

การทำแผนที่ป่าชายเลนและศึกษาการเปลี่ยนแปลงชายฝั่งทะเลโดยใช้การสำรวจข้อมูลระยะไกล และระบบสารสนเทศภูมิศาสตร์

Remote Sensing and GIS for Mangrove Mapping and Coastal Landscape Change Detection in Ranong Province, Thailand

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การสำรวจข้อมูลระยะไกลและระบบสารสนเทศภูมิศาสตร์ถูกประยุกต์ใช้เพื่อศึกษาและทำแผนที่ป่าชายเลนและสำรวจการเปลี่ยนแปลงชายฝั่งทะเลจังหวัดระนอง ด้วยวิธี Change Detection Technique (CDT) โดยใช้ข้อมูลภาพถ่ายเทียมเชิงเลข (RGB 452) วิเคราะห์ด้วยโปรแกรม ERMapper 7.1 และการเปลี่ยนแปลงชายฝั่งทะเลถูกศึกษาด้วยโปรแกรม ArcView 3.2a การศึกษาพบว่า พื้นที่ทั้งหมดของป่าชายเลนมีขนาดเท่ากับ 12.31 ตารางกิโลเมตร แบ่งออกเป็น 8 กลุ่มพื้นที่ กลุ่มที่ใหญ่ที่สุดมีขนาด 5.06 ตารางกิโลเมตร ขณะที่กลุ่มที่เล็กที่สุดมีขนาดเพียง 0.03 ตารางกิโลเมตร การเปลี่ยนแปลงชายฝั่งทะเลนำไปสู่ปัญหาสิ่งแวดล้อมที่เสื่อมโทรมและการสูญเสียแหล่งที่อยู่อาศัยและหากินของสิ่งมีชีวิต พื้นที่ชายฝั่งทะเลที่มีความอ่อนไหวและง่ายต่อการเปลี่ยนแปลงคือชายหาดและพื้นที่บริเวณปากคลอง การติดตามการเปลี่ยนแปลงสิ่งแวดล้อมชายฝั่งทะเลและการฟื้นฟูป่าชายเลนมีความจำเป็น ควรเริ่มในแต่ละกลุ่มพื้นที่ของป่าชายเลนและทำการเชื่อมโยงพื้นที่ให้ถึงกัน

ABSTRACT

Remote sensing and Geographic Information System (GIS) were used to study and map mangrove patches distribution and detect the changes of coastal landscape in Ranong Province, Thailand using Change Detection Technique (CDT). The false color composite (FCC) image with RGB 452 was processed using ERmapper 7.1 software, while features changed along coastline was created using ArcView 3.2a software. The total mangrove area was 12.31 sq km. There were a total of 8 mangrove patches. The largest patch was 5.06 sq km, while smallest patch area was 0.03 sq km. Change of coast led to ecosystem degradation and habitats fragmentation. Image processing revealed that vulnerable coastal areas mostly were sandy beaches and waterways. This study recommended

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that long term of coastal environments monitoring program is necessary. The mangrove restoration should be linked patches together to against sea wave magnitude and for biodiversity corridor.

Keywords: remote sensing, GIS, change detection, coastal landscape, mangroves

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INTRODUCTION

Coastal environments refer to various kinds of natural habitats such as muddy areas, sandy substrates, rocky beaches, mangrove forest, submerged aquatic vegetation and coral reefs. They provide foods, shelters, and breeding grounds for terrestrial and marine species (Wang, 2010). The coastal zone is the most dynamic interface between land and sea and represents the most challenging frontier between human civilization lives in the coastal zones (Crossett *et al.*, 2004).

On December 26, 2004 the Sumatra earthquake struck several countries and provinces included Ranong, Thailand and triggered monstrous waves that turned into a tsunami hitting the ocean regions and caused the most severe damages (Wang, 2010). At that time, remote sensing and GIS were used to provide real-time information for rescue and rehabilitation plans. Satellite images were applied to monitor and evaluate the damage over several devastated spots (Kelmelis *et al.*, 2006).

