MORPHODYNAMICS BETWEEN YELWANE TO BODHANI (MAHARASHTRA).

A Dissertation Submitted to

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For the degree of

Master of Philosophy

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By

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Year - 2010

CERTIFICATE

This is certify that the Dissertation entitled “Morphodynamics between Yelwane to Bodhani, (Maharashtra)”, which being submitted here for the award of the Degree of Vidyanishant (M.Phill.) in Geography of Tilak Maharashtra Vidyapeeth, Pune, is the result of original research work completed by Miss. Archana Patil under my supervision and guidance. To the best of my knowledge and belief the work incorporated in this dissertation has not formed the basis for the award of any degree or similar title of this or any other University or examining body.

Place: Pune Dr. Bhagyashree

Date: Yargop

(Research Guide)

DECLARATION

I hereby declare that the dissertation entitled, “Morphodynamics between Yelwane to Bodhani, (Maharashtra) “completed and written by me has not previously formed the basis for award of any degree or other similar title of this dissertation or any other university or examining body.

Archana D. Patil

(Research student)

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ABSTRACT

INTRODUCTION

Coasts are among the most dynamic part of earth's surface, the coastline changes; not only over centuries or decades, but in a matter of hours or minutes.

The shoreline migrates daily with tide it can change seasonally and varies over longer time scales as the coast erodes or deposits, or sea level changes. Coastal sediment deposits are shaped and reshaped by wave and current processes, through time.

Konkan coasts or coastal tract of Maharashatra is one of the major geographic divisions of western India covering a distance of about 720 km. with average width of 60 km. The beaches of Konkan are dotted with innumerable, small, and sandy. The sedimentary characteristics and the morphodynamics of these beaches are controlled mainly by specific wave and tidal environment related to seasonal change and tidal range.

Study area is on the western coast of Maharashtra. It is stretching between, Yelwane Inlet to Bodhani Bandar. The beach is located in Alibag Taluka of Raigad district in Maharashtra. Variation in sea waves and tidal waves, their intensity and frequency, approach height and persistence is the main factors that influence the coastal processes along study area.

The main aim of this study is to find the morphodynamics of the beach between the Yelwane inlet and Bodhani, in the Raigad district, Maharashtra with the help of GIS and geographical surveying. In order to achieve aim, following objectives have been setup.

To survey the shape of a beach

To investigate seasonal changes in the beach profile, by using Dumpy Level.

To incorporate information from topographic map as well as from satellite data.

To study the changing tidal environment, sea level, erosion and depositional works of tidal waves and wind on study area.

To prepare land cover map depicting marshy land, mud flats and sand deposition.

METHODOLOGY

In order to understand the morphodynamics at study area, the methodology adopted for the present study is divided into three phases namely pre- field work phase, field work phase and post field work phase.

Beach morphodynamics is mainly a study of deposition and erosion processes on the beach and also changing beach profiles in various seasons due to sea waves and wind direction. The field and analytical procedures are used in present study.

Dumpy level Instrument is selected to obtain contour and profile pattern. Location co-ordinates were obtained with help of GPS. GIS technology is adopted for mapping and data analysis.

Field work is carried out in two seasons viz.

A. Pre-Monsoon

B. Post-Monsoon

CHAPTERS

This work contains 6 chapters

1 Introduction

2: Study Area and Methodology

3: Beach Morphology

4: Factors of Sedimentation on the Beach

5: Data Processing and GIS Techniques

6: conclusions and Observations

Morphology of any beach is mainly a study of changing beach profiles in storm and fair weather season. It also includes the study of various micro features, type and extent of sediment deposits on the beach.

The beach of the study area is a pocket beach. The length of beach is approximately 1100 to 1136 meters. As mentioned earlier the beach is developed between a headland and a tidal inlet. This is mainly muddy beach.

On an average the beach at Yelwane inlet to Bodhani Bandar was observed. 12 profiles were selected from east to west roughly at an interval of 75 to 150 meters. It was tried to cover the whole lengths of the beach by using these 12 profiles. There is a definite seasonal changes on the beach and this is clearly indicated by its width, length and beach gradient.

The Coastal zone is affected by marine factors such as tides, waves, currents, sea level rise etc. The most marine coastlines are influenced by the ocean tide. Waves are the main factor of shaping the coast, Waves are important because of their work of both erosion and deposition; they are produced by the pressure and friction of wind on the sea surface.

Coast composed predominantly of mud comprising silt and clay sized sediment occur in low-energy settings, generally sheltered from wave action. Mudflats, salt marshes and mangroves are most extensive on micro tidal coast .They are especially associated with large embayment where tidal currents are strong and wave action limited.

Study area is an example of protected bay, which provides protection and ideal site for mud deposition, but recent data denotes the proportion of decreasing mud in study area.

DATA PROCESSING AND GIS TECHNIQUE

Data capture in GIS is the creation of data layers by a variety of techniques. These include digitizing, scanning, or generating data from a file. In other words data capture is putting information into a system. Or it is the operation of encoding data and writing them to the database.

The heart of GIS is the analytical capabilities of the system. What distinguish the GIS system from other information system are its analysis functions. The output of data processing is in form of maps viz. contour map and 3D displays of Digital Elevation Model (DEM) and Triangular Irregular Network (TIN). These maps can be used as spatio-temporal data. As these maps are generated in two seasons which are pre-monsoon and post-monsoon. In morphodynamic analysis, season wise data is compared for which the contour map and 3D displays as essential.

CONCLUSIONS AND OBSERVATONS

The beach between Yelawane inlet and Mandve is a pocket beach. Width of the beach changes from season to season, beach in post monsoon is narrower than that in pre monsoon. Tidal inlet plays a major role in mud deposition process, a mixture of very fine silt from tidal water dropping their load as they reach the sea, which is knows as mud flat.

While studying the area near Bodhani, mud was observed in thick layers. Mud balls, Mud flats, mangroves are also found, this may be due to the protected location of the area as it is a bay, while sandy deposition on the Rewas beach may be fronted by open sea.

With reference to satellite image and toposheet from year 2003 to 2009, the proportion of mud is decreasing in study area. Factors which may cause mud erosion may be the sea level change. A seasonal map denotes that deposition predominates in pre monsoon season, while erosional activity observed in post monsoon season. At the left side of the inlet there is thick deposit of mud layers while right side of inlet there is sandy beach, which is open to sea. This beach was occupied by mud in the recent past, but today we see no trace of mud. While studying the area near Mandve, mud was observed in thick layers. Mud balls are also found, this may be due to the protected location of the area as it is a bay, while sandy deposition on the Rewas beach may be due to the open sea. In short term mudflats may be appear to be accreting but over longer period erosion may be predominating force.

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CHAPTER ONE

INTRODUCTION

INTRODUCTION TO COASTAL GEOMORPHOLOGY

Geomorphology is study of landforms and Coastal Geomorphology is concern primary with explaining many different types of coastal landforms and understanding the factors that shape them. (Collin D. Woodroffe)

Coastal geomorphology is very significant branch of geomorphology. Coastal geomorphology deals with development of landforms due to oceanic waves, tides. The coastal region denotes, where land meets the ocean. This area is always under the influence of different processes. Hence, the coastal area shows continuous changes. A beach is geological landform along the shoreline of a water body. Beaches differ in shape, according to the forces that created them; like waves, tides, wind. They are also differ on the basis of material available; like mud, sand, iron sand, shells, cobbles, boulders etc.

Coasts are among the most dynamic part of earth's surface. The shoreline migrates daily with tide it can change seasonally and varies over longer time scales as the coast erodes or deposits, or sea level changes. Coastal sediment deposits are shaped and reshaped by wave and current processes, through time. The coastline changes not only over centuries or decades, but in a matter of hours or minutes.

Beaches are amongst the most dynamic landforms and most, if not all, of the material in them is periodically acted upon by waves. This body of sediment can be thought of as a prism (Tanner, 1958). A section through the upper section of this prism gives the sweep zone of (King, 1959), bounded by upper and lower sweep zone profiles. On beach where there is considerable periodic cut and fill the sweep zone may be a deep one; other beaches show relatively little change in profile with time. The other dimensions of the prism are given by the beach plan, which also may vary with time.

The material making up the beach varies physically and chemically from place to place, but from a geographic point of view the important variations are those in particle size and lime content. Particle size influences strongly the form of beach and development of large scale constructional features from it. The calcareous component may influence the formation of lithified beach and dune material, the persistence of which is significant in coastal form.

Theoretically the beaches are the depositional units along the coastlines that are developed between low water mark and high water line. The Geomorphology of the coast can be examined in platform, (also called shore parallel or long shore.) or in profile. (Also called cross-section, cross-shore, and shore normal or orthogonal) (Pethick)

Coastal Geomorphology is directly applicable to our lives; the world's coastline – some 440,000 km of it – encompasses only a small area of the total landform surface – about 0.03 percent if the coastal zone is regarded as about 100m. Wide – but its importance to man is fundamental. A United Nations estimate suggest that 66.00 % of the world's population lives within a few kilometers of the coast, consequently food production, communications, settlement, even recreation are concentrated here, however coastline represents enormous problems for such intensive use, flooding, erosion, pollution and the continued threats posed by rising sea level – all demand constant action in order to preserve mans investment.

Thus Coastal Geomorphologists have the great fortune to be involved in the study of the dynamic landform, whose development can be observed directly.

INTRODUCTION TO KONKAN COASTS

Konkan is the coastal lowland extending east–west from the Arabian Sea to the Western Ghat escarpment and north–south from north of Mumbai to north of Goa.

Konkan coasts or coastal tract of Maharashtra is one of the major geographic divisions of western India. The geomorphology of Konkan is characterized by coastal plains of variable altitude and width, backed by the escarpment of the Western Ghats on east coast and the Arabian Sea with or without cliff on the west. It covers a distance of about 720 km. with an average width of 60 km.

The beaches of Konkan are dotted with innumerable, small inlets and are sandy in character. The sedimentary characteristics and the morphdynamics of these beaches are controlled mainly by specific wave and tidal environment related to seasonal change and tidal range.

Swash aligned beaches are found along indented and irregular stretches. In some cases they are transformed to drift aligned beaches in monsoon. The ridge and the runnel and the rhythmic forms such as cusps, ripple marks, mega ripples, crescentic bars, berms and dune are the essential morphological features seen in Konkan beaches.

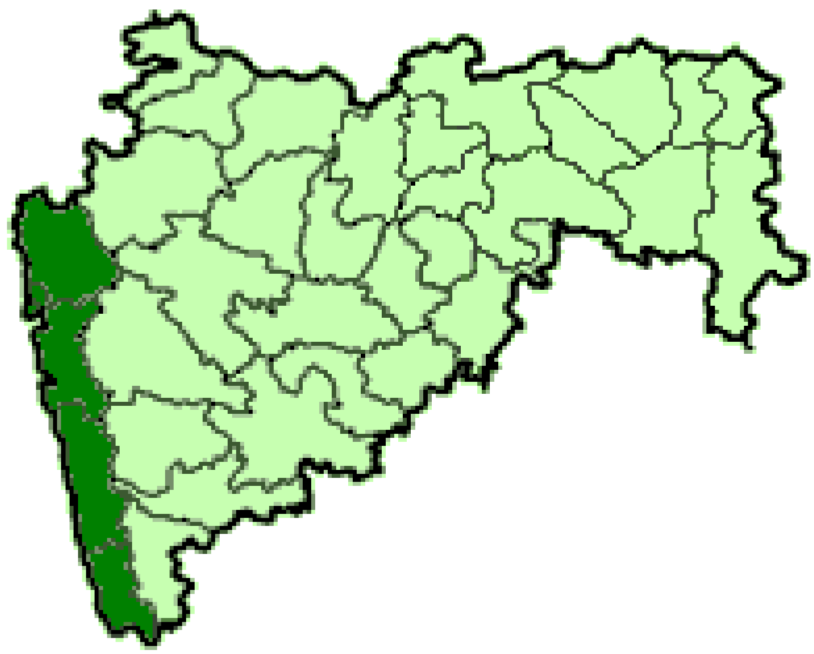
The material is poorly to moderately sorted. The mud is scoured, reworked and spread on the beaches in monsoon. This phenomenon is especially seen on the Konkan beaches. (Karlekar S. N. 1993)

The Maharashtra coast is characterized by a medium to high tidal range, which varies from 2.8 to 3.5 m. in addition to the spring and neap tides, semi diurnal tides, seems to have more impact on the tidal estuaries and creeks. The coastline is indented with numerous coastal inlets like bays, estuaries, and creeks. (Dikshit.1976; Karlekar.1981). Tidal waters penetrate to a distance of about 15 km inland at high tide. The mean annual rainfall of the region is about 2800mm. The environment is thus favorable for the muddy and clayey substratum in the estuarine and creek inlets. One can therefore expect a wide occurrence of tidal landforms at many sheltered places along the said coastline. The development of significant tidal landforms however is restricted only to the northern part of coastline, especially north of Alibag.

The Konkan division is an administrative sub division of Maharashtra comprising of all the coastal districts of the state.

- Area: 30,746 km^2
- Population (2001 census): 24,807,357
- Districts: Mumbai, Mumbai Suburban, Thane, Raigad, Ratnagiri, Sindhudurg.

THE KONKAN SUB DIVISION OF MAHARASHTRA



(Fig.1.1)

INTRODUCTION TO GIS

WHAT IS GIS?

Geographic Information System (GIS) has lead to the betterment of mapping and interpretation techniques as a means of understanding and effectively managing the present resource of sustainable.

Geoinformatics, also known as *Geomatics*, is the science and technology of gathering, analyzing, interpreting, distributing and using geographic information. Geomatics encompasses a broad range of disciplines including surveying and mapping, Remote Sensing (RS), Geographic Information Systems (GIS), and the Global Positioning System (GPS). (Geomatics Canada Web Site, 2000)

Geographic information systems are automated systems for the capture, storage, retrieval, analysis and display of spatial data. They consist of computer software and hardware that act together as both, a set of tools for analyzing geographic location and a kind of information system designed especially for spatial data.

At this point it is useful to consider exactly what Geographical Information System is (and what it is not). The definitions of GIS are numerous but a useful one is that – "It is a data base system in which most of the data are spatially indexed and upon which a set of procedures operates in order to answer queries about the spatial entities in the data base." Thus it is an information system whose relation basis is co-ordinate data of the form X, Y, Z, and concept familiar to the surveyor. The function of an information system is to improve a user's ability to make decision in research, planning and management; a GIS is therefore essentially a management tool.

Since the mid-1990's, GIS has played an ever increasing role in coastal resource management. The easy accessibility of the Internet has provided GIS users with a convenient medium for sharing and accessing geospatial data. Proper data management practices are the key to ensuring the functionality of your GIS data sets and analyses.

IMPORTANCE OF GIS IN COASTAL STUDIES

Coastal zone is a very complex, dynamic and delicate environment because this area is a transition, between land and marine process. This area is quite dynamic. For example, from the processes those occur in the coastline, abrasion occurs in some places and sedimentation occurs in another part, or even occurs in the same area continuously. Coastal zone is an environmentally sensitive interface between the ocean and land and responds to changes brought about by economic development and changing land-use patterns.

For decades transportation planners, managers and other decision makers have relied on surveying and engineering information derived from manual methods for making decisions on transportation issues. These methods usually have been field and ground surveys that produced location information, some of which was represented on maps produced manually by cartographers. For the surveyor, the main tools include theodolites, tripods, transits and levels while the map maker has drafting equipments and ink pens. Now use of aerial photography, photogrammetry and remote sensing technologies has enhanced the information content required by the surveyors. However the integration is done manually, that is to say that automation and use of computers were not employed until Geographic Information System (GIS) technology was introduced in 1980's. These technologies introduced digital data, new ways of acquiring, developing, analyzing and interpreting information for crucial transportation decisions.

GIS technology not only saves time but also enables us to work out many alternate options within less time and with less investment. For all transportation problems, it is essential to carry out many studies for connectivity, accessibility, preparation of master plans etc. All the studies require generation of databases at regular intervals and on different scales and levels. It is here that remotely sensed data and GIS systems offer the optimal data sources at different spectral and spatial resolutions and at different intervals of time that could help to carry different studies on transportation.

A number of examples are documented in the literature, describing the use of GIS technology for modeling processes and events within the coastal zone. Typical applications include the use of GIS for assessing the threat of sea level rise. Modeling of oil spills with a view to minimizing their environmental impacts, modeling possible impacts of dredge spoil dumping, modeling for multiple use of estuarine waters, and assessment of possible sites for aquaculture development.

GIS for coastal decision-making and policy formulation

By combining rapid data retrieval with analytical and modeling functions, GIS has the ability to respond rapidly and flexibly to ad hoc 'what if type questions'. Thus, a well-designed coastal zone information system could be significant as a decision-support tool, to aid development of integrated and sustainable coastal management strategies.

GIS should be viewed as an opportunity for the marine community to advance in the field of coastal zone management. GIS represents the latest weapon in the arsenal of tools to solve the spatial data-handling problem. Proper use of GIS required the data knowledge of the salt grimed hydrographic surveyor, the map composition skills of the experienced cartographer, the data base management skill of the data processing person, the scientific insight of geographer, the computer knowledge of a system analyst and the personnel and organization skill of the manager. The coastal zone GIS are currently enjoying a major upsurge in the level of interest and there are grounds for optimism in believing that the significant advances in this direction is not too far away. The use of GIS in coastal zone management coastal studies is interesting and stimulating.

