CHAPTER II
LITERATURE REVIEW

2.1 Study area

Nakhon Si Thammarat province has 10,169 km^2, located at latitude 8^{o} – 9^{o} 19' and longtitude 99^{o} 15' - 100^{o} 15'. Moreover it has 193 km. along coastal territory.

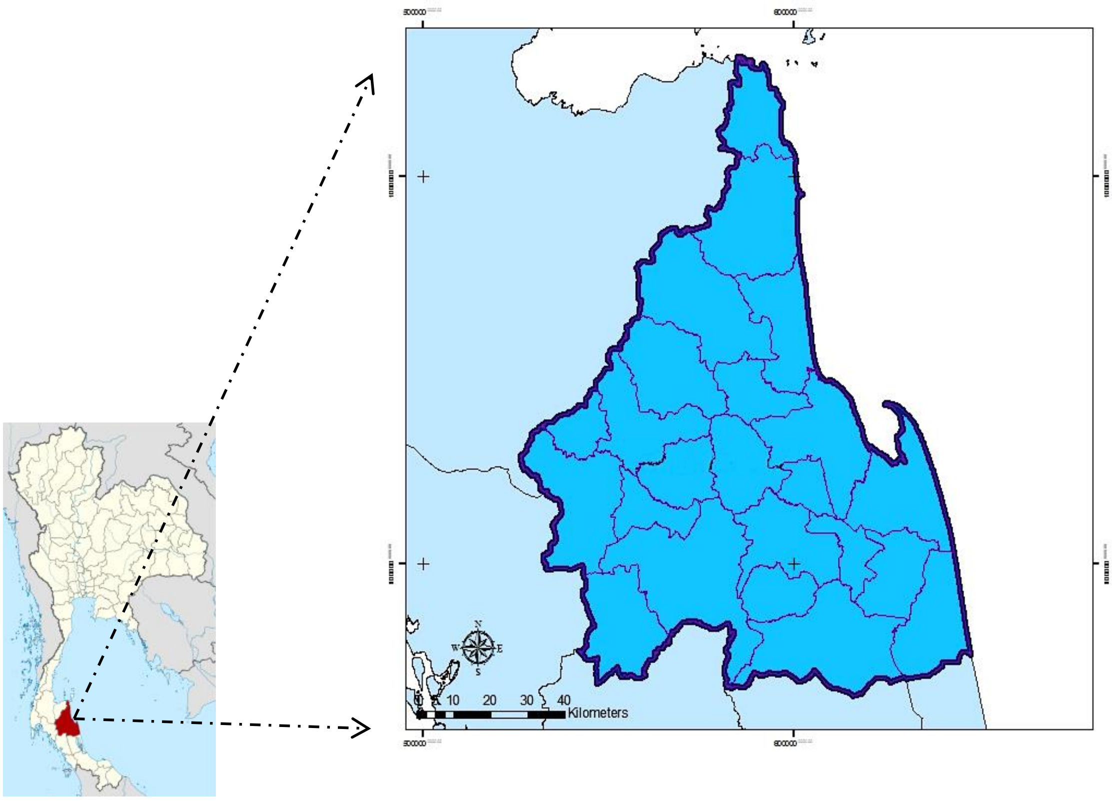

Figure 2-1 Boundary map of Nakhon Si Thammarat province

Modified : **:** Land Development Department

2.1.1 Topography

The terrain of Nakon Si Thamarat can be divided into 3 types as follow.

- Mountain areas locate in the center of the province from north to south. These areas are upstream area which is important because there are plenty of forests.

- Eastern coastal plain areas consist of fertile soils, which suitable for cultivation. Most of areas are using for rice field and orchard.

- Western plain valley has large amount of rubber plantation and orchard

2.1.2 Climate

Nakhon Si Thammarat province has influenced by 2 monsoons, Northeast monsoon and Southwest monsoon. These monsoons carry moisture to the Southern part of Thailand which affects Nakhon Si Thammarat climate.

Season : Nakhon Si Thammarat province has 2 seasons; summer and rainy

Temperature : The average temperature is about 27.5^{o}C, temperature influenced by the monsoon throughout the year.

Rainfall : Nakhon Si Thammarat has influenced by monsoon throughout the year, causing high rainfall which is 2,381mm/year.

