AN ASSESSMENT ON LAND USE CHANGE AND COASTAL EROSION IN HUA HIN DISTRICT, PRACHUAB KIRI KHAN PROVINCE, THAILAND

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Anchisa Tongtavesirikul

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AN ASSESSMENT ON LAND USE CHANGE AND COASTAL EROSION IN HUA HIN DISTRICT, PRACHUAB KIRI KHAN PROVINCE, THAILAND

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ABSTRACT

For this study, the remote sensing and geographic information systems were applied to classify and predict land use and land use change including coastal erosion in Hua Hin District, Prachuab Khiri Khan province. It was found that the land use change between the year 2000 and 2014 was mostly located in urban and built-up land, and it increased from 20.62 % to 36.58 % of total study area. Meanwhile, the agricultural area decreased from 31.30 % to 12.61 % of total study area. The prediction of the land use pattern in 2024 found that urban and built-up area would increase to 29.76 square kilometers or 40.37 % of total study area. The coastal erosion along Hua Hin beach (22 kilometers) between the year 2003 and 2014 was identified as stable situation (coastal change not more than 5 kilometers per year). However, the coastal erosion seriously occurred between kilometer's 8 to 9 of the beach. Most of the land use patterns within this area included airport, hotels, resorts, and jetty where a short beach was located. Thus, if trend of the land use change remains within those patterns, especially the rapid increasing of urban and built-up area without any better management, the coastal erosion might be worse. Therefore, the impact on tourist resource and activities might also be tremendously lost in the next future.

KEY WORDS: COASTAL EROSION / LAND USE CHANGE/ HUA HIN DISTRICT

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การประเมินการเปลี่ยนแปลงการใช้ที่ดินและการกัดเซาะชายฝั่ง อำเภอหัวหิน
จังหวัดประจวบคีรีขันธ์ ประเทศไทย
AN ASSESSMENT ON LAND USE CHANGE AND COASTAL EROSION IN HUA HIN DISTRICT, PRACHUAB KIRI KHAN PROVINCE, THAILAND

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บทคัดย่อ

ในการศึกษาครั้งนี้ได้ประยุกต์ใช้เทคโนโลยีการสำรวจระยะไกลร่วมกับระบบสารสนเทศภูมิศาสตร์ เพื่อจำแนกและคาดการณ์การเปลี่ยนแปลงการใช้ที่ดิน การกัดเซาะชายฝั่ง และประเมินผลกระทบจากการเปลี่ยนแปลงการใช้ที่ดินและการกัดเซาะชายฝั่งของ อำเภอหัวหิน จังหวัดประจวบคีรีขันธ์ ผลจากการศึกษาการเปลี่ยนแปลงการใช้ที่ดินระหว่างปี พ.ศ.2543 ถึง พ.ศ.2557 พบว่า พื้นที่ที่มีการเปลี่ยนแปลงเพิ่มขึ้นมากที่สุด คือ พื้นที่ชุมชนและสิ่งปลูกสร้าง โดยเพิ่มขึ้นจากร้อยละ 20.62 เป็นร้อยละ 36.58 ของพื้นที่ทั้งหมด และพื้นที่ที่มีการเปลี่ยนแปลงลดลงมากที่สุด คือ พื้นที่เกษตรกรรม โดยลดลงจากร้อยละ 31.30 เป็นร้อยละ 12.61 ของพื้นที่ทั้งหมด และผลจากการคาดการณ์แนวโน้มการใช้ที่ดิน พบว่า ในปีพ.ศ.2567 พื้นที่ที่อยู่อาศัยและสิ่งปลูกสร้างจะมีพื้นที่ประมาณ 29.76 ตารางกิโลเมตรหรือร้อยละ 40.37 ของพื้นที่ทั้งหมด จากการวิเคราะห์การเปลี่ยนแปลงชายฝั่งระหว่างปี พ.ศ. 2546 ถึง พ.ศ. 2557 พบว่า บริเวณชายหาดหัวหิน (ประมาณ 22 กม.) ส่วนใหญ่เป็นชายหาดที่มีเสถียรภาพ (การเปลี่ยนแปลงชายฝั่งไม่เกิน 5 เมตรต่อปี) มีการกัดเซาะสูงสุดเกิดขึ้นระหว่างกิโลเมตรที่ 7 ถึง 8 ของพื้นที่ศึกษา โดยลักษณะและรูปแบบการใช้ที่ดินในพื้นที่ดังกล่าว ได้แก่ สนามบิน โรงแรมรีสอร์ท และสะพานปลา บริเวณนี้ มีหาดทรายสั้น ๆ และมีการก่อสร้างกำแพงป้องกันคลื่น/ป้องกันตลิ่งพัง โดยเฉพาะบริเวณสนามบินหัวหิน ดังนั้น หากปล่อยให้การเปลี่ยนแปลงการใช้ที่ดินโดยเฉพาะพื้นที่ชุมชนและสิ่งปลูกสร้างซึ่งมีแนวโน้มเพิ่มขึ้นอย่างรวดเร็ว โดยขาดการจัดการที่เหมาะสมแล้ว การกัดเซาะชายฝั่งก็จะทวีความรุนแรงมากขึ้น อันจะส่งผลกระทบต่อการท่องเที่ยวอันเป็นกิจกรรมหลักที่สำคัญของอำเภอหัวหิน จังหวัดประจวบคีรีขันธ์ได้ในอนาคต

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CHAPTER I
INTRODUCTION

1.1 Background and Importance

From the past to the present, Thailand has changed rapidly and continuously. Its population and economic keep growing. The government promotion and development policies in various sectors including agriculture, industry, and tourism create incessantly the uses of its resources. The number of population increased from 61,973,621 in 2004 to 64,456,695 in 2012 (Department of Provincial Administration, 2013). It has increased by 2,483,084 (3.85 percent). In the last 10 years, the population tended to increase every year, 248,307 a year averagely (10 percent of the total population). This phenomenon affects many aspects of the human living like the changing of forest area, and the expansion of urban area. It also causes environmental problems like wastewater, solid waste, air pollution and others like traffic congestion, and deteriorated resources.

Prachuab Kiri Khan Province is an area with various land use patterns such as agriculture, community, and forest areas. It is a province with diversified tourism resources with 224.8 kilometers of beautiful beaches from north to south with various islands for coral diving such as Koh Talu and other natural tourist attractions like Kui Buri National Park. It is the province with diversified tourist attractions for domestic and foreigner tourists. Hua Hin in particular is one of important tourist attractions of the country. Coastal areas of the province, in the Gulf of Thailand, were promoted and developed as important tourist attractions to serve tourists. There are traveling facilities, both by train, car and air, making Hua Hin, with high potential, being popular tourist attraction for both domestic and foreigner tourists. The growing number of tourists and infrastructures and facilities to serve the increasing tourism cause the rapidly growing of the tourism in the region. This is very crucial to the economic development to create huge income each year. In addition to the economic development with various public utilities and infrastructures, the consequences,

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including those houses, hotels, and resorts, are affecting the natural resources and environment, making them deteriorated. Therefore, in 1996, Hua Hin had been promulgated the Pollution Control Area and in 2004 the Environment Control Area under the National Environment Quality Conservation and Promotion Act B.E. 2535.

Concerning the problems mentioned, the coastal area in Hua Hin District of Prachuab Kiri Khan Province will be focused for this study, applying remote sensing technology and geographic information system, on land use and coastal erosion changes and prediction, in addition to evaluation of their impacts. For the expected problems in the future, the study can be a guideline for appropriate and effective management of Hua Hin coastal area.

1.2 Objectives of the Study

1.2.1 To classify and predict the land use change and coastal erosion in Hua Hin District of Prachuab Kiri Khan Province, applying satellite image data.

1.2.2 To assess the land use change and coastal erosion impacts of the area.

1.3 Scopes of the Study

This study, researchers have determined the scope of the research is as follows.

1.3.1 The study area

The study area covers coastal area of Hua Hin District in Prachuab Kiri KhanProvince, consisting of 2 Subdistricts namely Hua Hin Subdistrict and Nong Kae Subdistrict, as shown in Figure 1-1 Scope of Study Area. The total area is 86.38 square kilometers with approximately 22.3 kilometers of shore, sand beach all along with some rocks. The sand beach is fine beautiful one. The sea is diurnal tide with 0.9 meters tidal range (Sinsakul, Sin, 2002).

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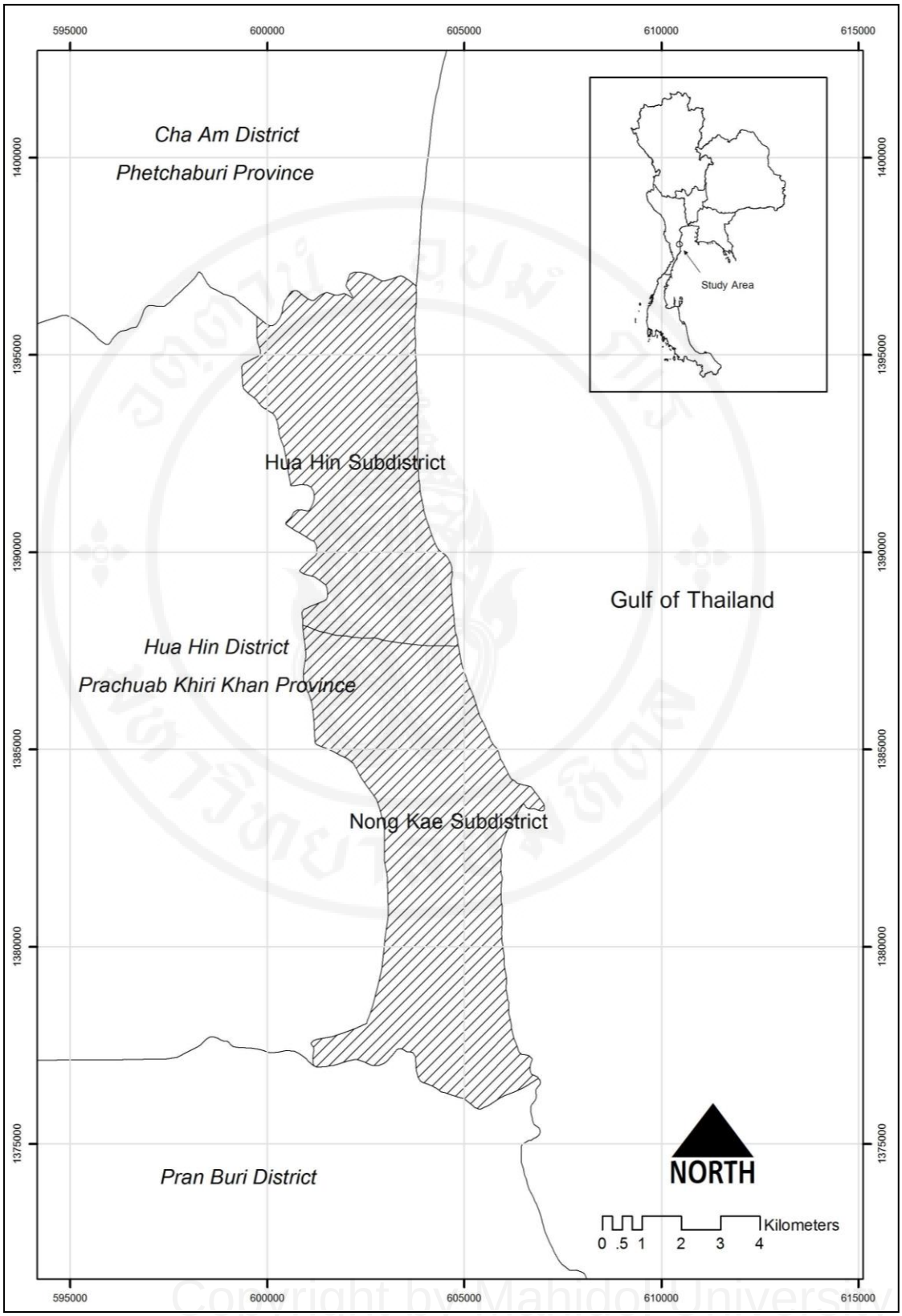

Figure 1-1 Study Area

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1.3.2 Scopes of Content

The study covered the followings:

1. The land uses were classified and the shorelines were analyzed, for 2003 2009 and 2014 using the remote sensing technology, in particular the satellite image data.

2. The land use and shoreline changes in 2003 and 2024 were analyzed using the geographic information system.

3. The tendency of land use and shoreline changes in 2014 and 2024 were predicted using data of the years 2003 and 2009, and 2009 and 2014 respectively.

1.4 Conceptual Framework

The conceptual framework in this study is shown in Figure 1.2

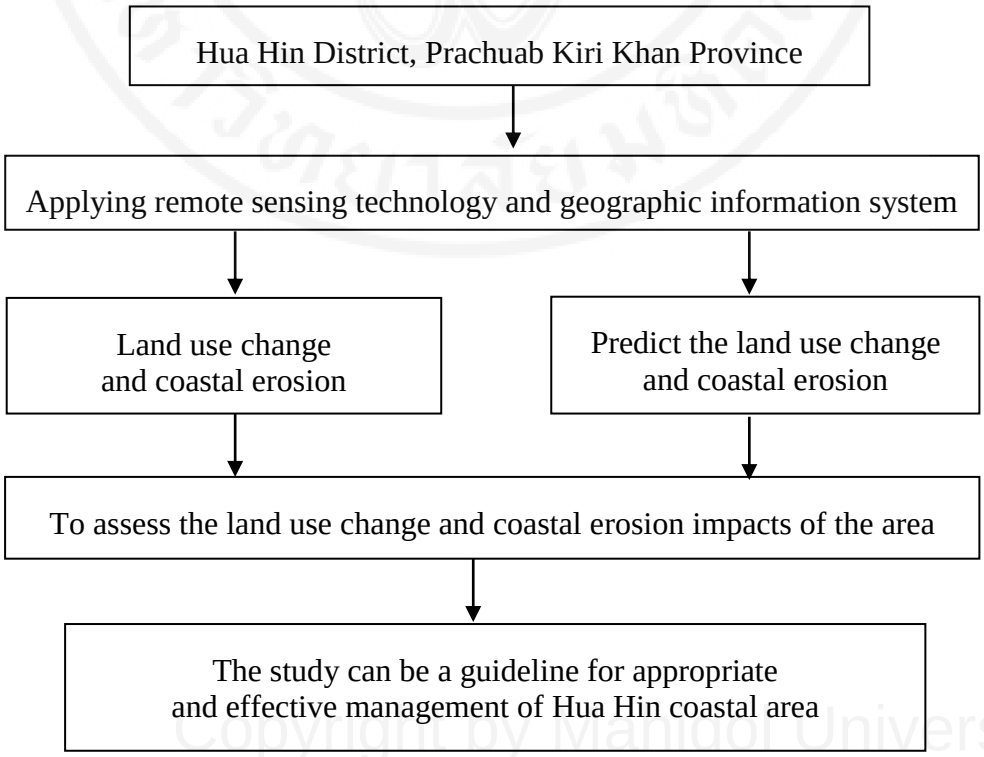

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Figure 1-2 Conceptual framework

1.5 Expected Results of the Study

1.5.1 To learn about the land use changes and the coastal erosion in Hua Hin District of Prachuab Kiri Khan Province.

1.5.2 To learn their tendency in the future as guideline for further appropriate regional management.

1.5.3 To be aware of their impacts.

1.6 Definition of term

1.6.1 The land Use Change is the change of land use from one category to the other, in order to response to economic, social and environmental needs both permanently and temporarily, such as the change of forest area to housing area.

1.6.2 The Coastal Erosion is the change of coastal line in the form of inland recession. This will cause damage to coastal resources, buildings, life quality, community ways of life and beautiful coast as important tourist attractions.

1.6.3 Hua Hin Coastal Area is the study area within the boundary of the Local Administration Areas namely Hua Hin Subdistrict and Nong Kae Subdistrict and the scopes under the following Notifications:

- The National Environment Board Notification No. 13 (1996), Stipulating Ban Laem and Muang Phetchaburi, Thayang and Cha Am Districts of Phetchaburi Province and Hua Hin and Pran Buri Districts of Prachuab Kiri Khan Province as Pollution Control Area.

- The Notification of the Ministry of Natural Resource and Environment, 2010, the Stipulation of Environmental Conservation Measurement in Ban Laem and Muang Phetchaburi, Thayang and Cha Am Districts of Phetchaburi Province and Hua Hin and Pran Buri Districts of Prachuab Kiri Khan Province.

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CHAPTER II
LITERATURE REVIEWS

This is to present concepts, theories and research documents concerning the study on the land use change evaluation and the coastal erosion in Hua Hin District of Prachuab Kiri Khan Province. There were 4 aspects studied.

2.1 Land Use and Its Changes

2.2 Coastal Erosion

2.3 Remote Sensing

2.4 Land Use Change Prediction Model

2.5 Study Area

2.1 Land Use and Its Changes

There are many but conforming definitions of land use and ground cover. Sanchai (2007) defined the land use as the human activities performed on the land for economic return such as fruit gardening and rice planting. This is in conformity with Datchani (1988) defining the land use as the use of land to fulfill human needs in various ways like agriculture, commerce, and housing. Somjet (1981) defined the land use as the use of land at present and in the future, but in some case it refer only to the present land use. The Food and Agriculture Organization, 1976, defined the ground cover as the physical environment conditions consisting of climate, soil, hydrology, and crops, which may influence the land use patterns; and the land use as direct human activity management which may change or maintain the ground cover in order to meet their objectives such as agricultural cultivation, forest production, and construction.

