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## Shoreline change detection from Karwar to Gokarna - South West coast of India using remotely Sensed data

**RICHA CHOUDHARY<sup>1</sup>, R. GOWTHAMAN<sup>2</sup> AND V. SANIL KUMAR<sup>2</sup>**

<sup>1</sup>Geoinformatics Division, Department of Marine Geology, Mangalore University, Mangalagangothri

<sup>2</sup>Ocean Engineering Division, National Institute of Oceanography (CSIR), Dona Paula, Goa-403004

Email: rchoudhary@nio.org, rgowtham@nio.org, sanil@nio.org

**Abstract:** IRS P6 satellite images and toposheet of study area was studied to carry out comparative study to quantify erosion and accretion in two phases (i) in the span of thirty years and (ii) in the span of seven years. It was detected that sediment accretion of 0.40975 km<sup>2</sup> occurred between North Breakwater and Arge Cape of Karwar region between 2004 and 2011. Northern part of Kali river spit has shifted by 426.3 m to the north in thirty years span and out of which 109.41 m was during the seven years period. Gangavali river mouth has narrowed due to siltation. Significant changes in the geomorphic features like spit growth, braided island, creeks, tidal flat are observed near Kali and Gangavali river mouth.

**Keywords:** Remote sensing, Shoreline Changes, Geomorphology

### 1. Introduction

Coastal zone is very dynamic, being the meeting place of land and sea water. The development in coastal area and subsequent population growth have given rise to problems such as erosion, sedimentation, saltwater intrusion, degradation of natural resources, etc. Satellite data has proved to be more appropriate for change detections quantifying and monitoring coastal zones compared to conventional sources. (Saranathan et al. 2011). It is of paramount importance for coastal settlements to know without bias whether local shorelines are advancing, retreating or stable. (Kasinatha Pandian et al. 2004). Littoral drift plays an important role in deciding the areas of coastal erosion and accretion, in shaping and orienting coastal landforms and finally in the evolution of the coast. (Praveen Kunte & B.G. Wagle, 2001).

Offshore breakwaters have been constructed with the purpose of preserving the properties and lowlands against the threats of high waves generated by typhoons, inundation and slow coastal erosion. (Moussa Sanea 2007). After the introduction of breakwaters for the port, beach erosion and accretion are considered as critical problems, resulting in damages to the natural set up of the coastal region. (Kasinatha Pandian et al. 2004). Bhat et al (2000) studied 100 km stretch of southern Karnataka to look at 90 years of shoreline changes using toposheet, PAN data of IRS-1C of 1996 and 1998. They reported the breakwater of New Mangalore Port, the breakwaters at the mouths of Nethravathi- Gurupur estuary, Udyavara estuary and seawalls elsewhere have contributed substantially to the modification of shoreline.

The availability of remote sensing data has ensured synoptic and repetitive coverage for the entire earth.

This information has been extremely useful in generation of spatial information. (Sheik Mujabar et. al., 2011). Remote sensing is the key to construct strong background knowledge of the natural landforms, the potential activities of geological agents and some man made activities. (Saranathan et al., 2011). Present study envisages the dynamic changes over long term for base line study in future.

### Study area

The study area (Figure 1) is located between latitude 14°32'39.56" to 14°53'54.78" N and longitude 74°5'45.14" to 74°18'43.81" E. The presence of beach ridges mainly along Karwar, Arge and Gokarna Beach (Bannur, 1994, Radhakrishna and Vaidyanathan, 1994), indicate the evidence of emergent coast. The coast of Uttara Kannada is characterized by the presence of linear beaches, pocket beaches, sheltered beaches, estuarine beaches, islands and tombolos etc. (Hegde et. al., 2008).

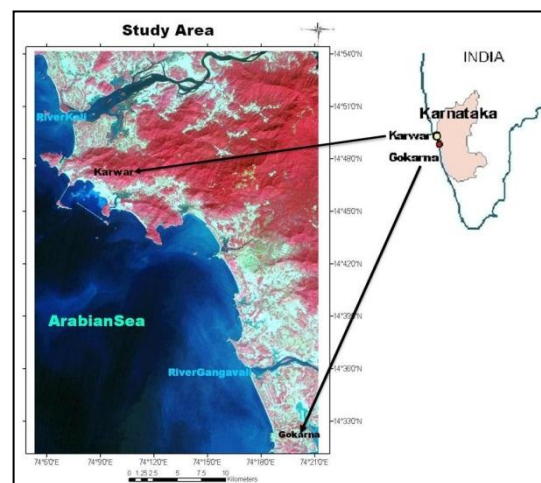


Fig: Study area

## 2. Data source

List of data product used for the study

**Table 1:** Satellite data information used for the study

Date and Year	Path/ Row	Satellite id	Sensor	Tidal height (m)
6/1/04	096-062	IRS-P6	LISS-III	0.95
17/1/11	096-063	IRS-P6	LISS-III	1.00

