

Coastal changes along the coast of Tadri River, Karnataka West coast of India and its implication

G.M. Tirodkar*, K.C. Pathak & S. Vaz
CSIR- National Institute of Oceanography, Dona Paula, Goa, India
*[Email: gtirodkar@nio.org]

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Present study of the coastal changes in Tadri, Uttara Kannada district of Karnataka, comparing Survey of India Toposheet, Coastal Zone Management Plan of Karnataka and traditional ground survey measurement merged with multi temporal satellite imagery (IRS-P6, LISS III, 2011). This analysis gives the result of erosion from year 1978 to 1996 is 7.83 km², during this period no accretion is noticed. Comparing data set of 1978 with 2011, area of erosion increases to 8.45km², and accretion by 0.15 km². And from 1996 to 2011 it is seen erosion of 3.61km² and accretion of 3.05 km². Erosion is observed in the northern bank of Tadri river, the probable cause of erosion is tidal action along the earthen embankments results in breaching and due to this flood are occurring in the adjacent area, and an accretion is noticed at the mouth result in narrowing the shape, due to sediments brought from upper reaches of Tadri river. The present studies give a scenario of changes and may help authorities to prepare the better Integrated Coastal Zone Management Plan for coastal protection and further developments.

[Keywords: CRZ, high water line, Remote sensing, Coastline Changes, Geomorphology.]

Introduction

Coastal zone is a significant area because of high productivity of its ecosystem, increasing of coastal habitat, exploitation of natural resources, Industrial development and increasing tourism activity, discharge of industrial and municipal waste etc¹. In order to maintain the ecological integrity of the coast under the Environment (protection) act, 1986 the Coastal Regulation Zone notification was introduced in 1991, than after 25 subsequent amendments the new CRZ notification was issued in January 2011. In this notification the coastline defines as line on the land upto which the highest water line reaches during the spring tide². The high tide line is very complex and dynamic in nature which continuously changes its shape and horizontal position. The horizontal runoffs of the water towards landwards mainly depend upon geomorphic processes such as erosion, deposition, sedimentation, periodic storms, flooding and sea level changes. These processes continuously modify the coastline³.

In this paper an attempt has been made to study the coastline changes along the Aghanashini/Tadri

coast in Uttara Kannada district of Karnataka State, and assess and quantify the erosion, accretion. Analysis the changes in the coastal zone in the study area, using a Survey of India Toposheet (No. 48 J/ 6/SW and 48 J/ 6/SE) in 1:25,000 scale as a base map, Coastal Zone Management Plan of Karnataka and a physical survey by traditional ground survey measurement along with multi temporal satellite imagery around survey period.

Materials and Methods

Karnataka coastline is located along the central west coast of the India extends over a length of 280 Km. It is divided in to three district Uttara Kannada, Udupi and Dakshin Kannada. Uttara Kannada district has been classified in two physiographic units, the high lands and the narrow lowland based on the distinct landscapes⁴. It is characterized by the presence of linear, pocket sheltered, estuarine, islands and tombolos beaches⁵. In Uttara Kannada confluence of Kali, Gangavali, Aghanashini/ Tadri, and Sharavati rivers with the Arabian Sea modifies the coastal morphology continuously. The Study area (Aghanashini/Tadri coast) is located between 14° 30' to 14° 35' N

Latitude and $74^{\circ} 20'$ to $74^{\circ} 23' 45''$ E Longitude (Fig. 1). It confines to the coastal stretch between Gokarna in the north extended up to Kumta in the south. This river is originated from two sources, the Bakurhole at Manjuni and Donihalla and flows for a distance of 121 km before meeting Arabian Sea. The river catchment area is 1330 km^2 and average annual discharge is 2556 mm^3 .⁴ The tide at this coast is semidiurnal nature and tidal range is 2.0 m .⁶ This area fall under tropical climate, summer season start from March and end in May and is dominated by southwest monsoon from June to September. The average annual rainfall is 3954 mm of which 87% is received during the monsoon season⁷. The significant wave height at Karwar vary between $1.0 - 2.1 \text{ m}$ during May to August whereas from September to April is $0.4-0.8 \text{ m}$, and its periods mostly varied between 5 and 7 sec. The wave approaches the coast predominantly from southwest sector⁸. The wave approaches from northwest during January and February. At the Gangavali the longshore current mostly persisted around $0.2 - 0.25 \text{ m/s}$ in October, November and December and about $0.25 - 0.3 \text{ m/s}$ in January, February, May, July, August and September. From February to August the direction of longshore current were southward, whereas in December it is northward. Longshore current is erratic in January and September⁸. The coast has a high productivity of ecosystem and ecologically it is sensitive area⁹. The main occupation is fishing,