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Datchani (1988), concerning the land use change, had stated that Thailand land use pattern changes from the past to the present time from forest area to various

other patterns like agriculture, urban and water resource. In the past most of the area of the country was the forest, whereas the population was not big so people can select their area for cultivation. As the population grew, demands for living and housing grew consecutively, changing the forest area to farm and urban areas. To meet their demand and to provide convenient conditions of living, technologies were used such as dam construction. This caused immediate change of land use pattern from farm and living areas to water resource, as shown in Figure 2-1. This kind of change was different from others which might be gradually. Without careful consideration, Its impacts can be severe.

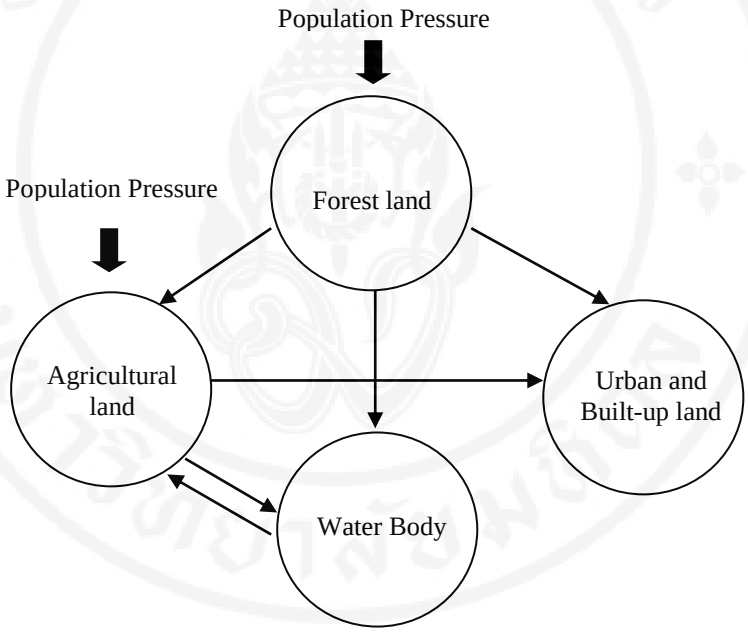

Figure 2-1 Land Use Evolution Model of Thailand (Datchani, 1988)

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The causes of the land use pattern and the ground cover changes were studied in many areas. Nuchari (2002) had found that the important factors to change the land use were the population growth and the government policy emphasizing the economic growth promotion. Similarly, Narunart (2012) had also found that the population growth from the tourism activities and the economic development resulting in high economic growth in Phuket Province were the main factor to reduce the forest area by the change of the farm area to housing area and the change of the forest area to the farm area. Whereas Wasant (2012) had found that the land use patterns and the land use changes in Phuket Province, from 2001 to 2011, had mainly turned from farm land to communities rapidly and vastly, within the period of only 10 years. Being the tourist city with highest minimum wage in the country, it attracted inward migration of both Thais and foreigners for work and investment in tourism business. In addition to the low economic value produced by the farm land, unable to cover the cost of land, people in the province therefore increasingly turned to tourism business.

Chutipong (2008) studying the land use and ground cover changes in Mae Chaem Basin in Chiangmai Province in 1988 to 1997 period, found that most of the land use and ground cover changes were turning from forest area to farm land.

Thanlak (2013) studying the land use affecting the runoff water in Central Yom Basin in 20 years period (1991-2011), found that the forest area had reduced vastly. Most of it was overrun by farm land. This caused the change of the upstream watershed ecological system, the major cause of the flash flood and flood disaster in rainy seasons.

Sunthri (2011) studying the coastal land use in some area of Prachuab Kiri Khan Province in 1984 and 2009, found that the farm land, urban and construction area increased whereas the areas for aquaculture and water resource decreased.

Aroonkit (2007) studying the shoreline change and the coastal land use change in Samut Prakarn Province, had found that the expansion of communities and constructions to support increasing industry reduced the farm land and aquaculture area.

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By the mentioned definitions and studies, it can be concluded that the ground cover is the physical conditions which are influencing the land use patterns including the human activities on the land. They cause the land use patterns to change from one category to the others to meet the demand. When the population grows, the demand for land use and living space also grows. The forest area turns into farm land, communities and water resources respectively.

2.2 Coastal Erosion

The coastal erosion affects the coast and changes its line or made it recess inland. It causes damages to coastal resources, buildings, life quality, community way of life and attractiveness of the coast which is the country important tourist attraction.

2.2.1 Causes of Coastal Erosion

There are 2 main causes of coastal erosion, natural and human ones, they are as follows (Office of Natural Resources and Environment Policy and Planning, 2007, and Department of Marine and Coastal Resources, 2008):

2.2.1.1 Natural Process

The natural factors to change the natural coastal lines, relating to geological features of the coast and the ocean, are wave, wind, current, and tide. These factors jointly influence the processes of deposition and sand movement making the coastal line change both accretion and erosion. The natural factors involving the coastal erosion are as follows.

1) Monsoon and Storm. The northeast monsoon during October to February has the effect on the Gulf of Thailand by producing heavy waves and strong wind hitting the coast, washing sand out from it. In the contrary, the southwest monsoon during February to April washes the sand back to it.

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2) Current. In the Gulf of Thailand, the current effect in the coastal area is higher than in the middle of the gulf. During the diurnal tide, the current is stronger than during the semidiurnal one. By the way, in the Andaman Sea the

north-south current is stronger than the east-west one. During the southwest and the northeast monsoons, the current at the ebb tide is stronger and carry more sediment than at the high tide. The sediment would deposit along the current flowing direction.

3) Tide. There are 3 types of tide in the Gulf of Thailand, diurnal, mixed semidiurnal and mixed diurnal. In the upper part of the Gulf, the difference of the high and ebb tides is averagely 1.5 meters. In Andaman Sea, the tide is the mixed semidiurnal one with different differences of high-ebb tides from place to place. Both the types of tide and the differences affect the deposition.

4) Physical Feature of the Coast. An open sea, sand beach, rock beach, mud beach, bay and cape affect the coastal line changes differently. The western coast of the lower part of the Gulf which is the open sea gets severe effects.

5) Global Climate Change. The global climate change affects the coastal ecological system and the coral such as coral bleach. It also increases temperature, causes extreme weather with many and heavy storms, and raises the sea level up. The rising sea level will then affect the eastern part of the coast of southern region, the lower part of the central region and the whole upper part of the Gulf. The measurement of the sea level in the Gulf indicates that it rise up 1-2 millimeters a year. It is 8-12 millimeters in Andaman Sea, by the way. The sea level in the Gulf might rise up to 3-4 meters in the future. This will cause the coastal erosion problem.

2.2.1.2 Human Activities.

The emphasizing of economic and social development using the natural resources as production base with less concern on natural resource and environmental conservation and rehabilitation causes the damage and deterioration of the resources, including the sea and coastal environment and adjacent areas. This accelerates the coastal erosion and increases its severity. The significant development activities are as follows.

1) Inappropriate Use and Misuse of Coastal Area. The tourist attraction coasts and those with similar potential usually are with high expansion of communities, and more addition of public facilities. These change the land use. The natural ecological system will turn into community areas, housing spaces,

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commercial areas, and local economic development areas, such as construction of condominiums, bungalows, hotels, seaside resorts, expansion of commercial buildings, and expansion of infrastructures. All of these change the land use of the coastal area in different patterns causing the loss of natural balance of the coast. In addition, the misuse of the coastal land inappropriate to the land capability, for example, the turning of mangrove forest to aquaculture farm, causes the land to be more vulnerable to the erosion, as the mangrove which helps protecting the natural wave and wind had disappeared.

2) Loss of Sediment along Coast. The quantity of sediment at the coast comes from the decay of parent rocks in the upstream washed down the streams and rivers and accumulated along the sea coast. The volume washed down to estuaries is smaller due to its deposition along many dams in main rivers. This causes the loss of sediment to substitute the eroded coast.

3) Seaboard Development. In responding to economic drives of the country, in transportation and industry, the development obviously affects the physical change of the coast. For example, the construction of deep sea port, coastal highway, and land reclamation will obstruct the movement of sand along the coast.

2.2.2 Erosion Impacts

2.2.2.1 Marine and Coastal Ecological Systems.

Important ecological systems, namely the coastal area are beach ecological system, sea grass ecological system and coral reef will be directly affected both in their structures and their roles in the systems. The fertility and diversity of marine living organism, and the food chain will be affected. The ecological systems in the eroded areas therefore will be deteriorated.

2.2.2.2 Economical Aspect.

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The physical condition of the eroded coast will change and its attractiveness will be lost. This will affect the country development investment both in industry and service sectors especially in tourism. In addition, the erosion also affects

household economy by making the people to lose their farmland, being unable to continue existing careers, reducing their incomes and in the same time increasing their expenses to maintain their normal life. Furthermore, the central and local governments have to spend a large amount of budget to cope up with the erosion by constructing engineering structures such as sea wall, groin, breakwater and other structures. However, these structures could not successfully solve the erosion problem; therefore, more budgets will be allotted to endlessly solve the problem.

2.2.2.3 Social Aspect.

Communities on the shores with coastal erosion will not be able to live anymore. Having to move to other areas will make them lose their existing way of life, culture and traditions.

2.2.2.4 Quality of Life and Mental Quality

Severe coastal erosion will affect communities making them lose their land, their occupations, and their living houses. They have to adopt different ways of living. Their security on their right on land is doubtful and their way of living uncertain. These will disturb them. Adoption of career unfamiliar to them may lower their quality of life.

2.2.3 Coastal Erosion Impact Prevention and Reduction Guidelines

The coastal areas are changing continuously. Many are with severe erosion. The erosion problem alleviation and impact reduction shall require economic and social impact assessment of the country. The assessment has to take in to account the prevention cost and return of the investment. The erosion prevention in the coast in the Gulf has been self- invested by people's own capability and in their acceptable patterns. Some areas therefore affect the nearby areas causing them losing attractiveness.

As the guidelines to solve the coastal problems which are in continuous change, in the change impact alleviation planning especially for the erosion which is more severe impact than the accretion, there are 3 guidelines or patterns of erosion

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prevention, according to their structures, namely soft structure, hard structure and mixed structure.

2.2.3.1 Hard Structures.

Mostly, these are concrete, reinforced concrete and rock structures. These structures prevent erosion in the coast area with different functions and impacts. Detailed study covering all and every dimensions such as civil engineering, geology, ecology, is required in their selection. Without the study, problems on the coastal area and more severe erosion problems in the same or the other areas might be created.

There are many patterns of hard structure constructed and installed scattering in the Gulf area such as:

1) Sea Walls. These are constructed immediately next to the coast both in sand beach and floodplain. Most of them are constructed with reinforced concrete with rock fill faced. They protect the coast and buildings and properties on it. They are the structures found most and are modified according to the area suitability, for example, rip rap rock and revetment wall, placed immediately next to the beach. These structures are the most found. They are constructed both by the government and private sectors.

2) Groins. These are structures protruding into the sea perpendicular to the coast. Usually they are constructed in parallel with others. The deposition usually will accumulate in between. The structures are usually built with rock on the sand beach.

3) Breakwaters. These are engineering structures to break the wave force rushing to the shore. They are usually placed parallel to the shore to impede heavy waves. There are different structures according to area suitability, for example rubble mound or pilling.

4) Offshore Breakwaters. These are engineering structures to break the long distance wave force. They are usually placed parallel to and far away from the shore. They might be constructed at the maximum tide height or underwater height. In some areas they are placed with groins and sea walls.

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2.2.3.2 Soft Structures

This is the problem solving for coastal erosion using natural imitation. That is to construct structures imitating existing patterns, for example beach nourishment, dune restoration and mangrove aforestation.

2.2.3.3 Mixed Structures. These structures are to solve the coastal erosion using both hard and soft structures combined. For example in Klong Dan Coast of Bangbo District of Samut Prakarn Province, bamboo was used to reduce wave force severity and when adequate sediments are deposited, mangrove afforestation is planted behind the bamboo line, to rehabilitate the fertile mangrove forest. Similarly in Ban Bred Nai community in Huang Nam Kao Subdistrict of Muang District of Trad Province, the mangrove forest had been rehabilitated and used vehicle tires were tied together in rectangular patterns and concrete was placed at the bottom to form a dice pattern called tire dice to be placed in the sea to reduce the wave force and to trap more sediments. In addition, this helps increasing propagation of mangrove plants to be coastal erosion protection line. In addition, the tire dice helps preventing trawlers coming too near to the shore.

2.3 Remote Sensing

The remote sensing contains 2 main processes, first data acquisition and second data analysis. The former is sensing of energy reflection through the ground cover, done by sensors on observation satellites then relayed to ground receiving station for photographic and digital data processing. The data sensing on the satellite uses both natural magnetoelectric waves like solar energy, called passive sensor, and generated energy called active sensor. The latter is the process of data analysis consisting of visual analysis and digital analysis, prior to utilization.

The magnetoelectric waves are continuous energy with many wave length ranges from many meters to nanometers. They can travel in the atmosphere at the light speed, 299,792.458, or 3 x 108 meters per second. The waves can be classified by their length, called bands, from the shortest band of gamma ray at under 10-6 meters, x-ray,

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ultraviolet, light, infrared, microwave up to radio wave at many kilometers, respectively.

2.3.1 Data Analysis

There are 2 methods of analysis, visual interpretation and digital analysis.

2.3.2.1 Visual Interpretation.

The visual interpretation requires many data types combined, for example, physical characteristics, biological characteristics, existing surveyed data or secondary data and environment association and human activities, to enable the interpreter to understand the area to be interpreted. The characteristics of photographic images will also be applied to examine the objects in order to identify the ground cover. They are as follows (National Research Council of Thailand, 1997).

1) Size. The size can be used to identify the objects on the satellite images and also to determine other information, for example, the planting area can determine the volume of fertilizer used.

2) Shape. Usually the shapes of manmade objects are geometrical, for example, rectangular and circle. The natural objects usually are irregular forms like a river bends.

3) Shadow. Usually the analysis applies the satellite images recorded at low sun angle as the shadow of an object would lay a long way, but by the way, the shadow would also hide other objects.

4) Tone and Color. Each ground cover would be shown in the satellite images differently according to the reflection capacity and the wave length band.

5) Texture This is the fineness of the images, for example, shrubs are coarse texture while pasture is fine.

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6) Patterns. There are patterns of arrangement of objects in an area which may be manmade or natural for example, fruit plantation is manmade pattern with regular interval of lows and plots.

7) Site. The appearance of an object on the satellite image of an area will relate with its topography, soil, rock and crops, for example, rice field will mostly situate in flood plain.

8) Association. The identification of an object will lead to the identification of the remaining related objects, for example, the smoke column with a group of many buildings with different heights and cooling water ponds can identify the area as a power plant.

2.3.2.2 Digital Analysis

The digital analysis consists of the following main processes.

1) Data Preparation. As the density of objects in each band is not the same, especially TM band which has up to 7 bands, in the analysis of data from the satellite image, appropriate bands and number of bands shall be selected in order to get accurate and short time data analysis. Usually the land use study uses 3 or 4 bands, 2-3-4 or 2-3-4-5, for TM data for example.

2) Pre-Processing. This is data adjustment process to get appropriate data prior to further analysis. It can be said that this is the first step of the data processing.

- Radiometric Correction. This is to adjust digital number, DN, produced by the difference between the magnetoelectric energy released or reflected from an object and the magnetroelectric energy measured by the sensor installed on the satellite from the same object. This difference is caused by azimuth, sun elevation, climate conditions such as fog or suspended particulars, and the response of the detector. To get actual incidence or actual reflection, to be the same standard, this error must be adjusted to get correct data especially the data from the same area recorded on different days or seasons.

- Geometric Correction. This is to correct geometric error of satellite data to get correct data in conformity with the fact on the earth surface. The adjustment uses 1:50,000 map as standard reference, or ground control point, GCP. Then the coordinates will be assigned to the satellite image data. The rule for point

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selection for coordinates assignment is that the points shall be the easily obviously noticeable points and must be permanent, without changing along the time.

3) Image Enhancement. This is to improve or enhance the image data to become conspicuous before analysis with more convenience and correctness. There are 2 techniques to enhance the image, point operation enhancement and brightness value enhancement. The former is a function which is performed on each pixel independently. The latter is the function performed on pixels of image depend on the reflection value of nearby pixels. The image enhancement can be performed on the data image of single or multiple wave bands. This will produce results of black and white or color enhanced images. Simple image enhancement methods favorably used in the data processing are linear contrast stretch, histogram equalization or non-linear stretch, and density slicing.

4) Image Classification. There are 2 methods to classify the image.

- Supervised Classification. This is numerical image classification which requires sample area reference. In assignment of the sample area, sample area image from many areas with not less than 10n-100n should be selected, n by the way is the number of bands applied. The more pixels in the sample image area, the higher accuracy the image is. Then statistical values, mean, standard deviation, variance and covariance for example, are applied in overall image classification.

The values obtained will enable the image to be clearly distinguished from others. Any pixel does not meet statistical values of any image will be classified as unclassified. There are many classification theories, categorized into 3 types, the minimum distance to mean classification, the parallelepiped classification and the maximum likelihood classification.

- Unsupervised Classification. This classification does not require the sample area of each type of image. It is usually used in the case without additional data in the study area. It is done by applying clustering technique. This is to assign the number of image groups for computer and assign sample area with

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heterogeneous reflection character covering all image groups which may be all areas or some particular areas without calculation of every pixel. The computer will divide image groups according to reflection character and then the centers of every image groups will be assigned by calculation. The calculation is repeated many times until the spectral separability value becomes highest. There are 2 types of clustering technique, hierarchical clustering and non-hierarchical clustering, which are ISODATA (Iterative Self-Organizing Data Analysis) and K-mean (Sequential Clustering).

