MONITORING SHORELINE CHANGE IN THE COASTAL AREA OF QUANG TRI, VIETNAM BY USING REMOTE SENSING AND GIS

Pham Thi Phuong Thao[(1)] and Ho Dinh Duan[(2)]

[(1)]Institute of Oceanography, Vietnam. Email: pthaopt@gmail.com

[(2)]Hue Institute of Resources, Environment and Sustainable Development.

Email: duanhd@gmail.com

Abstract

Shoreline evolution is one of great concerns for coastal engineers and managers. Nowadays, it is easy and effective when using remote sensing combining with GIS tools to monitor erosion/deposition and calculate rates of change along a coast. In this paper, these techniques were applied in Quang Tri province, Vietnam from 1986 to 2010 by using Landsat images. Shoreline change rate was calculated by Digital Shoreline Analysis System (DSAS), an ArcGIS extension. The results showed that shoreline tended towards accretion in this area in general. At two estuaries, shorelines were observed to have changed remarkably due to a complex littoral processes and sediment discharge from rivers.

Keywords: Landsat, remote sensing, GIS, DSAS, shoreline change

1. Introduction

Shoreline evolution is one of great concerns for coastal engineers and managers because it can make a lot of damage for local economy and people. The erosion, for example, can affect strongly to coastal constructions, tourism beaches, and fishing villages while the deposition can make trouble for ship to transport near estuary because of dunes, sand bars or a narrow width of river mouth.

In this paper, Landsat images were used for monitoring shoreline change at Quang Tri area, especially at two river mouths. First, shorelines at different time slices were extracted from analysis of Landsat images. After that, extracted shoreline data was imported into DSAS to calculate rates of change in the period of 1989-2010.

2. An overview of the study area - Quang Tri province coastlines

The study area is Quang Tri coast stretching from Mui Lay to Hai Duong with 50km in length. There are two estuaries, namely, Tung estuary and Viet estuary in this area. Therefore, four regions are divided as follows (Figure 1): Region 1 is Tung estuary; Region 2 is from southern Tung estuary to northern Viet estuary (~14 km); Region 3 is Viet estuary; Region 4 is from southern Viet estuary to Hai Duong (~30 km).

Quang Tri is affected by two monsoon seasons, the winter and the summer. The winter monsoon begins from October to March next year. The predominant wind direction in winter is from north and northwest with the mean wind speeds of 3.1-4.4 m/s and 3.4-4.0 m/s, respectively. The summer monsoon begins from April to September with hot and dry wind from southwest. The mean wind speed is approximately 4.5-5.2 m/s [Nguyen Van Cu *et al.*, 2008].

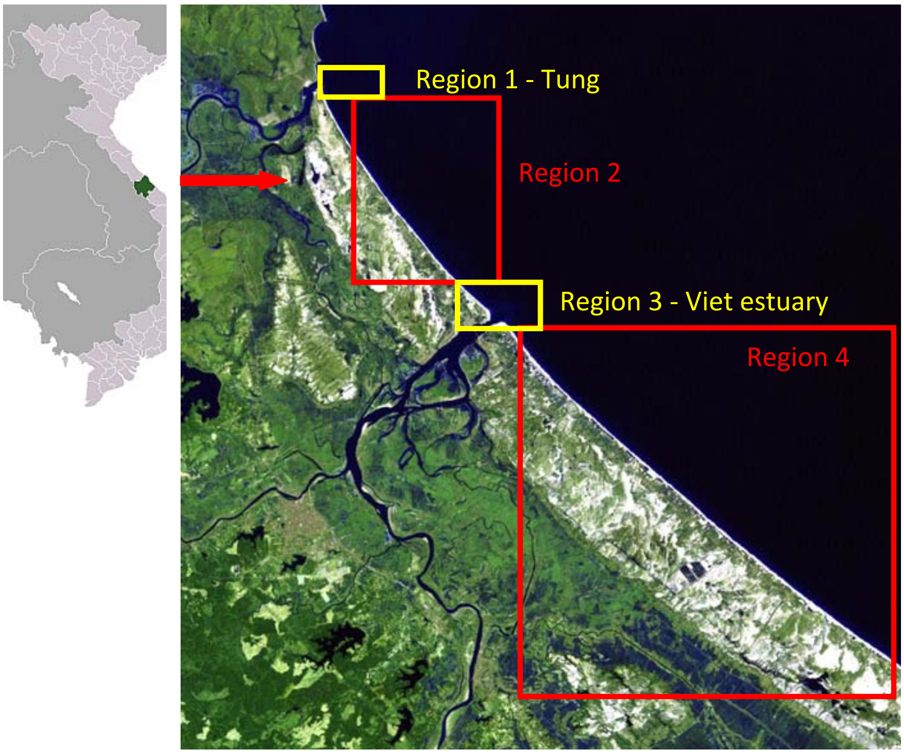


Figure 1. Quang Tri coast – the study area.