AIMS AND OBJECTIVES

The main aim of this study is to find the morphodynamics of the beach between the Yelwane inlet and Bodhani, in the Raigad district, Maharashtra with the help of GIS and geographical surveying. In order to achieve aim, following objectives have been setup.

- To survey the shape of a beach
- To investigate seasonal changes in the beach profile by using Dumpy Level.
- To incorporate information from topographic map as well as from satellite data.
- To study the changing tidal environment, sea level, erosion and depositional works of tidal waves and wind on study area.
- To prepare land cover map depicting marshy land, mud flats and sand deposition.

LITERATURE REVIEW

A few references which are very important in this study are as follows:

Mangrove responds to the climate change and sea level rise and mitigation measures: (H. S. Singh, IFS, Director, Gujarat Ecological Education Research Foundation, Gandhinagar describes in the paper "*Impact of climate change on Mangrove"*).

Coastal erosion is caused by the input of the wave energy to the coastal zone; this wave energy could sedimentation or erosion along the coastline: (Maged M.M. and S.B. Mansor, Faculty of Engineering, University Putra Malaysia, "*Coastal Erosion modeling using remotely Sensed Data*").Information related to area, adjutant to my topic is gain through following research papers.

Tidal landforms; especially the mud flats are very conspicuous coastal features of northern coast of Maharashtra. The tidal mud flats and beaches of Northern Maharashtra coast are strongly associated with the daily tidal range: (Shrikant Karlekar, "*The Tidal Landforms of Uran-Alibag-Murud Coast*").

The sediment body developed at Rewas on Konkan coast is a product of specific wave and tide depositional dynamics. From the morphological characteristics, this sediment body appears to be a drift aligned spit bar whose lower shore face is covered by thick mud deposits whereas upper shore face is covered by sandy deposits. The spit bar exhibits the pattern of sedimentary faces which suggest the complex depositional dynamics of the spit bar: (Bhagyashree Shrikhande, "*Depositional Dynamics of the Intertidal Spit Bar at Rewas*").

700 meter long Yelwane tidal inlet, experiencing flooding and ebbing twice daily, with tidal range of 3.5 meters, shows a remarkable influence of tidal water intrusion into small seasonal streams: (Charu Kenjale, "*The Morphology and Sedimentology of Yelwane tidal Inlet").*

CHAPTER TWO

INTRODUCTION OF STUDY AREA AND METHODOLOGY

The Bodhani Bandar to Yelwane inlet stretch of beach is selected for the study purpose. This beach is near Rewas in Alibag Taluka, District Raigad, Maharashtra.

RELATIVE LOCATION

Study area is on the western coast of Maharashtra. It stretches between, Yelwane Inlet to Bodhani Bandar. The beach is located in Alibag Taluka of Raigad district in Maharashtra. (fig.2.4)

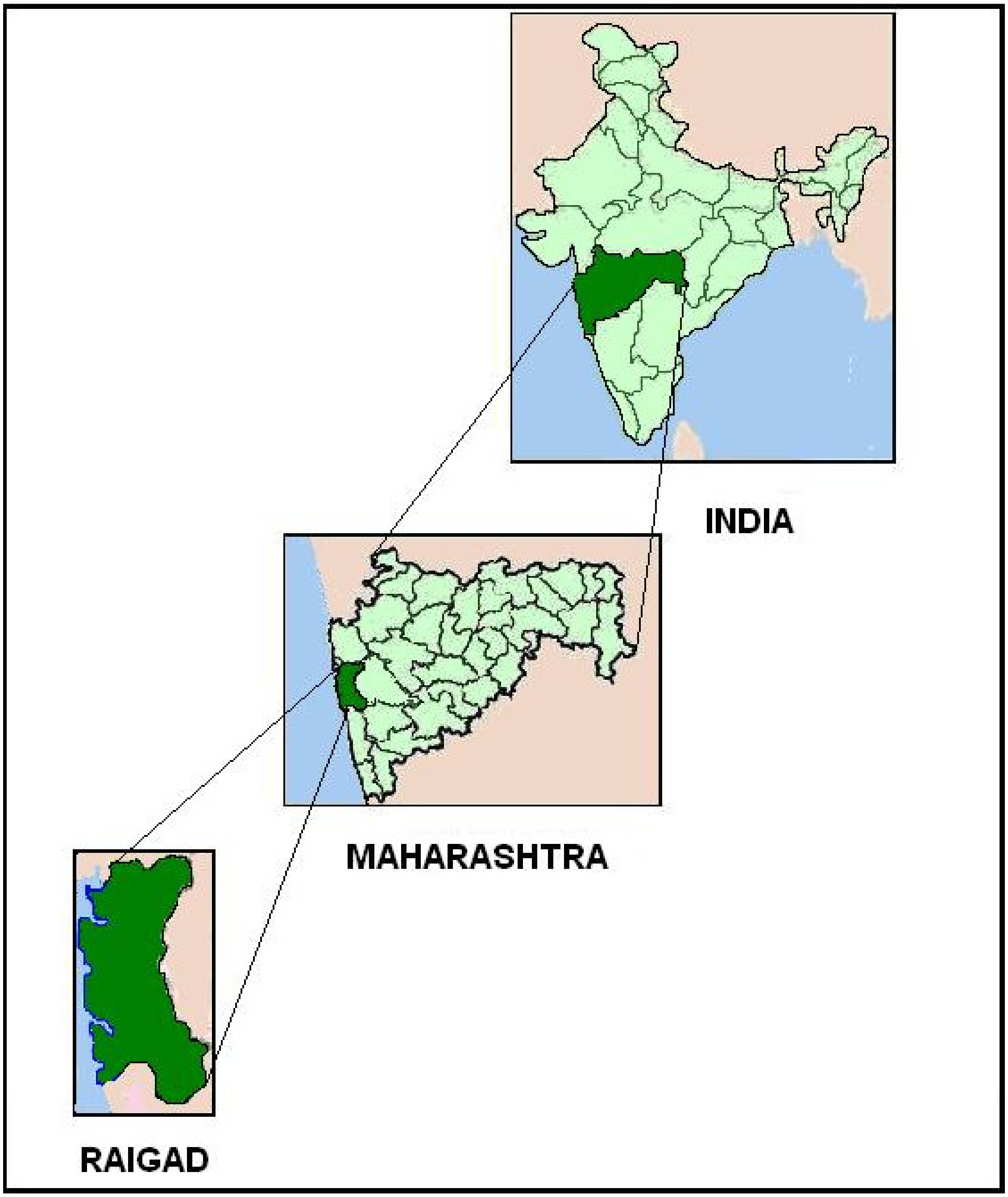
The Northern and Eastern side of study area is bounded by Dharamtar Creek; Arabian Sea is on the western side. The area stretches between Yelwane inlet to Bodhani Bandar. Rewas Bandar is the northeastern headland of Dharamtar Creek and Mandve Bandar is western mainland. There are many tidal inlets observed eg. Yelwane inlet, Chidipada inlet. The beach of Rewas is a macro tidal and long beach on the Konkan coast of Maharashtra. The total length of beach (from Mandve Beach to Rewas Bandar) is 10.5 km and the study area lies between Yelwane to Bodhani Bandar which measures approximately 1 km.

ABSOLUTE LOCATION

The extent of study area is 18^0 47' 41” N to 18^0 47’ 50'' N latitude to 72^0 53' 53'' E to 72^0 54' 89'' E longitude.

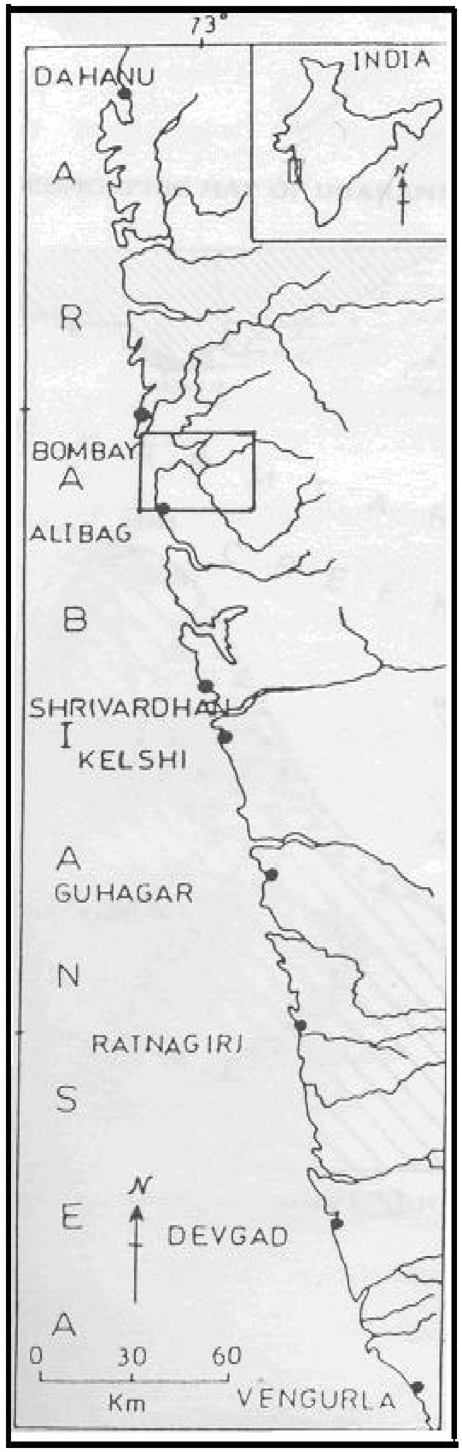
The study area is a field of mud deposit, it is confided to narrow stretch of land between two headlands, is of Mandve with height of 2m and Yelwane with height of 1m.

LOCATION MAP



(Fig. 2.1)

MAHARASHATRA KONKAN COAST

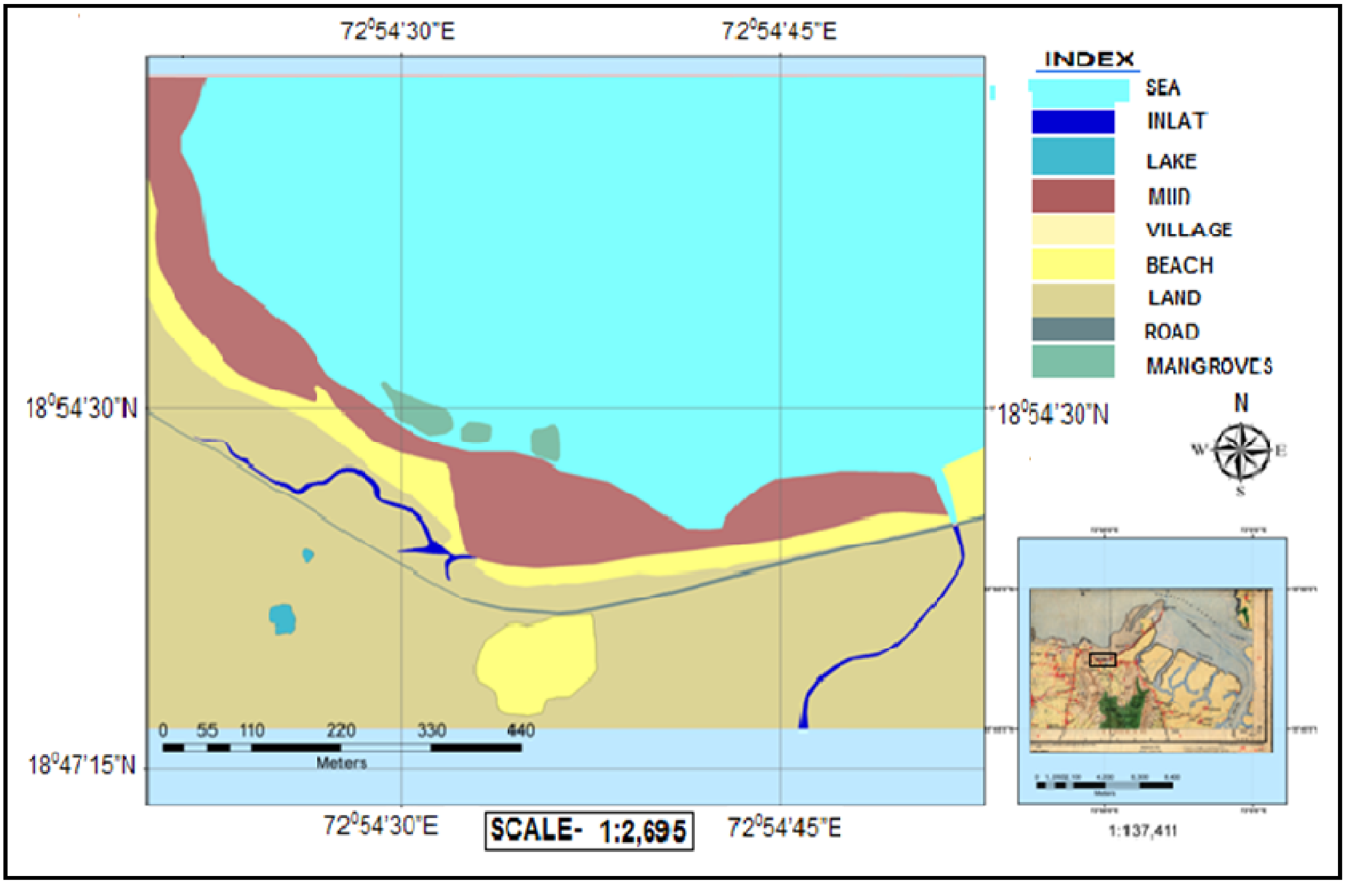


(Fig. 2.2)

LOCATION MAP (GOOGLE IMAGE)

(Fig. 2.3)

LOCATION MAP OF STUDY AREA



(Fig. 2.4)

YELWANE INLET TO BODHANI BANDAR

The Northern and Eastern side of study area is bounded by Dharamtar Creek; Arabian Sea is spread on the western side. The area stretches between Yelwane inlet to Bodhani Bandar. Rewas Bandar is the north - eastern headland of Dharamtar Creek and Mandve Bandar is western mainland in study area.

Variation in sea waves and tidal waves, their intensity and frequency, approach height and persistence is the main factors that influence the coastal processes along study area.

Yelwane inlet is the source of mud, the tidal waves that flow in and out of bay through narrow inlet are very swift and can score an inlet strongly, and this keeps the inlet open despite the tendency of shore drifting process to close it.

Transported material of silt, clay is deposited over the bay may be through Yelwane inlet, as well as by action of waves and wind.

At the left side of the inlet there is thick deposit of mud layers while right side of inlet there is a sandy beach, which is open to the sea. This beach was occupied by mud in the recent past, but today we see no trace of mud.

METHODOLOGY

Methodology is a way to systematically solve the research problem. In order to understand the morphodynamics at study area, the methodology adopted for the present study is divided into three phases namely pre- field work phase, field work phase and post field work phase.

In the first phase – pre-field work phase illustrate review i.e. previous work carried out by other researchers are obtained from various journals, internet, collection of survey of India Toposheet (SOI) having scale 1:50000(47 B/13).

In the second phase i.e. fieldwork phase extensive field surveys were undertaken, at study area. Leveling instrument like Dumpy level was used for field measurements. GPS reading altitude and the related information was noted which were also useful in location of sites.

In the third phase laboratory work was carried out that include plotting of profiles, generating of 3D, and KML view of location map, maps were geo referenced at the same time. Integrating all above information and maps with help of GIS software, Arc View 3.2a, Arc GIS 9.1 etc. Goggle earth software used for KML maps. Various thematic layers were generated for the purpose.

DATA CAPTURE

Data used in GIS often comes from many sources and are stored in different ways. A GIS provides tools and method for the integration of different data into a format to be compared and analyzed. Spatial data are mainly obtained through manual digitization and scanning of aerial photographs, paper maps and existing digital data sets. Satellite imagery and GPS are promising data input sources for GIS.

DATA TYPES

Geographic data are organized in a geographic database. This database can be considered as a collection of spatially referenced data that act as model of reality.

There are two important components of this geographic database:

1. Geographic position
2. Attributes or properties

In other words, **spatial data** indicates 'where is it?' and **attribute data** shows 'what is it?'

a) SPATIAL DATA

Geographic position refers to the fact that each feature has a location that must be specified in a unique way. To specify the position in an absolute way a co-ordinate system is used. For small areas, the simplest coordinate system is the regular square grid. For larger areas, certain approved cartographic projections are commonly used. Internationally there are many different coordinate systems in use.

b) ATTRIBUTE DATA

The attributes refer to the properties of spatial entities. They are often referred to as non-spatial data since they do not in themselves represent location information.

The Methodology which include study of depositional and erosion processes on the beach and changing beach profile in various seasons in study area.

First of all an overall survey was carried out in which the sites for profile and their GPS location were fixed. The programme was scheduled taking into consideration the high tide and low tide range and period. Profiles were taken which cover total study area. Each profiles instrument stations and back sites GPS points were taken. Beach at study area was surveyed and mapped in pre monsoon and post monsoon period. The surveys were conducted to understand the changing nature of beach in pre monsoon and post monsoon period.

