Kasetsart J. (Nat. Sci.) 47 : 182 - 190 (2013)

Remote Sensing for Mangrove Landscape Pattern Identification on the Coast of Ranong, Thailand

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ABSTRACT

The mangrove landscape in the Ranong coastal ecosystem provides habitat and niches for many aquatic animals. It also plays an important role in shoreline protection and serves as a livelihood source for millions of people. This study was conducted to identify and determine the pattern of mangrove patches and their species by using remotely sensed data and field methods, respectively. The point-centered quarter method was used for mangrove vegetation inventory. The results revealed that Mueng district had the highest number of mangrove patches. The smallest number of patches was identified in Kra Buri district. Most of the patches were clumped and elongated with a medium or large size. In total, 19 mangrove species were identified with 7 dominant species—namely, *Avicennia marina*, *A. officinalis*, *Bruguiera parviflora*, *Ceriops decandra*, *C. tagal*, *Rhizophora apiculata* and *R. mucronata*. The results provide useful information for mangrove habitat restoration and coastal landscape planning in Ranong province. The dominant species of mangrove found in the area could be promoted for mangrove rehabilitation.

Keywords: remote sensing mangrove landscape, coastal ecosystem, Ranong

INTRODUCTION

Mangroves are a unique ecosystem, linking the terrestrial and ocean ecosystems. They are one of the most vulnerable areas occupied by human society (Buot, 1994; Doydee and Buot, 2011). They thrive mainly in the tropical and subtropical regions of the world, and are capable of growth and reproduction in areas inundated by seawater (Aksornkoae *et al*., 1992; Smith and Smith, 2004; Doydee *et al*., 2008; Rhodes *et al*., 2011). They contribute to habitat complexity and the diversity of the associated fauna of the ecosystem (Othman, 1994; Lee, 1998; Doydee and Buot, 2010). In addition, they provide protection for habitats which are suitable as breeding and nursery grounds for many species of shrimp, crab, mollusk and fish (Sasekumar *et al*., 1992; Barbier and Stand, 1998; Doydee and Jaitrong, 2008). They also have important indirect services such as shoreline stability and water quality (Buot, 1994; Janssen and Padilla, 1999; Anongponyoskun and Doydee, 2006; Doydee and Buot, 2011; Tamin *et al*., 2011).

Mangroves are involved in the quality of life of the local people as the mangroves provide a wide scope of services ranging from mangrove wood products used for fuelwood, fishing gear and

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Received date : 22/10/12 Accepted date : 28/12/12

housing to aquatic species used as an anthropogenic food resource which are eaten or sold for income (Immink, 1996; Lee, 1998; Macintosh *et al*., 2002; Doydee, 2009). The mangrove landscape ecosystem in Ranong is one of the coastal elements that has formed over large areas. Thus, satellite data was the best option for identification of its pattern. Remote sensing has been used as a tool for natural resources management in South East Asia including Thailand (Doydee *et al*., 2010). Satellite data and image processing have been applied for detecting large coastal landscapes, for example mangrove patches (Fei *et al*., 2011) and the identification and determination of mangrove landscape patterns through the utilization of remote sensing have been considered to provide an optimal approach (Doydee *et al*., 2010; Anongponyoskun *et al*., 2011). However, field methods, including vegetation analysis, are still necessary to validate the localities and to examine the composition of the mangrove species in each patch of the mangrove landscape.

MATERIALS AND METHODS

The study area was located in Ranong province (9°43′N to 9°57′N and 98°29′E to 98°39′E) on the Andaman sea coast of Thailand (Figure 1) and about 570 km south of Bangkok. Ranong is geographically characterized by long expanses of sandy beaches, unspoiled upland and mangrove forests, waterfalls, parks and a biosphere reserve zone. Remotely sensed data (Landsat-5 TM) without cloud cover was received from the Geo-informatics and Space Technology Development Agency (GISTDA), Thailand. The imagery was acquired on 7 March 2006 with a spatial resolution of 25 × 25 m. This was an optimal date for capturing the image as the area was cloud free. For each mangrove patch, the location was recorded using a global positioning system receiver (eTrex; Garmin; New Taipei, Xizhi, Taiwan) with estimated accuracy of 10 m or better. To validate the coordinates, a geo-referencing technique was applied to recheck the collecting localities in

