USING TIME-SERIES REMOTELY SENSED DATA TO TRACE HISTORICAL CHANGES OF LOC AN RIVER MOUTH AREA

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ABSTRACT

Over the past 50 years, since 1953, the estuarine area of Loc An has significantly changed its shape five times indicating the low stability of the area. These can be identified by analyzing remotely sensed data including aerial photos and digital satellite imageries of 1953 up to 2002. Although the morphology of the area, a bar-built estuarine lagoon, slightly changes in general, the area is still on morphological development stage. This fact should be taken into account in exploration of the area and long-term resoures use planning.

1. INTRODUCTION

Loc An river mouth locates at the furthermost southern part of the central coastal zone, belonging to Ba Ria Vung Tau province. Dinh river, ended with Loc An mouth, has length of about 90 km with the catchment covering an area of 1200 sqkm. It is derived from low hills at altitude of 250m asl., 50km from the sea, with gentle slope and narrow channel at upstream, shallow at downstream and blockage by sandbars at the mouth.

The river mouth is of a mixed shape of a bar-built estuarine lagoon, like ones located in the central coastal area obstructed by sandy bars at the sea front, with one or two narrow inlets and usually two spits as arms covering water body inside. The coast has direction from northeast to southwest, extending about 6 kilometers length and less than one kilometer width. Sand and mud materials of the beach and estuarine bed were mainly originated from marine-river and wind, which sets up sandy dunes along the shores. Vegetation cover is mainly poor mangrove on the entire area while it is sparse grasses and shrubs on sand dunes.

At the present, requirement of land use for economic development activities has increased at the estuarine area and it is neccessary to have an appropriate plan of land use. Therefore, it is essential to understand locally various physical conditions, particularly the hydrological regime and geomorphology, to identify its spatial stability. This requires conducting a comprehensive study and collection of information. The information collection includes getting new data and historical ones. As the data prior to 15 years ago are not available, systematic study can not be completed. However, this difficulty can be overcome by making use of other sources available from aerial photos and satellite imageries – remotely sensed data, which can assist the identification of changes at the area in the past and up to date.

Using remotely sensed data to study estuarine areas usually focuses on deltaic shapes characterized by muddy flats and often extending in area. This extension results from a process of accretion in coastline and of shallowing channel of river mouth. Another type of estuary areas, the bar-built ones, is more complex. Its morphological change does not take place as the pattern of accretion and erosion, making prediction become more difficult because its variation is affected by various factors such as hydrology, sea-ocean current, geomorphology, local climate condition. The difficulty is even more as the area is located on coastal zones facing open sea.

This paper presents an application of time-series remotely sensed data including aerial photos and satellite images to study shape changing over past 50 years of the Loc An estuarine area to contribute understandings on complex morphological change of a bar-built estuary and to identify the changes in order to utilize the resources in this area more effectively.

2. METHODS

Data used in this study include aerial photos, digital satellite imageries of Landsat MSS, TM and ETM+. The aerial photos were taken in 1953, the earliest remotely sensed data in this area and digital satellite data of MSS were acquired in 1973 from Landsat 1. They are considered useful historical data for tracking changes.

Totally there are nine benchmarks of data from 1953 up to 2002, used to trace the changes. The available data are aerial image data of 1953, 1979 and 1990 and Landsat satellite images in 1973, 1989, 1993, 2001 and 2002. The vectorized topographic map at scale 1: 50.000 published in 1966 is used for baseline and for georectification of all imageries after the UTM projection. The MSS image at spatial resolution 80m was resampled to TM data with resolution 30m and all the rest remained at the original resolution. Only red and infra-red spectral bands of satellite data were chosen as these bands can support delineation of the shore lines clearly after making a band transformation. Aerial photos at different scales and dates were rasterized and processed as normally done for satellite data.

The change detection approach was applied to identify differences of morphology over times. This is a combination of transformed bands of each date creating multiple date data to identify changes and to extract directly shorelines of each separate date and then these were analysed in GIS to get an outcome of more accuracy.

3. RESULTS

The result of analysis shows a great change between presence and the past 50 years. From 1953 to 2002, there were significant movements of sand dunes – spits and sandy islets being natural barriers blocking estuarine lagoon of Loc An. These are changes of shape, size and position of inlets shallowed and displaced by connection of islets into spits at a stage. On other stages, bars are of trend cut-off to make a new inlet. There are six significant stages of changes considered in this research as the followings.

3.1. In 1953

The river mouth was almost directly connected with open sea because there was not any barrier at this position; stream ran directly into the sea. There were two separated sandy bars located further at the south area building up an open lagoon with three inlets. These were

two narrow sandy islets like sand dunes, on which there were patches of mangroves growing on the inside face of the lagoon and there were dense patches of shrubs. There were submerged sandy bars obstructing the ways of inlets (see fig. 1A)

3.2. In 1953 – 1966

The two bars were fixed together to become the main unique sandy bar of the lagoon, lengthened 4400 meters, making a lagoon with two ends opened. One end is the mouth of Loc An river, which was very narrow, less than 50 meter width. At this position, there was a minor adjust that made the shape of the mouth change. The other end occurred as one sandy bar broken at the most narrow position. The opened south end of this sand bar was filled and connected to the land to make a new long spit (fig. 1B).