DATA SOURCES

1. Primary Data - : Is collected by

    1. Dumpy level survey

    2. GPS Survey

2. Secondary Data

1. Books and Research papers
2. Toposheet
3. Satellite images
4. Internet

PRIMARY DATA

Primary data is collected during the field survey. The survey is carried in two ways.

A. Pilot survey

B. Field Work

A. PILOT SURVEY

Field observation and selection of study area is done in this survey. Discussions were carried with locals, on 15th March 2008 in summer season.

B. FIELDWORK

The selected beach is completely sandy beach. Beach has narrow width. Dumpy level Instrument is selected to obtain contour and profile pattern. Location co-ordinates were obtained with help of GPS. Field work is carried out in two seasons viz.

A. Pre-Monsoon

It was held on 30th May and 1st June 2008.

B. Post-Monsoon

It was held on 25th and 26th January 2009.

Seasonal survey is done to observe change in contour pattern, which helps to interpret erosional and depositional areas. At the time of survey study area was observed and taking in to consideration the high tide and low tide range profiles were plotted.

SECONDARY DATA

Secondary data is also called as 'Ancillary data'. Secondary data is collected with the help of different books, research papers, Toposheet, satellite image and from the internet.

1. Toposheet

SOI Toposheet of coastal areas can be effectively used for the extraction of precise information regarding various aspects. Toposheet number of study area is 47 B/13, from which study area covers some part of quadrant B3. Toposheet was surveyed the year 1962-66, the year of publication is 1970; a careful study of Toposheet trace covering Yelwane inlet and Chidipada inlet area gives wealth of information on the inlet itself, the mud flats developed and embankment within it.

2. Satellite image

The remote sensing images are acquired from www.googleearth.com. They are obtained at different scales. Google images were used for the purpose of generating location maps, beach profiles location etc. As compared to the toposheets, the Google images are the recent ones.

3. Books and Research Papers

Old dissertations, reports, books and research papers are referred throughout project completion.

4. Internet

Internet is an important source of secondary data. Internet was used for studying maps and images for reference. The websites frequently used are:

www.GISdevelopment.net

www.googleearth.com.

SOFTWARES USED

The methodologies used in my research show that the potential capabilities of a GIS are significant when used for coastal zone research.

ERDAS Imagine 9.1: to georeference the images and topomap

ERDAS is a window based GIS package with remote sensing applications. It handles vector as well as raster data. ERDAS is well-known image processing software. There are many more packages like MGE, IDRISI, GRASS and MAPINFO, etc.

Arc View3.2a: (Bentley product) to attach attribute data, to display spatial and non-spatial data. Presentation - analysis and output map generation

Arc View is made by Environmental Systems Research Institute (ESRI), the makers of ARC/INFO, the leading geographic information system (GIS) software. Arc View is a powerful, easy-to-use tool that brings geographic information to your desktop. Arc View gives you the power to visualize, explore, query and analyze data spatially.

Arc GIS 9.2: Presentation - analysis and output map generation

Arc GIS is a window based software. It handles vector based data generation, manipulation and map production.

OTHER SOFTWARES

Google Earth: To capture satellite imageries

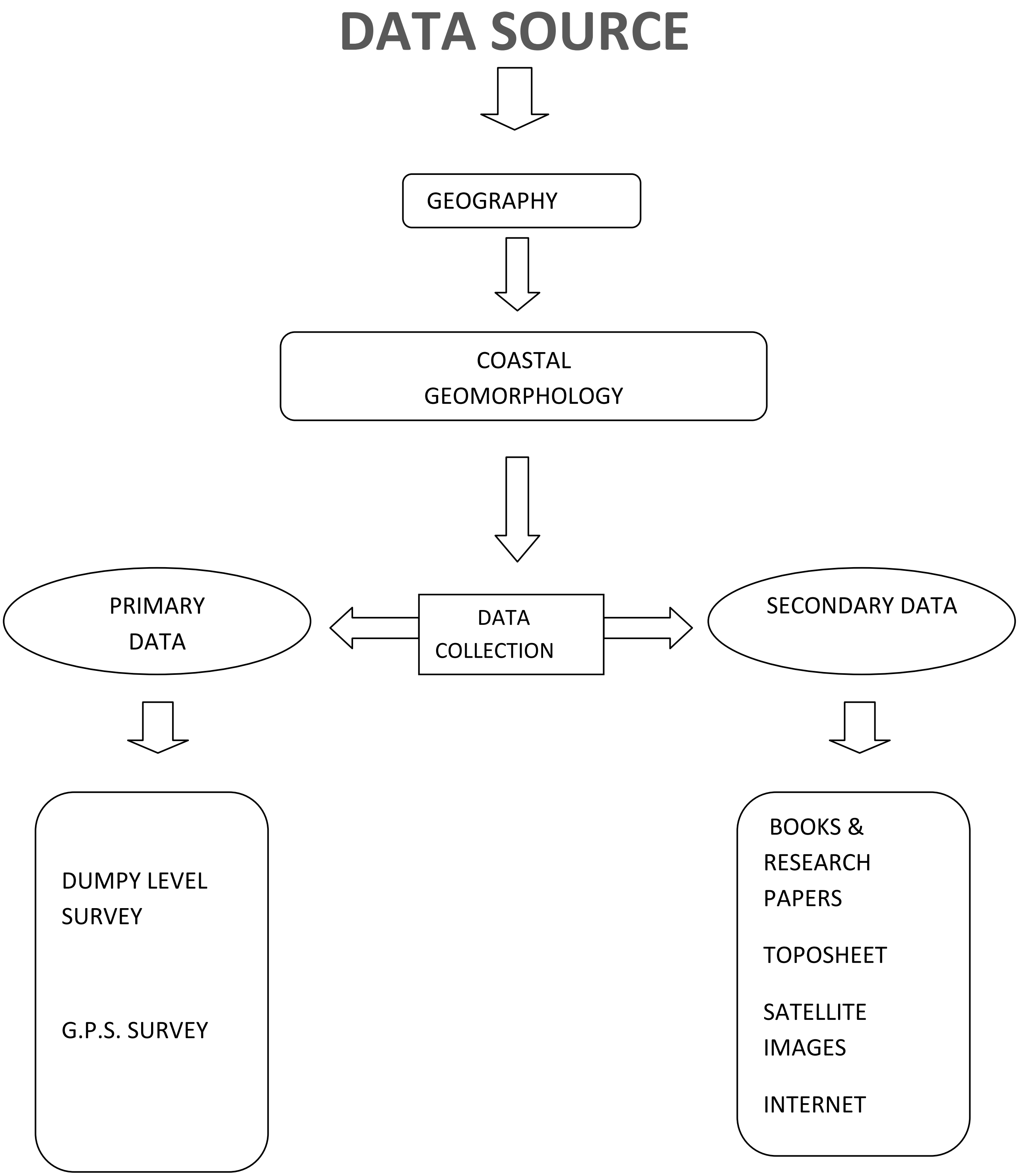
Google earth pro: to measure area

Microsoft excel: to prepare data table of GPS survey and calculate of dumpy level survey data

Microsoft word: to prepare and present report in text format

Microsoft PowerPoint: to present summarized project with the help of slideshow

METHODOLOGY - FLOWCHART



(Fig. 2.5)

CHAPTER THREE

BEACH MORPHOLOGY

Beach is the most dynamic part of the coasts; they are attractive not only from aesthetic and recreational point of view but also as field areas for geomorphologic research. The term beach describes wave deposited sediment. The term beach derived from Anglo Saxon word for shingle and gravel (pebbles and cobbles) is the dominant component of many mid to high- latitude northern hemisphere beaches.

The sea beaches are most unlikely of landforms to be found facing the open sea. (Pethick J. 1984)

Theoretically the beaches are the depositional units along the coastlines that are developed between low water mark and high water line. The beach interaction zone normally extends to the limit of swash action. There is a considerable variability in sandy beaches which is a result of wave environment. The entire beach zone consists of depositional facies formed by wave, current dynamics and associated flows.

To give a more precise morphological definition of the beach is difficult. Considering any beach profile it can be that a beach profile extends from low water of spring tide to the upper limit of wave action (King 1972, Ethic J. 1984).

During the summer, as gentle waves carry sand to the beach it widens and become gentle. High energy winter waves carry the sand offshore and producing a narrow steep sloping beach.

Morphology of any beach is mainly a study of changing beach profiles in storm and fair weather season. It also includes the study of various micro features, type and extent of sediment deposits on the beach.

The beach profile depends upon the height and width of the beach and also upon the beach face angle- the angle between the horizontal and the beach face or swash slope.

Gentle summer swells from distant storms build up the beach by pushing off shore sand bars back onto the shoreline. Local storm waves during the winter erode the beach and carry sand offshore where it is temporarily stored in sand bars. It is often possible to determine what season your beach profile was taken simply by looking at the shape of the profile line.

There is increasing evidence that on many muddy coasts wave processes shape the erosion concave-up profiles. And tide processes shape the more convex-up accretionary profile. (Roberts et al. 2000).

This work is the field study at beach profiles of Yelwane to Bodhani Bandar on Konkan coast in pre monsoon and post monsoon period.

THE MORPHODYNAMIC BEACH CLASSIFICATION

The beach respond quite sensitively to changes in different environmental conditions, especially the local wave climate, the beach profiles also undergoes periodic modification related to changes in seasonal wave climates. The classification that considers this aspect of beaches, in two groups namely winter and summer profile is synonymous with fair weather and storm profiles or dissipative and reflective profiles.

The beach in the study area is a pocket beach. The length of beach is approximately 1100 to 1136 meters. As mentioned earlier the beach is developed between a headland and a tidal inlet. The beach at Mandve is mainly a muddy coast.

The morphdynamic classification gives more emphasis on dynamic state, wave energy and beach profile. The morphology of the beach profile is almost infinitely variable. Two general classes of profile are recognizable, most widely used terms are ‘summer and winter profile’ (Johnson 1949), and ‘storm and swell ‘(Pethick J. 1984) are frequently used.

Field observations have shown the close relationship exists between beach profile gradient and seasonal variation. The low swell waves during the summer period built up seaward gentle profile. During winter high steep storm waves erode this beach face and transport this eroded material seaward, so the beach profile becomes steep and its overall gradient increases.

According to some researchers erosion of beach face and development of flat shallow profile is a result of specific angle of approaching waves rather than the steepness of the waves.

FIELD AND ANALYTICAL PROCEDURES

As pointed out earlier, the study of beach morphodynamics is mainly study of changing beach profiles in storm and fair weather season. It also includes study of various macrofeatures, sediment and extent of the deposits on the beach. The field and analytical procedures used in present study. This sort of study therefore, requires actual leveling of beach profiles by using a leveling instrument like Dumpy Level and field observation and field measurement representative of two different seasons.

The field work was carried out in June 2008 and January 2009, was considered to be representative of conditions and morphology in this period. The 1st field work was carried out in June 2008 was considered to be representative of conditions and morphology in pre- monsoon season.

WAVE CLIMATE

Wave climate is an important aspect that affects the beach. There is definite seasonal variation in wave climate at study area. In monsoon season the waves are strong and effective so swash and backwash is also powerful with spilling type of breakers, in this period wave energy is higher at eastern end than western, so there is more erosion to east and deposition to west, which is shelter and where mangroves are found.

In post monsoon there is considerable reduction in the width of breaker zone. Due to calm sea in post monsoon wave period is slightly longer. Swash and backwash is slower than monsoon. In this season width of surf zone and wave height is reduced.

FIELD OBSERVATIONS

YELWANE INLET HIGH TIDE

(Photoplate. 3.1)

YELWANE INLET LOW TIDE

(Photoplate. 3.2)

CHIDIPADA INLET AT LOW TIDE

(Photoplate. 3.3)

PROFILES IN BOTH SEASONS

Stability of a beach can be accessed from the profile changes during rough and fair weather seasons and can be monitored by recording the winds, waves, currents, tides breaker characteristics, sediment characteristics. If the beach material is washed away during the rough weather season, they are re-depositing during fair weather. Thus, erosion and accretion are continuous processes. Onshore winds cause a landward movement of the surface waters which must be compensate by seaward current at depth. Just the reverse is true with offshore winds, the near bottom currents being onshore. These currents will be factor in the onshore offshore transport of sediment and therefore have a bearing on the response of the beach profile.

During calm summer weather with waves gently lapping the shore the beach grows in size. Waves surge up the shoreface. The swash carries sediment. The swash slows, runs out of momentum and then slides back down toward the water. Some of the backwash sinks into the sand. The backwash has a little less energy to carry sediment down the beach so the beach gradually grows in size with the development of a summer berm. The summer beach profile is broader and with a more gentle slope.

During the stormy winter months, storm waves carry much energy to the beach with extra energy to suspend sediments and redistribute them in the nearshore environment. Steady strong winds from a storm can push water up on the leeward shore raising water levels. Return flow from this ***wind setup*** helps to carry sediment away from the shore. The summer berm is eroded away and the sands deposited offshore. The winter beach profile is steeper and narrower. Strength and direction of coastal winds can be an important factor in beach profile development. In addition to the response of the beach profiles to storm versus swell conditions, our series of profiles might show alternatives which correspond to tides. This would involve hourly changes resulting from the rising and falling water level of the tides and also longer- term effects.

As the tides rises, at any set location on the beach face a small amount of deposition occurred, followed by erosion as the site came under the intense swash, in turn followed by deposition as the breaker zone passed over. Just the reverse occurred with the falling tide.

BEACH PROFILES – SUMMER AND WINTER

On an average the beach at Yelwane inlet to Bodhani Bandar was observed. 12 profiles were selected from east to west roughly at an interval of 75 to 150 meters. It was tried to cover the whole lengths of the beach by using these 12 profiles.

There is a definite seasonal changes on the beach and this is clearly indicated by its width, length and beach gradient.

In post monsoon season there is decrease in height of breakers. Wave effect of swash and backwash decreases. Breaker zone retreats to far from the coastline. Due to the effect of these factors the beach is more exposed and wider than in monsoon (S. karlekar 1973)

In monsoon season the waves are powerful. Height of breaker is maximum, swash and backwash is strong. Due to this beach becomes narrow and concave.

Beach profiles in pre- monsoon and post monsoon are shown in figure. It can be seen that west section of the beach is characterized by maximum deposition in pre monsoon season (June) than in post monsoon season (January). Profiles in post monsoon season shows marked reduction in height, than pre monsoon season.

Scooping is the main activity near profile -3, 4, 5, 6 and 9 in post monsoon. Filling is a major activity in pre monsoon and it is seen near profile -7, 8, 9 where Chidipada inlet is located.

The situation of profiles in pre monsoon (1st June) season is quite different, comparative to post monsoon (26th January). Erosion activity is predominant in post monsoon, and deposition is predominant in pre monsoon. The area near Chidipada inlet shows large occurrence deposition in pre monsoon season.

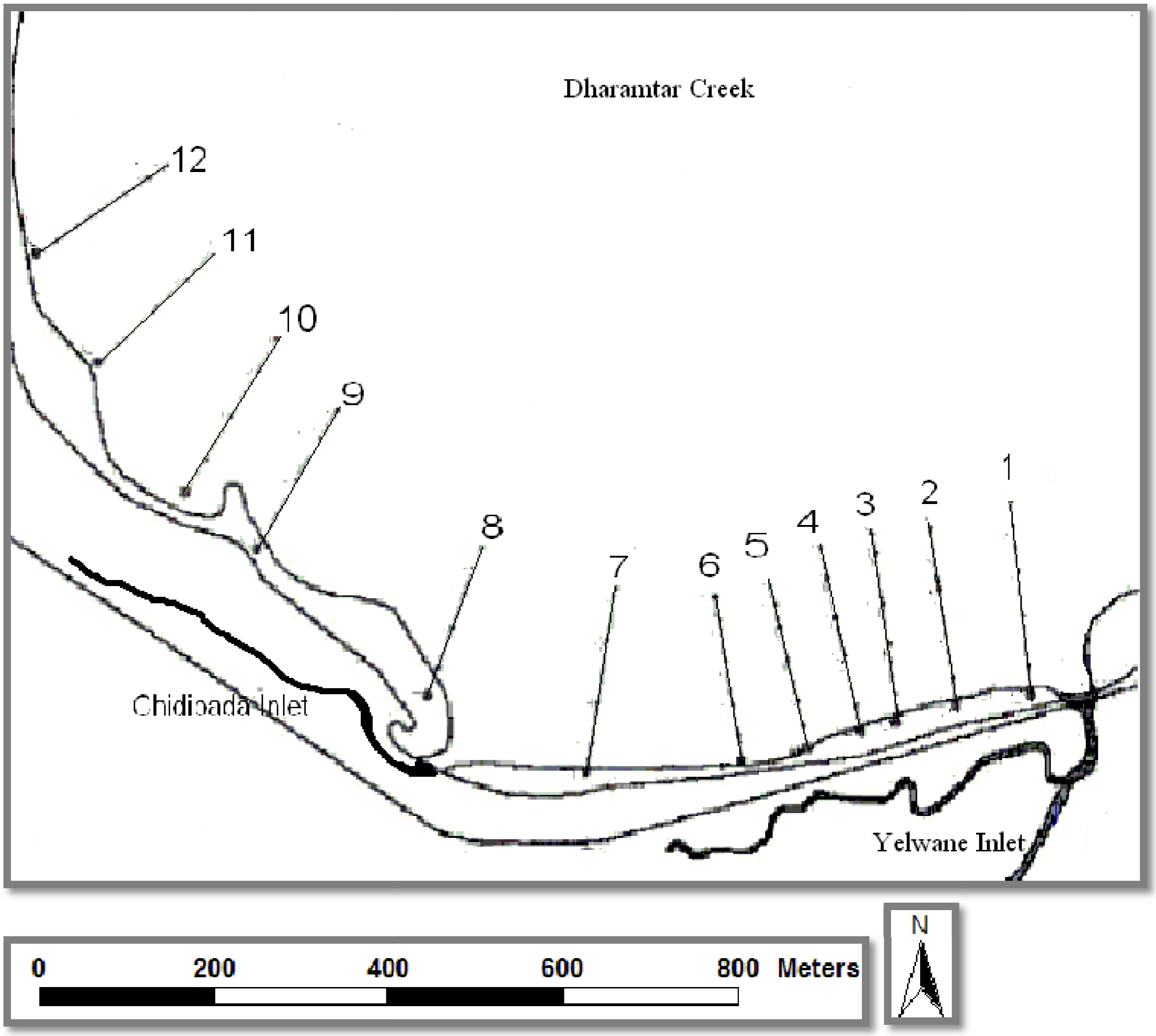
The beach profile typically can be divided into two distinct parts:

1. The seaward and relatively steep sloping foreshore, which is essentially the intertidal beach, and
2. The landward, nearly horizontal backshore.

