Recent morphology change at Da Rang River mouth, Phu Yen, Vietnam

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Abstract

Da Rang River mouth, resembles many coastal areas in Vietnam, has been recently encountering significant changes induced by either nature or human involvement. The instability of sandspit's formation at Da Rang River mouth can be detected by two major phenomena which are migration of the river mouth after the 1993 flood and shrinkage of the south sandspit owing to human interference. This study, by utilizing one main source of satellite imagery: Landsat imagery, investigates the recent morphology and its variation thoroughly.

Keywords: Da Rang River mouth, the 1993 flood, human interference, migration.

1. INTRODUCTION

Da Rang River mouth has a typically deltaic shape that is common in the world. Since the past, numerous studies about the formation of delta coast had been made and yet still have been researched extensively lately. This study focuses on the dramatic reversal of river mouth mechanism due to human involvement. The observed phenomena of Da Rang River mouth are not obviously distinctive which were considered in many prior studies: migration of the river mouth and gradual disappearance of Southern sandspit. FitzGerald et al. (2000) discussed fundamentally the mechanism of ebb-tidal delta breaching at stable coasts where dominant of longshore sediment transport and asymmetric accumulation of sediment on either sides of river mouth leads to a severe deflection of the main channel. In more specific study, Patchanok Srivihok and Tanaka (2004), by using aerial photos, stressed the seasonal migration of Nanakita River mouth, Japan controlled by the dominance of longshore sediment transport. Sato et al. (2014) with abundant of bathymetric data characterized the formation and deformation of Tenryu River mouth, Japan trigged by floods, the formation of bar and trough topography bound with frequency of storm waves and erosion as

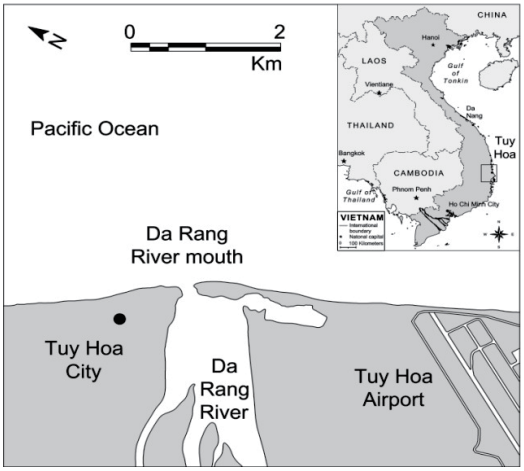

Figure 1: Study area

result of imbalance longshore sediment transport. The current situation of Da Rang River mouth is suspected that been causing by incidence of sand mining inside of river channel and the placement of beach protection construction on the South. This has already demonstrated widely, namely, Guangwei (2011) and Anthony et al. (2015) emphasized the same point of view of coastal erosion caused by the reduction of sediment supplied to coast owing to the impacts of major

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dams and channel bed erosion triggered by sand mining.

Da Rang River mouth has received attention of many studies for last few years due to its complicated changes. Hoang et al. (2015) claimed the existence of the sand terrace in front of the river mouth contributing a great deal of sediment on both sides of the entrance. Tanaka et al. (2016) indicated the elongation of the right sandspit created severe erosion on adjacent area. And more recent, Cuong et al. (2016) discussed the nearshore hydrodynamics and sediment transport in Da Rang River mouth in a short term from 2015 to 2016 by abundant of field data obtained within that time. However, these researches mainly did not reflect the most recent change and such a debatable discussion between mechanism variations is vague. Therefore, this study will provide a comprehensive view on the mechanism of Da Rang River mouth by using Landsat images from 1988 to 2018.

