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Land Feature Extraction-Identification and Descrimincation Using Geospatial Techniques

Case study along Sabarmati-Tapi Coastal belt

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Abstract

The Gulf of Cambay/Khambhat, (GoC), the study area is highly influenced by the tidal currents other than geological and structural set up of the region. In Gulf of Cambay, a large tidal range during high and low tides give rise to strong tidal currents and develops a mechanism of sediment transportation. Interestingly the inverted funnel shape of GoC has large contribution for the sediment deposition in this region. During high tide the tide currents move into the Gulf and encroaches the river mouth whereas during low tide, they move out. This regular phenomena since long period on geological time scale has modified the geomorphological features in this region.

Along the major estuaries of Sabarmati, Mahi, Narmada and Tapi, the sediment budget is controlled by seasonal variation and also by tide and ebb phenomena.

Using remote sensing images of different time scale and topographical map one can study the changes in geomorphological features. Satellite remote sensing technique has proven to be the paramount tool for studying surficial land features, especially for the inaccessible area or where time variable studies and regional scale studies are carried out. The well-developed natural or artificial features near to coastline viz salt pan, marshy land, mudflats, rocky cliffs, alluvial cliffs, wet land, mangroves, erosional and depositional features are well studied with the help of remote sensing techniques.

Keywords—Land feature, tidal flats, inter tidal zone, GoC, coastal belt, discrimination, Remote sensing techniques

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1 Introduction

The Gulf of Cambay / Khambhat (GoC), is located between latitude 20˚30' to 22˚20' N and longitude 71˚ 30' to 73˚10 E is an inverted funnel shaped (approximately 70 km wide, 130 km long), indentation featuring on the western shelf of India crammed between the Saurastra peninsula and the mainland Gujarat [2]. On the western side, the Gulf starts from Gopnath and lies between the coasts of Surat and Valsad district on the eastern side. The inverted funnel shape of GoC is the entrant of Arabian Sea lies between Gujarat Mainland and Saurastra blocks. This west coast of India exhibits geological, geomorphological and geoenvironmental diversities and hence researchers and scientists have divided the coastline into different units or blocks and segments based on recognizable characteristics.

Because of unique shape and configuration of GoC, much more studies are focused on the near shore estuarine environment and coastal geomorphology rather than off shore studies. Of course, the offshore studies are carried out time to time by few researchers and oil exploring groups.

In recent time the remote sensing tools and digital image processing techniques has proven to be the advanced approach to study various landform features. The abiotic landform features along coastline like rocky terrain, marshy land, flood plain, mud flats, cliffs, estuaries. Islands and biotic environment like mangroves, saltpan, and aqua culture can easily be recongnised.

An Indian and foreign Satellite missions have availed useful data for monitoring, analyzing coastal environment. The qualities of Remote sensing techniques like synoptic view, temporal based dataset and multi-spectral, multi-sensor concept could generate huge data and eventually useful for coastal studies.

In this paper, author has tried to extract, identify and discriminate the coastal features and events using Optical Remote Sensing and QGIS techniques. This paper describes about Sabarmati estuary to Tapi estuary, coastline constituting eastern half of the GoC and trending almost N to S.

2 Geology and geomorphology study area:

Briefly, to discuss, the structural framework of Gujarat is the result of sequential fragmentation of the western continental margin of the Indian sub continental plate during late Mesozoic. This was due to its collision with northern Eurasian plate [3]. The breakup of the margin caused the formation of the Kachchh, Cambay and Narmada rift basins along the Delhi, Dharwar and Satpura trends [3]. Further, the complex interaction between tectonism and sea- level changes during Cenozoic has played major role to build up geological environment of the Gujarat. . Hence, the sedimentation process in this basins show different genesis. The Tertiary sediments in these basins are of marine origin and the Quaternary sedimentation are of fluvial in nature.

