QUANTIFYING THE LAND USE CHANGES BY USING REMOTE SENSING AND GIS

by

ANIS QURRATU AIN BINTI APANDI

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DECLARATION

I declare that this thesis entitled "Quantifying of Land Use Changes by Using Remote Sensing and GIS" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature   :

Name   : Anis Qurratu Ain binti Apandi

Date   : 18 January 2019

APPROVAL

"I hereby declare that I have read this thesis and in our opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Applied Science (Natural Resources Science) with Honors"

Signature   : …………………….........
Name of Supervisor I   : Dr Shaparas binti Daliman
Date   : 18 January 2019

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Quantifying the land use changes by using remote sensing and GIS

ABSTRACT

Earth observations, monitoring, and information analysis can be conducted through remote sensing and geographic information system (GIS) techniques. These tools provide valid means of studying land use changes and environmental transformations. In this study, land use changes are monitored and quantified by using remote sensing and GIS in Mueang Surat Thani district, Thailand. This study focus on four interval years between year 2006 until year 2018. Landsat Thematic Mapper (TM) 5 images of two different years which are 2006 and 2010, and Landsat 8 of OLI/TIRS year 2014 and 2018 were compared and classified using supervised classification by using Maximum Likelihood Classifier in Erdas Imagine software 2015. The images of the study were categorized into four classes which are urban, agricultural, forest and water. Throughout the four period of years, the results show that there are increase in agricultural and urban area by 13.97% and 16.01% respectively which contributed to reduction of forest area by 19.97%. However, water area has no significant difference area by 0.57%. By using remote sensing data and GIS, this study provide the current analysis data representation of the land use changes for past years that could assist in formulating mitigation measures as well as minimizing the environmental degradation in future development.

Mengukur perubahan penggunaan tanah dengan menggunakan penderiaan jauh dan teknik sistem geografi (GIS)

ABSTRAK

Pemerhatian bumi, pemantauan, dan analisis maklumat dapat dilakukan melalui penderiaan jauh dan teknik sistem informasi geografi (GIS). Teknik ini menyediakan cara yang sahih untuk mengkaji perubahan penggunaan tanah dan transformasi persekitaran. Dalam kajian ini, perubahan penggunaan tanah dipantau dan dikira dengan menggunakan kaedah penderiaan jarak jauh dan GIS di daerah Mueang Surat Thani, Thailand. Kajian ini memberi tumpuan kepada empat tempoh antara tahun 2006 hingga tahun 2018. Imej Landsat Thematic Mapper (TM) 5 bagi dua tahun yang berlainan iaitu 2006, dan 2010 dan Landsat 8 (OLI/TIRS) bagi tahun 2014 dan 2018 telah dibandingkan dan dikelaskan dan menggunakan klasifikasi yang diawasi dengan menggunakan Maksimum Pengelas Kemungkinan dalam perisian Erdas Imagine 2015. Imej kawasan kajian itu dikategorikan kepada empat kelas iaitu kawasan bandar, pertanian, hutan dan air. Sepanjang tempoh empat tahun, hasil menunjukkan terdapat peningkatan dalam kawasan pertanian dan bandar sebanyak 13.97% dan 16.01% masing-masing yang menyumbang kepada pengurangan kawasan hutan sebanyak 19.97%. Walau bagaimanapun, kawasan air tidak mempunyai kawasan perbezaan yang ketara iaitu hanya perubahan sebanyak 0.57%. Dengan menggunakan data penderiaan jauh dan GIS, kajian ini menyediakan perwakilan data analisis semasa perubahan penggunaan tanah untuk tahun-tahun yang lalu yang dapat membantu dalam merangka langkah-langkah pencegahan serta meminimumkan kemusnahan alam sekitar dalam pembangunan masa hadapan.

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LIST OF ABBREVIATIONS

AM/FM	Automated Mapping/ Facilities Management
AOI	Area of Interest
CADD	Computer Aided Design and Drawing
ETM +	Enhanced Thematic Mapper Plus
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
Ha	Hectares
HSR	High Spatial Resolution
LDCM	Landsat Data Continuity Mission
LST	Land Surface Temperature
LULC	Land Use Land Cover
MSS	Multispectral Scanner System
NASA	National Aeronautics and Space Administration
NDVI	Normalized Difference Vegetation Index
OLI/TIRS	Operational Land Imager/Thermal Infrared Sensors
PSU	Prince of Songkla University
SRU	Suratthani Rajabhat University
TM	Thematic Mapper
USGS	United States Geological Survey
WWF	World Wide Fund for Nature

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Developing the quality of life in urban areas is known as land use planning. Development planning is vital for sustainability and to ensure that the resources are used wisely since resources are limited. World Wide Fund for Nature or WWF states that land use planning is a technique of organizing, managing, and regulating the use of land which is essential to protect the environment from degradation (WWF, 2017).

The needs and demands for agriculture, forestry, wildlife, urbanization and others are more than the land resources available. The pressure from the land use changes due to rapid development makes the land becoming a sparse resource. Thus, the need for land use changes is important to avoid unwanted changes and must be accepted by any authorities involved. According to Singh (2006), land use changes study also assist in managing the natural resources and observing environmental changes.

Earth observations, monitoring, and information analysis can be conducted through Geographic Information System and remote sensing techniques. These tools provide valid means of studying land use changes and environmental transformations. The

causes land use changes are including urbanization, agricultural development, and forestry (Paiboonvorachat & Oyana, 2011).

In Thailand, the area of land is approximately about 16.8 million hectares. Thus, this study will monitor and quantify the land use changes at the area of Mueang district Surat Thani including Prince of Songkla University (PSU), Surat Thani.

1.2   Problem Statement

Earth's land use and land cover are changing rapidly due to anthropogenic activities and natural disaster especially involving in losses of the forest (Muttitanon & Tripathi, 2005). Changes in land use due to development of learning institution in the study area will affect the surrounding area and also arise the environmental problems such as soil erosion, disturbance in biological cycles, floods, and deforestation. Thus, special attention is needed in monitoring and quantifying the land use changes in this study area.

Mueang Surat Thani districts where Prince of Songkla University (PSU) Surat Thani are places where one could have a better life because of the land use changes are mostly for development of learning institution. As a result, there will be a significant effect on the ecosystem surrounding due to drastic land use changes. Therefore, quantifying and monitoring land use changes can resolving the negative consequences. Also, the gathering data will be useful for future planning, environmental management and references for another future researcher.

1.3 Objectives

The main objective of this study is to quantify the land use changes in Mueang Surat Thani district which located in Thailand.

The specific objectives of this research are:-

i. To identify the data for land use changes in Mueang Surat Thani district from year 2006, 2010, 2014, and 2018.

ii. To analyze the land use change map Mueang Surat Thani district from year 2006, 2010, 2014, and 2018 using remote sensing and GIS.

1.4 Scope of Study

Basically, the research will analyze land use changes from year 2006, 2010, 2014, and 2018. It covered aspects of land use change that have a direct bearing on the socio-economic of the community in Mueang Surat Thani district. In addition, the classification of land use changes will be mapped into four which are urban or built-up land, agricultural fields, forest and water by using Maximum Likelihood Classification.

1.5 Significance of Study

The results from this research will help in understanding change in land use in Mueang district. By using remote sensing data and geoinformation system, the study will be able to provide the current analysis data representation of the land use changes for past years. Moreover, land use and land cover data changes will be useful to the body of

knowledge and its community such as government, public sector and private sector towards land use planning and sustainable management. Also, by having a proper planning for the land use, the data could assist in formulate mitigation measures as well as minimizing the environmental degradation in the study area in future.

1.6   Study Area

This study was carried out in one of district in Surat Thani, Thailand. Surat Thani or often shortened as Surat is the largest province in southern Thailand. It lies on the western shore of the Gulf of Thailand. Surat Thani means "city of good people", a title given to the city by King Vajiravudh (Rama VI). The area of Surat Thani province is 12,891.5 square kilometers. It covers a rainforest area with a diversity of flora and fauna. The main rivers of Surat Thani Province are the Tapi River and the Phum Duang River, which join at the town Tha Kham shortly before they flow into Ban Don Bay.