Remote sensing and GIS applications in disaster management have become critically important to support preparation through response to natural and anthropogenic induced hazards in coastal zones (Wang, 2010). The objectives of this study were to examine the utility of LANDSAT – 5 TM with integration of GIS data; to map mangrove forest patches and to detect the changes along the coast in Ranong, Thailand. The output of this analysis was thematic map of Ranong mangrove patches distribution in the study area and coastal landscape changes images. This study can serve as basis information for researchers, scientists, scholars and students who are interested in coastal habitats mapping and change detection using information technology.

STUDY AREA

Description of study area

This study was conducted in Ranong coastal environments which located along the coast of the Andaman Sea southern part of Thailand sharing the borders with Myanmar. This is about 568 kilometers from Bangkok. The study area is situated around 9.43° N and 9.57° N latitudes, and 98.29° E and 98.39° E longitudes (Figure 1). The important features of the Ranong coastal landscape are various habitats such as, mangrove forest, sandy beaches, waterways, and upland forest.

DATA ANALYSIS

Mangrove forest mapping

LANDSAT - 5 TM synoptically covered the study area of the Ranong coastal environments was used for mangrove forest mapping. The image false color composite (FCC) was performed to enhance the location of mangrove patches and their spatial distribution. Satellite remote sensing data have multispectral so that they allow observation and measurement of biophysical characteristics of coastal habitats (Colwell, 1983).

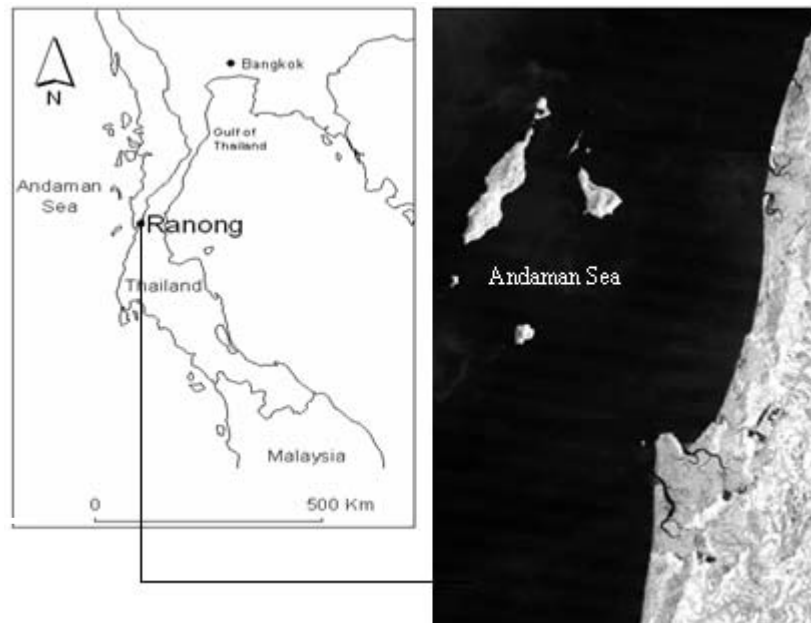


Figure 1 Study area showing the Ranong coastal landscape and Andaman Sea

LANDSAT - 5 TM was analyzed using visual interpretation associated with vegetation index and image classification. The GIS shapefile data was employed as geographical reference data to emphasize the boundary of mangrove patches by simply overlaying. New theme was created by screen digitizing for some mangrove areas in case the vector data were not available.

Coastal landscape change analysis

The multitemporal capability of LANDSAT - 5 TM allows tracking of changes in coastal landscape characteristic over time (Wang and Moskovits, 2001). This study performed change detection technique using two different dates of remotely sensed data, the first dataset was acquired before the tsunami attacking the Ranong coastal zones and the second dataset was derived after the tsunami ravaging the coast. Two satellite images were applied in coastal landscape change detection through multiple images geolink analysis with visual interpretation of FCC image. GIS shorelines and other feature changes were created base on coastal landscape changes observed in each sections.