2. STUDY AREA AND DATA COLLECTION

Da Rang River mouth is located in Tuyhoa City, south central Vietnam, away from from Ho Chi Minh City about 400 km in Northeast direction

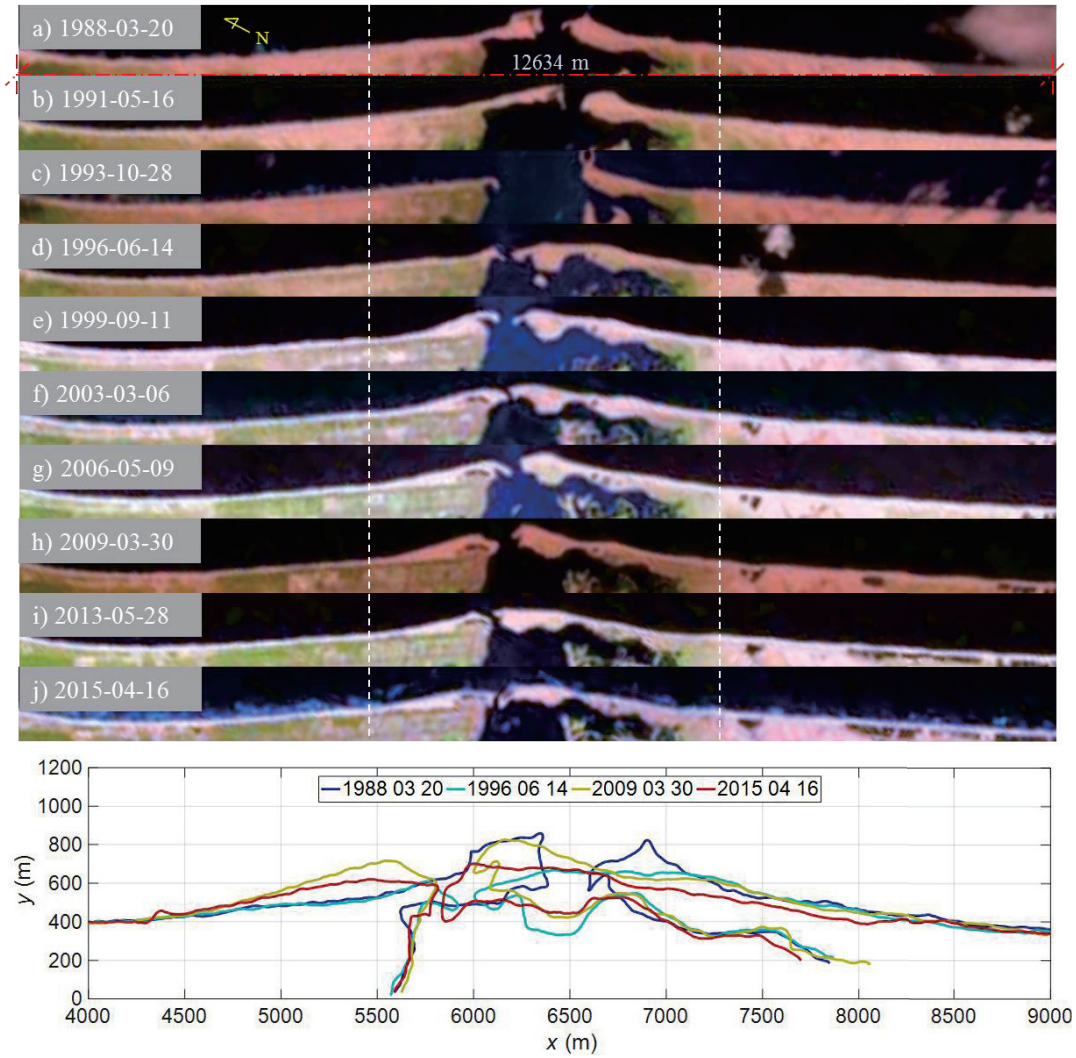

Figure 2: Morphology variation at Da Rang River mouth (1988~2015)

(Figure 1).The river mouth belongs to the largest river in South Central of Vietnam, Ba River which has the main stream of 307km in length and total basin area of about 13300 km^2. At the entrance of the river mouth, the formation of the spits as the accumulation of sediment beyond the shoulder of banks have existed for many decades. The sandspits on both sides have been fed by sediment supplied from the river and incident waves. However, the interference of human activities also created such a big impact on this area which the rate of sand mining has rised rapidly for last few years. It is reported by the local government that in the period from 2015 to 2017, at least 7 dregding activities had been executed on different locations. where the sand mining focuses on the upstream river bed and the entrance of the river mouth.

Approaching waves are a vital factor on the varied shapes of the sandpsits since seasonal effects are highly noticeable. Da Rang River mouth is influenced by the monsoon climatic regime; Northeast monsoon prolongs from October to April and Southwest wind lasts from May to September.

