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Satellite Images for Detection of Coastal Landuse and Coastline Change in Mueang Prachuap Khiri Khan District, Thailand during 1987-2009

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ABSTRACT

Satellite images were used to classify and annotate coastal landuse in Ko Lak and Klongwan subdistricts and to detect changes to the coastline in Ao Noi, Prachuap Khiri Khan, Ko Lak and Klongwan subdistricts, Prachuap Khiri Khan district in Prachuap Khiri Khan province, Thailand. The study used a remotely sensed dataset of LANDSAT-5 TM images with a spatial resolution of 30 × 30 m acquired during 1987–2009. Areas of coastal landuse and coastline changes were calculated using a pixel-based technique. Eight categories of coastal landuse were identified: 1) agriculture, 2) urban and buildings, 3) mangroves, 4) bare soil, 5) airport, 6) seascape, 7) upland forest and island vegetation, and 8) aquaculture and water bodies. The results found that between 1987 and 2009, areas classified as agriculture, urban and buildings, and mangroves increased by 1,150, 360, and 340 rai (1 rai = 0.16 ha) respectively, while aquaculture and water bodies decreased by 1,850 rai. Moreover, there were changes to the coastline in Ao Noi, Prachuap Khiri Khan, Ko Lak and Klongwan subdistricts based on a mixture of stable and eroded features. Comparing 2009 with 2004, the coastline area in Prachuap Khiri Khan, Ko Lak and Klongwan subdistricts had eroded by 31, 40, and 11 rai, respectively.

Keywords: remote sensing, coastal landuse, coastline change, Prachuap Khiri Khan district

INTRODUCTION

Coastal landuse and coastline change can be the result of both human activity and natural processes including environmental calamities (Doydee, 2005). Such problems could be prevented or mitigated through a proper coastal environmental planning and management program associated with local participation. As part of the present study, a field survey covering various landuse types of terrestrial and aquatic ecosystems was conducted in April 2010 in Ao Noi, Prachuap Khiri Khan, Ko Lak and Klongwan subdistricts that form part of the Prachuap Khiri Khan district in Prachuap Khiri Khan province, Thailand.

Remote sensing is a powerful tool for use in natural resources surveys and environmental management, especially in large areas that are difficult to access, which includes coastal wetland ecosystems (UNESCO, 2000; Doydee, 2004).

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Information can be recorded on features and phenomena that are visible from space without the need to contact objects on the earth surface (Lillesand and Kiefer, 1994; Nualchawee, 1998). Therefore, satellite images from LANDSAT-5 TM were applied to study the coastal landuse pattern in the Ko Lak and Klongwan subdistricts and to detect change associated with the coastline in Ao Noi, Prachuap Khiri Khan, Ko Lak and Klongwan subdistricts, in Prachuap Khiri Khan district.

MATERIALS AND METHODS

Study area

The study was conducted in Prachuap Khiri Khan district, Prachuap Khiri Khan province located on the west coast of the Gulf of Thailand. The district is divided into the six subdistricts of Prachuap Khiri Khan, Ko Lak, Khlongwan, Huai Sai, Ao Noi and Bo Nok. The physiography of the area is dominated by a plain which has beaches, islands, forests and mountains. For this study, only Ao Noi, Prachuap Khiri Khan, Ko Lak and Klongwan subdistricts which are associated with more urban human settlement were studied for changes to the coastal landuse and coastline, as shown in Figure 1.

Data processing

In this study, Landsat-5 TM images and associated geographic information system (GIS) data were used to classify and annotate coastal landuse types and to detect the coastline changes. Three steps were involved in the data processing.

1. Image preprocessing: Raster data from the LANDSAT-5 TM images with a spatial resolution of 30 × 30 m (data were collected on 25/12/1987, 09/12/1993, 09/02/1999, 26/03/2004 and 19/01/2009) were converted from raw data into GeoTiff (*.tif) grayscale with separate layers into grayscale dataset (*.ers) layers using ER Mapper 5.5 software (ERDAS Atlanta, GA, USA). Radiometric and geometric corrections were performed based on WGS84 and UTM Zone 47.

2. Ground Control Points (GCPs): The study area was located along the coast of Ao Noi, Prachuap Khiri Khan, Ko Lak, and Klongwan subdistricts, Prachuap Khiri Khan district. The GCPs of each site were recorded using global positioning system (GPS) equipment (GARMIN 2003eTrex^{TM} with a positional accuracy of 10 m or better). All coordinate data (eastings and northings) were stored as attribute data and converted into a geodatabase (*. dBaseIV).

