

Morphological change on Cua Dai Beach, Vietnam: Part I image analysis

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Abstract

Severe erosion has been occurred on Cua Dai Beach, Hoi An City, Quang Nam Province which is located in the central part of Vietnam. The erosion has been getting more serious in recent years. In this study, the changes of morphology are presented through analysis of satellite images. Sandy beach has been eroded severely. The propagation to the north of sandy beach wedge toe can be observed. Tourist facilities such as hotel, embankment, etc. have significant influence to the evolution of surrounding morphology. The reduction of sediment supply from river due to the construction of reservoirs upstream and sand mining along the river or at the river mouth has been pointed out as the highly possible mechanism of erosion.

1. Introduction

Hoi An is a city in the central part of Vietnam which is located about 600km on the north of Ho Chi Minh City. Its ancient town is UNESCO World Heritage site. Thu Bon River, which is one of the largest rivers in the central part of Vietnam, crosses this city and pours into the Pacific Ocean at the Cua Dai River mouth. In recent years, the erosion has been occurred severely on Cua Dai Beach which is located on the left side of the river mouth. That caused significant effect to the morphology, the tourism industry and the developing of this city.

Vietnam has the coastline of about 3260 km in length. The erosion of beach is commonly observed at places. However, there have been few studies on the erosion of coastal areas. Viet et al. (2014) present the mechanism of seasonal erosion of sandy beach on the right hand side of the Cai River mouth, in Nha Trang City, central Vietnam. Moreover, similar effect as groin in the coastal area of the hotel has been also presented in that study. Duc et al. (2012) analyze the evolvement and physical mechanism of the erosion at the estuary areas of Red River system, northern part of Vietnam. That is caused by the unequally distribution of river sediment. For the basin of Thu Bon River as well as Vu Gia River, there have been studies regarding to the flooding assessment, land use changes, environmental changes, etc (Nam et al, 2014; Loan and Umitsu, 2011). However, there have been lack studies for the estuary, and adjacent coasts.

Hence, in this study the morphological changes on Cua Dai Beach in recent years are investigated through the analysis of satellite images.

2. Study area and data collection

This study focuses on the beach of about 6km in length around the Cua Dai River mouth, Hoi An City, Quang Nam Province, Vietnam (Fig. 1). Thu Bon River has the average annual discharge of about 327m³/s and the length of about 152km. It pours into the Pacific Ocean at the Cua Dai River mouth, Hoi An City. The Vu Gia River has many tributaries. The length of this river is about 204km. Its mouth is located in Da Nang City where is about 30km on the north side from the Cua Dai River mouth. In the downstream area, there are connected rivers between these two

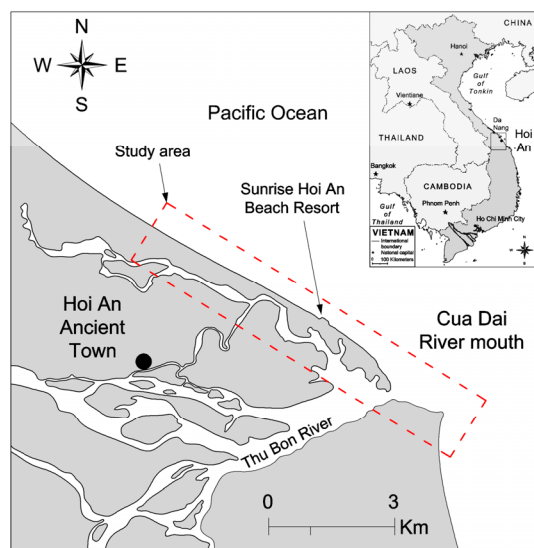


Fig. 1 Location map of study area

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rivers, Quang Hue River and Vinh Dien River. Quang Hue River diverts apart of flow from the Vu Gia River into the Thu Bon River, whereas, Vinh Dien River diverts apart of flow back to Vu Gia River. Total catchment area of Vu Gia-Thu Bon River system basin is about 10,350km².

Satellite images, which are used in this study, are collected from Google Earth. The satellite images cover the period from 2004 to 2014. All collected images are re-rectified into WGS-84 (World Geodetic System – 84). The line, which is 122.06 degree to the north, is selected to be the baseline for the measurement of shoreline. The point, which has coordinates 215004.27 E and 1761422.52 N on WGS-84, is selected as the initial shoreline position ($x=0m$). Detected shoreline positions are extracted from rectified satellite images in every 20m in direction along the beach. They are not corrected to tidal level due to the lack of exact time of satellite image capturing.