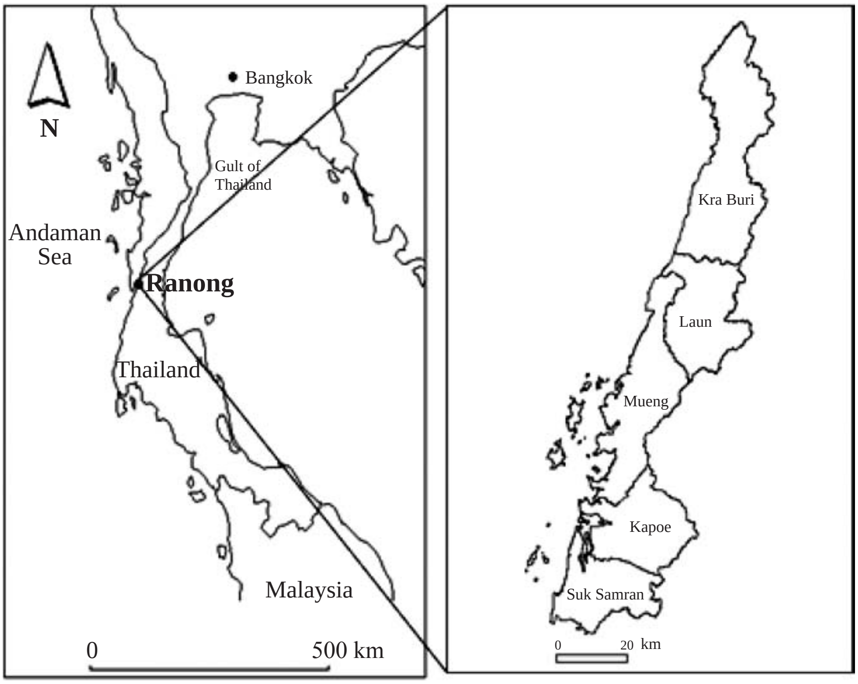

Figure 1 Study area in Ranong, Thailand showing the five districts in the study area: Kra Buri, Laun, Mueng, Kapoe and Suk Samran.

the study area (Doydee, 2005; Bantayan, 2006). The geometric correction was processed using polynomial geocoding associated with a cubic convolution order. The image processing was performed using ER Mapper 5.5 software (Earth Resource Mapping; West Perth, WA, Australia) while the spatial analysis was processed using ArcView 3.2 software (Environmental Systems Research Institute; Redlands, CA, USA).

A false-color composite (FCC) of the Landsat-5 TM image was compiled in which the red, green and blue layers were assigned for near infrared (band 4), red (band 3) and green (band 2), respectively with a spatial resolution or pixel size of 25 × 25 m. Radiometric and geometric correction was applied to all bands during the pre-image processing. The image was subjected to the Universal Transverse Mercator projection with the earth ellipsoid of World Geodetic System 1984 (WGS84).

This FCC helped to distinguish the mangrove areas from other landuse and landcover types. Consequently, the FCC was used to simply count the number of mangrove patches and to describe the size, shape and arrangement based on the concept of landscape mosaics of Forman (1995).

Screen digitization was employed together with image enhancement to convert the boundaries of the mangrove patches into polygon vector data. The mangrove species composition was accomplished using the point-centered quarter (PCQ) method of Mueller-Dombois and Ellenberg (1974). A minimum of 20 points spaced from 15 to 20 m apart and composed of at least 80 quarters were sampled along a line transect. At each point, the four nearest mangrove trees from the four cardinal directions were identified (Figure 2).