The main source data of this study is Landsat imagery obtained from U.S Geological Survey (USGS) database from 1988 to 2018 (190 photos). Every images are rectified to one coordinate system by linear transformation (Affine transformation) having a baseline of 148 degree to the North. Shoreline detection was also implemented to all images by extracting the wet-dry line by the maximum gradient pixel and nearest neighbour method. The drawback of using Landsat is its low resolution which neglects the effect of tide on shoreline.

3. RESULTS AND DISCUSSION

3.1 Natural morphology variation of Da Rang River mouth (1988 – 2015)

Da Rang River mouth from 1988 to 2015 encountered an overwhelm change in its mechanism. Figure 2 indicates clearly the migration of the river mouth from the South to the North after a big flood 1993. This implies the

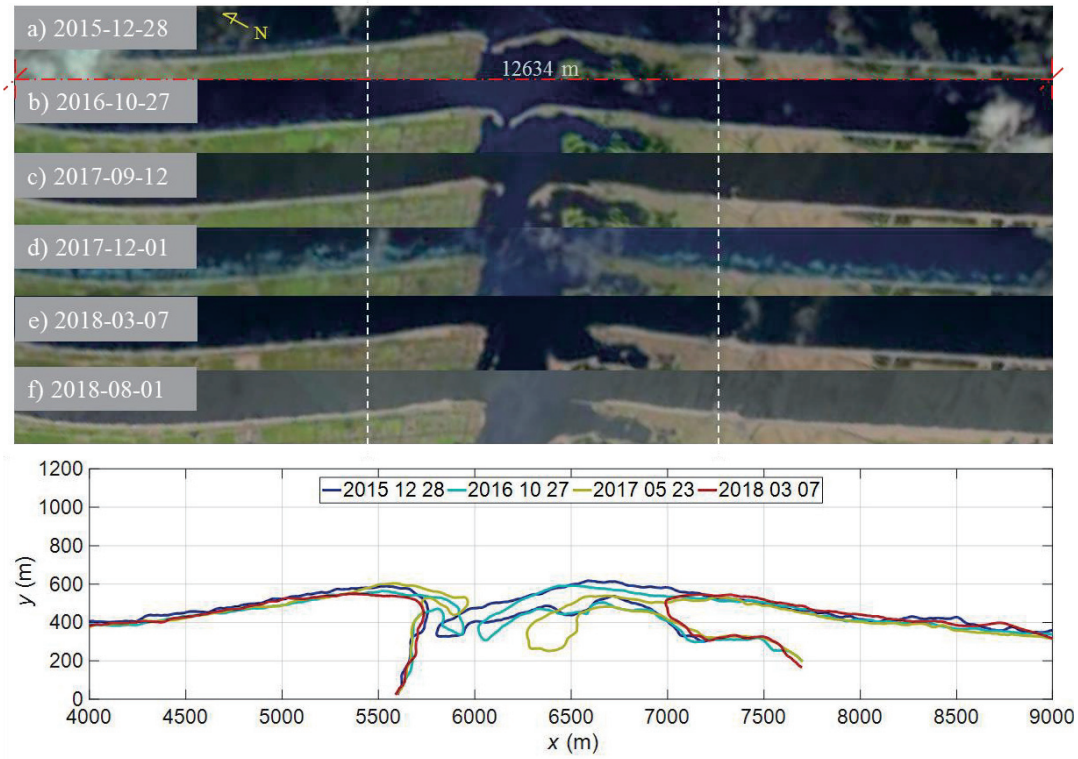

Figure 3: Morphology variation at Da Rang River mouth (2015~2018)

mechanism is turned into a new one which is more hydraulically efficient than the previous one due to a breakthrough by the flood. This new river mouth mechanism lasted for long period until late 2015. The mechanism during this period was discussed in detail by Hiep et al. (2016) which the predominance of longshore sediment transport or river mouth was cleared out thoroughly.