Tropical cyclone : Tropical cyclone occurs between November and January. This conducts heavy rainfall over the province and cause flash floods.

2.2 Flood

Flood is a natural disaster caused by heavy rainfall. High intensity of rainfall on steep slopes leads to flash floods. On flat areas, it may lead to ponding, or urban flooding when the drainage capacity is insufficient compared with high intensity of the rainfall.

Moreover flood has resulted from overloading capacity of water level from rivers and streams. Floods typically flow from higher to lower watershed area. Damage of life and property depend on conditions and size of flood (4), (5)

2.2.1 Flooding Factor

The flooding factors can be divided into 2 factors as follows.

2.2.1.1. Natural Factor Major cause of flooding in Thailand is heavy rain in monsoon season which is described in detail as follows.

1) Rainfall Intensity The intensity of rainfall is a measure of amount of rain that falls over time. The intensity of rain is measured in the height of the water layer covering the ground in a period of time. While flood mostly caused by heavy rain which can be classified into the following levels. (6)

Very light rain describes rainfall rate less than 0.25mm./hr.

Light rain describes rainfall rate 0.25-1mm./hr.

Moderate rain describes rainfall rate 1-4mm./hr.

Heavy rain describes rainfall rate 4-16mm./hr.

Very heavy rain describes rainfall rate 16-50mm./hr.

Extreme rain describes rainfall rate exceeding 50mm./hr.

2.2.1.2 Human factors Currently, human activities cause the worst flood risk. Floodplain and drainage basin were transformed to built up area, some urban area does not have suitable drainage system. Tarmac and concrete increase the rate of water flow on the surface. Heavy rainfall consequently caused flooding. Moreover deforestation is one of the major causes of floods. Deforestation reduces interception of the trees so rainwater could flow and reach surface quickly increasing surface run-off rate. (7)

2.2.2 Flood Risk Map

Flood can happen anywhere, but certain areas are especially prone to serious flooding. Flood maps have been created to define the area that has chance to inundated by the flooding. Flood risk map is a topographic map made to show flood risk zones and their boundaries, floodways, base flood elevations and other information which show the locations of high-risk, moderate-to-low risk and undetermined-risk areas. Most recent flood map is produced by using Geographic Information System (GIS). Flood-risk maps help people to understand the flooding areas, used to planning and prevent flooding situation.(8), (9), (10), (11)

2.3 Landslide

Landslide is a natural disaster. It is a movement of rock, earth, or debris down a sloped section of land. Landslide is caused by rain, earthquakes, volcanoes, or other factors that make the slope unstable. (12)

2.3.1 Causes of Landslides

Landslides have two major causes: natural causes and human causes.

1.) Natural causes

Slopes Many landslides occur in steeper slopes because gravity works more effectively on steeper slopes, but less-sloped area may also be vulnerable.

Geological factors refer to characteristics of the material itself. The rock might be weak or fractured, or different layers may have different strengths and stiffness. Many slides occur in a geologic setting that places permeable sands and gravels above impermeable layers of silt and clay, or bedrock. Water seeps downward through the upper materials and accumulates on top of the weakness layer.

Morphology refers to the structure of the land. For example, slopes that lose their vegetation to fire or drought are more vulnerable to landslides. Vegetation holds soil in place, and without the root systems of trees, bushes, and other plants, the land is more likely to slide away.

Heavy and prolonged rainfall Water is commonly the primary factor triggering a landslide. Slides often occur following intense rainfall, when storm water runoff saturates soils on steep slopes or when infiltration causes a rapid rise in groundwater levels. Groundwater may rise as a result of heavy rain as some slopes become unstable. (12)

2.) Anthropogenic Factors Human activities can trigger landslides such as inappropriate drainage system, change in slope/land use pattern, deforestation, agricultural practices on steep slopes, cutting and deep excavations on slopes for buildings, roads, canals and mining.

Inappropriate drainage system Natural drainage lines on slopes are blocked by contour bounding adopted to prevent soil erosion and to enhance percolation during dry season. Agriculture without appropriate drainage system for intense rains increases landslide vulnerability.