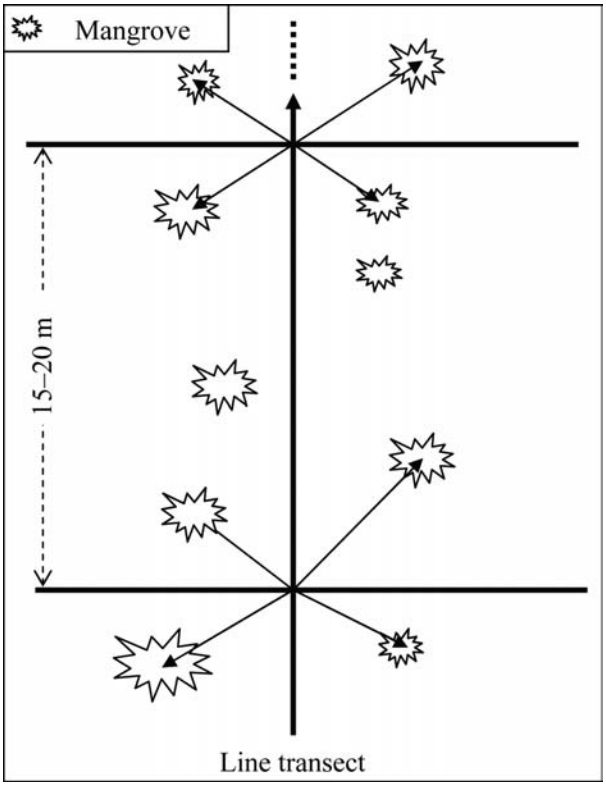

Figure 2 Sketch of point-centered-quarter sampling method which selected the four closest mangroves to each sampling point.

RESULTS AND DISCUSSION

The Landsat-5 TM satellite image provided vector data for the entire area of interest in the Ranong province covering the five administration districts of Kra Buri, Laun, Mueng, Kapoe and Suk Samran (Figures 1 and 3).

The attributes of mangrove patches that were defined are shown in Table 1 and consisted of the number of patches in each district, the patch size and shape and its arrangement. In total, there were 42 mangrove patches in the study area, with the largest number in Mueng district (17) with large size while the smallest number of patches was found in Kra Buri (3) with small size.

Doydee and Buot (2011) verified that Landsat imagery was suitable for mapping mangrove and detecting the pattern of patches. The present study also employed Landsat imagery to determine the mangrove landscape. Most of the patches were elongated and arranged in a clumped pattern, with various sizes (Figure 1). The characteristics of the mangrove patches were derived directly from zooming in on the satellite

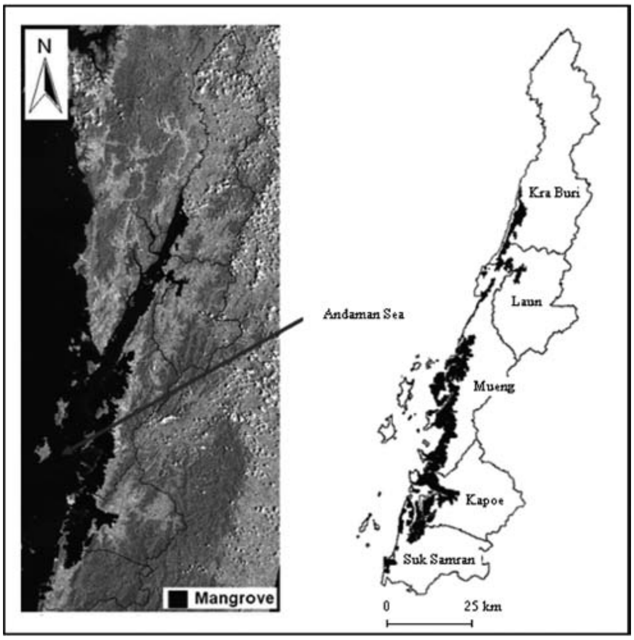

Figure 3 Integration of Landsat-5 TM image and spatial features showing mangrove patch distribution in Ranong, Thailand.

Table 1 Attributes of mangrove patches in Ranong, Thailand (based on Landsat-5 TM 2006).

District	Characteristic of mangrove patches			
	Number of Patches	Size	Shape	Arrangement
Kra Buri	3	Small	Elongated	Clumped
Laun	5	Small	Polygon	Random
Mueng	17	Large	Elongated	Clumped
Kapoe	5	Large	Polygon	Clumped
Suk Samran	12	Medium	Elongated	Clumped
Total	42			

image in each district (Figure 4). The results of unsupervised and supervised classification showed intermixing output which posed difficulties in the image interpretation. Therefore, the mangrove patches were obtained from visual interpretation associated with a screen digitizing technique using the ArcView 3.2 software to illustrate the mangrove landscape pattern. The accuracy assessment process was conducted by actual field survey using a topographic map covering the study area. However, the user accuracy and overall accuracy were not calculated for this research because image classification was omitted.

