A GEOENVIRONMENTAL STUDY OF CREEK AND RIVER ISLANDS IN KUNDALIKA BETWEEN KOPRI AND BAHE IN RAIGAD DISTRICT OF MAHARASHTRA

BY
VILEENA INAMDAR

THESIS SUBMITTED FOR THE DEGREE OF

VIDYAVACHASPATI
(DOCTOR OF PHILOSOPHY)

FACULTY OF MORAL AND SOCIAL SCIENCES

DEPARTMENT OF GEOGRAPHY
TILAK MAHARASHTRA UNIVERSITY,PUNE

UNDER THE GUIDANCE OF

DR.S.N.KARLEKAR

HEAD DEPARTMENT OF GEOGRAPHY
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FEBRUARY, 2010

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* * * * * * * *

CERTIFICATE

This is to certify that the thesis entitled "**A GEOENVIRONMENTAL STUDY OF CREEK AND RIVER ISLANDS IN KUNDALIKA BETWEEN KOPRI AND BAHE IN RAIGAD DISTRICT OF MAHARASHTRA**", which is being submitted herewith for the award of the Degree of Vidyavachaspati (Ph.D) in the Department of Geography of Tilak Maharashtra University, Pune, is the result of original research work completed by **Ms.Vileena Inamdar** under my supervision and guidance. To the best of my knowledge and belief the work incorporated in this thesis has not formed the basis for the award of any degree or similar title of this or any other University or examining body.

S.N.Karlekar
(Research Guide)

DECLARATION

I hereby declare that the thesis entitled "**A GEOENVIRONMENTAL STUDY OF CREEK AND RIVER ISLANDS IN KUNDALIKA BETWEEN KOPRI AND BAHE IN RAIGAD DISTRICT OF MAHARASHTRA**" completed and written by me has not previously formed the basis for the award of any degree or other similar title of this or any other University or examining body.

Place: Pune

Date:

(V.S.Inamdar)

Research Student

ABSTRACT

Chapter 1 of introduction throws light on characteristics of tidal sector in general. Ridges of detrital sediments, sand bars and sand lenses are an important geomorphic feature of modern tidal sectors of Konkan Rivers. Reduction in size, change in shape, linear growth in upstream and downstream direction are the salient features of these forms. The accumulation forms, which are not stable, are swept away by strong waves in monsoons. They are essentially sand bars in creeks. The islands are relatively stable and covered by vegetation, especially mangroves.

The shallowness of the intertidal areas in these estuaries allows the growth of swamps and marshes on sand islands and margins of tidal flats. The lower reaches of rivers, especially the tidal sectors of Konkan rivers show many islands, sand bars and sand lenses. The islands in the tidal sector of the rivers are submerged partially or fully in every high tide depending on their height above tidal level and are exposed during low tide. They are the breeding grounds of many tidal water organisms. The mangroves are the common plants which grow plentifully in the creek on substratum comprised of silt and clay. They are also the home to many shorebirds.

Chapter 2 provides a physical background of the study area and aims, objectives and method of this research work. Kundalika is a major river in konkan region of Maharashtra. River originates in Western Ghats at an altitude of 820 m. ASL near Hirdewadi and meets the Arabian Sea near Revdanda in Raigad District of Maharashtra. The study area is a tidal lower stretch of river Kundalika between Kopri in the west and Bahe to the East. The total length of the river is 67.9 km of which the lower 30 km. stretch from river mouth near Revdanda up to Roha is a tidal stretch.

Study area is a tidal stretch of river Kundalika up to Roha is a 26.5 km; stretch characterized by about 17 islands of varying sizes and

shapes. They are comprised by mud, sand and silt. Satellite view of the area clearly shows the orientation of tidal stretch and terrain around creek.

First 13 islands in the tidal inlet from Kopri to Roha are tidal islands. They are marshy, stable and are partially submerged at the time of high tide. At the time of low tide they get exposed and can be seen well above water level. These islands show mangroves and other species, which can thrive in brackish water.

The study of creek and river islands in Kundalika mainly aims at the geoenvironmental study and appraisal of these sandy clayey islands. It was necessary to study their morphology and sedimentology along with the vegetation cover, to understand the geoenvironment. Since these islands are mainly developed in tidal sector of the river, the salinity variation changes in silt and suspended sediments, tidal current velocity were also ascertained. The rate of sedimentation was computed.

The research work undertaken was based on primary data obtained from field survey. Sediment samples here collected from various islands, vegetation species found on these islands were then identified for finding out the association between the terrain and substratum on they found. Locational references were collected by GPS and satellite imagery in the digital format from www.google earth.com for 2007 and 2008 and survey of India topographical maps 47 F/6 at 1:50000 scale of the year 1927 and 1967 were used. Methodology statement is provided in the tabular format.

Chapter 3 studies the morphological characteristics of the islands in Kundalika. The islands in Kundalika are widely spread in the creek from Kopri in the west up to Bahe in the east. They occur in varying sizes and shapes. There are in all 17 islands all along this stretch. The first 13 islands are purely tidal islands and remaining 4 islands are river Channel islands. They are found in 34 km (33.75 km) long stretch of Creek and River, from the river mouth. Very First island in the tidal sector of Kundalika is 8.5 km. inside the creek from its mouth near Revdanda Bridge. It is an elongated lens shaped island comprising of thick mud deposits. Mud on this island is so thick and sticky that one cannot walk on it easily. It is covered by dense mangroves it is designated by letter ‘A’ in this study and no samples could be collected from its surface.

The channel under study is divided into three sectors as lower, middle and upper, for convenience. The lower sector is dominated by tides and experiences maximum period of tidal inundation. This period slowly goes on decreasing in the upstream direction, where the influence of daily tides decreases. The sector above 25 km is called the upper sector.

All these islands are basically very low in height. The height of any island hardly exceeds 4 m ASL.The elevation range of most of these islands is between 1 to 4 meters only. The heights at various locations on each island were obtained from goggle images and are recorded as place marks.

The scatter of elevation values shown for every island gives a good idea about the relative heights in various parts of the island. To know the pattern and variation in relief digital elevation models in x, y, z domain were prepared for first 13 islands including Mud Island using Surfer software. The DEM with exaggerated scale gives better idea about the island relief.

The lower creek islands in middle sector show significant change in areal extent. These islands have grown in size. Upper islands show decrese in area due to erosional processes within the channel.

In lower creek islands, tidal currents bring considerable sediments and help to increase the size of islands, where as in upper islands powerful river currents help to erode the islands. Island ‘A’ 8. 5 km inland and the middle stretch islands 23 to 26 km inland from creek mouth numbered 9, 10, 11 and 12, show remarkable change in their size in last 80 years due to depositional process.

There is a pronounced extension of right margins of islands in the upper sector, which show a downstream shift (seaward). Although extension due to filling is a dominant tendency seen in many islands, it is less pronounced in islands in lower part of the middle sector, which are shifting upstream (landward). Right bank of upper sector islands seems more prone to filling than the left bank. Cutting and extension tendencies are relatively more balanced in middle islands especially island 3,4,5,6 and 9.Maximum extension by 880 m in case of island 11 in last 80 years indicates an extension rate of around 11 meters per year towards northern bank of the creek.

Chapter 4 deals with the sediment characteristics of the creek and Channel islands. The sedimentary characteristics of the Kundalika creek were studied during the year 2007-2009.

In the creek mouth the sediments settle more slowly in turbulent water where seawater mixes with river water. But away from the creek mouth in upward direction in calm water settling rate increases, as it is the ideal condition for deposition. Salinity, velocity of water, silt content and suspended sediment matter are the main properties of creek water. Water samples collected at fixed distances from the creek mouth were analyzed to know the salinity, silt content and suspended material.

At high tide salinity remains constant in the inner zone. It increases slightly up to 15 km in sediment sink (middle sector) and after this it rapidly decreases at the limit of tidal incursion. A stretch 15 km upstream from creek mouth seems to be more critical in the sedimentology of islands.

At high tide silt content slowly increases up to 15 km distance, then it drops and again rises up to the margin of outer zone. The amount of suspended matter slowly increases and attains a peak at 15 km from mouth of the creek and thereafter decreases slowly up to the margin of the outer zone. The rate of sedimentation is highest between 12 to 15 km from mouth of the creek.

Sedimentation in the creek is governed by the velocity of tidal currents. Tidal velocity measurements at fixed intervals in high tide as well as low tide shows that the tidal current velocities are high inside the creek mouth at high tide as well as low tide also and at low tide upstream areas are characterized by lower values of velocity, ultimately shows stagnation of water in the creek.

An attempt is made in this work to determine the depositional environment of each island on the basis of the analysis of sediments collected from these islands. To achieve this sediment distribution profiles /graphical presentation of coarse sand, fine sand and clay were prepared for all the creek islands.

Further island types are recognized on the basis of average amount of sediments constituting these islands. The general patterns in preferred location of fine sand, coarse sand and clay were also identified. These sediments get deposited in areas of islands according to change in energy level and morphology of islands.

Sediment properties such as mean grain size, std. deviation, skewness is also calculated for all the samples. The amount of coarse sand rapidly decreases from inner zone boundary islands to middle area of the sink zone. Hereafter it increases again.Fine sand decreses till 19 km distance and then increases slowly. Clay increases up to a distance of 20 km inland.

The sorting of sediments in grouped islands shows that coarse sand is less consistently distributed on group ‘B’ islands and well distributed on group ‘D’ islands. Clay distribution is poor on ‘D’ group islands there by suggesting the irregular deposition of clay.

The negative skewness suggests the inability of tidal currents to move the coarser grains from specific locations. The island groups in the creek show specific tendencies in the depositional environment. The distributional patterns in coarse and fine sand and clay give sediment settling tendencies on these islands.

Chapter 5 gives details about the vegetation pattern found on all islands. A variety of plants are found on the islands in study area but mangroves are one of the most frequent forms of vegetation occur in inter tidal zones along Kundalika River up to Roha. Identification of the dominant species and other species found in Lower, Middle and upper sector have strong association with terrain and substratum where they grow. Terrain and substratum are the determinants in the type and density of vegetation on the islands in the study area.

Chapter 6 is a summery of the whole study and includes the concluding remarks. Some of the major findings are as follows.The creek and river islands have started showing tendencies of shifting within inlets since last decade or so. Reduction in size, change in shape, elongated growth in upstream or downstream direction are some of the features of change.

The lower sector of the channel is dominated by tides and has maximum period of tidal inundation, where as the influence of daily tides decreses in upper sector of the channel.

The islands especially in the lower and middle sector have moved upstream, where as islands in the upper sector have moved in the downward direction towards the mouth of the creek.

The creek islands in the area show tendency of cutting and growth especially along their cross sectional axis. There is a pronounce extension of right margins of islands in the upper sector, which show a downstream shift. Although extension due to filling is a dominant tendency seen in all islands, it is less pronounced in lower sector, which are shifting upstream.

Cutting and extension tendencies are relatively more balanced in middle sector. Middle sector islands show totally different pattern of sedimentation, morphology and vegetation growth. Terrain and substratum are the determinants in the type and density of vegetation on the islands in the study area. Channel bank shows thick mud deposits at a few places but the islands within the channel are sandy. Winnowing of finer sand and clay particles by tidal currents and preferred locations for the deposition of various size particles are also decided by tidal currents.

Landward and seaward shift of islands may be attributed to fluctuations in sea level The islands in Kundalika creek preserve many bio and geo indicators of environment and need more detailed investigation to understand Holocene sea levels.

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CHAPTER 1

INTRODUCTION

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Islands in the tidal creeks and river channels are unique aquatic ecosystems. Their geoenvironment is peculiar to their location in the tidal channel and non-tidal stretch of the river. The factors," distance from main land" and "size" suggested in the theory of Island biogeography by *Arthur and Wilson 1967* is also significant in the river islands. The distance from both the banks of the river, their size, tidal velocities, tidal current pattern, quantum of sediment in the tidal water, tidal range, limit of tidal incursion are the factors that influence the geoenvironment of creek islands. The non-tidal river islands are mainly influenced by nature of fluvial process, river discharge,suspended load and flood tendencies. The geoenvironmental study of any area or feature normally includes the identification of major land facets in the area e.g. relief, slope, soils, sediment composition, regolith, weathering and biotic aspects, mainly vegetation, associated with it (*Dhavalikar, 2001).* The geoenvironmental study of creek and river islands is also focused on terrain levels, slopes, type of substratum, vegetated areas and other land use types.

Aquatic ecosystems are classified on the basis of salinity (*Miller,2004)*. They are fresh water (rivers), brackish water (Mid Creek Islands) and salt water (Islands in mouth of estuaries and creeks). Biogeoenvironmental study of such islands gives more emphasis on the floral composition, sediments and morphology. A geoenvironmental study pertains only to morphological, geological and sedimentological aspects of these islands.