**Table 2:** Details of the toposheets used for the baseline study

State	Toposheet ID	Scale	Year
Karnataka	48J/1	1:50,000	1981
Karnataka	48J/2	1:50,000	1978
Karnataka	48J/6	1:50,000	1980

## 3. Methodology

SOI toposheet of the years 1978, 1980 and 1981 were used as base maps. All toposheets were georeferenced using Erdas Imagine 8.5, projected as geographic projection and modified everest as datum. Data during similar tidal phase is taken into consideration to avoid any error (table 1).

Images from IRS P6 for years 2004 and 2011 were geocoded using image to image rectification process identifying permanent 30 points such as cross roads, bridges etc. Nearest neighbour resampling was adopted.

The registered imageries were opened in ARC GIS 9.2 environment with a band combination of 3:2:1 (FCC) for displaying best contrast between land - water boundary in the satellite image and thus shoreline was identified and demarcated. High waterline of the toposheet was digitized as line feature. Digitized shorelines for different years were overlaid and polygons were created for every changed location. The polygon area was calculated to quantify erosion and accretion all along the shoreline of the study site.

### Geomorphology

Toposheet for the year 1981 and geocoded map for 2011 was used to identify geomorphology of estuarine environment of river Kali and Gangavali using ARC GIS 9.2. Visual interpretation technique was followed for the identification of landforms. (Selvavinayagam, 2008) Geomorphic features such as alluvial flat, coastal plain, braided island, island tidal flat, spit etc were identified and mapped as polygons. (Figure 7 and 8). Based on polygon area quantification was done for each of these features.

## 4. Result and discussion

**Erosion and accretion in seven years span** - It is found that the north spit of Kali river has shifted 109.41 m to the north. The northern part near river mouth shows an accretion of 0.1758 km<sup>2</sup> and erosion of 0.08 km<sup>2</sup> whereas the southern part is accreted by 0.1086 km<sup>2</sup>, no erosion observed for about 1.2 km of distance (Figure 2). The 10 km proximity from Panduranga Gudda, near the naval base of Karwar, accretion on the north part is 0.02059 km<sup>2</sup> and erosion 0.00623 km<sup>2</sup>. Between North Breakwater and Arge Cape it is 0.40975 km<sup>2</sup> of accretion and only 0.00432 km<sup>2</sup> of erosion, implying heavy accretion compared to erosion (Figure 4) .10 Km down south from Arge Cape 0.0320 km<sup>2</sup> of accretion and erosion of 0.04906 km<sup>2</sup> is noted. Field study conducted by Hanamgod & Mitra (2007) suggests accretion at the central portion of Arge Beach that is an artificial nourishment and construction activity. This result corroborates our results using remote sensing and GIS technology. Gangavali river mouth has become narrow as sediment accretion has increased on both the sides of river mouth, since spit has shifted 70 m down south on the north and 105.2 m shift north up on the southern part of the mouth. Calculated erosion is 0.05603 km<sup>2</sup> on the north part of the river mouth and 0.0297 km<sup>2</sup> in the south. Accretion observed is 0.0192 km<sup>2</sup> in the north and 0.0297 km<sup>2</sup> in the south (Figure 6). The total erosion of the study area is 0.5718 km<sup>2</sup> and total accretion is 0.9820 km<sup>2</sup>.