5) Post-Classification Image Dressing. This is to make pixel image being continuous, for example in scope which indicate the forest as teak forest but with few pixels indicate deciduous dipterocarp forest where said pixels should indicate the teak forest.

6) Classification Accuracy Verification. After the image classification, the results must be examined for accuracy and reliability. This can be done using error matrix and Kappa statistics. The error matrix is a table showing a number of assigned pixels according to reference pixels and the classified pixels. This matrix can be used in calculation of 3 values of accuracy, overall accuracy: the percentage of the number of classified pixels over total pixels to be classified, omission error or producer' accuracy: the ratio of pixels unable to be classified by the computer over total pixels of the image class to be examined whose outcomes are lower than reality, and the last one, commission error or user' accuracy, which usually obtain when other data contaminated : the ratio of the number of examined pixels over the total accurately classified pixels of the image class, whose outcomes are often higher than reality.

The use of Kappa statistics is the evaluation of error matrix by statistical values to explain the compatible level of 2 sets of data obtained directly from the classification. The compatibility might be obtained by chance agreement of the reference data with the classified data obtained from random classifier. The kappa values will be between 0-1, for example kappa 0.7 means the compatible value of the data is higher than the chance agreement.

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2.3.2 LANDSAT Data Thematic Mapper

The National Aeronautic and Administration, NASA, of the United states had successfully launched the first Earth Resource Technology Satellite, ERTS-1, to orbit the earth, on July 23nd 1972, later named LANDSAT-1. Under this projects satellites are launched continuously. The data obtained from LANDSAT are used extensively in Thailand. At present there are 8 satellites launched. LANDSAT-1, LANDSAT-2, and LANDSAT-3 are similar in shape and structure as there are modified from NIMBUS, a sea and meteorological satellite. LANDSAT-1 to LANDSAT-3 have similar data recording system, Return Beam Vidicon (RBV) and Multispectral Scanner (MSS). However the LANDSAT-3 is a little different from the first two in the number of RBV cameras and the number of MSS bands. The LANDSAT-3 has been designed to record additionally 10.2-12.6 μm band, called thermal infrared band. At present, all three are out of operation. By the way, LANDSAT-4 and LANDSAT-5 have different shape and structure from the first three. There is an important improved data recording system, called multispectral scanner (MSS) and thermal mapper (MSS) with higher spatial resolution. At present the LANDSAT-4 had been ceased to function the data recording but still orbits the earth. The LANDSAT-6 and the LANDSAT-7 are different from the LANDSAT-4 and the LANDSAT-5 both in shape and structure. The LANDSAT-6 had developed its data recording system, Enhance Thematic Mapper (ETM), but its launching to orbit around the earth had failed. The United States has replaced it by launching the LANDSAT-7 with higher developed data recording system , ETM + (Enhance Thematic Mapper Plus), to operate and connect to the LANDSAT-5 which is expected to be able to operate for not a long time as it has been operating for almost 20 years. The LANDSAT launching schedule can be seen in Table 2-1 (Charanporn, 2014).

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Table 2-1 LANDSAT launching schedule

Intrument	Launched	Terminated	sensor
LANDSAT-1	July 23, 1972	January 6, 1978	RBV, MSS
LANDSAT-2	January 22, 1975	February 25, 1982	RBV, MSS
LANDSAT-3	March 5 1978	March 31, 1983	RBV, MSS
LANDSAT-4	July 16, 1982	launching to orbit around the earth had failed	MSS, TM
LANDSAT-5	March 1, 1984	Still active	MSS, TM
LANDSAT-6	October 5,1993	Lost at launch	ETM
LANDSAT-7	April 15, 1999	Still active	ETM+
LANDSAT-8	February 11, 2013	Still active	OLI

Source: Charanporn, 2014

The National Research Council of Thailand (1993) had stated that the TM system had been improved with higher resolution than the MSS by enhancing the recording of the radiation from the earth surface in each band, and with narrower band. This enables the capacity to classify objects better. It is divided into 7 bands. 1 image covers 30x30 meters. Properties of each band are as follows.

Band 1 Its length is 0.45-0.52 micrometers (blue) and is used to indicate water at the shore and to display the difference or to differentiate the types of deciduous plants, to separate soil from various crops. It is sensitive to with or without chlorophyll objects.

Band 2 Its length is 0.52-0.60 micrometers (green) and is used to indicate the reflection of green energy of grown crops.

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Band 3 Its length is 0.60-0.69 (red) micrometers and is used to indicate the difference in chlorophyll absorption of various crops.

Band 4 Its length is 0.77-0.90 micrometers (near infrared) and is used to quantify biomass volume and to separate water and non water parts.

Band 5 Its length is 1.55-1.75 micrometers (shortwave infrared) and is used to censor plants and soil moisture and to separate snow and cloud.

Band 6 Its length is 10.40-12.50 micrometers (thermal infrared) and is used to censor the withering of crops by plant internal heat, to display difference of heat in a study area and to indicate soil moisture and plant stress.

Band 7 Its length is 2.08-2.35 micrometers (refletive infrared) and is used to censor water heat, and to classify minerals and rocks.

Table 2-2 Example of Band combinations used to create RGB composites in LANDSAT 5-TM

Land use Type	**Band 4**	**Band 4**	**Band 4**	**Band 4**	**745 RGB**	**457 RGB**	**453 RGB**	**543 RGB**
Snow	PW	PW	PW	PW	PW	PW	W	W
Cloud	W	W	-	-	W	W	W	W
Haze	DGR	BL	W	W	R	G	R	G
Forest	GR	DG	W	W	P	BY	R	G
Grass	GR	DG	W	W	P	BY	R	G
Urban	GR	W	GR	DGR	LB	RP	LB	RP
Water	DGR	BL	BL	BL	B	BP	BL/B	BL/B
Wetland	GR	W	GR	DGR	LB	RP	LB	B
Shadow	BL	BL	BL	BL	BL	BL	BL	BL

Note:

PW : pure white
W : white
DGR : dark gray
GR : gray
BL : black
R : red
G : green
B : blue
P : pink
BY : brandish yellow
LB : light blue
RP : reddish purple
BP : bluish purple

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Source : Somporn , 2009

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LANDSAT-8 is the newest one launched on February 11th, 2013 under USGS arrangement at 705 kilometers obit above the earth. It takes photo in different bands, blue, green, red, 2 close infrared bands, and 2 short wave infrared bands at 30 meters resolution, 2 heat infrared bands at 60 meters resolution and at 15 meters resolution black and white image; repeating at the same position every 16 days, 11 bands as shown in Table 2-3

Table 2-3 Wavelength and Resolution of LADSAT 8

Band	Wavelength (μm)	Resolution (meters)
1	0.43 - 0.45 (Coastal Aerosol)	30
2	0.45 - 0.51 (Blue)	30
3	0.53 - 0.59 (Green)	30
4	0.64 - 0.67 (Red)	30
5	0.85 - 0.88 (Near Intreared NIR)	30
6	1.57 - 1.65 (SWIR 1)	30
7	2.11 - 2.29 (SWIR 2)	30
8	0.50 - 0.68 (Panchromatic)	15
9	1.36 - 1.38 (Cirrus)	30
10	10.60 - 11.19 (Thermal Infrared - TIRS 1)	100
11	11.50 - 12.51 (Thermal Intrared - TIRS 2)	100

Source: Geo-Information and Space Technology Development Agency (Public Organization), 2014

2.4 Land Use Change Prediction Model

At present mathematical model is used extensively together with geographical information system to predict the land use change. The outcome from the model is displayed in both quantitative and area ones.

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CA-MARKOV model is a model capable to predict the land use change. The results both the quantitative and the areal ones are very close to reality. Change rules of model are also changeable following the user's conditions which may change according to scenarios and conditions meeting the land management policy (Chutipong, 2008). In the application of the CA-MARKOV to predict the land use change, Thanit (2005) studying the land use change at Ban Laem District sea shore area in Phetchaburi Province, had used the geographical information system, remote sensing data, and satellite geographical coordinate system, together with Markov chain model and Marko cellular automata to study the land use patterns and the land use changes during 1997-2003 and to predict the land use in the next 15 years, 2015. The result of the prediction using the model was 73.54 percent accurate comparing to actual land use.

Usawadi (2007) had studied the land use in 1990, 2000, 2004, and 2008 and the land use before and after tsunami, and verified the suitable model to predict the land use change in Krabi Province, applying the geographic information system together with the Markov chain and cellular automata (CA-MARKOV). The result from the comparison of the outcome of the land use change prediction with the outcome from the interpretation of satellite image by hybrid classification showed 74.83 percent of overall accuracy and kappa index value of 0.629.

Ing-On (2009) had studied the land use and its change in 15 years period from 1990 to 2005 and had predicted the land use change in the next 10 years for Nan Province using geographic information system with CA-MARKOV model and with regression model. The result of the application of the model to predict the land use change in 2010 showed 82.12 percent accuracy and kappa index value 0.87.

Dongjie Guan (2011) had studied the land use change in SAGA Prefecture in Japan in 1976, 1987, 1997 and 2006, and predicted the land use change in the future using the cellular automaton model and Markov model. The result of the land use change prediction indicated that CA-MARKOV model is capable to predict the land use distribution in the future with accuracy 95.13 percent of the actual land use area.

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Samereh (2011) had studied the land use change and ground cover of Isfahan City and surrounding in Iran in 1955, 1972, 1990 and 2001, with remote

sensing images and geographic information system (GIS) using aerial photos taken in 1955 and LANDSAT images in MSS, TM, and ETM+ systems taken in 1972, 1990 and 2001 respectively. The satellite images had been interpreted by hybrid classification, both supervised and unsupervised and the results were used to predict the ground cover and the land use in 1990 and 2001, using images from 1955 and 1972 to predict 1990 and 1972 and 1990 to predict 2001 respectively. Then their accuracies were examined by comparing with the satellite image interpretation using hybrid classification. It had been found that kappa coefficients values of 1990 and 2001 were 0.64 and 0.84 respectively, whereas the overall accuracy values of 1990 and 2001 were 74.69 % and 88.98 % respectively.

2.5 Study Area

2.5.1 Location and Boundary

Hua Hin District locates at the northern most of Prachuab Kiri Khan Province, at 12 degrees 35 minutes north latitude and 99 degrees 57 minutes east longitude. It is approximately 185 kilometers from Bangkok Metropolis and approximately 92 kilometers from Prachuab Kiri Khan City. Its area is 824.60 square kilometers. It is divided into 1 town municipality, 1 subdistrict municipality and 5 subdistrict administrative organizations (SAOs). There are 7 subdistricts namely Nongplub, Hinlekfai, Hua Hin, Huay Sat Yai, Thaptai, Nong Kae, and Bung Nakhon.

In this study, the study area is within Hua Hin District coastal area covering 2 subdistricts, Hua Hin and Nong Kae, under the administration of Hua Hin City Municipality, 86.36 square meters or 53,975 rais. It is approximately 195 kilometers south of Bangkok (via Samut Sakon, Samut Sonkram and Phetchaburi). Its shape is rectangular. 22 kilometers long from north to south and 3-4 kilometers wide. the east side is sea shore with railway and Petchakasem Road (Highway no. 4) run along through it, diving the area into 2 parts. The eastern part is coastal plain, 1 by 4 of the area of Hua Hin Municipality and all is community area. The western part, 3 by 4 of

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the municipality area, is dense communities at the center area on both sides of the highway. The city expansion is along the highway. There are many tourist attractions, restaurants, hotels and other tourism related business establishments (three years development plan). Especially on the east side there are highly dense communities and commercial establishments continually adjacent to other communities as follows, Cha Am Town Municipality of Cha Am District of Phetchaburi Province to the north, Pran Buri District of Prachuab Kiri Khan Province to the south, the Gulf of Thailand to the east, and Thap Tai and Hin Lekfai Subdistricts of Hua Hin District to the west.

2.5.2 Topography

Hua Hin District locates between Tanaosri range and the Gulf of Thailand, about 60 kilometers wide. The west is adjacent to Myanmar where it is high mountain range with wild forest. The area slopes gradually to the east with small grove woods to the sea coast. The area is suitable for farming. There is a small island at the south of Khao Takiab namely Koh Singto. Its natural resources are forest and quartz.

2.5.3 Climate

Hua Hin District is under monsoon climate with 2 annual monsoons a year, the northeast monsoon and the southwest one. The former blow from the northeast in winter time. It makes the weather of the upper part of the central region cool but on the east of the southern region, especially the lower part, be with abundant rain as there is not blocking mountains. Hua Hin District by the way is in the upper part of the east of the southern Region, the monsoon get in the district sporadically with rains in the early season. For the latter monsoon, it blows normally in rainy season from Indian Ocean giving Thailand heavy rain. However, as Hua Hin District hides itself behind Thanaosri mountain range so it become rain shadow zone. There is little rain in rainy season. Most of it comes during winter time between October to November. The average annual rainfall of Hua Hin District is therefore small. It is approximately 1,031.1 millimeters with 120 raining days. The month with heaviest rain is October, averagely 231.1 millimeters with 17 raining days. The

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average annual temperature is 27.5 degrees Celsius, the average maximum and minimum temperatures are 31.3 and 23.5 degrees Celsius respectively.

There are 3 seasons in Hua Hin District, according to Thailand weather.

- Winter. This starts from the middle of October to the middle of February. The temperature goes down and becomes generally cool. There are rains along the coast especially in October and November.

- Summer. This starts from the middle of April to the middle of May for about 3 months. As it is adjacent to the sea, cool wind and water vapor from the sea help alleviating the heat not to be very hot. The months with the hottest weather are April and May.

- Rainy Season. This starts from the middle of May to the middle of October with heavy rain in October.

2.5.4 Economic Conditions

The economic conditions mainly depend on tourism and commerce. There are many hotels, shops, and resorts. These are important sources of jobs for local people. There is also fishery occupation which is original occupation of Hua Hin people. As Hua Hin turn into important tourist attraction, together with its natural and marine resources, the fishing occupation goes down. There are still fishermen in Samore Riang Community, Thakiab Community and Khao Thao Community. There are also farmers especially in the west of Hua Hin Municipality. They keep farming because of suitable environment. Major crops are coconut and pineapple.

2.5.5 Social Condition and Population.

Hua Hin Municipality consists of 35 communities in 2 subdistricts, 28 communities in Hua Hin Subdistrict and 7 in Nong Kae Subdistrict. The population of the municipality was 58,275 in 2012, 28,344 male and 29,931 female, 48.64 % and 51.36 % respectively. The total households were 42,316. The average density of population was 675 heads per square kilometers (Registration Administration bureau, Department of Provincial Administration, 2013).

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2.5.6 Coastal Area and Geomorphology

Prachuab Kiri Khan Province is on the west of the Gulf of Thailand. Its coast is next to the upper part of the Gulf. Its coast is about 190 kilometers long, along the north-south line. Most of the coast is beaches parallel to the land. Every district has the coast starting from Ban Bo Fai coast of Hua Hin District to Pran Buri District coast, Kui Buri District, Sam Roi Yod Minor District, Muang District, Thap Sakae District down to Bang Bird District and Bang SaphanDistrict. The coast of this province is in many types, rock, cliff, beach, lagoon, and swamp forest and flood plain mangrove. The province therefore gets perfectly beautiful natural coastal conditions with rather high coastal potential. However, the development without clear and correct supportive plan and policy and without coastal potential appraisal for appropriate application according to geological conditions, the preceding coastal development had destroyed the coastal environment of the province enormously.(Sin et al., 2002).

The coastal area of Hua Hin District from Ban Bo Fai of Hua Hin Subdistrict down to Ban Khao Tao of Nong Kae Subdistrict has many geomorphologic features, sand beach lagoon and sand dune, as shown in Figure 2-2

The study of Sin el al. (2002) had found that Hua Hin District coast area along approximately 22 kilometers coast had been changed by erosion at the rate of 1-5 meters annually for about 9.5 kilometers or 43.18 percent of the area. The coast of Hua Hin District was moderately eroded as follows.

