Application of Geographic Information System for Coastal Erosion Analysis using Digital Shoreline Analysis System (DSAS): A Case Study of Songklong Sub-district, Bang Pakong District, Chachoengsao Province, Thailand

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ABSTRACT

This study aims to analyze the change of shoreline over the period of the year of 2002-2016 (15 years) by using Geographic Information System together with Digital Shoreline Analysis System (DSAS). The study was conducted at Songklong district, Amphoe Bangpakong, Chacheongsoa, Thailand with the coastal distance of 16.28 kilometers. Satellite imagery and aerial photography were used to analyze the coastal change in the study area. The statistics that were selected to evaluate the change of shoreline are included of Net Shoreline Movement (NSM), Shoreline Change Envelop (SCE) and Linear Regression Rate (LRR). The results show that in 2017 the average Net Shoreline Movement was -66.86 meters which means that the shoreline has been decreased continuously in the past 15 years due to coastal erosion. The Shoreline Change Envelop was 84.60 meters. The Linear Regression Rate results indicate that the average erosion rate was -5.62 m yr^{-1}. The high erosion rate area occupies the distance of 4.21 kilometers (40%), the moderate erosion rate area was 4.74 kilometers (45.01%), the stable coastal area was 1.25 kilometers (11.9%) and the coastal accretion rate area was 0.33 kilometer (3.09%), respectively. In conclusion, the coastal erosion situation of the study area can be defined as high erosion area because it has coastal erosion rate more than 5 m yr-1 (Department of Marine and Coastal Resources, 2013). Furthermore, the results can provide the contribution to practices of coastal planning and management in a coastal area, moreover, historical shoreline change statistics can be used to monitor coastal environmental changes such as climate change, global warming, sea level change, and sedimentation accumulation rates.

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Keywords- coastal erosion, Digital Shoreline Analysis System (DSAS), shoreline change analysis

1. INTRODUCTION

The coast of Thailand covers a total area of about 2,600 km covering 23 provinces. The coastal distance of the Gulf of Thailand is approximately 1,650 km long covering

coastal areas in 17 provinces including Bangkok, Samut Prakan, Samut Sakhon, Samut Songkhram, Phetchaburi, Prachuap Khiri Khan, Trat, Chanthaburi, Rayong, Chonburi, Chachoengsao, Chumphon, Surat Thani. Songkhla, Pattani and Narathiwat. Whereas the Andaman coast line has a length of about 950 km covering the coastal areas of six provinces including Ranong, Phangnga, Phuket, Krabi, Trang and Satun [1].

At present, Thailand's coastline is experiencing coastal erosion as well as coastal countries around the world. The erosional situation has continued throughout the Gulf of Thailand and the Andaman Sea. In the part of the Gulf of Thailand, the coastal erosion occurs along the coastline from the coast of Trat Province to Narathiwat Province. At present, many areas with severe erosional situation are in critical condition resulting in destruction to coastal resources, for instance, houses, buildings, habitats, quality of life and even local cultures of the community. Coastal erosion also affects the scenery of the coast. The government spent a lot of money in order to prevent and solve the coastal erosion problem.

Bang Pakong district, Chachoengsao province is situated in the coastal area of the Gulf of Thailand (figure 1) which is classified as a critical areas of high erosion rate at 5 m yr^{-1} [1]. The coastline of Bang Pakong district is 16.28 km in lenght which is characterized by a mudflat marine clay soil type covered by mangrove forests. At present, coastal erosion situation in Bang Pakong district is occurring continuously and coastal areas are severely eroded [1].