Human activity such as agriculture and construction can increase the risk of a landslide. Developmental activities like construction of buildings, road cutting, irrigation, deforestation, excavation, increase in settlements and water leakage are some of the common activities that can help destabilize on steep slopes. (12)

2.4 Land use and land cover change (LULCC)

Land-use and land-cover change (LULCC) is a general term for the human modification of Earth's surface. Humans have been modifying land to obtain food and other essentials. Land cover refers to the physical and biological cover over the surface of land, including water, vegetation, bare soil, and artificial structures. Natural scientists define land use in terms of human activities such as agriculture, forestry and building construction that alter land surface processes including biogeochemistry, hydrology and biodiversity. Social scientists and land managers define land use include the social and economic purposes. The current rates of LULCC are increasing higher than ever in history, driving unprecedented changes in ecosystems and environmental processes such as biodiversity loss at local, regional and global scales. (13), (14), (15)

2.4.1 Drivers of land use change

Driving forces on LULCC include factors that influences human activity, including local culture (food preference, etc.), economics (demand for specific products, financial incentives), environmental conditions (soil quality, terrain, moisture availability), land policy & development programs (agricultural programs, road building, zoning), and feedbacks between these factors, including past human activity on the land (land degradation, irrigation and roads). Investigation of these drivers of LULCC requires a full range of methods from the natural and social sciences, including climatology, soil science, ecology, environmental science, hydrology, geography, information systems, computer science, anthropology, sociology, and policy science. (13), (14), (15)

2.5 Remote sensing (RS)

Remote Sensing is close-up survey using Electromagnetic waves to get the data of an object or area. The data obtained from the survey will be in the form of Aerial Photograph or Satellite Imagery. So data can be used to analyst and plan of natural resources. (16)

2.5.1 Type

Remote sensing can be divided into 2 groups according to the source of electromagnetic waves.

2.5.1.1. Passive remote sensing This system is used extensively until now by using solar energy. This type of data will recorded in the daytime and cannot obtain information in a rainy or cloudy day.

2.5.1.2. Active remote sensing This system is a built-in radar systems to produce a range of microwave and then sent to the target area. This system can receive and record information without restrictions of time or climate. It can send and receive signals both on day and night. You can also penetrate fog, rain clouds in every season.

2.5.2 Data analysis

Data analysis consists of the following methods.

2.5.1.1 Visual analysis : This analysis based on ability and experience of users to interpret process using factors include Color, Shade, Tone, Shadow, Size, Pattern, Texture, Spatial components, and the principles of visual interpretation as well as aerial-photo interpretation.

2.5.1.2. Computer Analysis : This analysis uses computer to analyst data more quickly suitable for large amounts interpretation of data which is not easy to analyze visually. The principle is similar to the analysis of visual analysis. The data classification process can be divided into 2 types.

1.) Unsupervised Classification : The classification based on the statistics of the reflectivity of the objects, without using training area to help in the classification. This method is often used to identify an unfamiliar area.

2.) Supervised Classification : The classification using training area to represent the different object in the satellite imagery. It is used to calculate statistics such as Mean, Standard Deviation of each data.

2.6 Geographic information system (GIS)

GIS is the technology used to collect, store, analyze and display geographic information retrieval such as spatial data and attribute data that can be referenced by geographic coordinates. This system currently a primary tool used to help in decision making for natural resource management. For example, environmental impact study, studies and mapping of natural resources etc. (16), (17), (18)

2.6.1 Components of GIS.

GIS is divided into 5 parts as follows.

2.6.1.1. Hardware : The general hardware component of a GIS is the computer or central processing unit. It is linked to a storage unit, which provides space for storing data and programs. A digitizer, scanner and other device, used to convert data into digital. A plotter or other kind of display device is used to present the result of the data processing.

2.6.1.2. Software The GIS software includes the programs such as Arc Info, ArcView, etc.

2.6.1.3. Procedures The procedures include how the data will be retrieved, input into the system, stored, managed, transformed, analyzed, and finally presented in a final output. The procedures are the step taken to answer the question needs to be resolved.

2.6.1.4. Data is the most important component of a GIS. Geographic data and related tabular data can be compiled to custom specifications. A GIS can integrate spatial data with other existing data resources.

2.6.1.5. User People are the component who actually makes the GIS work. Such as GIS managers, database administrators, application specialists, systems analysts, and programmers. They are responsible for maintenance of the geographic database and provide technical support. (16), (17), (18)

2.6.2 GIS Data

GIS Data has divided into 2 types as follows.