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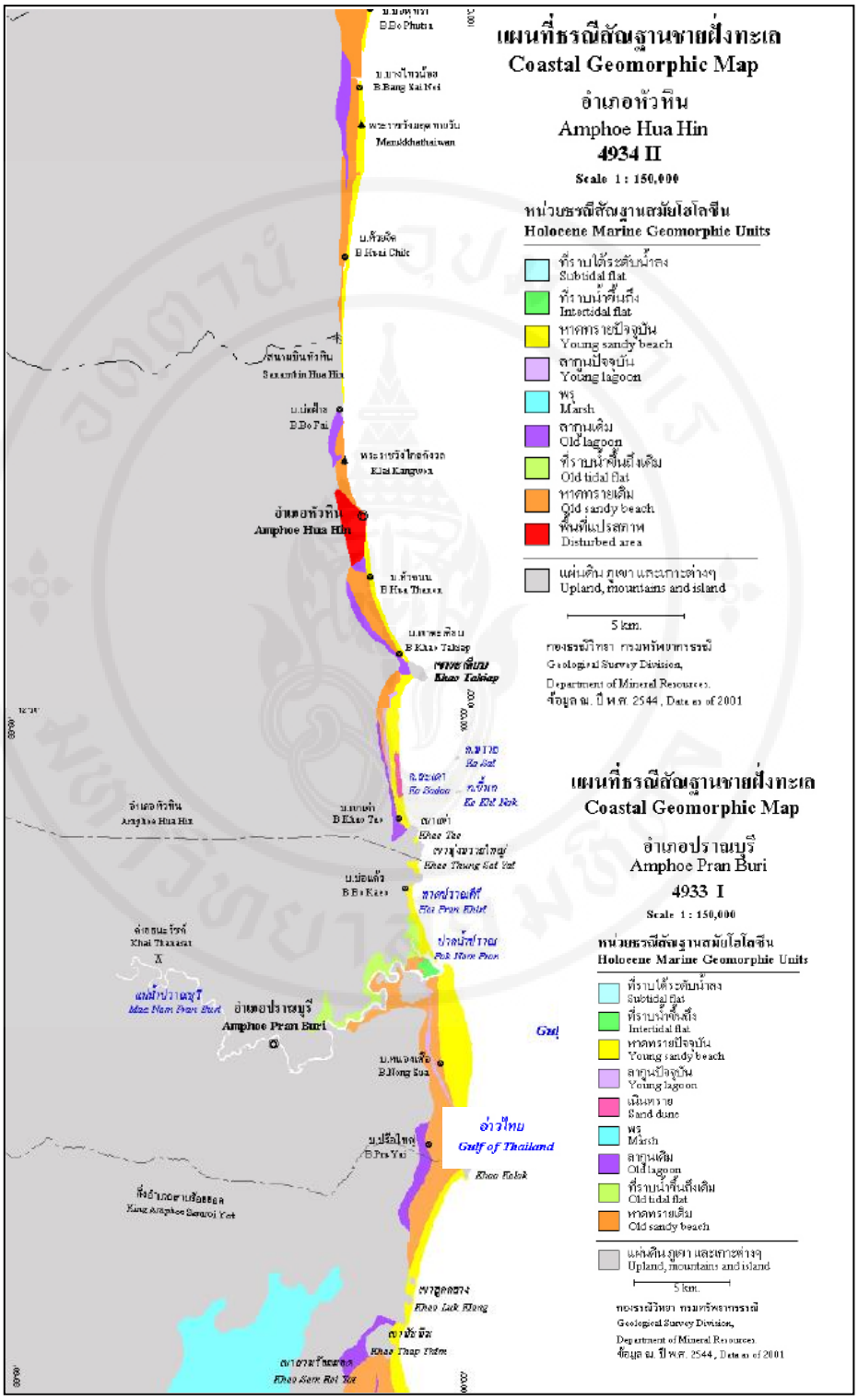

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Figure 2-2 Coastal Geomorphology of Hua Hin District of Prachuab Kiri Khan Province. (Sin et al., 2002)

1) Ban Bo Fai-Ban Hua Hin Coast. This is the northern part of Hua Hin District, about 5 kilometers long, from Bo Fai Airport down to Hua Hin Market Pier. The sand beach at present is 500-800 meters wide. It is sand beach parallel to the land along north-south direction, curve and tapering. This area is beach resort area with frontal sea walls constructed every beach with resorts. The erosion is found only narrow area without the sea walls. The survey during 1996 to 2000 revealed that the coastal erosion was averagely about 2 meters a year in the area of 5 kilometers long (coordinates UTM 604100E 1395600N to 604500E 139050N). In addition to natural wave and wind, the cause of erosion was the development from the past up to present especially the construction of the sea walls at will of officials and the draining of wastewater from houses and factories directly to the seacoast. These were additional causes of erosion and pollution to the coast as shown in Figure 2-3.

Figure 2-3 Moderate Erosion at Silt Cliff, Ban Bo Fai,
Hua Hin District On September 23, 1998 (Sin et al., 2002)

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2) Ban Saothong-Ban Khao Takiab. This is a part of southern Hua Hin District coast from Hua Hin College down to Khao Takiab. The coast was formed by the changing of sea levels in the past creating coastal geomorphologic feature consisting of lagoon, lowland, in the innermost area and primary sand beach and then present sand beach next to the sea. It is wider in the north then tapering to Khao Takiab. The erosion takes place on the present sand beach, about 3.5 kilometers. The comparison of aerial photographs of 1967-1995 revealed that the erosion was approximately 2-3 meters a year (coordinates UTM 605100E 1387500N up to 606800E 1384000N). In this part of the coast, there are many hotels, high-rise buildings, and walls next to the beach and both parallel and perpendicular to the coast. The erosion in this part occurs only in narrow areas without construction. This is caused by the building developed adjacent to the sea coast and all of them are constructed on present unsettled sand. The sand would move by the weight of the high-rise buildings baking the beach to subside. This can be observed by sand flat plain. The sand deposited in monsoon free season had been dispersed not far away due to obstructing walls. In the northeast monsoon season, the coming waves wash away sand in the bigger volume than the remaining sand so the erosion is obvious. A part of the sand is washed by the coastal current down south to deposit in front of Khao Takiab whereas the other part move up north and trapped by rock cape in the Hua Hin City area. The north and south of this beach therefore maintain its natural conditions.

3) Ban Khao Thao Coast of Hua Hin District. This coast is a bay between Khao Takiab in the north and Khao Thao in the south. The coast is in north south line consisting of geomorphologic features of lagoon in the innermost and then primary sand beach, present sand beach with eminent sand dune. This dune is formed by wind blowing topper sand to deposit on the beach being natural phenomenon to excellently protect the inner lowland. There are 3 rows of sand dune in Ban Khao Thao functioning as protecting fence for inner coastal area. The erosion occurs only at the frontal part of the dune on the outermost and at the lowest degree as naturally these dunes are covered by shrubs. However, the change of land for cultivation and housing has eradicated these shrubs so the erosion is easier and faster. The erosion in this area is at about 1 kilometer distance at Ban Bo Thale, a fisherman village. The frontal sand

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beach is eroded by about 1 kilometer long. Iron wood horsetail Pine trees along the beach die. The coastal erosion rate is approximately 1-2 meters a year (coordinates UTM 606500E 1378300N to 6o6500E 1377500N). A part of the causes of erosion is the sea wave and wind but another is the area development. There are walls constructed both in the north and south of the beach to fence private land plots and they can cause the erosion of the natural open areas as they are in between the cape tips. The sand along the coast will be trapped naturally by the two cape tips. This is similar to Hat Sai Noi, at the southern part of Khao Thao, which is small bay bottom beach, smaller and shorter than Khao Thao beach. At present there is the erosion in the north of the beach due to the construction of roads and houses next to the sea as shown in Figure 2-4: Moderate Erosion at Silt Cliff in Ban Bo Fai of Hua Hin District on December 23rd 2000 and Figure 2-5.

Figure 2-4 Erosion at sand dune, Ban Khao Thao, Hua Hin District
On December 23, 2000 (Sin et al., 2002)

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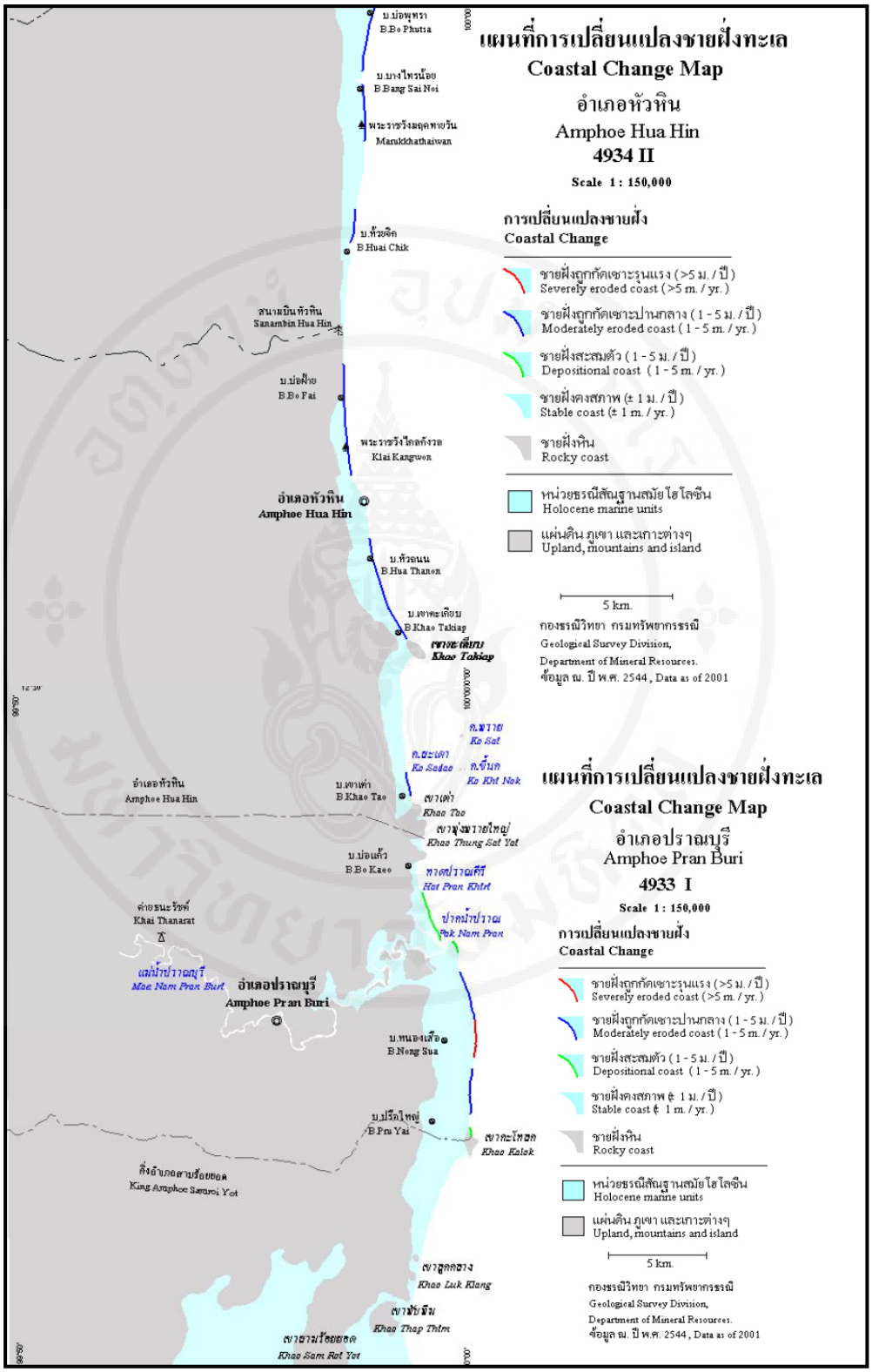

Figure 2-5 Coastal Change in Hua Hin District of Prachuab Kiri Khan Province. (Sin et al., 2002)

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CHAPTER III
METHODOLOGY

3.1 Study Data and Tools

The data and tools applied in the land use change and coastal erosion in Hua Hin District of Prachuab Khiri Khan Province are as follows:

1. Data from LANDSAT-5TM, 30x30 resolution, in path 129 row 51, recorded in years 2003 and 2009.
2. Data from LANDSAT-8, 30x30 resolution, in path 129 row 51, recorded in years 2014.
3. Topographic map from the Royal Thai Survey Department, 1:50,000, series L7018, sheets 4934II and 4933I, year 2004, covering coastal area of Hua Hin District of Prachuab Khiri Khan Province.
4. Global Positioning System: GPS to gather field data of the actual area condition to verify the correctness of the satellite image interpretation of the study area.
5. Photo camera to take pictures of the real area.
6. Personal computer for data processing.
7. GIS software: ArcGIS
8. Image analysis software: ENVI and IDRISI Andes Edition.

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3.2 Data Analysis

In this study, shoreline change and land use change, of Coastal area of Hua Hin District of Prachup Khiri Khan Province, were analyzed applying remote sensing data interpretation. Details of each procedure are as follow:

3.2.1 Coastal Erosion Study

3.2.1.1 Pre-Processing. This is to correct the satellite images before the processing begin as the satellite images contain geometric and radiometric errors.

1) Geometric Correction. This is to correct the distortion of positions in the images caused by the satellite orbit and the earth revolving. The errors are corrected according to the map projection system. This is done by applying acceptable reference standard using the UTM geographic coordinate system of the topographic maps, 1:50,000, of the Royal Survey Department as position reference or ground control point: GCP.

2) Radiometric Correction. This is to correct the errors of the light reflection (grey level) of the objects on earth due to the errors of the tools and their functions.

3) Processing.

(1) In the selection of band to use in the study of the shoreline change, in the study and data gathering, it has been found that near infrared band (0.76-0.90 μm), band 4, is the best functioning in the study of the shoreline change because the band is highly absorbed by water so the difference of land and water surfaces is obviously noticed, even in area with high deposition. The reflections obtained from the satellite are clearly different, the reflection of the land surface is higher than that of the water one.

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(2) Image Classification. This is to assign the shoreline with visual interpretation from the near infrared band for the classification of land and water surfaces from each other. This data would represent shorelines of the years 2003, 2009 and 2014.

(3) The shoreline change from the past to the present was analyzed applying ArcGIS program in which there is the Digital Shoreline Analysis System (DSAS) to be applied in the calculation for the perpendicular distances of the changed shoreline. The transect lines will be assigned every 100 meters perpendicular to the baseline of each year. Then the position changes of each period of 2 periods, 2003-2009 and 2009-2014, were analyzed. The negative result is area with erosion. On the contrary, that with positive result is area with accretion. The perpendicular distance of the shoreline divided by the period of time (years) will be the rate of shoreline change per year.

The calculated shoreline changes per year then will be classified according to the standard assigned by the Department of Mineral Resources (Sin Sinsakul et al, 2002).

- Severe shoreline erosion is >5 meters a year erosion.
- Moderate shoreline erosion is 1-5 meters a year erosion.
- Accretion shoreline is 1-5 meters a year of accretion.
- Stable shoreline is ±1 meter a year change.

(4) Field survey is conducted to examine scope and conditions of the changed areas along the coast and record their coordinates by the satellite geographic position system (GPS) and take photos of the actual conditions.

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3.3.2 Shoreline Change Prediction by Shoreline Model .

The shoreline model is a model for 3 direction prediction involving location coordinates of the shoreline (X,Y) and the time from the past to the present. In the numerical data analysis, transect lines are assigned to be perpendicular with the baseline and then the change rates are analyzed for each and every transect line in order to predict the shoreline in the future using linear relation between the position and time of the data under the equation : (Siriluck, 2011)

$$y = mx + c$$

y	is	new shoreline position.
m	is	shoreline change rate at the study location.
c	is	intercept y.
x	is	time (year of prediction).

In this study, data obtained from the analysis of the shoreline change in years 2003, 2009 and 2014 using the digital shoreline analysis system (DSAS) in which the perpendicular distances changed in every years are assigned into a simple linear regression in order to predict the shoreline in 2024. Then the correctness and reliability of the equation is examined using data obtained from the equation for the shorelines in years 2003, 2009 and 2014 in comparison with the shoreline from the analysis using the digital shoreline analysis system (DSAS).

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3.3.3 Land Use Change Study

3.3.3.1 The land use change of the coastal area was studied using images from LANDSAT-5-TM, for years 2003 and 2009, and from LANDSAT-8, for year 2014, respectively.

3.3.3.2 The geometric and radiometric errors were corrected to obtain images of the same standard and appropriate for analysis. The topographic map, 1:50,000, of the Royal Survey Department was used for assignment of Ground Control Points (GCPs) using ENVI program to select referent points on the satellite images and the referent images. Only clearly displayed points on both satellite images and the topographic maps shall be selected, covering the most of the study area.

3.3.3.3 The image enhancement was done applying remote sensing technology in spectral enhancement to intensify the sharpness of the images in the areas of interest. With false color composite the images will be clearer.

3.3.3.4 The nomenclature was used in the land use classification for the coastal area of Hua Hin District of Prachuap Khiri Khan Province, in years 2003, 2009 and 2014 respectively, to acknowledge the features of land use for the land use change study. This study classified the land use applied in the analysis into 5 categories, referring to the land use categories classification system level 1 of the Land Development Department year 1999, as shown in Table 3-1.

Table 3-1 Details of each land use category in the study area

Order	Land Use Category	Explanation
1	Urban and Built-up land	Area with communities, housing area, entrepreneurs, hotels, resorts, vacation houses, industrial area, telecommunication stations, and various constructions
2	Forest land	Natural forest, cultivated forest, deteriorated forest
3	Agricultural land	Cultivated area, plantations
4	Water Body	Rivers, ponds, canals, and constructed reservoirs
5	Miscellaneous land	Low land, waste and uncovered land, and other

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3.3.3.5 The corrected images were processed for land use classification under said categories. Here, image classification using supervised classification was applied. In this classification, training areas were assigned as representatives of each land use categories. The visual interpretation helped in the classification. In addition, the actual field survey helped in the training areas assignment. Then the 5 categories of land use in the area were identified using the maximum likelihood classification theory in the processing as it gives higher accurate results than other theories.

3.3.3.6 Prior to the classification, the images lacked continuity due to the mingling of the pixels with close reflection values. The post classification processing was done using majority filter to improve the images to be more smooth to get continuity of the images.

3.3.3.7 The field survey was conducted to verify the correctness, using GPS to identify the coordinates of various areas in the study area. Data and information were gathered by photographs to expose actual present conditions. Then the field survey data and information were used for land use classification adjustment in order to obtain actual correct land use categories and then the accuracy of the satellite images interpretation would be assessed.

3.3.3.8 The confusion matrix method was used in the accuracy assessment in this study. The results of the land use classification in 2014 were compared between the satellite images and the ground truth. The point sampling could be used in determining minimum number of pixels sampled to be examined appropriately under the binomial probability theory

$$N = 4(p)\ (\sim q)/E2$$

Whereas: N = Suitable minimum number of pixels sampled

P = Probability that said pixels are accurate

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Q = Difference between 100-p

E = Acceptable error in percentage

Then the data were improved for accuracy at appropriate level where the accuracy is assigned at over 80 percent.