ANALYSIS RESULTS

Spatial distribution of mangroves

Thampanya *et al.* (2006) reported that the presence of mangroves not only reduces the energy of tsunami but also mitigate the coastal erosion rate. Thus, the study of mangrove habitat mapping is important and needed. The Landsat image (acquired on December 30, 2004) was selected to study the spatial distribution of mangroves. This image was used as input dataset to determine the mangrove patches distribution using ER Mapper 7.1, while the mangrove forest thematic map was created using ArcView 3.2a. The FCC image with RGB 452 (Figure 2 - right) was applied to distinguish mangrove forest feature from other land cover types. Interpretation of FCC image revealed that the mangrove forests (red color) are located along the coastline and found that they have different pattern of patches.

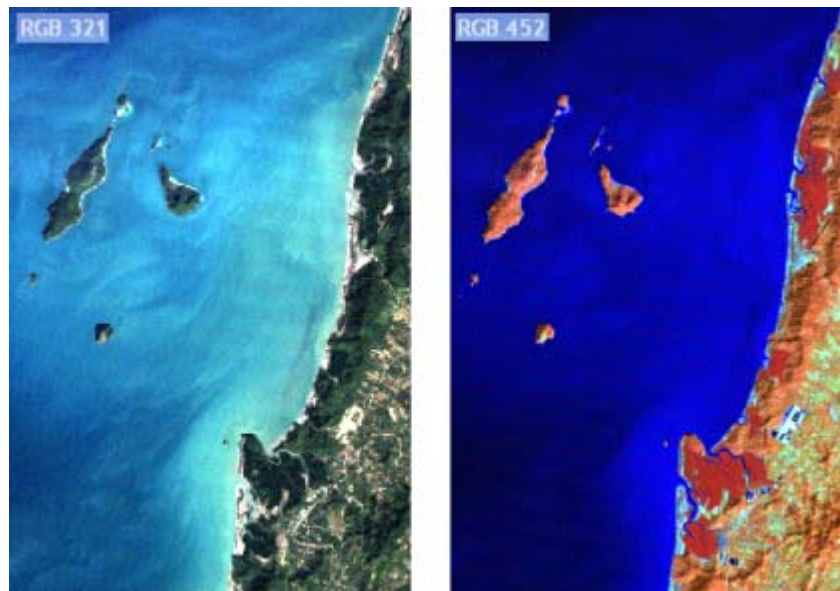


Figure 2 LANDSAT - 5 TM acquired on December 30, 2004 showing images of true color composite (TCC)-RGB 321 (left) and false color composite (FCC)-RGB 452 (right)

Normalized Difference Vegetation Index (NDVI) was attempted to enhance the mangrove forest. The comparison between mangrove forest and upland forest in this study revealed that the pixel ranging more or less the same (0.8 - 0.9). Thus, this technique can only differentiate vegetation and non-vegetation, but cannot distinguish the type of vegetation. The unsupervised classification was carried out to identify the mangrove vegetation class. However, the result gave the intermixing classes with other features. Therefore, the mangrove distribution was identified using visual interpretation and expert knowledge base on FCC image (band 4 (red), band 5 (green), and band 2 (blue)) as it was given the best visual guide of optical boundaries of mangroves. The FCC image was used as the reference data, then create new theme of mangrove polygons using screen digitizing technique. The mangrove feature

that obtained from this processed can link with geodatabase and ready to use as vector-based GIS application or apply for further study, for instance, GIS-criteria base analysis for mangrove restoration and site selection.

The result showed that there were a total of 8 mangrove patches. The largest area of mangrove patch was 5.06 sq km (patch no.1). It was classified as long shape with fragmented pattern. The second largest area of mangrove patch was 3.56 sq km (patch no. 6). The patch shape was round and located near shoreline. The smallest mangrove patch was 0.03 sq km (patch no. 7) associated with small eyebrow shape and located near shoreline (Figure 3 and Table 1).