An estuary or tidal creek of a river essentially has salt water, brackish water and fresh water zones with an increasing distance from the mouth of an estuary. Estuary is a high productive area in the coastal zone.

It is a partially enclosed, funnel shaped area of coastal water, where seawater mixes with fresh water and nutrients from rivers and runoff from land enriches the area. The coastal wetlands associated with estuary are creek and estuarine islands, covered with mangrove swamps or other halophytic (salt tolerant) varieties of plants (*Miller, 2004)*

The length up to which the tidal water penetrates in the estuary or creek is the inter tidal zone. This zone or river stretch experiences daily incursion and excursion of sea water.

Lower reaches of rivers on konkan coast of Maharashtra are submerged and exposed daily due to semidiurnal tidal cycle (*Karlekar, 1993*). The length of tidal ingress varies from north to south due to changing tidal range and coastal configuration.

The estuaries and creeks on konkan coast show a distinct tidal and fresh water regime (*Karlekar, 1996).* The tidal inlets to the south of 18 degree north parallel are generally wave dominated. Estuaries to the north of 18 degree parallel have a strong tidal control.

Many of the Konkan estuaries show a structural control in their tidal sectors and have a NW-SE orientation. The major sedimentary environments developed in these creeks are high and low tide flats, sand bars, sand islands and mangrove swamps *(Keskar et al, 1993).* The islands and bars are produced by specific hydrodynamic conditions like wave and tide action, flow velocities, turbulence, mixing and scouring. The mid estuarine areas in konkan are invariably the areas of sand bars and islands (*Karlekar, 1996).*

The depth of these tidal inlets varies from more than 4 meters near the entrance to about 1 meter near its head. Fresh water flow in monsoon is one of the fundamental control on the salinity structure of these estuaries. During monsoon due to high fresh water flow all traces of seawater in creeks are flushed out. In post monsoon the salt wedge is re-established rapidly. In monsoon, some amount of salinity stratification remains in the lower column of creek water.

Several areas of salinity and sediment concentration exist in most of the konkan estuaries. The deeper areas in creeks and estuaries act as sediment traps. A large amount of sediment settles on the mud flats and other areas outside the main tidal channel. The overall character of suspended sediment changes along the length of estuary.

The shallowness of the intertidal areas in these estuaries allows the growth of swamps and marshes on sand islands and margins of tidal flats. The lower reaches of rivers, especially the tidal sectors of Konkan rivers show many islands, sand bars and sand lenses. The islands in the tidal sector of the rivers are submerged partially or fully in every high tide depending on their height above tidal level and are exposed during low tide. They are the breeding grounds of many tidal water organisms. The mangroves are the common plants which grow plentifully in the creek on substratum comprised of silt and clay. *(Davies 1977,Pethic 1984*). They are also the home to many shorebirds.

A few konkan rivers such as Vashishthi, Terekhol, Savitri, Kajali show small to moderate size islands in their tidal sector. These islands in konkan creeks comprise of sand, silt and clay. Few are rock islands that are covered with sand and silt material.

Most of the sand islands are detrital accumulation forms. They occupy lower sectors of the tidal creeks whereas rock islands in general are seen in the upper sectors of the tidal creeks.

The availability of sediment and fluctuations in sea level exert a strong control on the morphology and sedimentology of creek islands (*Karlekar, 1997)*. As sea level rises there is an overall change in the tidal structure *(Carter, 1989).* If there is an infilling and redistribution of sediments, tidal friction increases due to shallowing of the creek. Such changes have long-term effects on the vegetation of islands and their overall morphology. (*Karlekar, 1997),* has identified a distinct erosional trend along mudflats of Shrivardhan Bay. Here Silt clay accumulation forms show a distinct landward shift. Reduction in fresh water and sediment supply and redistribution of available sediment are the major trends observed in konkan creeks in last decade or so.

Ridges of detrital sediments, sand bars and sand lenses are an important geomorphic feature of modern tidal sectors of konkan rivers (*Karlekar, 2009).* Reduction in size, change in shape, linear growth in upstream and downstream direction are the salient features of these forms. The accumulation forms, which are not stable, are swept away by strong waves in monsoons. They are essentially sand bars in creeks. The islands are relatively stable and covered by vegetation, especially mangroves. Their vertical growth by accretion however hinders the inland navigation through creeks. Sand islands in Terekhol River are studied in detail by (*Roy, 2008).* Her observations suggest that the bars and islands near Terekhol creek mouth are made up of medium to coarse sand.

Dense mangroves are found on the islands where recent sand is deposited in Terekhol creek. Bars well inside the creek comprise of fine sand deposits. She also observes that the old islands act as nucleus for recent accretion of sand.

Detrital material giving rise to sand islands, bars and ridges is largely drawn from immediate terrigeneous sources. In many cases it is a coarse grained sand with good sorting. Tidal currents can induce poor grading. The material becomes fined grained away from the source. In konkan, at majority of places these islands and bars are reduced in size or totally swept away in monsoon (*Karlekar, 2009).* They have started showing tendencies of shifting within inlets since last decade or so. Reduction in size, change in shape, elongated growth in upstream or downstream direction are some of the features of this change. Now a days these changes can be easily detected on IRS images of tidal inlets.

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CHAPTER 2

STUDY AREA AND METHODOLOGY

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Kundalika is a major river in konkan region of Maharashtra. River originates in Western Ghats at an altitude of 820 m ASL near Hirdewadi and meets the Arabian Sea near Revdanda in Raigad District of Maharashtra. (Maharashtra water and irrigation report 1999). The study area is a tidal lower stretch of river Kundalika between Kopri in the west and Bahe to the East .The total length of the river is 67.9 km of which the lower 30 km stretch from river mouth near Revdanda up to Roha is a tidal stretch.

Study area is a tidal stretch of river Kundalika up to Roha. It is a 26.5 kms stretch characterized by about 17 islands of varying sizes and shapes. They are comprised by mud, sand and silt. Satellite view of the area clearly shows the orientation of tidal stretch and terrain around creek (**Fig. 2.1**)

First 13 islands in the tidal inlet from Kopri to Roha are tidal islands. They are marshy, stable and are partially submerged at the time of high tide. At the time of low tide they get exposed and can be seen well above water level. These islands show mangroves and other species, which can thrive in brackish water. They include Avicennia Alba, Rhizophora, Thespesia and some plants of Acanthus family. Other 4 islands between Roha and Bahe are rock islands. They are bordered and covered by river alluvium, coarse sand and silt. They show sparse vegetation growth that can withstand fresh water. They include spider lily (Crynum Oliganthum), Saccharrum, Vitex Negundo etc.

The latitudinal extent of the study sector is $18^{0}27'$ to $18^{0}29'$ north and longitudinal extent is $72^{0}43'$ to $73^{0}10'$ east. The creek enjoys mix - semidiurnal tidal environment **(Table 2.1)**

KUNDALIKA CREEK AND ITS LOCATION IN RAIGAD DISTRICT

Fig 2.1

PHOTO PLATE: 1 VIEW OF KUNDALIKA CREEK FROM REVDANDA BRIDGE

PHOTO PLATE : 2 UPPER LIMIT OF TIDAL WATER NEAR ROHA

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Table 2.1 Basic data for Kundalika Creek

1	Creek length	30 km
2	Tidal range	Spring 2.5 m, neap 1.8 m
3	Tidal current velocity	(A). 70 to 80 cm /s, 10 km inland (B). 30 to 40 cm/s, 25 km inland
4	Wave height near creek mouth	(A). 3.5 to 4 m, In monsoon (B). 1 to 2 m, In fair weather
5	Limit of Tidal incursion	30 km
6	Average Salinity	32 to 34 o/oo (Per Thousand ml)
7	Tides	Mixed -semi diurnal

Study area is a tropical monsoon land. It displays significant regional variations in climatic conditions mainly in the amount and intensity of rainfall and the duration of the rainy season.

April and May are the hottest months where mean maximum temperatures rise above 35^0C. (Maximum temperature was recorded during summer in Roha 44.70^0C). December and January are the coldest months, with temperature of 16^0 to 20^0C. The range of temperature on the coast is low. The daily range of temperature on the coast in study area is around 10^0C, as compared to 13^0 to 15^0 C in plateau areas. The monthly temperatures in January, on an average are 5^0 to 8^0 C higher on the coast as compared to plateau. Average temperature observed in the study area is 23.0 ^{0}C.

The three seasons can be identified according to variation of rainfall and temperature. They are Summer (March to May), monsoon (June to September) and Winter (December to February). October and November are the months of retreating monsoon. Greater contrasts are observed in the distribution of rainfall than the temperature. The region receives an average annual of rainfall 3750 mm.Where Roha receives an average annual of rainfall 3202 mm. (M.W.I report 2009). July is the rainiest month with the largest number of rainy days,97% rainfall occurs due to southwest monsoon during June to September and 3% after September.

West coast receives very little rain from December to March. February is the driest month. On an average the Konkan coast has 80 to100 rainy days in a year. Winters in coastal areas are comparatively drier than the plateaus.

Kundalika River rises at an altitude of 820 m at Hirdewadi in western Ghat, flows westwards and meets Arabian Sea near Revdanda.The river basin is bounded in north by Amba River catchment and in south by Savitri River basin, on east by Western Ghat and on west by Arabian Sea.

The area is a moderately dissected plateau of Deccan trap of Maharashtra, it is observed that the basalt is well exposed in upper reaches of the stream. Source region of Kundalika is characterized by exposed basaltic lava flows. The deccan trap is overlain with alluvium along the bank of Kundalika.Both the banks of Kundalika are characterized by clay deposits in lower reaches. (Maharashtra water and irrigation commission Report, June1999).The thickess of clay deposits varies from 2 to 5 m. The islands in Kundalika in the lower reaches show coarse sand, fine sand and clay in varying amount. whereas upper reaches islands are rocky in nature.

The general appearance of the channel in lower reaches shows meandering tendency. The meanders themselves introduce local channel variation. The width of the channel increases considerably from upper reaches to lower reaches, where it meets the Arabian Sea. The estuaries of Konkan rivers are drowned and the tidal impact is felt as far as 40 km inland. The konkan streams have short courses, they flow east west roughly parallel to each other e.g. Rivers like Amba, Kundalika, Savitri, Vashishthi and Shastri (Dikshit*, 1982).*

River Kundalika is relatively more sinuous and shows 17 islands distributed unevenly along the tidal channel stretch of 30 km from mouth of the creek up to the upper sector of the channel. Lower islands have silt clay and sand substrata whereas upper islands are rock islands. River channel is relatively narrow in the east, its width is being 500 m and wider in the west, width being 1500 m.

Vegetation on the island is a sensitive indicator of environment (*Hickin, 1984).* Same is true for islands in Kundalika. Mangrove varieties are well adapted to the saline environment of lower sector islands of the creek. Middle sector islands show mixed type of vegetation and upper sector islands show fresh water varieties. All the islands show luxuriant and permanent growth of vegetation. Some of the islands, which are close to riverbank, show pollution-affected vegetation at few places.

Aims, Objectives and method of research:

The study of creek and river islands in Kundalika mainly aims at the geoenvironmental study and appraisal of these sandy clayey islands. It was necessary to study their morphology and sedimentology along with the vegetation cover, to understand the geoenvironment. Since these islands are mainly developed in tidal sector of the river, the salinity variation, changes in silt and suspended sediments, tidal current velocity were also ascertained. The rate of sedimentation was computed.

The vegetation in the creek primarily consists of mangroves. It was intended to study the mangrove varieties specific to islands and island groups in the creek. These were identified in the field. The other objective of the work was to find if there is any association between the location of island and its morphology, sedimentology and vegetation. The location of the islands was known from the SOI toposheet of 1927, 1967 and also from the recent Wikimapia satellite image. Their location within the creek with reference to the river mouth was important to understand the variations in morphology, sedimentology and vegetation cover. Sediment samples were collected from islands and sieved mechanically to

PHOTO PLATE:3 VEGETATION ON ISLAND NEAR ARE KHURD

PHOTO PLATE : 4 VEGETATION ON ISLAND NEAR KHARGAON

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PHOTO PLATE : 5

POLLUTION AFFECTED VEGETATION ON ISLAND NEAR KHARGAON

PHOTO PLATE: 6

POLLUTED WATER IN TIDAL SUBCHANNELS

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obtain the grain size distribution. The properties of sediments like mean and Std. deviation were ascertained. The properties of sediment distribution, mainly Skewness was also determined. GIS softwares such as Global mapper and Surfer were used to identify various regions of the islands and to prepare the sediment distribution maps of the islands 1 to 14. Frequent field visits were undertaken to study mangrove species and confirm the trends and patterns recognized after the analysis. A detailed methodology adopted is give in **Table 2.2**

Design of the thesis:

The work is presented in six chapters including introduction. The first chapter is devoted to the general information on tidal creeks having islands in their channel along with related survey of literature. Study area and the method of research employed are discussed at length in chapter two.