The province is divided into 19 districts. One of the district is Mueang Surat Thani which is also the capital district of Surat Thani province. Figure 1.1 shows the area of Mueang Surat Thani which previously known as Ban Don District is situated in coordinate from latitude 9°8'11"N and longitude 99°19'13"E. The district is divided into 11 sub-districts. It has an area approximately 233.80 square kilometers.
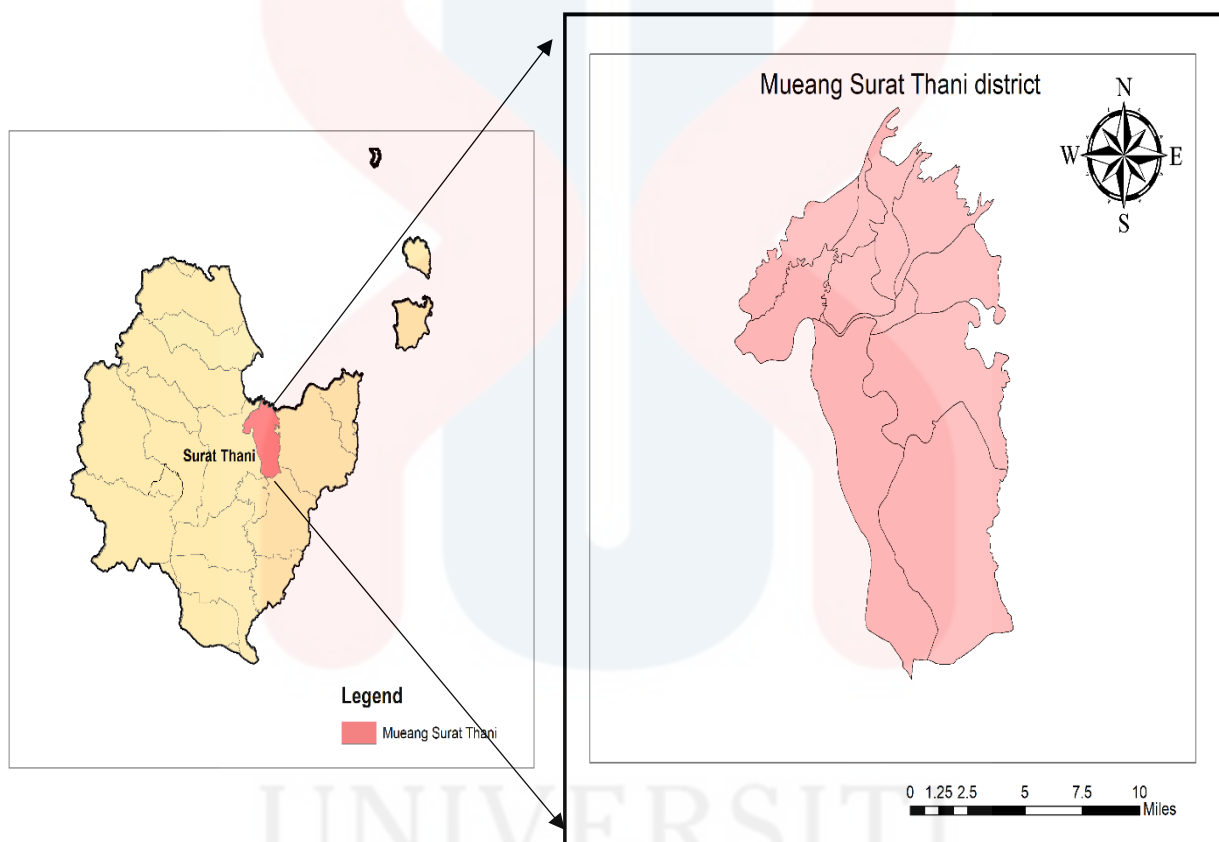
Figure 1.1: Map of study area in Mueang Surat Thani district, Thailand

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Literature review about the research quantifying the land use changes using remote sensing GIS will focus on Land Use / Land Cover (LULC), land use classification and method, issues and impacts of land use changes, remote sensing, Landsat image application, GIS and change detection.

2.2 Land Use / Land Cover (LULC)

Land use and land cover change have become one of the most important recognized changes occur in the earth. Land use and land cover comes from two different aspects. According to Gong et al., (2009), land cover is about land biophysical aspect. As mentioned by Ellis and Pontius (2007), land cover refers to the physical and biological cover throughout the surface of land which includes surface of water, land, vegetation, soil and also artificial structures.

However, on the other hand, land use is the land functional aspect. To be more precise, land use is more to social and economic purposes and its changes required integration of natural and scientific methods to determine which anthropogenic activities

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are involving in parts of the landscape even though the land cover is appears to be the same (Sarathi Roy & Roy, 2010).

The changes can be known by comparison between landscapes of two or more different time periods. For example, in Southern part of Khartoum, there is a study done by Yousif et al., (2015) about LULC change detection due to urbanization. The study of the LULC changes and effect of urbanization on vegetation cover is in between the year 1972 until year 2011. The outcome of the research shows that there is significant decrease of vegetation and bare land, from 29% in year 1972 to 8% in year 2006 and from 20% in year 1972 to 2% in 2006 respectively. Meanwhile, urban areas are increased about 38% from 47% throughout the 39 years.

For example, Figure 2.1 below is the satellite images of land use in Indonesia. This image shows that the land use has change because of natural disaster. The tsunami and earthquake occurred in Indonesia has contributed to major changes in land use in the certain area involved. This image is captured from satellite image so that we can see the changes occur before and after the event.

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Figure 2.1: Satellite images of land use changes in Indonesia

(Source: Digital globe, 2018)

In addition, in Srinagar City, Ahmad Tali and Murthy (2013) focuses on LULC changes in between years (1979-2010) by comparing two satellite images of different dates and other similar information related for quantifying and magnifying the LULC change. Also, Reis (2008) study in Riez, North-East Turkey analyzed LULC changes from Landsat images acquired between year 1976 and year 2000. The results of the study revealed that most of the LULC changes occur in coastal areas and areas that having low slope values.

As studied by Santiphop (2009) in Kanchanaburi, Thailand, the study used two different data which are from remote sensing data and metrological data. The data collected were through years 1978-2007 in the study area. Based on spatial analysis done in the study, it is confirmed that there are LULC changed occur at the study site.

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Hence, this study will focus on LULC changes in between four interval years of 2006 until 2018.

2.3   Land Use Classification and Method

Land use data have essential role in management, government policy-making, and population monitoring. Liu et al., (2017) in their study revealed that the complexity of urban systems makes the accuracy classification of urban functional zones become harder. In fact, there are many studies focusing on land use classification by considering quality either from high spatial resolution (HSR) remote sensing images or from social media data. However, there are also studies considering both of the quality due to limited available models.

There are many classifications of land use. As example, in Hu & Wang (2013) research, they used decision tree classification algorithm. Meanwhile, Kim (2016) classified the land use area of his study site as 1) forest, 2) cropland, 3) coconut plantation, 4) upland grassland, 5) wetland, 6) settlements 7) shrub land and others.

Novack & Kux (2010) in their study in Brazil indicates that land use and land cover classification can be classified by using the InterIMAGE system and QuickBird sensor imagery mainly for object-based and knowledge-based image classification. On the other hand, land use classification using multi-temporal JERS-1 L-band SAR images was done by Kurosu et al., (2001) to improve classification accuracy.

Meanwhile, in Rozenstein & Karnieli (2011) research, they used Anderson classification system. There are six different classes used by the study which are detailed in Table 2.1.

Table 2.1: Land use classification system and description

Land use class	Description of the land use class
1) Urban or Built-up Land	Residential, industrial, agricultural commercial and services. Transportation and utilities.
2) Agricultural Fields	Cropland, orchards, vineyards, and nurseries.
3) Rangeland	Herbaceous, shrub, brush, and mixed rangeland.
4) Forest	Deciduous, evergreen, and mixed forest.
5) Water Bodies	Reservoirs, coastal water.
6) Barren Land	Bare exposed rock, quarries, and disturbed ground at building sites, and dirt roads.

