Chapter 33
Studying Shoreline Change in Ky Anh Coastal Area of Ha Tinh Province during 1989–2013 Based on the Digital Shoreline Analysis System (DSAS)

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Abstract Studying shoreline changes is aimed at determining the important engineering techniques and dealing with challenges in multidisciplinary data integration. It becomes the interests of many researchers, local government, and local stakeholders. Various effective models and systems are developed to identify the trend of changes. The Digital Shoreline Analysis System (DSAS) combined with a Geographical Information System (GIS) is applied to monitor the shoreline changes along the Ky Anh Coast (Ha Tinh, Vietnam) in the period 1989–2013. The shoreline positions are determined using Landsat images; the quantification of the erosion and accretion relationship between 1989 and 2013 in different topographical segments; and a map of affected areas where the shoreline is equal to the high tide water line. The findings offer the decision makers, researchers, and local communities to be benefits of monitoring shoreline change and to help have quickly response to the abrupt change in the area.

Keywords Digital Shoreline Analysis System (DSAS) · Shoreline change · Erosion · Accretion · Ky Anh Coastal Area

1 Introduction

Vietnam is one of the most vulnerable countries damaged badly by hazards and risks of climate change impacts, which affect strongly on over 3000 kilometer long coastal line. The coastal area of Vietnam is mainly influenced by three types of hazards that the integrated effect could be associated with climate changes including drought, sea level rise, and extreme weather conditions. The turns of these primary

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effects cause floods and erosion. The impacts of both sea level rise and storms result in the erosion of beaches and dune ridges. As well as through the world, from 1990 up to now, the coastal erosion in Vietnam has witnessed an increase in both length and intensity, especially in the low-lying coastal land made by unconsolidated sediments (sand, silt, and clay).

Digital Shoreline Analysis System (DSAS henceforth) has its own advantages for examining historical shorelines compared with traditional ground survey techniques (Thieler, Himmelstoss, Zichichi, & Ergul, 2009). It is considered as a practical application for decision making in coastal management. Most recently, the combination of remote sensing, GIS, and DSAS was applied in coastal studies, which can be found in notable research on determining the rate of shoreline change along the Kenitra Coast, Morocco, during 1969–2009 (Moussaid, Fora, Zourarah, Maanan, & Maanan, 2015), along the Mangalore Coast, West Coast of India (2005–2013) (Aedla, Dwarakish, & Reddy, 2015), in the north of the Coromandel Coast (1972–2013) (Salghuna & Bharathvaj, 2015), along the Tamil Nadu Coast (1978 to 2014) (Natesan, Parthasarathy, Vishnunath, Kumar, & Ferrer, 2015), along the Karnataka Coast (1991–2014) (Hegde & Akshaya, 2015). In Vietnam, several shoreline studies that applied DSAS are listed below: calculating shoreline change in Nam Dinh Coastal Area (To & Thao, 2008); examining the rates of coastal shoreline change in Kien Giang Coast during 1995–2009 (Nguyen, McAlpine, Pullar, Leisz, & Galina, 2015); and detecting long-term mangrove shoreline changes in Mui Ca Mau (Tran, Tien, Phan, Dahdouh-Guebas, & Koedam, 2014). This paper aims at identifying historical shoreline changes during the period 1989–2014 in the Ky Anh Coastal Area of Ha Tinh Province (in central Vietnam). The rate of erosion and accretion was calculated based on the data derived from satellite images and the result of DSAS analysis.

The rest of the paper is organized as follows: Section 2 presents the DSAS methodology; case study results are indicated in Sect. 3; and finally, conclusion and recommendation are determined in Sect. 4.

2 DSAS Methodology

DSAS, or USGS DSAS (United States Geological Survey Digital Shoreline Analysis System), is a GIS tool (a free available ArcGIS extension) designed by the United States Geological Survey (USGS). Its Web-based version (DSAS Web) was published in 2013. DSAS has been used to analyze coastal change based on detecting shoreline movements and calculating the rate of change as follows: (i) mapping historical shoreline position by using available spatial data; (ii) evaluating historical changes and trends of selected transects; (iii) analyzing shoreline geometry; and (iv) predicting shoreline patterns.