Analysis showed that the mangrove patches were more concentrated in Mueng, Kapoe and Suk Samran districts. Therefore, these sites were selected to investigate the ecological data of mangrove vegetation using the PCQ technique. The mangrove species abundance in terms of stand percentage was examined in the selected area with two subsites within each of the districts chosen based on accessibility, size of mangrove patches, and associated elements such as channels and distance. In Mueng district, the subsite were at Ngaw and Rachakrud, in Kapoe district, the subsites were at Bangben and Banghin and in Suk Samran district, the subsites were at Talaynog and Hadsaykaow. Table 2 presents the mangrove species abundance (% stand) at the six sampled coastal sites in Ranong province, Thailand. In total, 19 mangrove species were identified. The highest species richness of mangrove trees was found at the Rachakrud site (14 species) while the lowest species richness shared by the Banghin and Talaynog sites with only 7 species .

Seven dominant mangrove species were identified: *Avicennia marina*, *A. officinalis*, *Bruguiera parviflora*, *Ceriops decandra*, *C. tagal*, *Rhizophora apiculata* and *R. mucronata* as indicated by the colored values in Table 2 showing high values of % stand in which considered the values of greater or equal 20 as a clearer value. *Rhizophora apiculata* was the most dominant compared with other mangrove trees species having the highest % stand value (66.25), and this species was found in Ngaw A where the World Biosphere Reserve Office is located. The remaining species were rare. This condition was discovered by counting all the individual trees of mangrove species along the PCQ plots within a community and then determined by counting the percentage of each contributing to the total number of all species.

CONCLUSION

The research was conducted in Ranong province, Thailand with the aim to identify the mangrove landscape pattern and to determine the mangrove tree species associated with species abundance in selected areas. Remotely sensed Landsat-5 TM raster data was used to evaluate the characteristics of mangrove patches. The point-centered quarter technique was used to investigate the total number of mangrove trees and their species composition. In total, 19 species of mangrove trees were identified with 7 dominant species—namely, *Avicennia marina*, *A. officinalis*, *Bruguiera parviflora*, *Ceriops decandra*, *C. tagal*, *Rhizophora apiculata* and *R. mucronata*. These species could be considered as options for mangrove reforestation and coastal habitat restoration in the Ranong mangrove ecosystem.

ACKNOWLEDGEMENTS

We are very grateful to the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA), Los Baños, the Philippines for their kind support of partial research funds. We would like to express our deep thanks to the Geo-Informatics and Space Technology Development Agency (GISTDA), Bangkok, Thailand for providing the Landsat-5 TM dataset.

