Evaluation of Urban Expansion on the Change of Coastal Morphology Using Digital Shoreline Analysis System (DSAS) : A Case Study of Rayong Province, Thailand

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ABSTRACT

Coastal land use change is a major cause of landform change along the coastline. The majority of lands in Rayong province are used for tourism and industrial sectors. The expansion of the city and its buildings occurs to have a persistent influence on the change of coastline. This study aims to study the change of coastal area caused by the expansion of the urban area in Tambon Phe, Rayong province in order to compare the landform change rate using Digital Shoreline Analysis System (DSAS) with geographic information system. The land use data and satellite images from 1999 to 2015 were used in this study.

The results from Linear regression rate (LRR) calculation showed that the coastline movement rate of Tambon Phe had increased with an average rate of 1.96 meters per year. The coastline of agricultural land use had increased with an average rate of 3.12 meters per year. The coastline of urban area had increased with an average rate of 2.13 meters per year. The coastline of forest area average forest had increased with an average rate of 1.43 meters per year. The beach area had increased with an average rate of 1.34 meters and the open space area had increased with an average rate of 0.75 meters per year, respectively.

Keywords: Coastal geomorphology, Digital Shoreline Analysis System (DSAS), GIS

1. INTRODUCTION

Nowadays, urban growth is projected to be the largest wave in the human history. More than half of the world's population now lives in towns and cities. Coastal zones have been populated by human settlement all around the world. Coastal areas are attractive because of their fertile soils, access to water resources and especially economic activity in many major cities (Bruschi V.M., et al., 2013). The study of urbanization in coastal zones is a relatively new area, however the impacts of overpopulation in the future is sensible, which include land use change, accelerated subsidence, diminished water quality, pollution and vulnerability of coastal wetlands and coral reefs (UNU-IHDP, 2015).

Rayong Province is one of the eastern seaboard provinces of Thailand which makes it one of the biggest coastal cities of Thailand because of its thriving economic activity. Rayong is a province with high potential in terms of investment, industry and tourism. The population has increased in the past decades resulting in a rapid change in land use along the coastlines.

Coastal land use change is a major cause of landform change along the coastline. The majority of lands in Rayong province are used for tourism and industrial sectors. The expansion of the city and its buildings occurs to have a persistent influence on the change of coastline.

This study aims to study the change of coastal area caused by the expansion of the urban area in Phe district, Rayong province in order to compare the landform change rate using Digital Shoreline Analysis System (DSAS) with geographic information system (Figure 1.). Digital Shoreline Analysis System (DSAS) is a computer software extension in ArcGIS that can be used to calculate the rate of change of coastline positions over several periods of time using Geographic Information System (GIS). It is also useful to calculate the rate of change of other boundaries with clearly defined positions in discrete time (USGS, 2017).

The results of this study provide useful information for the community, government authorities, and private organization in order to frame their policies and plans for coastal management and protection in the future. Furthermore, historical shoreline change statistics can be used to monitor coastal environmental changes such as climate change, sea level change, and sedimentation accumulation rates.