About wave regime, predominant direction is from northeast offshore and changes to east nearshore in winter. The wave height is about 0.5-1.5 m. In summer, predominant wave is from southwest and west offshore with 0.5-0.75 m in height and changes to southeast nearshore with 0.3-0.5 m in height [http://moitruong.quangtri.gov.vn/].

3. Methodology and Data

3.1 Methodology

Waterlines were extracted from Landsat images for Quang Tri area. Band threshold was applied in this study. Band 7 was used because its spectrum is good to discriminate water from land [Jensen, 1996]. Tide adjustment was neglected. The first reason is because the resolution of Landsat image is not very high (30m) and tide amplitude is small (approximately 1.2m) in this region. Second, the precise data of beach profile are not always available. Therefore, extracted waterlines were assumed as shorelines.

After having shoreline data, rates of change were calculated by using DSAS. The process includes three main steps: (1) setting up baseline and shorelines; (2) choosing parameters for transects; and (3) calculating shoreline change rates

3.2 Data

Source of imagery data is from the website of United States Geological Survey (USGS). All Landsat images have the same projection of WGS-84, zone 48 and the same 30m resolution. In addition, sea level data was collected from WXTide32 (http://www.wxtide32.com) for Nhat Le River station. All data are listed in Table 1.

Tabe 1. List of Landsat scenes used to extract Quang Tri shorelines and sea level data.

No.	Sensor	Date	Local Time	Sea level (cm)
1	Landsat 4TM	08/01/1989	09h45	66
2	Landsat 5TM	28/06/1996	09h25	61
3	Landsat 7ETM+	30/05/2000	10h04	44
4	Landsat 5TM	04/05/2005	10h00	29
5	Landsat 5TM	11/02/2010	10h03	46

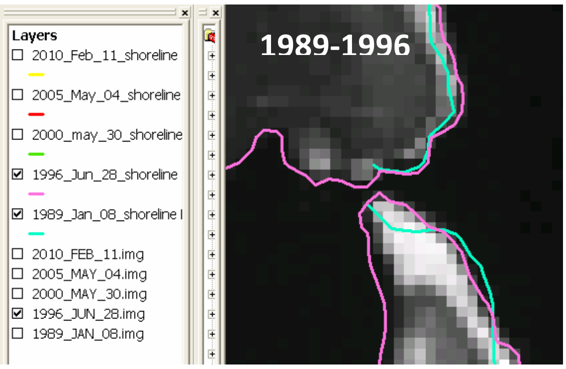
Note: Mean sea level at Nhat Le station (for Quang Tri area) is about 60 cm.

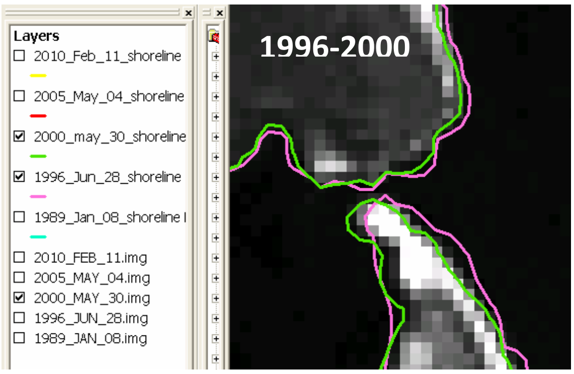
All images are from January to June in year to prevent sudden great shoreline changes in a very short time due to storm period.

4. Results and Discussions

In region 1 and 3, shoreline change has occurred so complex because of hydrodynamic processes in the estuaries and the interactions between the estuaries and coastal zone as well. In region 1, there was no jetty at southern Tung estuary before 2005. The width of beach was so narrow. In addition, sand bar at southern estuary tended to spread up to northern estuary, which decreased the width of the river mouth. This could make trouble for ships to go to Viet estuary port which is near the river mouth. After 2005 with jetty construction, sediment deposited at southern estuary, which increased the width of beach and made the river mouth much wider (Figure 2). The presence of the jetty was not so clear in Landsat image in 2005 and 2010 because the width of the jetty (15m) is so small when comparing to the resolution of image (30m). In region 3, both northern and southern of estuary tended to accretion in 1989-1996 but tended to erosion in 1996-2000 and accretion again in 2000-2005 (Figure 3). However, in the period of 2005-2010, northern part was eroded while southern part was deposited. The reason may be due to the effect of alongshore current combining to sediment source flowing down from river.