(Source: Rozenstein & Karnieli, 2011)

Based on Fenta et al., (2017) study, LULC maps can be produced by using Multi-temporal Landsat images and Maximum Likelihood Classifier. The results then will be analyzed by using post-classification change detection and spatial metrics. This maximum likelihood classification also approved by Reis (2008) in his study where applied in two different images from Landsat with the aid of ground truth data obtained from aerial images dated 1973 and 2002. According to Mahmon et al., (2015), Maximum Likelihood Classifier gives more accurate result compare to other two classifier which are Minimum Distance Classification and Mahalanobis Distance Classifier.

Aburas et al., (2015) using normalized difference vegetation index (NDVI) as classification methods for measuring LULC changes in Seremban, Malaysia. To extract the NDVI values, they used two Landsat TM images from year 1990 to 2010. Then, Natural Breaks (Jenks) method is used to compute NDVI values for NDVI map classification. The results of the study show that there is significant increase in water

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bodies, urban areas, barren lands from 3.55% in 1990 to 7.25% in 2010. However, in vegetation area, the percentage decreases from 78.57% in 1990 to 65.44% in 2010.

Thus, this study classified into four classes which are forest, urban, water and agriculture. Then, classification system from Fenta et.al, (2017) and Reis (2008) used as references for this research because the classification system is mainly designed to rely on remote sensing and GIS. In fact, this classification also approved by Mahmon et al., (2015) where Maximum Likelihood Classification gives more accurate result. Also, only LULC types identifiable by remote sensing and GIS are used as the basis for organizing this classification which is suitable for this study.

2.4   Issues and Impacts of Land Use Changes

One of the most critical environmental issues that should be highlight is land use changes. Improper planning of land use changes can bring significant impact on the Earth's surface biophysical variables. For example, land surface temperature (LST) and normalized difference vegetation index (NDVI) (Tan, Lim, & Jafri, 2011).

Due to rapid urbanization and modernization a study case in the coastal region of China, Zhejiang has undergone a drastic land use changes over the last past years. The impact of the land use changes to the study area is cropland loss due to urban sprawl (Han et al., 2007). However, in Santiphop (2009), the study revealed that changes in rainfall and humidity variable had an impact on LULC changes.

Besides negative consequences from the land use changes, there is also the positive impact from the changes of landscapes, such as agricultural land use give human

various benefits which are supplies of food, water, aesthetics, and others. To date, there is a study that evaluating the benefits and trade-off which done by Wallace et al., (2015). In the study, they use classification of benefits. Firstly, the classification of benefits must not redundant among other categories. Next, the classification of benefits must inconsistent with other categories. Also, it must be scalable. Lastly, must be exhaustive and readily understood by those applying the classification.

Based on El Hadary et al., (2011) study in Penang, land changes occur due to urbanization gives positive impact to the community of Penang because there are economic opportunities that can help them in generating income and the development of livelihood becomes better. However, despite positive impact, there are also negative consequences which the expansion of built-up areas at the farming activities area has caused significant lost of agriculture land. Thus, the consequences affecting negatively the livelihood and food security of the people in the urban developing area.

Therefore, this study is crucial in order to know the consequences either negative or positive towards the land use changes occur in Mueang Surat Thani district.

2.5   Geoinformation Technologies

Brunn et al., (2013) stated in their study that geoinformation technologies is computer based system where database system can convert to spatial data that can be represented on a map. Geoinformation technologies is a multidisciplinary field that includes surveying, photogrammetry, remote sensing, mapping, geographic information system (GIS), geodesy and global navigation satellite system (GNSS) (Yusuf, 2007).

2.5.1   Remote Sensing

Remote sensing and GIS is computer based system. This computer based system is affordable, powerful and widely available. Furthermore, the demand in the applications of remote sensing and GIS for monitoring and quantifying as well as for the spatial and temporal patterns of the structures of building is increasing (Maktav et al, 2005).

Robila (2006) in his study revealed that remote sensing is a way that use energy of light, heat and radio waves to detect and extract the point and ground characteristics. Also, remote sensing is used to produce a large area map to access any changes in the area at different times which can help us to understand the earth ecological system. Remote Sensing also involves interaction between incident radiation and the targets of interest includes seven elements which are 1) Energy sources or illumination, 2) Radiation and the Atmosphere, 3) Interaction with the target, 4) Recording of energy by the sea, 5) Transmission, Reception, and Processing, 6) Interpretation and Analysis, and 7) Application.

Remote sensing information is accessible which it can gather information about inaccessible areas where it is not possible to gather information through ground surveys. Thus, it can allows large area coverage and enable to do surveys in variety of fields (Manugula & Bommakant, 2017). Also, a single data of satellite image can be analyzed and interpreted for different purposes and applications. The analyzed work also can be done in the computer laboratory thus can reduce the amount of field work. Despite that, remote sensing data can produce colour composite from three individual band images. The combination of three band images can provide better details of the area rather than

single band image or aerial photograph (Kumar, 2005). Last but not least, the data can be easily access at different scale and resolution.

Moreover, remote sensing can be applied in various environmental fields. For instance, agriculture, geography, zoology, meteorology, civil engineering, and forestry. In detail, for the process, remote sensing helps in gaining information about land cover, agricultural crop, water quality, urban growth, and vegetation dynamics (Jong et al., 2004).

2.5.2 Landsat Image Application

Landsat is one of advanced application more than camera that have great specification of lens orbiting Earth. Reflected light by Earth from the Sun can be measures by Landsat which gives various information about the earth's surfaces (Irons, 2018) which made Landsat image extremely useful source for science, management and development of policy (Wulder et al., 2011). Landsat images were designed to use in various type of fields especially forestry, agriculture, land use planning with the suitable choice of combination band to enhance the image.

Cohen et al., (2012) mentioned in their study, all collection of Landsat data provide by United States Geological Survey (USGS) can be downloaded freely to any user since 2008 after change of data policy. The accessibility data gives benefit where scientific investigation and applications using Landsat has increase. Also, Landsat imagery is used widely in LULC monitoring or land use planning because it has many advantages rather than traditional methods (Gordon, 2000).

Based on Almazroui et al., (2017) study in Jeddah, their study proved that Landsat image Multispectral Sensor, Thematic Mapper (TM), and Enhanced Thematic Mapper Plus (ETM +) can be used to monitor urban expansion. This study also revealed that uses of Landsat image can determine the environmental impact efficiently.

Landsat TM 5 can be used for LULC change detection analysis (Zaidi et al., 2017). Due to the failure of Landsat 7's scan line corrector in 1993, Landsat TM 5 becomes important for data continuity. Thus, Landsat TM 5 provide a valuable information for the next generation especially in monitoring LULC changes (Gillan, 2013).

According to Jia et al., (2014), Landsat 8 Operational Land Imager (OLI) data gives more accuracy than data Landsat 7 Enhanced Thematic Mapper Plus (ETM +) in terms of monitoring land use or land cover. This is due to the availability of near-infrared band of OLI that gives more clear improvement than shortwave-infrared bands available in Landsat 7 ETM +. The Landsat 8 OLI capabilities also was supported by Roy et al., (2014) where the availability of new spectral bands, radiometric resolution improvement and duty cycle improvement allow more collection images per day. Hence, the image of Landsat 8 OLI/TRIS is clearer than other Landsat images.

In T. Hu et al., (2016) studies, 14 Landsat images 8 OLI of year 2013 and open social data were used to recognize land use classes in the study area at Beijing, China. The combination uses of both data gives more accuracy and detailed about land use. The results shows that overall accuracy for the generated land use map is 81.04% which can be accepted for LULC studies. Hence, this study used Landsat TM 5 and Landsat 8 OLI_TRIS based on the Zaidi et al., (2017) and Jia et al., (2014) studies.

2.5.3   Geographic Information System (GIS)

GIS is a computer software which is powerful for mapping and analyzing things that occur and exist on Earth. GIS also is a tool that can stored, retrieved and organized spatial information in user friendly way.

Raster and vector are two major types of GIS file formats (National Geographic, 2018). As mentioned by United Nations Centre for Human Settlements (2000), raster formats is composed by row and columns grid of picture element or known as pixels each with numeric value. Raster formats are very benefit for storing GIS data. Meanwhile, vector format are polygons that consists of line and points.