Chapter three discusses all the morphological aspects of the islands in the study area i.e. size and shape of the islands, distances of islands from the mouth of the creek, inter distances between the islands, distances from left and right bank of the river etc.

Digital elevation models prepared from the data in x, y, z, domain, obtained from goggle images of islands, are discussed in this chapter.

The fourth chapter discusses upstream variation in sediment percentage and its distribution on islands, on the basis of coarse sand, fine sand and clay. Vegetation on all islands, pollution affected vegetation, healthy vegetation (Luxuriant growth), their types, density, marshy habitat, and fully submerged habitat is explained in chapter five. Association between vegetation and sedimentation is also explained in this chapter. The observations, findings, conclusions and suggestions are provided in final chapter of the thesis.

Table 2.2 Method of Research

Maps / Images	Field study	Laboratory Work
●Toposheet 47F/6 (1927, 1967)	1. Field visits in post monsoon, monsoon and pre monsoon	1. Preparation of Base maps
●Wikimapia Image (2007)	2. Preparation of Geomorphic Map	2. Calculation of size/shape/interdistance between islands
	3. Preparation of vegetation map.	3. Sieving for grain size distribution.
	4.Collection of sediment samples	4.Calculation of mean /std.dev./Skewness /Coefficient of variation.
	5. Determination of velocity	5. Preparation of isoline maps using surfer software
	6. Collection of water samples	6. Mapping of island regions from satellite image using Wikimapia.
	7.Identification of mangrove varieties.	7. Digital elevation models for all creek islands.

CHAPTER 3
CREEK AND RIVER ISLANDS IN KUNDALIKA

CHAPTER 3

CREEK AND RIVER ISLANDS IN KUNDALIKA

Survey of India toposheet No. 47 F/6 of the year 1927, 1967 and wikimapia image of the study area for the year 2007 and 2008 was used to know the location of the islands within the creek. The islands in Kundalika are widely spread in the creek from Kopri in the west up to Bahe in the east. They occur in varying sizes and shapes. There are in all 17 islands all along this stretch. The first 13 islands are purely tidal islands and remaining 4 islands are river Channel islands. They are found in 34 km (33.75 km) long stretch of Creek and River, from the river mouth. (**Fig.3.1)** Very First island in the tidal sector of Kundalika is 8.5 km inside the creek from its mouth near Revdanda Bridge. It is an elongated lens shaped island comprising of thick mud deposits. Mud on this island is so thick and sticky that one cannot walk on it easily. It is covered by dense mangroves it is designated by letter 'A' in this study and no samples could be collected from its surface.

Next to 'A' is Island 1 in the study area. It is seen at a distance of about 14.4 km from the creek mouth and is situated near southern bank of acute bend of the river near Kopri. It is an oval shaped island and is oriented NW-SE, it covers an area of 44000 Sq. m (0.044 Sq. km). **(Table3.1)**

Island 2 close to it, is a very small semicircular island with an area of 0.0108 Sq. km. It is smallest among all islands in the creek. Island 3 and 4 are elongated in shape and are situated in the mid creek and on left bank respectively within the meandering sector. First four islands excluding mud island have maintained a specific location along the southern bank and middle sector of the channel. These four islands are situated in the middle sector of the channel 19 km inland from the mouth of the creek.

ISLANDS IN THE STUDY AREA

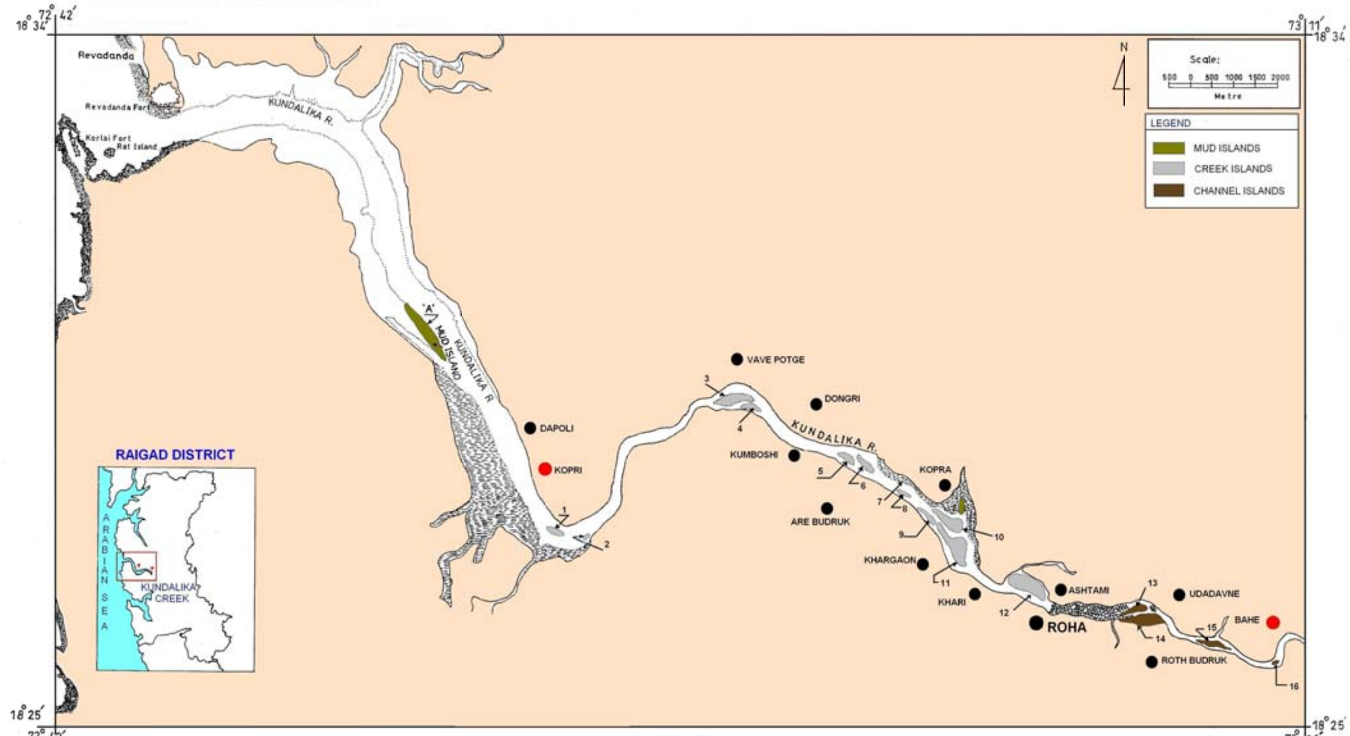


Fig.3.1

The channel under study is divided into three sectors as lower, middle and upper, for convenience. The lower sector is dominated by tides and experiences maximum period of tidal inundation. This period of tidal inundation slowly goes on decreasing in the upstream direction, where the influence of daily tides decreases. The sector beyond 25 km is called the upper sector.

The Sector in between these two ends is conveniently identified as middle sector. Island, 'A' which is a mud island, lies in the lower sector. Island 1 to14 is in the middle sector and remaining is in the upper sector of the channel.

First island and fourth island are similar, area wise, where as second and third have area less than 0.01 and 0.14 sq. km respectively, as per 2007 image.

Island 5 and 6 have elongated shape with their two tapering ends towards upper and lower stretch of the channel in creek. They have very similar sizes. They have an area of 0.064 sq. km and 0.074 sq. km respectively. These two islands are located centrally in a broad meandering section, near Kumboshi.

Island 7 and 8 are not visible on the toposheet of the year 1927, 1967. They can be seen only on the satellite image of 2007.They are small, elongated and inconspicuous islands. Further in the middle sector of the channel the group of three islands i.e. island 9, 10 and 11 and a very small mud island is seen.

Island 9 has elongated shape & has an area of 0.03 sq. km whereas island 10 and 11, centrally located, are slightly larger islands in the channel. They have an area of about 0.279 and 0.272 sq. km respectively.

Island12 is the largest island among all the islands excluding island 'A' in the channel. It is semicircular in shape. The island is situated near Roha. It has an area of about 0.437 sq. km and most of it is cultivated under paddy. It is situated along the northern bank and near

Table 3.1Area of islands and their location in creek (1927 to 2007)

Sr.No.	Island No.	Area on Toposheet in sq. km	Area on Image in sq.km	Distance from mouth of the creek km
1	A	0.275	1.67	8.5
2	1	0.3	0.0441	14.0
3	2	0.005	0.0108	14.5
4	3	0.135	0. 144	18.9
5	4	0.035	0.0477	19.65
6	5	0.0325	0.0648	21.65
7	6	0.0425	0.0747	22.15
8	7	----------	0.006	23.35 (seen on image)
9	8	-----------	0.013	23.35 (seen on image)
10	9	0.0275	0.0315	23.90
11	10	0.0145	0.279	24.30
12	11	0.016	0.2727	24.40
13	12	0.2225	0.4375	26.86
14	13	0.035	0.0261	29.25
15	14	0.1425	0.0873	30.20
16	15	0.045	0.0243	31.00
17	16	0.0125	0.099	33.75
(Island 7 and 8 are not seen on the Toposheet of 1927 and 1967)				

the limit of tidal creek. All the islands in the lower and middle sector have profound tidal impact on their location, size, shape, orientation and the processes like deposition and erosion.

Of the upper part of the middle sector islands, Island 13 and 14 are closely located to each other. Island 13 and 14 has 0.026 sq. km and 0.08 sq. km area respectively. The former is smaller in area than the later. This sequence of size is also maintained for the next group of islands i.e. island 15 and 16. Island 13 and 14 are elongated and fragmented islands. Island 14 has a very narrow tapering end towards upper reach of the channel. Island 15 and 16 are situated far from each other. They are centrally located in the channel.

Island 13, 14, 15 and 16 are river islands beyond the reach of daily tides. These are basically rock islands in the channel.

All these islands are basically very low in height. The height of any island hardly exceeds 4 m ASL.The elevation range of most of these islands is between 1 to 4 meters only. The heights at various locations on each island were obtained from goggle images and are recorded as place marks.

The scatter of elevation values shown for every island gives a good idea about the relative heights in various parts of the island. To know the pattern and variation in relief digital elevation models in x, y, z domain were prepared for first 13 islands including 'Mud Island' using Surfer software. The DEM with exaggerated scale gives better idea about the island relief.

The maps showing elevation scatter **(Fig.3.2 to 3.5) and** DEM **(Fig.3.6 to 3.8)** show that the surface of islands is not flat. It is an irregular surface with heighs and lows scattered everywhere. The surface irregularity is more pronounced in island 1, 3,4,9,10 and 11.Mud Island in the lower sector of the creek shows a smoothly rolling surface. This is due to the mud, which dominates the sediment material on this island.

Island 1 is more craggy and irregular due to frequent change in relative height. Its average height is 2 m ASL.The height slowly decreases in upstream direction. Island 2 shows relatively more height along its side facing left bank. Island 4 and 6 are very low, inconspicuous islands. Island 3 and 4 show many high and low areas. The relief of