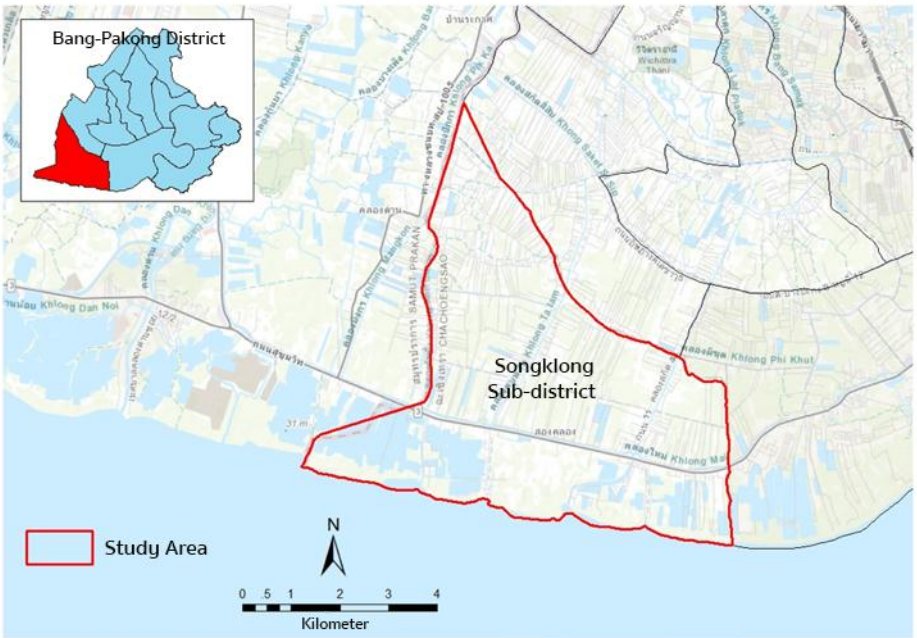

Figure 1. Map of the study area location at Songklong district, Amphoe Bangpakong, Chacheongsoa, Thailand

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 [3]. This study is focuses on analyzing the shoreline changes situation in the area of Songklong sub-district, Bang Pakong district, Chachoengsao Province using Digital Shoreline Analysis System (DSAS) and GIS to study the severity rate of coastal

erosion. The results of this study provide useful information for the community, local government and government authorities and private organization to formulate policies and plans for coastal erosion management and protection. It also reduces the impact of coastal, economic, social and environmental erosion in the future. Furthermore, the results can provide the contribution to practices of coastal planning and management in a coastal area, moreover, historical shoreline change statistics can be used to monitor coastal environmental changes such as climate change, global warming, sea level change, and sedimentation accumulation rates.

2. OBJECTIVE

2.1 To analyze the changes of shorelines over a 15-year period in Songklong sub-district, Bang Pakong district, Chachoengsao Province from the year of 2002 to 2016.