3. Results and discussion

(1) Morphological changes on Cua Dai Beach in recent years

Various coastal mapping techniques have been developed over the last decades. Moore (2000) synthesizes the existing information into a comprehensive guide to shoreline mapping. Elizabeth et al. (2005) give review on the shoreline definition and detection from images. More details about the image analysis technique, which is used in this study, can be found in Pradjoko and Tanaka (2010).

In this study, position of shoreline is extracted from satellite image. Satellite images of study area in recent years are shown in Fig. 2[(a), (b), (c) and (d)]. Detected shoreline positions, which are extracted from those images, are plotted in Fig. 2(d). Based on the specific characteristics of each sub-area, this study area is divided into four zones as below.

Zone 1 ($x=7500-9200m$) – The beach on the right side of river mouth

Zone 2 ($x=5000-7500m$) – The beach adjacent to the left side of river mouth

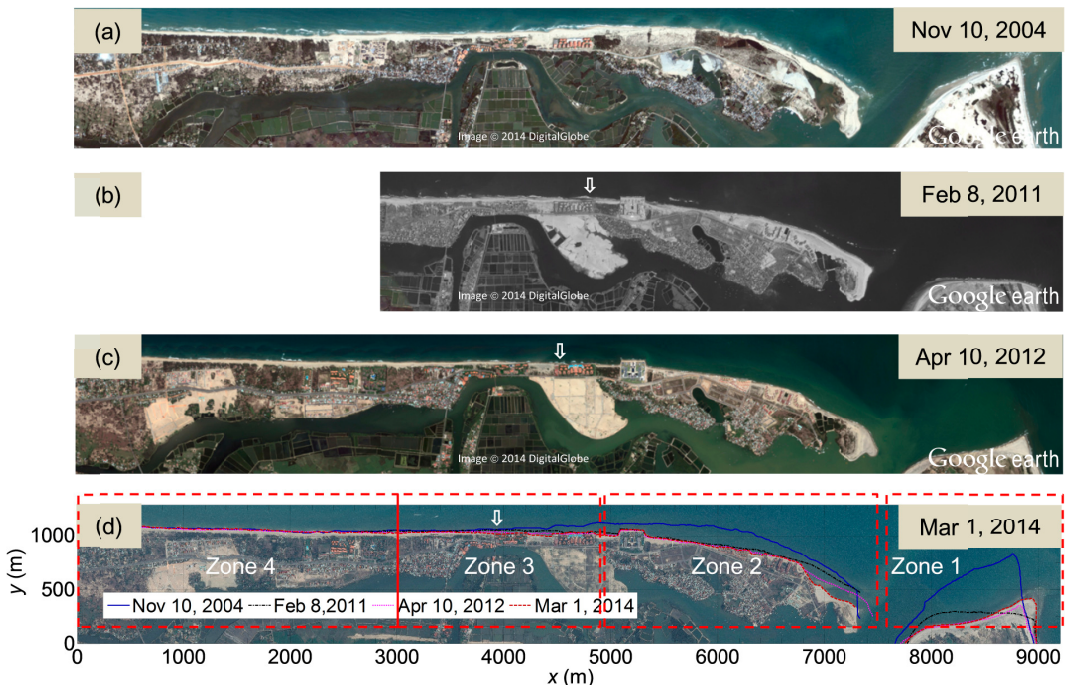


Fig. 2 Aerial photographs and detected shoreline positions of study area (Google Earth)

(a) Nov 10, 2004; (b) Feb 8, 2011; (c) Apr 10, 2012; (d) Aerial photograph on Mar 1, 2014 and detected shoreline positions. (white arrow showing the location of sandy beach wedge toe at each time)