3. Raster and Vector Data Integration: The remotely sensed data were used to classify coastal landuse types using the iterative self-organizing data analysis (ISODATA) technique associated with each object's base classification in conjunction with visual interpretation to differentiate coastline change using line vector data which were based on line transect and micro-elevation data from actual field surveys in April 2010.

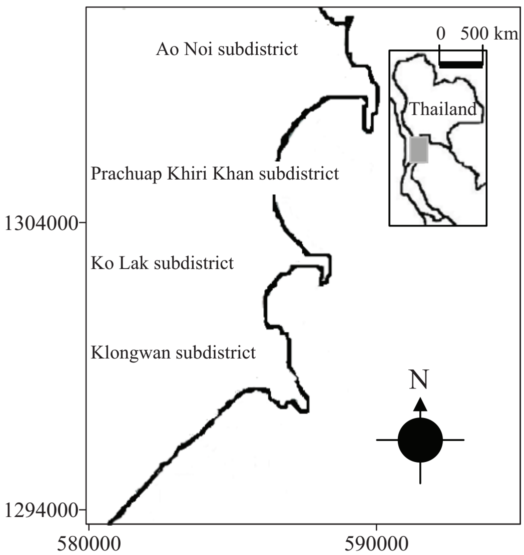

Figure 1 Study area location in Ao Noi, Prachuap Khiri Khan, Ko Lak, and Klongwan subdistricts, Prachuap Khiri Khan district, Thailand.

RESULTS AND DISCUSSION

LANDSAT-5 TM satellite images were used to classify coastal landuse types and to detect coastline changes using image processing. Initially, an unsupervised classification of the images was performed to reveal the types of coastal landuse and coastline changes from clusters of reflectance based on digital number (DN) values. The coastal landuse classes and coastline changes gave acceptable results based on the actual field survey of more than 50 GCPs. After obtaining the types of coastal landuse and coastline changes, statistical calculations of each class were performed using a pixel-based technique.

Coastal landuse

Eight coastal landuse types were identified: 1) agriculture, 2) urban and buildings, 3) mangroves, 4) bare soil, 5) airport, 6) seascape, 7) upland forest and island vegetation, 8) aquaculture and water bodies (Figure 2).

