HIGH WATER LINE DETECTION AND ITS IMPACT IN DIGHA-MANDARmani COASTAL TRACT USING RS & GIS TECHNIQUE

RESEARCH SCHOLAR
Goutam Bauri
OPJS University Churu
Rajasthan

SUPERVISOR
Dr. Dhananjay Upadhyay
Principal, Maa Shanti Devi College
Sabalgarh (Morena)

Index Terms- Digha, Image pre-processing, Remote Sensing &GIS, Coast line, Coastal erosion. (Keywords)

1. Introduction:
This study is about the changes of high water line for a 25 km coastal tract of Purba Midnapore district, between the Orissa borders and the Jaldha Mouza of Digha Planning Area. Digha planning area lies in the southwest corner of the Purba Medinipur district of West Bengal, India and it is very famous for its seaside resorts. The scenic beauty of these beaches of Digha attracts thousands of tourists every year. It is very famous weekend destination for Kolkatans.
The coastal zone area is generally understood as a broad transitional area between the land and sea and the shoreline is deliberated as a boundary line between land and sea. The shoreline, which is often termed as High Tide Line or High water Line, is very dynamic in nature and changes gradually. These changes are governed by many factors such as: sequences of storm, cyclones, coastal processes, sea level rise, and various seismic events occurring in a specific range of space and time. The dynamicity of shoreline or high tide line broadly affects coastal area in an occurrence of time. The effects of these cumulative alterations result in an overall modification in geometry of the shoreline which leads in long-term impact on the coastal area. So it is very necessary to determine the shoreline changes and its rate.

Accurate determination of rate of change in shoreline is important for a wide range of coastal studies, such as development of planning, hazard zoning, erosion-accretion studies and regional sediment budgets. In the view of requirement of study, four satellite images of different years and vintage acquired (1972 to 2014) and Survey of India Toposheets (SOI) of the year 1972 used as a reference for the study. After georeferencing of these satellite images with reference (SOI toposheet) map, the high water line is identified through visual image interpretation of images. To improve visual image interpretation, image enhancement techniques, such as image thresholding and edge enhancement are also performed. The study reveals that the coastal process and coastal erosion are the major factors behind the high water line shifting. The accelerated rate of erosion on the beach and unprotected eastern side from hotel Sea Hawk to Digha Mohana (mouth) is severely threatened by coastal dune retreat. The western part of unprotected coastal area is under threat of encroaching sea. In the west of Shankarpur beach (from beach up to 100m west) towards Ramnagar Khal is under deposition and rest of the area is under erosion. Jaldha, Chandpur areas are also under erosion. Field observations of those areas also indicate severe damages in construction and pockets of beach erosion in several places adjacent to the seawall.
1.1 Aims and objective of the project

The present study area stretching from digha to mandarmani, part of digha junput coastal plain is very dynamic and vulnerable tract. Past literature reveals that the area is under erosion as well as accretion. The incidents of natural hazards and disasters are also frequent here. The understanding of these natural processes can be facilitated with the use of Remote Sensing and GIS technique as a tool. In this context the present study therefore aims at:

- Geomorphologic characteristics of the study area.
- Landuse /landcover pattern of this area.
- High water line delineation of 1954 and 2011.
- Estimating the eroded and accredated area in two mouzas.
- Environmental changes due to erosion and accretion.
- Suggesting measures to combat erosion in the study area.
1.2 Data Used

Data used for this study are –

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>• LISS-IV (7Jan2008 and 11Oct2008)</td>
</tr>
<tr>
<td>2</td>
<td>Toposheet</td>
<td>• SOI toposheet (73 O/10)</td>
</tr>
<tr>
<td>3</td>
<td>Ancillary Data</td>
<td>• Cadastral Maps</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Rainfall data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Temperature</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Other maps</td>
</tr>
</tbody>
</table>

1.3 Software Used

Good Database is very essential for valuable information extraction and sustainable management. Without database it is very difficult to analyze different research works. In the present study different software are used for digital image processing and creation of various thematic maps and database. The software used primarily are listed below:

- ERDAS IMAGINE 12
- Arc GIS 10.1
- ENVI
- GEOMATICA

2. Methodology

Assessment of shoreline change along the coastal area involves series of remote sensing and spatial analysis methods such as preprocessing of satellite images, images analysis, modeling and analysis of vector data. The shore line variation mainly analyzed with the help of Cadastral map and with the level of acceleration and erosion rate over the period of time. The classification of various terrain features accomplish with the level of indices calculation, segmentation, grouping of pixels and classification. The ERDAS / ENVI / GEOMATICA software is used for image processing. The figure --- shows the flow chart for Coastal and Shore line Mapping.
2.1 Image Pre-processing