In region 2 and 4, shorelines are quite straight, so it is convenient to calculate rates of change by using DSAS. Distance between transects is 100m. Transects are perpendicular to shoreline as shown in Figure 4.





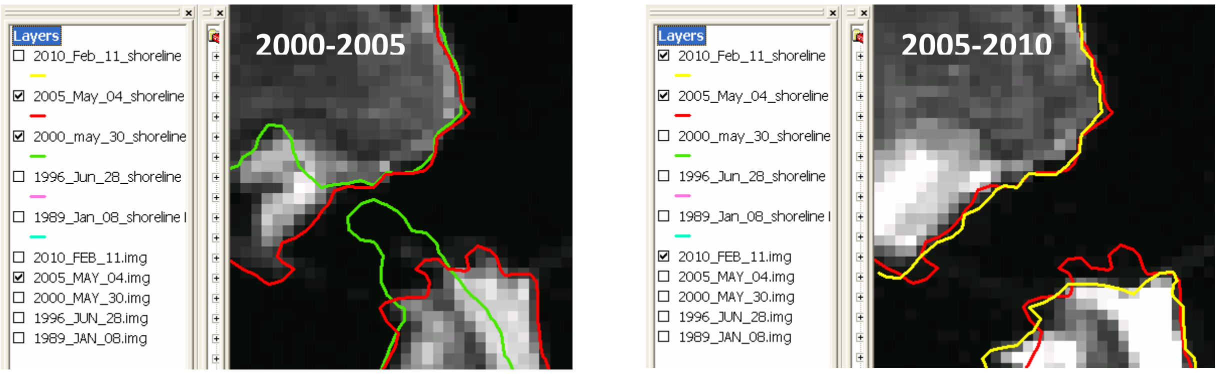


Figure 2. Shoreline change in region 1 – Tung estuary in the period of 1989-2010.

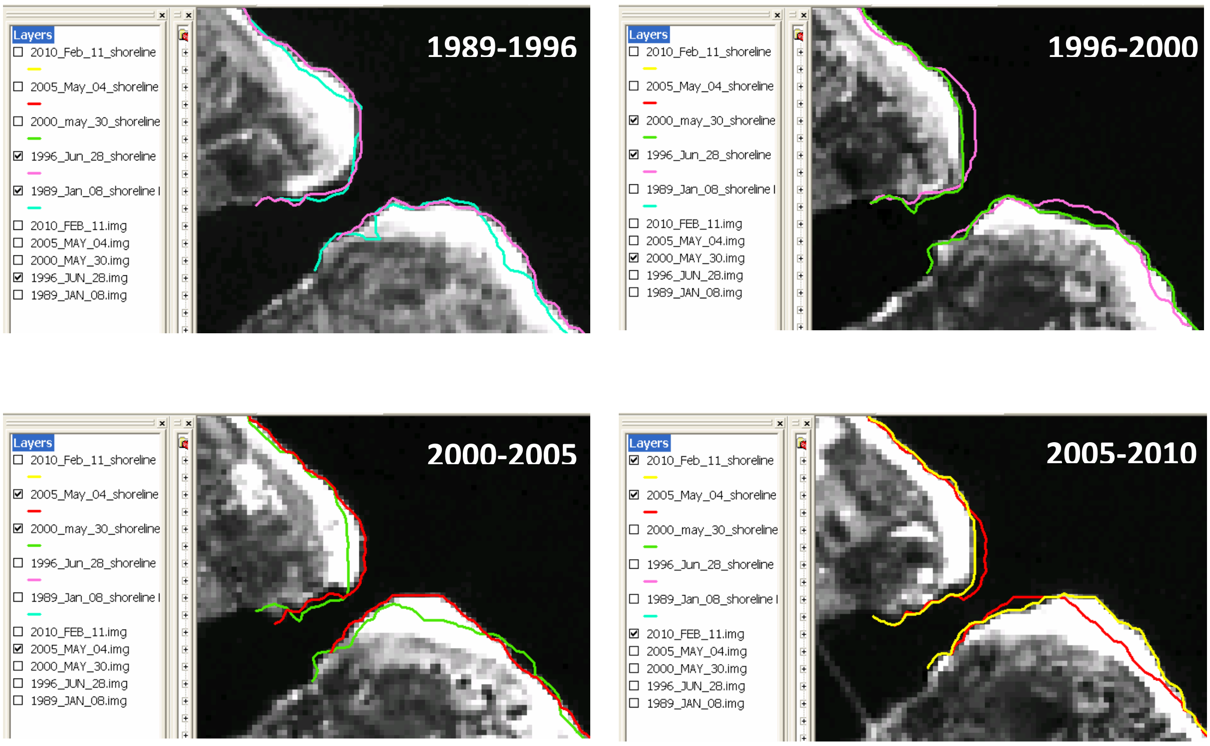


Figure 3. Shoreline change in region 3 – Viet estuary in the period of 1989-2010.