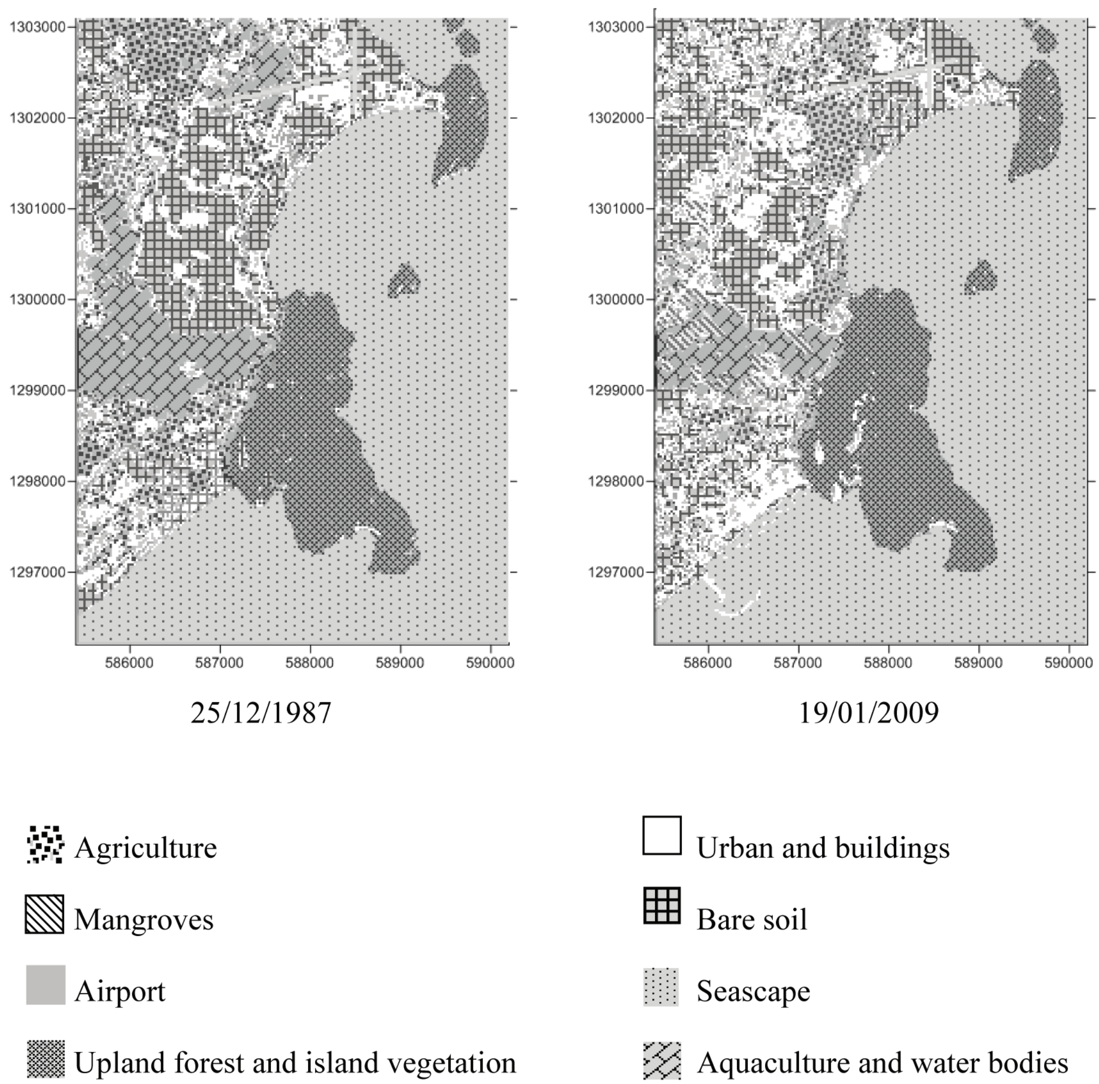

Figure 2 Coastal landuse types using LANDSAT-5 TM imagery between 25/12/1987 and 19/01/2009.

The results of image classification (Figure 2) delineated obvious features to the end users and could be interpreted more easily than results from image layer combinations based on false color composite (FCC) and true color composite (TCC) images (Doydee, 2005). Moreover, it was possible to determine the extent of temporal variability in each coastal landuse class between 25/12/1987 and 19/01/2009. Table 1 presents the type, area and change for the coastal landuse types in Ko Lak and Klongwan subdistricts, Prachuap Khiri Khan district between 1987 and 2009. Areas were calculated using a pixel-based technique. The coastal landuse had changed in three ways—increased (+), decreased (-) and unchanged (0).

The total area of coastal landuse was 32,080 rai (Table 1). The largest type was seascape while the smallest class was airport. The agricultural area increased from 2,100 rai to 3,250 rai. This implied that the population in this coastal area had increased requiring more agricultural products for their subsistence (Doydee and Rebancos, 2008). This corresponded with the size of the increase in the urban and buildings area. The increase in agricultural area was reflected in other coastal landuse types and was confirmed by the decrease in aquaculture and water bodies.

The mangroves area increased from 80 rai to a new total of 420 rai due to the success of a mangrove rehabilitation project. On the other hand, the local people understood and recognized the benefits to their livelihoods of the mangrove resource; therefore, they were involved in mangrove restoration and conservation initiatives (Doydee, 2009; Doydee and Buot Jr, 2010). The area classified as aquaculture and water bodies decreased from 3,460 rai to 1,610 rai. Many parts of coastal Thailand, including Prachuap Khiri Khan district, had practiced aquaculture particularly black tiger prawn (*Penaeus monodon*) prawn farming. However, a shrimp disease virus had negatively affected shrimp farming and aquaculture in the study area. Thus, many shrimp farmers ceased their business resulting in abandonment of areas previously classed as aquaculture and water bodies. Another important reason was the of ecotourism boom that had effected growth and expansion of the urban community. Ecological succession had replaced the areas previously under aquaculture and water bodies with mangrove plants. There had been new construction in some areas classed as urban and buildings, as well as some replacement.

Table 1 Type, area and changes in types of coastal landuse in Ko Lak and Klongwan subdistricts between 25/12/1987 and 19/01/2009. (1 rai = 0.16 ha).