**Erosion and accretion in three decades** - When the satellite image of the year 2011 was compared with the toposheet data; it was found that the north spit of the Kali river has shifted 426.3 m to the north. Accretion near the north part of the river mouth is 0.2738 km<sup>2</sup> and 0.0844 km<sup>2</sup> in the south. Erosion taken place is 0.08839 sq km in the south, no erosion was observed for a distance of about 1.2 km (Figure 1). The 10 km proximity from Panduranga Gudda, near the naval base of Karwar, on the northern part, the coastline is eroded by 0.0896 km<sup>2</sup> and accreted by 0.01744 km<sup>2</sup> Between North Breakwater and Arge Cape erosion taken place is 0.08036 km<sup>2</sup> and accretion is 0.012736 km<sup>2</sup> (Figure 3). 10 Km down South from Arge Cape the coastline is eroded by 0.0554 km<sup>2</sup> and accreted by 0.0511 km<sup>2</sup>. It may be noted that continuous erosion and accretion scenario, as an affect of the construction of breakwater, was observed to in Elmer beach, United Kingdom. (King et. al., 2000). Gangavali river spit has shifted 94.6 m to the north on the northern part of the river mouth and 309.2 m towards the north in the southern part of the river mouth. Accretion near the river mouth is 0.00250 km<sup>2</sup> in the north and erosion 0.06939 km<sup>2</sup>. Similarly the southern part is accreted by 0.04828 km<sup>2</sup> and eroded by 0.06851 km<sup>2</sup> (Figure 5).The total erosion of the study area is 1.33712 km<sup>2</sup> and total accretion is 0.92448 km<sup>2</sup>.

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**Table 3:** Geomorphology near Kali River mouth

Geomorph ic Feature	Area1981 (sq km)	Area2011 (sq km)	Change in area(sq km)
<b>Braided Island</b>	0.16	0.27	0.11
<b>Coastal Plain</b>	0.69	0.78	0.09
<b>Creek</b>	2.4	1.8	-0.6
<b>Island</b>	0.18	0.18	0
<b>Sandy Beach</b>	0.50	0.68	0.18
<b>Spit</b>	0.81	0.63	-0.18
<b>Alluvial Plain</b>	16.18	16.47	0.29
<b>Tidal Flat</b>	3.39	5.16	1.77

Coastal regions, in particular the regions around the river mouths are the important habitats. Geomorphic process in these regions is complex, and is the net result of inland geology, shoreline configuration, tectonics, sea level rise and fall, near-shore wave climate and sediment influx (Nayak, 2010).

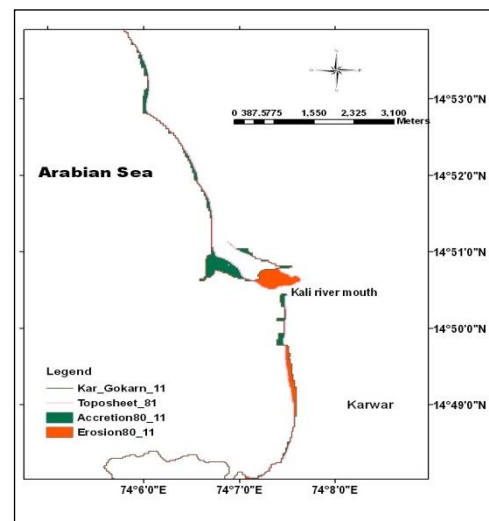
The coastal geomorphology of India is divided into offshore features, shore features, coastal features and littoral geomorphology in relation to human activities and problems (Ahmad E. 1972). The coastal region between Karwar and Bhatkal is complex in nature owing to the geomorphic feature like spits, headlands, cliffed shoreline, lagoons and river mouth beaches in addition to the general north north west (NNW) orientation (Shailesh Nayak et. al. , 2008) . P. Vinayraj et al., 2011 has given results for the year 1981 for geomorphology near river Kali. Tidal flat shows area increment. It can be noted that braided islands have eroded by 0.11 km<sup>2</sup>, creek area has also come down whereas islands have not undergone any changes (Table 3).

**Table 4:** Geomorphology near Gangavali river mouth

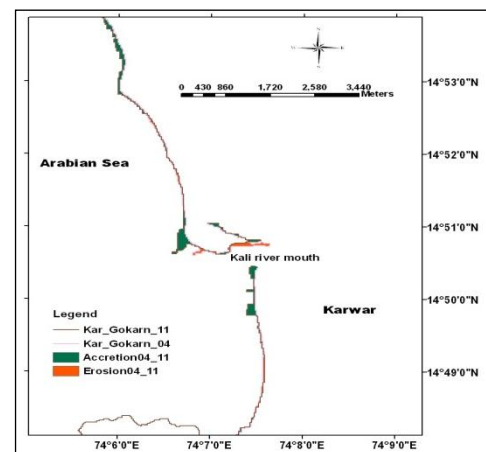
Geomorphic Feature	Area 1981 (sq.km.)	Area 2011 (sq.km.)	Change in Area (sq. km.)
Braided Island	0.90	0.61	-0.29
Coastal Plain	6.48	7.08	0.6
Creek	0.34	0.20	-0.14
Lateritic Plateau	5.41	5.41	0
Sandy Beach	0.78	0.80	0.02
Sandy Ridge	0.75	-	-0.75
Spit	0.06	0.08	0.02
Tidal Flat	1.20	1.99	0.79

