

MONITORING COASTAL EROSION IN RED RIVER DELTA, VIETNAM, AND A CONTRIBUTION FROM REMOTE SENSING DATA

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ABSTRACT

Stretching from Do Son to Lach Truong, Red River Delta coastal zone is concentrated by many important socio-economic and residential areas. Recently decades, coastal erosion in this zone has happened very complicated. Coastal erosion can break sea dyke and bring about terrible disaster for populous residential areas. Remote sensing satellite, with capability of providing near real-time data, can be used to monitor coastline changes. This paper presents a case study using remotely sensed data in recent years in combining with traditional topographic maps and field survey data to monitor coastal erosion in Red River Delta during last 70 years. Method of coastline identification from satellite data was used and GIS overlay function was performed to assess coastline changes. For processing the satellite data, the shoreline was defined as the mean sea level on the muddy coast where the tide is a dominant dynamical factor and as mean high sea level on the sandy coast where the wave is a dominant dynamical factor. It was estimated that the coastal erosion in Red River Delta has happened complicatedly with every periods and coastal parts. By the three periods from 1930-1965, 1965-1990 and 1990 to present, coastline length and coastal erosion rate have been determined as 46.4 km and 7.0m/year; 59 km and 8.1m/year; and 23.7 km and 11.0m/year respectively. The north coastal part has decreased in erosion scale and intensity obviously from 1930 to present. The south coastal part has decreased in erosion scale a little, but increased in erosion rate during the last 70 years. Four development tendencies of eroded sites were discovered: 1) lasting coastal erosion for the last 70 years; 2) changing accretion into erosion; 3) changing erosion into accretion; and 4) interchanging between erosion and accretion for the short duration.

1. INTRODUCTION

Stretching from Do Son to Lach Truong, Red River Delta (RRD) coastal zone is concentrated by many important socio-economic and residential areas. But most of this zone are lowland areas and protected by sea-dyke systems. During recent decades, the coastal erosion in this zone has happened very complicated. Coastal erosion can cause sea dyke to be broken and bring about terrible disaster for populous residential areas. Monitoring is extremely necessary for predicting and preventing the coastal erosion of RRD.

Assessment and monitoring of the coastal erosion in Red River Delta are difficult tasks and concerned in different level (Cu, N.D., *et al.*, 1993; Huy, D.V., *et al.*, 1999; Ninh, P.V., *et al.*, 2000; Thanh, T.D., *et al.*, 1998). However, because of a limitation in data, the existing assessment results were still limited in systematic and reliability. Remote sensing satellite, with capability of providing near real-time data, and continuous revisit, can be effectively used to monitor coastline changes.

This paper presents the initial results of case study using remotely sensed data recently years in combining with traditional topographic maps and field survey data in GIS database to monitor the coastal erosion in Red River Delta during last 70 years.

2. METHODOLOGY

2.1 Data used

This study used field survey data of many projects since 1990, especially data from general field survey on the present status of coastal erosion in North Vietnam in early of year 2000. Map scale of 1:250,000 made by French in 1930, UTM 1:50,000 maps made by American Army from air-photo in 1965 was used for the study.

The satellite data used for this study including SPOT XS satellite data acquired on 18th May 1995 and MOS-1 MESSR satellite data acquired on 25th October 1991 of Thanh Hoa - Nam Dinh provinces. SPOT XS satellite data acquired on 21st December 1998 and MOS-1 MESSR satellite data acquired on 27th November 1990 of Thai Binh - Nam Dinh provinces was used.

2.2 Methodology

The methods used for this study was collection existing documents, field survey, digital image processing, image interpretation and GIS change analysis.

The ground truth was defined as observation, measurement and collection of information about the actual condition on the ground in order to determine the relationship between color, shape, tone of remote sensing data and surface objects to be observed. The field surveys provide an overview of coastal erosion as a base for correcting the erroneous in digital image processing.

Major digital image processing methods such as geometric correction to rectify image to geographic coordinate system, image enhancement, and color composite were implemented (Jensen, J. R., 1996, Dien, T.V, 1999).

