การเปลี่ยนแปลงพื้นที่ชายฝั่งทะเลและการใช้ประโยชน์ที่ดิน
ในจังหวัดสุราษฎร์ธานี ประเทศไทย[*]

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บทคัดย่อ

การศึกษาครั้งนี้มุ่งเน้นการศึกษาเพื่อติดตามการเปลี่ยนแปลงชายฝั่งทะเลและการใช้ประโยชน์ที่ดินของจังหวัดสุราษฎร์ธานี โดยการวิเคราะห์หาอัตราการเปลี่ยนแปลงชายฝั่งเฉลี่ยรายปีและการวิเคราะห์ปัจจัยหลักที่มีผลต่อการกัดเซาะชายฝั่ง ได้แก่ การใช้ประโยชน์ที่ดิน โดยการประยุกต์เทคโนโลยีการสำรวจระยะไกลและระบบสารสนเทศภูมิศาสตร์เป็นเครื่องมือในการวิจัย ซึ่งใช้ข้อมูลภาพจากดาวเทียม LANDSAT-5 ปี พ.ศ. 2551 2545 และ 2537 พร้อมวิเคราะห์ความสัมพันธ์ระหว่างการเปลี่ยนแปลงชายฝั่งและการใช้ประโยชน์ที่ดินโดยใช้หลักการทางสถิติ ได้แก่ การทดสอบสมมติฐานความสัมพันธ์แบบสองทาง และการหาค่าสัมประสิทธิ์สหสัมพันธ์เพียร์สันหรือค่าสัมประสิทธิ์สหสัมพันธ์อย่างง่าย

ผลการศึกษาพบว่า พื้นที่ชายฝั่งทะเล จังหวัดสุราษฎร์ธานี (629,536 ไร่) ระหว่างปี พ.ศ. 2537-2551 ส่วนใหญ่มีการเปลี่ยนแปลงชายฝั่งในระดับตำบลแบบสะสมตัว จำนวน 14 แห่ง อัตราการสะสมตัวเท่ากับ 0.61 เมตรต่อปี และพื้นที่รายตำบลที่มีการกัดเซาะชายฝั่ง จำนวน 6 แห่ง อัตราการกัดเซาะ 0.83 เมตรต่อปี คิดเป็นจำนวนพื้นที่ที่เกิดการเปลี่ยนแปลงประมาณ 3,746 ไร่ สำหรับการใช้ประโยชน์ที่ดิน ส่วนใหญ่ไม่มีการเปลี่ยนแปลงการใช้ประโยชน์ที่ดินระหว่างปี พ.ศ. 2537-2551 มากนัก โดยเปลี่ยนแปลงจากพื้นที่ป่าชายเลนน้ำเค็มไปเป็นพื้นที่เพาะเลี้ยงสัตว์น้ำ (นากุ้ง) และพื้นที่เกษตรกรรม (สวนผลไม้ผสม, สวนปาล์มน้ำมัน) เป็นต้น สำหรับความสัมพันธ์ระหว่างการเปลี่ยนแปลงชายฝั่งและการใช้ประโยชน์ที่ดินแต่ละประเภท พบว่า ส่วนใหญ่การเปลี่ยนแปลงชายฝั่งไม่มีความสัมพันธ์กับการใช้ประโยชน์ที่ดินทางสถิติที่ระดับนัยสำคัญ 0.05

คำสำคัญ : การเปลี่ยนแปลงพื้นที่ชายฝั่งทะเลและการใช้ประโยชน์ที่ดิน ในจังหวัดสุราษฎร์ธานี ประเทศไทย

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Changes in coastal area and land use in Surat Thani province, Thailand[*]

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Abstract

This study has focused on coastal area changes and land use in Surat Thani province, Thailand by analyzing the rate of shoreline change and analysis of the main factors that affect coastal change such as land use, by application of remote sensing and GIS as research tools. This satellite imaged data study was conducted by using LANDSAT 5-TM from the years 1994, 2002 and 2008. Analysis of relationships between changes in coastal area and land use used Pearson's correlation coefficients.

The results showed that most of the changes in coastal areas (629,536 rai) during 1994-2008 in the coastal districts studied were coastal deposition (14 districts), which had a deposition rate of 0.61 m/y, whereas 6 districts showed coastal erosion, and had an erosion rate of 0.83 m/y, representing a total area of approximately 3,746 rai of changes. For land use change, we found that there has not been much changed; most of the changes were from the mangrove forest areas into agriculture areas (shrimp farms) and farmland (mixed orchards, oil palm). For the study of the relationship between changes in coastal area and land use for each type, it was found that most of the changes in coastal area did not correlate with land use with statistic significance at 0.05, and for most, the direction of relationship between two variables was positive.