3.3.3.9 The land use change at the coast was studied from the satellite images using overlay analysis technique overlaying land use images of years2003, 2009 and 2014 of the periods 2003-2009 and 2009-2014, applying geographic information system processing program. Then the land use area of each category was calculated and land use changes in the periods 2003-2009 and 2009-2014 were analyzed respectively.

3.3.4 Land Use Prediction

3.3.4.1 The land use data of the years 2003, 2009 and 2014 were processed for prediction of land use tendency. The land use data of the years 2003 and 2009 were used in prediction of 2014 land use tendency to verify the accuracy of the model. The data of land use of the years 2009 and 2014 were used to predict the land use tendency of the year 2024 by using Makov model. The result obtained was the probability of changing and the transition area proportion.

3.3.4.2 The transition area proportion obtained was then used in formulating the model for land use prediction in 2014 and 2024 respectively using Cellular Automata and Markov Model (CA_MARKOV).

3.3.4.3 The model was examine for accuracy using the land use data in 2014 obtained from the prediction by CA_MARKOV model and the land use data of 2014 obtained from the satellite data classification and the field survey with the error matrix to calculate the overall accuracy of the classification, the omission error or producers' accuracy and the commission error or the user's accuracy and the Kappa statistics.

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CHAPTER IV
RESULTS AND DISCUSSION

This study was analyzed the satellite images and the field survey in order to classify and predict the land use and the coastal erosion change and to assess the coastal erosion impacts in Hua Hin District of Prachuab Khiri Khan Province. The sequence of the study is including (1) data preparation, (2) coastal land use classification, (3) shoreline change interpretation, and (4) the land use change and the coastal erosion impacts assessment, in Hua Hin District of Prachuab Khiri Khan Province.

4.1 Land Use Classification and Land Use Change in Hua Hin District of Prachuab Khiri Khan Province

4.1.1 Land Use Classification in Hua Hin District of Prachuab Khiri Khan Province

From the LANDSAT-5TM images of the years 2003 and 2009 and the LANDSAT-8 of the year 2014, land use patterns of the coastal area of Hua Hin District of Prachuab Khiri Khan Province were classified. The supervised classification of the land use patterns was used in assignment of the training areas in all three periods. The maximum likelihood classification technique was used because it gives the best classification results. Then the results obtained were screened using the majority function.

The results of the classification of the LANDSAT images of the years 2003, 2009 and 2014 as shown in Table 4-1

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Table 4-1 Land use patterns in Hua Hin District of Prachuab Khiri Khan Province

Land use pattern	Year 2003		Year 2009		Year 2014	
	Km2	%	Km2	%	Km2	%
Agricultural land	23.07	31.30	5.91	8.02	9.29	12.61
Forest land	21.22	28.79	19.62	26.62	17.17	23.30
Urban and Built-up land	15.19	20.61	22.74	30.85	26.96	36.58
Water Body	0.36	0.49	0.67	0.91	0.52	0.71
Miscellaneous land	13.87	18.81	24.77	33.60	19.76	26.81
Total area (Km2)	**73.71**	**100.00**	**73.71**	**100.00**	**73.71**	**100.00**

Source: LANDSAT imageries analysis and ground survey

From the classification of the satellite images of Hua Hin District of Prachuab Khiri Khan Province of the year 2003, among the 5 categories classified land use, it had been found (as shown in Figure 4-1) that the agricultural area was approximately 23.07 square kilometers (31.30 percent of the area). The next ones were the forest area approximately 21.22 square kilometers (21.22 percent of the area), the urban and build-up area approximately 15.19 square kilometers (20.61 percent of the area), and the miscellaneous area approximately 13.87 square kilometers (18.81 percent of the area), respectively. The water resource area was approximately about 0.36 square kilometers (0.49 percent of the area).

From the classification of the satellite images of Hua Hin District of Prachuab Khiri Khan Province of the year 2009, among the 5 categories of the classified land use, it had been found (as shown in Figure 4-2) that the miscellaneous area was the largest area approximately 24.77 square kilometers (33.6 percent of the area). The next ones were the the urban and build-up area approximately 22.74 square kilometers (30.85 percent of the area), the forest area approximately 19.62 square kilometers (26.62 percent of the area), and the agricultural area approximately 5.91 square kilometers (8.02 percent of the area), respectively. The water resource area was approximately about 0.67 square kilometers (0.91 percent of the area).

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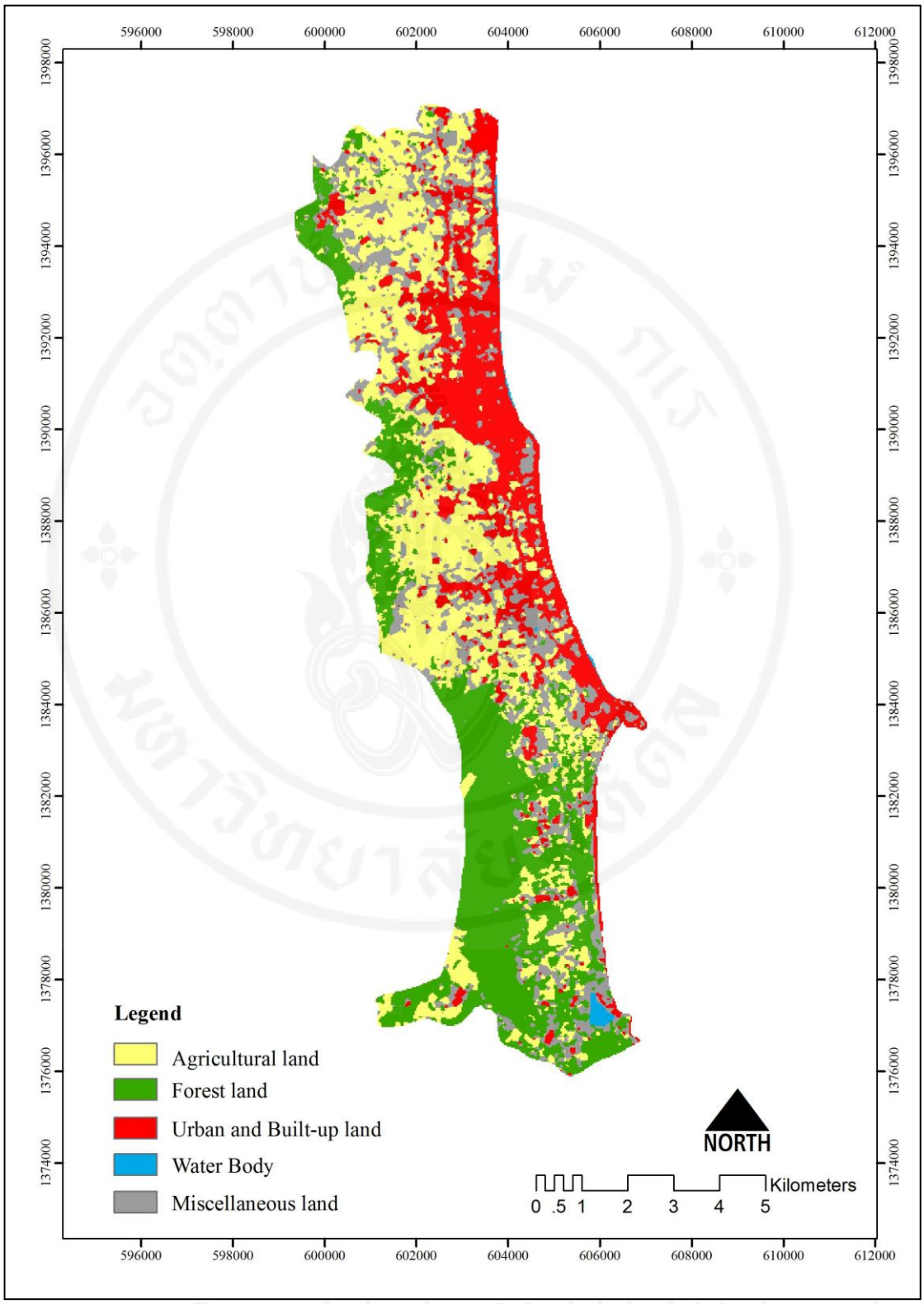

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Figure 4-1 Land use patterns in Hua Hin District of Prachuab Khiri Khan Province of the year 2003

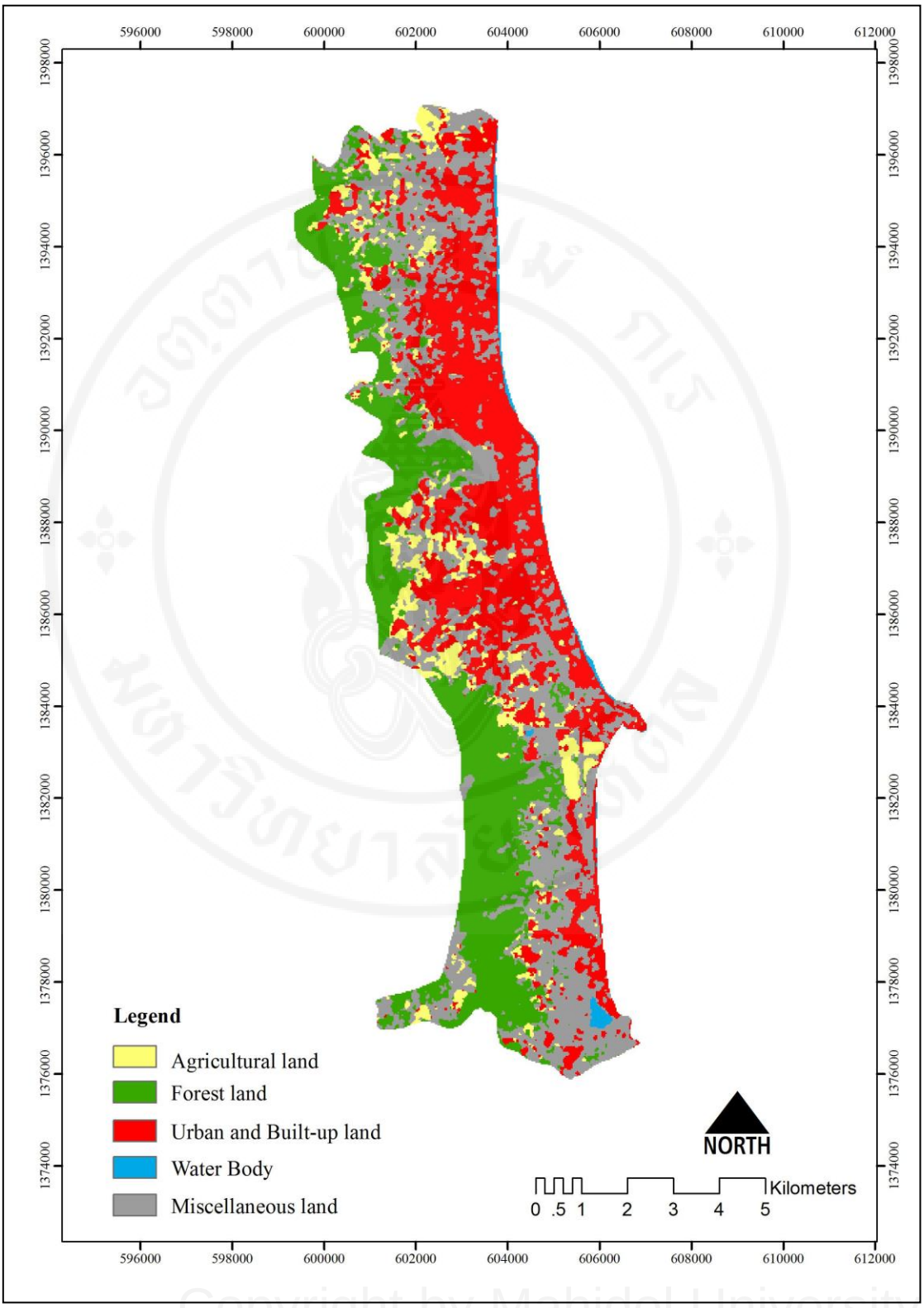

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Figure 4-2 Land use patterns in Hua Hin District of Prachuab Khiri Khan Province of the year 2009

From the classification of the satellite images of Hua Hin District of Prachuab Khiri Khan Province of the year 2014, among the 5 categories of the classified land use, it had been found (as shown in Figure 4-3) that the the urban and build-up area was the largest area approximately 26.96 square kilometers (36.58 percent of the area). The next ones were the miscellaneous area approximately 19.76 square kilometers (26.81 percent of the area), the forest area approximately 17.17 square kilometers (23.30 percent of the area), and the agricultural area approximately 9.29 square kilometers (12.61 percent of the area), respectively. The water resource area was approximately about 0.52 square kilometers (0.71 percent of the area).

4.1.2 Accuracy Verification of the Land Use Analysis Year 2014

The accuracy verification t of the land use using the 5 categories land use classification was conducted by comparing the land use patterns in 2014 obtained from the satellite images and from the actual field survey, applying confusion matrix accuracy method by comparing the minimum sample points for accuracy verification calculated by formula of binomial probability theory at 20 % accepTable error and the probability that the pixels are 80 % accurate. It has been found that the minimum number of pixels appropriate for comparison are 36 sample points. The result of the accuracy verification indicated the overall accuracy at 90 % with the Kappa coefficient 0.73.

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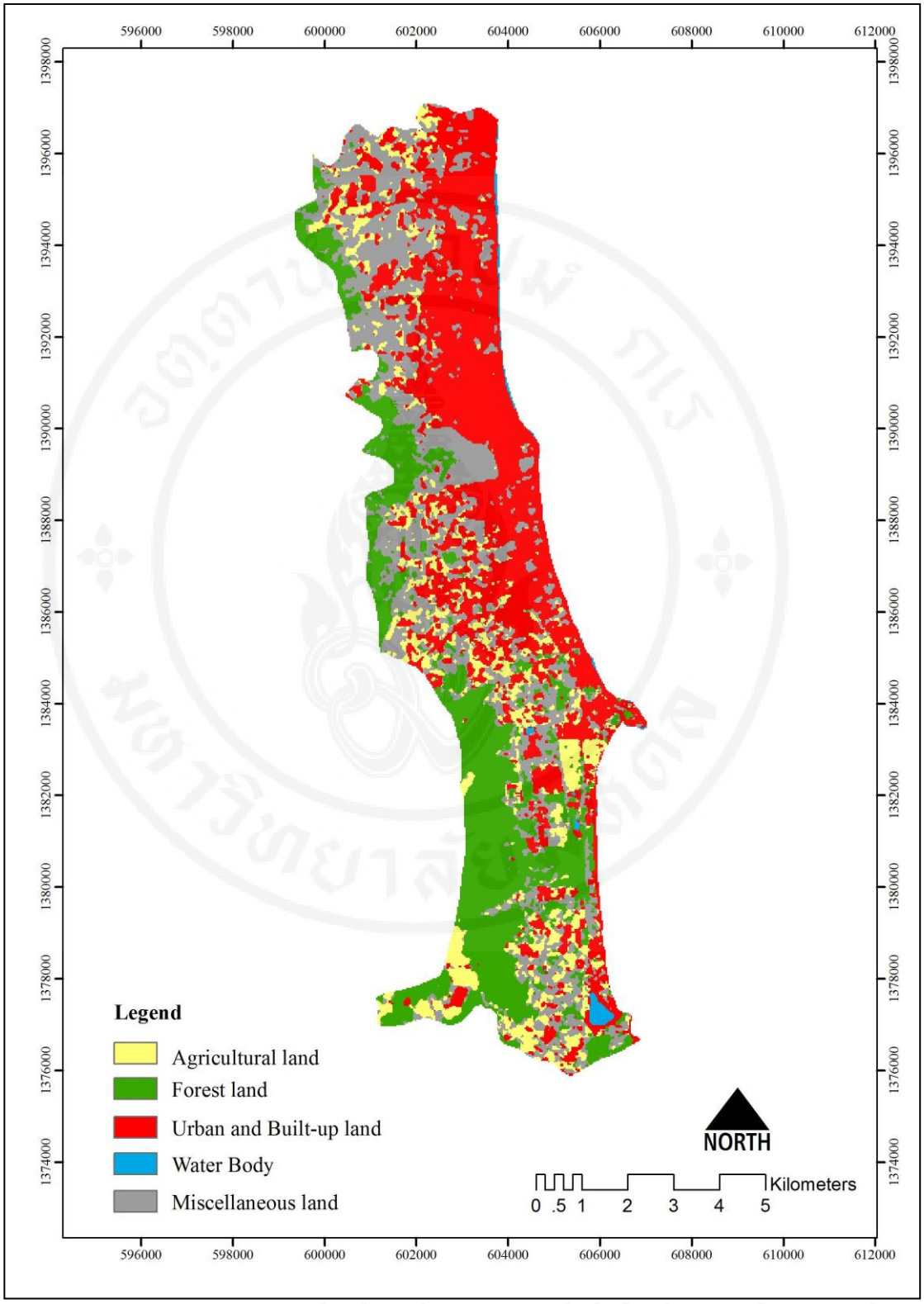

Figure 4-3 Land use patterns in Hua Hin District of Prachuab Khiri Khan Province of the year 2014

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4.1.3 Land Use Change in Hua Hin District of Prachuab Khiri Khan Province

The results of the land use change analysis during years 2003-2009 and 2009-2014, applying the land use classifications of the 2003-2014, to analyze the changing of land use from one pattern to the other, by change detection method, were as follows.