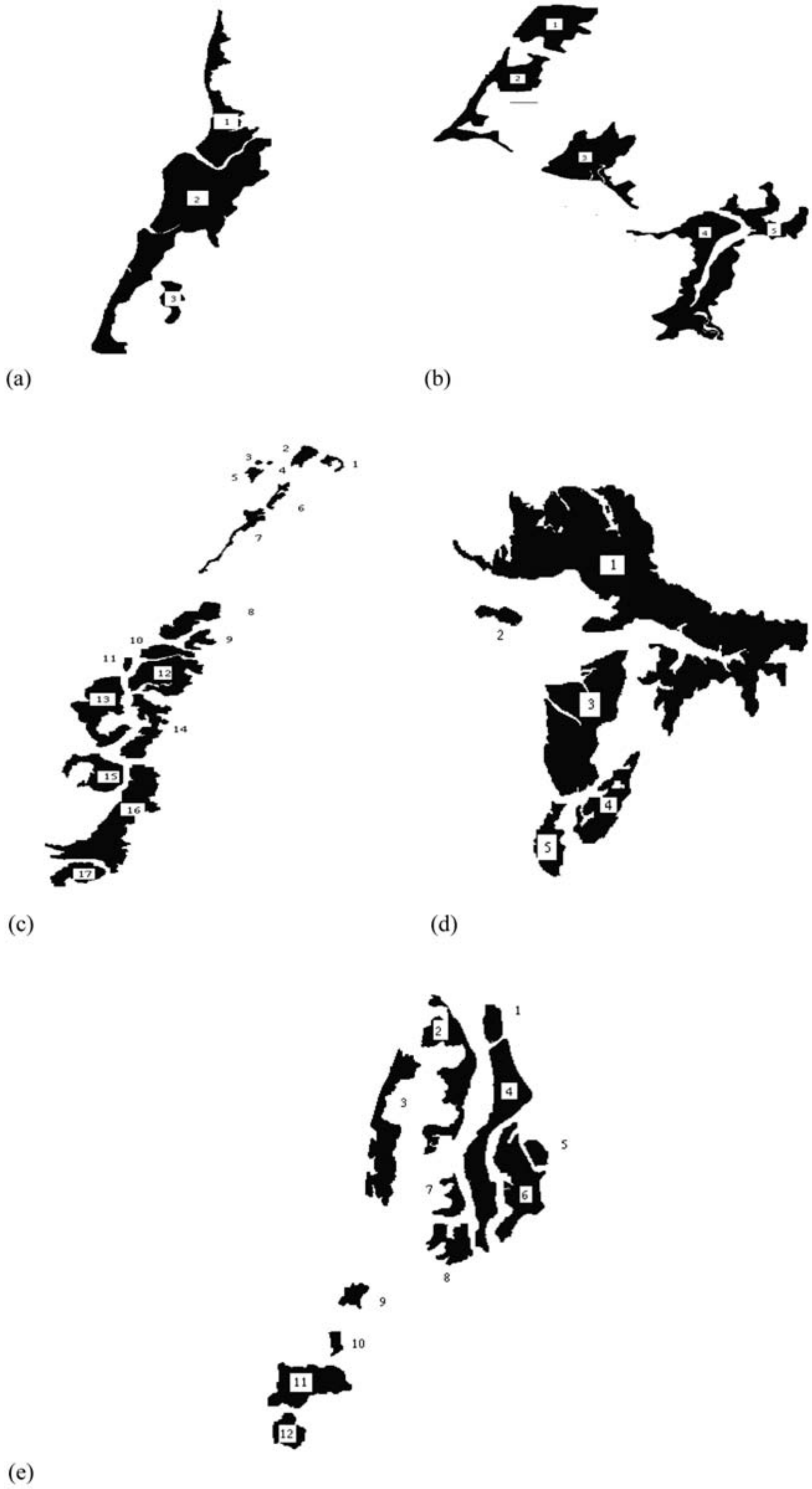

Figure 4 Individual mangrove patches identified by zooming in using the satellite image in each district: (a) Kra Buri, (b) Laun, (c) Mueng, (d) Kapoe, (e) Suk Samran.

Table 2 Species abundance (% stand) of mangrove vegetation at six coastal subsites in Ranong province, Thailand. Shaded values show high abundance for seven species.

Name of species (Family)	Mangrove forest subsite											
	Ngaw		Rachakrud		Bangben		Banghin		Talaynog		Hadsaykaow	
	A	B	A	B	A	B	A	B	A	B	A	B
Aegiceras corniculatum (Myrsinaceae)	1.25			3.75								
Avicennia alba (Avicenniaceae)			1.25	6.25								
Avicennia marina (Avicenniaceae)			37.50	21.25	1.25	8.75						
Avicennia officinalis (Avicenniaceae)	3.75	5.00	1.25	30.00					8.75	7.50	3.75	2.50
Bruguiera cylindrica (Rhizophoraceae)	6.25	2.50	3.75	2.50		1.25	1.25					2.50
Bruguiera gymnorrhiza (Rhizophoraceae)			1.25									
Bruguiera parviflora (Rhizophoraceae)	10.00	21.25	20.00	12.50		3.75	28.75	1.25	43.75	28.75	16.25	6.25
Ceriops decandra (Rhizophoraceae)	2.50	8.75			40.00	40.00					1.25	1.25
Ceriops tagal (Rhizophoraceae)	1.25	3.75					28.75	10.00	8.75	6.25	1.25	
Excoecaria agallocha (Euphorbiaceae)				1.25	2.50	1.25						
Heritiera littoralis (Sterculiaceae)					1.25							
Lumnitzera littorea (Combretaceae)				1.25	2.50							
Lumnitzera racemosa (Combretaceae)					8.75							
Rhizophora apiculata (Rhizophoraceae)	66.25	46.25	26.25	7.50	28.75	37.50	26.25	47.50	15.00	21.25	37.50	65.00
Rhizophora mucronata (Rhizophoraceae)		6.25	1.25			3.75	1.25	13.75	21.25	36.25	36.25	21.25
Scyphiphora hydrophyllacea (Rubiaceae)					10.00							
Sonneratia alba (Sonneratiaceae)			2.50	7.50			2.50	12.50				
Xylocarpus granatum (Meliaceae)	8.75		1.25	6.25	5.00	3.75	11.25	15.00	1.25			1.25
Xylocarpus moluccensis (Meliaceae)		5.00	3.75						1.25		3.75	

Sampling by the point-centered quarter method: Plot A is perpendicular to the channel and Plot B is parallel with the channel.

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