Key words: Coastal change; Shoreline change; Land use; Correlation; Surat Thani Thailand

Introduction

Thailand's coastal areas are facing serious change, especially the problem of coastal erosion. In the past decade, coastal areas of Thailand have lost its land numerously; some areas have lost over 100 meters of distance, resulting in migration of communities to other areas. This includes the ecosystem of mangrove forests that has been devastated. Department of Marine and Coastal Resources [1], the government agency with directly in charge, reported about the problems of coastal erosion that the severe erosion around the Gulf of Thailand has increased more than 5 meters per year averagely, in total of distance over 180.9 kilometers, or approximately 10.9 percent of Thailand's shoreline.

One of factor that influence of the shoreline change is its geological characteristic as on that particular coast and affecting sensitivity of changes. In addition, there are co-factors contributed to the changes, for examples, climate change, higher sea level, land subsidence, amount of sediment on the coast, and human activities. From the study of Intergovernmental Panel on Climatic Change (IPCC) in the 40 years past (1960-2003) about the climate change of Thailand show that temperature has risen around 1 degrees Celsius and it was expected that global temperature will increase approximately 2-4 degrees more [2]. This also affects changes on

wind and wave pattern, water current, severity of storms and monsoon, speed and volume of water, and also plants that cover the coast [3]. For changing in sea level, which contribute to change in the shoreline, the finding of the Inter-governmental Committee on issues of climate change (Based on the fourth Assessment Report : AR4) indicated that average global sea level has increased approximately 3.1 meters per year (from 1993-2003). This was considered as a rapid increase in volume. In regional level, the increase in sea level will vary according to climate variability and circulation in the sea [4]. Impact on ecosystems of the sea level change will result in flooding of low areas; especially on the area of mangrove forests may also be destroyed. All of these affect the loss of biodiversity on earth [5].

Surat Thani is one of the provinces that its border connected to the east of the Gulf of Thailand. The coastline of Surat Thani caused by the lifting formation of land which creates a shallow sea on the coastal area. The coastal area has a variety of patterns, such as sea, flood plains covering the river delta plains, etc. Surat Thani is considered as a province that is facing the problems of severe coastal erosion. Department of Marine and Coastal Resources mentioned that the severe erosion in coastal area of Surat Thani is averagely greater than 5 meters per year [6]. This study aimed to apply techniques in Geo-informatics technology for the study of

relationship between changes in coastal areas and land use in Surat Thani province from satellite images, in order to derive map of risk areas for coastal erosion. Results from this study may be useful in prevention and reduce the impact of coastal erosion that may occur in the short and long-term in this area further.

Objectives

1. To study the rate of coastline change in Surat Thani province during 1994, 2002 and 2008.

2. To study land use characteristics in coastal area in Surat Thani province during 1994, 2002 and 2008.

3. To study the relationship between shoreline change and land use in coastal area in Surat Thani province.

Research Methodology

The coverage area of this study is the coast of Surat Thani Province, located on the east coast of the south on the Gulf of Thailand, covers 7 districts or 20 sub districts with a total length of approximately 155 km. This research study aims to investigate and survey the condition of study area in order to establish the collections of spatial data, to facilitate in research analysis and data manipulation. Research study processes are;
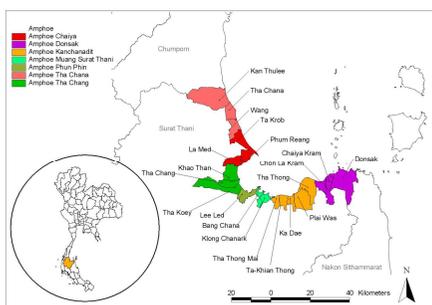

Figure 1 Study area

1. Image processing

In this study, the application of Geo-informatics technologies utilize an analysis of the two proceeding in order to derived information from remotely sense imagery. That information hereafter facilitates to investigate the changes of the coastline and land use over the time in study area. A series of LANDSAT 5-TM satellite imagery was used for this study and the image pre and post processing were conducted as process; Data preparation, Pre-processing and Image enhancement. The temporal sets of LANDSAT-5 TM satellite imagery covered study area (the coastal of Surat Thani province) which consist of three periods of time (1994, 2002 and 2008) have been used for this study [7].