Based on geology and geomorphology, Gujarat can be divided into 3 main units as all exhibits geological and structural diversity, pointing to quite distinct evolutionary histories for each of them [5].
(i) The Mainland Gujarat ii) The Saurastra Peninsula and iii) The Kutch

They all represent different geology, physiography, topography, and climate. All these units have their individual coastline too. This paper is focused on coastal studies, so the further general discussions are:

Kachchh unit Coastline: The Kachchh coastline has widespread mudflats in the east and well developed beaches and backshore areas from Mandvi to Suthri. Further west, mudflats appear with rocky cliffs which sharply rising above the mudflats of Quaternary deposits.

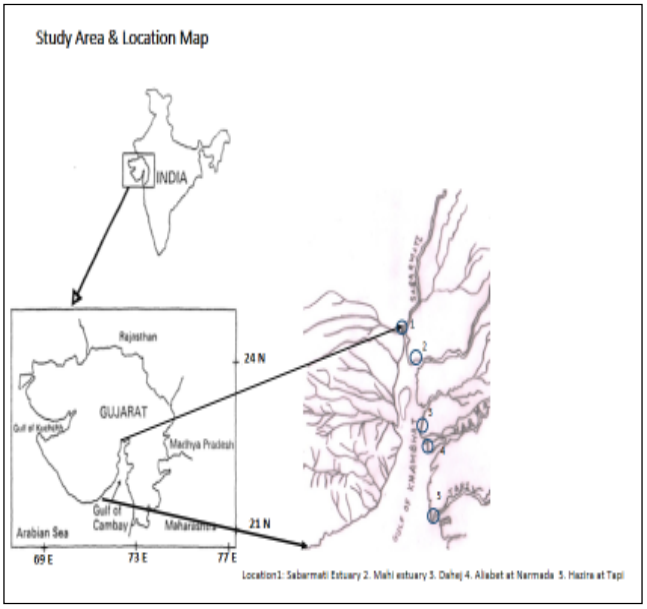
Saurastra unit coastline: The coastline of Saurashtra is highly diverse in nature and is characterised by the presence of a narrow belt of low ridges and cliffs of miliolite limestone and other shore deposits

[6]. The southern coast is marked by 40–50 m vertical cliffs of these rocks. The northern coastal area has a gentle seaward slope with tidal flats dominating the landscape. The coastline of the Dwarka–Okha segment exhibits cliffs of Tertiary rocks (10–40 m) high. The coastline from Porbandar to Kodinar is straight and is noted for some of the best exposures of miliolite rocks. The coast is irregular and dissected further east up to Diu. Extensive tidal flats are observed to the northeast of Diu Island. The southern coast of this island is cliffy. Beyond Diu, the coast is characterised by a rocky foreshore with occasional beaches and miliolite cliffs. Locally extensive mudflats are seen near Jafrabad. Thirty to forty meters high miliolite cliffs and several sea stacks are the major features of the coast further east. The miliolites completely disappear near Bhavnagar and the Tertiary rocks extend right up to the coast [4]. North of Bhavnagar to the mouth of the Sabarmati, the coast is muddy with several tidal channels.
Mainland Gujarat unit coastline: The alluvial zone shows a gentle slope towards the southwest. The geomorphology of the area to the south of the Narmada River is slightly different. A well-defined alluvial zone is absent. The width of the alluvial plain decreases to 20–25 km to the south of Narmada River compared to its width of about 200 km to the north. Although the fluvial geomorphology is similar to the area north .The geomorphology around the various river valleys of Mainland Gujarat shows three distinct geomorphic surfaces: the alluvial plain and the ravine surface comprising Late Pleistocene sediments; and the Mid-Late Holocene valley fill terrace [6].