Types of coastal landuse	Area (rai)		Change (+/-)
	25/12/1987	19/01/2009	(rai)
Agriculture	2,100	3,250	+1150
Urban and buildings	3,890	4,250	+360
Mangroves	80	420	+340
Bare soil	4,150	4,230	+80
Airport	210	210	0
Seascape	14,110	14,090	-20
Upland forest and island vegetation	4,080	4,020	-60
Aquaculture and water bodies	3,460	1,610	-1850
Total	32,080	32,080	

Coastline changes

Based on the satellite image data from 1987 to 2009, Table 2 details the area involved in coastline change in Ao Noi, Prachuap Khiri Khan, Ko Lak and Klongwan subdistricts. The coastline area increased from 7 rai in 1993 to 149 rai in 2004, which represents a substantial increase over this 12-year period. However, after 2004, coastal areas of Prachuap Khiri Khan, Ko Lak and Klongwan subdistricts decreased noticeably by 82 rai during the five years to 2009 (Figure 3) implying a dangerous trend in coastal erosion. The construction of coastal infrastructure such as piers, seaports, sand barriers and seawalls has an ameliorating effect on coastal erosion (Anongponyoskun and Doydee, 2006).

During 2004–2009, there was construction of ports, stone barriers, seawalls and offshore breakwaters along the coast which influenced coastal erosion. For example, a seawall can protect the coastline and protect property behind the seawall. However, as a static structure located in a dynamic environment, seawalls can affect the surrounding area. The seawall may change the morphology of the coast forming an ordinary sloping beach of unconsolidated sediment by letting the waves break and dissipate their energy. The seawall structure acts like a cliff which is a form of eroded coast. It also changes the coastal processes by increasing the height of the wave attacking the seawall (Siripong, 2008). Therefore, the construction can solve some problems of coastal erosion but it does not solve the causes of coastal erosion.

An offshore breakwater is a seawall in the deep water and causes the same effects as a seawall. Its purpose is to diminish the wave energy as it approaches the coast, but it creates another devastating wave. This wave will hit the wall of the breakwater with considerable force and scour the base of the structure. In addition, the edge effect will cause erosion at the ends of the breakwater (Siripong, 2008).

Coastline changes can result from both natural processes and human activities. Many scientists have found that beach and coastal erosion is caused mainly by human activities such as ship channels and coastal structures, including seawalls and offshore breakwaters. Many solutions that address coastal erosion, especially those that are engineering-based and use hard structures, only treat the symptoms and not the causes (Siripong, 2008). Thus, the coastal erosion issue requires urgent attention to mitigate destruction and manage the protection of the coastal habitat and this task should be dealt with by various stakeholders, particularly local communities.

CONCLUSION

Remote sensing was used as a tool to classify coastal landuse types in Ko Lak and

Table 2 Size of coastline changes in Ao Noi, Prachuap Khiri Khan, Ko Lak and Klongwan subdistricts, Prachuap Khiri Khan district compared with the coastline base in 25/12/1987.

Site	Area change (rai)			
	09/12/1993	09/02/1999	26/03/2004	19/01/2009
Ao Noi	-9	1	11	11
Prachuap Khiri Khan	11	23	46	15
Ko Lak	-1	27	60	20
Klongwan	6	25	32	21*
Total	7	76	149	67

* = excludes construction.

(1 rai = 0.16 ha).

Klongwan subdistricts and to detect coastline change in Ao Noi, Prachuap Khiri Khan, Ko Lak and Klongwan subdistricts, Prachuap Khiri Khan district. LANDSAT-5 TM satellite data with a spatial resolution of 30 × 30 m and collected during 1987–2009 were used to determine coastal landuse types and differentiate between coastline changes. Coastal landuse types were classified into eight categories: 1) agriculture, 2) urban and buildings, 3) mangroves, 4) bare soil, 5) airport, 6) seascape, 7) upland forest and island vegetation and 8) aquaculture and water