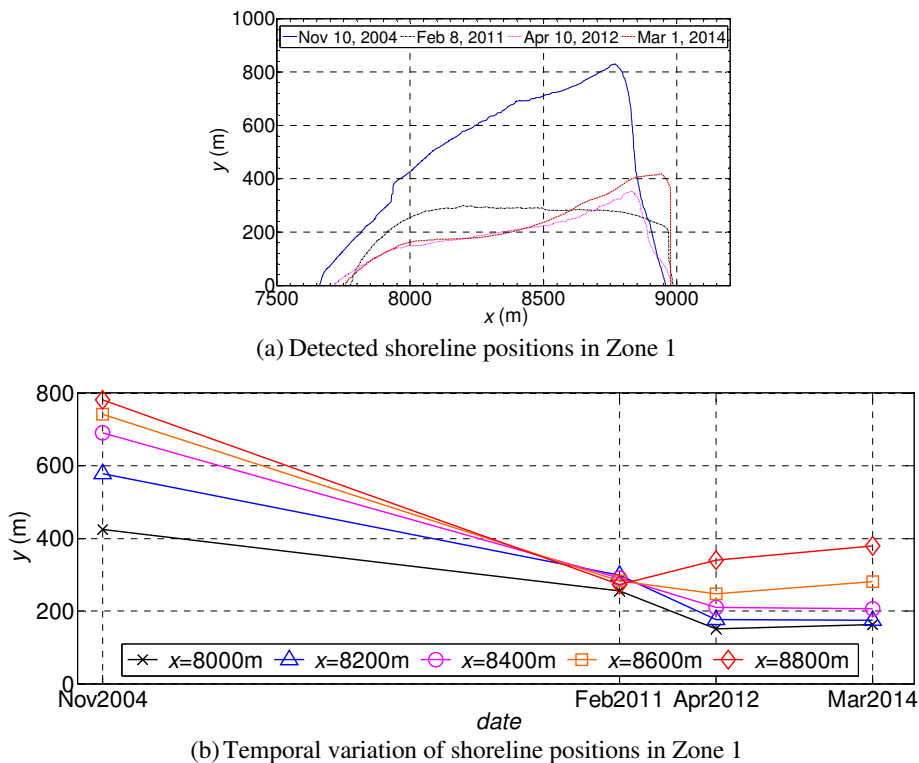


Fig. 3 Detected shoreline positions and temporal variation of shoreline positions in Zone 1

Zone 3 ($x=3000-5000\text{m}$) – The beach on the left side of river mouth

Zone 4 ($x=0-3000\text{m}$) – The beach on the left side of river mouth

Morphological changes in each zone are presented as below.

Zone 1 – The beach on the right side of the Cua Dai River mouth ($x=7500-9200\text{m}$)

Figures 3(a) and 3(b) show detected shoreline positions and temporal variation at transections of shoreline position of the beach on the right side of the Cua Dai River mouth, respectively. According to those figures, shoreline position in this zone has been retreated about 500m in the period from 2004 to 2012. However, it has been stable after that, in the period from 2012 to 2014. In addition, it can be observed that the tip of this sandy coast is migrated to the south.

Zone 2 – The beach adjacent to the left side of the Cua Dai River mouth ($x=5000-7500\text{m}$)

Figures 4(a) and 4(b) show detected shoreline positions and temporal variation at transections of shoreline position of the beach adjacent to the left side of the Cua Dai River mouth, respectively. Shoreline position in this zone has been retreated about 200m in the period from 2004 to 2014. The erosion in this zone has been occurred since a long time, and it has most serious erosion compared to other zones. The beach on the close side of river mouth has more significant erosion than the beach on the far side. The beach on the left side of Cua Dai River mouth is the famous place for tourist. Hence, since 2004, resort hotels have been constructed along this beach [Fig. 2(a)]. At that time, sandy beach was still remained in front of the hotels. However, after the severe erosion these hotels are now locating protrusion into the seawater body, for instance, Sunrise Hoi An Beach Resort. The sandy beaches vicinity to this hotel are eroded severely. The hotel plays the role as groin in the coastal area. It is similar to the case of the hotel on Nha Trang Beach which reported by Viet et al. (2014). For the safety of tourism facilities in this area, some