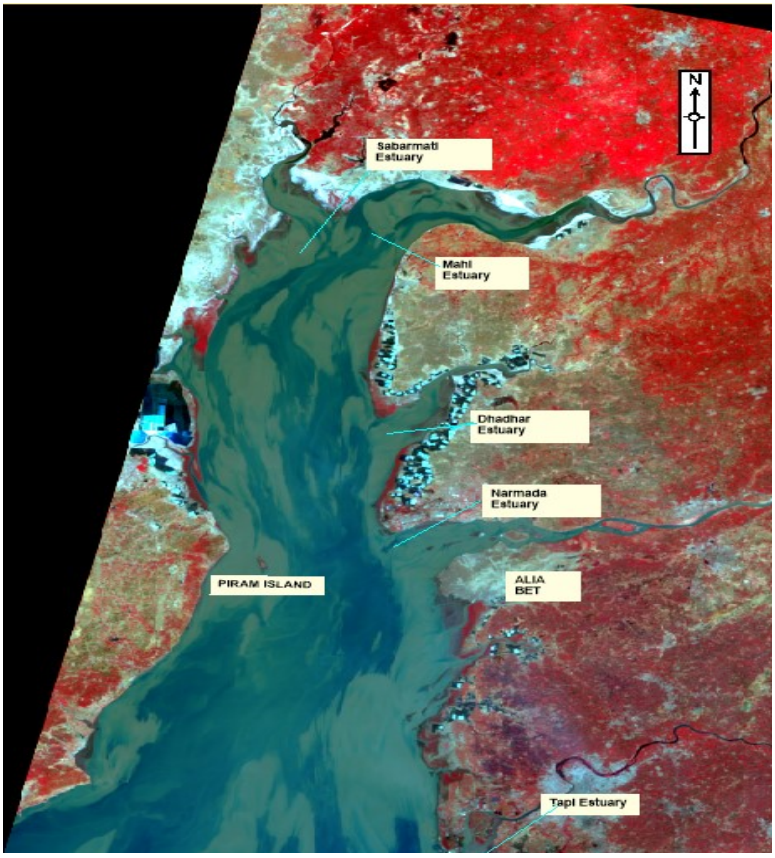
2.1 Map of Gulf of Cambay (GoC)

The inverted funnel shaped GOC is one of the two Gulfs of Gujarat state, on the western coastal belt of India. The study area includes Sabarmati to Tapi river coastline, eastern part of GOC and runs almost half of the total length of GOC. This segment is the part of mainland unit and comprises major rivers like Sabarmati, Mahi, Narmada, Tapi and their respective estuaries debouching their water in to Gulf.

Plate # 1 (a) & (b))



(a)Study area



(b) Landsat8 image shows some of the major rivers and estuaries beside the location of Piram , Island and Aliabet

2.2 Geological influence

The geological set up of Gujarat has also played vital role for shaping the coastline and spreading sediments along onshore and offshore of the GoC. Considering the fact Geologically, Gujarat represents diversity and comprises deposits of Precambrian to Recent age. The sediments added in the Late Quaternary period along GoC has been derived from the different provenances. Resultant deposited material show variation in colour, tone, texture and composition. Hence, knowledge of regional geological set up is essential.

Diversities in climate along the Gujarat Coast, has influenced the environment and hence based on environmental parameters the three major units / blocks of Gujarat can further be segmented [5] as below:

1. Kachchh Unit: i) Jakhau – Kandla segment

2. Saurastra Unit: ii) Jamnagar – Okha segment iii) Dwarka – Diu Segment iv) Diu – Bhavnagar Segment
3. Mainland Gujarat: v) Cambay – Dahej Segment vi) Hansot – Umergaon segment

Additionally, based on distinct variations in the wetland / landform categories, SAC, 1992 categorised the Gujarat Coast into five regions viz., the Rann of Kachchh, the Gulf of Kachchh, the Saurastra Coast, the Gulf of Cambay, and the South Gujarat Coast.

3. Methodology:

To achieve original project work, partly to accomplish this paper, and to fulfil the objectives, it realised ample amount of data is required from different sources. This outcome is a result of limited quantity of material. Initially Toposheets were acquired in hardcopy form or even softcopy form and got all digitized for further work. For attainment of Ground Control Point (GCP) and ground truth, repeatedly field visits were carried out. These field visits were to obtain the information about the Ground Control Point (GCP), studying geomorphological features, observing shoreline behavior, shoreline dynamics and actions of regular tide and ebbs. Beside this geological information were also gathered.