The DSAS approach calculates rates of shoreline change through measuring gaps between the shoreline positions in specific periods of time. According to

Thieler et al. (2009), it is possible for DSAS to measure statistical data. Table 33.1 lists measures, which can show the spatial patterns of shoreline change statistics.

3 The Case Analysis

As shown in Fig. 33.1, Ky Anh is the furthest southwestern district of the Ha Tinh Province. The total district area is 105,428 hectares, entailing 7 coastal communes from Ky Xuan in the north to Ky Nam in the south. The coastline of 7 communes spans 63 kilometers, mainly covering beaches, sandy, and the lesser extent of rocky. Behind the dune ridge, delta zones are covered with irrigated rice fields. A small area, which is dryer, is used for growing peanuts and vegetables. There are low hills, which are covered by conifers, mixed leafy trees, and scrub vegetation. Mangroves, which are merely planted, surround rivers. Lakes provide water for the irrigation of rice.

The most significant driving forces (from both nature and humans) of coastal erosion in Ky Anh are storms, floods, and sandy collection (in Vung Ang Economic Zone). The Ky Anh Coastal Area is frequently affected by tropical storms and induced flooding. Storms happened from the southeast to the northwest or from the southeast east to the northwest west over the area. The frequency increases from January to August, decreasing and dipping in December. During the last 50 years, the Ha Tinh Province was affected by 47 storms, 18 of which impacted directly on the Ky Anh Coastal Area. Ky Anh witnessed on average 0.9 storm per year, and there was an increase in the frequency during recent years. In Vietnam, there were 285 tropical storms between 1951 and 2010 (on average 4.75 tropical storms per year) and 38 tropical storms from 2011 to 2013. However, during recent two half decades (1996–2005), there were only 4 storms (on average 0.4 storms per year). This figure was lower than that in the long-term trend analysis, shown. In the study area, a progression from 20 to 200 m, depending on the inclination of the beach, is reported for the period 2003–2010.

Table 33.1 Statistical measures in DSAS

Statistical measures	Definition
Shoreline change envelope (SCE)	A measure of the total change in shoreline movement that considers all available shoreline positions and reports their distances without reference to their specific dates.
Net shoreline movement (NSM)	A measure reports the distance between the initial position and the latest position of shoreline.
End point rate (EPR)	A measure derived from dividing the distance of shoreline movement during the period of time between the initial positions and the latest position of shoreline.
Linear regression rate (LRR)	A measure that determines a rate of change statistic by fitting a least square regression to all shorelines at specific transects.

Source: Thieler et al. (2009)

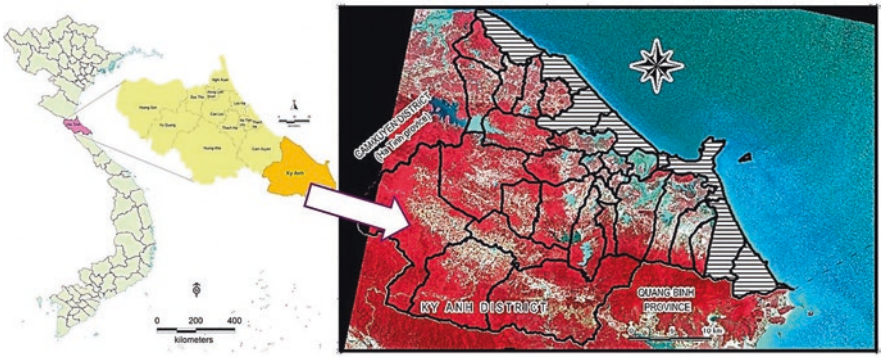

Fig. 33.1 Selected study area in Ky Anh District (Ha Tinh, Vietnam)

Shoreline changes happening in the study area were investigated based on five satellite images, which are available in the period 1989–2013. Movements of both the mean low water (MLW) and mean high water (MHW) are observed through GIS based on DSAS extension developed by the USGS (Thieler et al., 2009). Shorelines were digitized from individual map. Net shoreline movement (NSM) and end point rate (EPR) were calculated. NSM showed the distance between the initial position (1989) and the latest position of shoreline (2013), which indicated the overall change in shorelines position over the 24 years. EPR converted net shoreline movement into an annual rate of shoreline change by dividing the distance of shoreline movement from the initial position to latest position of shoreline passed during a particular period of time period. The 200 m of shoreline in 2013 was chosen as baseline, and 961 transects were created (about the 50 meters of a range of distance) and were numbered in order (Fig. 33.2).