3.2 Morphology variation under impingement of human involvement (2015 – 2018)

In 2015, the closure of Da Rang River mouth nearly happened led to the urgent excavation to maintain the navigation channel. But the sand dredging was overdone that sand and gravel of some places inside the river mouth were intentionally taken way. And the elongation of the right sandspit caused a severe erosion on adjacent area that threatened the whole area behind that. With the aim of both reduction of wave heights at the shore and collection of more longshore transport of sediment, the former structures were 6 groins placed on the far South of Da Rang river mouth and the latter were several headland and detached breakwaters on the groins. Breakwaters are detached, generally shore parallel structures that reduce the amount of wave energy reaching a protected area. They are similar to natural bars, reefs or nearshore islands that dissipate wave energy. The reduction in wave energy slows the littoral drift, produces sediment deposition and a shoreline bulge or salient feature in the sheltered area behind the breakwater. Some longshore sediment transport may continue along the coast behind the nearshore breakwater. However, the downside took place consequently when the right sandspit was becoming smaller until hit by a big typhoon in 2017. The entire sandspits dissappeared and have not recovered afterwards as indicated in Figure 3.

3.3 Longterm morphological change

A simple analysis was conducted to investigate the longterm morphological change at Da Rang River mouth by comparing the entire shoreline data to the very first one. The expression of the analysis can be seen at Eq.1 below:

$$\Delta y(x,t) = y(x,t) - y_0(x) \qquad (1)$$

The dark red area around 1993 in Figure 4 emphasizes the severe erosion on the left sandpsit which indeed the flood wiped out the entire left sand spit. Then the left sandspit was not be able to reach its previous position and as a result deposited to the Northern adjacent area. In the meanwhile, the South sandspit accretion appeared after the flood and prolonged further to the opposite side. This is because large sediment was attached on this area by ebb shoal in front of the river mouth and sand bypassing from the North side. The elongation of the sandpsit also triggered the erosion beyond it and became more severe until the 2017 typhoon emptied the entire South sandpsit.

3.4 Analysis of river mouth charateristics

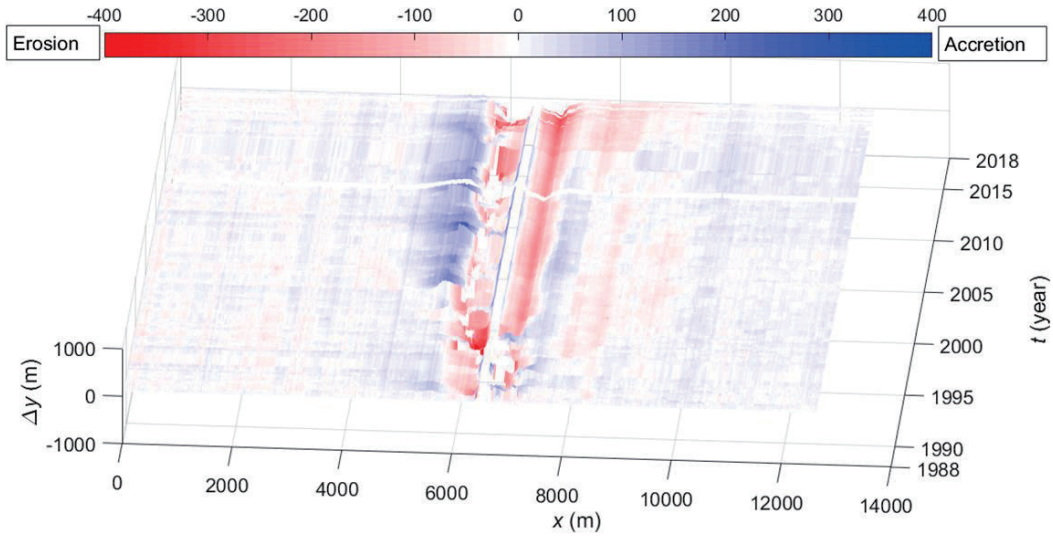

Figure 4: Long-term shoreline change at Da Rang River mouth

To investigate the morphology change at Da Rang River mouth by a quantitative appoarch but not only by visual. Several vital quantities of the river mouth are defined which are the center point, x_C, y_C; river mouth with, B; and area of each sandspit, A. Plus, yearly maximum fresh water discharge, Q_{max} from a hydrological station located far upstream from the entrance about 37 km is also brought up to make a contrast with river mouth parameters. The definition of these quantities and their measured values are shown discreetly in Figure 5.