Satellite image dataset were collected to work on geospatial platform. These raw datasets were brought under working form through layer stacking, WGS '84 Projection system and geo referencing wherever required, mosaicking, preparing subsets, image classification through supervised and unsupervised classification, image enhancements, and band changes and so on. These exercises were performed to extract more amount of information for better analysis.

3.1 Dataset Used:

The data set used for the work is listed below table wise.

Table: 1: List of Landsat data:

Sl N	Satellite (Date of scene)	Sensor	Bands	Path	Row	Resolution (m)
1	Landsat 8 (20.12.'16)	ETM+	1 to 11	148	45	30 *
2	Landsat 8 (05.07.'16)	ETM+	1 to 11	148	45	30
3	Landsat 8 (29.02.'16)	ETM+	1 to 11	148	45	30
4	Landsat 7 (10.11.'01)	ETM+	1 to 7 + Pan	148	45	30 6th band 60 m
5	Landsat 5 (19.10.'90)	TM	1 to 7	148	45	30 6th band 120 m

* Landsat 8 has ETM+ sensors, 8th band is Panchromatic with 15 m Resolution;
ETM+ sensor has Pan Band with 15 m resolution
(Source: https://earthexplorer.usgs.gov/)

A. Table: 2 : List of SOI Toposheets

Sl No	Toposheet no.	Region (District)	Scale	Survey Period
1	46 B/8	A'bad, Bharuch, Bhavnagar, Kheda	50,000	1977
2	46 C/6	Bharuch , Bhavnagar	50,000	1968
3	46 C/9	Bharuch	50,000	1973
4	46 C/10	Bharuch	50,000	1973
5	46 C/11	Bharuch , Surat	50,000	1974
6	46 C/12	Surat, Valsad	50,000	1974
7	46 C/14	Bharuch, Surat	50,000	1974
9	46 C/16	Surat, Valsad	50,000	1974

Software:

1. ERDAS IMAGINE 2015- Digital Image Processing
2. QGIS Lyon (2.12.2) : A free and open source Geographic Information System Software

4 Fieldwork observations and discussion:-

Discussion is about landforms and river action along Sabarmati to Tapi coastline at few locations of interest.

The GoC is indented by estuaries and comprise extensive mudflats, dunes, patch mangroves, salt marsh, saltpan and patches of sandy beaches.

- The coastline Gopnath to Sabarmati is trending NE-SW to N-S, which is highly indented traversed by rivers Shetrunji, Bhogavo and Sabarmati. Among these rivers, Sabarmati is an active and heavily sediments laden. Since the area is almost plain at meeting point to Gulf of Cambay, sediments are spreading throughout wide region and consequently the river changes its course regularly. This has up to 50 feet alluvial cliff towards river Mahi i.e. near Khambhat and beyond that. The gradient from alluvial plain to mudflat is less while it is negligible to low (1 to 2 m) in littoral zone. The nature of littoral zone is silty and the width is high, which is about 4 to 6 km. on account of high tidal this region display mix nature of sediment types.(Plate #2)
- Similarly, Mahi River at meeting point to sea carries more amounts of sediments. From upper reaches to the gulf, the river has carved out alluvial cliffs while passing through it and has developed numbers of variable sized gullies. It meets GOC at Cambay and forms estuarine delta. The alluvial cliffs, alluvial plains, vast mudflats, drowned river mouth, intertidal zones are conspicuous features. The nature of littoral zone is silty and attaining the gradient of 1 to 2 m. The ankle deep walk through within littoral zone during low tide is little slippery. (Plate #3)
- Moving from Mahi to Narmada, the coast line attains the trend of NNW-SSE and traversed by Dhadhar and Narmada rivers. Both have developed estuarine delta and mudflats. Vast mudflats backed by projected alluvial cliffs, drowned river mouths and alluvial plains are very common features. The nature of littoral zone is silty and attaining the low gradient. (Plate #4)
- The South Gujarat coast trending almost N-S is uniform and is broken by few indentations. The major rivers traversing are Tapi and Mindhol. The dominant coastal features of south Gujarat are

series of estuaries, creeks, mudflats, beaches and marsh vegetation. The nature of littoral zone is muddy, clayey and slippery too.