Input data gathered for the study during the respective time period and once data collection completed data preprocessing phase is performed to prepare the data for the research analysis. The images, which are acquired for the study purposes, have different spatial resolutions such as Google images, which have highest resolution (1m), while Landsat images have 30 m resolution so it was very necessary to have a definite resolution of the input images. Therefore, before analysis, all images were resampled to the same spatial resolution (10m). To minimize the alteration of original spectral value of Landsat images, Nearest Neighbor method was used for resampling.

The study area is covered by 2 scenes of Landsat images. These images are geo-corrected (RMS< 1pixel) using control points collected from panchromatic band (15m resolution) of Landsat 8 images. The coastal land use and land cover features are derived from a process which is of three kinds namely, classification, segmentation and grouping. For classification process, the supervised and unsupervised classification, various statistical, tonal and textural parameters is considered for classifying different features in the terrain. The feature set contains various classes which include river, tanks, swale, and saltpan, salt affected land with scrub, mudflat, beach ridges, and vegetation, urban and rural built up areas. These are classified with the aid of segmentation and
grouping of the various terrain features. The features are identified with the help of various indices methods and its combinations. These indices can be listed as Normalised Difference Water Index (NDWI), Modified Normalized Difference Water Index (MNDWI), Normalised Difference Pond Index (NDPI), Normalised Difference Turbidity Index (NDTI) and Normalised Difference Vegetation Index (NDVI).

2.2 GIS Analysis:
In this project various GIS analysis methods are used for analysis of spatial and attribute Data such as overlay analysis, Neighborhood function, Point-in-Polygon and Line-in-Polygon, Topological overlay, Topographic Functions, Thiessen Polygons and Interpolation. GIS analysis mainly helped in finding of shore line changes.

3. Physiography of the Study Area

3.1 Climate
The study area is located in the tropical hot and humid climate. The summer is very hot. It extends from March to June. Rainy season extends from June to November and finally winter extends from December to February. South-west monsoon blows in summer and rainy season while north-east monsoon blows in winter season. However, the wind velocity and direction of the coastal belts are also affected by the influence of land breeze and sea breeze. Climatic extremes are followed by the attack of tropical cyclones in the monsoon season and Nor’easter in the pre-monsoon season. These cyclonic storms, when occur together with high tides may cause overtopping of protective embankments, thereby causing damage to the standing crops and rendering soil saline.

3.2 Soil
The soil type of this area is influenced by saline water of the sea. The soil is salty in nature so the water holding capacity is low. Three types of soil is seen here:

- sandy soil,
- clayey soil and
- loamy soil.

3.3 Plants
Different types of plant presents on the study area depends on different soil type, like loamy soil, sandy soil, clayey soil. The Digha sea front has numerous casuarina trees lined up, coconut tree also available here. The soil type of the area is loamy and sandy. The predominant commercial tree species is Shorea robusta, characteristic produce of clayey soil, commonly known as Sal. Among other vegetation mango tree, different types of dune scrub, bamboo etc. can be found all over the study area.
Coastal vegetation species varies on the basis of salt tolerance capacity. The study finds out that vegetation cover of this area shows in regular shape. Many types of vegetation has been found over the study area and its surrounding. Mainly settlement with home stead orchard are seen over the study area. Different types of scrubs and trees are shows here, like casuarinas tree, coconut tree.

### 3.4 Drainage System

This study area is well drained with many canal and khal which are presents here and depending on this canal & khal the socio economic activities are developed. Jaldha creek is very much helpful to develop fish farming activities in the junput village while Ramnagar khal, Pichaboni khal, Panipia khal and Orissa coast canal also play an important role in developing agriculture along Digha Junput coastal plain. The eastern part of the study area bordered by Rasulpur River. This river captures very short distance. Many small river and canal presents in this area, which helps to develop cultivation pattern in the study area.
3.5 Landuse/Landcover

A land use map was prepared by on screen visual interpretation of the Geo-referenced image. The landuse pattern depicts, depending upon present condition of the area according to the field verification and the satellite imagery, the 47% of the area is agricultural land and the major part of landuse/landcover is covered by settlement with homestead orchards. The other place is covered by saltpan and aquaculture, which is the most important occupation in this area. The area in Landuse/landcover data of study area is mention in Sq km.