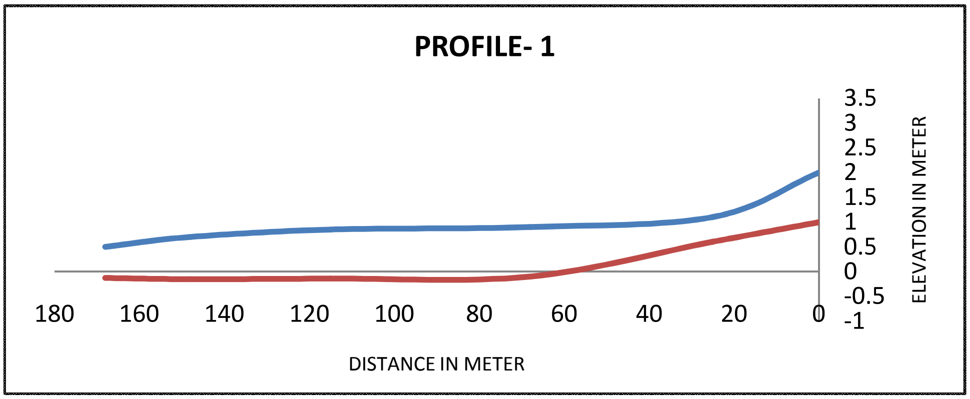
Successive profiles are superimposed in sets of two, to show the changes that took place between the surveys. As noted by Hayes (1969) the erosional profile is characterized by a steep concave up landward sector and gentle, slightly concave or flat lower profile above the MSL.

Generally the profile reaches highest level in the premonsoon months, due to the impact of high wave on the beach. The profile reaches their nadir during the rough season. The lowest level of the beach is observed in monsoon when wave intensity is at its maximum.

LOCATION OF PROFILES



(Fig. 3.1)

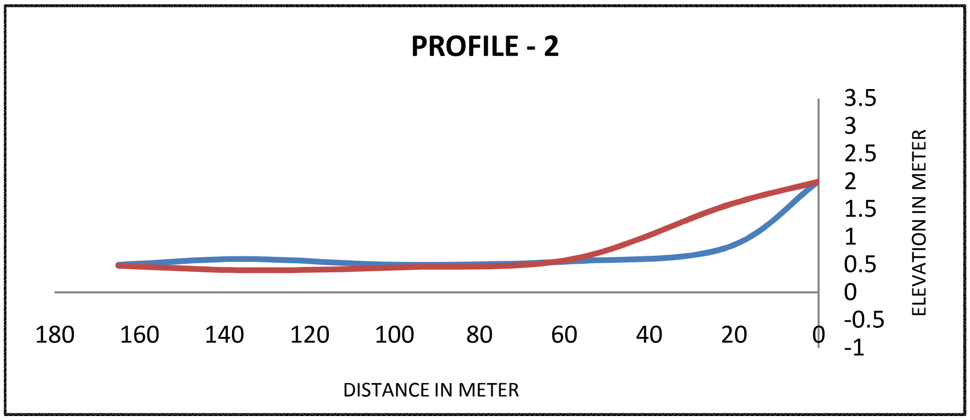


(Fig. 3.2)

A profile shows marked difference in both seasons, 1st profile taken out near Yelwane inlet. In pre monsoon period profile shows gentle slope towards sea. While in post monsoon season profile shows much reduction in height.

During the monsoon period high steep storm waves erode this beach face and transport the sediment to seaward, the each profile widens accordingly and its overall gradient reduces.

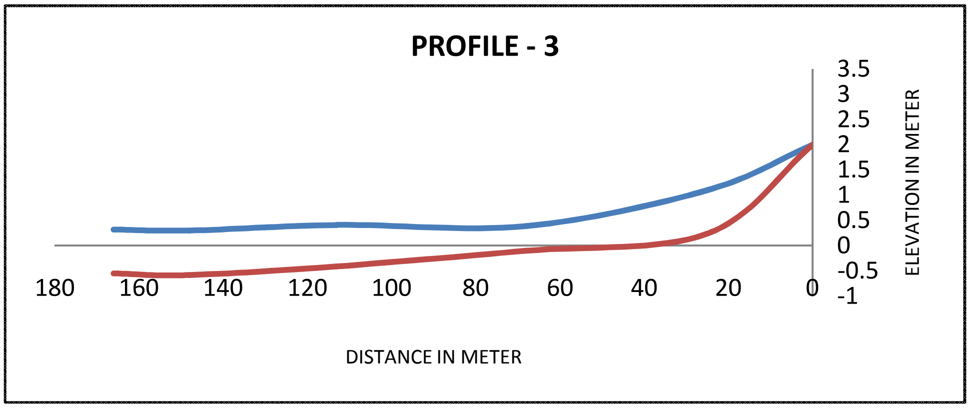
1st profile stretches from sea wall towards sea up to 165 meters. Profile is between 18° 47’ 30” N to 72° 54’ 53” E and 18° 47’ 38”N to 72° 54’ 50” E.



(Fig. 3.3)

Like the previous one this 165 meters long profile (2nd) is between 18° 47' 2"N to 72° 54' 50" E and 18° 47' 38" n to 72° 54' 50" E.

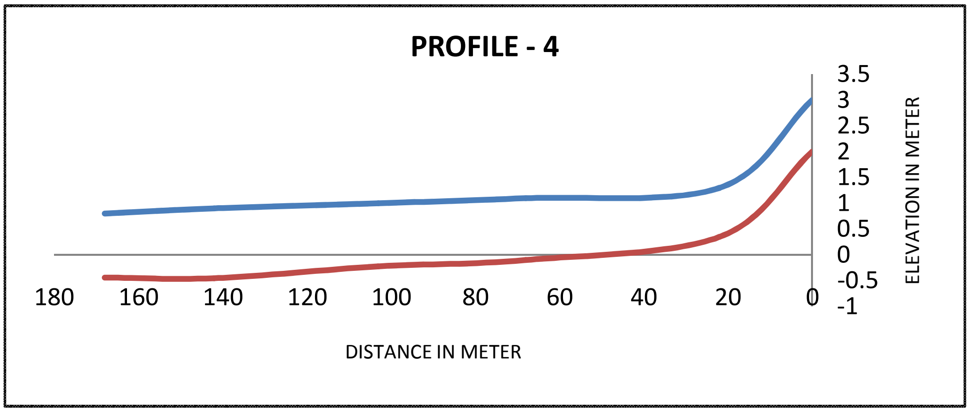
Profile 2nd in pre monsoon period also shows gentle slope towards sea. In Post monsoon the waves tend to be steep, and erosion of the beach occurs, with the mud moved down the beach by the wave's action.



(Fig. 3.4)

3rd profile stretches from protected wall towards sea up to 166 meters. This Profile is between 18° 47’ 29” N to 72° 54’ 48” E and 18° 47’ 34” N to 72° 54’ 47” E

In case of this profile there is marked difference in both seasons, profile in post monsoon period shows scooping activity, having steep slope. While feeling activity predominant in pre monsoon period having, gentle slope towards sea.

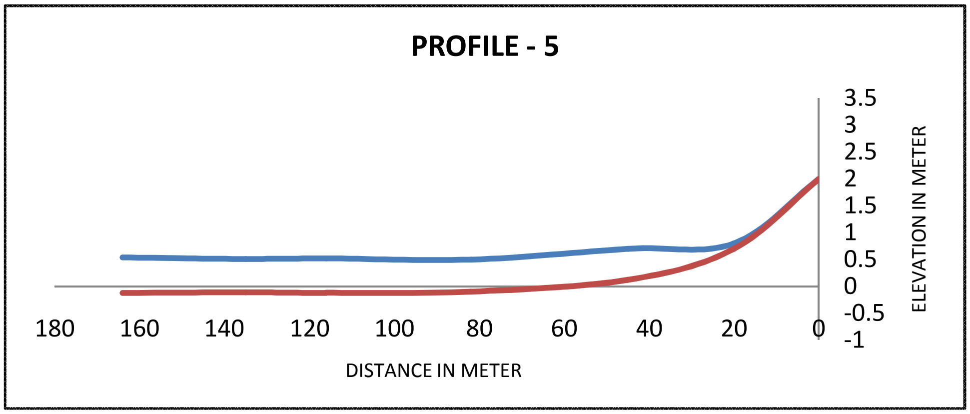


(Fig. 3.5)

Having 168 meters length 4th profile is between 18° 47’ 29” N to 72° 54’ 46” E and 18° 47’ 34” N to 72° 54’ 45” E.

During non-storm conditions the back-beach is relatively inactive except for wind action. Although there is a common trend to the beach profile, some variation exists both because of energy conditions and because of the material making up the beach.

In post monsoon season profile shows much reduction in elevation, and steep slope towards sea, while in pre monsoon deposition activity is predominant, having gentle slope towards sea.

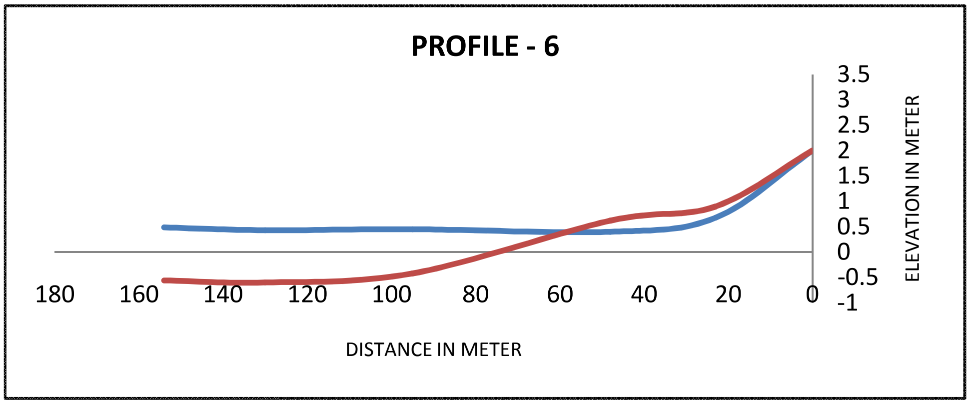


(Fig. 3.6)

5th profile is between 18° 47’ 28” N to 72° 54’ 45” E and 18° 47’34” N to 72° 54’ 44” E, having 164 meters length.

Profile in pre monsoon season shows gentle slope towards sea, while post monsoon profile shows steep slope towards sea. Feeling is major activity in pre monsoon, while post monsoon shows scooping activity.

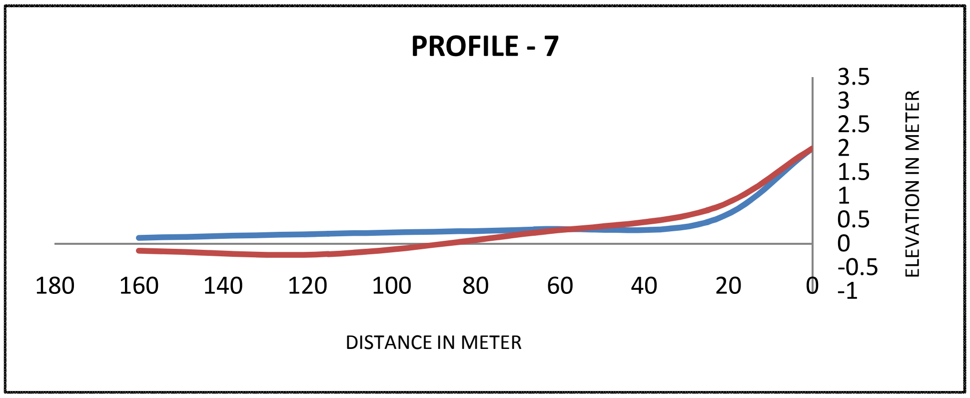
In summer, waves are generally far apart, low and gentle. These waves tend to flatten the beach by deposition. As monsoon approaches, waves become shorter, choppier and more frequent as well as more forceful which erode the beach.



(Fig. 3.7)

6th profile is between 18 47’ 28” N to 72 54’ 43” E and 18° 47’ 33” N to 72° 54’ 42”E, having 154 meters length.

In post monsoon this profile became concave towards sea due to scooping activity, there was no immediate gain. In post monsoon near beach face profile is bit convex, having steep slope towards sea. Pre monsoon profile shows, feeling activity. Profile in pre monsoon period shows gentle slope towards sea.

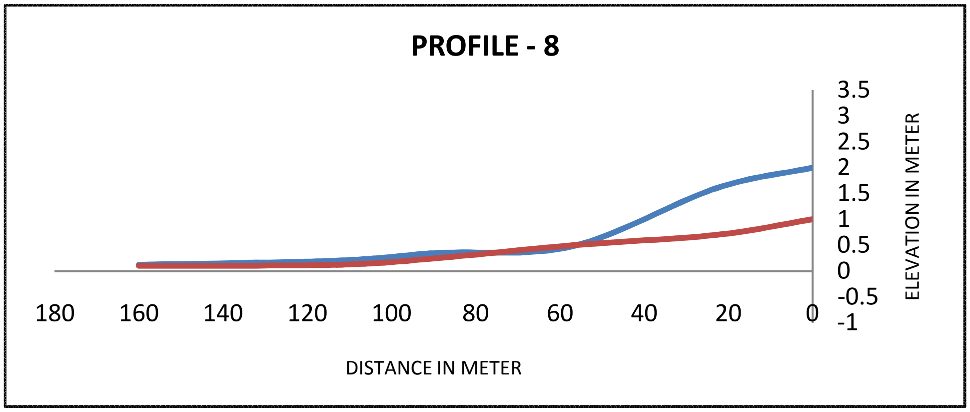


(Fig. 3.8)

Having 160 meters length 7th profile is between 18° 47’ 28” N to 72° 54’ 45” E and 18° 47’ 33” N to 72° 54’ 38” E.

This profile is near Chidipada inlet, in both seasons there is no much difference regarding sedimentation. Profile is concave near beach face in pre monsoon season, having gentle slope towards sea. While in post monsoon profile shows steep slope towards sea.

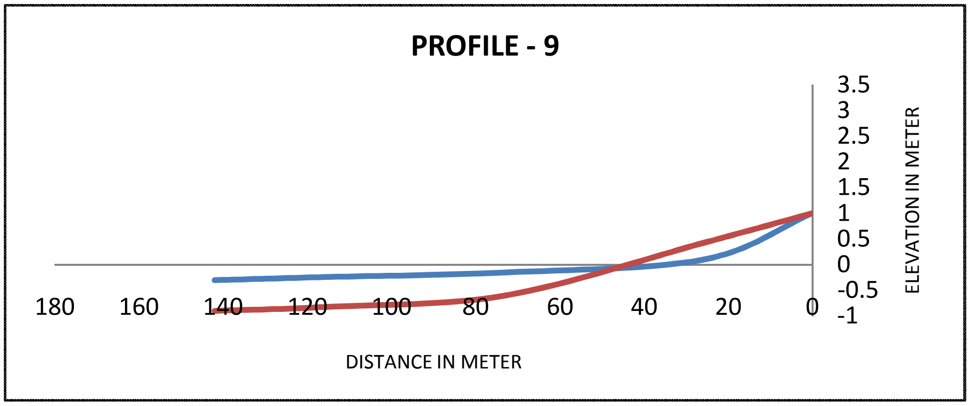
Mangrove trees are thinly scattered in this area. Remains of mangrove trees are also found at this area.



(Fig. 3.9)

8th profile is between 18° 47’ 29” N to 72° 54’ 32” E and 18° 47’ 34” N to 72° 54’ 35” E, having 160 meters length.