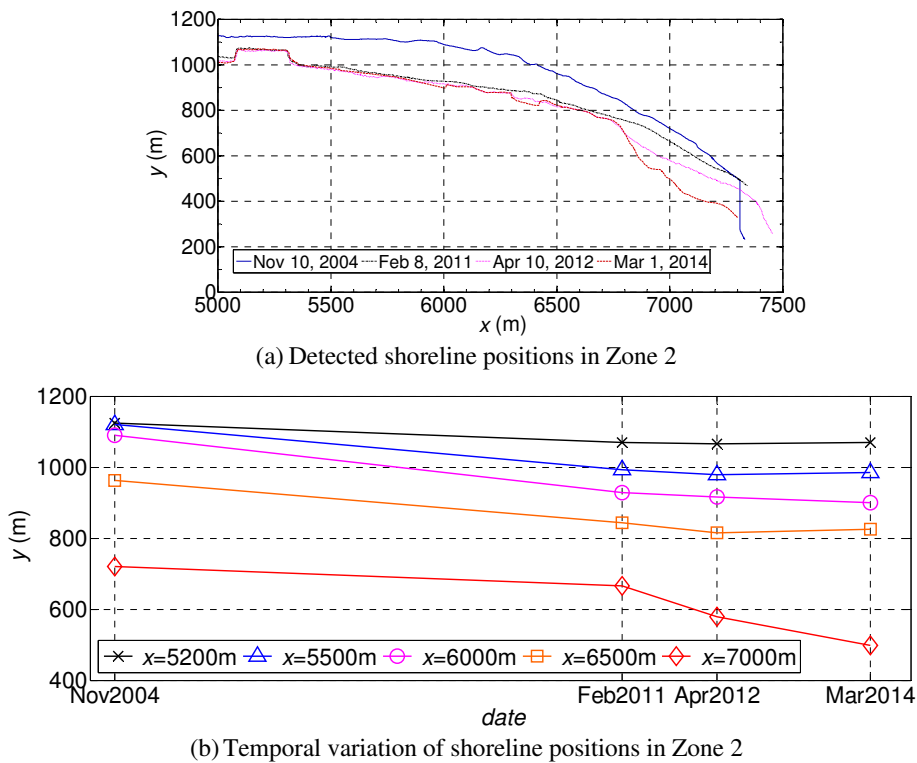


Fig. 4 Detected shoreline positions and temporal variation of shoreline positions in Zone 2

parts of the beach have been protected by sheet pile seawall. At these locations, the erosion of the sandy beach on the back side of seawall due to overtopping waves is very serious. It caused collapsing of resort hotels. At the locations without protection of hard-structures, severe retreat of shoreline can be observed.

Zone 3 – The beach on the left side of the Cua Dai River mouth ($x=3000\text{--}5000\text{m}$)

Zone 3 is adjacent to the north side of Zone 2. The right boundary of this zone is about 2500m to the left side of the Cua Dai River mouth. Detected shoreline positions and temporal variation at transections of shoreline position of the beach in this zone are presented in Figs. 5(a) and 5(b), respectively. The amplitude of beach erosion is decreasing from the right side to the left side in this zone. It is about 120m on the right, whereas about 30m on the left.

Zone 4 – The beach on the left side of the Cua Dai River mouth ($x=0\text{--}3000\text{m}$)

Figures 6(a) and 6(b) show the detected shoreline position and temporal variation at transections of shoreline position of the beach in Zone 4. This zone is located adjacent to the north side of zone 3. Shoreline data in 2011 is not available for this zone. According to the results presented in Figs. 6(a) and 6(b), shoreline positions in this zone are rather stable. Only slightly advance of shoreline can be observed at some locations on the north side of the zone.

(2) Movement to the north of sandy beach wedge toe

According to the satellite images analysis, very interesting results showing that the wedge toe of sandy beach on the left side of river mouth propagates to the north. Location of wedge toe at each time is represented by white vertical arrow in Fig. 2. In addition, according to the field observation data in December, 2014, the location of beach wedge toe is shifted about 900m toward to the north from the

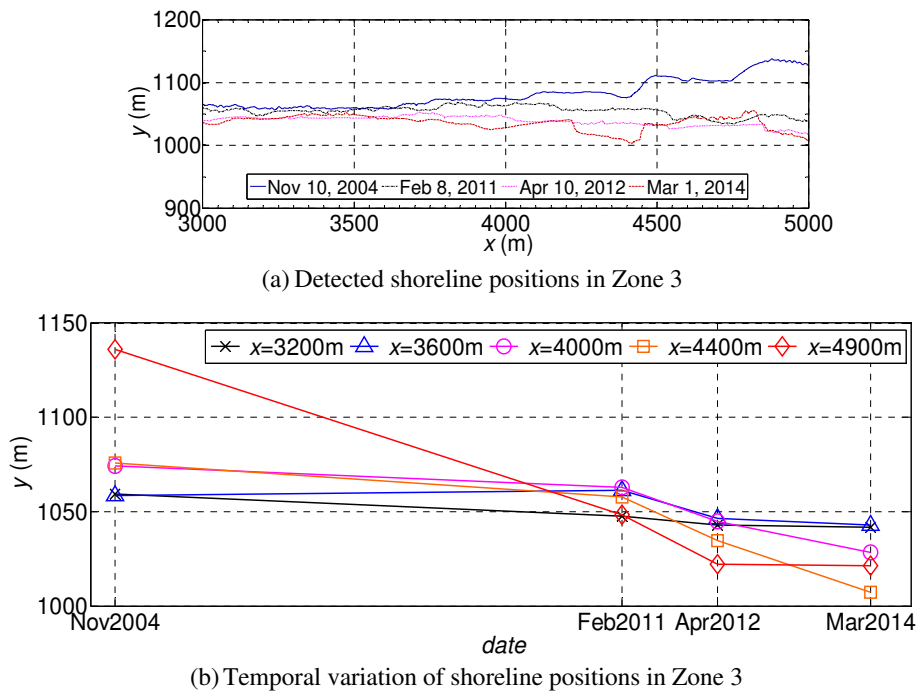


Fig. 5 Detected shoreline positions and temporal variation of shoreline positions in Zone 3