There are many advantages of GIS compare to the traditional systems such as Computer Aided Design and Drawing (CADD or CAD) or Automated Mapping/ Facilities Management (AM/FM) or conventional information system (Bhatta, 2008). GIS can displayed and inventoried numerous of data such as data from natural resources, roads, houses and also wildlife. Quantities and densities of a certain data within a given area could be displayed and calculated (GISTIC, 2015).

According to Hiew (2014), GIS helps in various types of project such as land use land cover mapping, development of urban studies, mapping of groundwater, mapping of floodplain, hydro morphological studies, wasteland comprehensive procedures, standards and preventive measures embedded throughout the development.

Therefore, this study used remote sensing and GIS application as technology used to detect the land use changes occur at the study area.

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3.0   Change Detection

Change detection is not just a way to recognize any changes that have occur. It is also method to identify how the changes occur, to determine the areal extent and spatial pattern of those changes (Yedage, 2017).

Change detection has become a major application in the field of remote sensing and GIS application as updated land cover information can be extracted efficiently from remote sensing that can be used in various decisions making processes (Freddy et al., 2014). Also, good change detection study should have information such as area change, rate of change, spatial distribution of changed types, change trajectories of land cover types and accuracy assessment of the change detection results.

There are various categories for change detection methods. For example are algebra based approach, transformation, classification based, and advanced models (Rahaman, 2013).

However, based on research, classification based is one of the change detection method that widely used in this modern times. Attri et al., (2015) stated in their study that post classification method is easy to used and understand.

Post classification method also used by Butt et al., (2015) in their study for land use change mapping and analysis using remote sensing and GIS. Reis (2008) in his study in Riez also applied post classification method or pixel by pixel technique for the change detection analysis for the time period between year 1976 and 2000.

Thus, this study used post classification method change detection for land use change based on Butt et al., (2015) and Reis (2008) as references.

CHAPTER 3

METHODOLOGY

3.1   Material

3.1.1   Data of Landsat TM 5 & Landsat OLI_TIRS 8

The satellite image data used of land use change for this study are from Landsat 5 Thematic Mapper (TM) of year 2006, 2010 and Landsat 8 OLI_TIRS of year 2014 and 2018. Landsat 5 was launched by NASA on March 1, 1984 from Vandenberg Air Force Base, California. Landsat 5 was designed and built at the same time as Landsat 4 and carried the Multispectral Scanner System (MSS) and the Thematic Mapper (TM) instruments. Meanwhile, the Landsat 8 was launched on February 11, 2013. Landsat 8 was developed as a collaboration between NASA and the U.S. Geological Survey (USGS). NASA led the design, construction, launch, and on-orbit calibration phases, during which time the satellite was called the Landsat Data Continuity Mission (LDCM). On May 30, 2013, USGS took over routine operations and the satellite became Landsat 8. The Landsat images which available from the United States Geological Survey (USGS) website were downloaded.

3.1.2   Software

Arc Map 10.3 software and Erdas Imagine 2015 in Figure 3.1 were used to classify and analyze the remote sensing images in this study.
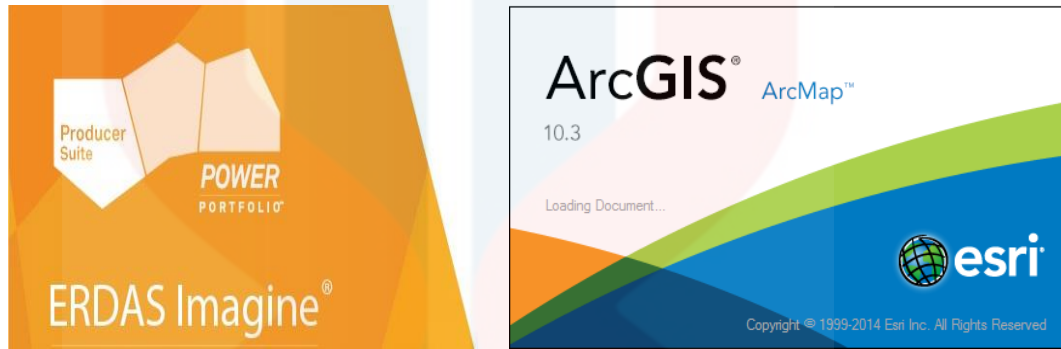
Figure 3.1: Software used for classify and analyze land use map

3.2   Methodology

Figure 3.2 is the flow chart of methodology that follows to achieve result for this study. The methodology chart is divided into four stages. First, data collection of Landsat 5 and Landsat 8. Second, data processing including image processing and image classification. Thirdly, data verification which are accuracy assessment and point validation and Global Positioning System (GPS). Lastly, data analysis. The techniques used in this study were remote sensing and Geographic Information System (GIS).

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                          │    Remote Sensing & GIS  │
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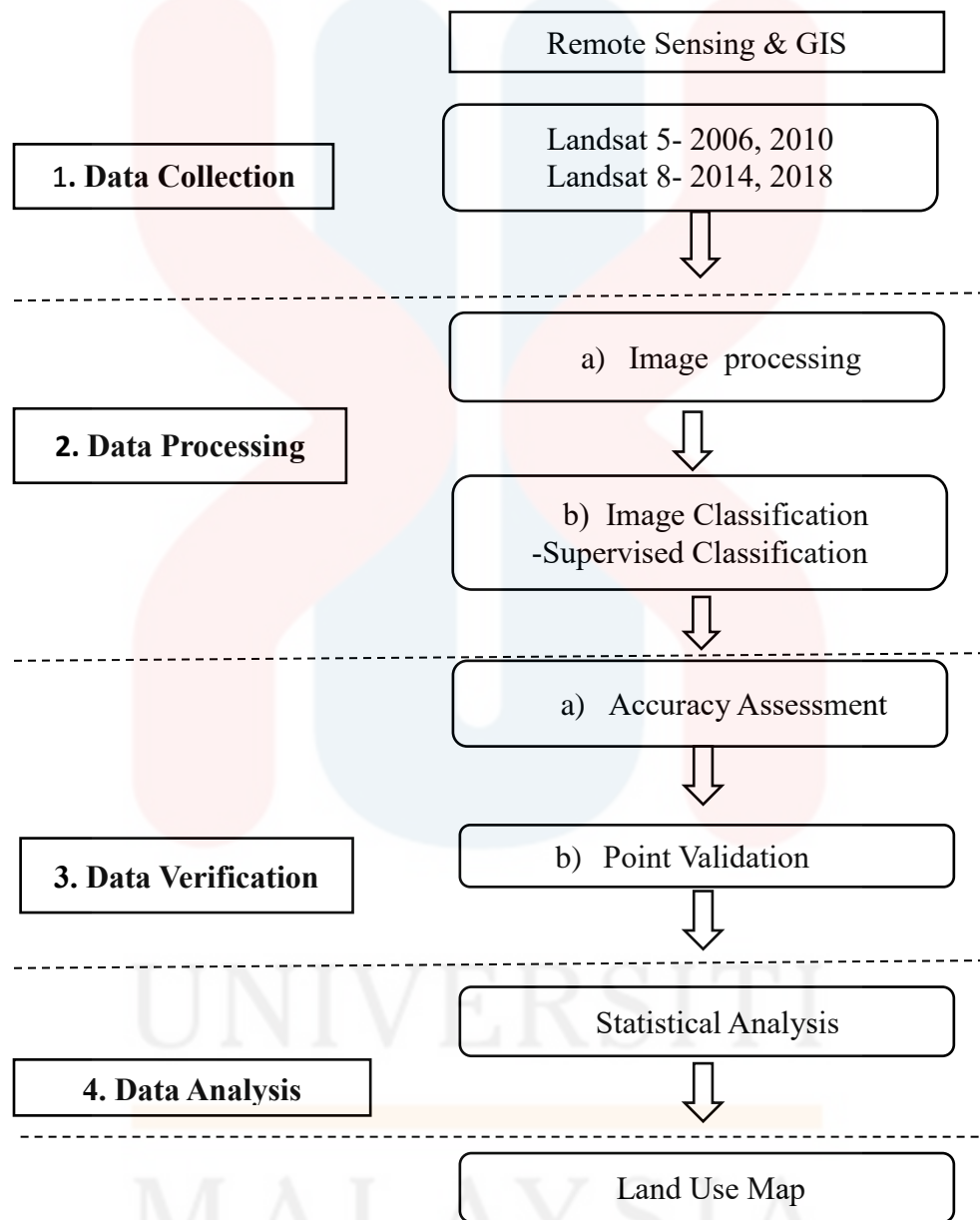
**Figure 3.2** : Flow Chart Methodology of Accessing Land Use Changes

3.2.1 Data Processing

The landsat images were layer stacked by using combination of band 4- near infrared, band 3- red and band 2- green for Landsat TM 5 and band 5- near infrared, band 4- red and band 3- green for Landsat 8 OLI_TIRS respectively. Then, the images were clipping, extracted by mask (Figure 3.3) to produce the best quality and reliable images as the information will affect the classification accuracy. Four different year of same coordinate images has been identified with minimum cloud covers. All Landsat images downloaded have spatial resolution of 30m were used in this analysis.