This profile is also near Chidipada inlet. In pre monsoon period profile shows mud deposition having convex slope near beach face, while in post monsoon profile decreases in height due to scooping activity in monsoon period.

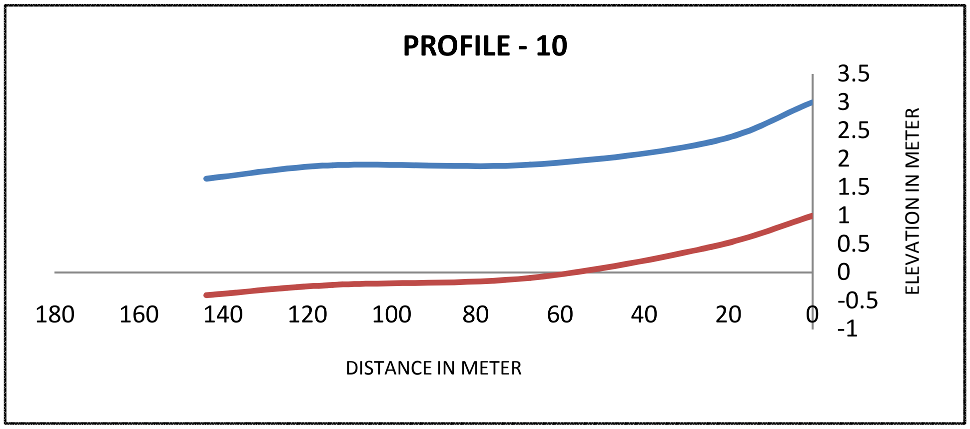


(Fig. 3.10)

9th profile is between 18° 47’ 34” N to 72° 54’ 26” E and 18° 47’39” N to 72° 54’25” E, having 142 meters length.

Near profile 8 and 9 scattered mangrove trees are found, quantity of mangrove trees is more compare to previous one due to coalesce of Chidipada inlet having thick mud deposits.

Profile in pre monsoon period shows gentle slope, while post monsoon profile shows steep slope towards sea.

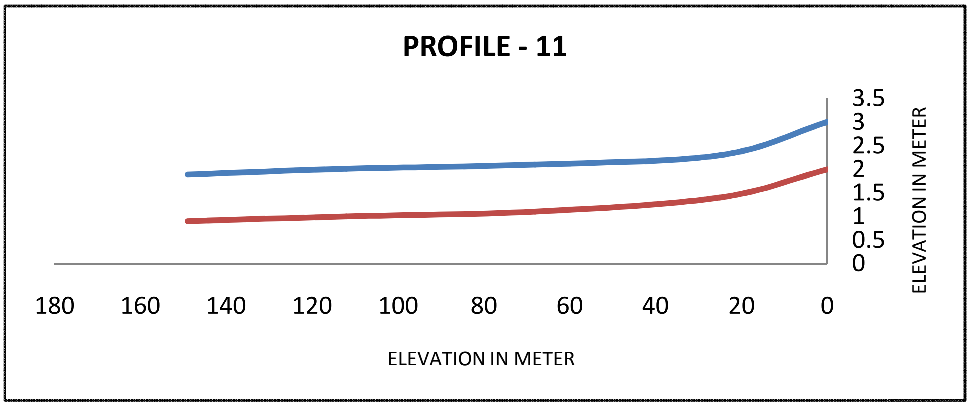


(Fig. 3.11)

10th profile is between 18° 47’ 35” N to 72° 54’ 25” E and 18° 47’ 39” N to 72° 54’ 27” E, having 144 meters length.

Elevation of the beach slightly increases from left side of the Chidipada inlet towards Mandve port; in post monsoon period profile shows much reduction of mud considerably.

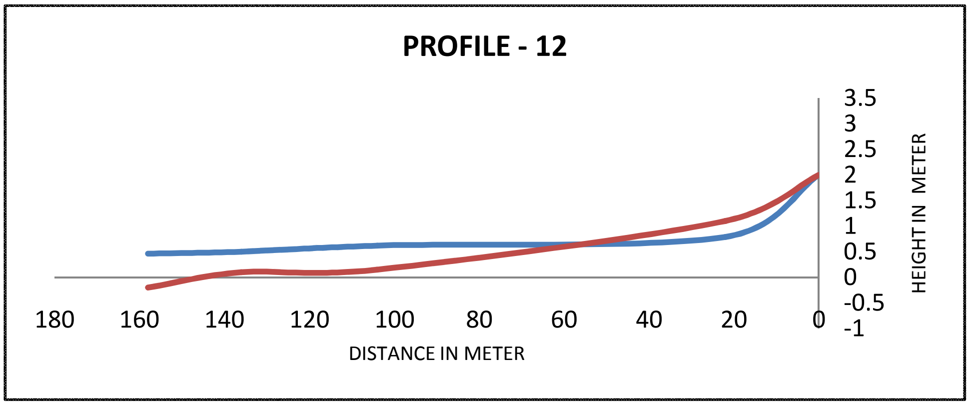
Proportion of mangrove trees decreases from this profile towards Mandve port. Accretion is predominant in pre monsoon period, having thick deposits of mud.



(Fig. 3.12)

11th profile is between 18° 47' 38" N to 72° 54' 21" E and 18° 47' 41" N to 72° 54' 25" E, having 149 meters length.

In pre monsoon period profile shows gentle slope towards sea having thick mud deposit. Like the previous one, in post monsoon period profile shows reduction of mud considerably and patches of mangrove trees are found. Profile in post monsoon period also shows gentle slope towards sea.



(Fig. 3.13)

Last one 12th profile is between 18° 47’ 28” N to 72° 54’ 43” E and 18° 47’ 33” N to 72° 54’ 42”E, having 158 meters length towards sea. Profile in post monsoon period have steep slope towards sea, proportion of mud as well as mangrove trees decreases towards port. In pre monsoon period profile shows gentle slope towards sea.

During the monsoon months the profiles exhibits characteristic storm profiles with steep foreshore. The beach building up starts from September.

Making a beach profile gives a recording of the surface or profile of the beach and is an excellent way to determine beach topography. It can also be used to measure the rate of change to a beach if subsequent visits can be made throughout the year.

PROFILE TABLE -1

PROFIE NO.	DISTANCE FROM BM.	ELEVATION - PRE MONSOON	ELEVATION - POST MONSOON
Profile.1	0	2	1
	25	1.1	0.6
	68	0.9	-0.1
	115	0.85	-0.14
	148	0.7	-0.15
	168	0.5	-0.13
Profile.2	0	2	2
	22	0.8	1.56
	58	0.56	0.6
	98	0.5	0.45
	135	0.6	0.4
	165	0.5	0.48
Profile.3	0	2	2
	25	1.1	0.24
	68	0.39	-0.1
	113	0.41	-0.41
	148	0.3	-0.58
	166	0.32	-0.55
Profile.4	0	3	2
	22	1.3	0.35
	68	1.1	-0.1
	103	1	-0.22
	142	0.9	-0.45
	168	0.8	-0.44
Profile.5	0	2	2
	20	0.8	0.7
	45	0.7	0.12
	82	0.5	-0.1
	116	0.52	-0.12
	135	0.51	-0.11
	164	0.54	-0.12
Profile.6	0	2	2
	23	0.68	0.9
	48	0.4	0.62
	95	0.45	-0.42
	130	0.43	-0.6
	154	0.49	-0.56

(Table - 3.1)

PROFILE TABLE – 2

PROFIE NO.	DISTANCE FROM BM.	ELEVATION - PRE MONSOON	ELEVATION - POST MONSOON
Profile.7	0	2	2
	25	0.45	0.7
	66	0.3	0.23
	115	0.21	-0.22
	160	0.12	-0.15
Profile.8	0	2	1
	23	1.6	0.7
	57	0.48	0.5
	89	0.35	0.25
	113	0.2	0.12
	160	0.12	0.1
Profile.9	0	1	1
	26	0.1	0.42
	73	-0.15	-0.6
	115	-0.24	-0.82
	142	-0.3	-0.9
Profile.10	0	3	1
	24	2.3	0.45
	67	1.9	-0.1
	114	1.89	-0.22
	144	1.65	-0.4
Profile.11	0	3	2
	25	2.3	1.4
	68	2.1	1.1
	112	2.01	1
	149	1.89	0.9
Profile.12	0	2	2
	22	0.79	1.1
	104	0.62	0.15
	136	0.5	0.1
	158	0.46	-0.2

(Table - 3.2)

CHAPTER: FOUR

FACTORS OF SEDIMENTATION ON THE BEACH

FACTORS OF SEDIMENTATION

Muddy coast have received far less intensive study than sandy coasts but their complexity is becoming increasingly apparent. Muddy coast generally comprise of an inter tidal zone that can contain significant quantities of sand and upper intertidal salt-marsh or mangrove areas fed by a tidal inlet or dissected by tidal creek networks. The long term accumulation of mud leads to a sedimentary record within which there is evidence of cycle of erosion and accretion that are likely to have occurred at a range of scales. Physical factors and biological response occur at several overlapping time scale. (Woodroffe, 2002).

Sediment enters the shore zone of breaking wave from number of possible sources, it may be derived directly from marine cliff or scrap that is being actively eroded, sediment entering the ocean or a lake from the mouth of a stream is another supply storm waves may score the offshore zone, dragging sand and gravel landward to reach the breaker zone. Whatever the origin of sediment, it shaped by swash and back washes into wedge shaped sediment deposit familiar to everyone as beach.

The Coastal zone is affected by marine factors such as tides, waves, currents, sea level rise etc. The most marine coastlines are influenced by the ocean tide, which is a rhythmic rise and fall of sea level under influence of changing attractive forces of moon and sun on the rotating earth. Where tides are great, the effect of changing water level the currents set in motion is of major importance in shaping coastal landforms. (Arthur N. Strahler, Alan H. Strahler). Everyday many coastline experience two high tide (rising tide, known flood tide) and two low tides (falling tide, known as ebb tide).

The rising tide sets in motion currents of water, known as tidal currents, in bay and estuaries tidal currents carry much fine silt and clay in suspension derived from streams that enter the bay, or from bottom mud agitated by storm wave action against outer shore line, this fine sediment settles to the floor of bay and estuaries, where it accumulates in layers and gradually fills the bay with time, mud flats produce at this type of site. Organic matter present in this sediment. Next, a growth of salt tolerant plants takes hold on the mud flat.

In most of the case however the source of the mud can be traced directly through nearby rivers much of the sediment is derived from land and delivered to sea by major rivers, sediment that reaches the coastal regions normally will be finer in texture often mud-flats develop along the shore because only tiny clay sized and silt sized particles are emptied into the ocean.

Typically the river channels divides and subdivides into lesser channels called distributaries, the course particles settle out first forming foreset beds, silt and clay continue out farthest and come to rest as bottomset bed. Contact of fresh with salt water causes the finest clay to clot (flocculate) into larger aggregates which settle to the seafloor (Strahler A. N.)

Waves are important because of their work of both erosion and deposition; they are produced by the pressure and friction of wind on the sea surface. It should be noted that while the form of the waves advances in the direction in which the wind is blowing. When the wave moves towards the shore on a gently sloping bottom, it become shorter and higher and develops an over steepened crescent shaped front. Since the motion the lower part is retarded the upper part rushes over it forward and downward forming surf forms is called the breaker zone, this forward rush of water carries much sediment with it which is deposited over area (A. Banerjee).

Waves are the main factor of shaping the coast. Their erosive capacity is partly due to the effect of impacts of water against the coast and partly due to the action of beach material moved by the waves themselves. Nevertheless, there are several factors that influence the erosive force of waves: Strength of wind, length of time wind blows and the fetch. Waves with a large fetch and subjected to strong winds are generally known as destructive waves. These waves are steep and tend to break downwards onto the beach. They possess both a strong swash and a strong backwash, the latter being sufficient to erode the beach yet the former being able to build a large berm by adding material to a zone, which the backwash cannot reach. Therefore, destructive waves tend to erode the beach.

Seasonal cycles of sand deposition and loss dramatically affect the appearance of beaches from summer to winter. Wide and gently sloping in summer, they become steep-fronted and narrow in winter, and can vanish overnight, stripped of sand by violent storm waves. Most of the sand removed from winter beaches is deposited in offshore sandbars and is returned to the beach during the mild summer months by gentle swells that push the sand to the exposed shore. River sediments are the source of 80 to 90 per cent of beach sand; some beaches are built to great widths by sediments washed to the sea by episodic floods, gradually eroding until the next major flood replenishes the sand.

Coast composed predominantly of mud comprising silt and clay sized sediment occur in low-energy settings, generally sheltered from wave action. Fine sediments are transported considerable distances in suspension but if subject to flocculation into low density deformable aggregates can behave like larger particles. After deposition, muddy sediments tend to be cohesive making them more resistant to resuspension and highly organic supporting a diverse biota.

On muddy coast, sediment become finer onshore in contrast to beach and barrier coasts which become coarser onshore. Mudflats, salt marshes and mangroves are most extensive on micro tidal coast (Hayes 1975). They are especially associated with large embayment where tidal currents are strong and wave action limited. Muddy landforms can occur wherever there is a large supply of fine sediment irrespective of tidal range. (Woodroffe, 2002).

A mixture of very fine silts from tidal waters and alluvium from rivers dropping their load as they reach the sea, is deposited, causing a built of mud layer, called mud flats. Mudflats (also tide flats) are coastal wetlands that form when mud is deposited by the tides or rivers, sea and oceans. They are found in sheltered areas such as bays, bayous, lagoons and estuaries. Mudflats may be viewed geologically as exposed layer of bay mud, resulting from deposition of estuarine silts, clays and marine detritus. All mud flats are usually crisscrossed by winding channels that are kept open by tidal action. Unless these channels are fed by active water sources such as streams and rivers, they will usually dry out at low tide and contain no water.

Where the mud is sufficiently stable to support vegetation, salt marshes may form, or in tropical areas, mangrove swamps.

The term tidal ‘flat’ is very broad and covers a range of generally muddy low gradient intertidal or supratidal surfaces. (Amos.1995; Dyer.1998; Eisma.1998). Intertidal flats are defined as sandy to muddy flats emerging during low tide and submerging during the highest tide. These are often colonized by halophytic vegetation (salt marshes and mangroves) at their upper margins.

Although tidal flats are particularly associated with areas with large tidal range, extensive plains can develop that are flooded rarely or by seasonal rainfall rather than tidal processes.

Tidal landforms, especially the mud flats, are very conspicuous coastal features of northern coast of Maharashtra. The formation of wider and thicker mud flats and mud beaches is associated, generally with the high tidal range, greater than 3 meters, the well known fact that they are developed usually in areas sheltered from the effects of wind driven wave action.

Tidal flats are particularly associated with areas with a large tidal range, extensive plains can develop that are flooded rarely or by seasonal rainfall rather than tidal processes.

Intertidal flats show site-specific shore-parallel zonation of sedimentary characteristic bed forms and ecological communities varying in relation to tidal range. A decrease in grain size from coarse sediments at low water to mud at high water occurs over most intertidal flats in response to decrease in tidal current speed.

The velocity of tidal currents is important and muddy coasts tend to show an asymmetry which is a function of the morphology of the system. Sedimentation on the upper parts of tidal flats implies landward movement of sediment although ripple patterns after an ebb tide may misleadingly indicate flow direction only during that most recent ebb tide (Collins, 1981).

Mangrove represents a type of azonal vegetation confined to salt water of tidal regions along the creeks and backwaters and even the main sea shore. The occurrence of Mangrove trees in quiet depositional environment of tropics has been one of the facts of climatic coastal geomorphology.

In tropical areas the inter-tidal mudflats are colonized by mangrove tree whose branching root system and twisted trunks and branches provide resistance to tidal currents. Mangrove swamps are, however, composed of much higher amounts of organic debris. Mud flats and mud beaches and salt marshes are the main mud beach, tidal landforms which are found along the coast. Halophytes are plants that can survive in saline substrates. Mangrove forests are upper- intertidal environment in which a generally a generally muddy substrate supports varied and normally dense stands of halophytic (salt- tolerant) plants.

THE MAJOR FACTORS GOVERNING MANGROVE ECOSYSTEM

The mangroves are fragile complex and dynamic ecosystem, and are dependent on the following inter-related, environmental both, biotic and abiotic factors:

CLIMATIC FACTORS

Climate of any inter-tidal region acts as the most significant and important factor for the natural growth, development and succession of the mangroves. Among these climatic factors:

Atmospheric temperature fluctuation ranges between 20° C and 35°C.

Rainfall

Regular wind flow

Frost free

Radiation

Sedimentation play very dominant role for the mangrove viability in a holistic manner.

MORPHOLOGY BETWEEN YELWANE TO BODHANI BANDAR

There are many factors which cause mud deposition in study area. Some general factors mention here which may be applicable to study area. Direction of wind and waves affects the study area, waves are westerly in pre monsoon period having 5-10 knot speed and in monsoon period direction of waves is westerly to southwesterly while a speed exceeding 10 knots, which may cause transportation and deposition of mud in exposed area.

During spring and summer the salinity of tidal water is high, causing increased flocculation at the seaward edge. The intensity of biological activity is also highest at this time so that the effects of plants and animals on depositional is maximized. As winter sets the depositional rate at this season decreases and sediments deposited in summer are dispersed and eroded.