As shown in Fig. 33.3, net erosion and accretion rates were calculated for five sections of coast, using the same boundaries during the periods 1989–2013. During 1989–1996, the rapid accretion of more than 25.25 meters per year (average values are approximately 6.6 meters per year) was observed in the southern Ky Anh District with low erosion of 13.86 meters per year (on average − 3.4 meters per year). The results show that the accretion trend in this period was dominant, and it changed quickly. During 1996–2006, the main trend of shoreline changes was the erosion with more than 5.3 meters per year, which was higher than the accretion rate (3 meters per year) in the study area. Beginning with the erosion, this process happened continuously in whole shorelines with the range featuring from 24 meters per year to 92.5 meters per year during 2006–2013.

Net erosion and accretion rates were calculated for each commune as follows:

- *Ky Xuan Commune:* The coastal zone was observed at 202 transects, which showed that accretion is more than erosion in the period of 1989–2006. The Net Shoreline Movement (NSM) changed from −60 meters at the nearest point to 110 meters at the farthest point. The changing trend in this period was the accretion, with the average highest rates reducing from approximately 14 meters per

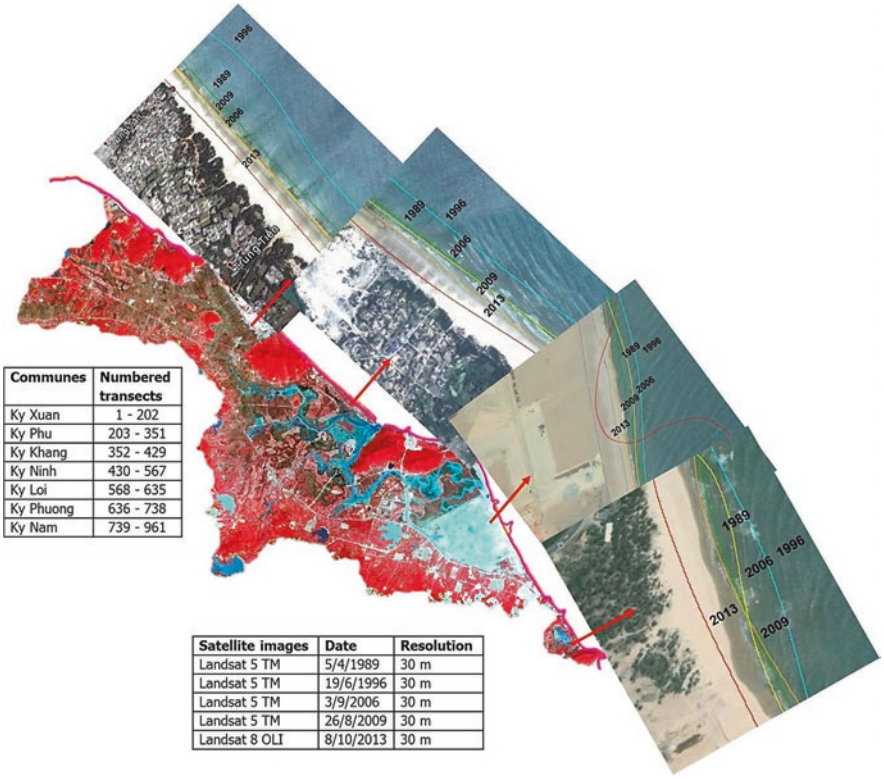

Fig. 33.2 Numbered transects were classified by administrative boundaries

year at the period of 1989–1996 to 5 meters per year at the period of 1996–2006. However, in the year of 2006–2013, the changing trend was transformed into the erosion. The highest rate was 10 meters per year, with the highest movement change of erosion increasing to 160 meters.