ELEVATION LEVELS ON MUD ISLAND

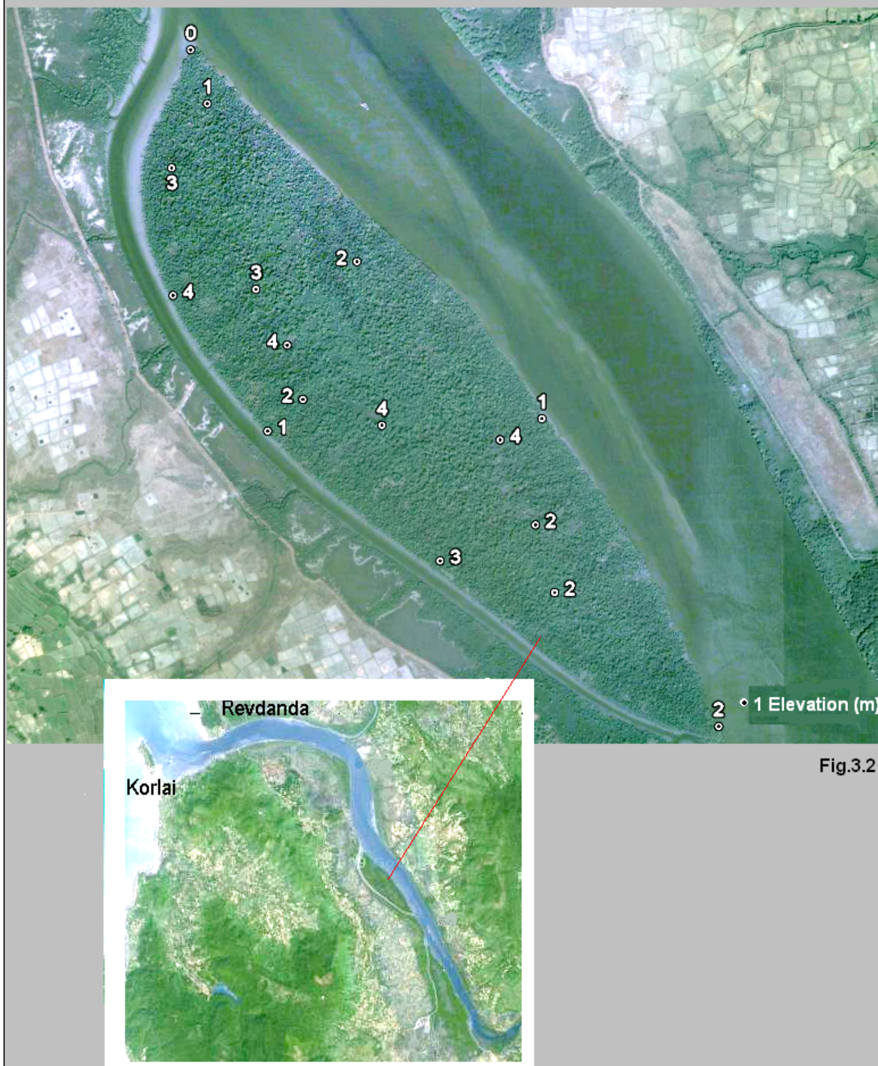
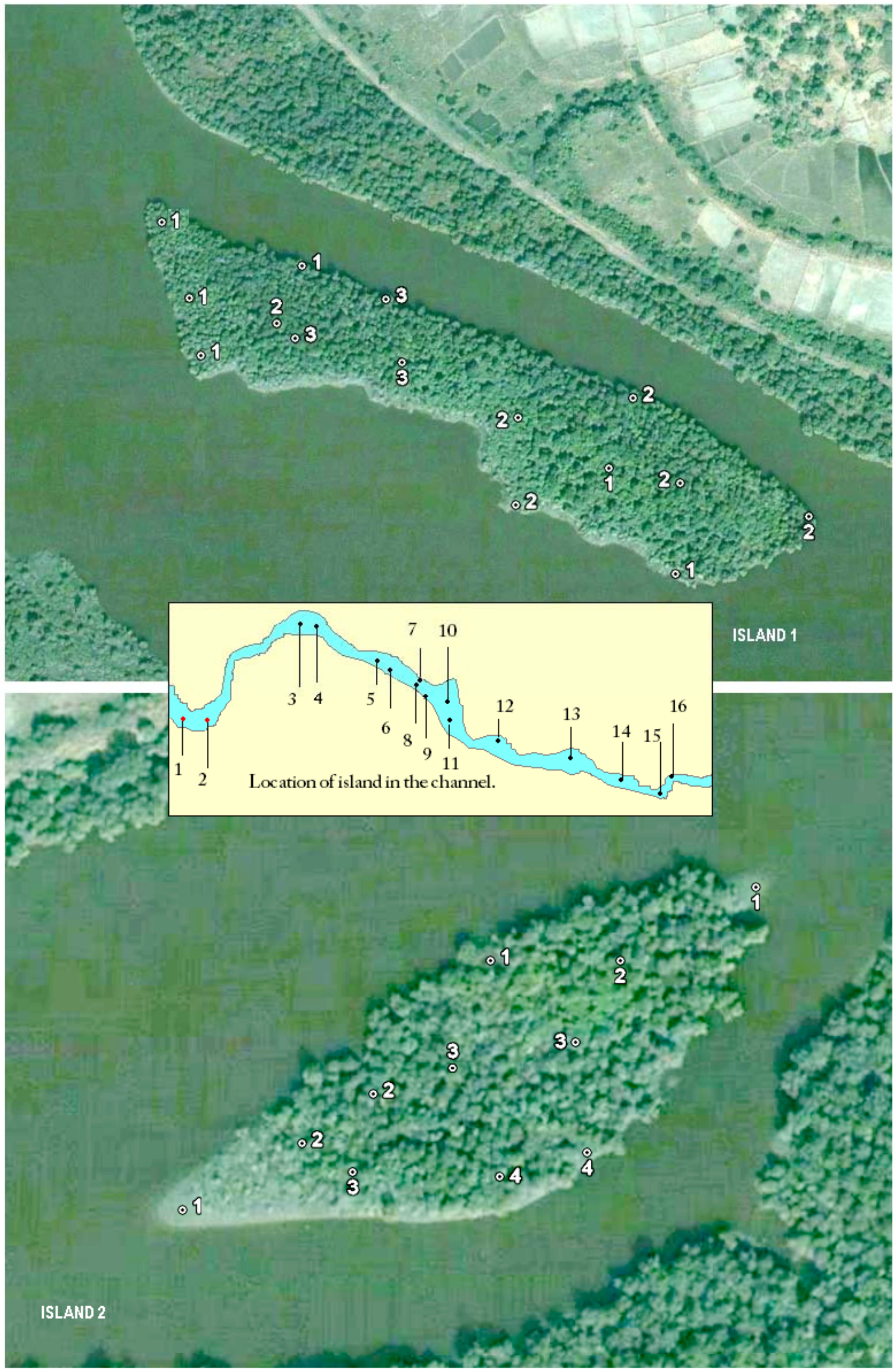