The value of the centerpoint regarding longshore direction reveals the movement of river mouth as the river mouth migrated to the left after the 1993 flood and its reverse on which the sandspit was getting smaller. between 2015 and 2018. With regard to crosshore direction, the specific trend is not able to be detected; however during the reduction period, the right sandspit was intruding into the upstream due to incident waves and lack of sediment from river mouth. The river mouth width also fluctuated through the entire period but 2 extreme values are those of two catastrophical events.

The area of two sand spits showed how

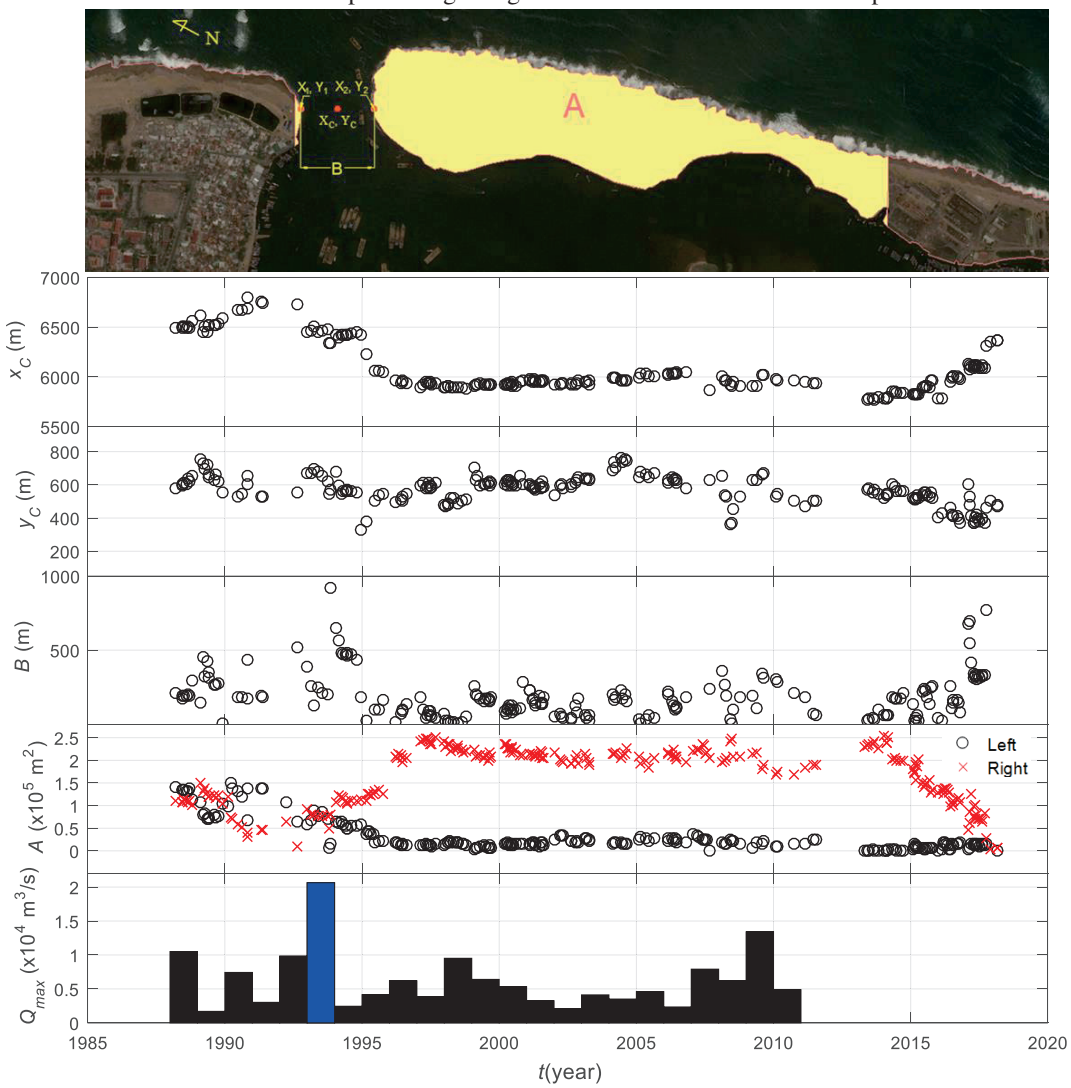

Figure 5: Definition and analysis of river mouth characteristics

dominant the growth of right sandspit was. Before the 1993 flood, the river mouth was stable although the area of two sandspit kept varying. After getting struck by the flood, the North sandspit was flushed almost entirely that the value of it nearly reached the bottom, while the South sandspit was faded away a smaller amount. The flushed sediment then stayed offshore and in front of the river mouth creating ebb shoal and bars. The recovery started immediately afterwards but the shoal and bars and dominant longshore sediment from South to North play their important roles to deposit plenty of sediment onto the right sandspit. This is why the South sandspit developed by a remarkable amount, whilst the North one remained constantly small. From 2015, the area of right sandspit was reducing to the amount of the left sandspit before they both went nothing after the 2017 typhoon.

The maximum fresh discharge data majorly referred to the flood events in Phu Yen and it is distinct to detect the extreme value caused by intensity of the 1993 flood.

4. CONCLUSIONS

Da Rang River mouth has a typical morphogolical change of a deltaic coast which can clearly be seen by the shoreline position varition. The shifting of the river mouth occurred when a new mechanism had been formed after the flood in 1993. This mechanism stayed stable till 2015 and to break this regime, it is believed to take decades or until next extreme event. However, since human started getting involved in the natural process, the equilibrium of river mouth has broken making severe erosion on two sandspits. With the lack of sediment from both main sources, which are sediment discharge from river and longshore sediment transport, it is presumed the recovery of sandspit is a tall order.