– *Ky Phuong, Ky Khang, and Ky Ninh communes:* The shoreline status experienced a change from the accretion during 1989–1996 to the erosion during the period 1996–2013. The shoreline movement changed from 5–20 meters in 1989–1996 to −17.27–0.0 meters in 1996–2006 and to −14–0 meters during 2006–2013. The highest accretion rate was 140 meters per year during 1989–1996. The dominant processes were the erosion, with the highest rate reducing from 170 meters per year in 1996–2006 to 140 meters per year during 2006–2013.
– *Ky Loi Commune:* In Ky Loi Commune, the shoreline movement in 1989–1996 was at the change from −2.5 to 12.3 meters, with the highest accretion rate reaching approximately 88 meters per year and highest erosion rate being −20 meters per year. Therefore, the process of accretion was faster than that of erosion during this period. During 1996–2013, the highest erosion rate increased

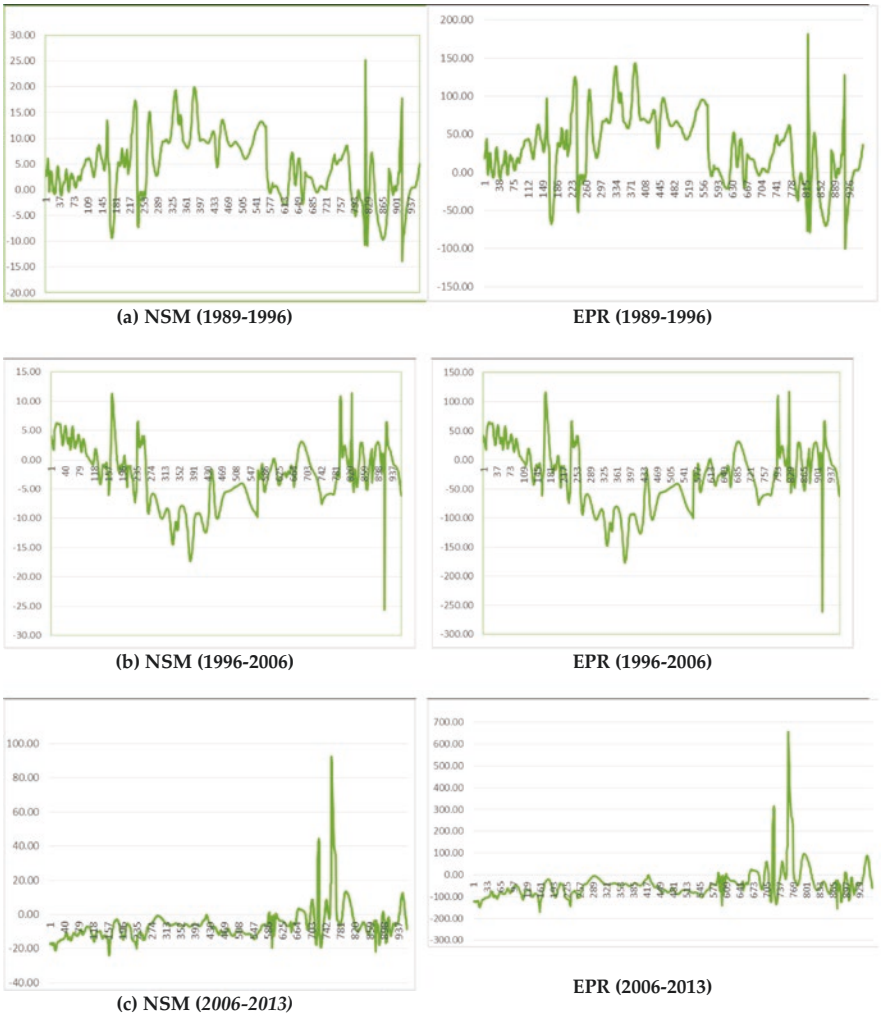

Fig. 33.3 Change in NSM and EPR values during 1989–2013

from −100 meters per year in 1996–2006 to −140 meters per year in 2006–2013. The shoreline movement in 1996–2013 was at the range from −10 to −20 meters.