1) Land Use Change during 2003-2009

By the comparison of the land use during the years 2003-2009, the maximum change was the forest area of which 3.91 square kilometers had changed to agricultural area, next 1.43 square kilometers changed to miscellaneous area and the next 0.13 square kilometers to the urban and build-up area. The next changed was the urban and build-up area of which 4.67 square kilometers had changed to forest area, 4.61 square kilometers to miscellaneous area and 1.15 square kilometers to forest area. The miscellaneous area had changed to agricultural area 11.27 square kilometers, forest area 5.12 square kilometers, the urban and build-up area 2.02 square kilometers, and water resource area 0.04 square kilometers respectively. The agricultural area had changed to miscellaneous area 1.5 square kilometers, to forest area 0.81 square kilometers and to the urban and build-up area 0.03 square kilometers respectively. These are shown in Tables 4-2 and 4-3

Table 4-2 Land use change between 2003 and 2009

Land use pattern	Area (Square kilometres)			
	Year 2003	Year 2009	Different[1/]	(%) different of Total area
Agricultural land	17.51	8.56	-8.95	36.16
Forest land	24.83	21.51	-3.32	13.41
Urban and Built-up land	22.58	34.95	12.37	49.98
Water Body	0.35	0.35	0	0.00
Miscellaneous land	8.37	8.26	-0.11	0.44
Total	**73.64**	**73.64**	**24.75**	**100.00**

Source: By data analysis

Remark: [1/]positive changes = increasing aspect and negative changes = decreasing aspect

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Table 4-3 Land use change between 2003 and 2009

Year 2009 / Year 2003	Agricultural land	Forest land	Urban and Built-up land	Water Body	Miscellaneous land	Total
Agricultural land	4.62	1.88	0.86	0.00	1.19	**8.55**
Forest land	2.11	17.20	1.31	0.00	0.89	**21.51**
Urban and Built-up land	6.57	4.76	19.24	0.00	4.40	**34.97**
Water Body	0.00	0.00	0.00	0.35	0.00	**0.35**
Miscellaneous land	4.21	0.98	1.18	0.00	1.89	**8.26**
Total	**17.51**	**24.83**	**22.58**	**0.35**	**8.37**	**73.64**
Total change area[1/]	**-8.95**	**-3.32**	**12.37**	**0**	**-0.11**	

Source: By data analysis

Remark : [1/]positive changes = increasing aspect and negative changes = decreasing aspect

2) Land Use Change during 2009-2014

By the comparison of the land use during the years 2009-2014, the maximum change was the the urban and build-up area of which 6.12 square kilometers had changed to miscellaneous , 1.52 square kilometers changed to agricultural area, 0.61 square kilometers changed to forest area, and 0.24 square kilometers changed to water resource area. The next change was the forest area of which 3.23 square kilometers has changed to miscellaneous area, 0.43 square kilometers to the urban and build-up area and 0.21 square kilometers to agricultural area respectively. The miscellaneous area had changed to forest area 4.87 square kilometers, agricultural area 2.15 square kilometers, and the urban and build-up area 1.62 square kilometers respectively. The agricultural area had changed to miscellaneous area 4.25 square kilometers, to the urban and build-up area 2.18 square kilometers and to forest area 0.83 square kilometers respectively. The water resource area had also changed to miscellaneous area 0.05 square kilometers, the urban and build-up area 0.03 square kilometers, and agricultural area 0.01 square kilometers respectively. These are shown in Tables 4-4 and 4-5

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Table 4-4 Land use pattern change between 2009 and 2014

Land use pattern	Area (Square kilometres)			
	Year 2009	Year 2014	Different[1/]	(%) different of Total area
Agricultural land	8.56	5.85	-2.71	15.49
Forest land	21.51	15.48	-6.03	34.46
Urban and Built-up land	34.95	36.41	1.46	8.34
Water Body	0.35	0.35	0	0.00
Miscellaneous land	8.26	15.56	7.3	41.71
Total	**73.64**	**73.64**	**17.5**	**100.00**

Source : Calculate

Remark : [1/]positive changes = increasing aspect and negative changes = decreasing aspect

Table 4-5 Land use change between 2009 and 2014

Year 2014 / Year 2009	Agricultural land	Forest land	Urban and Built-up land	Water Body	Miscellaneous land	Total
Agricultural land	1.60	0.85	3.56	0.00	2.55	**8.56**
Forest land	1.65	13.19	3.07	0.00	3.60	**21.51**
Urban and Built-up land	1.85	1.36	25.51	0.00	6.23	**34.96**
Water Body	0.00	0.00	0.00	0.35	0.00	**0.35**
Miscellaneous land	0.75	0.08	4.26	0.00	3.18	**8.26**
Total	**5.85**	**15.48**	**36.40**	**0.35**	**15.56**	**73.64**
Total change area[1/]	**-2.71**	**-6.03**	**1.46**	**0.00**	**7.30**	

Source : By data analysis

Remark : [1/]positive changes = increasing aspect and negative changes = decreasing aspect

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4.1.4 Land Use Prediction

Form the land use tendency prediction of the year 2024 by CA-Markov model applying land use data of the 2 periods, 2003-2009 and 2009-2014, as based data, the results from the analysis showed the change opportunity as shown in Table 4-6. Most of the land use change will be the the urban and build-up area of which 0.0040 square kilometers. It will changed into miscellaneous area, 0.0037 square kilometers, agricultural area 0.0001 square kilometers, and forest area 0.0002 kilometers respectively. The next changing area will be the forest area of which 0.0057 square kilometers, which changed into miscellaneous area, 0.0024 square kilometres, the urban and build-up area, and 0.0017 square kilometers respectively. The miscellaneous area will change into the urban and build-up area 0.0081 square kilometers, agricultural area 0.0036 square kilometers, forest area 0.0034 square kilometers, and water resource area 0.0001 square kilometers respectively. Finally, the agricultural area will change into the urban and build-up area 0.0041 square kilometers, miscellaneous area 0.0032 square kilometers, and forest area 0.0009 square kilometers respectively. These changes are shown in Table 4-7. When the change proportion integrated into a land use model analyzed by CA-Markov model, the results obtained from the land use prediction of the year 2024 from the model as shown in Figure 4-4.

Table 4-6 Probability of changing

Year 2014 / Year 2009	Agricultural land	Forest land	Urban and Built-up land	Water Body	Miscellaneous land
Agricultural land	0.2043	0.0882	0.3963	0.0023	0.309
Forest land	0.091	0.4823	0.1252	0.0007	0.3009
Urban and Built-up land	0.1237	0.0411	0.6994	0.002	0.1338
Water Body	0.0032	0.0006	0.0594	0.9342	0.0025
Miscellaneous land	0.1633	0.1547	0.3713	0.0036	0.3071

Source: CA_Markov model

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Table 4-7 Transition area

Year 2014 / Year 2009	Agricultural land	Forest land	Urban and Built-up land	Water Body	Miscellaneous land
Agricultural land	0.0021	0.0009	0.0041	0.0000	0.0032
Forest land	0.0017	0.0091	0.0024	0.0000	0.0057
Urban and Built-up land	0.0037	0.0012	0.0211	0.0001	0.0040
Water Body	0.0000	0.0000	0.0000	0.0003	0.0000
Miscellaneous land	0.0036	0.0034	0.0081	0.0001	0.0067

Source: CA_Markov model

The land use prediction indicates that in the next 10 years (2024), the most land use will be the urban and build-up area approximately 29.76 square kilometers (40.37 percent of the area). The next one will be the miscellaneous area approximately 24.98 square kilometers (33.89 percent of the area), following by the forest area approximately 15.07 square kilometers (20.45 percent of the area), and the agricultural area approximately 3.59 square kilometers (4.88 percent of the area) respectively. The water resource will be the smallest land use only approximately 0.30 square kilometers (0.41 percent of the area).

Table 4-8 Prediction land use pattern in 2024

Land use pattern	Area Square Kilometers	(%) of Total area
Agricultural land	3.59	4.88
Forest land	15.07	20.45
Urban and Built-up land	29.76	40.37
Water Body	0.30	0.41
Miscellaneous land	24.98	33.89
Total	**73.71**	**100.00**

Source: Calculated

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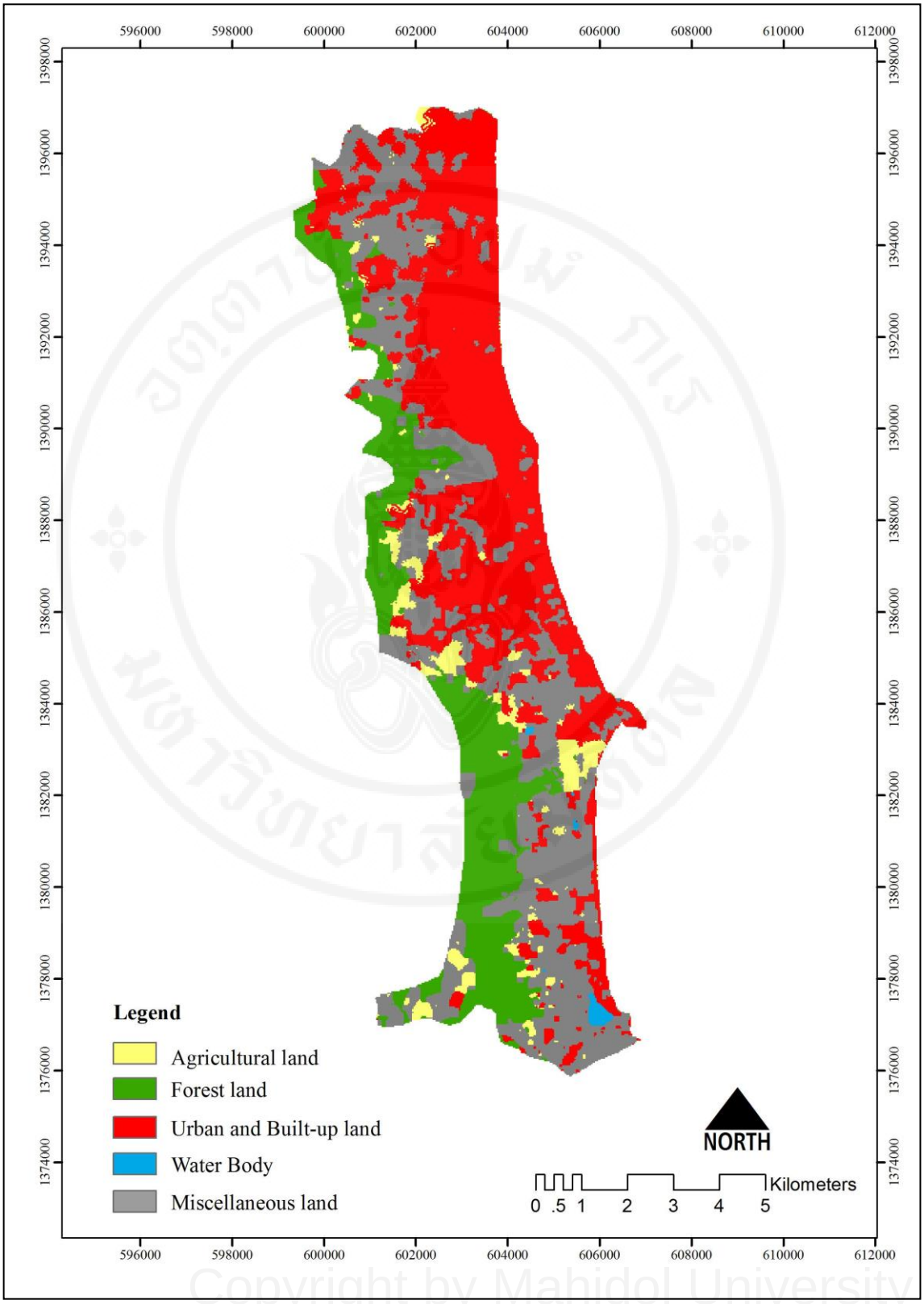

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Figure 4-4 Land use prediction of the year 2024

4.1.5 Model Accuracy Verification

The accuracy verification of the land use data of the year 2014 obtained from CA-MAKOV model in comparison with the land use data of the year 2014 obtained from the satellite images classification revealed that the model had the overall accuracy at 61.95 percent with overall kappa 0.47 as shown in Table 4-9.

Overall accuracy = $\frac{\sum_{i=1}^{k} n_{ii}}{n}$

= ((317.57+5.04+9.47+15.17+0.13+0.68)/ 391.28) x100

= 88.95

Overall Kappa: Khat = $\frac{n\sum_{i}^{k} n_{ii} - \sum_{i=1}^{k} n_i + n + i}{n_i - \sum_{i=1}^{k} n_i + n + i}$

Part a = 317.57+5.04+9.47+15.17+0.13+0.68

= 348.06

Part b = (317.57x317.57)+(9.12x24.47)+(32.70x10.04)
+(25.92x20.34)+(0.68x0.15)+(5.29+18.71)

= 102,028.5

Khat = ((391.28x348.06) - 102,028.5) /
((391.282) - 125,961,392,921)

= 0.67

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Table 4-9 Error matrix of prediction model

		Land use pattern in 2014 (Landsat image)							
	CLASS	Class1	Class2	Class3	Class4	Class5	Class6	Row Total	User's Accuracy (%)
Prediction Landsat use in 2014	Class1	317.57	0.00	0.00	0.00	0.00	0.00	317.57	100.00
	Class2	0.00	5.04	10.94	5.74	0.00	2.75	24.47	20.59
	Class3	0.00	0.30	9.47	0.17	0.01	0.09	10.04	94.30
	Class4	0.00	1.35	1.50	15.17	0.55	1.77	20.34	74.58
	Class5	0.00	0.00	0.00	0.02	0.13	0.00	0.15	87.04
	Class6	0.00	2.42	10.79	4.81	0.00	0.68	18.71	3.65
	Column Total	317.57	9.12	32.70	25.92	0.68	5.29	391.28	
Producer's Accuracy (%)		100.00	55.28	28.95	58.53	18.55	12.91		

Source: Calculated

Remark: 1. Data analysis based on raster format

2. Class 1 Unclassified
   Class 2 Agricultural land
   Class 3 Forest land
   Class 4 Urban and Built-up land
   Class 5 Water Body
   Class 6 Miscellaneous land

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4.2 Coastal Erosion Study and Shoreline Change

The analysis of shoreline physical change of Hua Hin District of Prachuab Khiri Khan Province was the comparison of changes of the shoreline from the satellite images in order to identify the difference of areas with coastal erosion and area with deposition accretion from the past up to the present.

In the assignment of the shoreline was analysed by the satellite images, to represent the shoreline of each years 2003, 2009 and 2014 respectively. For the shoreline change study, the inward curve of the shore indicated that the shore had been eroded. In the contrary, the outward curve indicated the deposition accretion. The study was applied the data from the field study to assign the shoreline boundary. When the shoreline boundary assigned by the satellite images, the data would be analyzed by geographic information system with overlapping process. The results of the shoreline change analysis of the years 2003 and 2014 would be obtained. When the shorelines of the 3 periods were obtained then they would be next applied for the calculation of changing distance of the shorelines of all 3 periods using ArcGIS programe called Digital Shoreline Analysis System (DSAS). Its working principle is that the DSAS will assign perpendicular line from the given baseline to cross with every shorelines and then compared. The distance between each transect line is up to the details required for the analysis. In this study, the distance between the perpendicular lines is 100 meters. The results of the analysis are (1) distance from the baseline to each perpendicular line, (2) the coordinates of the starting point and the crossing point of the perpendicular line and the shoreline, and (3) azimuth angle of the perpendicular lines.

In the calculation to get the rate of shore erosion, which overlapping of shore images of the required years, used for the comparison. The shores with erosion or with deposition accretion has been analysed. The rate of shoreline change determined by the calculation of the distance of the change or the perpendicular distance to the shore by dividing the erosion area (square meter) with the shoreline distance of the area (meter). Then the shoreline change rate per year would be determined by dividing the perpendicular distance to the shore (meter) with the time (year) of comparison.

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The followings are the results found in the study, separated into 2 periods, 2003-2009 and 2009-2014 respectively.

4.2.1 Change in 2003-2009

It has been found from the comparison of the changes of erosion and deposition accretion along Hua Hin beach during 2003-2009 that most of the shoreline had been eroded by approximately 58.37 meters (of year 2003 compared with 2009). The total eroded area was 5,286.95 square meters or 3.04 rai. The area with the most erosion was Khao Tao area with the maximum erosion rate of -2.81 meters per year. It is moderate erosion according to the standard stipulated by the Department of Mineral Resources (Sin Sinsakul et al, 2002). For the deposition accretion area, approximately 41.67 meters distance had been found (of year 2003 compared with 2009), about 166,863 square meters or 104.24 rai. The area was within iron wood horsetail pine plantation where it is the largest deposition accretion area at the rate of 7.99 meters a year.

For the coastal erosion and the shore deposition accretion studies, it had been found that Hua Hin beach ,in the period of 2003-2009, was mainly accretion beach (not more than 5 meters per year of shore change) (Sin Sinsakul et al, 2002) with the highest erosion rate at Khao Tao area. It was beach area with hotels resorts and restaurants be located. The survey had found that the area consisted of short sand beach and constructed sea walls, especially areas with human stimulants for the erosion such as restaurants, hotels, resorts, beach tourist activities, royal palace, and the national park. There were sea walls constructed to prevent waves or collapsing of banks to prevent the erosion. The beach therefore was without change in the long term. For the deposition accretion area, the largest area was in the iron wood horsetail pine plantation area, a beach area with beach plantation, or wide beach, with few hotels, resorts or restaurants. There was not sea wall found and without erosion but be influenced by the deposit washed and accumulated to cause the accretion in the area as shown in Figure 4-7 to Figure 4-9.