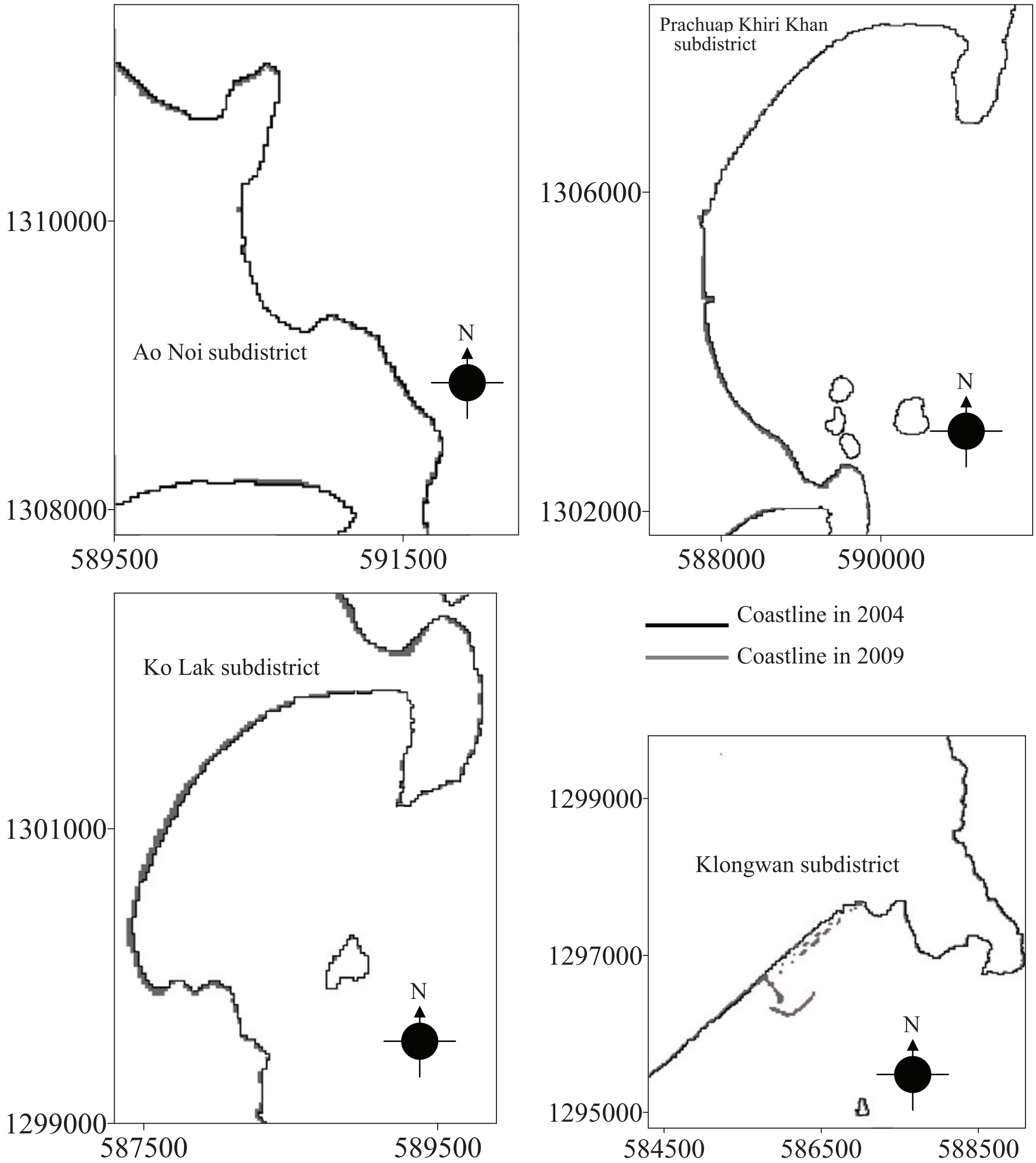

Figure 3 Comparison of coastline changes between 26/03/2004 and 19/01/2009 in Ao Noi, Prachuap Khiri Khan, Ko Lak and Klongwan subdistricts, Prachuap Khiri Khan district.

bodies. The results showed that areas classified as agriculture, urban and buildings and mangroves from 1987 to 2009 had increased by 1,150, 360 and 340 rai, respectively, while aquaculture and water bodies had decreased by 1,850 rai. Changes to the coastline in Ao Noi, Prachuap Khiri Khan, Ko Lak and Klongwan subdistricts were the result of erosion, but some areas had remained stable. Erosion of the coastline in Prachuap Khiri Khan, Ko Lak and Klongwan subdistricts over the period from 2004 to 2009 accounted for 31, 40, and 11 rai, respectively. Moreover, from 2004 to 2009, human construction activity on the coast and in the sea affected the coast. Such problems could be prevented or mitigated by environmental planning using satellite imagery data.

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