– *Ky Nam Commune:* The coastal zone in Ky Nam witnessed the erosion more than the accretion during 1996–2013. The highest shoreline movement changed from −13 to 17 meters in 1989–1996; reducing the range from −25 to 6.3 meters in 1996–2006; and maintaining the range between −21 and 10 meters in 2006–2013. Thus, during the period of 1989–1996, the erosion rate was 100 meters per year, whereas the accretion rate was 128 meters per year. The accretion was the dominant process in this period. During remaining years, the highest erosion rate was 260 meters per year, while the highest accretion was 66 meters

per year. The domination processes were transformed into erosion, which featured high rates.

During the 24-year period (1989–2013), Ky Anh District witnessed many changes in shoreline. A total of 961 transects were established, where there were 881 transect records of the erosion and 80 transect records of the accretion. There was no transect record of no change (no accretion or no erosion). The movement of erosion ranged from −1.39 to −223.89 meters, the rate ranged from −0.06 to −9.13 meters per year, and the average rate of the whole period was −2.27 meters per year. The erosion point was located in Ky Khang and Ky Ninh communes. The accretion movement fluctuated from 1.99 to 669.43 meters, and the rate fluctuated from 0.08 to 37.31 meters per year. The average accretion rate was 4.81 meters per year, distributing in port construction area in Ky Loi Commune.

In comparison with the changes between three periods, it can conclude that the erosion trend saw an increase in both the movement and the rate during a whole period. The rate of erosion increases from 0.02 to 13.86 meters per year during 1989–1996, to 0.01–25.66 meters per year during 1996–2006; and to 0.02–24 meters per year during 2006–2013. The average erosion rates grow from 3.34 to 5.33 meters per year. The accretion process experienced downward trend in the rate and the movement (Fig. 33.4).

4 Conclusions

Due to significant factors such as storm, flooding, and sandy collection, Ky Anh is regarded as one of the coastal areas experiencing the strongest shoreline changes among Central Coast in Vietnam. The results of DSAS show that during 1989–1996, low erosion was on average 3.4 meters per year. However, from 2006 to 2013, the

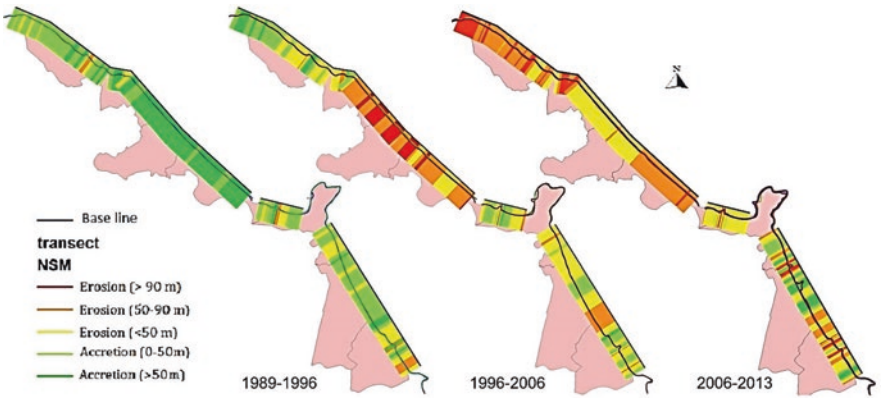

Fig. 33.4 DSAS shoreline change results in the Ky Anh District

erosion witnessed an rapid increase, going up from 24 to 92.5 meters per year. It is similar to recent research on coastal erosion in this area.

Ky Anh is an example of Vietnam's wide and international importance of coastal protection and regional planning. Vietnam has many experiences of coastal protection and flood management; however, the tropical storms and monsoon conditions frequently offer challenges. The local government builds dykes, plants protecting tree ridges, and restores and extent mangroves. The shoreline change extraction and change detection analysis using DSAS could be applied in several fields such as setback planning, hazard zoning, the erosion and accretion studies, regional sediment budgets, and conceptual or predictive modeling of coastal morphodynamics (Aedla et al., 2015). Especially, a setback planning has been designated as an effective spatial planning for coastal erosion mitigation in Ky Anh District.

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