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Area [Km²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural Land</td>
<td>1345.64</td>
</tr>
<tr>
<td>Forest (non-tidal)</td>
<td></td>
</tr>
<tr>
<td>Natural</td>
<td>1.37</td>
</tr>
<tr>
<td>Man-made</td>
<td>12.29</td>
</tr>
<tr>
<td>Brick Field</td>
<td>0.79</td>
</tr>
<tr>
<td>Harbour</td>
<td>1.52</td>
</tr>
<tr>
<td>Tidal Flat/Mud Flat</td>
<td>168.79</td>
</tr>
<tr>
<td>Sand/Beach/Shoal/Bar</td>
<td>31.15</td>
</tr>
<tr>
<td>Dense Mangrove</td>
<td>1952.87</td>
</tr>
<tr>
<td>Sparse Mangrove</td>
<td>226.18</td>
</tr>
<tr>
<td>Salt Marsh</td>
<td>22.13</td>
</tr>
<tr>
<td>Barren Land</td>
<td></td>
</tr>
<tr>
<td>Habituation with Vegetation</td>
<td>449.61</td>
</tr>
<tr>
<td>Open/Vacant Land</td>
<td>2.69</td>
</tr>
<tr>
<td>Other Features</td>
<td></td>
</tr>
<tr>
<td>Salt Pans</td>
<td>28.61</td>
</tr>
<tr>
<td>Aquaculture Ponds</td>
<td>267.18</td>
</tr>
<tr>
<td>Ponds and Lakes</td>
<td>4.41</td>
</tr>
<tr>
<td>Canal</td>
<td>16.12</td>
</tr>
</tbody>
</table>
Table No. 1
This table showing area of landuse/landcover

<table>
<thead>
<tr>
<th>SETTLEMENT WITH HOMESTEAD ORCHARD</th>
<th>145</th>
</tr>
</thead>
<tbody>
<tr>
<td>SINGLE CROP</td>
<td>81</td>
</tr>
<tr>
<td>DOUBLE CROP</td>
<td>91</td>
</tr>
</tbody>
</table>

Fig.6  Census data 2001

3.6 Agriculture
The study clearly reflects that agriculture is a predominant activity in the western sector. In the eastern sector, the reclaimed lands are now supporting single-crop agriculture with low productivity. In the study area irrigation is a major problem due to high saline creek waters. Some winter irrigation is carried out by storing rainwater in shallow channels. Water melons and green chillies are good winter crops in the eastern zone. Coconuts plantation has been raised throughout the reclaimed inter tidal zones of the Sundarbans as well as on the Digha Junput coastal plain.

![This graph shows yield of single & double crop of East Midnapore Block](image)

Fig.7  * Meteorological dept, Govt. of India

3.7 Fish Farming
Fish farming is the most important economic activity in this area. In the area about (32sq.km)area is used for this purpose. Besides this, saltpan activity in Dadanpatrabar area is traditionally carried out which covers an area of over 2861ha. Brickfields are also mushrooming along the river and backwater courses (over 243 ha. of CRZ area).
3.8 Communication

The study area has an excellent transport and communication network of road and railways. Contai (Block-I,II,III) and Ramnagar (Block-I.II) is well-connected by roads/highways with other nearby cities and towns like, Digha, Dantan, Kharagpur, Midnapore,Tamluk, Haldia, Howrah, and Kolkata. The town is also connected by a rail link to Howrah/Kolkata which is again extended to Digha. Internal communication is still via narrow red macadam roads fit for cycle,vans between widely scattered homesteads. The rail line is believed to be main cause of raising the local economy. For local transportation, bus, mini-bus, taxi, and cycle rickshaws are available. The opening of Central Bus-stand has eased the traffic congestion within the city to a great deal. The region holds great potential in tourism but lamentably enough, no other place except Digha has been developed properly.

3.9 Geomorphology:

A geomorphological map was prepared by on screen visual interpretation of the georeferenced image. On the basis of present condition of the area which are revelaed according to the field verification and the satellite imagery, following geomorphological features are found in the study area.