Plate #2

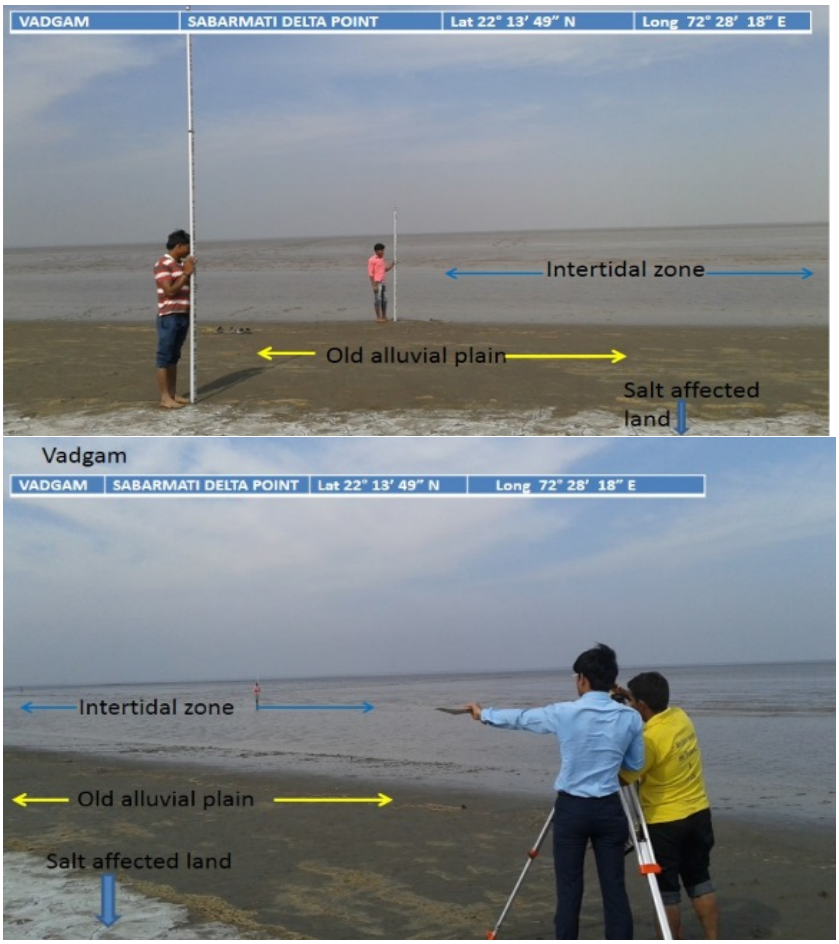


Plate #3


DHUVARAN – MAHI RIVER
LEFT TO TEMPLE SIDE
Lat 22° 14' N
Long 72° 45' E
Alluvial raised topography with relict and recent mudflats and intertidal zone at Dhuvaran
30 to 40 ft. high Alluvial cliff with gullies
Old alluvial plain vegetation covered
Intertidal zone development of recent mud flats