3.3. In 1966 – 1973

The main bar again was split at the middle position and this situation was similar to the period of 1953 but positions of inlets were altered. Generally, the form of lagoon was of two spits and the new main inlet became the mouth of the stream. At this period, there was exchange of water between lagoon and stream because the mouth moved farther to the south (fig. 1C).

3.4. In 1973 – 1979

The form appeared to be as at the period of 1966 with a small change, indicated by the shorter main bar. The middle inlet went on downward and the tip of south spit bended upward to make the shape of lagoon more complex. Water exchange between stream and lagoon was limited as the form of main bar changed (fig.1D).

3.5. In 1979 – 1989 – 1990 – 1993

The short spit at the mouth stretched and the inlet actually moved downward, a small inlet re-occurred at the position of 1965 period at the other end of lagoon. Inside the lagoon was almost shallowed by muddy accumulation covering with mangove patches. The isolate sandy bar still existed but its length and position of the two inlets at two ends slightly moved; this status did not last long because later on the small inlet was closed again by a connection of the main bar with the south spit. At this period, there was a steady movement of river mouth along with development of spits like the two arms of lagoon; but this was an unbalanced extension. This process had continued until 2002 and the main sandy bar became more narrow and shorter than the previous period (fig. 1E, 1F, 1G).

3.6. In 1993 – 2001 – 2002

The north spit connecting to the mouth of stream has become longer and wider at the tip while the south spit has developed less, on which there was one small inlet. The south spit was very narrow, about 20 – 40 meters wide, forming a slender sandy bar. Because of the development of the north spit, the stream appeared to be extended more in length and it ran almost parallel with the coast in a distance of about 2500 meters before the flow runs into the sea (fig. 1H, 1 I).

In general, the change of the Loc An estuary has mainly been at size of sandy bars and position of the main inlet that has been a shift up and down along the northeast – southwest axis (fig. 2). Development of the two spits is unequal. The north part gradually extends

southward and at some periods, it is cut off to make two separate sand bars while the south spit has been narrower. The lagoon channel has become shallowed at the south part while the north part is supplied with water from the river and its form becomes like a stream. This process also has taken place at inlets, where the channels have been filled, making separated bars connected together. As a result, spits extended longer but narrower at the middle segment, which became unstable and easily broken.