2. The study of shoreline change

In order to derive information to facilitate for analysis of shoreline changes in this study, LANDSAT-5 TM satellite imagery was used for this purposed as following:

2.1 Shoreline detection

Each year image was used for delineated the coastline of study area by utility of geographic information systems techniques. The coastline is drawn by tracing along the beach ridge line [8]. Afterward, the digitized coastline of each year was used for compared with the image of the year earlier to find the discrepancy over the time that possibly to be depositional, erosion or stable coastline.

2.2 Change detection

To detect coastline change over the time by remotely sense imagery, one needs a temporal of satellite images. In this study LANDSAT-5 TM of three year as year 1994, 2002 and 2008 were used and measuring the distance from the reference line to the coastline of each year (Reference line is assumed to parallel along the coast) [9]. The distance must be measured vertically from image year 1994, 2002 and 2008 coastline to reference line. The results obtained on each year then use for subtract out of the prior year coastline. In this study, coastline was divided into segment of every 1 kilometer by splitting the cross sect-line along the coast as shown as figure 2 [10]. The outcome as positive value means the coastline was depositional and if it has a negative value means the coastal was erosion. The analysis of coastline change has performed three times for the pair of images of year 1994 and 2002 (as a period of 8 years), year 2002 and 2008 period (as 6 years period) and lastly, years 1994 and 2008 period (14 years).
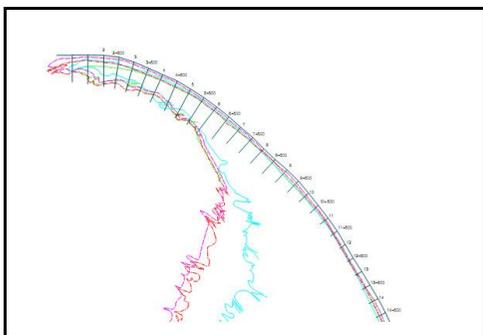

Figure 2 Sample of split the cross sect-line along the coast for finding the rate of shoreline change

2.3 Severity the coastal change

The severity of the shoreline changes in this study, using the same basis with the change of the Gulf of Thailand coast by Sin Sinsakul and Inc (2002) [11] characterization of coastal change into 4 level;

*   *Severe erosion;* the rate of coastline erosion greater than 5 meters per year.

*   *Moderate erosion;* the rate of coastline erosion 1-5 meters per year.

*   *Deposition coastal;* the rate of coastline deposition 1-5 meters per year.

*   *Stable coastal;* the rate of coastal change **+/-**1 meters per year.

3. The study of land use

The study of land use characteristics and land use change whether each types of land use was affected to coastline change; such as urban and built up area may influence to the erosion of coastline greater than the area that covered by mangrove forest. Land use change was derived by image classification and GIS technique as illustrated. After the image pre-processing of LANDSAT-5 satellite images in 3 years (1994, 2002 and 2008) has been completed, proceeding to investigate the land use in study areas was done by the classification of land use into 10 types; rubber plantation, mixed orchard, oil palm, paddy field, shrimp farm, mangrove forest (including melaleuce forest and nipa forest), water bodies, urban and built up area, unused land and others area. The land use classification of

year 1994, 2002 and 2008 then facilitated as information to analyze the rate change of land use in further step of the study. The land use classification of year 1994, 2002 and 2008 then use for comparing the change of land use from by means of overlay images (Overlay Function in GIS).

4. The analysis of relationship between changes in coastal area and land use

The investigated of the relationship between in coastline and land use changes in this study in order to determine the correlations between these two factors. For the test, changes in coastal area and land use are related or not will test the hypothesis of the basis of the Sig. (2 tailed) and the level significance was α = 0.05 by using an α > 0.05 accepted hypothesis $H_0 : \rho = 0$ but if α < 0.05 accepted $H_1 : \rho \neq 0$ [12]. And for test the level of relationship will considered the correlation coefficient "r" in "Pearson product-moment correlation coefficient" where if the value is (+) means the two variables are related linearly, but if the value is (-) means the two variables have the opposite relationship and if the value is (0) that means the two variables is not statistically related [13]. The SPSS program is used as tool for analyzing the relationship as two issues.

