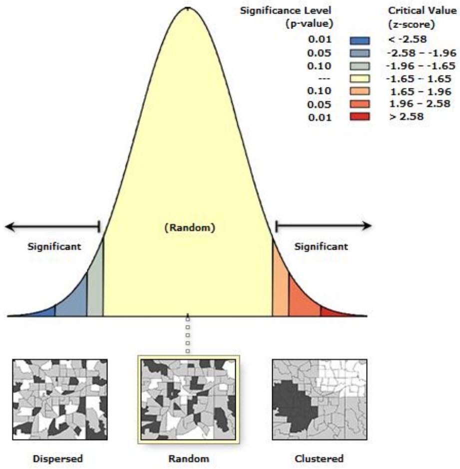

Figure B.1 rainfall the summery of Moran's I (Global Statistic)

Result of this method evaluates the pattern expressed is random shown in Figure B.1 .Output of Global Morn's I summaries are Moran's Index = -0.247082, Expected Index = -0.05556, Variance = 0.034034, Z – Score = -1.038178 and P – Value = 0.299187

Given the z-score of -1.04, the pattern does not appear to be significantly different than random.

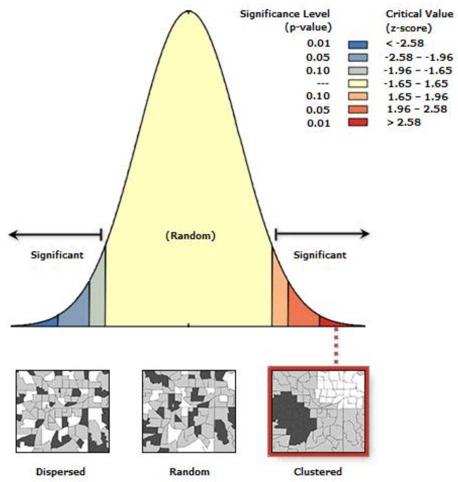

Figure B.2 Air pressure the summery of Moran's I (Global Statistic)

Result of this method evaluates the pattern expressed is random shown in Figure B.2.Output of Global Morn's I summaries are Moran's Index = 0.615902, Expected Index = -0.04719, Variance = 0.042752, Z – Score = 3.209060 and P – Value = 0.001332

Given the z-score of 3.21, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

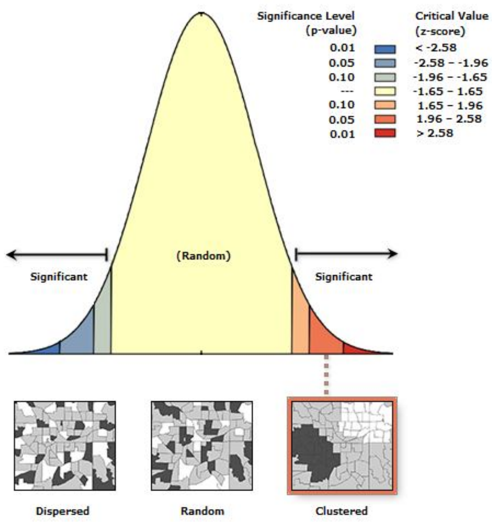

Figure B.3 Temperature the summery of Moran's I (Global Statistic)

Result of this method evaluates the pattern expressed is random shown in Figure B.3. Output of Global Morn's I summaries are Moran's Index = 0.410125, Expected Index = -0.0625, Variance = 0.043587, Z – Score = 2.263937 and P – Value = 0.023578

Given the z-score of 2.26, there is a less than 5% likelihood that this clustered pattern could be the result of random chance.

APPENDIX C

Getis – Ord General G

This spatial tool calculates the High/Low clustering analysis. We used data of rainfall in area each Amphoe represent in Figure C.1.