2.2 To assess the erosion situation of Songklong sub-district, Bang Pakong district, Chachoengsao Province.

3. METHODOLOGY

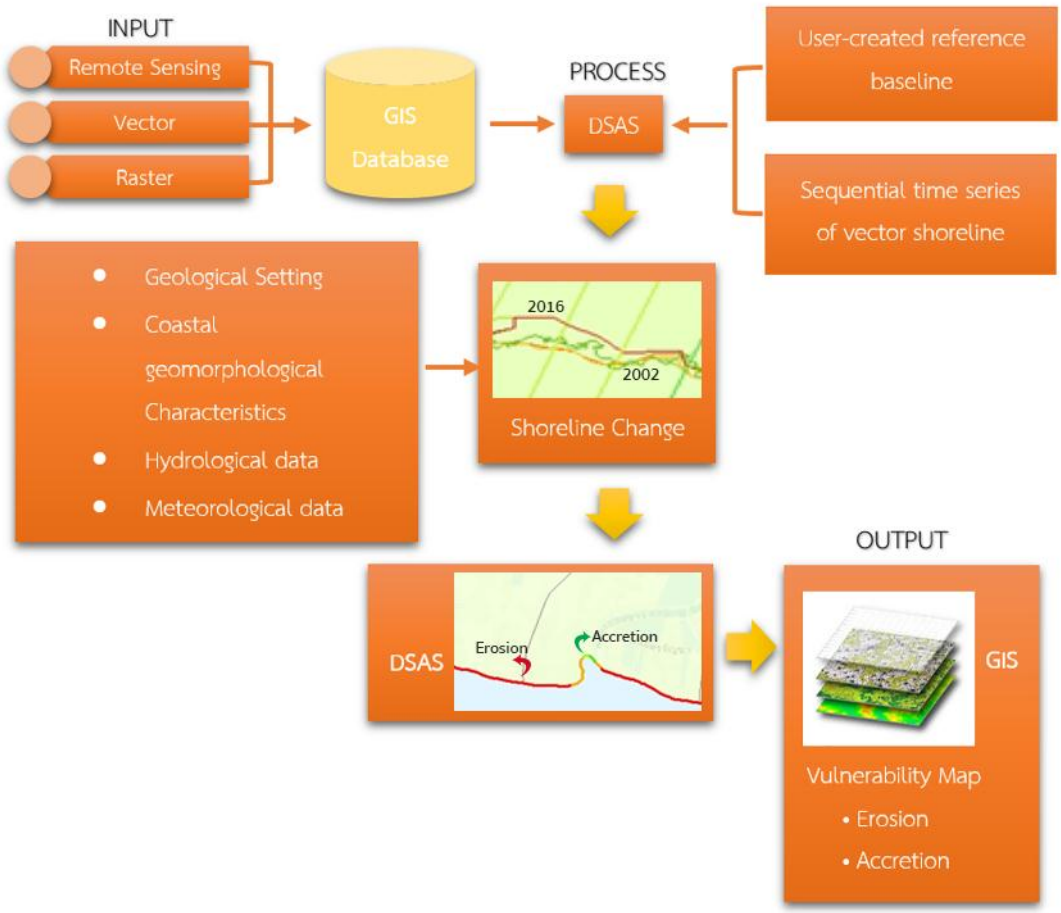

Figure 2. Conceptual framework of the study of Application of Geographic Information Systems for Coastal Erosion Analysis Using Digital Shoreline Analysis System (DSAS): A Case Study of Songklong sub-district, Bang Pakong district, Chachoengsao Province, Thailand

Conceptual framework of the study of Application of Geographic Information Systems for Coastal Erosion Analysis Using Digital Shoreline Analysis System (DSAS): A Case Study of Songklong sub-district, Bang Pakong district, Chachoengsao Province represents the process of the study. This can be explained as shown in figure 2. GIS database consists of Remote Sensing (RS), Vector (Vector), and Raster data. Then, data is imported into the digital shoreline analysis system (DSAS) using following methods; 1) User defined baseline and 2) Define multiple coastline dataset 3) Then, the coastline analysis was performed by comparing shoreline movement in DSAS. 4) The map of coastal erosion and shoreline change is generated from digital shoreline analysis system in geographic information system environment.

The investigation of changes in shoreline positions in Songklong sub-district's muddy coastal area is carried out using Satellite imagery (Landsat5 and Landsat8) and aerial photography available for the period between 2002 and 2016. Shoreline movements were measured from historical vegetation line index by digitizing in GIS using the DSAS extension developed by the United States Geological Survey (USGS). In this study, the Digital Shoreline Analysis System (DSAS) was used to analyze shoreline changes. 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)

The choice of DSAS statistical parameters in the case study has been able to explore the temporal and spatial dynamics of the coastal change and the geomorphic variability along the beach because of their ability in making use of all shoreline positions (SCE), the cumulative shoreline movement (NSM) and Linear regression rate (LRR) which summarize the rate-range of the historical dataset.

Shorelines were digitized from each Satellite image and aerial photograph. The standard DSAS shoreline change measures - Net Shoreline Movement (NSM) was calculated. Net Shoreline Movement (NSM): reports the distance between the oldest (2002) and the youngest (2016) shorelines, which presents the overall change in shoreline position for the 15 year period.