Coastline identification was defined by combining of tidal data and satellite image acquired date to identify tidal level when images were acquired. Coastline was defined as mean sea level line. However, this task is very complicate when interpret coastline from satellite data. So, coastline identification from interpreted satellite image must be combined both image interpretation ability and coastal dynamic data. At the areas of strong erosion such as Van Ly, Cat Hai, specified by cliffs and beaches, the coastline was defined as a coincidence with highest tidal level. The erosion cliff foods coincide with the high tidal level in horizontal projection. These coastlines can be easily interpreted from satellite data and the coastline change can be observed clearly at these areas. In muddy accreted areas, coastline was identified as boundary of mangrove forest.

After mapping coastline, the GIS overlay procedures were implemented to assess coastline changes. The coastline change at specific coastal section was measured, calculated with mean erosion rate, and erosion length during period time.

SPOT multi-spectral satellite image with 3 spectral channels, and 20m spatial resolution, and MOS-1 MESSR satellite image with 4 spectral channel, and 50m spatial

resolution was enhanced, geometric rectified to geographic coordinate and composed to false color composite image for identifying coastline. The coastline was identified and converted to vector format. According to satellite data, coastline maps were established in GIS database. Overlay analysis was implemented in GIS database to assess coastline changes in RRD.

The coastal erosion in RRD was classified according to scale and intensity of erosion as follow:

Intensity	Erosion rate (m/year)	Scale	Erosion length (km)
Weak	0 – 2,5	Small	< 0,5
Medium	2,5 – 5	Medium	0,5 - 2
Strong	5 - 10	Large	2 - 5
Very strong	> 10	Very large	> 5

3. RESULTS AND DISCUSSIONS

3.1 Coastal erosion in Do Son - Ba Lat coastal part

The coastal erosion of Do Son - Ba Lat coastal part was assessed by map data scale of 1:250,000 made in 1930, UTM maps scale of 1:50,000 made in 1965, SPOT XS satellite image in 1998 and MOS-1 MESSR satellite image in 1990.

During 1930-1965, strong intensity erosion coast was of 60% and very strong was 40% of total length of erosion coasts. The highest erosion rate was recorded at Thuy Truong coastal section with 17.1m per year. As regard to erosion scale, large scale occupied 60% and very large scale was of 40% of total length of erosion coasts.

During 1965-1990, medium intensity erosion coast occupied 25%, strong intensity was of 50% and very strong intensity was of 25% of total length of erosion coasts. The highest erosion rate was recorded at Bang La coastal section with 13.2m per year. As regard to erosion scale, small to medium scale occupied 36%, large scale occupied 34% and very large scale was 30% of total length of erosion coasts.

During 1990-1998, coastline of this region was relatively stable and accretion was predominated. Only Thuy Xuan coastal section was still eroded with very strong intensity (10m/year), but with small scale (1800m).

Thus, from 1930 to present, scale and intensity of coastal erosion in this region has been decreased and general trend is gradually stable and accretion.

3.2 Coastal erosion in Ba Lat - Lach Truong coastal part

The coastal erosion of Ba Lat - Lach Truong coastal part was assessed by map data scale of 1:250,000 made in 1930, UTM maps scale of 1:50,000 made in 1965, SPOT XS satellite image in 1995 and MOS-1 MESSR satellite image in 1991.

During 1930-1956, weak intensity erosion coasts occupied 12.5%, medium intensity - 12.5%, strong erosion - 25%, and very strong erosion - 50% of total length of erosion coastal sections. The highest erosion rate was recorded at Giao Long coastal section (19.4m/year). As

regard to erosion scale, medium scale occupied 25%, large scale occupied 62.5% and very large scale - 12.5% of total length of erosion coastal sections.

During 1965-1991, medium intensity erosion coast occupied 9%, strong erosion - 45.5% and very strong erosion - 45.5% total length of erosion coastal sections. The highest erosion rate was recorded at Giao Long coastal section (20.4m/year). As regard to erosion scale, the large scale occupied 45.5% and very large scale - 54.5% of total length of erosion coastal sections.