Results and Discussion

The images pre-processing of radiometric correction were conducted to modify DN values in order to account for noise, from images. Images histogram analysis was showed that the characteristics of the digital number in the band are consisting with the physical characteristics of the region. Geometric correction was processed through the images by map to image correction method using Ground Control Point: (GCP) from the topographic map scale 1:50,000 series L7017, UTM zone 47, references on Indian 1975 of Royal Thai Survey Department. And can conclude the result of the study as follow;

1. The shoreline change detection

The changes of shoreline along the coastal in Surat Thani province were detected from the comparison of 1994, 2002 and 2008 LANDSAT-5 TM satellite imagery. Utilized tools of GIS technology as following; the first step, the coastline the images of each year were digitized, then they were use to overlay to calculate the rate of change of each years. The rates of coastal formation change were determined by comparing the distance measurements from the reference line to each year coastline derived from the images. Afterward the coastlines along the study area later were divided into a cross section of 1

kilometer long, which consist of 154 sections cross section-line. Each section, then measured the distance in order to offset with the set of last year data. The average rates of coastal change in study area were classified by sub-district as follows;

1.1 Shoreline change during 1994 and 2002

* Coastal erosion

It could claimed from the study results that coastal area of 7 sub-districts named Kan Thulee, Wang, Ta Krob, Khao Than, Tha Chang, Lee Led and Chaiya Kram had been eroded. Tha Chang sub-district had maximum erosion rate of 14.76 meters per year and Kan Thulee sub-district has minimum erosion rate of 3.81 meters per year.

* Coastal depositional

The study results could conclude that coastal area of 12 sub-districts named Tha Chana, Phum Reang, Lamed, Tha Koey, Lee Led, Klong Chanark, Bang Chana, Ka Dae, Ta-Khian Thong, Tha Thong, Tha Thong Mai, Plai was, Chaon La Kram and Donsak had been deposited**.** Ka Dae sub-district had maximum deposition rate of 17.98 meters per year and Lamed sub-district had minimum deposition rate of 2.43 meters per year.

* Stable coastal

It was found from the study results of the year 1994 and 2002 that Tha Chana sub-district had rather unchanged coastal area. Its erosion and deposition rate was similar by 3.44 meters per year and 3.15 meters per year respectively.

1.2 Shoreline change during 2002 and 2008

* Coastal erosion

The study results that coastal area of 11 sub-districts named Kan Thulee, Tha Chana, Lamed, Tha Chang, Lee Led, Klong Chanark, Bang Chana, Tha Thong Mai, Chon La Kram, Chaiya Kram and Donsak sub district had been eroded. Lamed sub-district had maximum erosion rate of 12.07 meters per and Chaiya Kram sub-district has minimum erosion rate of 4.20 meters per year.

* Coastal depositional

The study results could conclude that coastal area of 7 sub-districts named Wang, Ta Krob, Phum Reang, Khao Than, Tha Koey, Ta-Khian Thong and Plai**.** Ta Krob sub-district had maximum deposition rate of 9.51 meters per year and Khao Than sub-district had minimum deposition rate of 5.09 meters per year.

* Stable coastal

It was found from the study results of the year 2002 and 2008 that Ka Dae and Tha Thong sub-districts had rather unchanged coastal area. Its erosion and deposition rate was not more than ±1 meters per year.

1.3 Shoreline change during 1994 and 2008

* Coastal erosion

It could be claimed from the study results that coastal area of 6 sub-districts named of Kan Thulee, Tha Chana, Lamed, Khao Than, Tha Chang and Lee. Lee Led sub-district had maximum erosion rate of 10.12 meters per year and Kan Thulee sub-district has minimum erosion rate of 4.30 meters per year.

* Coastal depositional

The study results could conclude that coastal area of 14 sub-districts named Wang, Ta Krob, Phum Reang, Tha Koey, Klong Chanark, Bang Chana, Ka Dae, Ta-Khian Thong, Tha Thong, Tha Thong Mai, Plai, Chaon La Kram, Chaiya Kram and Donsak. Chaiya Kram sub-district had maximum deposition rate of 11.53 meters per year and Tha Koey sub-district had minimum deposition rate of 2.82 meters per year.
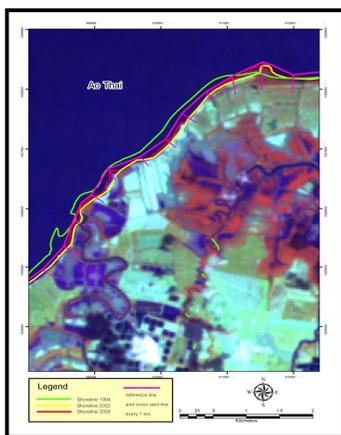

Figure 3 The segment of split the cross sect-line along the coast in study area

* Stable coastal

It was found from the study results of the year 1994 and 2008 that there was not any sub-district having stable coast.