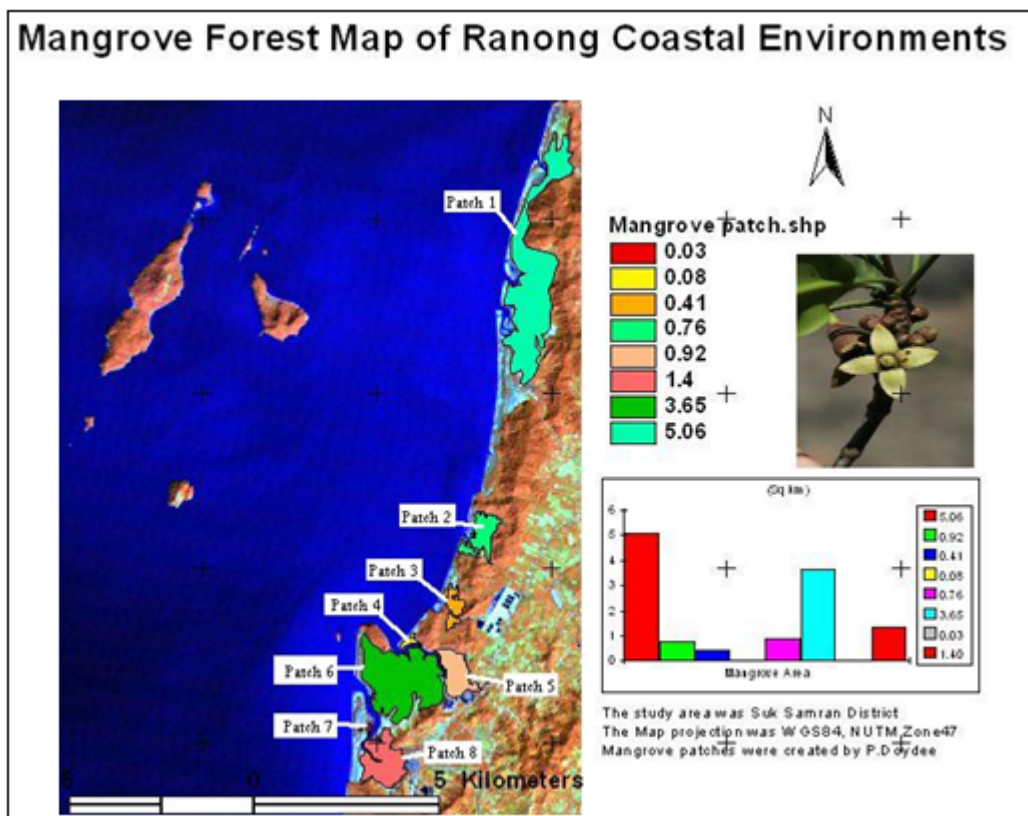


Figure 3 Thematic map showing the mangrove patches distribution along the coast

The mangrove was fragmented in Ranong coastal environments mainly due to the disturbance of anthropogenic such as wood utilization and mangrove land conversion into aquaculture area (Macintosh *et al.*, 2002). The total mangrove area within the boundary of the study area was 12.31 sq km (Table 1).

Table 1 Characteristic of mangrove vegetation in the Ranong coastal areas

| Type | Patch No. | Mangrove Area (sq km) | Mangrove Patch Status |
|---------|-----------|-----------------------|--|
| Polygon | 1 | 5.06 | Long shape and fragmented |
| Polygon | 2 | 0.76 | Square shape and moderate fragmented |
| Polygon | 3 | 0.41 | Random shape and moderate fragmented |
| Polygon | 4 | 0.08 | Small and located near shoreline |
| Polygon | 5 | 0.92 | Oval shape and near shrimp ponds |
| Polygon | 6 | 3.65 | Round shape and near shoreline |
| Polygon | 7 | 0.03 | Small eyebrow shape and near shoreline |
| Polygon | 8 | 1.40 | Round shape and near shoreline |
| Total | 8 | 12.31 | |

To map the mangrove forest distribution along the Andaman coastal area in Ranong, this study have employed various techniques such as visual interpretation, NDVI, image classification and integration of raster and GIS data. Each approach has their advantage and disadvantage. This study found that image rater dataset integrated with GIS data was the best option for mangrove mapping. The summary information of approaches presented in Table 2.