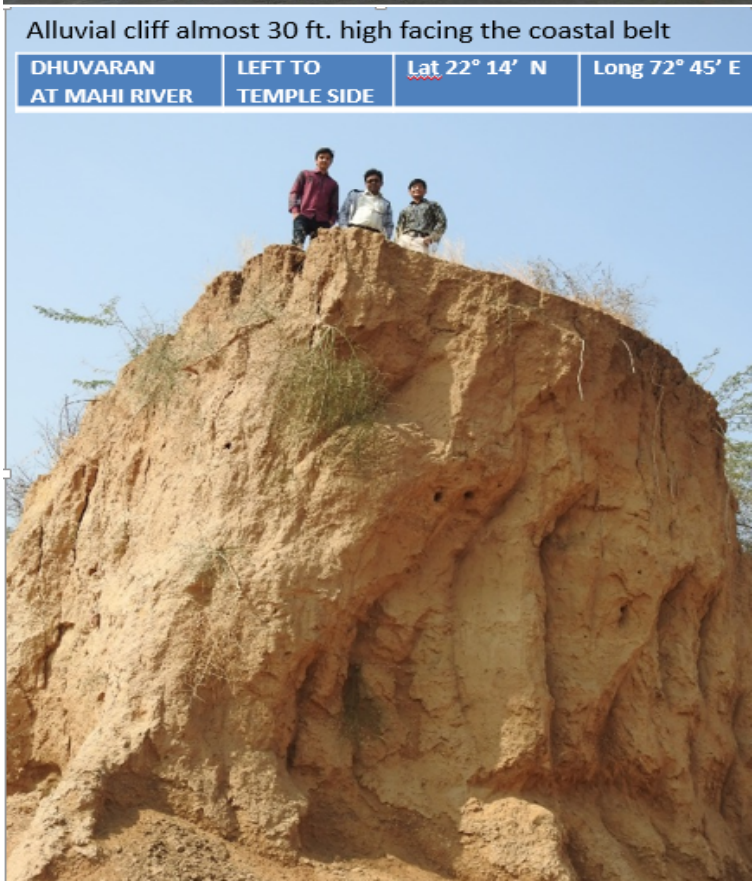
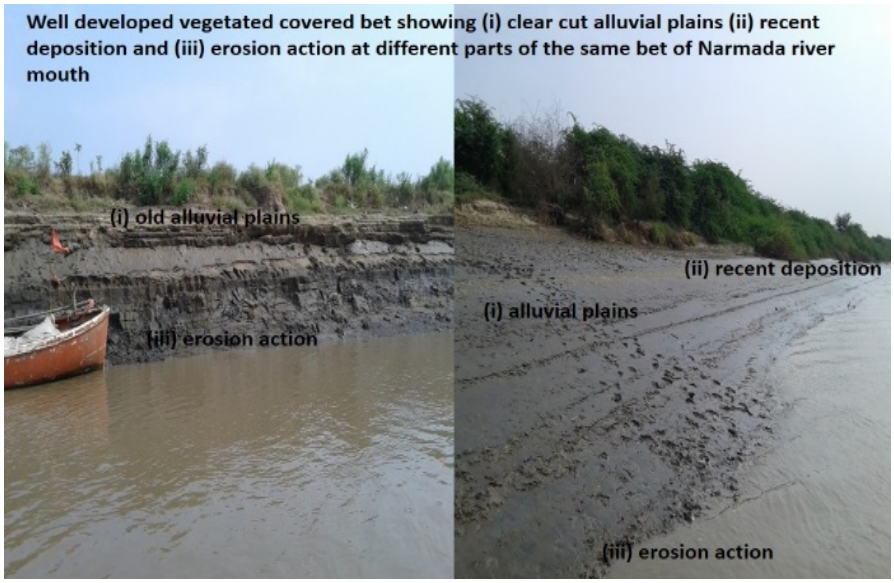
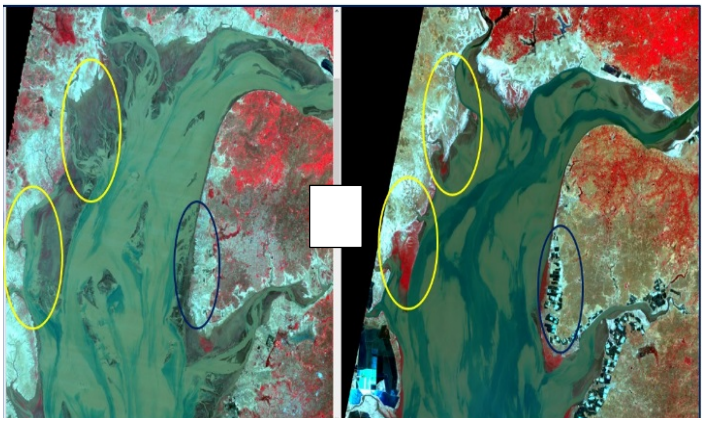