4. RESULTS

4.1) Shoreline Change Envelope (SCE)

Table 1. Shoreline Change Envelope (SCE) of Songklong sub-district

Level of change	**interval (m)**	**Average distance (m)**
Very low	0-50	3,985.65
Low	50.01-100	2,742.64
Moderate	100.01-150	1,364.99
High	>150.01	1,781.20

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 and is not governed by the age of the shorelines. The average coastline of 84.60m was moved as shown in figure 3. The results show that changes of coastline during the period of 15 years from 2002 to 2016 can be classified into 4 levels (table 1): 1) Very low level change of coastline ranges from 0 to 50 m with an average distance of 3,985.65 m. 2) Low level change of coast line ranges from 50.01 to 100m, with an

average distance of 2,742.64m. 3) Moderate level of coastal change variates in the range of 100.01 to 150 meters, with an average distance of 1,364.99m. And 4) High level of the shoreline change ranges from 150.1 to 213.43m with an average distance of 1,781.2 m.

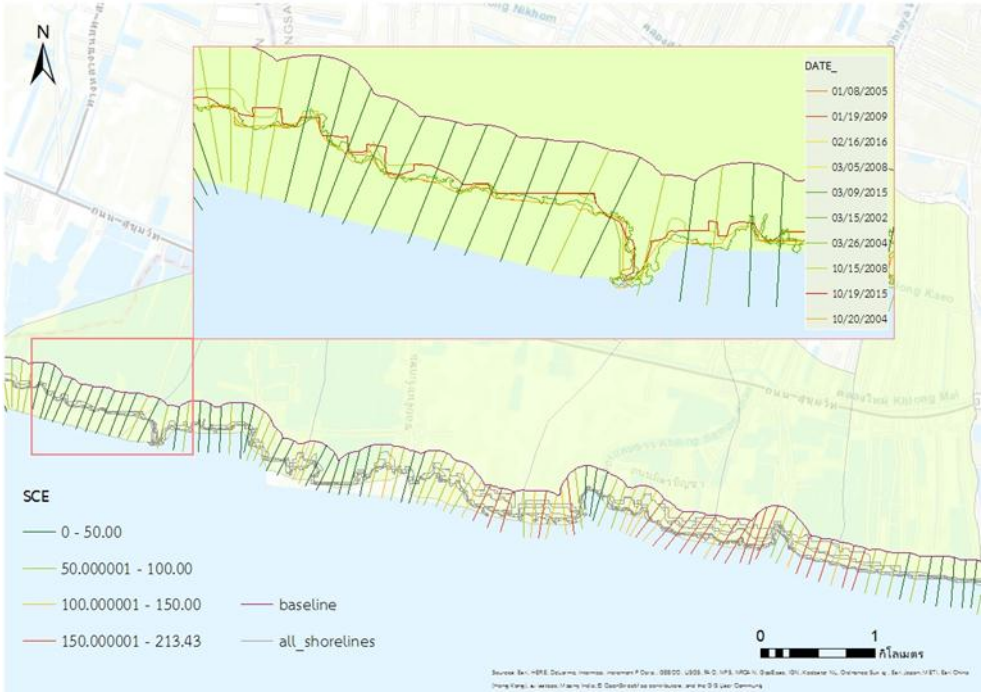

Figure 3. Map of Shoreline Change Envelope (SCE) of Songklong sub-district

4.2) Net Shoreline Movement (NSM)

The Net Shoreline Movement reports the distance between the oldest and youngest shoreline features for each transect. The results indicate that net shoreline movement in the area of Songklong sub-district during the period of 15 years from 2002 to 2016 can be classified into 4 levels (table 2), which are 1) Very low level of net shoreline movements are in the range of 0.01 to 50 meters, with an average distance of 1,581.19 meters. 2) Low level of net shoreline movement is in the range of -49.99 to 0 meters with an average distance of 3,685.65 meters. 3) Moderate level of net shoreline movement ranges from -99.99 to -50 meters, with an average distance of 1,766.65 meters. 4) High level of net shoreline variation ranges from -19.22 to -100 meters, with an average distance of 2,940.75 meters. The average net shoreline movement in the study area is 66.86 meters shown in figure 4.