Table 2 Approaches and information for mangrove mapping

| Approaches | Information |
|------------------------------------|---|
| Visual interpretation | The FCC image using RGB452 can distinguish the mangrove areas from other features in the coastal landscape |
| NDVI | Helpful in enhancing the vegetation area but cannot distinguish upland forest and mangrove forest |
| Image classification | This approach can calculate the statistic of mangrove area base on pixel, the result of this study showing the intermixing class of mangrove forest and upland forest |
| Integration of raster and GIS data | This is the best way to present the mangrove forest in thematic map. The area of each mangrove patches was calculated using ArcView 3.2a. It takes time but most accurate. The map production is meaningful and easier for user interpretation. |

Change detection

The change detection through the use of remote sensing and GIS was applied to determine changes in the Ranong coastal landscape particularly along the Andaman Seacoast. Two dates of

LANDSAT - 5 TM images dataset (March 17, 2004 and December 30, 2004) were processed to highlight the feature of changes between images focusing on the area near the coastline which obviously changed after tsunami attacked Ranong coastal zone, Thailand. The geolink technique was applied to both images. This technique is an ideal for investigate the changes of coastal landscape which have a same geodetic datum, otherwise the geometric correction is needed. The images of FCC and TCC were used to examine the changes. There were 6 major areas located near the coast have been explored and found the changes (Figure 4).

The basic premise in using remote sensing for change detection is that the process can identify change between two or more dates (Shalaby and Tateishi, 2007). This study aimed to highlight the changes of coastal features such as sandy beaches, waterway and mangrove forest between two dates. The coastal areas with more mangrove forest have less damaged from tsunami than the coastal area without the mangroves. Comparison by section revealed that sections 2 and 5 have been damaged more than other sections (Figure 5). Both sections are existed with sandy beach patches before but since their areas have been changed consequently the waterway also changed. The sand particles from both sections moved into the mangroves ecosystem and changed mangrove soil surface properties.