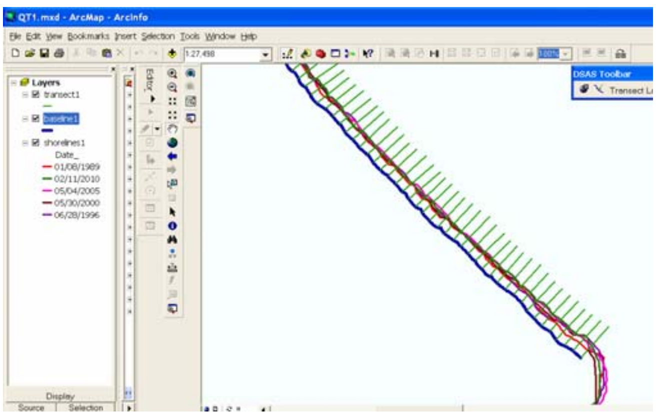


Figure 4. Transects along region 2 - northern Viet estuary.

In region 2, there are 145 transects which were set up along the coast. The shoreline change rate in this region is shown in Figure 5. The positive rate means that shoreline tended to accretion and the negative value means that shoreline tended to erosion. In general, annual rate of change in this region is about +1.4 m/yr by EPR and +1.3 m/yr by LRR. Therefore, shoreline has tended to accretion. However, some places have had small negative rates but values were not excess -0.4 m/yr by EPR and -0.6 m/yr by LRR. Near the mouths of the rivers, high positive rates can be seen with values of +5.6 m/yr and +6.1 m/yr by EPR and LRR respectively. It has shown that shoreline has been strongly affected by sediment source from river and hydrodynamical processes at the river mouth. Comparing the rates between two methods, they have a same trend with a quite small difference in value.

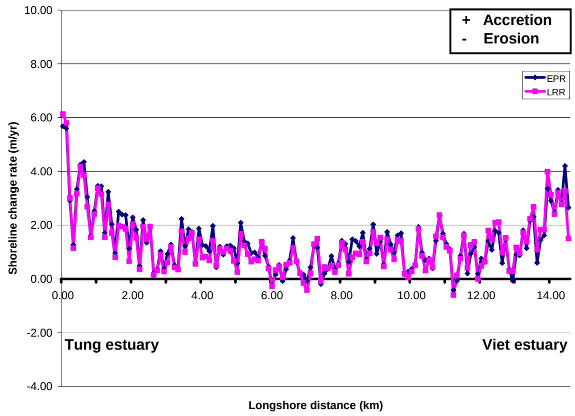


Figure 5. Shoreline change rates in region 2.

In region 4, 305 transects were built along 30 km coast. The shoreline change rates in this region are shown in Figure 6. Average rates of change are +0.9 m/yr (EPR) and +1.0 m/yr (LRR) in the period of 1989-2010. Shoreline tended to go offshore, except some places at the middle of the area was eroded. The maximum rates of change were not over -2m/yr by EPR and -1m/yr by LRR. As same trend in the southern part of Tung estuary, southern Viet estuary tended to accretion with high rates up to +8.9m/yr and +6.9 m/yr by EPR and LRR respectively. The magnitude of rates in this region is higher than in region 2, especially at the river mouth.

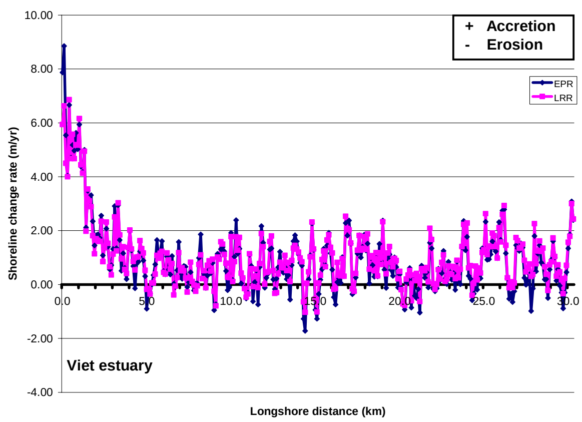


Figure 6. Shoreline change rates in region 4.

5. Conclusions

Using Landsat images can help us to monitor shoreline change in long-term period. At the river mouths as Tung and Viet estuary, shorelines changed significantly due to the interaction of complex processes between river and coastal zone. In addition, the presence of artificial constructions such as jetties was affected so much to sediment discharge in these regions. In region 2 and 4, shoreline tended to accretion in general with the rates around +1m/yr during 1989-2010. The highest rates are near the river mouth with value over +5m/yr.

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