2.6.2.1 Spatial data Spatial data contains the coordinates and identifying information for various map features. Three types of features can be represented in the map: points, lines, and areas. The various physical aspects of the map--political boundaries, roads, railroads, waterways. In GIS, there are 2 basic spatial data as follows:

1) Raster Data In the raster data model, land cover is represented as single square cells. Each cell will have a value corresponding to its land cover type.

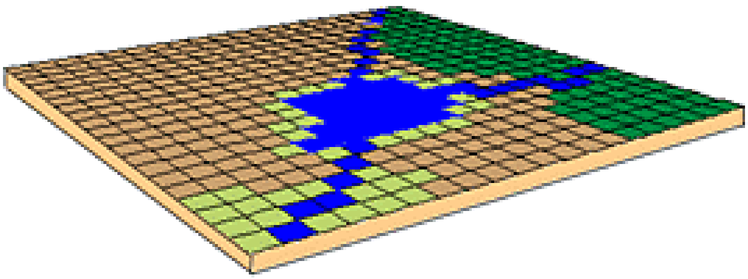

Figure 2-2 Raster Data
Source : Sura Pattanakiat (2002)

Raster data are good at:

- Representing continuous data (e.g., slope, elevation, chemical concentrations)
- Representing multiple feature types (e.g., points, lines, and polygons)
- Analysis of multi-layer or multivariate data (e.g., satellite image processing)

2) Vector Data In the vector data, features on the earth are represented into 3 types as follows.

- Points represent anything that can be described as an x, y location on the surface of the earth, such as shopping centers, customers, utility poles, hospitals, or cellular towers.

- Lines represent anything having a length, such as streets, highways, and rivers.

- **Polygons** describe anything having boundaries, whether natural, political or administrative, such as the boundaries of countries, states, cities, census tracts, postal zones, and market areas.

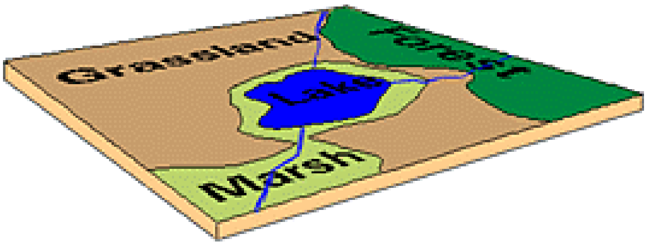

Figure 2-3 Vector Data
Source : Sura Pattanakiat (2002)

Vector data are good at

- Accurately representing true shape and size
- Representing non-continuous data (e.g., rivers, political boundaries, road lines, mountain peaks)
- Creating aesthetically pleasing maps
- Conserving disk space

2.6.2.2 Attribute data. The attribute data contains information that can be linked to the spatial data. For example, matching addresses or coordinates in the spatial data which are collected and compiled for specific areas like boundaries, population information, streets, etc.(16)

2.6.3 Normalized Difference Vegetation Index (NDVI)

NDVI is a vegetation index that indicates the proportion of plants in the area by calculation of the Near-infrared Reflectance and Red visible Reflectance. NDVI details are as follows. (20)

NDVI = NIR-RED / NIR+RED

With NIR = Near-infrared Reflectance (%)
RED = Red visible Reflectance (%)