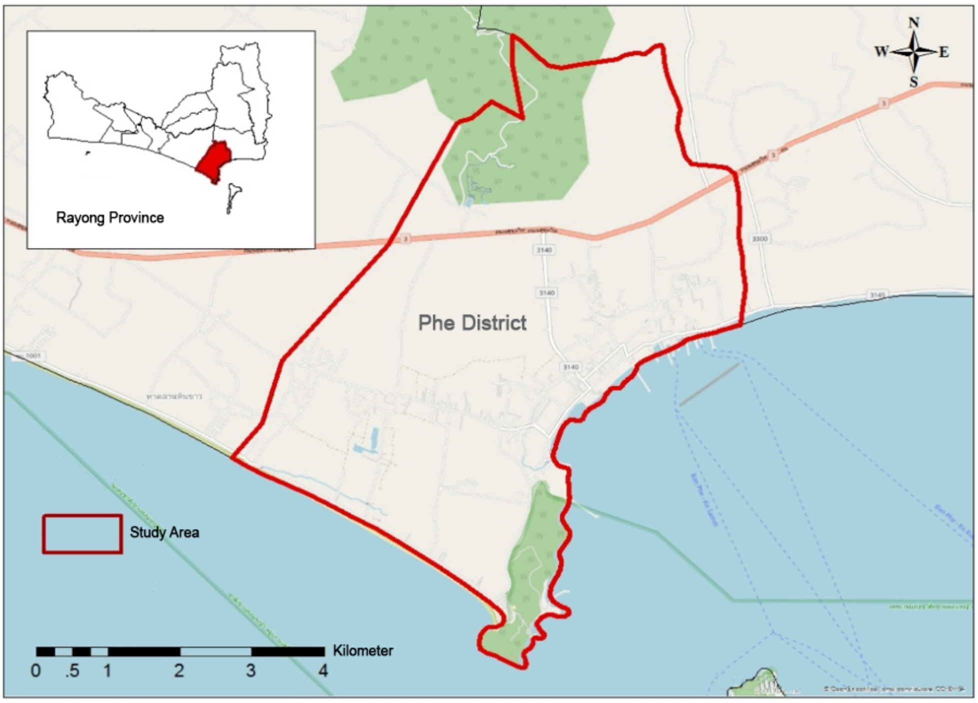

Figure 1. Map of study area located in Phe district, Royong province, Thailand

2. OBJECTIVE

2.1 To analyze the changes of shorelines over a 16-year period in Phe district, Rayong province, Thailand from the year of 1999 to 2015.

2.2 To assess the shoreline change situation of Phe district, Rayong province, Thailand.

3. METHODOLOGY

Conceptual framework of the study of Evaluation of Urban Expansion on the Change of Coastal Morphology Using Digital Shoreline Analysis System (DSAS): A Case Study of Rayong Province, Thailand represents the process of the study as shown in Figure 2. GIS database consists of Remote Sensing (RS), Vector, and Raster data. The dataset is imported into the digital shoreline analysis system (DSAS) using following methods; 1) User defines the baseline and 2) multiple coastline dataset is defined 3) Then, the coastline analysis was performed by comparing shoreline movement in DSAS. 4) The map of shoreline change is generated from digital shoreline analysis system in geographic information system environment.

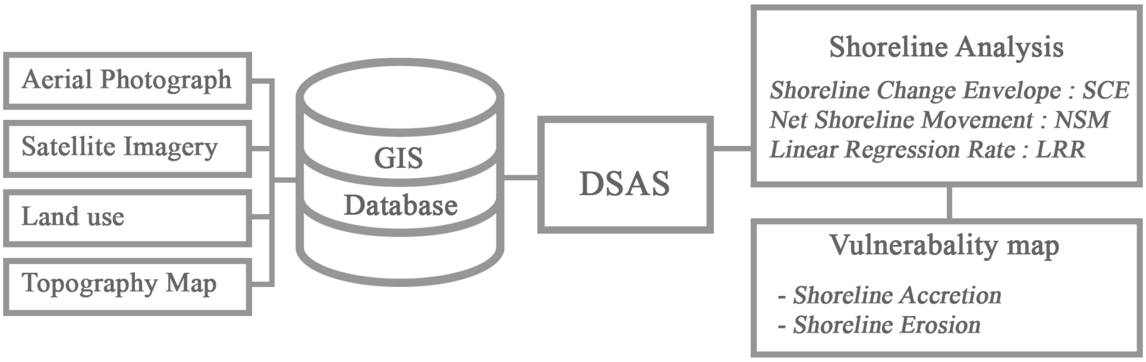

Figure 2. Conceptual framework of the study of Evaluation of Urban Expansion on the Change of Coastal Morphology Using Digital Shoreline Analysis System (DSAS): A Case Study of Rayong province, Thailand