Due to the growth of sand spit across the river Gangavali from south to north, the river mouth is getting reduced and mouth is being shifted northward, as a result rapid changes in estuarine morphology are taking place, which in turn is influencing sedimentation process (Shailesh Nayak et. al. , 2008). Sedimentation in the river mouth, narrowing of river mouths, shoreline erosion, and rapid changes of the mouth configurations are the common problems observed along the central west coast of India (Nayak, 2010). In west coast, India, Netravati – Gurupur river system has contributed a major amount of sediments for the growth of spits. (Jayappa et. al., 1991). Near Gangavali river, river's mouth narrows down, the result shows the same as spit area has increased near the mouth. Sandy ridge that existed before is now converted to agriculture land. Creek shows decrease in the area; on the other hand tidal flat area has increased. No changes detected in the lateritic plateau (Table 4).

Due to space constrain selective erosion/accretion sites are shown in the figures below:



**Figure 1:** Erosion and accretion during 1981-2011 near kali river mouth



**Figure 2:** Erosion and accretion during 2004-2011 near kali river mouth

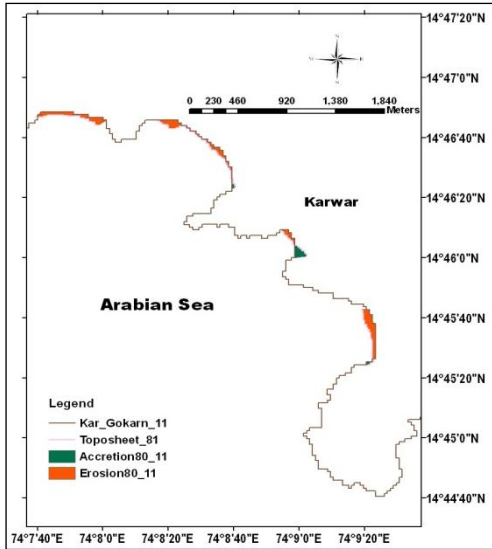


Figure 3: Erosion and accretion between 1981-2011 near breakwater

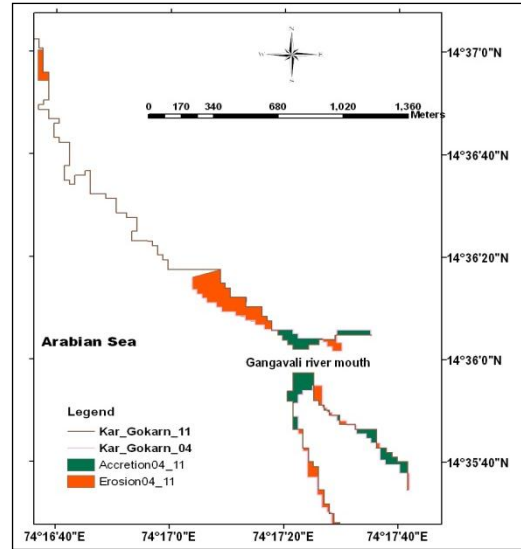


Figure 6: Erosion and accretion during 2004-2011 near Gangavali river mouth

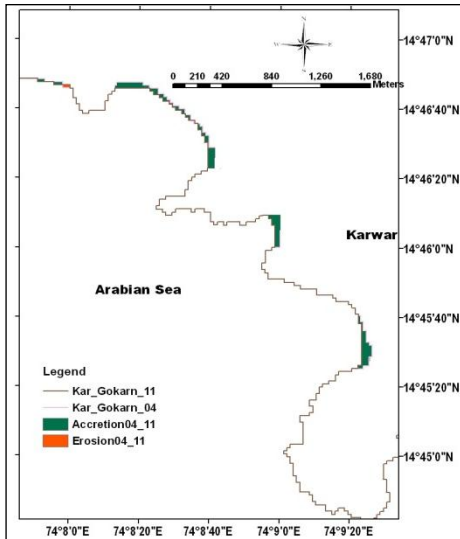


Figure 4: Erosion and accretion between 2004-2011 near breakwater

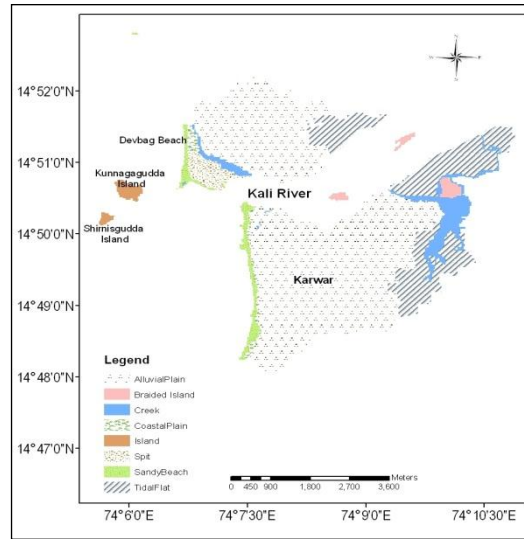


Figure 7: Showing geomorphology near river mouth of river Kali for 2011

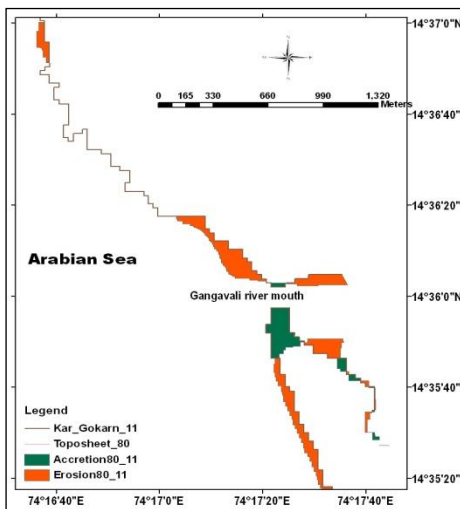


Figure 5: Erosion and accretion during 1980-2011 near Gangavali river mouth