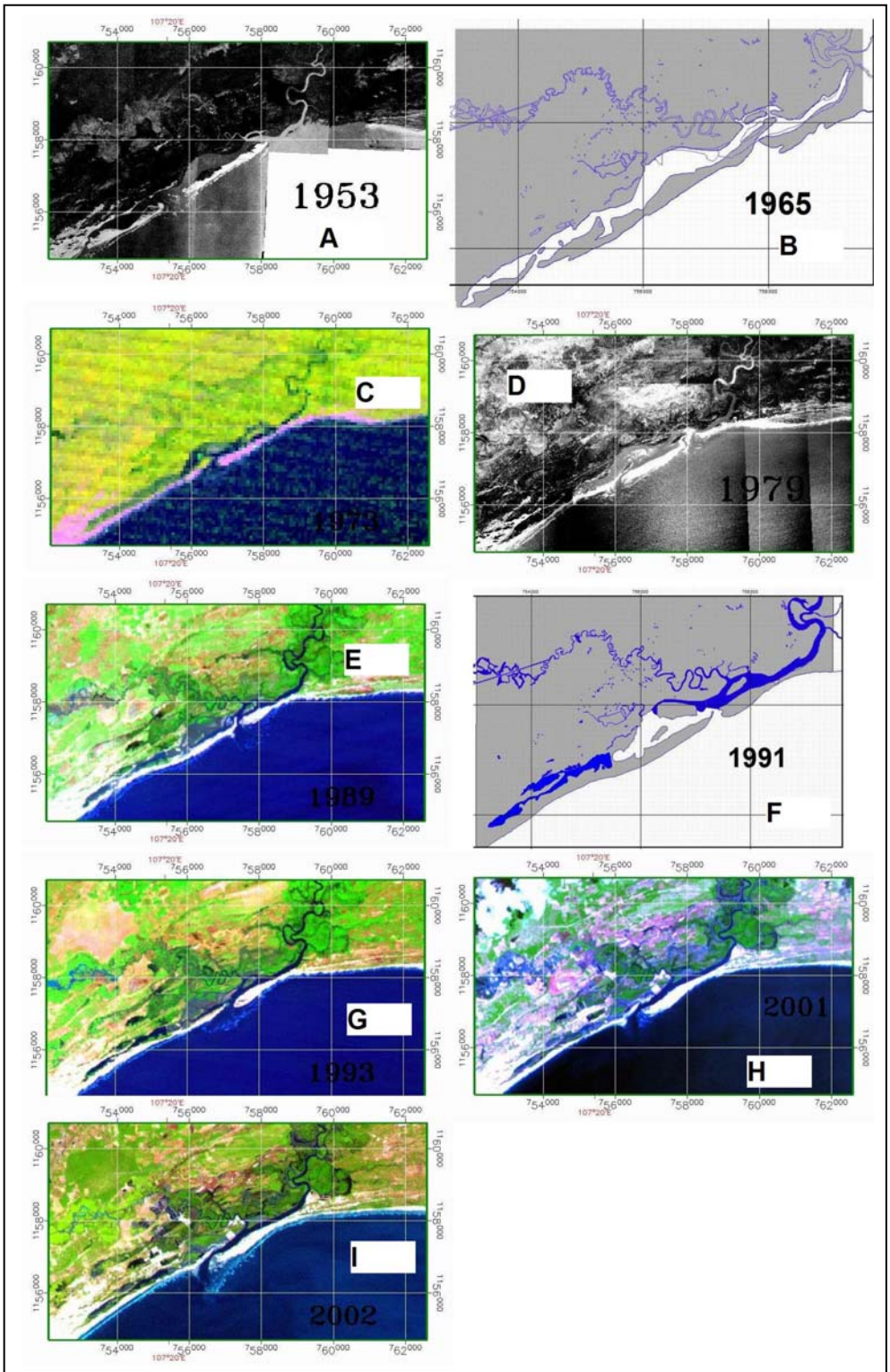

Figure 1: Loc An estuarine area over times, 1953 to 2002

These changes do not follow a clear pattern of accretion and erosion although these can be observed as eroded on one tip and accumulated on the other. Process of shorterning, splitting, extending in length has occurred repeatedly over periods. Position of the main inlet moves from place to another and there is a tendency that previous status (shape of the lagoon in the past) could re-occur at weak positions of spit.

It is necessary to notice that in the study area, historically before the 1980s, there were not clear evidences on the relation between human activities and shape change. In the whole area, from river mouth area to upper stream and adjacent zones, vegetation cover rate is very high, showing dense forests. Before the 1980s, shape and size of spits critically changed three times; sequentially, changes mainly were in movement of inlets. In addition, from 1993 to 2002, outside the main inlet, submerged sandy bar has occurred causing a possibility of the inlet channel being shallowed. In the long term, this inlet could be filled, and other segments of the spit could be broken again.

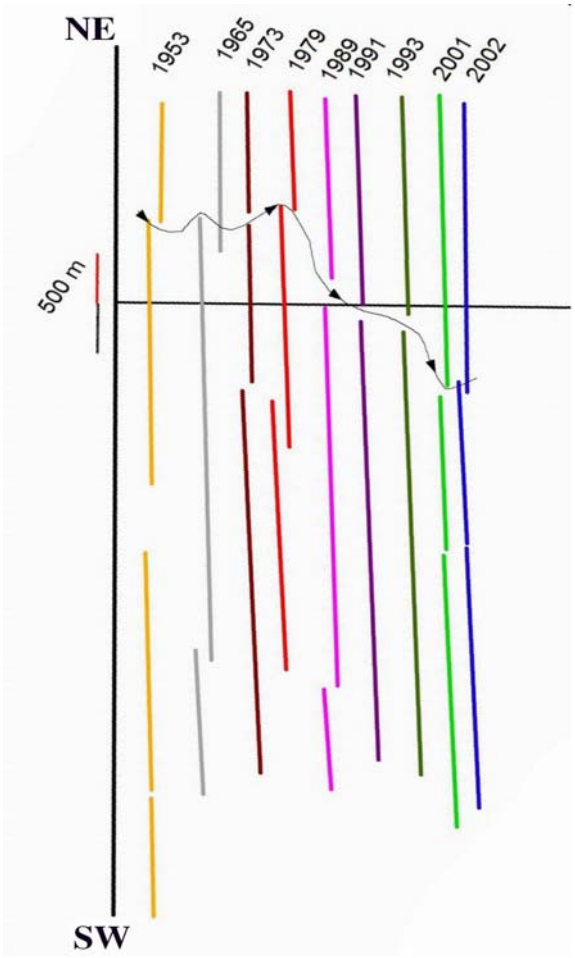

Figure 2. Change profile of Loc An - movement of inlets from 1953 to 2002

4. CONCLUSIONS

The changes of Loc An estuary indicate an unstable status of Loc An river mouth. A relatively stable period could prolong only about 10 years. Within a period, shift of inlets could steadily be up or down along the coast but the moment at which spits could be broken is difficult to identify. The reason is that the process is influenced by various factors. One of these is occurrence of submerged sandy bars outside the main inlet, which is depended on materials loaded by the sea current. In addition, an abnormal weather condition as tropical cyclone could cause the process become faster.

Although the resolutions of the used imageries are not unique (aerial photos at different scale, Landsat MSS, TM and ETM+), in this research, the study of morphological changes did reveal significant changes of the Loc An river mouth over different periods. The results present the potential of remotedly sensed data could be applied for a small scale as at Loc An estuarine. The more available data used in the research will get the more systematic, better results.

On recent years, intervention of human includes activities of harbor construction, removing mangrove and related constructions, dam making and vegetation cover clearance in the area will make processes of change more complex. Any planning to exploit resources on both land and watercourse should take unstability of the area into account.

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