Table 2. Net Shoreline Movement (NSM) of Songklong sub-district

NSM	**interval (m)**	**Average distance (m)**
Very low	0.01 to 50	1,581.19
Low	-49.99 to 0	3,685.65
Moderate	-99.99 to -50	1,766.65
High	< -100	2,940.75

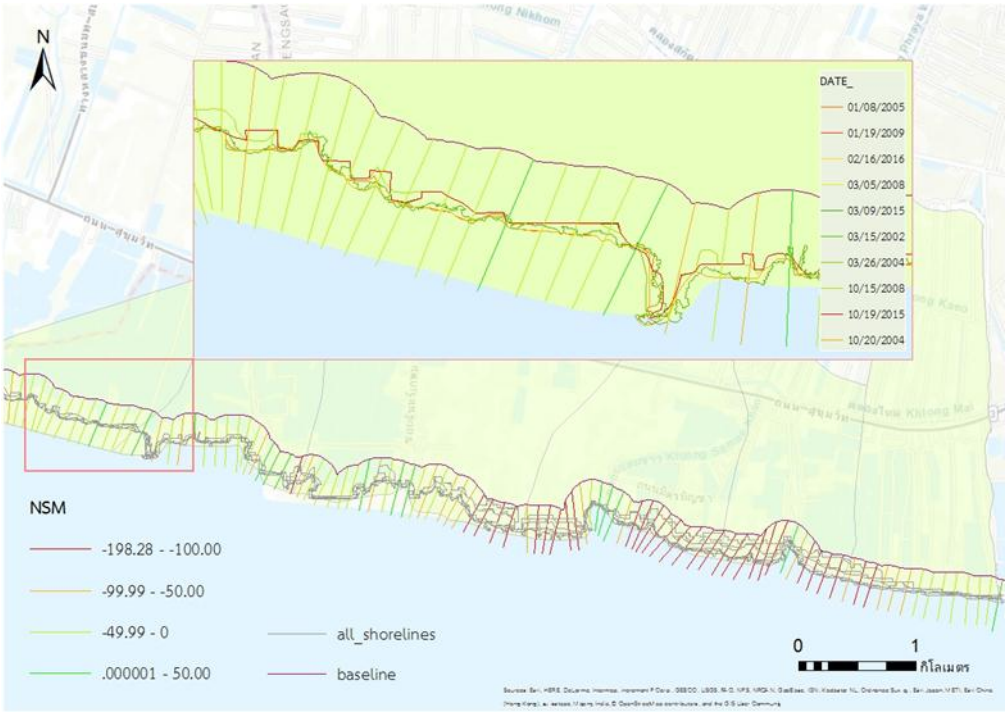

Figure 4. Map of Net Shoreline Movement (NSM) of Songklong sub-district

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 a regression. 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 smaller the variability of the residual values around the regression line relative to the overall variability, the better the prediction. The results show that the erosion rate of the study area over the 15 years from 2002 to 2016 can be divided into 4 levels (table 3): 1) Accretion coastline is rated over 1 m yr^{-1} with the average distance of 330m. 2) Stable coastline is rated between -0.99 and 0 m yr^{-1}, with an average distance of 1,250m. 3) Low erosion is rated between -4.99 and -1 m yr^{-1}, with an average distance of 4,740m. 4) High erosion is rated between -15.99 - 5 m yr^{-1}, with an average distance of 4,210m. The study found that the study area has erosion rate of -5.62 m yr^{-1} with R2=0.9819 (figure 5 and figure 6)

Table 3. The table shows the erosion rate of the study area over the 15 years from 2002 to 2016

Erosion Rate	Interval (m yr^{-1})	Distance (m)
Accretion	< 1	330
Stable coastline	-0.99 to 0	1,250
Low erosion	-4.99 to -1	4,740
High erosion	-15.99 to -5	4,210

Figure 5. The map summarizes the scales and rates of change in shoreline position at Songklong sub-district beach with the average erosion rate of -5.62 m yr^{-1} with R2=0.9819.