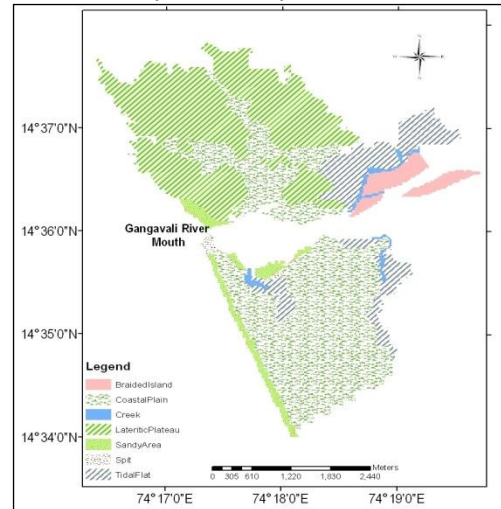


Figure 8: Showing geomorphology near the river mouth of river gangavali for 2011



#### 4. Conclusion

Coastline mapping and coastline change detection are critical for coastal resource management, coastal environmental protection and sustainable coastal development and planning. Changes in the shape of coastline may fundamentally affect the environment of the coastal zone. These may be caused by natural processes and human activities. (Faik Ahmet Sesli, 2010). It may be noted that the rate of erosion varies over time and site to site, due to many factors such as longshore current regime, erodibility of beach material and its composition, near shore seabed shoals and slopes, storm wave energy and duration, shoreline orientation, shore protection structures etc. (ICMAM, 2009).

Remote sensing technology has been aptly utilized to study shoreline and geomorphic changes in the study area. The long term and short term study reveals that erosion rate is higher in the study area in the thirty years span (0.0445 km<sup>2</sup>/year.) whereas accretion is higher in the last seven years (0.140 km<sup>2</sup>/year.), certain places where erosion is high in thirty years shows high accretion in seven years; these are areas of developmental activities. Rocky beaches have not undergone any major changes. Since sediment discharge takes place near river mouth, it is very dynamic and changes seasonally; long term observation shows a shift of Kali river mouth towards north and Gangavali river mouth has narrowed due to accretion of the spit. Geomorphic features like braided islands have eroded near Kali river. In the coastal plain adjacent to Gangavali river estuary sandy ridge has been converted to agriculture land in thirty years.

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