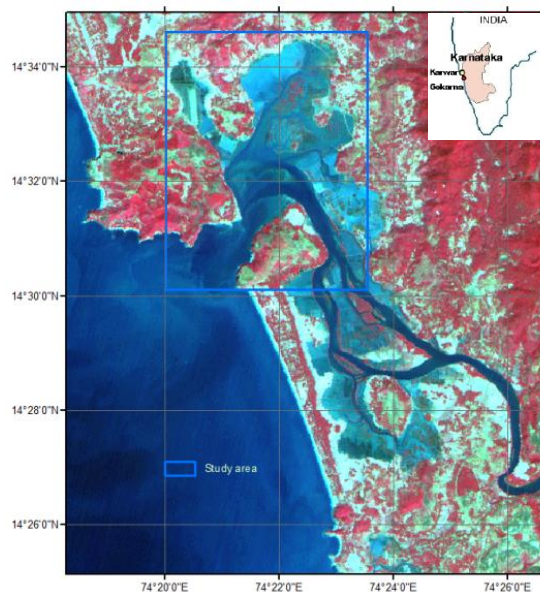


Fig. 1—Map showing the study area

agriculture, shell mining, tourism, extraction of edible bivalves etc.

The main objective of present study is to quantify the coastline change through integrated approach using the available data in the Geographical Information System software and to analysis and quantify the erosion, deposition and associated changes. The following data sets are used (Fig. 2):

- The Survey of India Toposheet 48 J/ 6/SW of 1978 and 48 J/ 6/SE 1979.
- Coastal Zone Management plan of Karnataka prepared by Karnataka association for advancement of science (regd.), Bangalore and Karnataka state remote sensing technology utilisation centre Bangalore prepared for department of Forest Environment & ecology Govt. of Karnataka 1996¹⁰.
- Data of physical ground survey measurement by National Institute of Oceanography^{11,12} along with multi temporal satellite imagery IRS-P6, LISS III remote sensing data, dated 17th January 2011, path 096, row 063, IRS-P6, LISS III, by National Remote Sensing Centre (NRSC), Hyderabad

Methodology

The Survey of India toposheet were scanned and georeferenced and projected into Mercator projection and modified Everest datum by using geographical information system. Image is subset for the study area. These map again

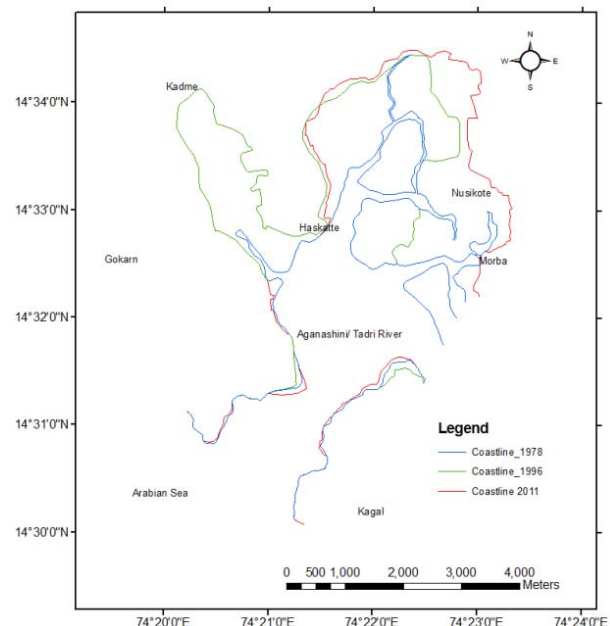


Fig. 2—Coastline changes from 1978-1996-2011

re-projected in to Universal Transverse Mercator (UTM) and World geodetic system-1984 (WGS -1984), the root mean square error were less than 1. Ground control point collected during the study area was used for field validation. These map were used as a base map. Map of coastal zone management plan and satellite image of 2011 were georectified by using image to image rectification process, first order polynomial and the nearest re-sampling method was used for image rectification.

The field data were collected in January 2011 by using differential global positioning systems (Ceeducer pro), 12 channel, accuracy 2-3m and total station (Lasertrak) Distance Accuracy ± 20 cm, Vertical and Horizontal Angle Accuracy are 0.25° and 0.01° respectively. The geographical position of the base and reference station was established by using DGPS. The high tide lines were identified based on the geomorphological feature as per CRZ notification. These identified high tide line position were surveyed by traverse method using the total station, the traverse were closed and total error were distributed to obtain the correct position of the high tide line¹³. For the portion of the area which was unapproachable for physical demarcation of high tide line data was digitized from the satellite image of year January 2011 used^{11,12}.

The coastline was digitised from the geo-corrected image of survey of India, coastal zone management plan as a line feature. The HTL data collected during the field survey as a point feature were jointed forming to line feature, in the hilly terrain area near the mouth, the data extracted from the satellite image of the same survey month. Theses set of coastline data were overlaid for comparison polygons were created at compares change location. Quantification of erosion/accretion was calculated by using created polygon feature by ArcGIS following standard procedures^{3,14,15}.

The paper maps was torn, wrinkled due to aged, the error are created due to shrinkage and expansion of the hard copy, this copy were scanned, geo-corrected, transformed and digitized the probably overall inherent error will be 2 to 3 pixel on the scale of paper maps.