In this study, the Digital Shoreline Analysis System (DSAS) was used to analyze shoreline changes. The investigation of changes in shoreline positions in Phe district coastal area was carried out using Satellite imagery (Landsat 5 and Landsat 8) and aerial photography available for the period between 1999 and 2015. Shoreline movements were measured from historical vegetation line index by digitizing in GIS using the DSAS extension developed by the USGS. The statistics that were used to analyze are as follows; 1) Shoreline Change Envelope (SCE), 2) Net Shoreline Movement (NSM), 3) Linear regression rate (LRR)

4. RESULTS

4.1 Shoreline Change Envelope (SCE)

Shoreline Change Envelope reports the distance between shorelines measured furthest and closest to the baseline for each transect. This represents the total change in movement of the shorelines. The average coastline of 32.81 meters had changed during the period of 16 years from 1999 to 2015 which can be classified into 5 levels (Table 1): 1) Very low level of coastline change ranges from 0 to 20 meters with an average distance of 2,780.10 meters. 2) Low level change of coastline ranges from 20.01 to 40 meters with an average distance of 6,090.22 meters. 3) Moderate level of coastal change variates in the range of 40.01 to 60 meters, with an average distance of 4,017.24 meters. 4) High level of change ranges from 60.01 to 80 meters with an average distance of 296.99 meters. And 5) Very high level of the shoreline change ranges more than 80 meters with an average distance of 199.84 meters

4.2 Net Shoreline Movement (NSM)

The Net Shoreline Movement accounts the distance between the oldest and youngest shoreline features for each transect. The results indicate that net shoreline movement can be classified into 5 levels 1) Very low level is in the range of 0 to 20 meters, with an average distance of 1,663.10 meters. 2) Low level is in the range of 20.01 to 40 meters with an average distance of 6,619.31meters. 3) Moderate level ranges from 40.01 to 60 meters, with an average distance of 3,893.10 meters. 4) High level ranges from -60.01 to 80 meters, with an average distance of 795.27 meters. The average net shoreline movement in the study area is 32.95 meters (Table 2).

4.3 Linear regression rate (LRR)

The R-squared statistic, or coefficient of determination, is the percentage of variance in the data that is explained by regression statistics. It is a dimensionless index that ranges from 1.0 to 0.0 and measures how successfully the best fit line accounts for variation in the data. In other words, it reflects the linear relationship between data sets. The r-squared value quantifies the proportion of the variability in the dependent variable (Y) that is explained by the regression model through the independent variable (X). The results show that the erosion rate of the study area over the 16 years from 1999 to 2015 had an average linear regression rate of 1.96 m yr^{-1} with $R^2 = 0.9819$ (Figure 3). The study divided the LRR rates into 5 levels: 1) High accretion coastline is rated over 8 m yr^{-1} with the average distance of 385.91m. 2) Moderate accretion coastline is rated between 4.00 and 7.99 m yr^{-1}, with an average distance of 448.73m. 3) Low accretion coastline is rated between 2.001 and 4 m yr^{-1}, with an average distance of 7,069.62m. 4) Stable coastline is rated between 0.001 and 2 m yr^{-1}, with an average distance of 2,096.73m. And 5) Erosion coastline is rated below 0.001 m yr^{-1} (Table3).

Table 1. Shoreline Change Envelope (SCE).

SCE	interval (m)	Average distance (m)
Very low	0 - 20	2,780.10
Low	20.1 - 40	6,090.22
Moderate	40.1 - 60	4,017.24
High	60.1 - 80	296.99
Very high	> 80.1	199.84

Table 2. Net Shoreline Movement (NSM).

NSM	interval (m)	Average distance (m)
Very low	0 - 20	1,663.10
Low	20.1 - 40	6,619.31
Moderate	40.1 - 60	3,893.10
High	60.1 - 80	795.27
Very high	> 80.1	399.74

Table 2. Linear regression rate (LRR).