During 1991-1995, strong intensity erosion coast occupied 12.5%, and very strong erosion - 87.5% of total length of erosion coastal sections. The highest erosion rate was recorded at Hai Hoa coastal section (20.5m/year). As regard to erosion scale, the medium scale occupied 25%, and large scale - 75% of total length of erosion coastal sections. In Hai Hau area, the intensity of erosion was rapidly increasing and the erosion boundary was moving southward to Hai Thinh.

During period from 1930 to 1995, the erosion intensity was gradually increasing. Up to 1995, the very strong erosion was dominated. The weak and medium erosion has been not existed recently. The erosion scale has decreased, but still happened in large area with very serious level. Recently, sea dyke system has been consolidated and newly built, so damage by coastal erosion has been lightened.

3.3 General assessment of coastal erosion in Red River Delta coastal area

The erosion and the accretion in RRD coastal area have been happened complicated with different levels in scale and intensity depending on coastal sections and periods. At Day river mouth, the accretion has dominated and happened rapidly with rate over 100m/year. Diem Dien and Ba Lat river mouths have also accreted with an average intensity of 10m/year. In other coastal sections such as Dong Chau, Thanh Chau, Giao Xuan, Thai Thuong, the erosion and the accretion have been alternative. The continuous and strong erosion in sections such as Thuy Xuan, Hai Hau have happened seriously. In the North of Vietnam, the strong coastal erosion has been concentrated to Red River Delta coastal area, which is also one of the most serious erosion area in Vietnam (Figure 1).

The coastal erosion in RRD has happened complicatedly depending on coastal structure and dynamics. The erosion has happened in long coastal sections lying between accretion section nearly river mouths. In all coasts from Do Son to Hau Loc, 6 coastal sections have been eroded for long time, since 1930 to present. They are Bang La, Thuy Xuan, Dong Long, Giao Long, Hai Hau, Hau Loc. Among 6 them, Hai Hau has been eroded at strongest level.

Van Ly – Hai Thinh coast (Hai Hau section) has been eroding since early years of 20 century. In early years of 20 century, this area was natural eroded with rate of 5-10m/year. Recently, some coastal sites at Van Ly have been embanked by stones, so erosion rate has decreased. The coastal section from Hai Trieu to Hai Thinh has still naturally eroded with very strong rate, reaching 20 to 30m per year at some sites.

The erosion at of Hau Loc coastal section has happened since 1930. From 1991-1995, it happened with stronger intensity and larger scale in comparison with previous periods. Recently, although this coastal section has been embanked by stones, but the erosion have been still happening.

Table 1. General view of coastal erosion in Red River Delta

Area		1930-1965		1965-1990		1990-present	
		Km	%	Km	%	Km	%
Do Son - Ba Lat	Length of erosion	25,12		19,07		1,8	
	Weak	0	0	0	0	0	0
	Medium	0	0	0,67	3,5	0	0
	Strong	15,52	61,78	4,90	25,7	0	0
	Very strong	9,60	38,22	13,5	70,8	1,8	100
	Area of erosion	17,2 ha/year		9,87 ha/year		2,0 ha/year	
Ba Lat - Lach Truong	Length of erosion	21,26		39,9		22,75	
	Weak	3,3	15,5	0	0	0	0
	Medium	2,5	11,8	2,0	5,0	0	0
	Strong	3,8	17,9	8,2	20,6	0,8	3,5
	Very strong	11,66	54,8	29,7	74,4	21,95	96,5
	Area of eroion	15,1 ha/year		37,98 ha/year		26,08 ha/year	

The other strongly eroded areas such as Bang La, Thuy Xuan, Dong Long, Giao Long happened in scale smaller than areas such as Hai Hau and Hau Loc, their erosion intensity and scale have been decreasing.

At river mouths, such as Ba Lat, Tra Ly, Day, accretion have been strongly continuously. Especially at Day river mouth, accreted rate was over 100m/year seaward. Mean while Hau Hau area has been continuously eroded with increased intensity. Xuan Thuy coast was eroded in width of 1000m during 1965-1990. Now, it stopped, some sites started with accretion. Other coastal sections such as Bang La, Tien Lang, Thuy Xuan, Ngoai Chau have been eroded during 1965-1990, to now erosion rate has decreased and some areas have started to accrete.