3.9.1 Beach Face:

Smooth (almost) flat, gently sloping 1:55 to 1:75 towards see. Width of the beach face varies from 200 meters to 1000 meters. The sediments are sand, greyish white to yellowish white ,very fine to fine, subangular to subrounded ,moderately well sorted, nearly symmetrical , mesokurtic to leptokurtic.No soil cover, vegetation typically absent.almost bare land,and no agriculture is found here.
3.9.2 Present Day Intertidal Flat:
It is nearly flat terrain dissected by tidal creeks. The area is inundated regularly during high tide through tidal creek system. sediment type is mud/silt fine sand(with mangroves).No soil cover. Bare land to sparse natural vegetation.no agriculture fisheries or salt pans found here.

3.9.3 Older Dune Complex:
Undulating to rolling topography, steep to gentle sloping, irregular dome shaped ridges (oblique to beach front dune complex) of varying height, discontinuous in nature with interdunal depressions. Sand, yellow to yellowish brown,moderately well sorted,symmetrical skewed,mesokurtic. The unfossilised teeth of large bovini,probably bos of recent age present.Very thin veneer of inceptisol,sparse natural vegetation(grass) and plantation at places.with or without seasonal agriculture. The converted build up land(settlement) are very common in digha sector.

3.9.4. Older Beach Ridge:
Nearly flat raised sheet like terrain from the ancient intertidal flat.In the western side,part of the beach ridge being reactivated by wind action,forms dune ridges.sediment types is sand,yellowish brown to brownish yellow,subangular to subrounded,fine grained,moderately well sorted to near symmetrical to positive skewed, mesokurtic. Mica and heavies present.Thin veneer of entisol to inceptisol(sandy loam).Human settlement.and betal garden in the reactivated portion.

3.9.5. Ancient Intertidal Flat:
Nearly flat terrain,no more inundated by tidal effect.Traversed by tidal channels.Roots of mangroves present.Sediment type is less sticky grey clay with silt intercalations(quartz in major amount and illite in good amount)with marine microfossils.Thin veneer of entisol to inceptisol(clayey loam),cultivable land scattered salt pans and human settlement.

4. Cadastral map of study area
Cadastre is a scientific term for a set of records showing the extent, value and ownership of land. Particularly, a cadastre is a record of areas values of land and of landholders that initially was accumulated for purposes of taxation. The cadastre serves two other equally significant purposes. It offers a ready means of accurate description and recognition of specific pieces of land and it performs as a continuous record of rights in land. It is a map which provides detailed information about real property within a specific area. Real property is
property in the form of land, what lies beneath the land, and objects fixed to the land. This cadastral map were prepared with the help of mouza map of study area.
5. High water line detection and digitization

LISS IV image, TOPOSHEET(SOI), MOUZA MAP of study area are used to identify the coastlines. The high water line was also identified and confirmed from high resolution satellite image and mouza map. These marked pixels, representing high water line are converted into a line vector layer for shoreline position. Shoreline data from different images are compared corresponding to toposheet for obtaining spatial changes of shoreline position.

3.9.10 Geomorphological effect of digha junput coastal plain change in high water line of digha junput coastal area

The geomorphic settings for the coastal tidal flats under study vary from place to place. Around Chandipur, SW of the estuary of the river Sub-arnarekha (figure a), the coast can be divided into two broad morphozones: (a) a landward zone characterized by monotonous lowland modified by fluvial processes of the main stream, the river Geomorphological setting of the study area Burahbalang, and (b) a seaward zone bordered by a single line of shore-parallel coastal dune lying on old marine terraces. The line of coastal dune is fronted by the open sea tidal flat (figure b).
The tidal flat has two distinct morphometric facets, (a) a sandy sloping (av.6 degrees) shoreward zone with an average width of 30m, and (b) a wide silty flat matted with ripples, having an average width of 1.5 km. Near the Burahbalang estuary, the silty intertidal flat is ornamented with clusters of river-mouth bars of varying dimension, criss-crossed by tidal channels of varying depths. Initiation of mangrove growth can be seen near the...
Burahbalang estuary. The width of the intertidal flat has dampened the wave activity in this region; consequently the effect of tidal action can be felt in an otherwise open-sea wave-dominated domain. The general geomorphic map of the area is shown in figure b.

The coastal stretch around Digha lies in the eastern fringe of the Subarnarekha delta, and is characterized by different lines of beach ridges/dune belts, and marine terraces of different levels. The coastal outgrowth near the Subarnarekha river mouth is accomplished by different stages of development of barrier beaches, lagoons, and salt marshes with mangrove outgrowth. Development of eolian dunes of low heights is common on these barrier beaches. The geomorphological map of the area drawn from air-photos is given in (figure c).