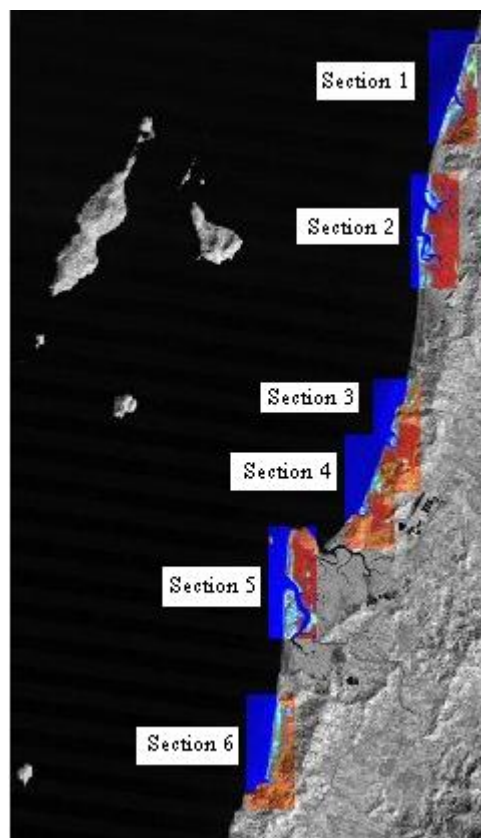


Figure 4 The Ranong coastal area showing 6 sections of landscape changes

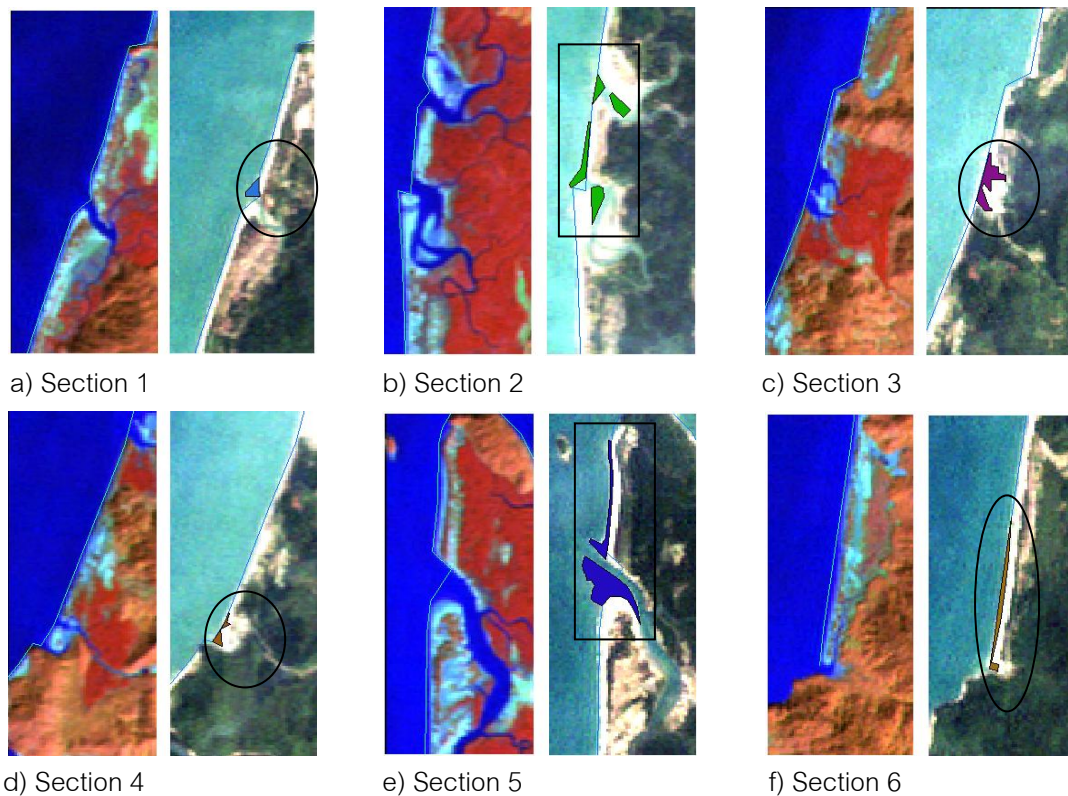


Figure 5 Coastal landscape changes in Ranong, Thailand by sections (a-f)

Most vulnerable coastal areas were sandy beaches and waterway. From the study confirmed that these features have been very severe changed as a result of tsunami on 26 December 2004. The changes in coastal landscape led to ecosystem degradation and mangrove fragmentation in part of the study area and later could impact to the local people who dwelling in the coastal zone.

The finding from this study suggested that the long term coastal environments monitoring program is necessary especially where the mangrove areas are being rehabilitated. The mangrove restoration should be linked patches or areas together to against current wave magnitude and for biodiversity corridor purposes. The result from this study can serve as basis information to decision-makers. This kind of information will be used by related organization such provincial government, private sectors, non-governmental organizations (NGOs), etc to update their digital coastal environments land use and land cover files; to plan and design the integrity and currency of escape route; and coastal resettlement management plan.

CONCLUSIONS

The objectives of this study were to map mangrove forest area and to detect changes of the Ranong coastal landscape along the Andaman Seacoast, Thailand. Remote Sensing and GIS were used to study the spatial distribution of mangrove patches. The FFC image visual interpretation and GIS was the best option for mangrove mapping, while the geolink technique and vector data was used to

identify coastal landscape changes particularly along the coast. Two sections among six in the study area has undergone very severe on sandy beaches change from tsunami impact. This study revealed that GIS and remote sensing can play an important role to study about coastal environments. The mangrove restoration and coastal urban resettlements will be future studies. Information about biophysical environments in this area would benefit for achieving next research.

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