4. CONCLUSIONS

Remote sensing data interpretation and GIS analysis in combination with survey data have permitted to monitor coastal erosion in RRD in three periods 1930-1965, 1965-1990 and 1990 to present. The results of erosion assessment show that erosion has happened complicatedly by place and time. First period, the erosion happened on 46.6km, with average rate of 7m/year; second period, the erosion happened on 59km coast, with average rate of 8.1m/year; and third period, erosion happened on 23.7km coast, with average rate of 11m/year. Thus, at recently general trend erosion has decreased in scale (may due to better coastal protection or little typhoon), but increased in intensity. The north coastal part has decreased in erosion scale and intensity obviously from 1930 to present. The south coastal part has decreased in erosion scale a little, but increased in erosion rate during the last 70 years. Four development tendencies of eroded sites were discovered: 1) lasting coastal erosion for the last 70 years (Hai Hau, Hau Loc); 2) changing from accretion into erosion (Thuy Xuan, Hai Thinh, Da Loc); 3) changing from erosion into accretion (Bang La, Vinh Quang, Giao Thuy); and 4) interchanging between erosion and accretion for the short duration (Diem Dien, Dong Chau, Dong Long).

Using remote sensing data and GIS technology brought an effectively results for monitoring coastal erosion in RRD. In this study, coast was defined as mean sea level at mud-sandy coast, where tidal dynamics dominated, and as high sea level in sandy coast, where wave dynamics dominate. Monitoring coastal erosion by remote sensing and GIS is an important task of coastal environment monitoring regularly

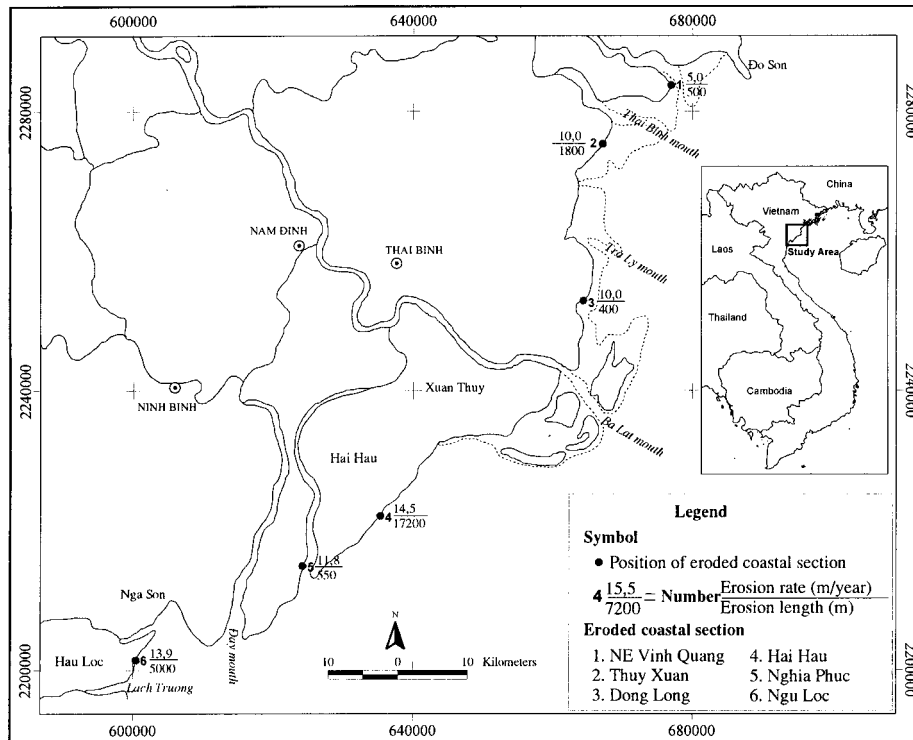


Figure 1. Position of important erosion sites in Red River Delta coastal zone

5. REFERENCES

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