Results and Discussion

The 25 km long Aghanashini/ Tadri coastline has been delineated from the survey of India toposheet of year 1978, map by coastal zone management of year 1996, ground survey measurement in year 2011 and satellite image of 2011. The area has a various geomorphic features as beaches, mudflats, salt pans, shell mining zones mangroves, etc.

The study area shows the erosion from 1978 to 2011. The coastline from Toposheet (SOI) of year 1978 is compared with CZMP 1996 (Fig. 3), then it is compared with 1978 to 2011 (Fig. 4) and from 1996 to 2011 (Fig. 5). The result is tabulated as follows:

The width of the river mouth is reduced by nearly 750m in three decades. The erosion can be accented 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 its duration, shoreline orientation, shore protection structures, shell mining etc¹⁶. Deposition of the sediments brought from upper reaches of Tadri River deposit at the mouth due to velocity decreases in summer season, resulting into narrowing of mouth.

In Coastal Zone Management plan of Karnataka prepared by Karnataka association for advancement of science (regd.), Bangalore and Karnataka state remote sensing technology utilisation centre Bangalore prepared for department of Forest Environment & ecology Govt. of Karnataka 1996, it is seen that the area under salt pan is considered as mudflat and coastline is delineated covering the entire

Table 1—Details of data used in the study

Data Set	Scale/resolution	Year of Publication	Source of Data
48 J/ 6/SW	1:25000	1979	Survey of India
48 J/ 6/SE	1:25000	1978	Survey of India
Sheet 7 (48 J/6/SW)	1:25000	1996	Karnataka Coastal Zone Management Plan
Sheet 8 (48 J/ 6/SE)	1:25000	1996	Karnataka Coastal Zone Management Plan
CRZ Map	1:25000	2013	CSIR-NIO, Goa
Satellite image	23.5m	2011	NRSC, Hyderabad

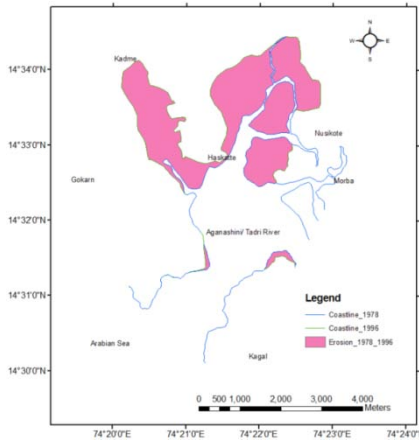


Fig. 3—Erosion during 1978-1996

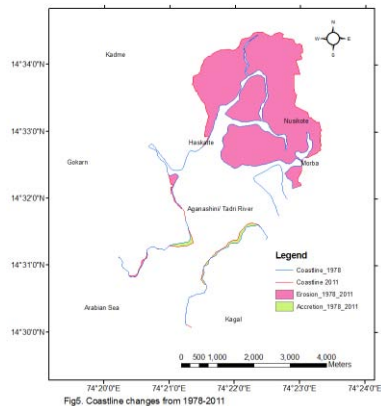


Fig. 4—Coastline changes from 1978-2011

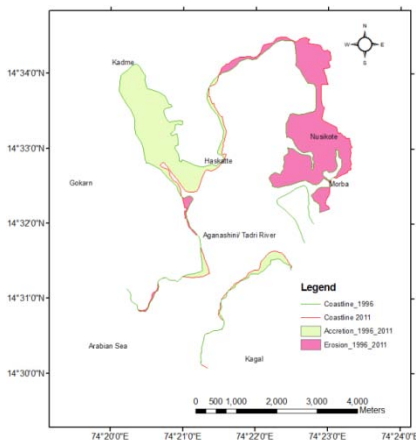


Fig. 5—Coastline changes from 1996-2011

salt pan, but as per the toposheet (SOI) and during physical ground survey measurement in year 2011, it is observed that the tidal oscillation are taking place along the earthen bund which also act road connecting

Table 2—Table shows changes in study area

Year	Erosion (Km ² .)	Accretion (Km ² .)	Loss of coastline (Km.)	Gain of coastline (Km.)
1978-1996	7.83	Nil	11.333	Nil
1978-2011	8.55	0.17	3.297	0.073
1996-2011	3.61	3.05	6.785	5.116



Photograph showing the sluice gate near salt pan at Sanikatta village

Tore Gazni village to Sanikatta village which goes to Gokarna and Tadri port. The saline water which required for the cultivation of salt is control by sluice gate at the earthen bund. It appear in CZMP map that the entire salt pan is consider as wet boundary while preparing the CZMP by using Satellite data and Toposheet map.

Conclusions

The study area is seen to be eroded due to many factors such as breaching of earthen bunds, shell mining, habitation, shore protection structure etc. in addition sediments deposition is notices at the river mouth, resulting narrowing of river mouth. In case of erosional area, classification to be changes from CRZ III to CRZ I (B). As per This study the coastal environment/authority needs to improve the integrated coastal zone management plan for development in sustainable manner.

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