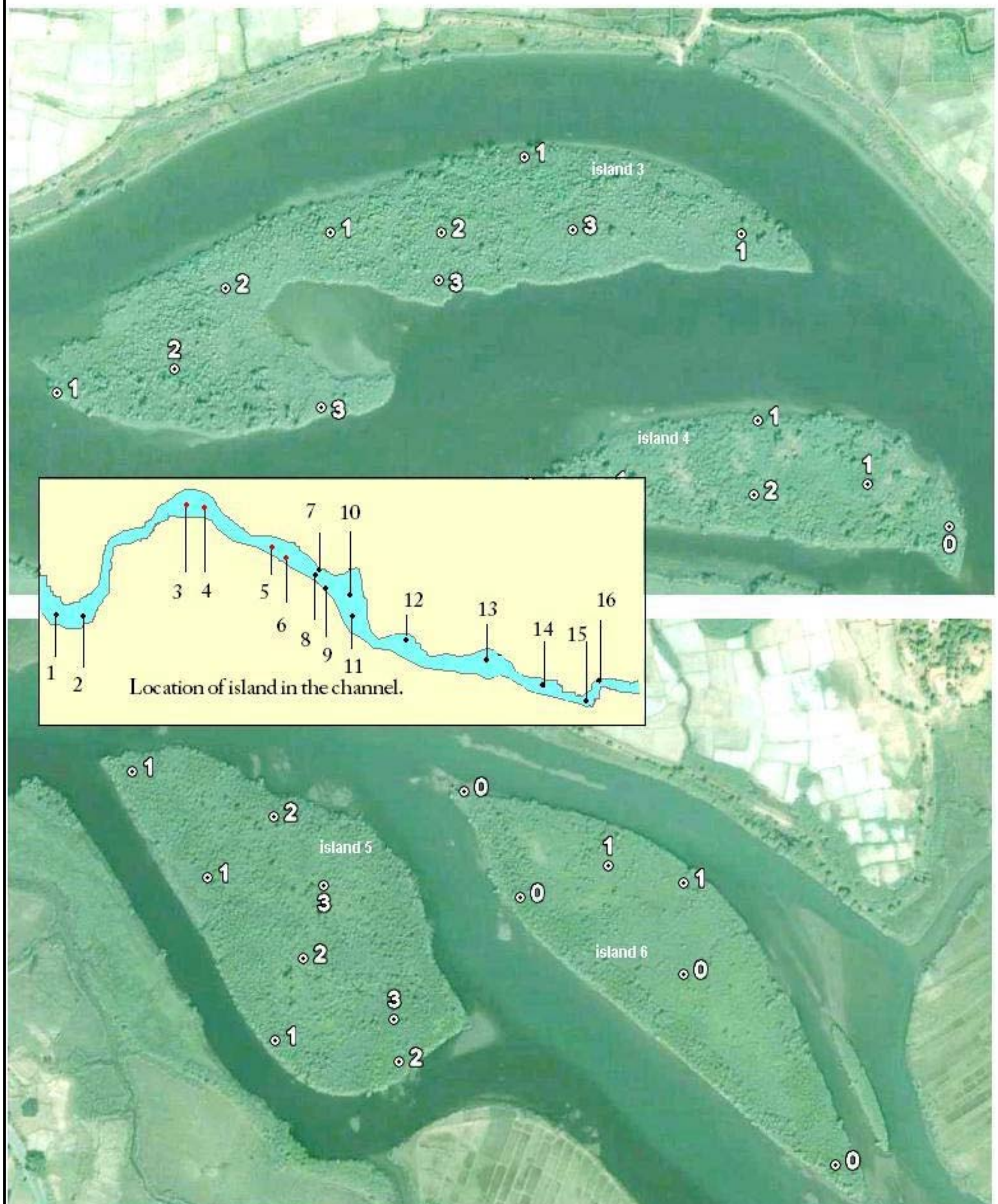
Fig.3.2

43



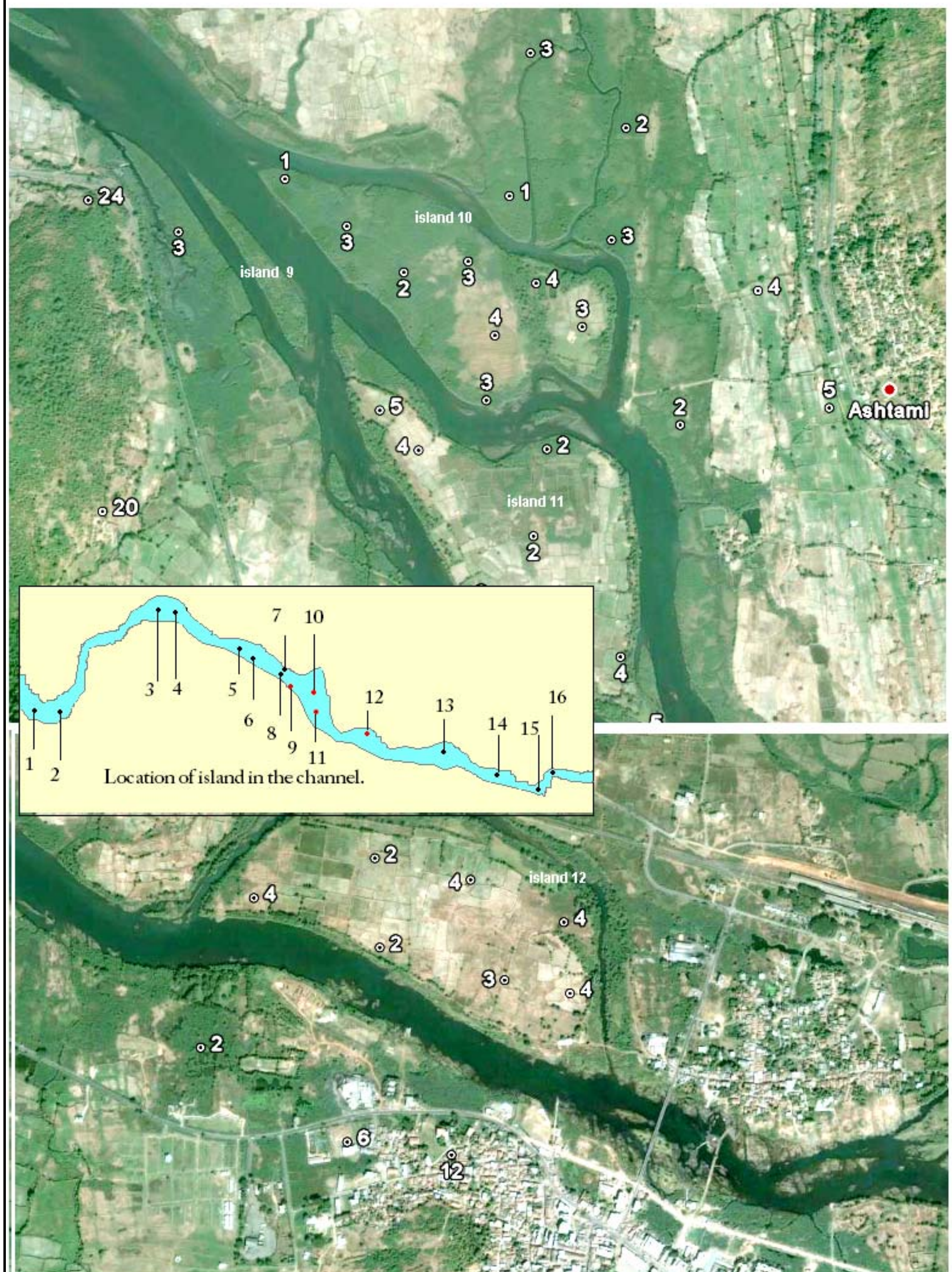
Elevation levels (m) on island 1 and 2

Fig.3.3



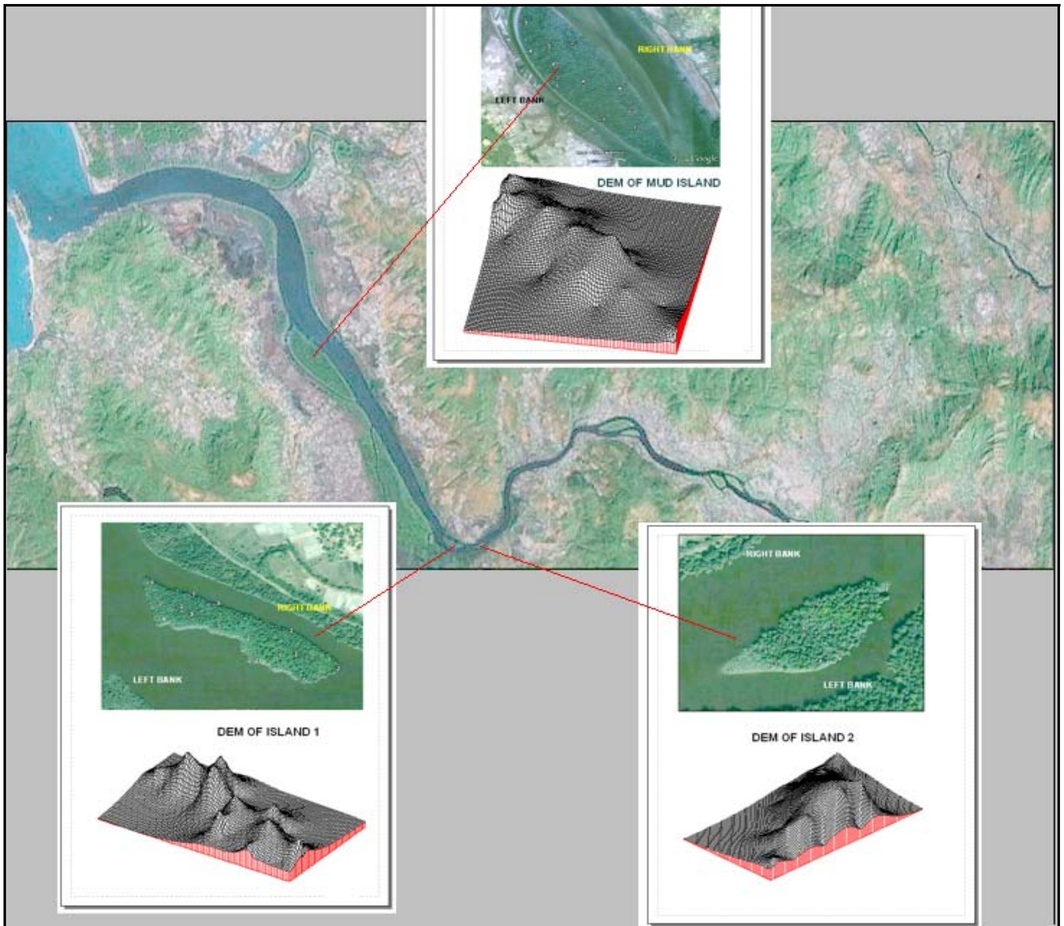
Elevation levels (m) on islands 3 to 6

Fig. 3.4



Elevation levels (m) on islands 9 to 12

Fig. 3.5



DEM OF MUD ISLAND AND ISLAND 1 AND 2 Fig. 3.6

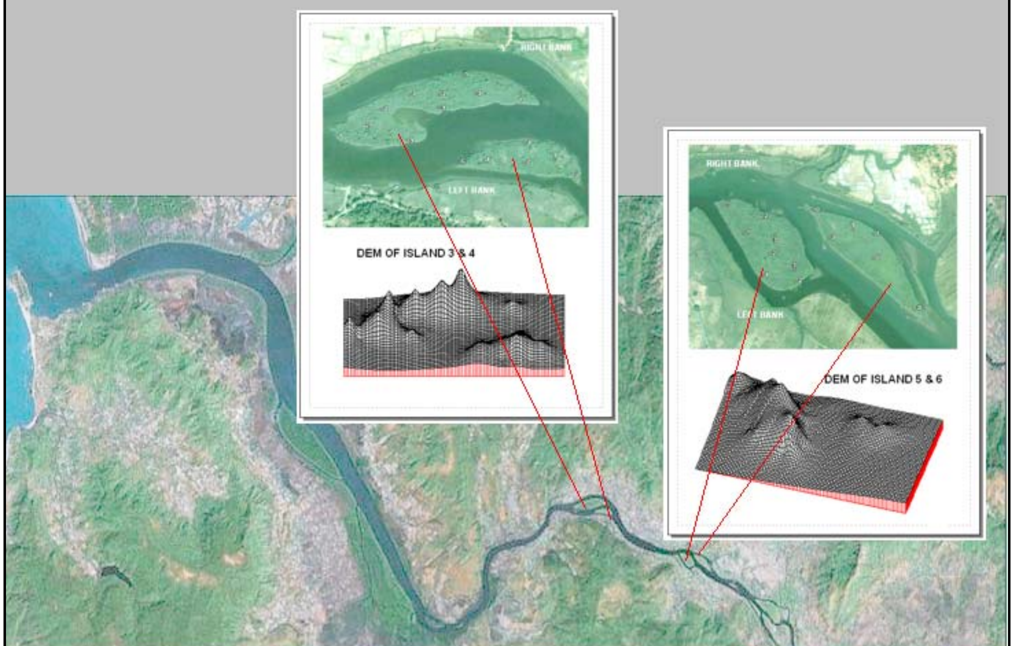


Fig.3.7

DEM OF ISLAND 3 TO 6

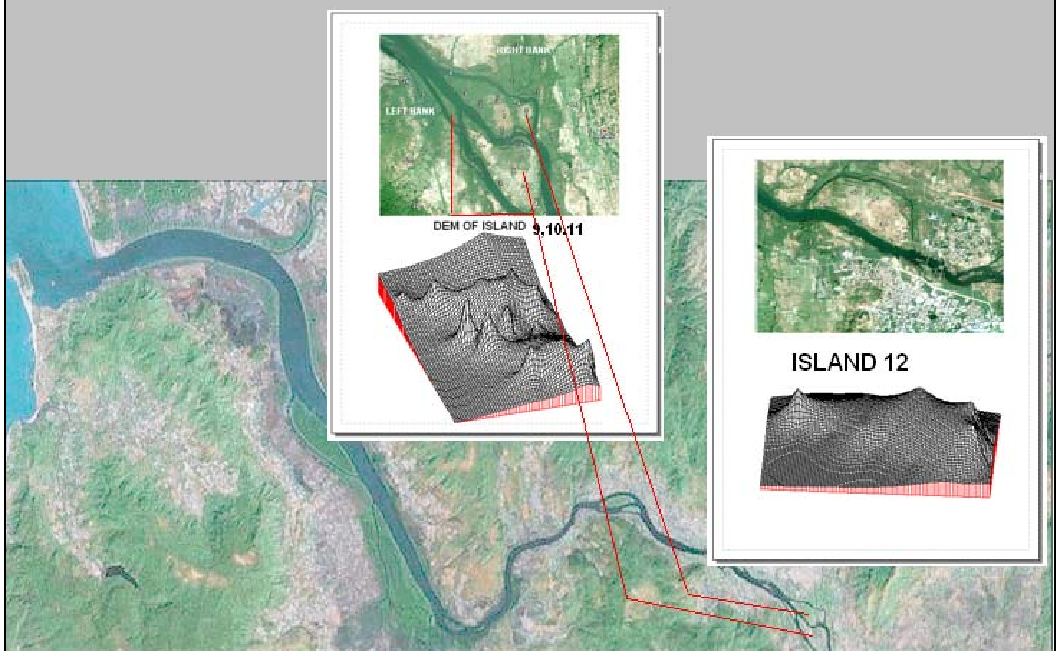


Fig.3.8

DEM OF ISLAND 9 TO 12

Island 9,10 and 11 are different than rest of the islands, although here also average height is around 3 m ASL only. Island 12 is almost flat and its height ranges from 2 m to 4 m. Various views of digital elevation models from different angles when seen by rotating models in Surfer, showed that the island morphology and relief has specific pattern in upstream and downstream direction and not along their edges facing left or right bank. This is obvious as these islands are mainly controlled by tidal incursion and excursion in the creek. The longitudinal component of tidal flow is more influential than the tidal circulation across the channel.

Change in area of islands from (1927-2007)

The change in area is insignificant in lower sector as well as upper sector islands except mud island 'A'shows 1395.0 m increase in its area from 1927 to 2007. **Fig.3.9 and Table 3.2** show change in area of islands from 1927 to 2007. It is quite remarkable in all middle sector islands, especially island 10,11 and 12.Island 3, 14,15 and16 are reduced in size, but the remaining islands have grown in size in last 80 years.

The negative areal change indicates decrease in the area of island and positive change suggests increase in area. Island 13, 14 and 15 lying on the margins of the upper sector i.e. 31.5 km from mouth of the creek show negative change. Remaining islands show positive change. They show increase in the area. The decrese in area ranges from 8.9 sq. m to 55.2 sq.m and increase in area ranges between 4.0 sq. m and 1395 sq.m.

Thus the lower islands in middle sector show significant change in areal extent. These islands have grown in size. Upper islands show decrese in area due to erosional processes within the channel.

In lower creek islands tidal currents bring considerable sediments and help to increase the size of islands, where as in upper islands powerful river currents help to erode the islands. Island 'A' 8.5 km inland and the middle stretch islands 23 to 26 km inland from creek mouth numbered 9, 10, 11 and 12 show remarkable change in their size in last 80 years due to depositional process.

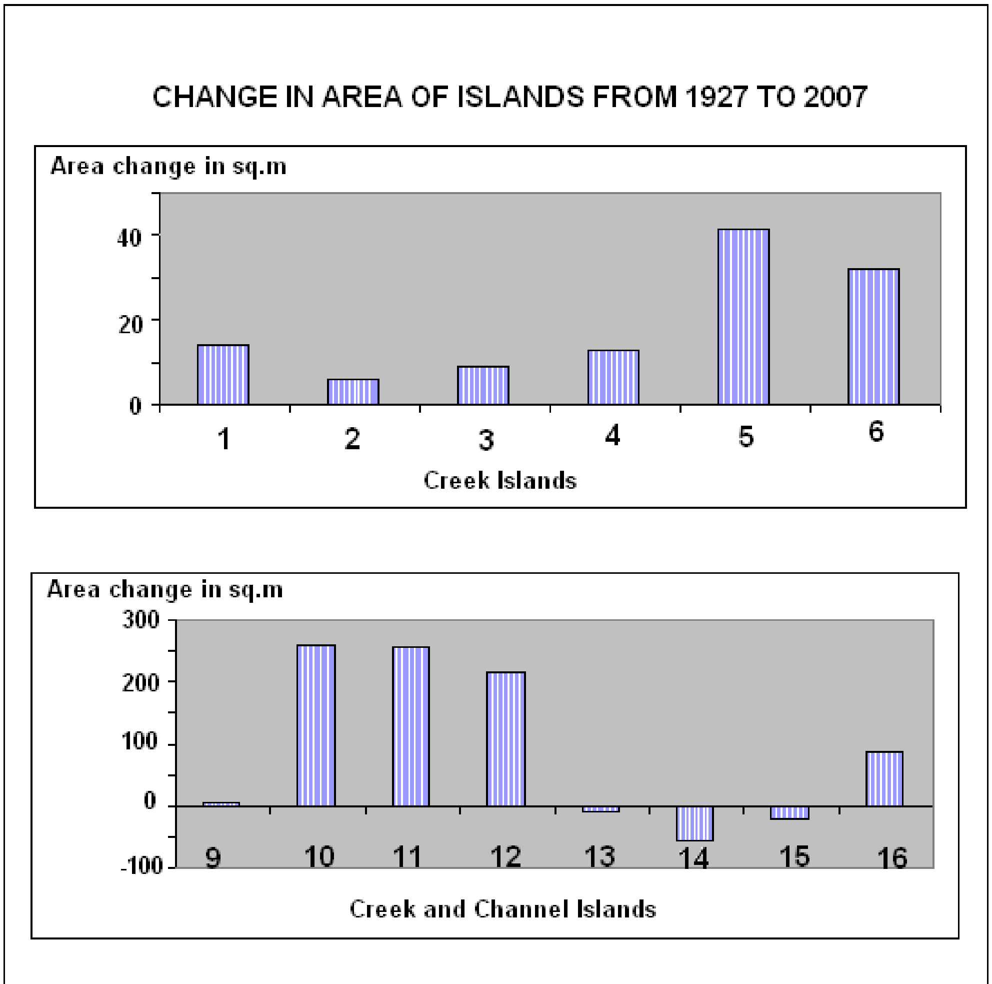

CHANGE IN AREA OF ISLANDS FROM 1927 TO 2007
Area change in sq.m
40
20
0
1
2
3
4
5
6
Creek Islands
Area change in sq.m
300
200
100
0
-100
9
10
11
12
13
14
15
16
Creek and Channel Islands