LRR	Interval (m yr^{-1})	Distance (m yr^{-1})
Erosion	-1.570 – 0.000	3,570.31
Stable coastline	0.001 – 2.000	2,096.73
Low accretion	2.001 – 4.000	7,069.62
Moderate accretion	4.001 – 7.999	448.73
High accretion	>8	385.91

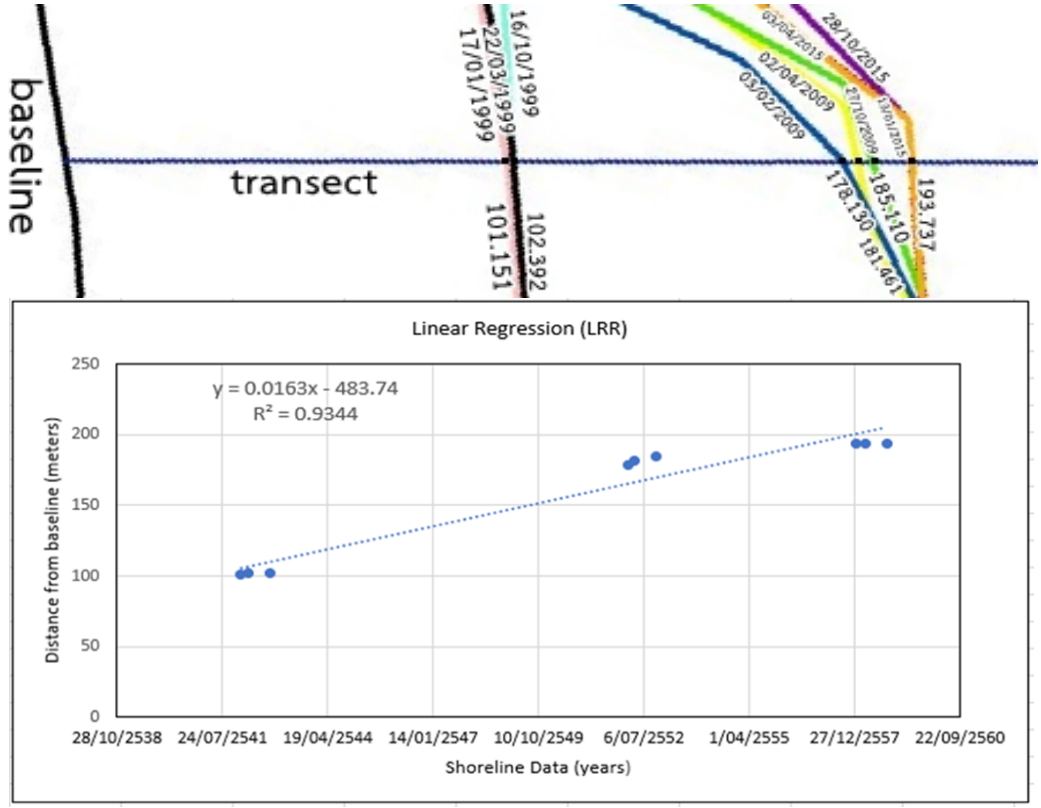

Figure 3. Graph of Linear regression rate (LRR) with $R^2 = 0.9344$

5. CONCLUSION AND DISCUSSION

Application of Geographic Information System for Coastal Erosion Analysis using Digital Shoreline Analysis System (DSAS): A Case Study of Phe District, Rayong Province applied the remote sensing technique to analyze the change of shoreline over the 16 years from 1999-2015. The study discovered that the study area has average accretion rate of 1.96 meters per year with r-squared value of 0.9344. The coastline of agricultural land use had increased with an average rate of 3.12 meters per year. The coastline of urban area had increased with an average rate of 2.13 meters per year. The coastline of forest area average forest had increased with an average rate of 1.43 meters per year. The beach area had increased with an average rate of 1.34 meters and the open space area had increased with an average rate of 0.75 meters per year, respectively (Figure 4).

The scenario observed here can be compared to the study of Cheryl J. et al. (2013) who investigated the change of coastline using NOAA satellite images by applying geographic information system (GIS) in conjunction with digital shoreline analysis system (DSAS). The study found that human activities related to land use had influenced the coastal landforms change with increasing rates in urban areas and tourist areas.