The intertidal region of Digha has an average width of 400m, and is characterized by remarkable straightness of the shoreline and smoothness of the flat. It is bounded on the landward side by a dune belt situated on the old marine terrace. Backshore is absent in the eastern part of the area, whereas in the west, the backshore is formed. The western part is characterized by shore-parallel low-height barrier beaches and tidal channels. Unlike the Chandipur flat, the intertidal region of Digha area is not densely matted with ripples. However, low-height barrier beaches are sculptured by ripples with lee directions pointing shoreward (figure d).

The waves around Digha coast approach the shore at an angle of nearly 70 degrees and are very active in the non-barred part of the coastal stretch causing erosion. The intertidal area of Juneput is also wave dominated, and is characterized by the development of ridge and runnel system. A combination of lagoon/barrier bar/salt marsh is the dominant pattern of coastal outgrowth in this area. Unlike Digha area, shore-parallel growth of coastal dune is absent. Average width of the intertidal area is 800m, and because of its wide expanse waves do not impinge the flat with strong forces. The growth of shore shoals is noticeable. The geomorphic map of the area, as constructed from air-photos, is shown in (figure e).

Compared to the intertidal expanses of the coastal region, the tidal point bars of the river Subarnarekha have a smaller width. Jaldha creek, a composite form of several small bars, is dissected by small creeks during the monsoon period. These point bars are relatively stable in their geographic position, though their outcrop patterns vary during the monsoon period.
6.0 Environmental effects due to high water line shifting

The study finds out that the Digha-Junput coastal tract is being eroded by sea-water resulting in lowering of the beach and recession of the bank. The rate of erosion has been found to be about 17 meters per year at some parts. Besides erosion, beach lowering (submergence) rate is about 15 to 20 cms per year, appears to continue unabated. Apart from coastal erosion caused by wave actions and storms of high tide, artificial methods of beach protection at some places also accelerate coastal erosion elsewhere. The coastal accumulation is occurring at Shankarpur. The increasing pressure of human activities on the Hugli unstable coastal zone which has been assessed by IIT, CSME and GSI during last 15 years, but no effective action plan for controlling the phenomenon is yet visible.

RESULT & DISCUSSION

The study clearly depicts that there is a narrow beach in old Digha and become wider towards the new Digha. The breaker condition is spilling. The coast of Chandpur is more prone to erosion by mainly long shore current which is due to greater angle of wave impact. One unit of incoming long shore drift is concentrated to a smaller portion of the coast here which is due to steeper angle and it enhances intensity of erosion. Angle of wave impact is not related directly with wave but with high water line configuration and prevailing wind direction, it impacts a lot. In Shankarpur-Chandpur region angle of wave impact is more than old and new Digha and it is responsible for erosion. The breaking wave energy is also responsible for the erosion of coastline in this region. The result shows that- the shoreline in the eastern part (New Digha) has seaward shifting tendency with average
rate of 14 m/yr, and hence the area is depositional. In eastern part, covering seawall protected Old Digha, Chandpur up to Jaldah, show shoreline shift in the opposite direction with an overall rate of 13 m/yr, and the area is under severe erosion.

CONCLUSION
A comparative analysis of physical processes among Old Digha, New Digha, Shankarpur and Chandpur shows that the erosion is more active and intensive at the coast of Old Digha. The shore high water line can effectively reach the coastal embankment on narrow beach with high energy plunging occasional surging breaker, daily at high tide and takes huge amount of sand back to mid ocean causing the lowering of beach. The difference of elevation between coastal land and beach is increasing at a faster rate, also exposing the base of the coastal cliff due to attack of sea wave. In New Digha comparatively low rate of erosion is distinguished due to gentle slope of beach, low energy spilling breaker and wider beach. The swash cannot reach up to the coastal embankment with high energy. In Shankarpur East upto Jalda, the condition is between that of Digha and Junput and due to impact of wave at a high angle here, the erosion is more. Due to moderate wider beach with gentle slope the spring tide reaches the unprotected coastal cliff as a result high rate of erosion occurs.

References
NRIS-PROJECT(2003)-Lower Damodar Subcatchment ,Rupnarayan Subcatchment , Lower Kasai Subcatchment, District Purba Medinipur,WEST BENGAL
Directorate of Agriculyure(1985),Govement of West Bengal-Soils of West Bengal (A Modern Classification)
Natural Resource data Management (NRDMS).District Data Base Center ,Bankura (1991)-A Block Profile
Barjora Block, District Purba Medinipur