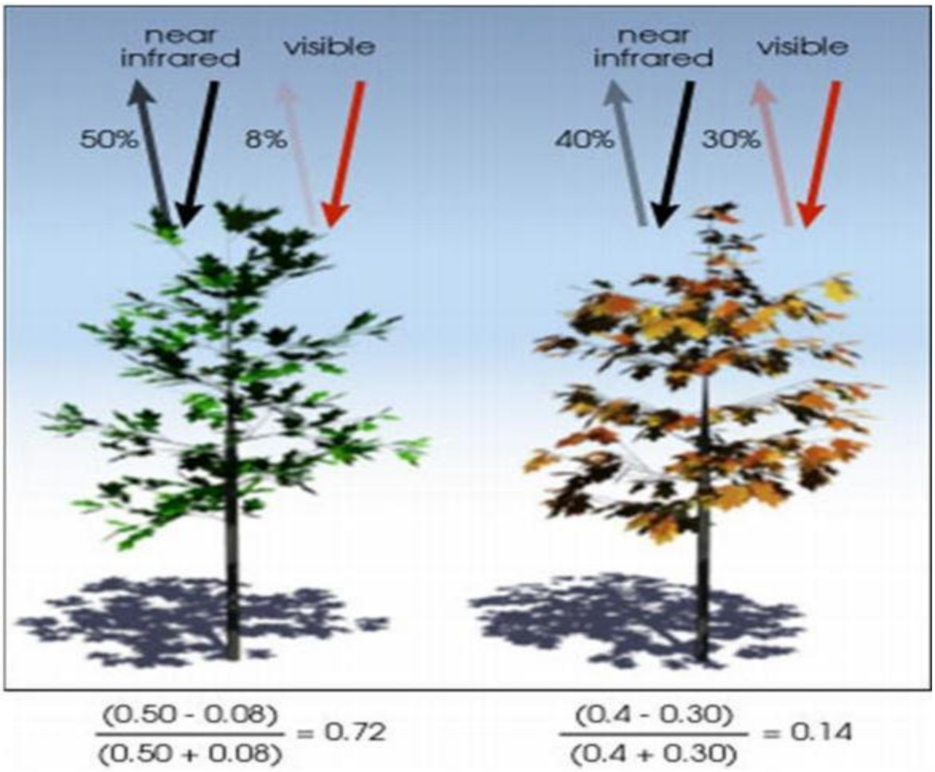

Figure 2-4 Normalized Difference Vegetation Index
Source : http://earthobservatory.nasa.gov

- NDVI value is between-1 and 1

- Surface covered with plants reflects Near-infrared wavelength higher than Red visible wavelength, the NDVI is positive value. (NIR > Red)

- Surface covered with soil reflects both Near-infrared wavelength and Red visible wavelength, the NDVI value closes to zero (NIR = Red)

- Surface covered with water reflects Near-infrared wavelength less than Red visible wavelength, the NDVI is negative value. (NIR < Red)

2.6.3. Benefits of NDVI

1. To study the distribution of vegetation in the area.
2. To classify plants in the area.
3. To calculate biomass, productivity, and leaf area.

2.7 Potential surface analysis (PSA)

Potential Surface Analysis (PSA) is a technique to analyze potential of area with quantitative data by determining relevant factor of study objective (16).

The steps of PSA process is shown below:

1) Identify study objective

2) Identify indicator for achievement

3) Weighting of objectives

4) Identify study area

5) Collect data

6) Adjust value of data to be agreed with weighting and objectives

7) Calculate for final surface value

Weighting each factor will be done to calculate the average area of intersection in map boundary. Weighted value is high while a factor is significant; on the contrary, a value is lower while factor is lower significant but must not lower than 0. The basic equation of PSA is shown as follows:

Score of potential (S)	=	(R1 x W1)+(R2 x W2)+...+(Rn x Wn)
R	=	Rated value of each factor
W	=	Weighted value of each factor
n	=	Nunber of factor for analysis

(2-1)

Source : Sura Pattanakiat (2002)

The data analysis is done to identify value of factor for calculation by identifying 2 significant components as follows:

- **Rating value** is defined the relative levels of the study factors that have associated with the study objective. The low relative factor has low-level score and high relative factor has high-level score.

- **Weighting value** is to specify value of major factor which is affected or related to study objective. Identification of weighting value based on the same principle as rating value data manipulation which is calculated with an appropriate equation.

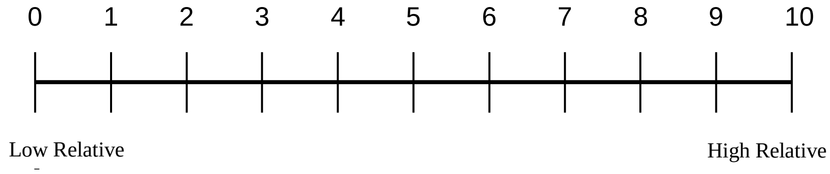

Figure 2-5 The Priority Score of Rating and Weighting value
Source : Sura Pattanakiat (2002)

After calculation, statistical method is applied to classify the potential class using the following statistical formula. (16)

$$\text{Range} = (\text{Max} - \text{Min}) / \text{Number of Level} \qquad (2\text{-}2)$$

2.8 MARKOV model

Markov model is used to predict the data that will change in the future. The analysis needs to know the proportion of land use (land use proportion, V) on second period for analysing opportunities of change (Probability, P) and types of land use. Then the opportunity of change (P), which is in the form of matrix, multiplies with ratio (V) of the land use in Phase 2. The information on land use in difference patterns in Stage 3 is evaluated by Markov way as follows.