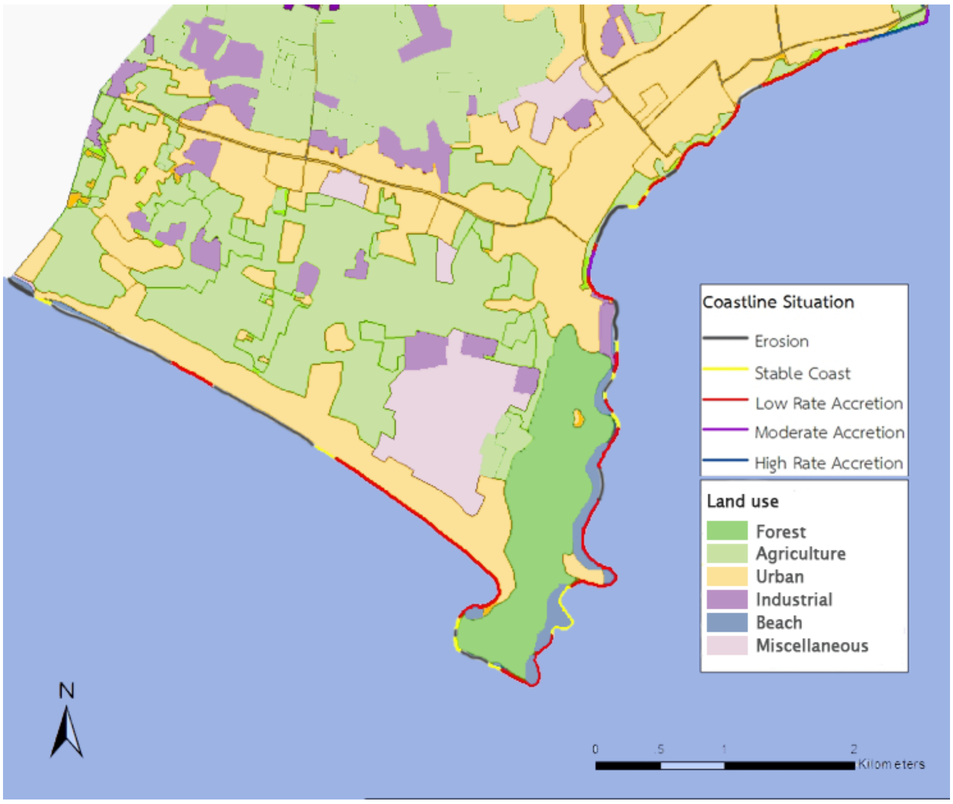

Figure 4. Coastline situation of Phe district, Rayong province, Thailand

6. RECOMMENDATION

DSAS is a computer software that calculates the rate of change in coastline positions over several periods of time using GIS for data analysis. The software developed by U.S. Geological Survey is a reliable institution. Accuracy and accuracy are reliable in the middle. DSAS can also be used to calculate the rate of change of other boundaries that are clearly marked in a discrete time. In this research, it is only an analysis and evaluation of the erosion situation using statistical methods. Fieldwork should be studied in the actual area in order to obtain accurate information.

7. REFERENCES

Bruschi V.M., Bonachea J., Remondo, J., Gómez-Arozamena J., Rivas V., Méndez G., Naredo J.M., Cendrero A. (2013). Analysis of geomorphic systems' response to natural and human drivers in northern Spain: Implications for global geomorphic change. Geomorphology 196. pp 267–279.

Cheryl J. Hapke, Meredith G. Kratzmann, Emily A. Himmelstoss. (2013). Geomorphic and human influence on large-scale coastal change. Geomorphology 199. pp 160–170.

UNU-IHDP. (2015). Coastal Zones and Urbanization Summary for Decision-Makers.

U.S. Geological Survey. (2016). Digital Shoreline Analysis System. NOAA.