Study area is an example of protected bay, which provides protection and ideal site for mud deposition, the mechanism may be the tide waves carry much fine silt and clay in suspension that enter in the bay, this fine sediment settles to the floors of bay, it accumulates in layers and gradually fill the bay with time and produce mud flat, which are barren expanses of silt and clay exposed at low tide but covered at high tide.

It has long been recognized that flooding and sedimentation of muddy coast occurs through a network of tidal channel, called tidal creeks where these traverse salt marsh or mangrove wetland. Flow in these tidal systems is bi-directional and are driven primarily by the stage of the tide. In the case of salt marshes and mangrove system tidal creeks networks are routes through which much of the upper intertidal is flooded and drained (Jakobsen.1954).Tidal current activity is responsible for the sand transport through tidal inlets. The unsteadiness of the flow further complicates the issue of sand transport. The back and forth movement of sediments through the inlet is responsible for its deposition at both ends that is near the head and mouth of inlet.

The second source of mud deposition is Yelwane inlet, a small seasonal stream that originates on Kankeshwar hill joins the inlet at Yelwane, having 50 km length and average width of inlet is 26.8meters. Tidal inlets play major role in mud deposition process, a mixture of very fine silt from tidal water dropping their load as they reach the sea, is deposited, causing a buildup of layers in study area, which are called as mud flats.

This tidal channel experience flooding and ebbing twice daily. With a tidal range of 3.5 meters, show a remarkable influence of tidal water intrusion into a small seasonal stream. The Yelwane tidal inlet is a short, narrow waterway of quiet tidal environment where fresh water from land meets the salt water from sea. The inlet is governed by tidal flow. The relatively deep axial channel of the inlet is straight or curved. It is flanked by shallow shoulders, and cuts through gravel, clay, rocks or barrier of sand (Fairbridge 1968). The tidal range in this region is 3.5 meters. Thus it is a mesotidal estuary.

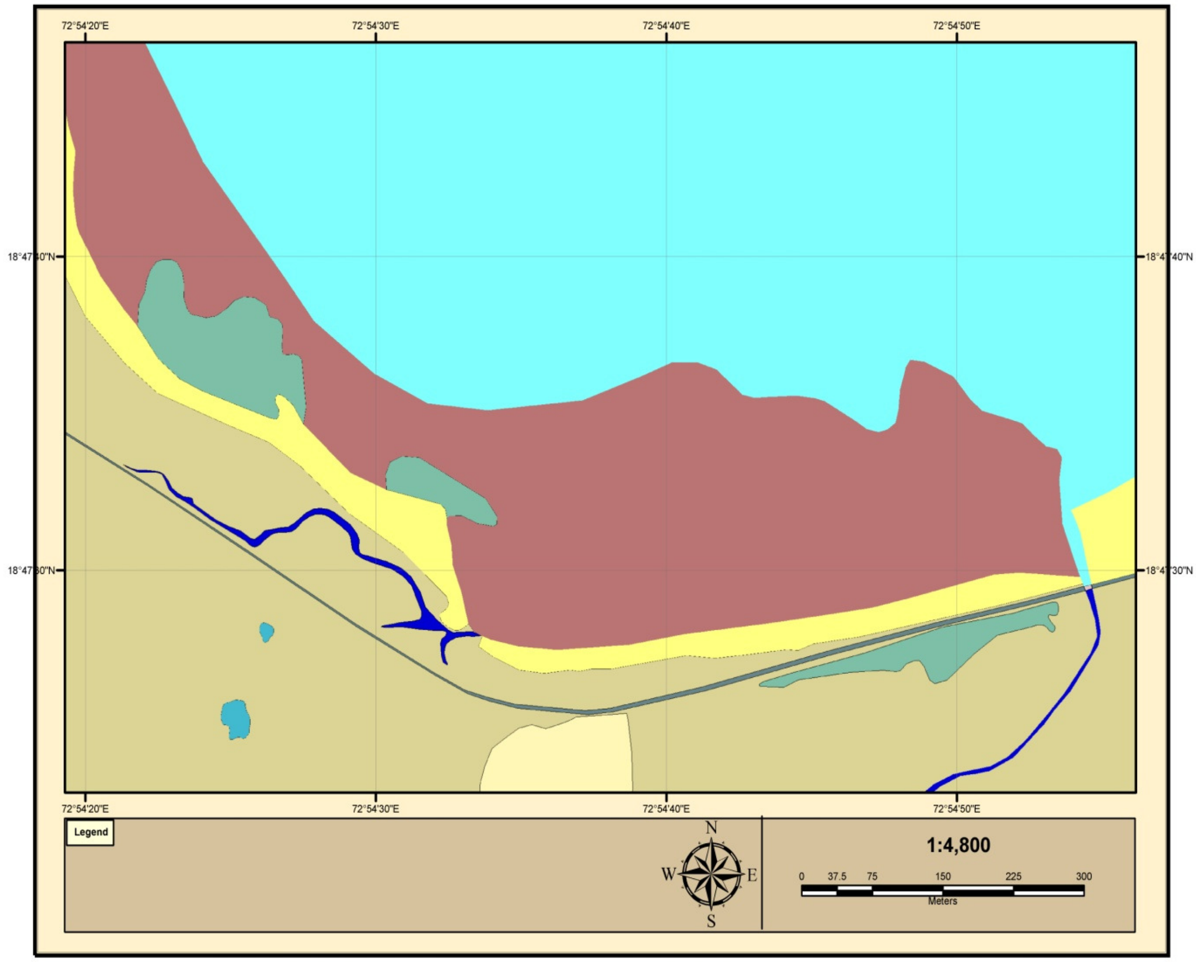
Chidipada – A small inlet near village Chidipada, is another source of mud deposition in study area. Having average width of 10 meters, a thick deposit of mudflats and mangrove trees are found at this sheltered crescent shaped area.

The entire beach between Mandve and Rewas is a sheltered beach. It is bounded by two headlands Mandve and Rewas respectively. On the coastline with headlands and sheltered beach, wave refraction concentrates wave energy upon the headlands the waves reach shallow water sooner at the headlands and thus slows down while the crest on either side continues to move at greater speed so the waves is bending nearly parallel to the headlands and wraps it from all three sides. The refraction pattern results as the waves shorten their wavelength and focus their energy on the point of the headland. Along the headlands, the energy is concentrated in into a short piece of shoreline and along the protected bay; it is spread over a much greater length of shoreline the central area at the mouth of the bay is usually deeper than the areas to each side and so the advancing waves slow down more on the sides than in the centre and shorten on each side, the wave crests bulge towards the centre of the bay. Since the wave in the centre of the bay do not shorten up as much, they have less height and also less energy to expand. Therefore, bay is an environment of low wave energy and provides sheltered water. Consequently, the breaking waves act as powerful erosional agent on the headlands, but are relatively weak and ineffective at the bay head. Waves breaking obliquely on the bay shores cause littoral drift of the detritus towards the bay heads. The sediment accumulation becomes a crescent – shaped pocket beach.

Sheltered beach, wave and wind direction, suitable temperature, ample sediment supply all these factors have resulted into growth of mangroves. Occasional patches of mangroves are present especially along tidal channel and beyond the limit of inter- tidal slope at western end of the beach near Chidipada inlet. Mangrove spread approximately over 32sq. km area. Sparse mangrove species and remains of mangrove roots are found in remaining area. This shows occurrence of mangrove trees in recent past at that area. Due to general intertidal slope and heavy mud deposition, environment supports occurrence of mangroves.

In June 2003,nearly 0.21 sq.km. area was occupied by mud in study area, in March 2004, due to pre monsoon period nearly 0.42 sq.km areas was occupied by mud, recent data denotes the proportion of decreasing mud in study area. In March 2009 only 13 sq. km. area is occupied by mud. (Mud deposition in study area is denoted with reference to maps.

CHANGING BEACH PATTERN BETWEEN YELAWNE TO BODHANI - 2003



(Fig. 4.1)

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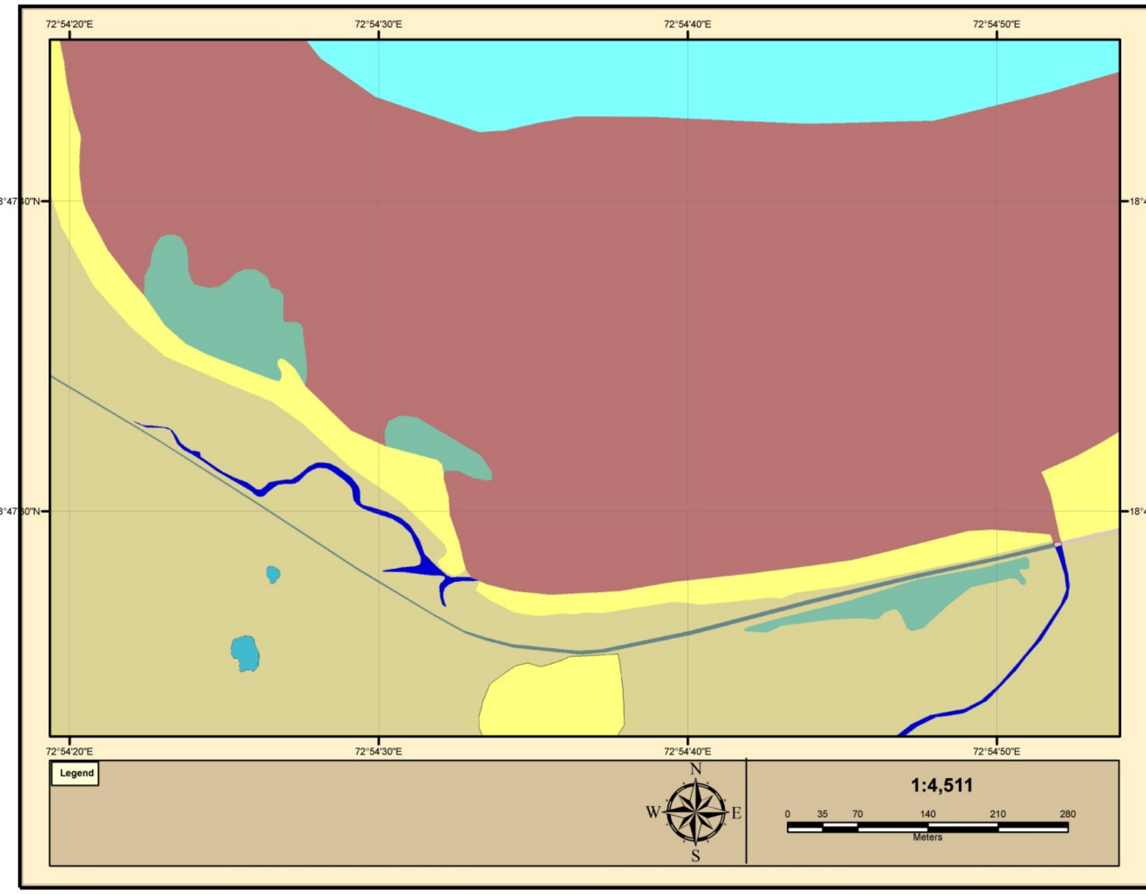
CHANGING BEACH PATTERN BETWEEN YELAWNE TO BODHANI - 2004



(Fig. 4.2)

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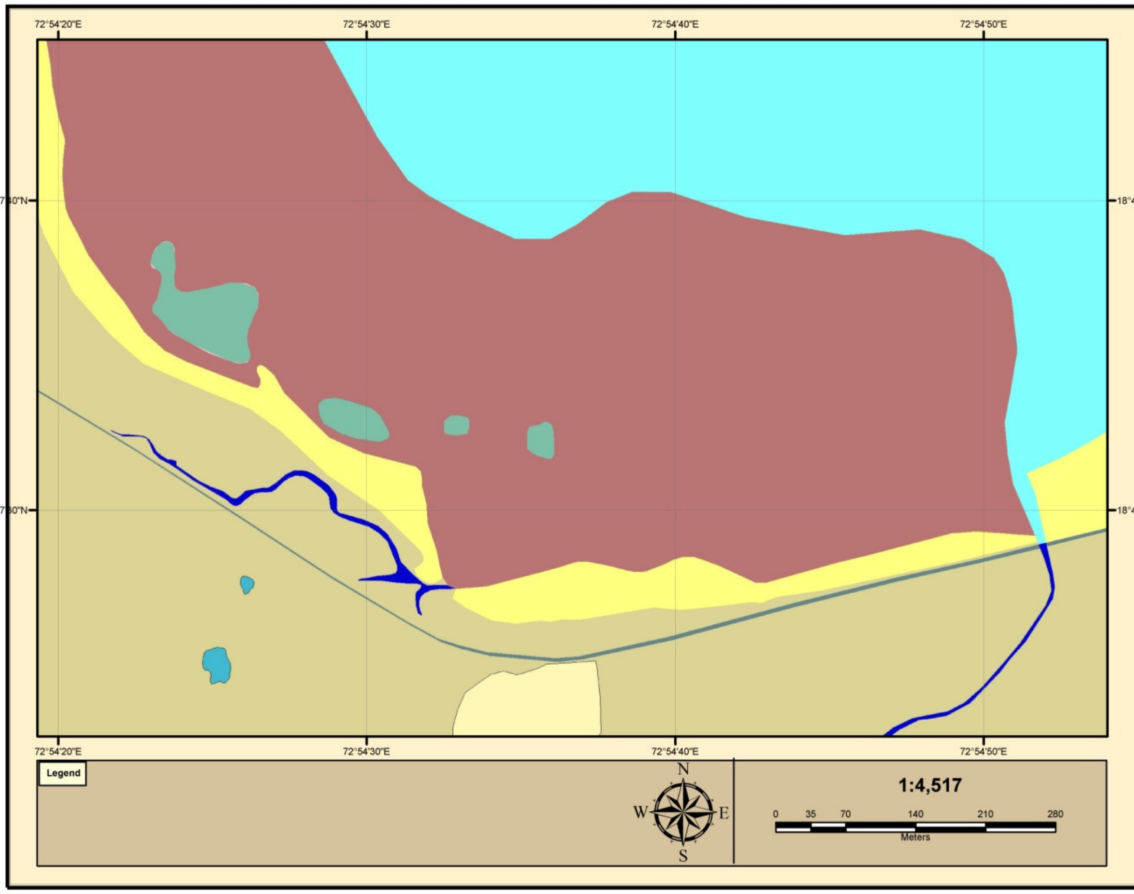
CHANGING BEACH PATTERN BETWEEN YELAWNE TO BODHANI - 2005



(Fig. 4.3)

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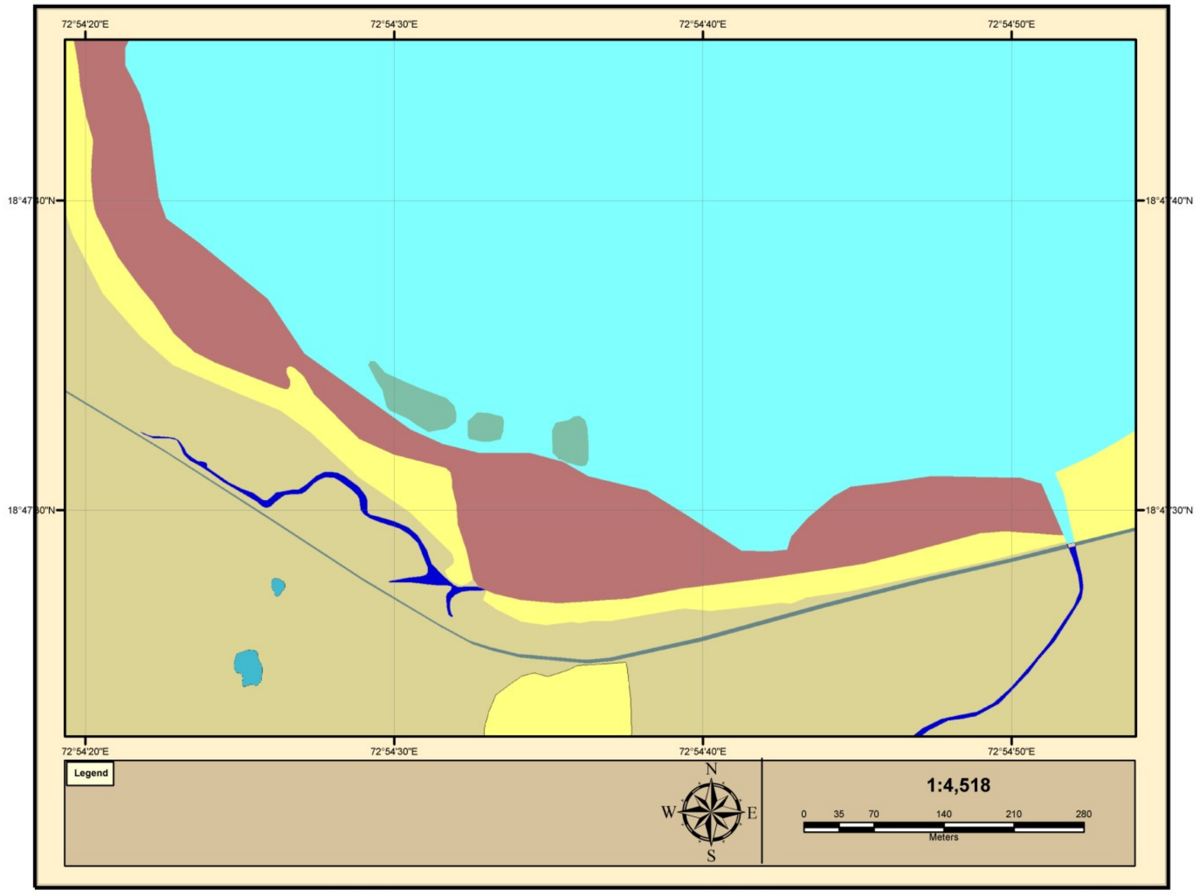
CHANGING BEACH PATTERN BETWEEN YELAWNE TO BODHANI - 2006



(Fig. 4.4)

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VIEW OF CHIDIPADA INLET AT LOW TIDE

(Photoplate. 4.1)

MUD FLATS AT CHIDIPADA INLET

(Photoplate. 4.2)

CHAPTER 5

DATA PROCESSING and GIS TECHNIQUES

Data capture is the most expensive and time - consuming component of a GIS. Data capture in GIS is the creation of data layers by a variety of techniques. These include digitizing, scanning, or generating data from a file. In other words data capture is putting information into a system. Or it is the operation of encoding data and writing them to the database. Data capture for GIS can be best described under five headings.