Then, the image classification was done. Image classification is the stage of image analysis in order to categorize all the pixels in the digital satellite images into land cover classes. Image classification used for this study was supervised classification.

Change detection was done to detect the differences between each pair of LULC maps. Images acquired at different times (2006, 2010, 2014 & 2018) are independently classified and then compared. Ideally, similar thematic classes are produced for each classification. Changes between the two years can be visualized using a change matrix indicating, for both years, the number of pixels in each class.
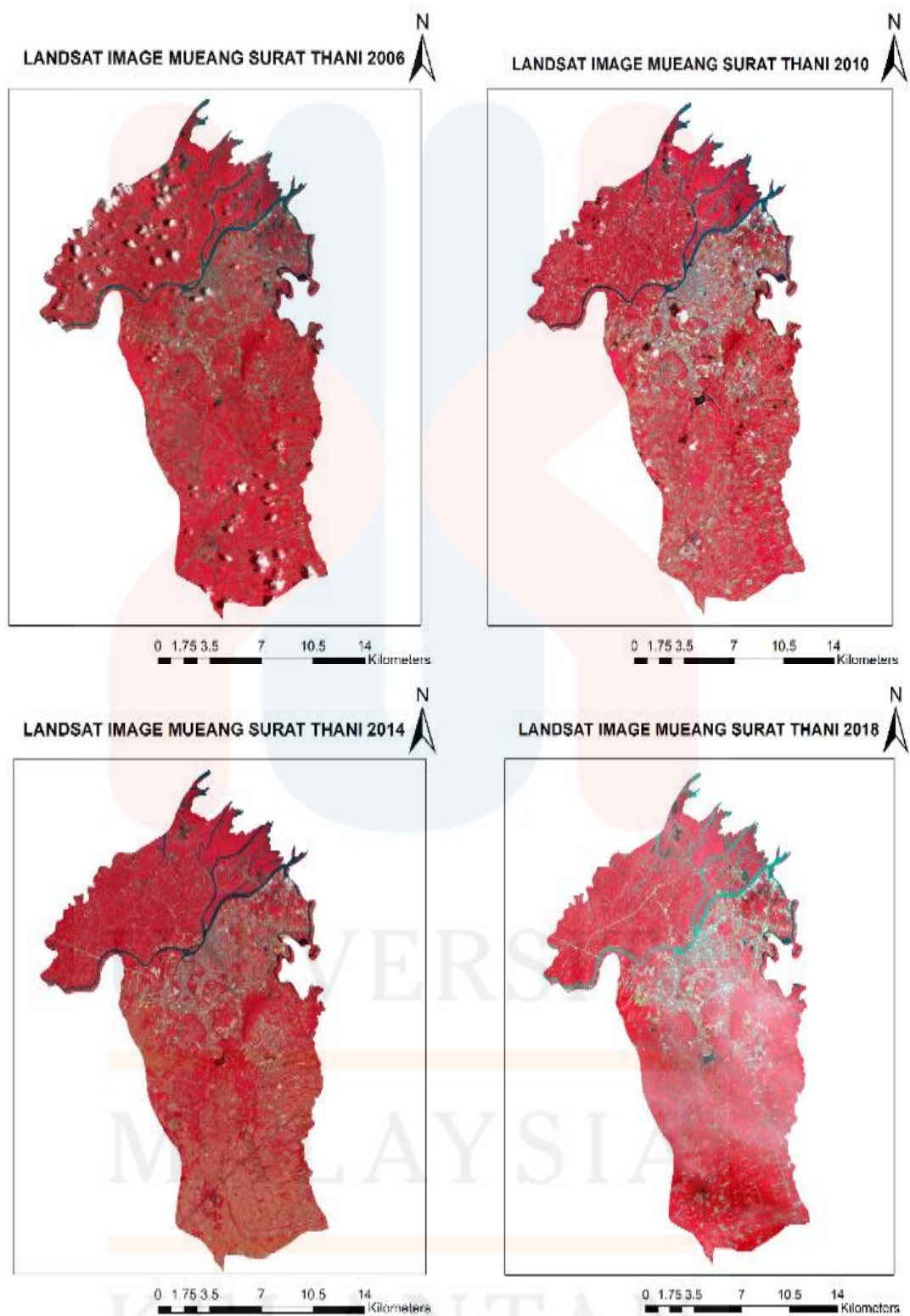
Figure 3.3: Extracted images of Mueang Surat Thani district

3.2.2 Data Verification

Next, after classification of the images done, the image classified will be assessed for classification accuracy. Accuracy assessment is vital in order to ensure the final classified images has good quality images. There are three accuracy classification were tested in this study which are error matrix, overall kappa statistics and overall accuracy.

Error matrix is a specific table layout that allows visualization of the performance of an algorithm. Each row of the matrix represents the instances in a predicted class while each column represents the instances in an actual class. Meanwhile, the overall accuracy is potray as percentage of the text pixel that successfully assigned to the corrected classes that want to be classified.

3.2.3 Data Analysis

Accuracy assessment was measured through error matrix using classification by user and reference image. Individual accuracy was calculated by using Eq. 3.1.

$$\text{Individual accuracy} = \frac{\text{Reference value}}{\text{Total value}}$$

(3.1)

Meanwhile, overall accuracy percentage of the accuracy assessment was measured by using Eq. 3.2.

$$\text{Overall accuracy} = \frac{\text{Number of correct predictions}}{\text{Total predictions}} \times 100$$

(3.2)

Kappa statistics was computed by using Eq. 3.3. If kappa statistics equals to 0, there is no agreement between the classified image and the reference image. If kappa statistics equals to 1, then the classified image and the reference image are totally identical. So, the higher the kappa statistics, the more accurate the classification is (Ukrainski, 2016).

$$\text{Kappa coefficient} = \frac{[\text{Total x sum of corrects - sum of all (row total x column total)}]}{\text{Total squared - [sum of all (row total x column total)]}}$$

(3.3)

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1   Supervised Classification: Maximum Likelihood Classifier