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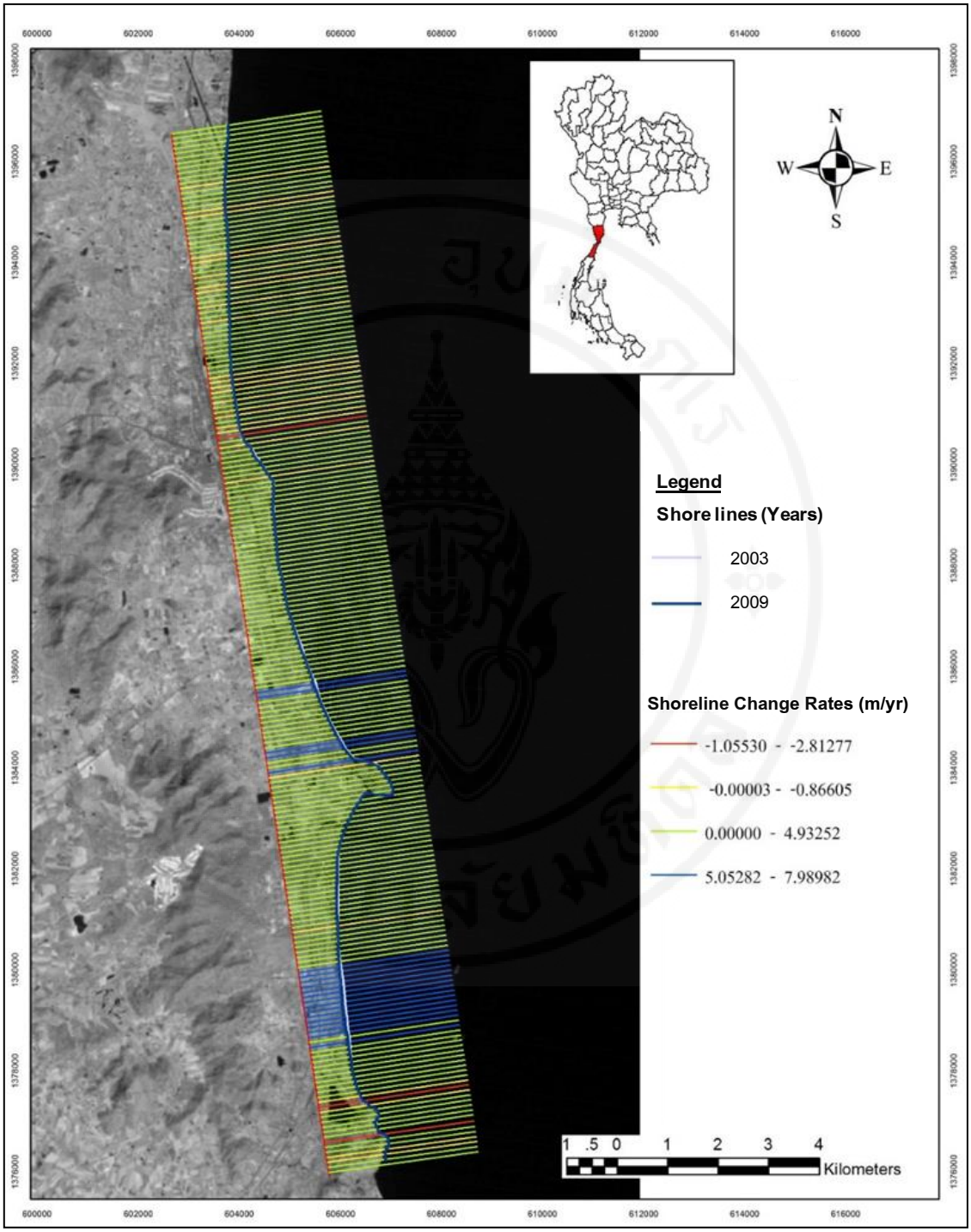

Figure 4-7 Change rate of the shore in Hua Hin District of Prachuab Khiri Khan Province during the years 2003-2009, analyzed from the Landsat-5TM together with the digital shoreline analysis model

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Figure 4-8 Shoreline erosion field survey points in Khao Tao area of Hua Hin District of Prachuab Khiri Khan Province

Figure 4-9 Shoreline deposition accretion field survey points in iron wood horsetail pine plantation area of Hua Hin District of Prachuab Khiri Khan Province

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4.2.2 Change in 2009-2014

It had been found from the comparison of the changes of erosion and deposition accretion along Hua Hin beach during 2009-2014 that most of the shoreline had been eroded by approximately 206.43 meters (of year 2009 compared with 2014). The total area eroded was 92,159.71 square meters or 57.60 rai. The area with the most erosion was the iron wood horsetail pine plantation area, about 1,283.42 square meters or 0.8 rai, with the maximum erosion rate of 4.96 meters per year. It is moderate erosion according to the standard stipulated by the Department of Mineral Resources (Sin Sinsakul et al, 2002). For the deposition accretion area, approximately 2,461.03 meters distance had been found (of year 2009 compared with 2015), about 190,522.18 square meters or 119.08 rai. The area was at Khao Takiab area where it was the largest deposition accretion area, 19,110.87 square meters or 11.95 rai, at the maximum rate of 13.14 meters a year.

From the coastal erosion and the shore deposition accretion studies, it had been found that Hua Hin beach, in the period of 2009-2014, was mainly accumulated beach, not more than 5 meters per year of shore change, (Sin Sinsakul et al, 2002). The highest erosion rate were located at ironwood horsetail pine plantation area, where it was beach area with an airport, hotels resorts and jetties. The survey had found that the area was with short sand beach with rock walls, bank walls, or sea walls constructed to prevent waves at the beach especially at the airport and especially at areas with human stimulants for the erosion such as restaurants, hotels, resorts, beach tourist activities, royal palace, and the national park. There were sea walls constructed to prevent waves or collapsing of banks to prevent the erosion. The beach therefore was stable without change in the long term. For the deposition accretion area, it had been found that the largest area was at Khao Takiab area, a beach area with wide beach, with few hotels, resorts or restaurants. There was not sea wall found so it indicated that there was not erosion but was influenced by the deposit washed and accumulated to cause the accretion in the area as shown in Figure 4-10 to Figure 4-12

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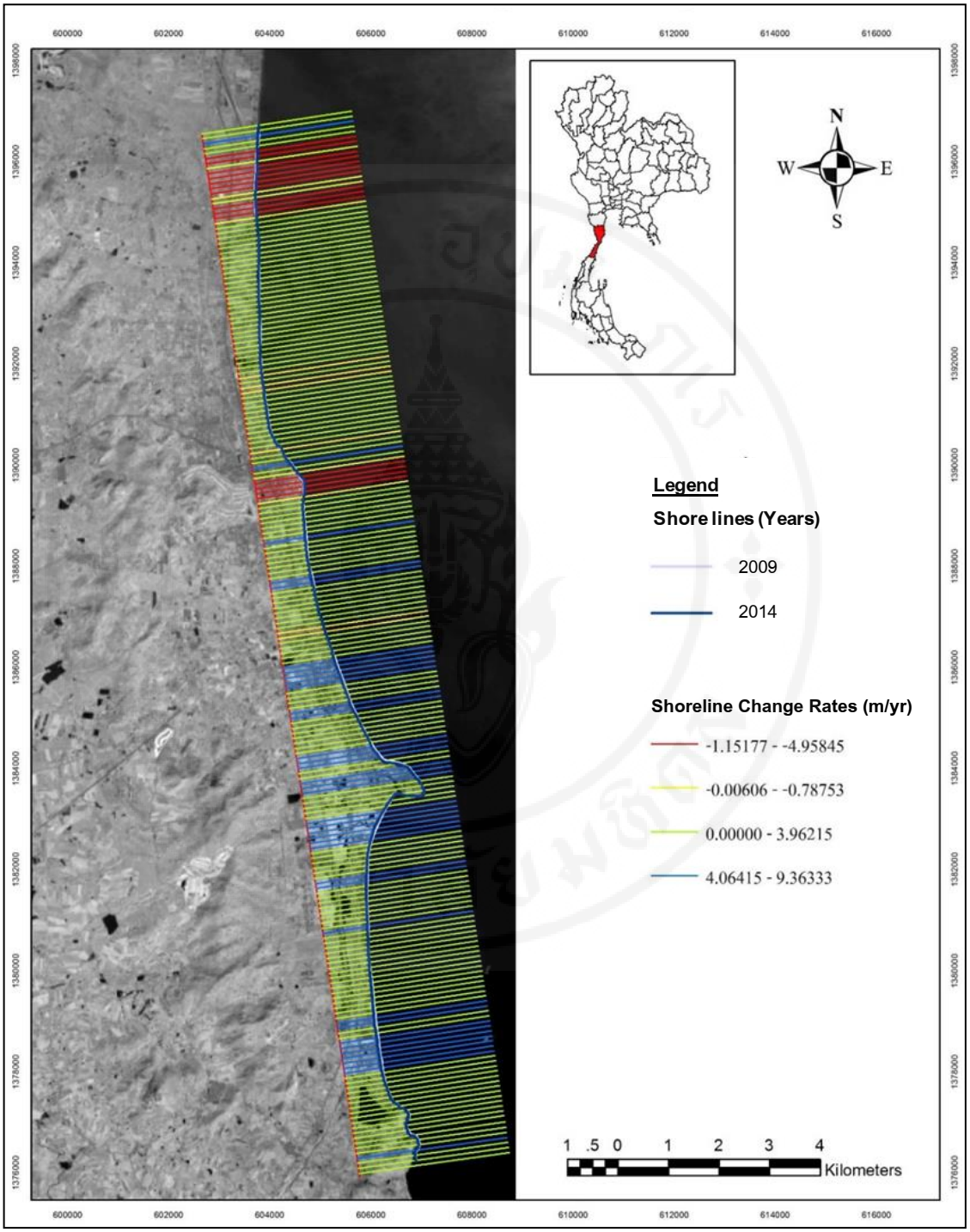

Figure 4-10 Change rate of the shore in Hua Hin District of Prachuab Khiri Khan Province during the years 2009-2014, analyzed from the Landsat-5TM together with the digital shoreline analysis model

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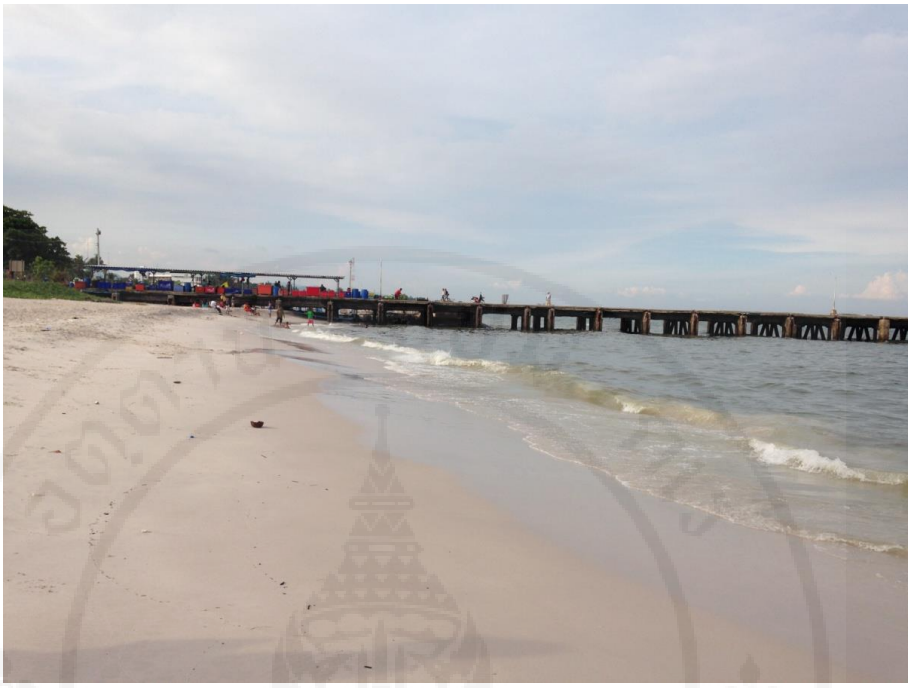

Figure 4-11 shoreline erosion field survey points at iron wood horsetail pine plantation area of Hua Hin District of Prachuab Khiri Khan Province

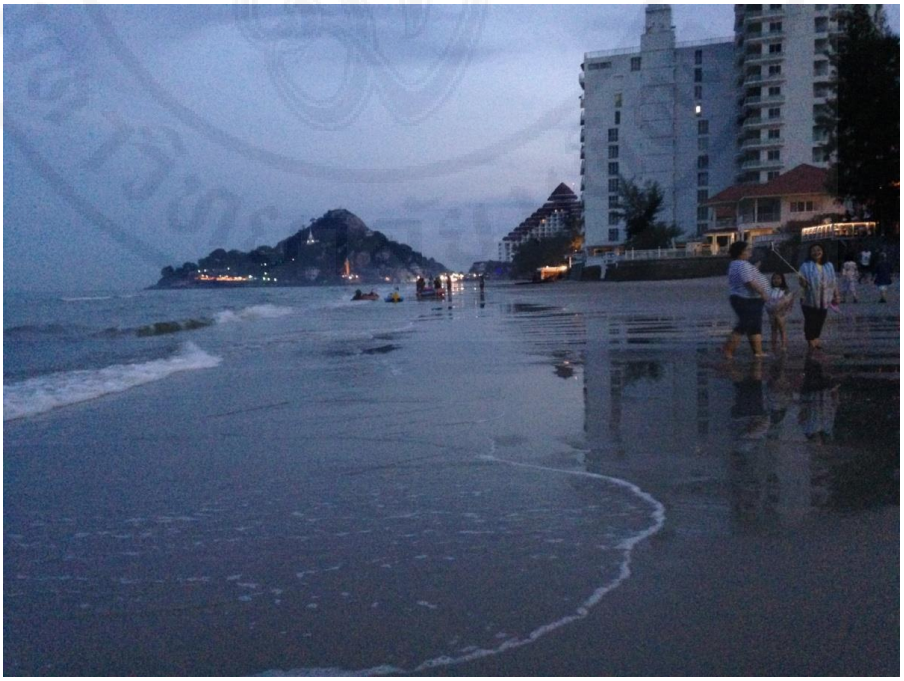

Figure 4-12 shoreline deposition accretion field survey points in Khao Takiab area of Hua Hin District of Prachuab Khiri Khan Province

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4.2.3 Shoreline Change Prediction

In the shoreline change prediction for Huan Hin District of Prachuab Khiri Khan Province using the data obtained from the analysis of the shoreline change years 2003, 2009 and 2014 by the digital shoreline analysis system (DSAS). The simple linear regression equation was formulated for the prediction of the shoreline in 2024. The perpendicular lines with the changing shorelines of each year were integrated in the simple linear regression equation. This study had divided the analysis into 21 points, each approximately 1 kilometer from each other. The point with the highest erosion was the 19th, at -5.346 meters a year. It is severe erosion according to the standard stipulated by the Department of Mineral Resources (Sin Sinsakul et al, 2002). It is at Ban Khao Tao of Hua Hin District. The one with the minimum erosion was the 11th, -0.1266 meters a year, a stable coast according to the standard stipulated by the Department of Mineral Resources (Sin Sinsakul et al, 2002). It is at Ban Khao Takiab as shown in Table 4-10 and Figure 4-7. The linear regression and R^2. It showed the relationship between the studied years and the distances between the crossing points of shoreline and each transect line and the baseline. For the shoreline prediction for the future, the obtained linear regression used to predict the future shoreline (2024) as shown in Table 4-11. The shorelines of the years 2003, 2009 and 2014 are also predicted to verify the equation as shown in Table 4-12 to Table 4-14

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Table 4-10 Shoreline change rate Hua Hin District of Prachuab Khiri Khan Province 2003, 2009 and 2014

Point	Simple linear regression equation	Coastal erosion rate (meters per year(	R^2
1	y = 0.0989x + 938.94	0.0989	0.2967
2	y = 1.2921x - 1661	1.2921	0.7033
3	y = 0.0824x + 647.39	0.0824	0.206
4	y = -1.0151x + 2725.2	-1.0151	0.7173
5	y = -1.3525x + 3277.2	-1.3525	0.7033
6	y = -0.3184x + 1095.9	-0.3184	0.5446
7	y = -0.4668x + 1396.8	-0.4668	0.424
8	y = 2.1889x - 3484.7	2.1889	0.7065
9	y = -1.4801x + 3825.9	-1.4801	0.7033
10	y = -2.4719x + 5806.8	-2.4719	0.7033
11	y = -0.1266x + 1178.7	-0.1266	0.7782
12	y = -3.2675x + 7680.3	-3.2675	0.926
13	y = -2.2522x + 5883.6	-2.2522	0.9994
14	y = -2.5381x + 7264.1	-2.5381	0.8558
15	y = -3.4121x + 8257.7	-3.4121	0.7033
16	y = -3.5702x + 8211.5	-3.5702	0.9786
17	y = -1.679x + 4274.5	-1.679	0.6464
18	y = -4.0926x + 9034	-4.0926	0.8354
19	y = -5.346x + 11504	-5.346	0.9637
20	y = -1.7105x + 4203.1	-1.7105	0.7033
21	y = -1.7674x + 4609.2	-1.7674	0.9432