- Digitization
- Rectification
- Entering the non- spatial data
- Topology
- Linking spatial to attribute data
- Map products

DIGITIZATION

It is the method of translating a map into a digital form. Digital data can be created using primary data source such as satellite or GPS data or secondary data sources such as paper maps. This data capture from maps is carried out in one of the three principal ways: viz. manual, semi automatic and automatic.

DATA FOR GIS APPLICATION

Autodesk map 2005 software is used for digitization. The georeferenced map is imported from ERDAS Imagine 9.1. Digitizing is the process of converting the spatial features on a map into a digital format. Point, line and polygon are spatial features that form a map, are converted into x, y coordinates. A point is represented by single coordinate, a line by a string of coordinates, and when combined, one or more lines with the label points inside outline are identified as polygon.

RECTIFICATION

Rectification is the process of geometrically correcting an image so that it can be represented on a planar surface, conform to other images or conform to a map. It is the process y which geometry of an image is made planimetric. It is necessary when accurate area, distance and direction measurements are required to be made from the imagery.

Rectification is not necessary if there is no distortion in the image. Scanning and digitizing produce images that are planar, but do not contain any map coordinate information. These images need to be georeferenced, which is a much simpler process than rectification.

GEOREFERENCING

Georeferencing is the process of assigning geographic identifiers (e.g. codes or geographic coordinates expressed as latitude-longitude) to map features and other data records, such as street addresses.

The image of the study region is georeferenced in Arc GIS 9.1. A georeference defines the relation between rows and columns in a raster map and XY-coordinates. The location of pixels in a raster map is thus defined **LOCATING GROUND CONTROL POINTS (GCP).**

This process employs identification of geographic features on the image called ground control points (GCP's), whose positions are known such as intersection of streams, highways, airports, etc. Longitude and latitude of GCP's can be determined by the accurate base maps where maps are lacking GPS is used to determine the latitude and longitude from navigation satellites. Thus a GCP is located in the field and determining its position using GPS. Accurate GCP's are essential to accurate rectification. GCP should be best described under five headings.

- Reliably matched between sources and reference (e.g. coastline features road intersection, etc.)

- Widely dispersed throughout the source image

ENTERING THE NON SPATIAL DATA

Attribute data or non - spatial data are these properties of a spatial entity that need to be handled in the GIS. Attribute data may be come from many different sources such as paper records, existing database, spreadsheet, etc. they may be input into the GIS database either manually or by importing the data using a standard transfer format such as TXT, CSV, and ASCII. Where relational databases are used an identifier is included in the attribute record to link the spatial and attribute data together.

TOPOLOGY

The topology is a set of object or object data that defines spatial relationships between the objects. In GIS term topology is used to represent the spatial relationship that exists between geographic data. Topology can be created from many types of data-e.g., from a point (well locations), line (roads, rivers) or polygon (parcels).

TOPOLOGY TYPES AND APPLICATIONS

1. Node topology

Node topology defines the interrelation of nodes (point objects). These are often used in conjunction with other topologies for analysis. Some examples of node topologies are street lights, city-maintained trees, or drill holes for core samples.

2. Polygon Topology

A polygon topology defines polygons (tidal inlets and villages) that represent enclosed areas such as land parcels and census tracts. A single link defines the common boundary between adjacent areas. Uses of polygon topology include tax assessment and land planning in which parcels of land are represented by polygons. Political boundaries, such as voting districts, city, state, or provincial boundaries, special districts and school districts are other examples of the use of polygon topology.

3. Network Topology

Network topology defines the interconnection of links (road) and optionally, nodes at link junctions. Network may contain loops and network segments have a specified direction. Links can be lines, open polylines or arcs.

LINKING SPATIAL AND ATTRIBUTE DATA

Final process in the data capture involves the linking of the attribute and spatial database through unique identifiers. The linking operation provides as ideal chance to verify the quality of both spatial and attribute data.

- Attaching Attribute Data To An Object

While attaching attribute data to an object, a new record is crated in the selected table. It is possible to use the default values or enter new values for the object.

- Creating Attribute Data Table

Once object data table is defined, new field is created. The first step in attribute data entry is to define field according to what type of information will contain in that field. You can even specify a default value for each field.

- Modifying Attribute Data Table

User can add, modify and delete fields in newly defined object data tables until a save operation is performed (either saving objects back to source drawings or saving the project).

DATA ANALYSIS AND INTERPRETATION

The heart of GIS is the analytical capabilities of the system. What distinguish the GIS system from other information system are its analysis functions. The output of data processing is in form of maps viz.

contour map and 3D displays of Digital Elevation Model (DEM) and Triangular Irregular Network (TIN). These maps can be used as spatio-temporal data. As these maps are generated in two seasons which are pre-monsoon and post-monsoon. In morphodynamic analysis, season wise data is compared for which the contour map and 3D displays as essential.

COMPARISION OF 3D DISPLAYS AND MAPS

In a GIS, the modeling of the Z-axis has become an important element. When the 3-D model is specifically applied to represent terrain, then this digital representation of the elevation is termed as a Digital Elevation Model (DEM).

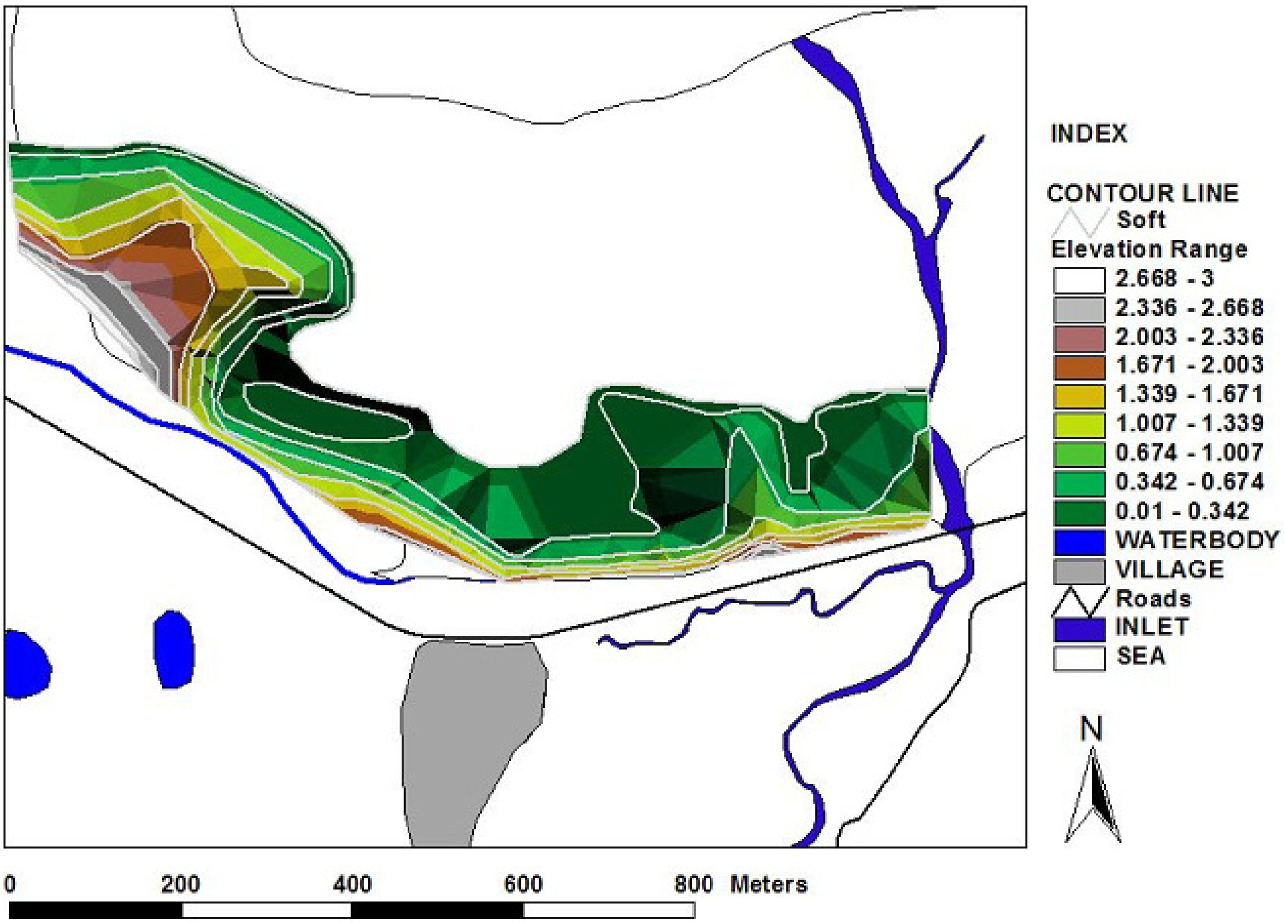
The 3D view also helps make it clear what is topographically high and what is topographically low. As illumination direction changes perception of what is up and what is down changes. A 3D map is the representation of geologic units and structures seen as actual volumes following a 3D matrix (x, y, z) at a given time (t). A geologic unit volume is defined within two surfaces corresponding to the layer�s top and bottom. The volume can be further limited either by fault surfaces (if the geologic unit has been faulted) or by erosion surfaces.

Periodic changes should be observed as we compare both of 3D display. Shape and size of study area shows maximum changes in both seasons. 3D map of survey 1 (Pre-monsoon) is showing deposition while map of survey 2 (Post-monsoon) is showing erosional activity predominated. In 3D map displays this variation in surface is very clear. The erosional areas are particularly observed in the near Yelwane inlet, near Chidipada inlet rate of erosion decreases. In post monsoon season mud is deposited near Chidipada inlet, while remaining area experiences erosion. Coastal processes play a major role in shaping the coastal configuration of this area.

The data analysis can also be done by comparing old data and recently collected data. It is done to observe the trend in changes occurred within the long period.

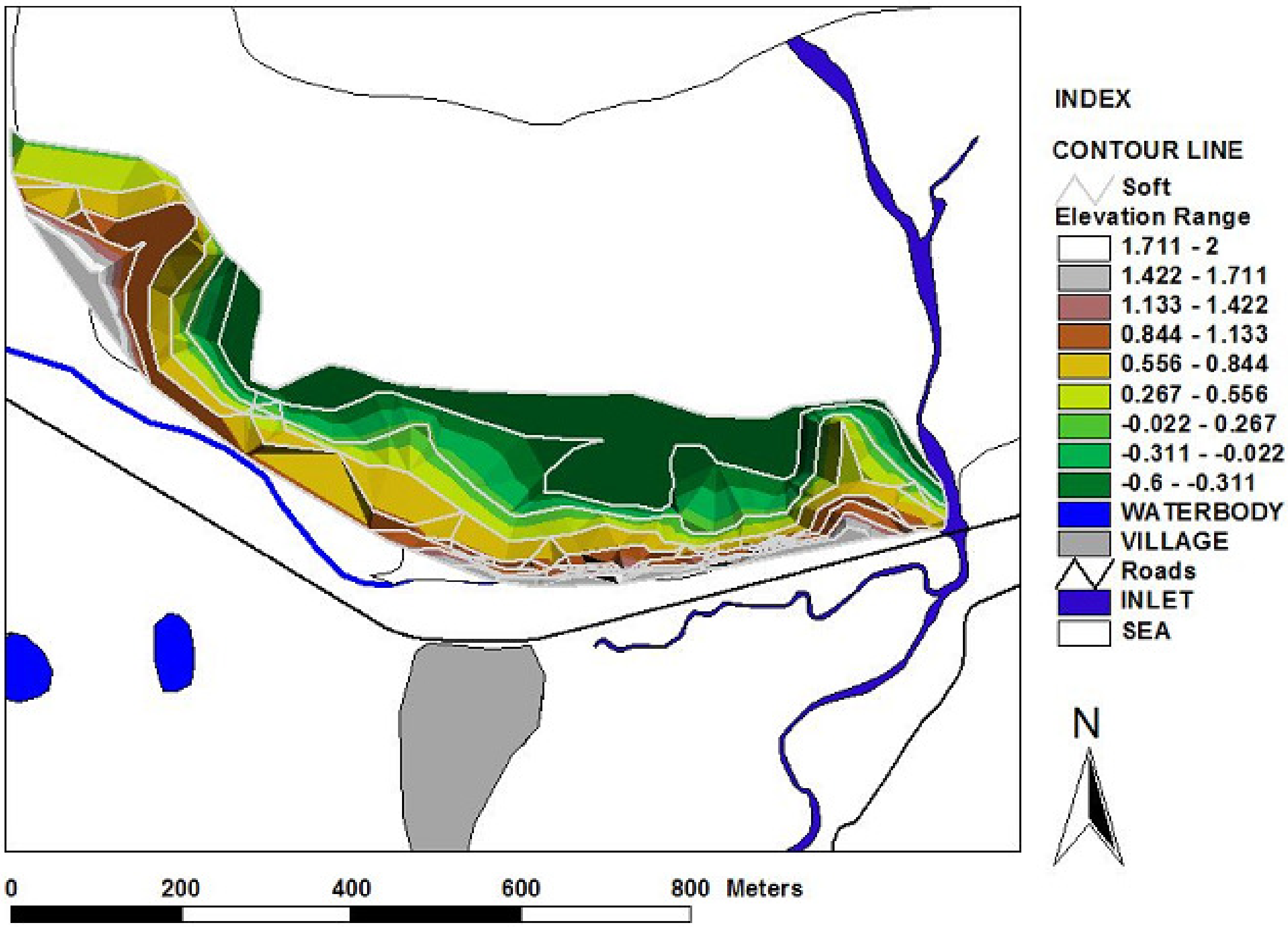
S.O.I. Toposheet no. 47 B/13 is referred as old data. Toposheet is published in 1970. On the other hand, Satellite imagery is captured from Google Earth Website, which is using the data of 2009 Digital Globe. Hence, satellite imagery data is considered as recent data source for further analysis.