Proportion of land use in the next period = (Vj) X (Pjk)

$$(Vj) \times (Pjk) = (V1, V2, V3 \ldots Vn) \begin{pmatrix} P11, P12, \ldots P1m \\ P21, P22, \ldots P2m \\ . \; . \; \ldots \; . \\ Pm1, Pm2, \ldots Pmm \end{pmatrix}$$

With Vj is proportion of land use in phase 2
Pjk is opportunity of land use changing from phase 1 to phase 2

The advantages of Markov Chain Model are easily calculated and adaptable with geographic information system (GIS) for following land use in the future. For limitations of this model is that the cause of increase or decrease of the area is unexplainable (19).

2.8.1 Markov Cellular Automata (CA-MARKOV)

Cellular Automata is an applied computer skill and physics. Cellular Automaton is the cell integrated in a rectangular grid or a grid cell. Each grid contains information that can change which defines neighborhood cell by the table size 3X3. For this reason, Cellular Automaton has applied to predict the changing of data in the future.

Markov Cellular Automata or CA-MARKOV is the application from both Cellular Automata and Markov Chain to predict land use using GIS. The patterns of change in each cell are determined by the Neighborhood. The operation of CA-MARKOV is as follows:

1) Analysis of CA-MARKOV uses the opportunity of change. (Probability, P) obtained by Markov Chain analysis with CA filter size 5X5 neighborhood to determine the probability of land cover types in the study period.

2) CA filtering to move all data to the stack with the cells. The mobile will loop indefinitely. A number of round equal to the length of time required to study as predicted in the next 10 years, the analysis process will repeat up to the 10^{th} round.

3) In the analysis of each loop, land cover will change or remain the same depending on the type of land cover of the surrounding area and the opportunity of change. (Probability, P).

4) The result shows land cover data in the future. This includes areas that have not changed and changing the area of land use.

Therefore, it is concluded that CA Markov process consists of two parts. Part one is the CA filtering, the second part is the opportunity of change (probability, P) and the ratio of the change (Transition areas) derived from Markov Chain Analysis. The area will change or remain the same depending on the type of land use of the surrounding area together with the ratio of the change (Transition areas) (19).

In this study, CA-MARKOV is applied to analyze the trend of land use in the future. CA-MARKOV is calculated by matrix. This calculation is suitable for calculating area, which is known matrix data such as satellite images. This method is unlike Regression analyzes which were calculated using the linear equation y = a + bx, if the value is not in a straight line, value could not be calculated.

2.8.2 Transition Probability ใน MARKOV Model

MARKOV model is used to forecast future scenarios. The need to know the current situation and to know the probability of transition from one to other such as know the probability of land use in Type A. Land use now remains a type A in the next year or to change to a Land use type B.

Example, one of the villages found that there are two types of land use which are Para rubber and Orchard, 80% of para rubber in the first year still remains the same in next years, and 20% change to the orchard in the next year. Meanwhile, 70% of orchard area in the first year still remains the same in next year and 30% change to para rubber in the next year. This can be written in the probability of a change in the matrix as follows.

	Para Rubber	**Orchard**
Para Rubber	0.8	0.2
Orchard	0.3	0.7

$$P = \begin{pmatrix} 0.8 & 0.2 \\ 0.3 & 0.7 \end{pmatrix}$$

By means of the horizontal is the first year. The vertical section refers to the second year. Generally, if it has two states like in this examples Matrix that represents the transformation of the state.

$$P = \begin{pmatrix} P11 & P12 \\ P21 & P22 \end{pmatrix}$$

Where Pij refers to the probability of transition from state at I, in the current state at j, in the future as P12 is the probability that current state at I, but in the future is a second state. In addition, positive probability, the landscape has to be equal to 1 (P11 + P12 = 1, P21 + P22 = 1) (19).