The classification of land use were done by using Erdas Imagine Software 2015. Several Area of Interest (AOI) have been selected and were chosen to interpret the type of land use on the low resolution (30m) of satellite images. There are three steps for classification using supervised classification which are training, classified and accuracy assessment. Training sites is needed for supervised classification. Therefore, the polygon element under drawing raster tool was used to established the selected area of interest. The training sites selected area then were grouped under four classes. There are at least 50 training sites selected for each class (Manandhar et al., 2009). Once the training site and classes were done (Figure 4.1) and assigned, the images then were classified into one of supervised classification method which are Maximum Likelihood Classifier to conduct the land use map of each landsat data (Figure 4.2). The Maximum Likelihood Classification is the most widely used per-pixel method by taking into account spectral information of land cover classes. Figure 4.3 below shows processed classified images of each year 2006, 2010, 2014 and 2018.
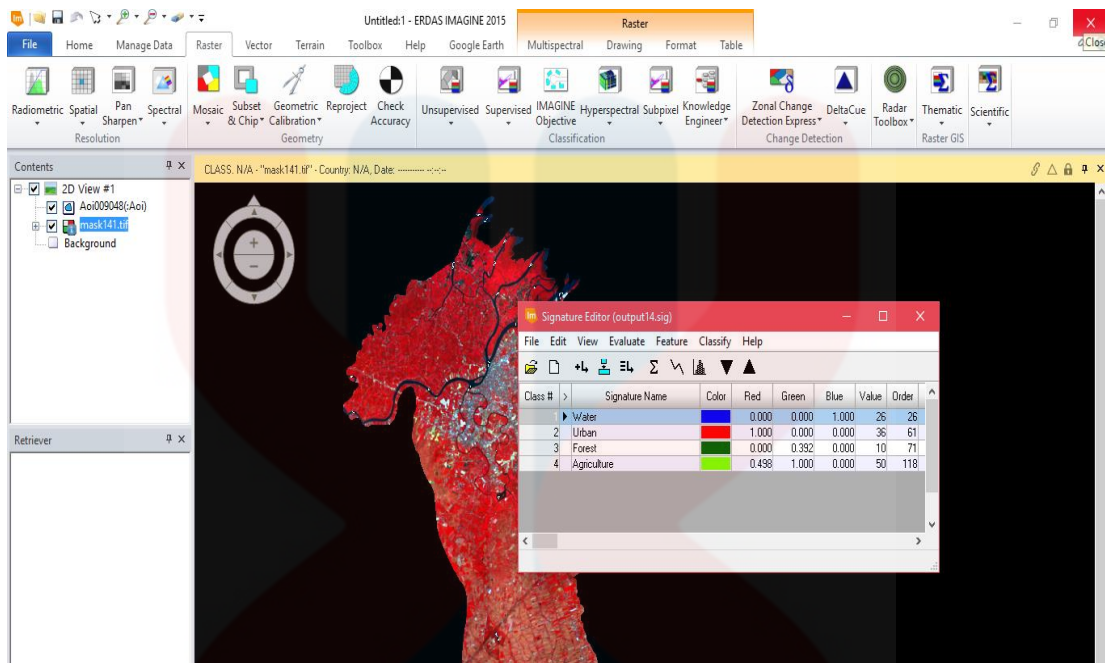
Figure 4.1: Signature editor table for classified images in Erdas Imagine 2015
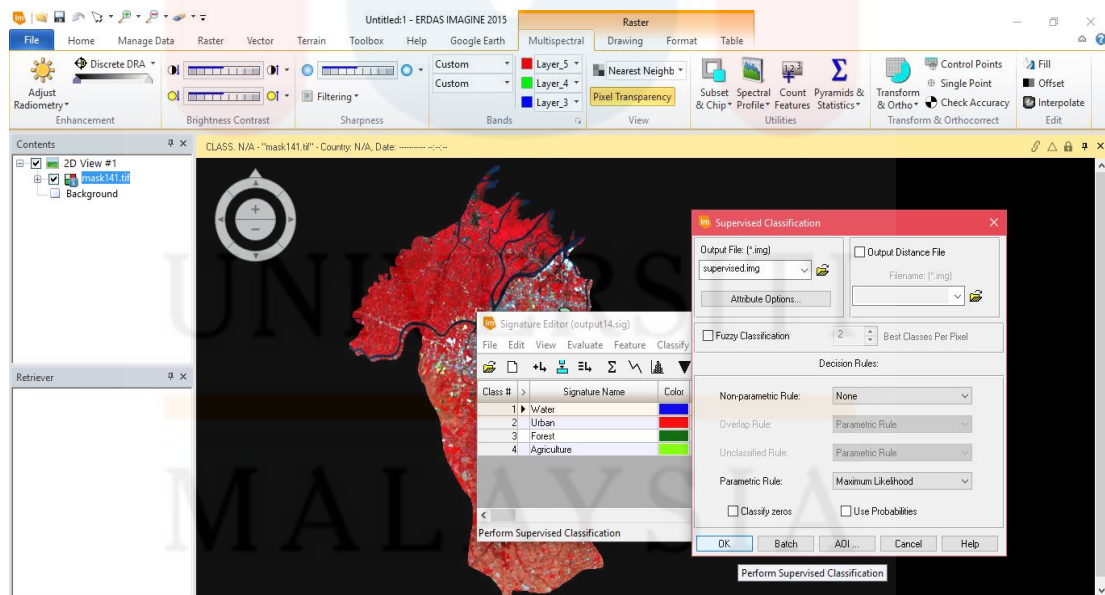
Figure 4.2: Maximum Likelihood Classifier in Supervised Classification
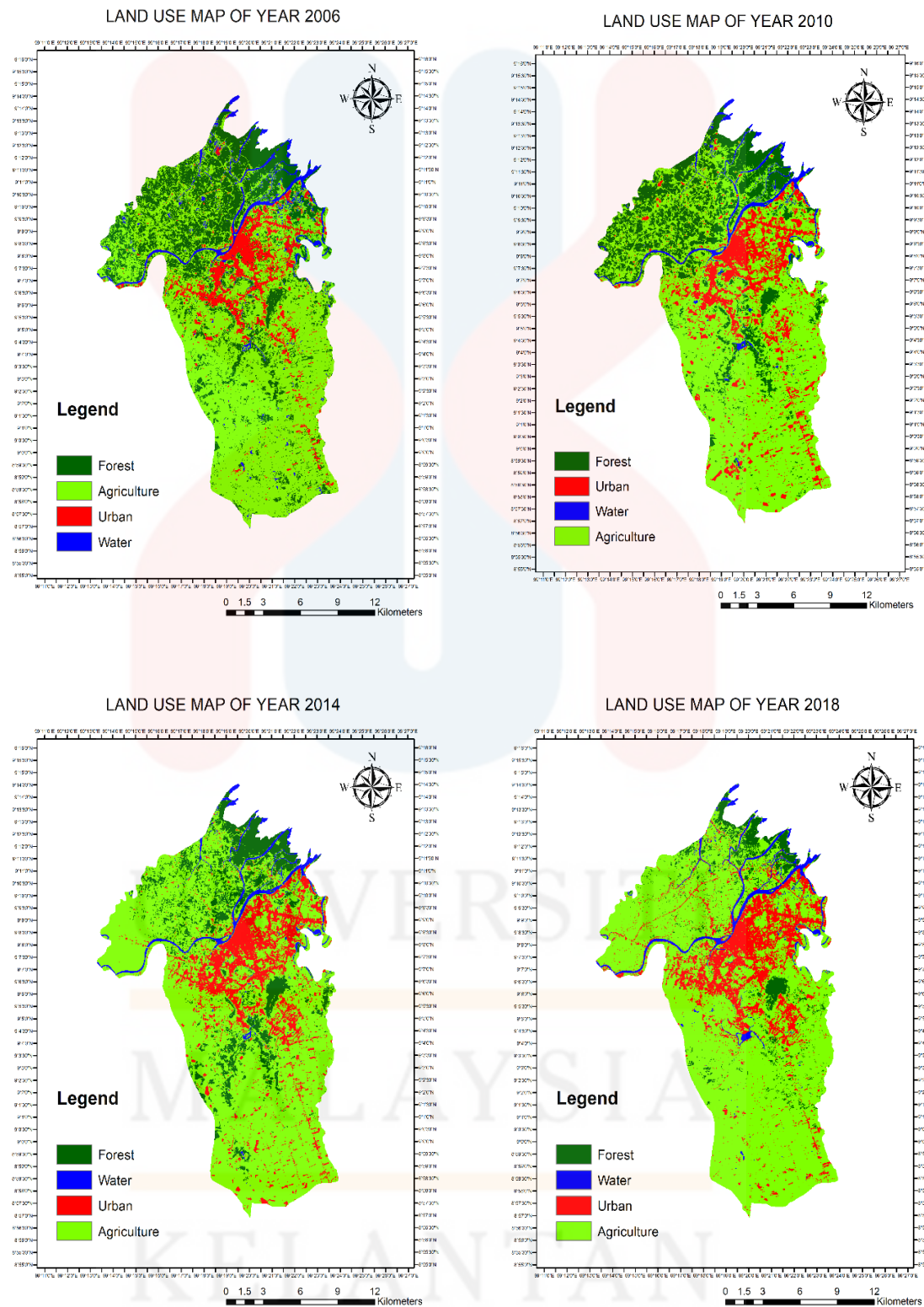
Figure 4.3: Results of classification for Land Use of Mueang Surat Thani district

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Below in Figure 4.4 and Figure 4.5 shows one of the area in study site which is urban area before and after overlay with classified map in Google Earth Pro.