Fig.3.9

Table3.2 Growth or reduction of islands from 1927 to 2007

Sr.No.	Island No.	Area on Toposheet (Sq. km.)	Area on Image (Sq. km)	Distance from mouth of the creek (km)	Area Change (Sq. m)
	Lower Sector Island				
1	A	0.275	1.67	8.5	1395.0
	Middle sector islands				
2	1	0.03	0.0441	14.0	14.1
3	2	0.005	0.0108	14.5	5.8
4	3	0.135	0. 144	18.9	9.0
5	4	0.035	0.0477	19.65	12.7
6	5	0.0235	0.0648	21.65	41.3
7	6	0.0425	0.0747	22.15	32.2
8	7	-	0.006	23.35	-
9	8	-	0.013	23.35	-
10	9	0.0275	0.0315	23.90	4.0
11	10	0.0145	0.275	24.30	260.5
12	11	0.016	0.2727	24.40	256.7
13	12	0.2225	0.437	26.86	215.0
14	13	0.035	0.0261	29.25	-8.9
15	14	0.1425	0.0873	30.20	-55.2
	Upper Sector islands				
16	15	0.045	0.0243	31.00	-20.7
17	16	0.0125	0.099	33.75	86.5
(Island 7 and 8 are not seen on the Toposheet of 1927 and 1967)					

Terrain around the creek and the location of islands:

The regional cross sections give a good idea about the relative location of all islands with respect to the left and right bank of the channel and terrain around.**Fig.3.10** shows the location of cross profiles for all the islands in river.

Fig.3.10 (A to E) shows the location of terrain cross-sections and location of islands. **Fig 3.10** (A) Shows that the Mud Island is located near left bank, the hinterland of which has the maximum height of 240 meters. The bank to the right is gently sloping and has a height not more than 20 meters.

Island 1 is located slightly nearer to the northern or right bank. Both the banks are gently sloping and comprise of gentle terraces of less than 10 meter in height. **Fig.3.10** (B) shows that the left bank relief is moderate to high in case of island 3 & 4 whereas it is high on the right bank in case of island 12 **Fig.3.10** (D). The right bank relief is generally moderate to low in case of most of the islands. It is very low near island 13, 14, and 16 (Fig.3.10**)** (D and E).

Such variation in channel bank relief usually controls the location of the islands within the channel and the type of dominant sediment constituting the islands.

PHOTO PLATE :7 VIEW OF NORTH BANK TERRAIN FROM KUMBOSHI

PHOTO PLATE : 8 VIEW OF SOUTH BANK FROM ASHTAMI

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LOCATION OF CROSS PROFILES

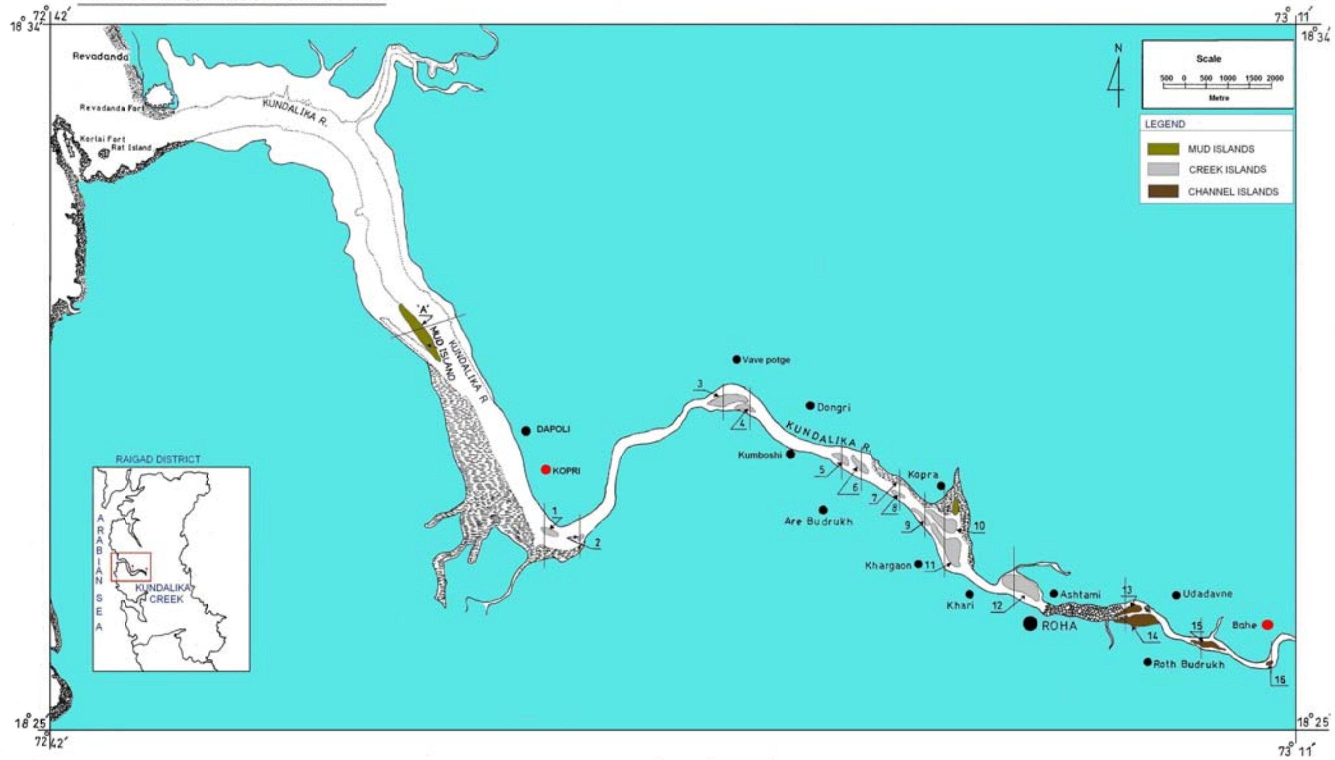


Fig.3.10

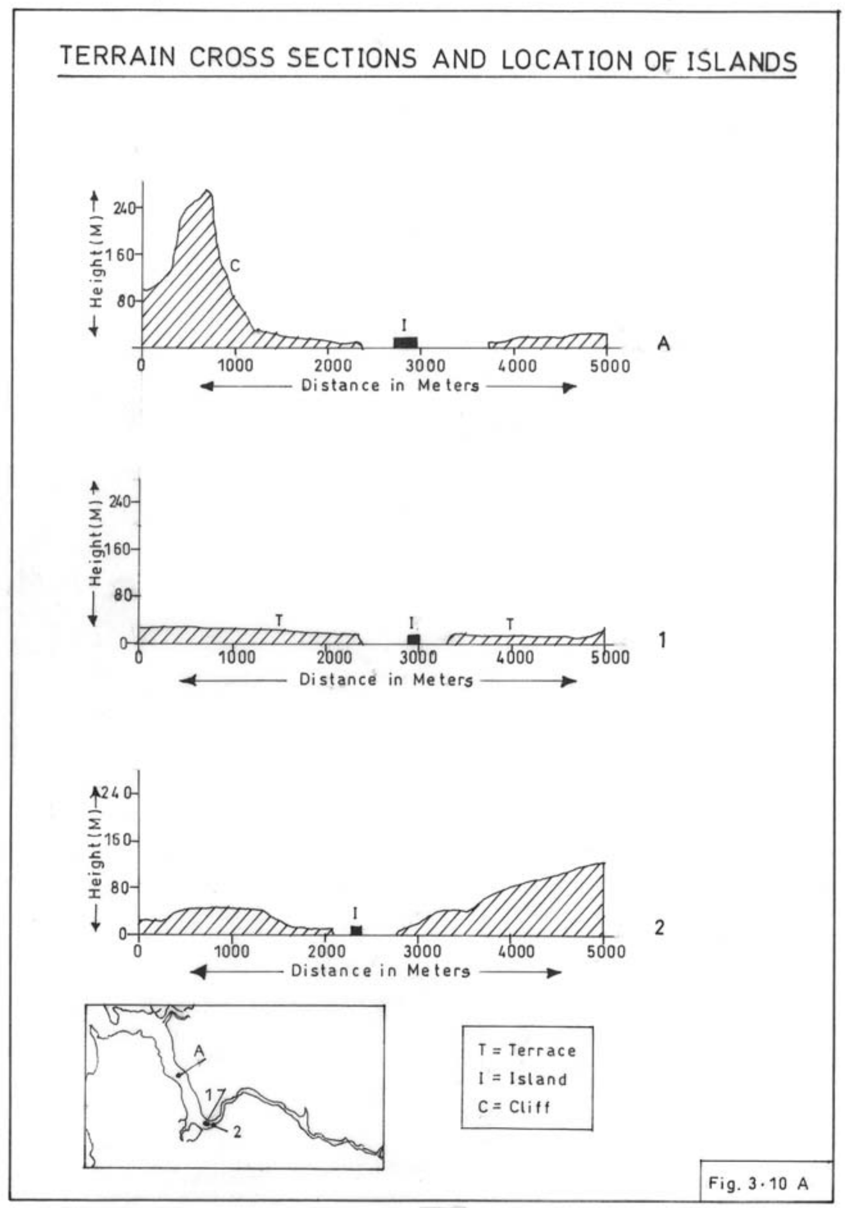
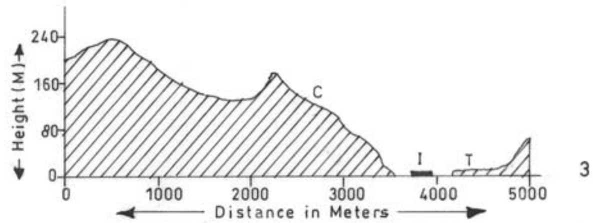
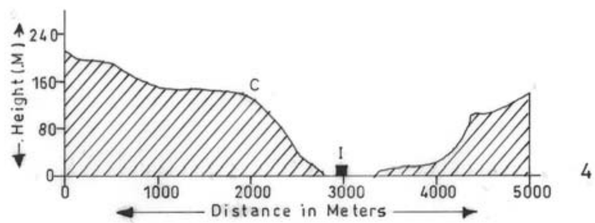
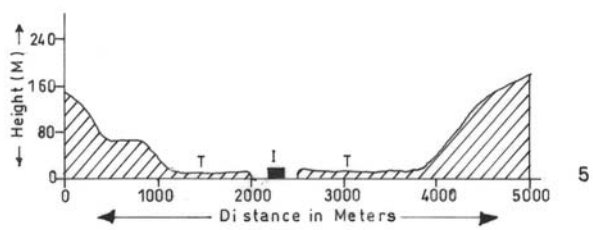

TERRAIN CROSS SECTIONS AND LOCATION OF ISLANDS
Height (M)
240
160
80
C
I
A
0
1000
2000
3000
4000
5000
Distance in Meters
T
1
2
T = Terrace
I = Island
C = Cliff

