Evaluation of Hydrodynamic effects on the Geomorphology of Indus Delta (Pakistan) by land sat data

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Abstract: A land sat satellite data based temporal study has been conducted to findout the varying intensity of the morphologic changes of several deltaic features of Indus delta. The dominant marine dynamic conditions are because of the shortage of water supply in downstream. These rapid and dynamic landward sea invasion are responsible of irrepairable loss to the delta. Based on the temporal landsat data results, geomorphic features like coastal line, creeks' network system, tidally swamped area, river course and the mouth of the river and Indus Canyon were found under the severe degradation conditions.

Keywords: Indus Delta, Coastline, Creeks, Indus River, Indus Canyon

1. Introduction

World's deltas study due to their locations between the oceanic and the terrestrial environment, exhibits mutidisciplinary feature and complex dynamic geomorphic characteristics. The features developed in the delta are due to the interaction between the river system and the ocean system *(Chaudhuri, 2002; McManus, 2002; Ericson, 2006*). Indus delta in Pakistan is one of the unique features of the world. The Delta under the natural phenomena of enormous water-flow and sediments discharge was called fluvial dominated delta (Mahar, 2010). Fluvial system is mainly responisble for the degradation of the geomorphic features of the Indusa deltaic.

2. Methodology

Satellite images of landsat dated 1978, 2000 and 2007 have been analyzed to find out the varying spatiotemporal geomorphic feature of the Indus Delta, Pakistan. Color Composit Image (CCI) of each scene has been made and Projected Coordinated System) on the datum of World Geodetic System (WGS) 1984 has been given. Changes in geomorphic features especially creek network, tidally influenced area and shoreline have been digitized by setting CCI of relevant spectral bands. The area of each set has been calculated to get the difference.

Two sets of Bathymetry maps historical (1895) and modern (1998) have been projected on the same datum. The depth of the shelf has been compiled in digital format with same resolution to get the accurate result. This way the difference in the shelf and Indus Canyon was evaluated.

Water flow data from Irrigation Department has been collected, compiled and analysed.

3. Geomorphic Change in Indus Delta

In order to detect the terrestrial and sub-equous major geomorphic changes of Delta, many delta features were selected to study from the satellite images. Coastline changes, creeks' network, tidally influenced area, downstream river course near the mouth of river nad Indus Canyon found in physically degrading conditions.

3.1 Coastline

The coastline features extracted from land sat images of years 1978, 2000 and 2007 show noteable difference on larger scale. However, the rate of retreat, measured and calculated, is 8.44 m/year in 22 years from 1978 to 2000, but during the 7 years period from 2000 to 2007, it has been significantly increased at the rate of 29.76 m/years (Figure 1).

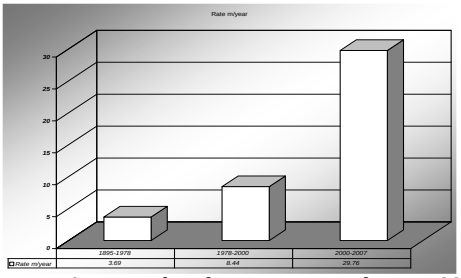

Figure 1: Average shoreline retreat rate during 1895-1978 (83 years periods) 1978-2000 (22 years periods), 2000-2007 (07 years periods).

3.2 Creek's Network System

Centuriies old creek network system also shows abrupt changes in their morphology with respect to the studied periods via land sat image. The total network area estimated was about 1173 km^2 in 1978, 1217 km^2 in 2000 and 1878 km^2 in 2007. The difference in decades which was detected is about 139 km^2 area in 1978-2000 period at the rate of 6.30 km^2/year and about 679 km^2 areas in 2000-2007 peior at the rate of 97 km^2/year have been enchrached by sea intrusion (Figure 2). Inversely, it is also found that about 83 km^2 areas from 1978 to 2000 at and 18.60 km^2 area from 2000 to 2007 has been reduced due to the active accretion processes.