Figure 4.4: Urban area before overlay with classified map in Google Earth Pro

Figure 4.5: Urban area after overlay with classified map in Google Earth Pro

The different colour of the classified map is represent four different classes. Red represent urban, dark green represent forest, blue represent water and lastly light green represent agriculture. The red area is the urban area where the city center and institutional development developed.

Google Earth Pro provides images taken at different time periods which very useful for urban planners to perform land use change detection studies. The only limitation of Google earth is that it may not be possible to obtain the original multispectral band data (Malarvizhi et al., 2016).

4.2   Accuracy Assessment

During accuracy assessment, total of 1000 random points were assessed and applied to all classified images used. Each of the land use map was compared to the reference data to assess the accuracy of the classification. The reference data was prepared by referencing available information from the google ground control points. The google ground control points was generated from historical Google Earth Pro. Table 4.1, 4.2, 4.3 and 4.4 shows the accuracy assessment of land use map 2006, 2010, 2014 and 2018 respectively.

Table 4.1: Accuracy Assessment of Land Use Map 2006

Classification	Agriculture	Forest	Urban	Water	Total	Producers Accuracy
Agriculture	**323**	41	1	3	368	87.77%
Forest	8	**287**	0	1	296	96.96%
Urban	2	1	**222**	0	225	98.67%
Water	0	0	0	**111**	111	100.00%
Total	333	329	223	115	**1000**	
Users Accuracy	97.00%	87.23%	99.55%	96.52%		

Overall Classification Accuracy = 94.30%   Overall Kappa Statistics = 92.05%

Table 4.2: Accuracy Assessment of Land Use Map 2010

Classification	Agriculture	Forest	Urban	Water	Total	Producers Accuracy
Agriculture	**378**	38	13	3	432	87.50%
Forest	11	**242**	0	0	253	95.65%
Urban	10	0	**150**	0	160	93.75%
Water	3	0	0	**152**	155	98.06%
Total	402	280	163	155	**1000**	
Users Accuracy	94.03%	86.43%	92.02%	98.06%		

Overall Classification Accuracy = 92.20%   Overall Kappa Statistics = 88.96%

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**Table 4.3:** Accuracy Assessment of Land Use Map 2014

Classification	Agriculture	Forest	Urban	Water	Total	Producers Accuracy
Agriculture	**373**	28	15	2	405	92.10%
Forest	10	**288**	0	0	298	96.64%
Urban	7	0	**188**	0	195	96.41%
Water	2	0	0	**100**	102	98.04%
Total	392	316	203	102	**1000**	
Users Accuracy	95.15%	91.14%	98.95%	98.04%		
Overall Classification Accuracy = 93.60%			Overall Kappa Statistics = 89.67%			

Table 4.4: Accuracy Assessment of Land Use Map 2018

Classification	Agriculture	Forest	Urban	Water	Total	Producers Accuracy
Agriculture	**338**	52	13	0	403	83.87%
Forest	4	**366**	0	0	370	98.92%
Urban	14	0	**146**	1	161	90.68%
Water	1	0	0	**65**	66	98.48%
Total	357	418	159	66	**1000**	
Users Accuracy	94.68%	87.56%	91.82%	98.48%		
Overall Classification Accuracy = 91.50%		Overall Kappa Statistics = 87.34%				

From all the table above, it can be discussed that the most errors occurs were due to the confusion and low ability to differentiate between agriculture area especially rubber tree plantation, coconut tree with forest area. This is due to their quite similar spectral reflectance signatures on Landsat images. The tones of forest appears dark reddish brown while the agriculture usually shows light redder and smoother than forest. However, urban and water areas are relatively well distinguished in Landsat imagery. On the Landsat TM and OLI_TIRS false color composite image, the urban appear white greyish colour while water area appear dark blue or light blue.

` Even so, the results of this accuracy assessment shows that the percentage of overall accuracy for four different years (2006, 2010, 2014 & 2018) shows overall accurracy more than 90% which can be accepted for this study (Bogoliubova & Tymków, 2014). However, before overall accuracy manage to get 90% and above for all years**,** about 200 random points of agriculture class especially rubber was generated from Google Earth Pro. Then, the data were copied into Microsoft Excel, compared and joint with the classified point of Maximum Likelihood Classifier before being exported to Keyhole Markup language Zipped (KMZ) file to be open in Google Earth Pro. 200 hundred points of rubber plantation sites were selected to determine the accuracy of agriculture class and forest that took place in the study area (Figure 4.6). About 85% of classification were corrected.
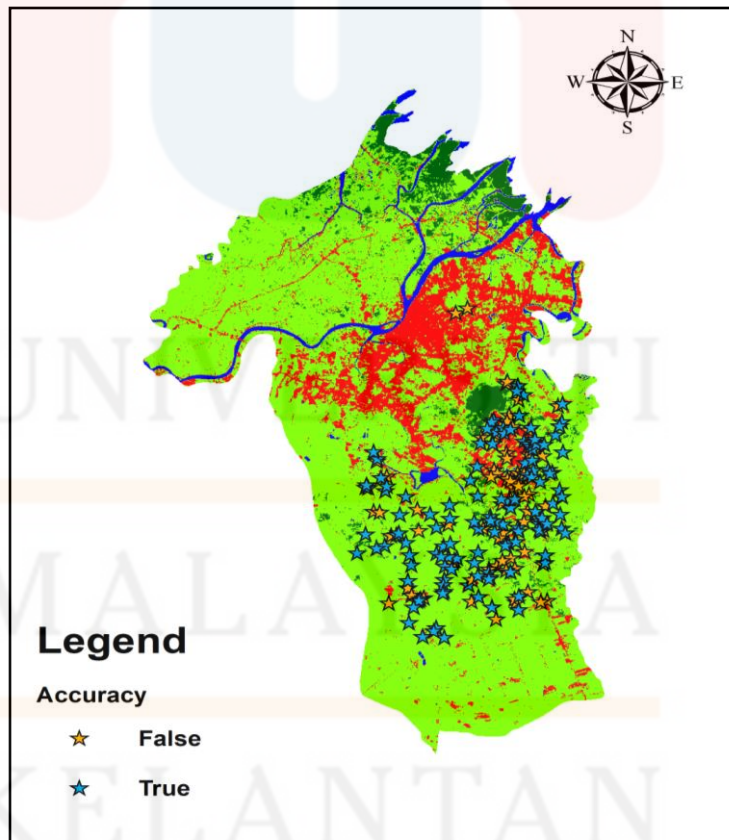
Figure 4.6: 200 points of rubber plantation

Next, point validation was done by doing ground true validation using Global Positioning System (GPS). 50 random points of wrong classified of rubber plantation nearby Prince of Songkla University Surat Thani has been recognized. These points is selected as example to separate the forest area and agriculture area especially forest and rubber plantation thus to improve the classification using Maximum Likelihood Classifier.

4.3 Statistical Image Analysis

The land use classification of four different years which are year 2006, 2010, 2014 and 2018 were produced from the supervised classification method. The classification were divided into four categories which are agriculture, urban, water and forest. The total area for the all land cover classified is 33456.78 hectares.

Table 4.5: Pattern of land use changes in hectares

Class	2006		2010		2014		2018	
	Ha	%	Ha	%	Ha	%	Ha	%
Agriculture	20656.53	61.74	21456.18	64.13	23174.37	69.27	25328.79	75.71
Urban	2871.36	8.58	4275	12.78	4756.86	14.22	5073.48	15.16
Water	1409.76	4.21	1116.81	3.34	1063.53	3.18	1217.07	3.64
Forest	8519.13	25.46	6608.79	19.75	4462.02	13.34	1837.44	5.49
Total	33456.78		33456.78		33456.78		33456.78	

The areas are arranged by year and by land use class. As of all four interval years 2006, 2010, 2014 and 2018, agriculture area dominates the land cover of this region, comprising the highest percentage other than three classes. Agriculture sector seems to be practice highly as the basis of living that contribute to 75.71% in year 2018.