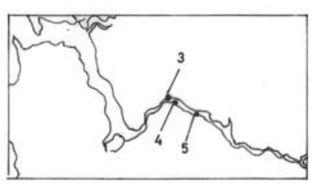
Fig. 3·10 A

TERRAIN CROSS SECTIONS AND LOCATION OF ISLANDS





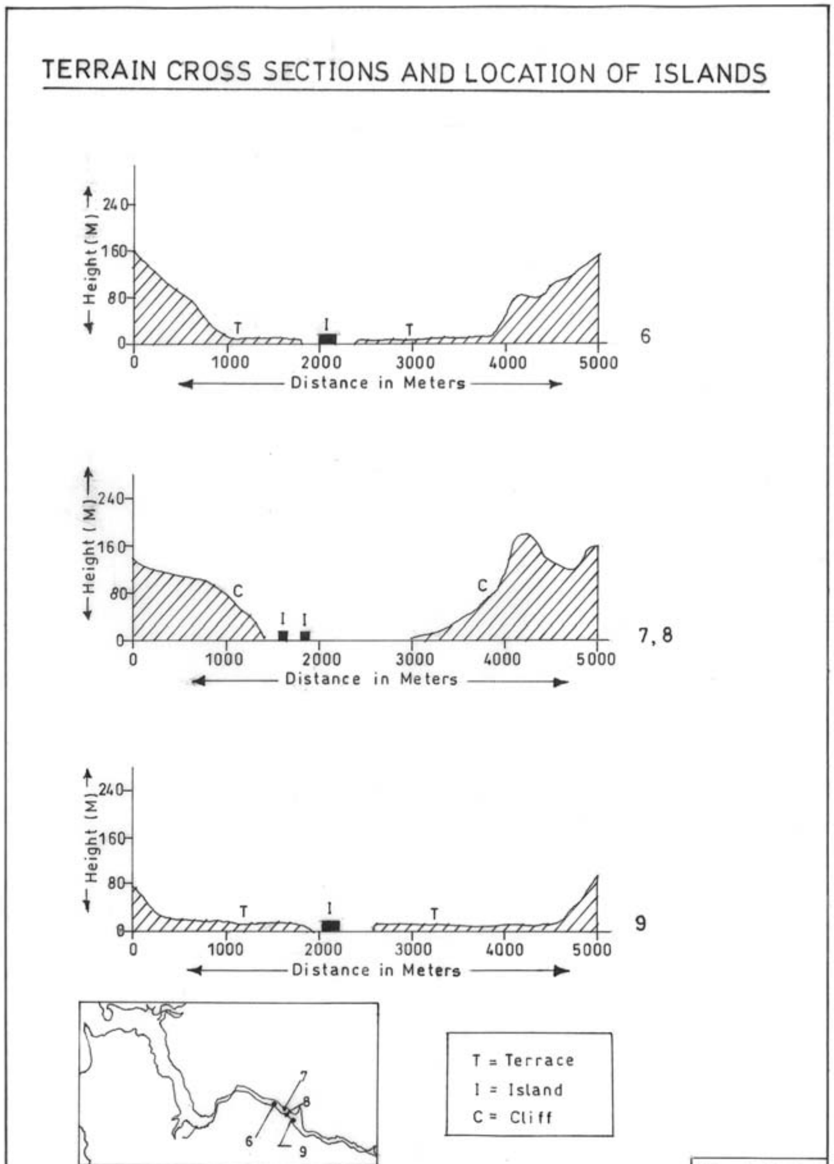


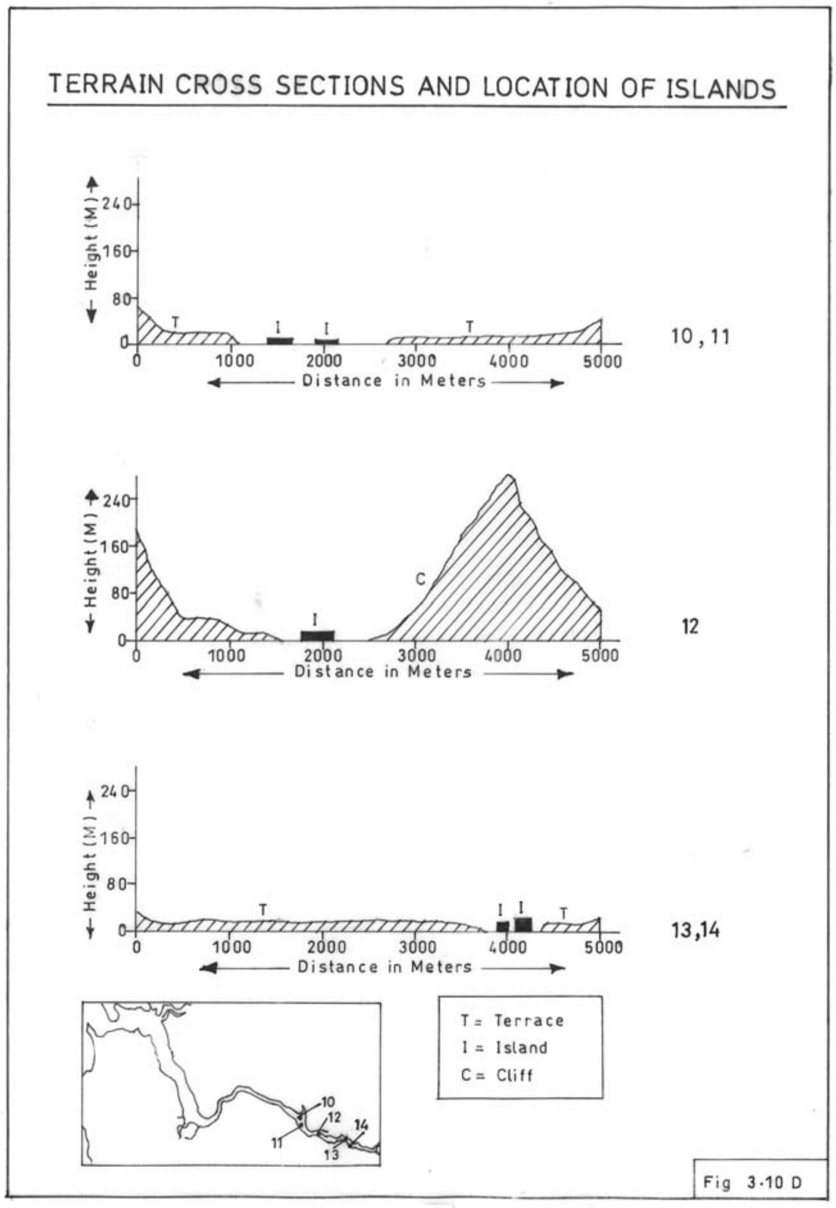


T = Terrace
I = Island
C = Cliff

Fig. 3·10 B

57


TERRAIN CROSS SECTIONS AND LOCATION OF ISLANDS
Height (M)
240
160
80
0
T
I
T
6
0
1000
2000
3000
4000
5000
Distance in Meters
C
I I
C
7, 8
T
I
T
9
7
8
6
9
T = Terrace
I = Island
C = Cliff
Fig. 3·10 C


TERRAIN CROSS SECTIONS AND LOCATION OF ISLANDS
Height (M)
240
160
80
0
T
I
I
T
0
1000
2000
3000
4000
5000
Distance in Meters
10, 11
Height (M)
240
160
80
0
I
C
0
1000
2000
3000
4000
5000
Distance in Meters
12
Height (M)
240
160
80
0
T
I
I
T
0
1000
2000
3000
4000
5000
Distance in Meters
13,14
10
12
14
11
13
T = Terrace
I = Island
C = Cliff
Fig 3·10 D
59

TERRAIN CROSS SECTIONS AND LOCATION OF ISLANDS

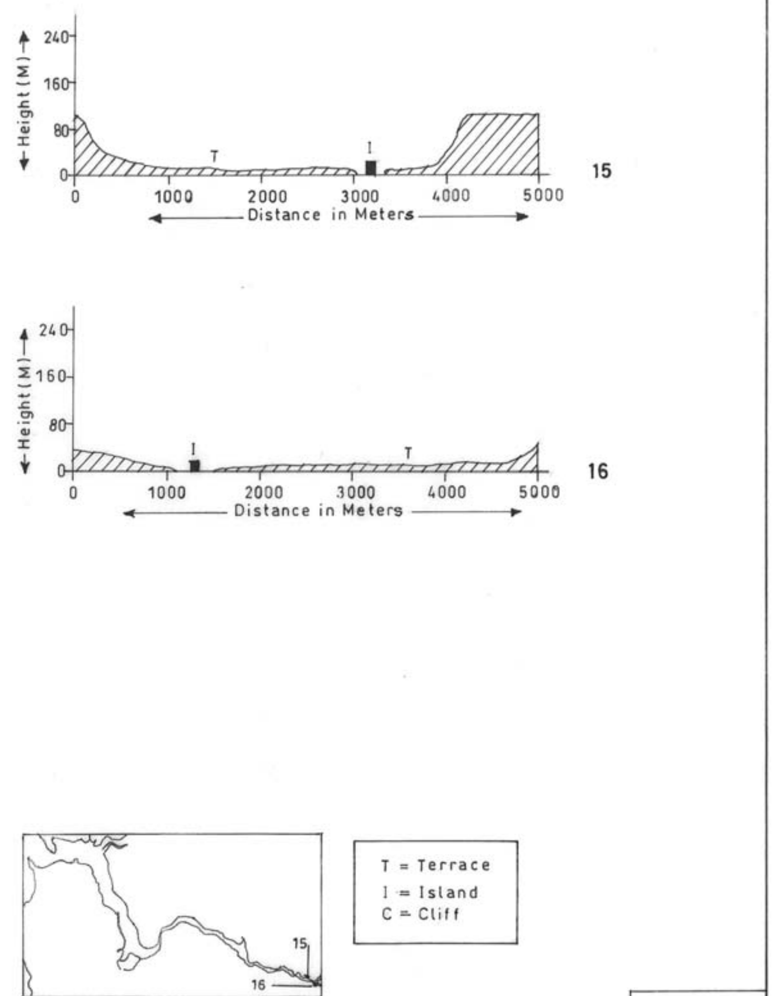


Fig. 3·10 E

60

Upstream or downstream shift of islands from 1927 to 2007:

Survey of India toposheet 47 F/6 of the year 1927, 1967 and Wikimapia image of the study area for the year 2007 was used to know the location of the islands within the creek. The distances at which these islands are located are shown in **Table 3.3.** It clearly shows that the islands are located at varying distances with reference to each other.

Very first island of appreciable size and shape, at a distance of about 14.0 km. from the mouth of the creek has shifted upstream by distance of 161 meter since 1927. The next island (island 2) is very close to first island (450 meter) but the third one is about 4.5 km away from the second island. Island 4 is situated at 0.1 km from island 3.Island 5 and 6 are close to each other. Island 5 is close to island 4 by 1.8 km, whereas island 6 is very close to island 5 by 0.1 km.

Island 7 and 8 identified on the 2007 satellite image are not seen on the toposheet of the area. It can also be seen that the farthest and the last two islands have moved by 730 meters and 780 meters respectively in downstream direction in last 80 years or so.

Thus there is a distinct landward shift in lower islands and seaward shift in upper islands. Another peculiar thing about these islands is that they exists as group of islands, for example (1and 2), (3 and 4), (5 and 6), (7 and 8), (9, 10 and 11). Island 12 is situated in outer zone of middle sector, which is largest of all islands except mud island in lower sector. This island has an area of 0.4375 sq. km. and it has no neighbouring island.

Island 13 and 14 again show-grouping tendency. Island 15 and 16 are actually the islands influenced by riverine discharge, flow and sedimentation. Others are influenced by daily tidal incursion and excursion. Thus it can be seen that the very first island from the creek has shifted inside the creek by a distance of 161 m, whereas the second island has shifted closer to the first island by a distance of 45 m. Although, the island 3,4 and 5 have drifted inside the creek, island 6 has drifted towards the mouth. Overall tendency of forming clusters is retained till 2007.All these islands are pushed in the creek towards the upstream direction. **(Table 3.3 and Fig. 3.11).**

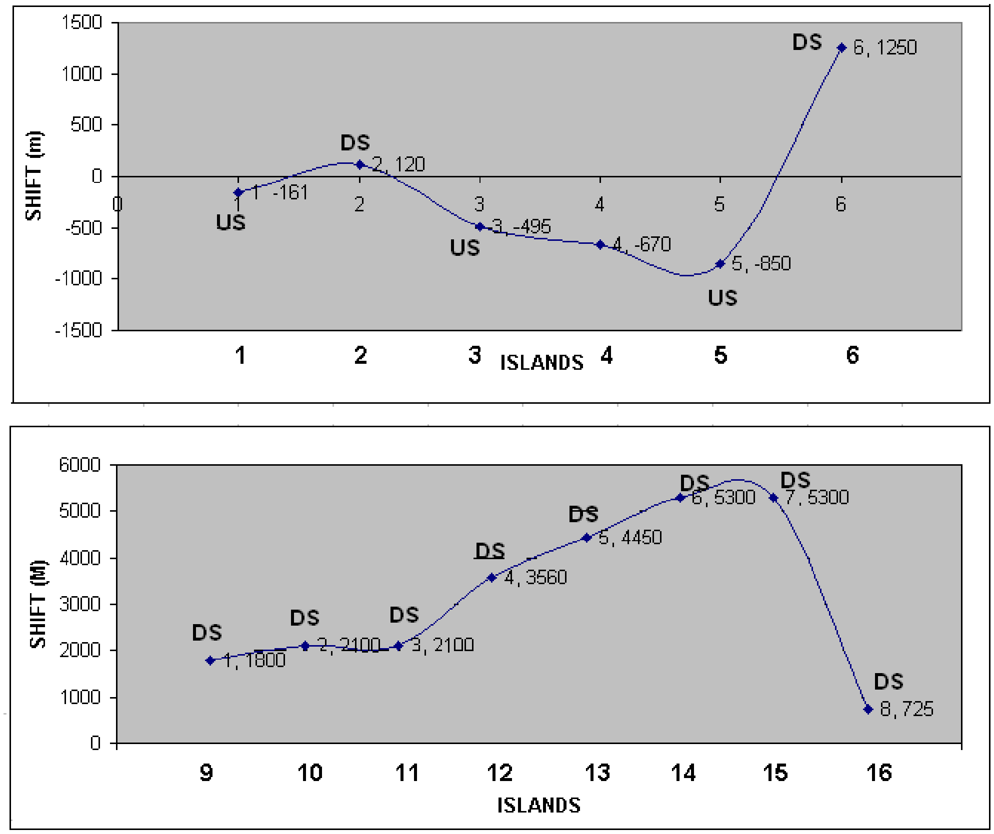
Islands especially in the lower and middle sector have moved upstream whereas islands in the upper sector have moved in the downward direction towards the mouth of the creek.