Alluvial cliff almost 30 ft. high facing the coastal belt
DHUVARAN AT MAHI RIVER
LEFT TO TEMPLE SIDE
Lat 22° 14' N
Long 72° 45' E

Plate #4

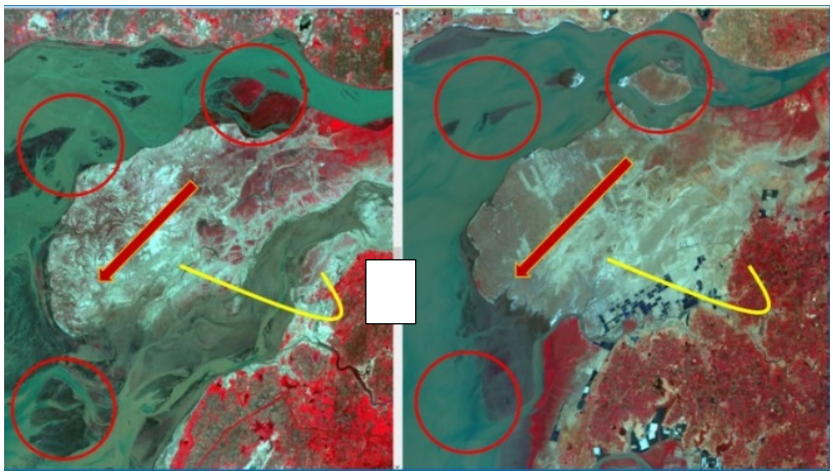


4.1 Processing satellite dataset and result:

Series of Landsat data were downloaded and major operations were carried out. It was tried to work upon cloud free imageries. This helped to extract and identify many of the features and events to make out the discrimination among the images. One of the Landsat 5 image dated 19th October, 1990 was compared with the Landsat 8 image of 29th Feb, 2016 and that has ensued better discrimination as displayed below.



(a) **Sabarmati to Mahi river coastline**



(b) **Aliabet at Narmada mouth**

(c) Tapi river course and surrounding

5.0 Result and conclusion

While generating the results, the author has overlooked the influence of season and the situation of tide during data collection through satellite. Of course these are very essential requirement, but the changes are conspicuous. (These all changes are specially marked on images and narrated as below,(a) The comparison between two images along Sabarmati to Mahi river coastline shows severe change in river course, extent of salt encrusted land, and newly developed commercial salt farming region which was previously absent. The major river Sabarmati and Mahi have a meeting point (estuary) towards their mouth claims change in their width and course too. The Sabarmati shows widespread development of delta.

(b) These two images show vast difference through expansion of Aliabet along the mouth of Narmada River. This notable change can be understood through developmental activities in the region. Further the river shifting, disappearance of the channels, expansion of mudflats are visible.
(c) There is a comparison of these images along the course of Tapi River before emptying its water into Gulf of Cambay. The shifting of the river course, change in width, sprawling of the Surat city urbanization is clearly visible.
These temporal and space related changes were studied on different available images of last two decades to judge the pace of change along the coastal belt of GOC.

Conclusion:

The present study is an attempt towards continuous monitoring the changes along coastal belt of Cambay. Periodic studies and monitoring can provide pertinent information about the past and current situations to predict future of the GoC beside the pace of changes.
The accelerated increment in industrialization and urbanization in the last 2 decades has stressed on coastal area. Again, the complex interaction of anthropogenic activity with natural events has tempted researchers and scientist to monitor the region in accordance with advance technology. It could be inferred that the incremental rise can transform the scenario of the region. For the refined outcome, using satellite data of higher resolution at specific smaller interval and at micro level is essential.

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