3.3 Tidally Influnced Area

The trend of creek enlargement indicates that landward sea invasion tookplace at higher rate into the active deltaic region as overlay result shows day by day increase of tidally swamped areas. The comparative study of tidally swamped areas measured from images of 1978 is 5325 km^2, from image of 2000 is 5413 km^2 and from image of 2007 is 5601 km^2. These results show an expansion of area about 88 km^2 in 22 years (1978-2000) with 4 km^2/year rate and an expansion of 188 km^2 in 7 years (2000-2007) with 27 km^2/year rate.

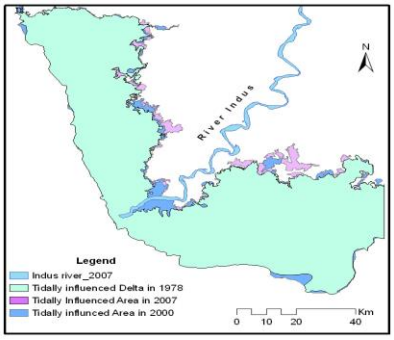

Figure 2: Overlays map, dated 1978, 2000 and 2007 shows increase of tidally influenced area along the delta.

3.4 Indus River Course

Prominent morphological changes were also observed along the course of river in the delta using land sat images of studied periods. Results show that the water shortage from upstream and sea waves & tidal currents are main causes of erosion and widening of the river near the mouth of delta during the last 30 years from 1978 to 2007. In general, the course and thalweg have broadened at rate of 26 meter/year and 6 meter/year from 1978 and 2007 period respectively in the southern deltaic area. The widths of the same features were reduced with an average 64 meter/year and 16 meter/year respectively during the same period in northern deltaic area. The trend of the morphological changes indicates the inflow (inverse flow) of seawater in the course from mouth of river. Sometimes, it goes up to the Kotri barrage due to depleted flow of river water into the delta that has weakened fluvial processes.

3.5 Indus Canyon

The changes in the Indus canyon have been detected from two (historical and modern) bathymetry maps. Historical map was surveyed in 1895 and modern bathymetry map was compiled in 1998 from different recent and satellite data. Major changes found in this study were changes in the head of the canyon. . The axis of canyon has been moved from N 52^0 E to N 74^0 E. The distance of westward shift of head of canyon is about 15 km (Figure 3). Other changes like slope of the canyon; canyon's walls and width have also been detected from the study.

4. Indus Water Flow

Flow data of Indus river after Kotri barrage between 1931 and April 2009 have been carried out quantitatively as well as qualitatively (Figure 4).

The flow history have been studied comparing the construction time-period of dams and barrages serving to interrupt the flow of water and sediments to the lower indus plain. The flow history trend discover from substantial decline of Indus water-flow to near about zero level in 2000.

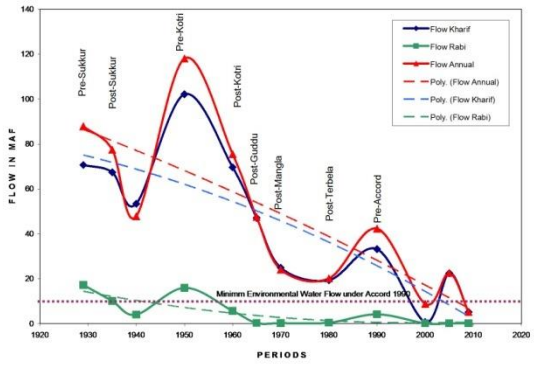

Figure 4: Graph shows that the waterflow (polylines) decline is linked with consstructions period of barrages and dams.

5. Conclusion

Results evaluated from the satellite data show that Indus Delta presently is under the severe crises of degradation. It is not only degrading the geomorphic features of delta but it seems that day by day overall scenario is shrinking the delta. Main cause is the scarcity of freshwater and dominance of seawater invasion over the active part of the delta.

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