2.9 Related researches

Kaori A. studied of assessing coastal environmental changes in Nakorn Si Thammarat Province using remote sensing (RS) and geographic information system (GIS). This research aimed to assess land use changed on coastal areas of Nakhon si thammarat province. Also this research using aerial photograph and satellite images from LANDSAT-5TM (1966, 1967, 1990, and 2004) combined with Arcinfo and Arcview program for land cover classification. Then use overlay technique to show the land use changed during that time. Moreover, it checked for water quality in the study area by using 9 water sampling points to analyze the Dissolve Oxygen (DO) and pH of the water. The results showed that during years 1990-2004, the rice fields, swamp areas, and mangrove were decreased continuously due to the constantly increasing of shrimp farm. The increasing of shrimp farming impacted to coastal environment, soil, and water quality degradation and coastal erosion. (2)

Prasit Mekaroon applied geographic information system (GIS) in order to assess the flood risk area on Yom watershed by using flooding factors as annual rainfall, elevation, slope, water network, transportation, land-use, and soil data. The result showed most of study area was medium risk area which is 35.22%, low risk area is 22.23% and non risk area is 3.73%. Moreover, this research suggested measures to prevent flooding such as conserve the forest in the first level watershed area and control the inappropriate land-use development. (3)

Siam L. studied of Expert Classification for Land Cover Mapping of Bang Pakong Watershed using Unsupervised Classification (ISODATA clustering method) combined with Knowledge-based Operation and GIS Data, using LANDSAT-5TM images. This research classified land cover type into following categories, Residential and open space area, abandons land, mixed deciduous forest, mangrove forest, wetland, paddy field, vegetation, and water body. The results showed that residential and open space area was 481.99 km^2 (5.48%), abandoned land area was 925.67 km^2 (10.52%), mixed deciduous forest was 1,727.33 km^2 (19.64%), mangrove forest and wetland was 54.20 km^2 (0.02%), paddy field was 244.61 km^2 (2.78%), vegetation was

4,265.66 km^2 (48.50%), water body was 1,095.88 km^2 (12.46%). Comparing to the accuracy between the Expert classification and Maximum likelihood found that expert classification accuracy is 78% and maximum likelihood accuracy is 67%. (20)

Aingorn Chaiyes applied geographic information system (GIS) combined with CA Markov model and Regression model in order to study land use change in Nan province during year 1990-2005 and to predict land use change in the next 10 years. The results showed the mixed deciduous forest were the largest declined and converted into agriculture plantation during year 1980-2004. Moreover, similar result of the CA_Makov and Regression model was 89.81% and kappa index was 0.87. (21)

Ruthairat Mangsilp () applied Geographic information system (GIS) combined with Hydrological Model (HEC-RAS Model) to assess flood risk area in Mae Taeng Watershed and Chiang Mai Province. This research used flooding factor as annual rainfall, slope, elevation, water network, drainage basin, transportation, land-use, and soil data. Then the potential surface analysis (PSA) was utilized to weight the flooding factor rate. The last step, Hydrological Model (HEC-RAS Model) was applied to define flood risk area. The result showed that a high risk area was 0.93%, medium risk area was 9.59%, low risk area was 39.32% and the accuracy of result was 96.51%. (22)

Chaow Yongchaleamchai applied geographic information system (GIS) combined with Remote sensing in order to assign flood risk area in Tapi watershed. This research used satellite image from Landsat-7 ETM combined with the influence factors of flooding such as rainfall, size of area, slope of area, land use data, soil and transportation, then used rating and weighting technique to priority the flood factor. The high value represented that all factors were important to flooding. The results showed a high risk area was 15.7%, medium risk area was 5.38% and low risk area was 0.40% of the total study areas. (23)

Pirapit Peudmongkol applied geographic information system (GIS) combined with Remote sensing in order to assign flood risk area in upper southern of Thailand. This research used Rating Weighting technique to determine the factors of flooding. The result showed that most of flood risk area was located in the east of the study area. The reason was because this area was a large basin area leading to high chance of flooding. A high risk area was 12.90% and most high risk area was lowland such as rice field, swamp, mangrove, and aquaculture area. A medium risk area was 4.11% and low risk area was 0.48% of the study area. (24)