This is because Surat Thani is agricultural rich region due to many rivers crossing the province and it includes the study area. Mostly the agriculture product are rubber tree, coconut and oil palm. Domination of agriculture area also might be influence by the changing of agricultural policy by government in year 2004. Due to the changing of agricultural policy, there is government scheme known as "Rubber Cultivation for Raising the Sustainable Income to Farmers in the New Planting Area" where the aim is to increase foreign exports of rubber into the international market (Arunyawat & Shrestha, 2016). This scheme has provided various incentives to farmers. More detailed about the area of land use in hectares are given in Table 4.5.

Forest is the second dominant land cover class in year 2006, covering approximately 8519.13 ha or about 25.46% of the land. However, in 2018 forest decline into 1837.44 ha or 5.49% of the total area. Meanwhile, urban occupying 2871.36 ha or 8.58% of the land area in 2006 and increase to 5073.48% or 75.71% in year 2018.
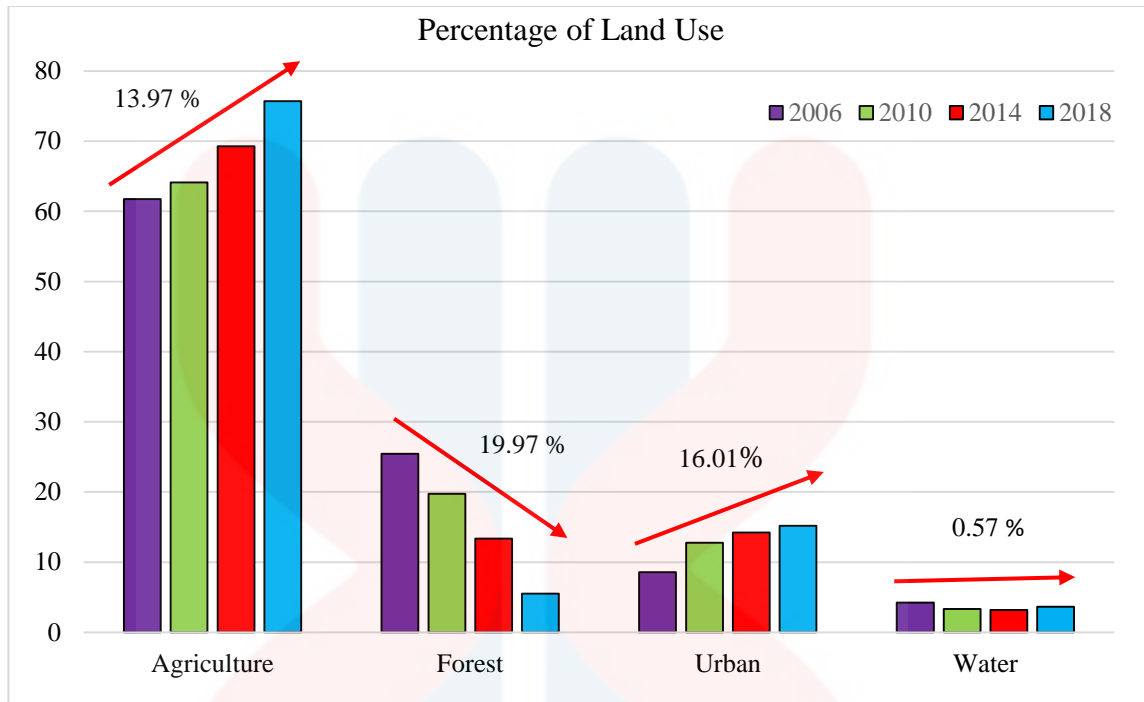
Figure 4.7: Graph of Percentage Area Land Use for year 2006, 2010, 2014 and 2018

Based on Figure 4.7, the agriculture, forest and urban area has shown significant differences from four different period of years which are year 2006, 2010, 2014 and 2018. The agriculture area has been increased by 13.97% between the 12 years. Meanwhile, urban area expanded by 16.01% throughout the year 2006 until year 2018.

Mueang Surat Thani district as the capital district of Surat Thani province is one of the reason for the changes. There are many commercial relationship occur thus increase the number of population. Increase number of population will lead to development of new building, housing area, and also institutional development. For example, the institutional development are Prince Of Songkhla University (PSU) and Suratthani Rajabhat University (SRU).

In fact, most of the development of building and expansion in agriculture area in Mueang Surat Thani district has caused reduction on forest area by 19.97%. Meanwhile, the water area shows no significant difference wheres only 0.57%. With these ongoing agriculture economic developments, there is a high possibility that most natural resources in the area may have been invaded and cleared for serving human activities for the future.

4.4 Change Detection

Table 4.6: Change detection matrix table

| | Class | Land use 2018 | | | | |
		Agriculture	Forest	Urban	Water	Grand Total
	Agriculture	5114	1893	4617	1099	12723
	Forest	6159	1524	2526	267	10476
Land use 2006	Urban	1962	69	1105	218	3354
	Water	1325	161	632	462	2580
	Grand Total	14560	3647	8880	2046	29133

A change detection matrix table for four interval years between year 2006 until year 2018 was produced by intersect method using Arc Map 10.3. Application GIS provide an ideal environment to perform change detection using methods that have been developed to collect, organize, and evaluate spatial data (Scott, 2001).

This table produce details about land use change "from and to" information which includes what type of class, and how much change has occurred in hectares (Table 4.6). As seen in the matrix table, 28.16% of land covers remained unchanged between the years,

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since the values reported along the diagonal express the unchanged area. It is seen that the increased land areas of agriculture mostly came from forest and urban classes.

Also, it is inferred that forests were significantly converted to agriculture area and urban during the past 12 years. These given data expressly state that the forest areas mostly change into agriculture area about 6159 hectares which means some forest areas were removed and convert to para rubber plantation and oil palm plantation. This conversion also occur in other studies (Senrit et al., 2012; Reis, 2008).

The conversion of forest gives negative impact to the environment. For example, soil erosion. Soil erosion usually occur after forests area convert to agricultural area by sweeping away fertile soil and pesticides. Other than that, soil erosion also act as pollutant to rivers, lakes, and other water system.

Being the capital district and city centre of Surat Thani, Mueang Surat Thani district shows a growing in urban land use. Most conversion classes of urban comes from agriculture, 4627 hectares and forest, 2526 hectares. It was obvious that its growth has threatened the areas that were reserved for forest and agricultures.

However, in Kim (2016) study, discussed that the temporal rate and spatial extent of forest loss was largely affected by timber extraction, expansion of agricultural land and urban development, and weak governance institutions.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATION

5.1   Conclusion

Throughout this study, the objectives have been achieved. The data of land use changes in Mueang Surat Thani district from four interval years has been identified and the land use map has been analyzed. The overall accuracy of all land use map is above 90%. The land use change of Mueang Surat Thani district has shown significant differences obviously in agriculture, forest and urban area. Most of the area is dominated by agricultural area. Rubber tree plantation, oil palm plantation and others crops has been seen growing rapidly throughout the years.

From this pattern of land use change, the agriculture area and urban shows increase in land use area about 13.97% and 16.01% respectively. Meanwhile, the forest area show reduction about 19.97% through the four interval years. The water area shows no significant different where there is only 0.57% changes occur. It can be conclude that most of the activity occur in the district is more to agriculture activities for socioeconomic purposes. As for the urban areas, the changes seen is mostly at the city area and also institutional area where the most population occur.

The changes occur gives negative impact towards environment especially due to conversion of forest to agriculture and urban area. Negative impact that arise from this conversion are such as climate change, environmental degradation and also loss of natural resources. Thus, this latest data can be used by government or authorities involved in future for planning, managing and monitoring the land use changes as well as minimizing the environmental degradation.

This study also prove that geoinformation technologies such as remote sensing and GIS are powerful tools that can be used to detect land use change and produce land use map of Mueang Surat Thani district. This study further demonstrated that these modern technologies in conjunction with field observation can be a very good tool in showing both land cover conversion and modification. LULC mapping and detection of changes shown here may not provide the ultimate explanation for all problems related to LULC changes but certainly serves as a base to understand the patterns and possible causes and consequences of LULC changes in the study area.

5.2   Recommendation

Further studies based on the latest data are needed to continue monitoring of land use and land cover change in this area, focusing on sustainable development of agriculture and with the minimum expense of deforestation. Also, to improve this study, next researcher are recommend to use high resolution of images as the quality will affect the classification accuracy and give more accurate results.

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