2. Land use

To derive the information Geographic information System was selected as a tool for classified land use information from the reflections value of entities (Digital Number: DN) that covered the ground. For accuracy assessment and classification verification field surveyed and field data collection were conducted and use as a ground truth data. Each selected year of LANDSAT-5 TM satellite image has been supervised classified into 10 classes to represent land use of study area. The results of land use classification are as follow;

2.1 Utility of land in year 1994

Image of year 1994 has been classified as para rubber 27.01%, mixed orchard 19.01%, shrimp farm 15.16%, unused land 14.12%, mangrove forest 10.91%, others area 10.69%, paddy field 4.61%, oil palm 1.78%, water bodies 1.24% and urban and built up area 0.46%.

2.2 Utility of land in year 2002

Image of year 2002 has been classified as para rubber 28.98%, shrimp farm 16.01%, unused land 15.46%, mixed orchard 14.98%, mangrove forest 10.66%, others area 5.24%, oil palm 4.43%, urban and built up area 1.60%, paddy field 1.40% and water bodies 1.24%.

2.3 Utility of land in year 2008

Image of year 2008 has been classified as para rubber 31.24%, shrimp farm 20.48%, mixed orchard 14.07%, unused land 10.02%, mangrove forest 8.54%, oil palm 7.24%, others area 4.25%, urban and built up area 1.62%, paddy field 1.31% and water bodies 1.23%.

3. Relationship between changes in coastal area and land use

The result for the relationship between changes in coastal area and land use in Surat Thani province are related or not were shown that the majority of coastal area changes were not statistically related to land use at the level of significance 0.05. It was because significance level (α, Sig) had to be more than 0.05, then the hypothesis $H_0 : \rho = 0$ would be accepted (as shown in table 1). And for the level of relationship between changes in coastal area and land use, statistical method, Pearson product-moment correlation coefficient (r) was used. Shoreline data and each type of land use were tested in pair and the details of the tested results were shown as follows;
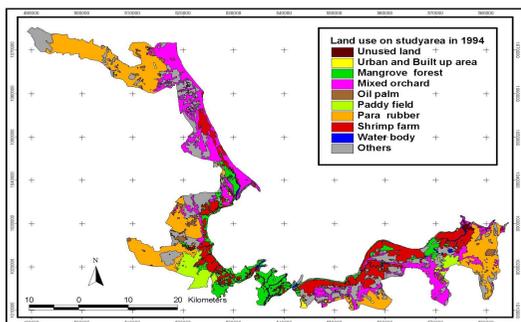

Figure 4 Sample of thematic map present land use on study area in 1994

* Relationship in the same direction

(1) Very high level (r = 0.90-1.00); para rubber = 0.999, palm oil = 0.999, shrimp farm = 0.934 and mangrove forest = 0.914

(2) High level (r = 0.70-0.90); urban and built up area = 0.870

* Relationship in the opposite direction

(1) Very high level (r = -0.90-0.00); mixed orchard = -0.936, water bodies = -0.985 and others area = -0.980

(2) High level (r = -0.70- -0.90); paddy field = -0.874 and unused land = -0.730

Table 1 Results of Sig. value for relationship between changes in coastal area and land use

Land use	Sig.	Results
Urban and Built up area	.328	No related
Para rubber	.018	Are Related
Mixed orchard	.228	No related
Oil Palm	.006	Are Related
Paddy field	.323	No related
Shrimp farm	.232	No related
Mangrove forest	.266	No related
Water bodies	.110	No related
Unused land	.479	No related
Others area	.129	No related

Conclusion

This study assessed the relationship between coastal area and their land use properties in Surat Thani province, Thailand. The analyzed tendency of coastal change from past to present by considering the correlation between land use and coastal erosion. Geographic Information System (GIS) has been utilized as a tool to assist for as

images interpretation. The series of LANDSAT-5 TM satellite imageries of year 1994, 2002 and 2008 used for derived information for compared and detected changed for both of land use as well as derived of the rate of shoreline change. The results of study can be summarized as follows;

1. Shoreline change

In the study was compared a set of data to investigate change of the coastline during year 1994-2002 (8 years), 2002-2008 (6 years) and 1994-2008 (14 years) by using satellite LANDSAT-5 TM imageries. The results showed that the area around the coastline described by sub districts has changed and could be illustrated depositional, erosion and stable coastline (shown in table 2). The coastal area of Surat Thani province level to deposition rather than erosion, especially when comparing year 1994 and 2008 which is 12 year interval, trend of changed was likely to occur of depositional. The level of coastal change have been defined into 4 classes category , according to the annual rate of coastal change from the years 1994 to 2008 as follows;

* **Severe erosion**: severe erosion has found in 4 sub district namely, Lamed, Khao Than, Tha Chang and Lee Led.