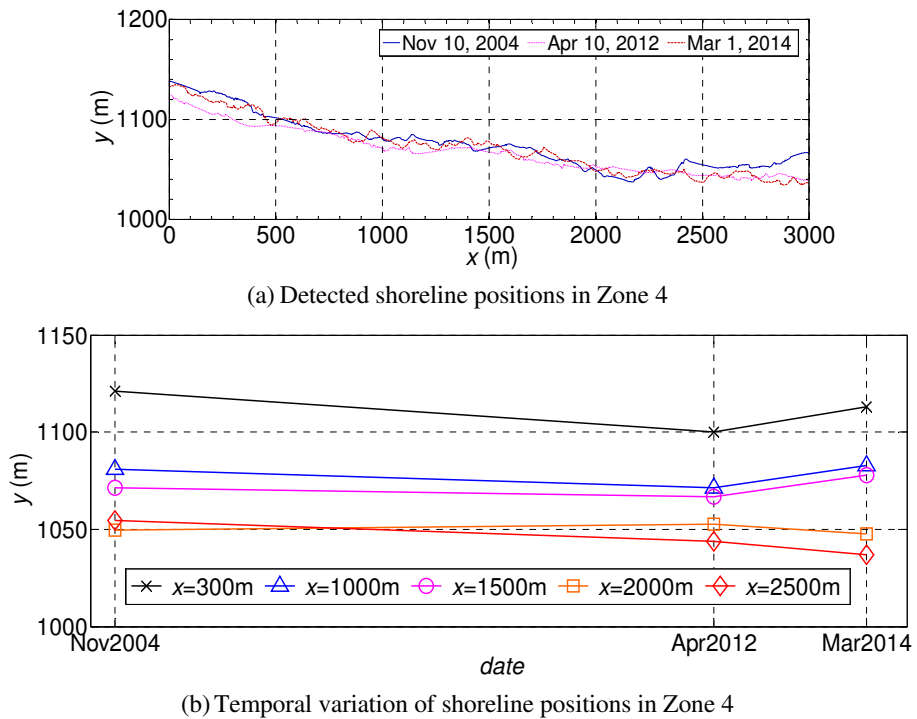


Fig. 6 Detected shoreline positions and temporal variation of shoreline positions in Zone 4

location of wedge toe in the beginning of March, 2014. Shoreline was retreated about 30m in this period. The movement of sandy beach wedge toe is also one of the indicators of the reduction of the sediment supply to river mouth area.

(3) Highly possible mechanism of severe erosion on Cua Dai Beach

Thu Bon River is ranked fourth in Vietnam for potential hydropower generation capacity after the Da, Dong Nai and Se San river systems. In responding to the highly energy demand on fast economic growing in the past decade, several hydropower reservoirs have been constructed in the upstream of Thu Bon River. In addition, reservoirs have been also constructed for irrigated and flooding storage purposes. The operation of these reservoirs can interrupt the sediment movement in the river flow. Besides the reduction of sediment to the downstream induced by the construction of reservoirs, the sand mining from river channels also can reduce the sediment supply to the downstream. This activity is commonly observed along Thu Bon River (ICEM, 2008). Due to the effect to the transportation of fishing boats, the dredging sediment deposition at the river mouth area is conducted frequently. All above actions can remarkably reduce amount of sediment supply to the river mouth area. Thus, the reduction of sediment supply could be the highly possible mechanism of erosion of the Cua Dai Beach. The reduction amount and more details on the mechanism of erosion of shoreline will be discussed in Part II of this study (Hoang et al., 2015).

It is noted that, the highly erosion mechanism mentioned above is presented based on quite general information and past experiences. Hence, in order to obtain proper mechanism of the erosion, more data such as wave, bathymetry, water level, etc. are required to acquire and further analysis need to be done.

4. Conclusions

This study has investigated the changes of morphology on Cua Dai Beach. Shoreline has been retreated severely in recent years. The erosion of sandy beach is more severe in the zones which are closer to the river mouth. Coastal structures have significant influences to adjacent beaches. The wedge toe of sandy beach on the left side of river mouth propagates to the north. Highly possible erosion mechanism of the Cua Dai Beach has been presented. The reduction of sediment supply from river is considered as the highly possible mechanism of erosion. Details in the sediment reduction amount and the erosion phenomenon induced by the reduction of sediment will be presented in Part II of this study (Hoang et al., 2015).

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