PRE MONSOON MAP



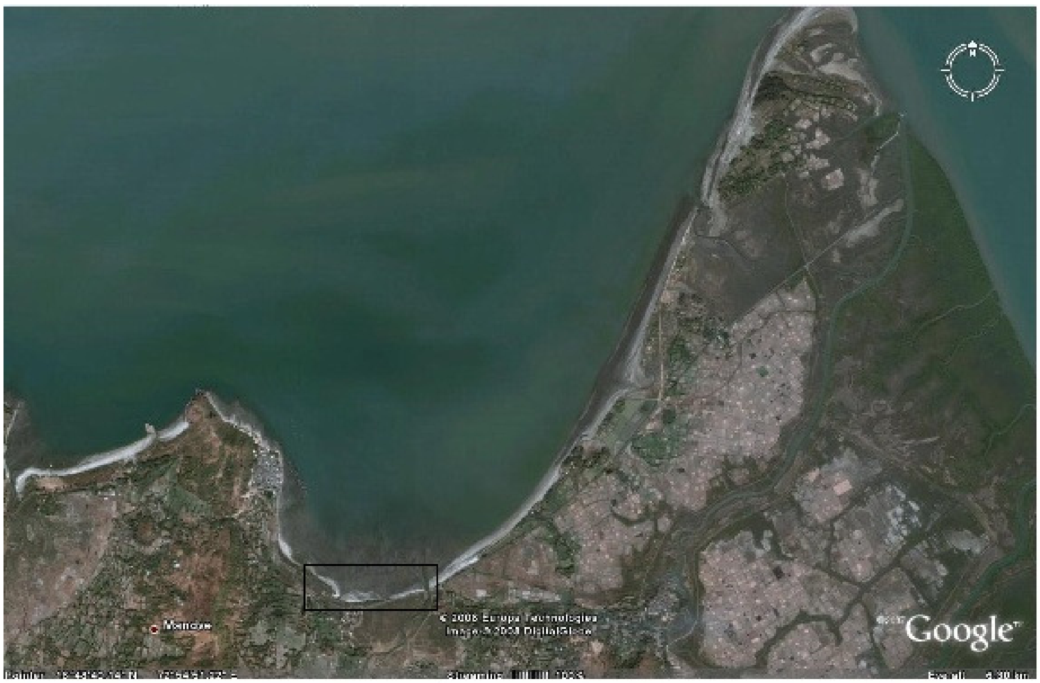
(Fig. 5.3)

POST MONSOON MAP



(Fig. 5.4)

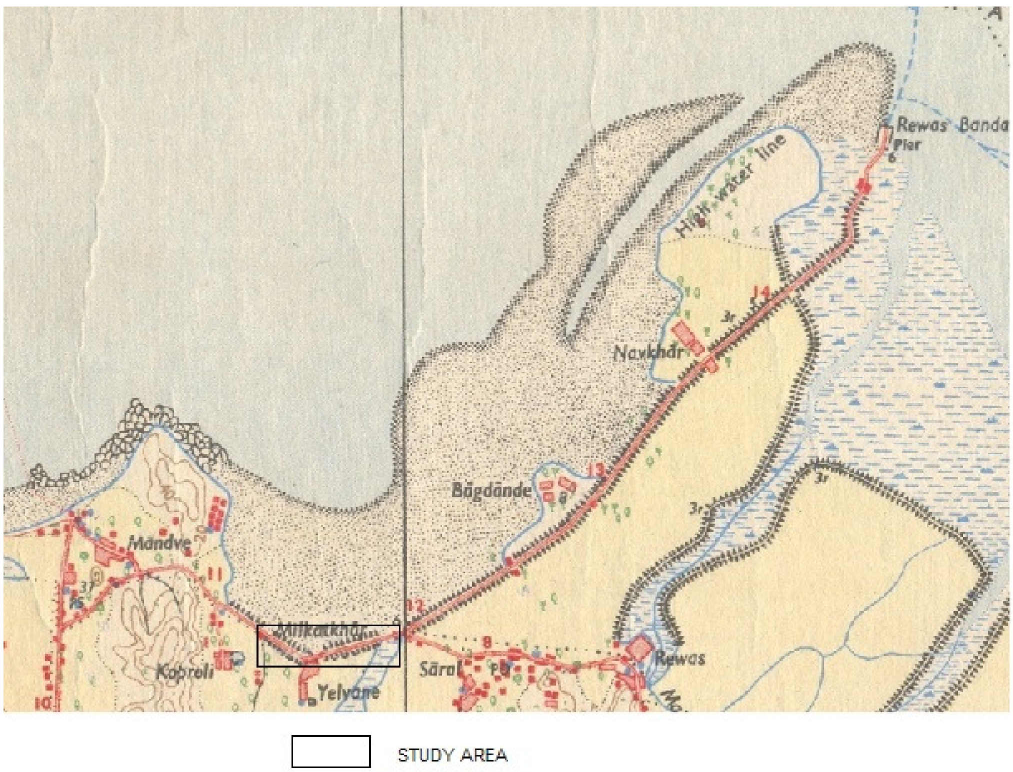
MANDVE TO REWAS BEACH: SATELLITE IMAGE



STUDY AREA

(Fig. 5.5)

STUDY AREA



(Fig. 5.6)

CHAPTER: SIX

CONCLUSIONS AND OBSERVATONS

- The beach between Yelawane inlet and Mandve is a pocket beach.

- Width of the beach changes from season to season, beach in post monsoon is narrower than that in pre monsoon.

- Tidal inlet plays a major role in mud deposition process, a mixture of very fine silt from tidal water dropping their load as they reach the sea, which is knows as mud flat.

- Deposition is major processes in pre monsoon season on the beach. The erosion of the nearby headlands supplies material to breakers and longshore drift that is deposited on the beach.

- While studying the area near Bodhani, mud was observed in thick layers. Mud balls, Mud flats, mangroves are also found, this may be due to the protected location of the area as it is a bay, while sandy deposition on the Rewas beach may be fronted by open sea.

- With reference to satellite image and toposheet from year 2003 to 2009, the proportion of mud is decreasing in study area. Factors which may cause mud erosion may be the sea level change. A seasonal map denotes that deposition predominates in pre monsoon season, while erosional activity observed in post monsoon season.

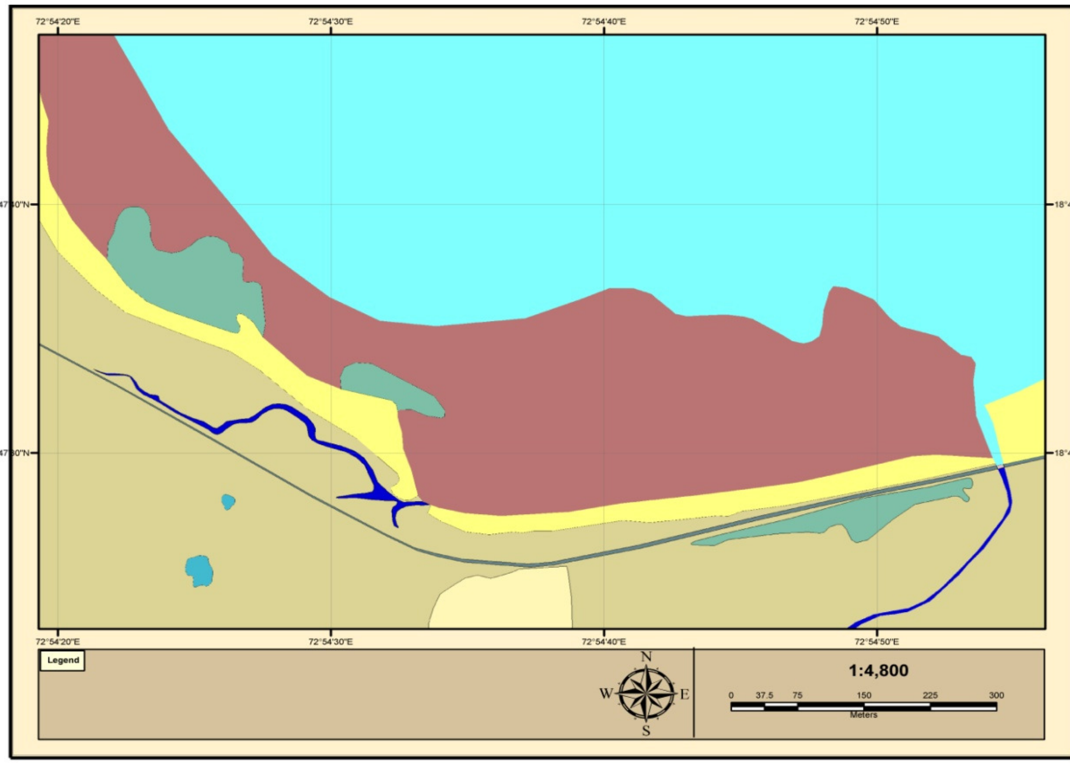
- **YEARLY CHANGES IN VOLUME OF MUD**

Mud field (year)	**Area in Square meter**	**Area in Square km**
3rd June 2003	2,14,646.59 m^2	0.21 km^2
30th March 2004	4,23,083.47 m^2	0.42 km^2
28th December 2005	3,57,927.80 m^2	0.36 km^2
23rd March 2009	1,34,394.78 m^2	0.13 km^2

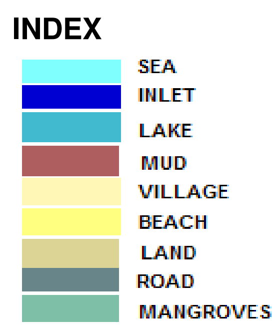
(TABLE - 6.1)

In June 2003,nearly 0.21 $km^{2.}$ area was occupied by mud in study area, in March 2004, due to pre monsoon period , deposition occurs and nearly 0.42 km^2 areas was occupied by mud deposits in study area, recent data denotes the proportion of decreasing mud in study area. In December 2005 nearly 0.36 km^2 area and In March 2009 only 13 km^2. area was occupied by mud. (Mud deposition in study area is denoted with reference to maps.)

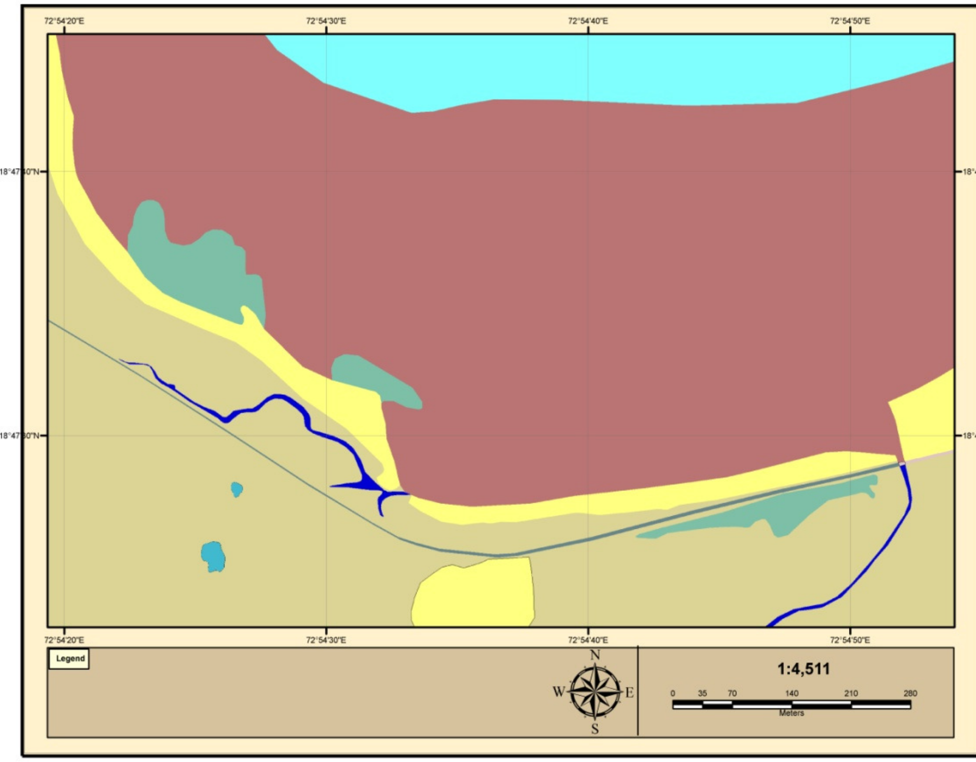
MAP 2003 JUNE



(Fig. 6.1)



MAP 2004 MARCH



(Fig. 6.2)

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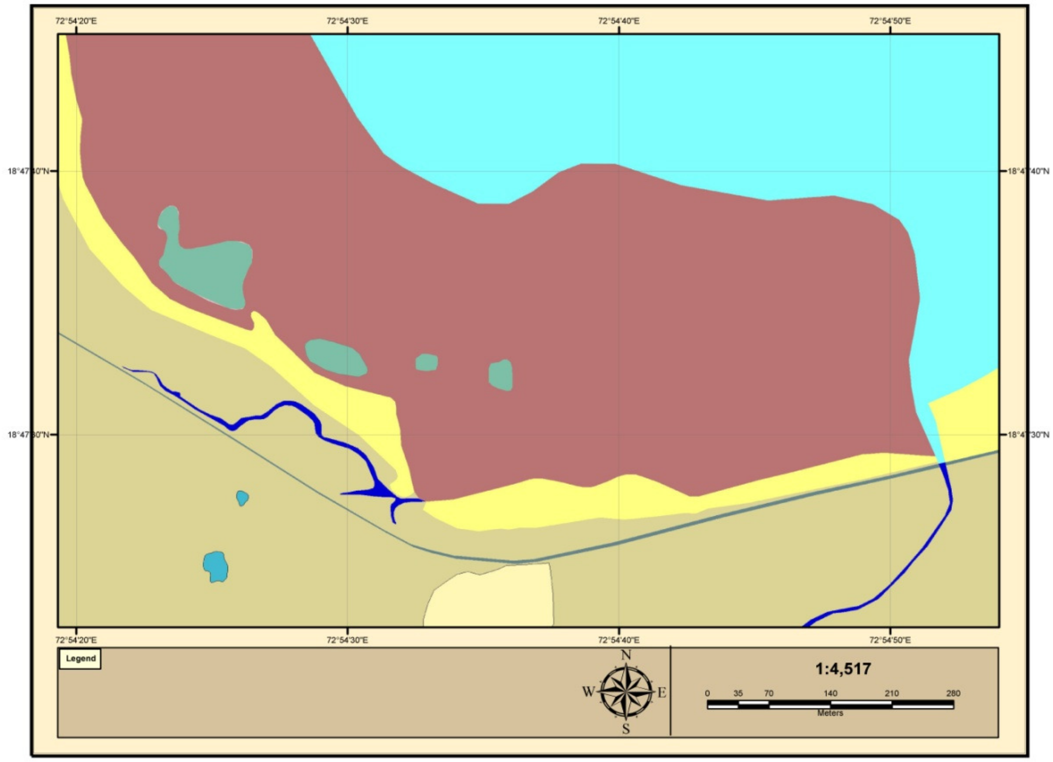
MAP 2005 MARCH



(Fig. 6.3)

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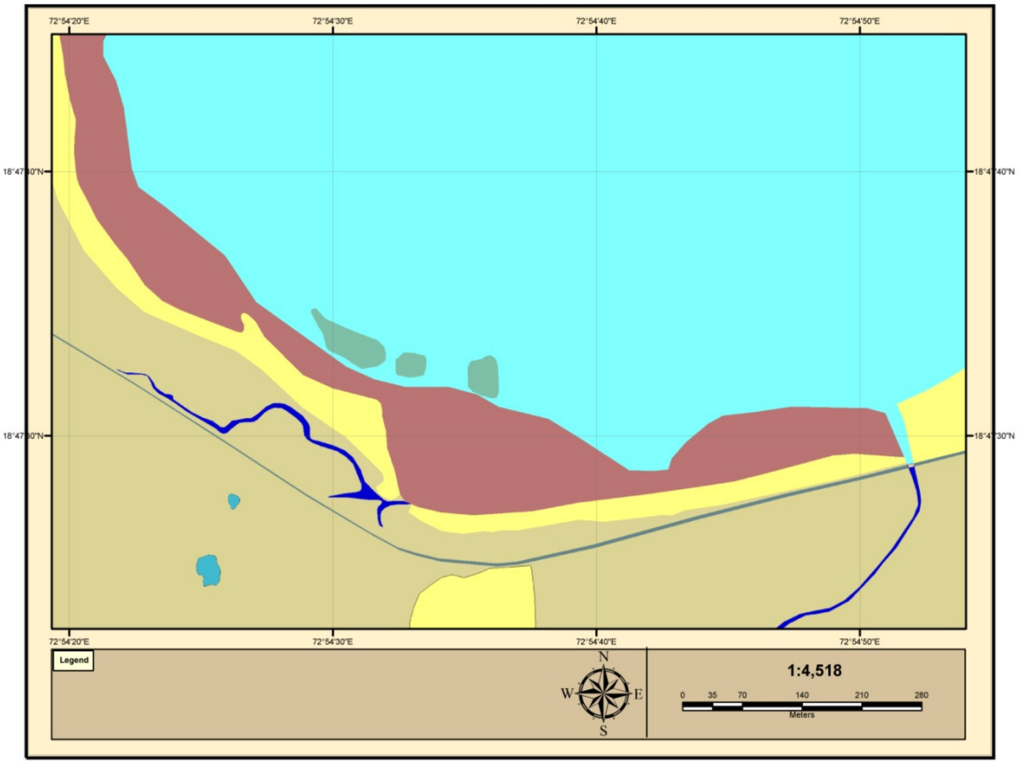
MAP 2009 DECEMBER



(Fig. 6.4)

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- Mangroves vegetation is largely observed in satellite image of 2003 – 2004 and also in the topsheet. Now mangroves are found very sparse in satellite image of 2009.

- At the left side of the inlet there is thick deposit of mud layers while right side of inlet there is sandy beach, which is open to sea. This beach was occupied by mud in the recent past, but today we see no trace of mud.

- Mandve beach is an example of protected beach, having crescent shape, due to this wind and waves affects differently. The barrier land towards west side protects beach from direct effects of wind and wave action as well as tidal erosion, so the south west winds cannot affect directly on Mandve beach also the action of swash and backwash cannot affect directly on this protected beach.

- The erosion power of waves depends partly on velocity of winds, as waves derived their energy from wind and partly on the distance of open ocean over which they are blown. The land barrier decreases the velocity of waves; waves bumped on Rewas beach and taking turn at Mandve beach waves go ahead due to which the speed and intensity of waves decrease and deposition of mud took place, while erosion took place at Rewas beach.

- As per localities, the beach is completely covered with ocean water in monsoon season. The sea level increases due to heavy rainfall.

- Mud flat -

  While studying the area near Mandve, mud was observed in thick layers. Mud balls are also found, this may be due to the protected location of the area as it is a bay, while sandy deposition on the Rewas beach may be Ddue to the open sea.

- In short term mudflats may be appear to be accreting but over longer period erosion may be predominating force.

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