* **Moderate erosion**: moderate erosion has found in 2 sub districts of Kan Thulee and Tha Chana sub district.

* **Deposition coastal**: deposition coastal has found in 10 sub districts as follows; Phum Reang, Klong Chanark, Bang Chana, Ka Dae, Ta-Khian Thong, Tha Thong, Tha Thong Mai, Plai was, Chaiya Kram and Donsak.

Stable coastal: none of the area found to be a stable coastal.

Whole picture of the level of shoreline changes along the coast in study area of Surat Thani province during 1994-2008 were shown in figure 5.

Table 2 Changes in coastal area during 1994, 2002 and 2008

Shoreline change during 1994, 2002 and 2008				
Time	Area (rai)		Rate (m/year)	
	Increase	Decrease	Deposition	Erosion
1994-2002	4,274.99	7,386.90	+1.79	-1.55
2002-2008	2,507.75	2,243.59	+1.37	-14.08
1994-2008	5,159.41	1,412.91	+0.61	-0.83

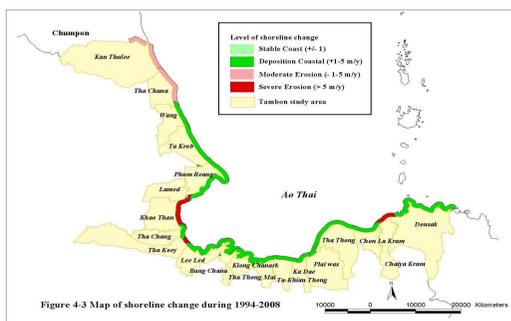Figure 4-3 Map of shoreline change during 1994-2008

Figure 5 Map of shoreline change during the year 1994 and 2008

2. Land use

The assessed of land utility in studled area consist of 20 sub districts within 7 districts area with adjacent to the coastline of Surat Thani province, from LANDSAT-5 TM satellite image in order to compare the changes over times. The imagery was selected for comparison as year 1994 and 2002, year 2002 and 2008 and year 1994 and 2008.When analyzed as a whole, found that patterns of land use around the coast of Surat Thani province, mainly agricultural area especially para rubber plantations. The main crops of the south area and mixed orchard there are majority of the coconut groves. In addition, the shrimp farms, paddy fields and other areas prominent types of mangrove forest areas such as melaleuce forest and nipa forest because the study area was a coastal area, to provide clarity and understanding of patterns of change. The comparison of land use area in each type of years 1994, 2002 and 2008 was shown in figure 6.

3. Relationship between changes in coastal area and land use

The results of the analysis were two characteristics as mentioned above and can be concluded that the majority of coastal formation change is not statistically related to land use at significance 0.05 level by analyzing the Sig. value within area urban and built up area, mixed orchard, paddy field, shrimp farm, mangrove forest, water area, unused land and others area. The analysis of correlation coefficients were mostly as same direction at a high level (para rubber, oil palm, shrimp farm, mangrove forest and urban and built up area). Therefore, it could not conclude that change of land use was the factor affecting to change of coastal area. However, it might be one of the relating factors apart from hydro meteorology, wind, wave, storm, sea level, sea current and so on.
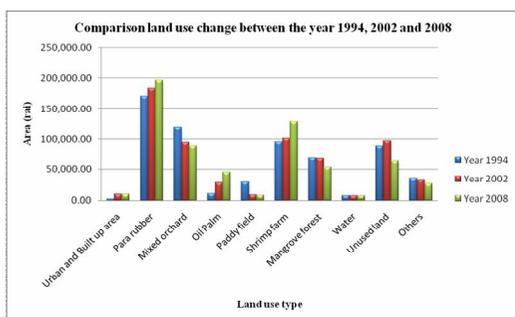

Figure 6 Comparison land use changes from the year 1994, 2002 and 2008

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