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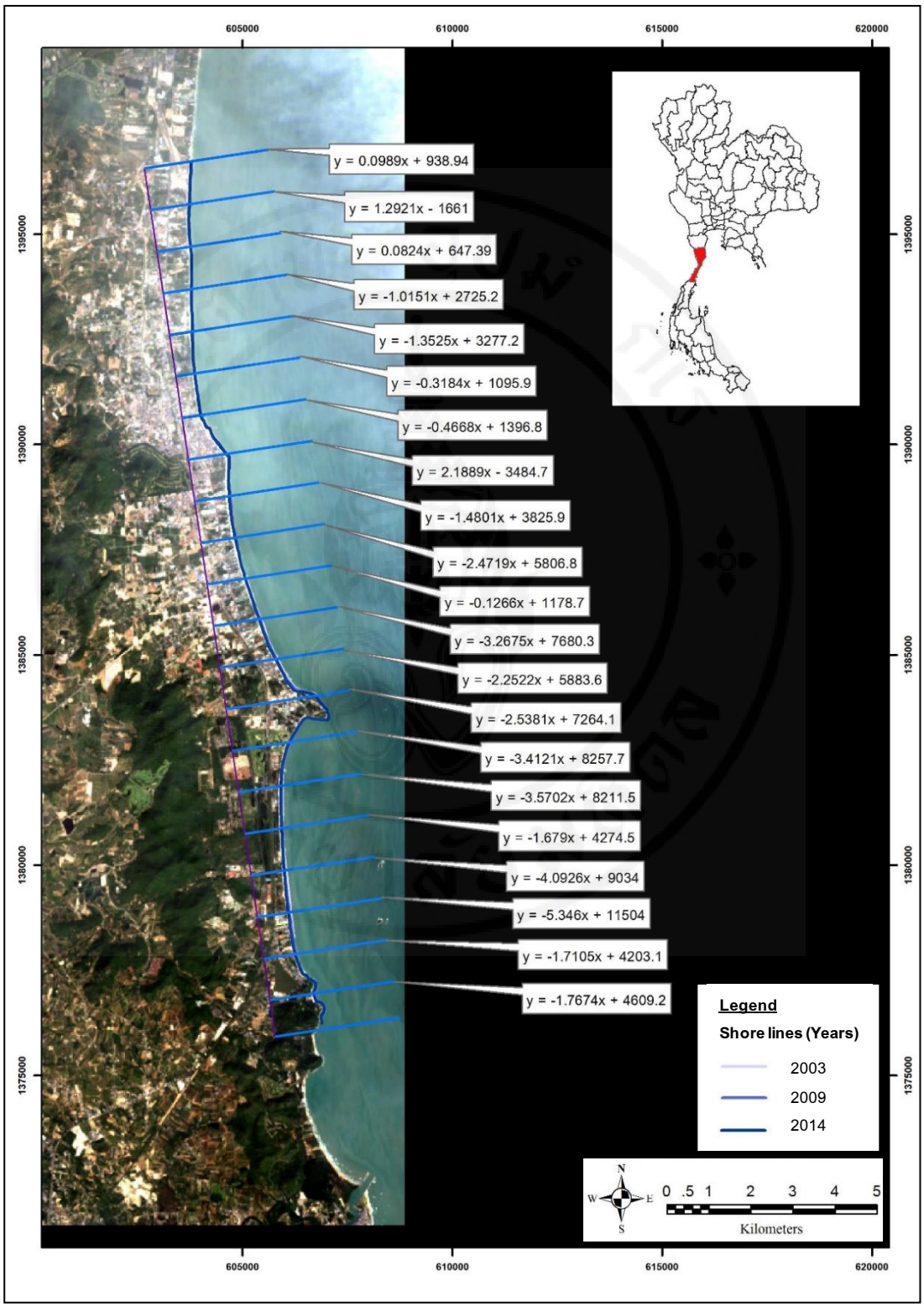

Figure 4-7 showing linear regression

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Table 4-11 Shoreline prediction of the year 2024

Point	Simple linear regression equation	Distances (meters)
1	y = 0.0989x + 938.94	1139.1136
2	y = 1.2921x - 1661	954.2104
3	y = 0.0824x + 647.39	814.1676
4	y = -1.0151x + 2725.2	670.6376
5	y = -1.3525x + 3277.2	539.74
6	y = -0.3184x + 1095.9	451.4584
7	y = -0.4668x + 1396.8	451.9968
8	y = 2.1889x - 3484.7	945.6336
9	y = -1.4801x + 3825.9	830.1776
10	y = -2.4719x + 5806.8	803.6744
11	y = -0.1266x + 1178.7	922.4616
12	y = -3.2675x + 7680.3	1066.88
13	y = -2.2522x + 5883.6	1325.1472
14	y = -2.5381x + 7264.1	2126.9856
15	y = -3.4121x + 8257.7	1351.6096
16	y = -3.5702x + 8211.5	985.4152
17	y = -1.679x + 4274.5	876.204
18	y = -4.0926x + 9034	750.5776
19	y = -5.346x + 11504	683.696
20	y = -1.7105x + 4203.1	741.048
21	y = -1.7674x + 4609.2	1031.9824

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Table 4-12 Prediction of Shoreline Year 2003 to Verify the Equation

Points	Simple linear regression equation	Distance of shoreline from Satellite image (meters)	Distance of shoreline position in 2003 (meters)	difference (meters)	Error (%)
1	y = 0.0989x + 938.94	1136.60	1137.04	0.44	0.04
2	y = 1.2921x - 1661	929.57	927.08	2.49	0.27
3	y = 0.0824x + 647.39	812.93	812.44	0.50	0.06
4	y = -1.0151x + 2725.2	690.07	691.95	1.88	0.27
5	y = -1.3525x + 3277.2	565.67	568.14	2.48	0.44
6	y = -0.3184x + 1095.9	457.25	458.14	0.90	0.20
7	y = -0.4668x + 1396.8	460.18	461.80	1.62	0.35
8	y = 2.1889x - 3484.7	903.86	899.67	4.20	0.46
9	y = -1.4801x + 3825.9	858.57	861.26	2.69	0.31
10	y = -2.4719x + 5806.8	850.90	855.58	4.69	0.55
11	y = -0.1266x + 1178.7	925.21	925.12	0.09	0.01
12	y = -3.2675x + 7680.3	1132.86	1135.50	2.64	0.23
13	y = -2.2522x + 5883.6	1372.40	1372.44	0.04	0.00
14	y = -2.5381x + 7264.1	2177.19	2180.29	3.10	0.14
15	y = -3.4121x + 8257.7	1416.86	1423.26	6.40	0.45
16	y = -3.5702x + 8211.5	1058.89	1060.39	1.50	0.14
17	y = -1.679x + 4274.5	907.86	911.46	3.60	0.40
18	y = -4.0926x + 9034	841.82	836.52	5.30	0.63
19	y = -5.346x + 11504	799.30	795.96	3.34	0.42
20	y = -1.7105x + 4203.1	773.82	776.97	3.15	0.41
21	y = -1.7674x + 4609.2	1070.40	1069.10	1.30	0.12

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Table 4-13 Prediction of Shoreline Year 2009 to Verify the Equation

Points	Simple linear regression equation	Distance of shoreline from Satellite image (meters)	Distance of shoreline position in 2009 (meters)	difference (meters)	Error (%)
1	y = 0.0989x + 938.94	1138.60	1137.63	0.97	0.08
2	y = 1.2921x - 1661	929.57	934.83	5.26	0.57
3	y = 0.0824x + 647.39	811.93	812.93	1.00	0.12
4	y = -1.0151x + 2725.2	689.87	685.86	4.01	0.58
5	y = -1.3525x + 3277.2	565.67	560.03	5.64	1.00
6	y = -0.3184x + 1095.9	458.03	456.23	1.79	0.39
7	y = -0.4668x + 1396.8	462.40	459.00	3.40	0.74
8	y = 2.1889x - 3484.7	903.96	912.80	8.84	0.98
9	y = -1.4801x + 3825.9	858.57	852.38	6.19	0.72
10	y = -2.4719x + 5806.8	850.90	840.75	10.14	1.19
11	y = -0.1266x + 1178.7	923.82	924.36	0.54	0.06
12	y = -3.2675x + 7680.3	1121.79	1115.89	5.90	0.53
13	y = -2.2522x + 5883.6	1359.38	1358.93	0.45	0.03
14	y = -2.5381x + 7264.1	2171.58	2165.06	6.53	0.30
15	y = -3.4121x + 8257.7	1416.86	1402.79	14.07	0.99
16	y = -3.5702x + 8211.5	1042.35	1038.97	3.38	0.32
17	y = -1.679x + 4274.5	909.26	901.39	7.87	0.87
18	y = -4.0926x + 9034	800.48	811.97	11.48	1.43
19	y = -5.346x + 11504	757.63	763.89	6.25	0.83
20	y = -1.7105x + 4203.1	773.82	766.71	7.12	0.92
21	y = -1.7674x + 4609.2	1055.79	1058.49	2.71	0.26

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Table 4-14 Prediction of Shoreline Year 2014 to Verify the Equation.

Points	Simple linear regression equation	Distance of shoreline from Satellite image (meters)	Distance of shoreline position in 2014 (meters)	difference (meters)	Error (%)
1	y = 0.0989x + 938.94	1137.60	1138.03	0.43	0.04
2	y = 1.2921x - 1661	944.27	940.00	-4.27	-0.45
3	y = 0.0824x + 647.39	813.93	813.26	-0.67	-0.08
4	y = -1.0151x + 2725.2	678.54	681.80	3.27	0.48
5	y = -1.3525x + 3277.2	550.28	554.62	4.34	0.79
6	y = -0.3184x + 1095.9	453.58	454.96	1.38	0.30
7	y = -0.4668x + 1396.8	454.73	457.13	2.40	0.53
8	y = 2.1889x - 3484.7	928.76	921.56	-7.20	-0.78
9	y = -1.4801x + 3825.9	841.73	846.46	4.73	0.56
10	y = -2.4719x + 5806.8	822.78	830.87	8.09	0.98
11	y = -0.1266x + 1178.7	923.85	923.85	0.00	0.00
12	y = -3.2675x + 7680.3	1096.38	1102.82	6.44	0.59
13	y = -2.2522x + 5883.6	1347.60	1349.92	2.33	0.17
14	y = -2.5381x + 7264.1	2148.67	2154.90	6.24	0.29
15	y = -3.4121x + 8257.7	1378.05	1389.14	11.09	0.80
16	y = -3.5702x + 8211.5	1019.31	1024.69	5.38	0.53
17	y = -1.679x + 4274.5	888.68	894.67	6.00	0.67
18	y = -4.0926x + 9034	797.85	795.60	2.26	0.28
19	y = -5.346x + 11504	741.09	742.50	1.41	0.19
20	y = -1.7105x + 4203.1	754.36	759.86	5.50	0.73
21	y = -1.7674x + 4609.2	1051.21	1051.42	0.22	0.02

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4.3 Land Use and Shoreline Change Impact Assessment

The coastal erosion is a natural process of changing of current and wave moving sand deposits from former locations to the other ones. Usually a balanced coast has the erosion rate more or less the same as the deposition rate (Suwaluck, 2011). In addition to the natural factors affecting the coastal erosion, human is an important part or factor causing the erosion. Naturally, the coastal area has crops and plants covering the land balancing the natural ecological system. Then the human uses the coastal area to fulfil his need in many activities like agriculture, community, and building for example. They damage the crops. This is one of the main causes of erosion. In addition, the huge construction projects in the coastal area create large drainage gullies by which sand deposits washed down to the sea and increase the erosion. In addition, waste from human activities is scattered along the coastal area obstructing natural wave movement. The expansion of the city and construction in the coastal area and the agricultural practicing caused the soil cavities, loosen the soil cohesion, and increase the soil erosion during storms or heavy rains causing the coastal erosion eventually.

Prachuab Khiri Khan Province has many land use patterns, agriculture, community, and forest for example. As the province has many types of tourism resources and beautiful and long sand beaches from north to south, 224.8 kilometers altogether. In the land use change and the coastal erosion in the past in Hua Hin District during the years 2003 to 2014, the the urban and build-up area has been increased causing the change of the land use condition. The next is forest area especially the coastal forest whose area be reduced. There is also coastal erosion by human as stimulant causing problems of land use especially at the seashore area. The erosion then follows (Sin Sinsakul, et al, 2002). In this area there are sea walls constructed to prevent waves and bank collapse to prevent erosion so the beach is stable without change. However, at the south of Hua Hin beach, the impact of the sea walls causes the sand beach in the frontal area of the walls become rather narrow without sand deposition so the beach lose the tourism value comparing with nearby sand beach rich with crops and with rather wide sand beach. The area nearby the jetty who acts like sand trap, sand deposit increasingly accumulated. The frontal side of the beach is rather wide with crops and bushes causing the land use to change from the past.

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CHAPTER V
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

5.1.1 Land Use Patterns and Land Use Change in Hua Hin District of Prachuab Khiri Khan Province

From the satellite image classification of Hua Hin District of Prachuab Khiri Khan Province in years 2003-2014, the land use was classified into 5 categories namely agriculture, forest, the urban and build-up land, water resource and miscellaneous areas.

In 2000, the largest land use area was forest area, 33.72 percent of the area following by the urban and build-up area, 30.67 percent, agriculture area 23.57 percent, miscellaneous area 11.36 percent and water resource area, the smallest area, 0.47 percent respectively.

In 2009, the largest land use was the the urban and build-up area, 47.47 percent of the area following by the forest area, 29.22 percent, agriculture area 11.62 percent, the miscellaneous area 11.22 percent and finally the water resource area, the smallest area, 0.47 percent respectively.

In 2014, the largest land use was the the urban and build-up area, 49.44 percent of the area following by the forest area 21.03 percent, the miscellaneous area 21.13 percent, the agricultural area 7.94 percent and finally the water resource area, the smallest area, 0.47 percent respectively.

The land use change during the years 2000-2014, the most changing was the urban and build-up area following by the agricultural area, the forest area and the miscellaneous area, the least one, respectively. Whereas, the water resource area had

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not changed to other area. The urban and build-up area and the miscellaneous area were increased, meanwhile the agricultural area and the forest area decreased.

5.1.2 Land Use Prediction of Hua Hin District of Prachuab Khiri Khan Province

For the land use prediction, using CA-MAKOV model for the next 10 years (2024), the study revealed that, in 2024, the land use as the urban and build-up area will be the largest, 40.37 percent, following by the miscellaneous area 33.89 percent, the forest area 20.45 percent, the agricultural area 4.88 percent and the water resource area as the smallest use at 0.41 percent of the area, respectively.

The verification of the land use data in 2009 obtained from CA-MAKOV model comparing with the land use data of the year 2009 obtained from the satellite image classification showed the overall accuracy of 45.42 % with the Kappa coefficient at 0.47.

5.1.3 Coastal Erosion Study and Shoreline Change Tendency

The study of shoreline was change about 22 kilometers of total shoreline of Hua Hin District in Prachuab Khiri Khan Province.

In the years 2003-2009, the total erosion area was 52,865.95 square kilometers or 3.04 rai, approximately 58.37 meters long. The total accretion area was 166,863 square meters or 104.24 rai, about 41.67 meters long. Most of the shore was accumulated beach (shore with not more than 5 meters per year change) (Sin Sinsakul et al, 2002). The area with the highest erosion was at Khao Tao area, where there were hotels, resorts and restaurants. The area with the highest accretion was in the iron wood horsetail pine plantation where there were beach plantation, wide sand beach with few hotels, resorts and restaurants and there was not a sea wall.

In the years 2009-2014, the total erosion area was 92,159.71 square kilometers or 57.60 rai, approximately 206.43 meters long. The total accretion area was 190522.18 square meters or 119.08 rai, about 2461.03 meters long. Most of the shore was accumulated beach (shore with not more than 5 meters per year change)

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(Sin Sinsakul et al, 2002). The area with the highest erosion was at iron wood horsetail pine plantation area, where there were an airport, hotels, resorts and a jetties. The area with the highest accretion was in the Khao Takiab area where there were wide sand beach with few hotels, resorts and restaurants and there was not a sea wall.

For the shoreline prediction of Hua Hin District in Prachuab Khiri Khan Province, the data obtained from the analysis of the shoreline change of the years2003, 2009 and 2014, by the digital shoreline analysis system (DSAS). The shoreline prediction obtained by simple linear regression to assign new points and connection line, which drawn to show new shoreline in the future, the year 2024. The results of the equation indicated that the highest erosion is the 19th point, -5.346 meters a year. The area with the lowest erosion was the 11th point, -0.1266 meters a year. The area with the highest accretion was the 8th point, 2.1889 meters a year. From the verification of the equation of the years 2003, 2009 and 2014, in which the analysis divided into 21 points, each was 1 kilometer from each other approximately; the prediction of the change was close to the change at present.

5.1.4 Land Use Change and Coastal Erosion Impact Assessment

Prachuab Khiri Khan Province consisted of various land use patterns, including agriculture, community, and forest for example. As the province has supported for many tourism resources and beautiful and long sand beach from north to south, 224.8 kilometers altogether. In the land use change and the coastal erosion in the past in Hua Hin District during the years 2003 to 2014, the urban and built-up area had been increased that causing the change of the land use condition. The forest area especially the coastal forest area was reduced. There was also coastal erosion by human as stimulant causing problems of land use especially at the coastal area. The erosion then followed the study of Sin (2001). In this area there were sea walls constructed to prevent waves and bank collapse to prevent erosion so the beach was stable without changes. However, at the south of Hua Hin beach, the impact of the sea walls caused the sand beach in the frontal area of the walls which become rather narrow without sand deposit. Thus, the beach might lose the tourism value comparing with nearby sand beach that rich with crops and with rather wide sand beach. The area

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nearby the jetty, which acted like groin and sand deposition, were also increasingly accumulated. The frontal side of the beach was rather wide with crops and bushes causing the land use to change from the past.

5.2 Recommendations and Constraints in the Study

5.2.1 The use of simple linear regression to predict the shoreline change caused by the coastal erosion is a simple and appropriate way in some areas especially those without severe impacts of environmental change or without constructions, or in the areas without high physical change. It also is suitable to use in overall decision making prior to further deeper study.

5.2.2 The high resolution of satellite data needs to be provided for better accuracy outputs.

5.2.3 The number of ground truth sample point needs more to cope with the better verification for the prediction.

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