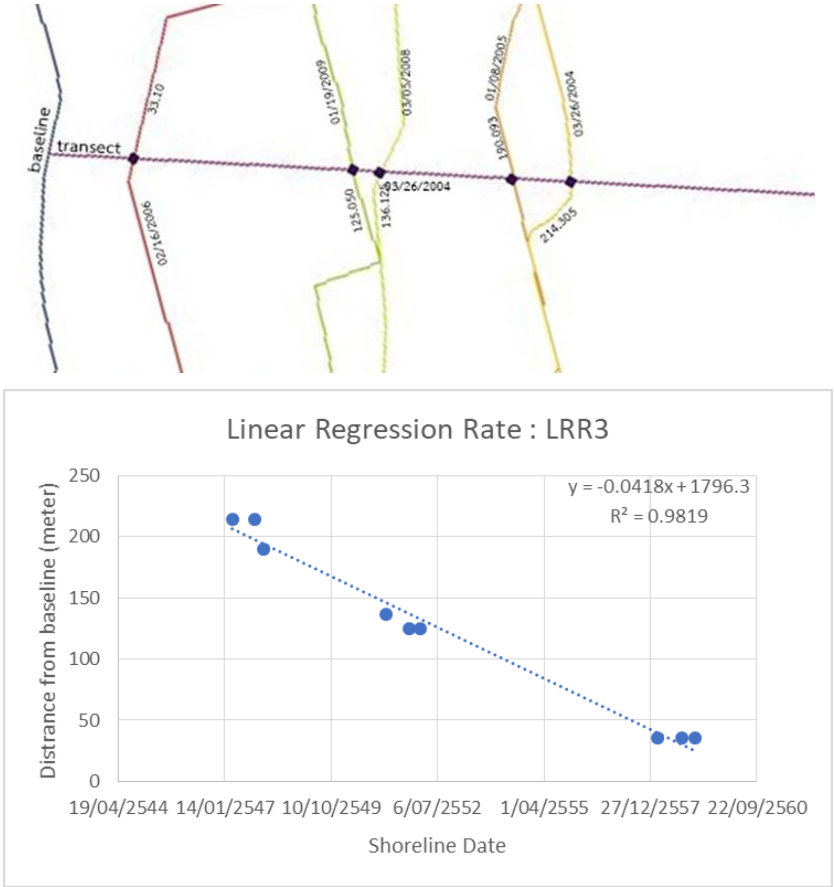

Figure 6. The figure shows Linear Regression Rate : LRR at Songklong sub-district beach with the average erosion rate of -5.62 m yr^{-1} with R2=0.9819.

5. CONCLUSION AND DISCUSSION

Application of Geographic Information System for Coastal Erosion Analysis using Digital Shoreline Analysis System (DSAS): A Case Study of Songklong Sub-district, Bang Pakong District, Chachoengsao Province utilized the satellite imagery and aerial photos to analyze the change of shoreline over the period of the year of 2002-2016 (15-year period). The study found that the study area has erosion rate of -5.62 m yr^{-1} with R2=09819, which indicates that area is classified into the level of severe erosion with erosion rates of more than 5 m yr^{-1}.

The coastal area of Songklong sub-district is characterized by a mudflats covered by mangrove forest during the high tide it will be submerged and will emerge when the water is low. The sediment dated less than 5,000 years old with gray or greyish green, consisting of a large amount of organic matter. The area is abundant of many living organisms with a complex ecosystem. This area is the most sensitive and prone to erosion area because of the sediment transportation activities [1].

The situation observed here can be compared to what S. Oraon and K. Nakapakorn (2014) [2], who applied geographic information system to the erosion situation of the coast. The study found that the coastal area of Phetchaburi was eroded at a total distance of 11,638 m. The coastline eroded severity by more than 4 m yr^{-1}, which is different from the results of Songklong Sub-district, Bang Pakong District, Chachoengsao Province.

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.

REFERENCES

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