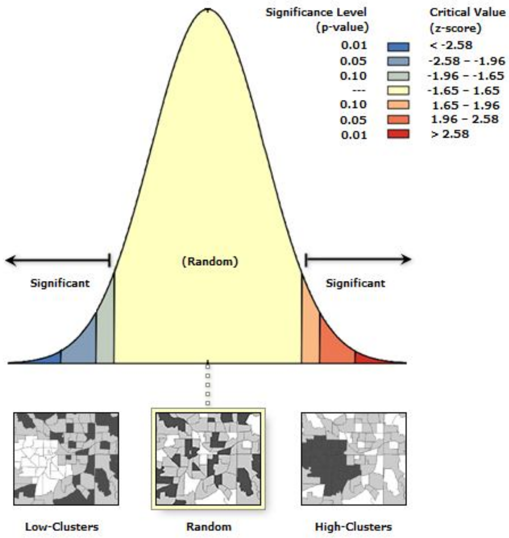

Figure C.1 rainfall high/low clustering report.

Result the high/low general G value are Observed General G = 0.000010, Expected General G = 0.000009, General G Variance = 0.000000, Z – score = 1.234166 and p- value = 0.217141

Given the z-score of 1.23, the pattern does not appear to be significantly different than random.

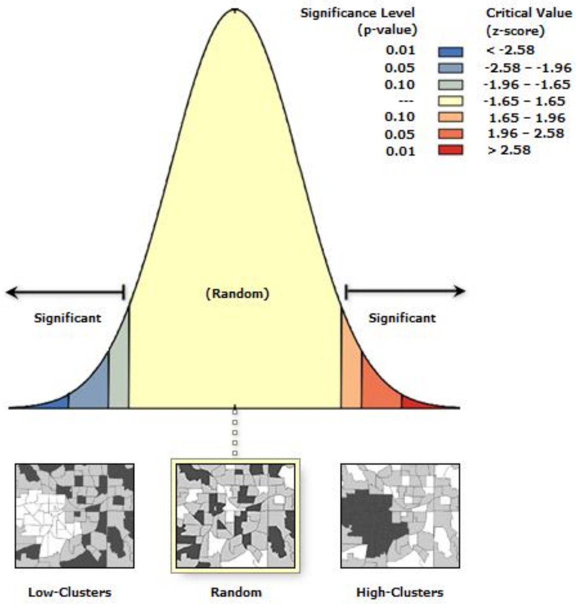

Figure C.2 Air pressure high/low clustering report.

Result the high/low general G value are Observed General G = 0.000006, Expected General G = 0.000006, General G Variance = 0.000000, Z – score = 0.612438 and p- value = 0.540248

Given the z-score of 0.61, the pattern does not appear to be significantly different than random.

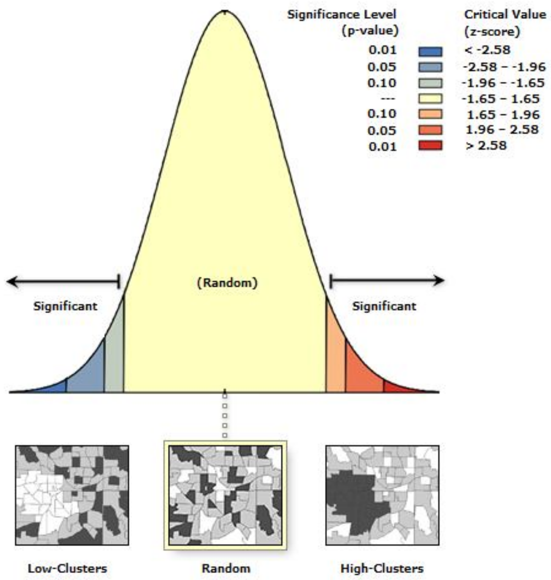

Figure C.3 Air pressure high/low clustering report.

Result the high/low general G value are Observed General G = 0.000003, Expected General G = 0.000003, General G Variance = 0.000000, Z – score = -0.061619 and p- value = 0.950866

Given the z-score of -0.06, the pattern does not appear to be significantly different than random.

BIOGRAPHY

NAME	Mr. Suchart Aoochay
DATE OF BIRTH	14 November 1980
PLACE OF BIRTH	Suratthani, Thailand
INSTITUTIONS ATTENDED	Sirindhorn College of Public Health, Yala, 2006 Bachelor of Science Program in Community Health Mahidol University, 2013 Master of Science (Technology of Information System Management)
HOME ADDRESS	101/10 Moo 3 T. Tharongchang, A. Phunphin, Suratthani 84130 Tel 084-993-3662 Email: kapom3@gmail.com