REFERENCES

Anthony, E.J., (2015). *Wave influence in the construction, shaping and destruction of river deltas: A review*. Marine Geology, Vol. 361, 53-78.

Cuong, K.N., Giang, T.N., Anh, N.T., Duc, D.D. and Vinh, N.T., (2016). *Hydrodynamics and Short-term morphological change in the Da Dien Estuary of Phu Yen Province, Vietnam*. Proceedings of the 8th Asia-Pacific Workshop on Marine Hydrodynamics in Naval Architecture, Ocean Technology and Constructions, APHydro 2016.

FitzGerald, D.M., Kraus, N.C. and Hands, E.B., (2000). *Natural Mechanisms of Sediment Bypassing at tidal Inlets.* Coastal and Hydraulics Engineering Technical Note ERDC/CHL CHETN-IV-30, U.S. Army Engineering Research and Development Centre, Vicksburg, MS.

Guangwei, H., (2011). *Time lag between reduction of sediment supply and coastal erosion.* International Journal of Sediment Research , 26(1), 27-35.

Hiep, T.N., Tanaka, H., Mitobe, Y., Viet, T.N., Hoang, C.V., Thanh, M.T., (2016). *Shifting of Da Rang River mouth and its relationship with erosion on adjacent sandy coast*. Journal of JSCE, Ser. B3 (Coastal Engineering), Vol. 72 (2016) No.2, p.I_1663-I_1668.

Hoang, C.V., Tanaka, H., Viet, T.N., Binh , H.T.L., (2015). *Analysis of shorel ine erosion at the Da Rang River mouth, south central Vietnam.* Proceeding of Vietnam – Japan Workshop on Estuaries, Coasts and Rivers, September 2015, Hoian, Vietnam, VJWECR 2015, 60-68.

Patchanok, S., Tanaka, H., (2004). *Monitoring of river mouth morphology change by aerial photograph analysis.* Annual Journal of Hydraulic Engineering, JSCE, VOL.48, 733-738.

Sato, J., San-nami, T., Uda, T., Ishikawa, T., (2014). *Field investigation of topographic response to floods and waves around Tenryu River mouth*. Proceedings of 34th Conference, on Coastal Engineering, Seoul, 1-13.

Tanaka, H., Hoang, C.V., Thanh, M.T., Hiep, T.N, Viet, T.N., (2016). Relationship between estuary morphology change and sand terrace formation at Da Rang River mouth, Vietnam, Journal of JSCE, Ser. B3 (Ocean Engineering), Vol. 72 (2016)