Table 3.3 Upstream or Downstream Shift of Islands from 1927 to 2007

Island No.	Distance from mouth of the creek in km (1927)	Distance from mouth of the creek in km (2007)	Shift (m)
1	14	14.161	-161.0
2	14.5	14.38	120.0
3	18.9	19.395	- 495.0
4	19	19.67	- 670.0
5	20.8	21.65	- 481.0
6	20.9	22.15	- 850.0
7	-----	23.35	---
8	-----	23.35	---
9	22.1	23.90	1800.0
10	22.2	24.30	2100.0
11	22.3	24.40	2100.0
12	23.3	26.86	3560.0
13	24.8	29.25	4450.0
14	24.9	30.20	5300.0
15	25.7	31.00	5300.0
16	26.5	33.75	7250.0

(Negative change indicates upstream shift and positive change indicates downstream shift.)

UPSTREAM OR DOWNSTREAM SHIFT OF ISLANDS 1 TO 6 AND 9 TO 16 FROM 1927 TO 2007



US:Upstream DS:Downstream

FIG.3.11

Table3.3 and Fig.3.11 show the upstream or downstream shift of islands from 1927 to 2007.The distances of islands measured from mouth of the creek on the toposheet of the area in the year 1927 and on satellite image of the year 2007. Negative change indicates upstream shift and positive change indicates downstream shift of the islands. Islands 1,3,4 and 5 in lower part of the middle sector show negative change, suggesting their landward (upstream) shift, whereas Islands in the upper part of middle sector island 9,10,11,12,13, 14 and upper sector islands 15 and 16 show downward shift. Island 2 and 6 although situated in lower part of the middle sector they show downward shift.

The relative change in upstream shift is remarkable in island 3 and 5 as well as relative change in downstream shift is remarkable in island 9,15 and 16.These changes are graphically shown in (**FIG 3.11)** for island 1 to 6 and 9 to 16.Since island 7 and 8 were not visible on earlier toposheet of 1927 and 1967.

Shift of islands from left and right bank (1927 to 2007):

The creek islands in the area show tendency of cutting and filling (extension) especially along their cross sectional axis. This has resulted in the increase or decrese in the distance from left and right bank of the tidal creek. To know these tendencies, the distances of islands from both the banks were measured. Average distances for year 1927 and 2007 are shown in **Table 3.4.** and **Table 3.5.** show change in distances from left and right bank from the year 1927 to 2007. **Fig.3.12** show change in distances indicating cutting and /or filling (extension).

Island 1,2,5 and 6 i.e. lower islands of middle sector show extension on both the banks, whereas island 3 and 4 show increase in distances between the bank of island and river channel. Middle sector island 10,11,13 and upper sector island 16 show positive change whereas island 14 and 15 show negative change. **Fig.3.12** indicates that island1,2,5,6.10,11,12 and 13 in middle sector and island 16 in upper sector of the channel show positive change i.e. distances between bank of the island and channel have decreased, whereas island 3,4 and 9 in middle sector and island 14 and 15 show negative change, i.e. distances between bank of the river islands and channel have increased. It clearly points to the fact that extension due to filling is a dominant process on these islands.

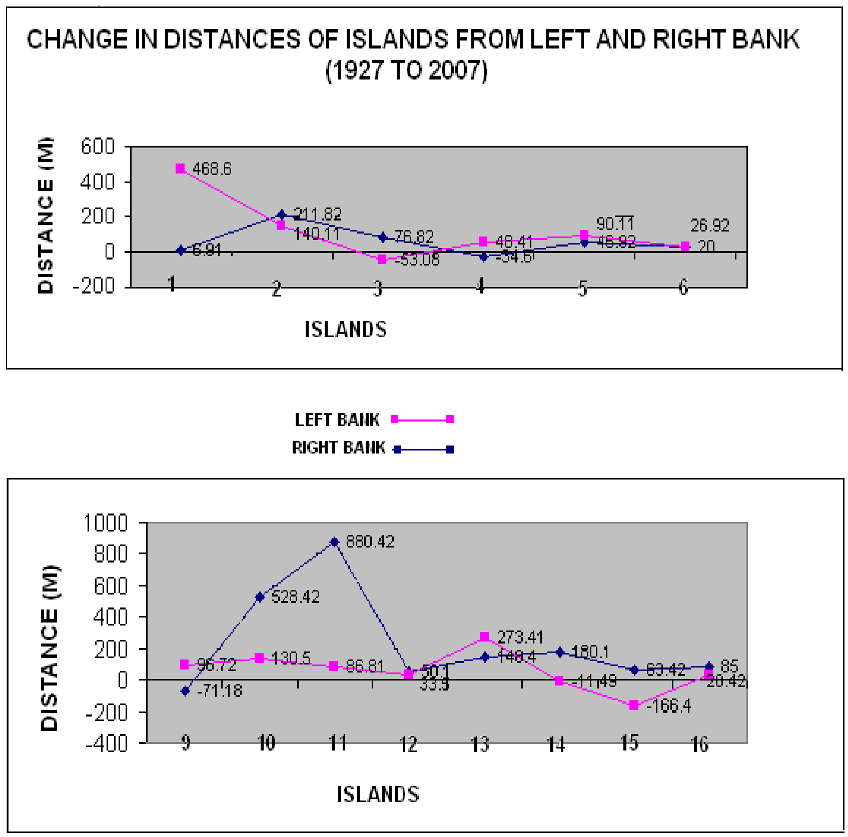

CHANGE IN DISTANCES OF ISLANDS FROM LEFT AND RIGHT BANK
(1927 TO 2007)
DISTANCE (M)
ISLANDS
LEFT BANK
RIGHT BANK
DISTANCE (M)
ISLANDS

FIG.3.12

Table 3.4 Average distances of islands from right and left bank (1927 to 2007)

Island No.	Distance from Right Bank (m)(1927)	Distance from Left Bank (m) (1927)	Distance from Right Bank (m) (2007)	Distance from Left Bank (m) (2007)
1	250.0	650.0	243.09	266.4
2	365.0	250.0	153.18	109.89
3	230.0	200.0	153.18	253.08
4	365.0	125.0	399.6	76.59
5	300.0	200.0	253.08	109.89
6	300.0	280.0	143.19	253.08
7	-	-	-	-
8	-	-	-	-
9	415.0	150.0	486.18	53.28
10	615.0	630.0	86.58	499.5
11	1300.0	230.0	419.58	143.19
12	150.0	200.0	99.9	166.5
13	215.0	350.0	66.60	76.59
14	280.0	165.0	99.9	176.59
15	150.0	100.0	86.58	266.4
16	200.0	115.0	209.79	86.58

Table 3.5 Change in distances of islands from left and right bank (1927 to 2007)

Island No.	Distance change on Right (north) bank	Distance change on Left (south) bank
1	6.91	468.6
2	211.82	140.11
3	76.82	-53.08
4	-34.6	48.41
5	46.92	90.11
6	20.0	26.92
7	---------	------------
8	---------	-------------
9	-71.18	96.72
10	528.42	130.5
11	880.42	86.81
12	50.1	33.5
13	148.4	273.41
14	180.1	-11.49
15	63.42	-166.4
16	85. 0	28.42

(- ve values suggest island bank cutting and + ve values suggest extension due to filling)

Relative shift and Extension or cutting of the islands in River Kundalika (1927 to 2007):

Fig.3.13 and Table 3.6 shows upstream or downstream relative shift of the islands and their bankward extension or cutting together. Figure clearly shows that there is a pronounced extension of right margins of islands in the upper sector, which show a downstream shift. Although extension due to filling is a dominant tendency seen in many islands, it is less pronounced in islands in lower part of the middle sector, which are shifting upstream. Right bank of upper sector islands seems more prone to filling than the left bank. Cutting and extension tendencies are relatively more balanced in middle islands especially island 3,4,5,6 and 9.Maximum extension by 880 m in case of island 11 in last 80 years indicates an extension rate of around 11 meters per year towards northern bank of the creek.

It is interesting to see that island 3 and 4 in lower part of the middle sector have maintained an alternate rhythm of cutting towards left bank and extension towards right bank, extension towards right bank and cutting towards left bank. **Table 3.6** lists extension and erosion tendencies of all the islands with reference to creek bank. Extension due to filling is clearly a dominant process in most of the islands.

RELATIVE SHIFT AND BANKWARD EXTENTION AND CUTTING OF THE ISLANDS IN RIVER KUNDALIKA

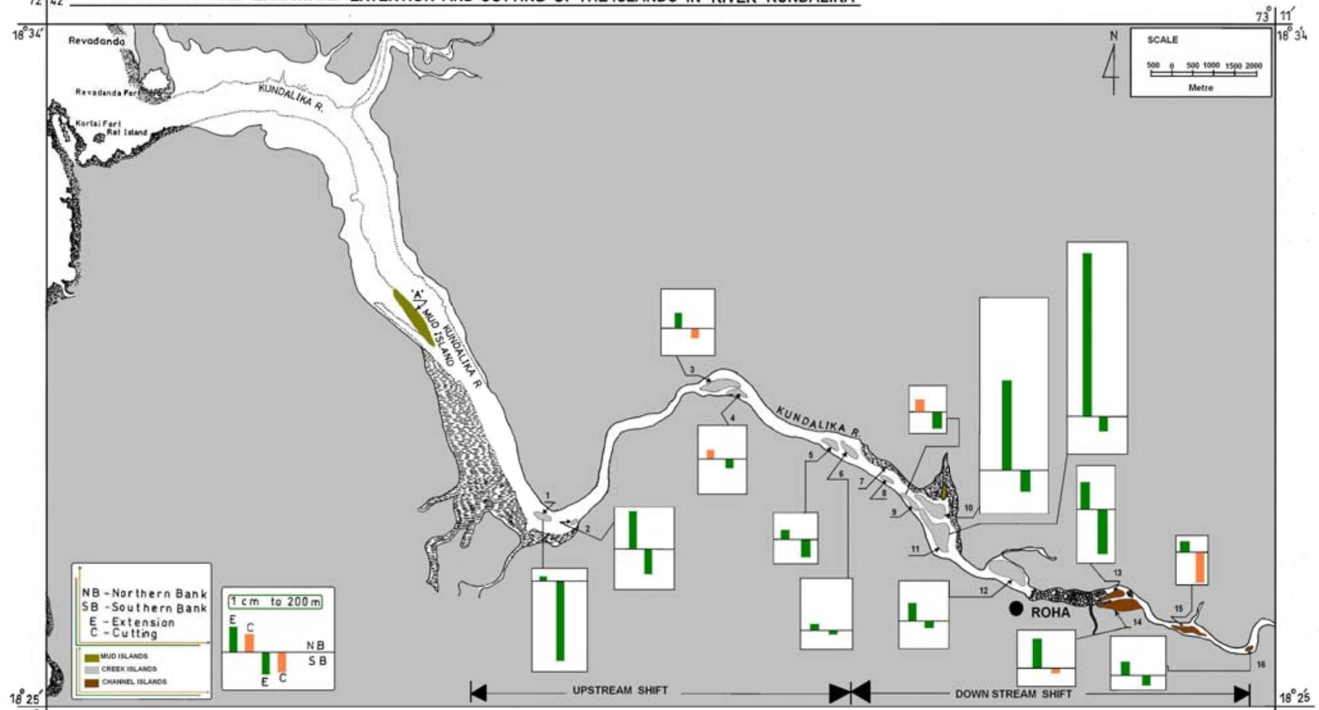


Fig.3.13

Table 3.6 Extension or cutting of island margins facing right / left bank

Island No.	Dist.from Northern Bank in meters.	Dist.from Southern Bank in meters.	Comment
1	E (6.91)	E (468.6)	Extension due to filling towards both the banks.
2	E (211.82)	E (140.11)	Extension due to filling towards both the banks.
3	E (76.82)	C (-53.08)	Extension to right bank, cutting towards left bank.
4	C (-34.6)	E (48.41)	Cutting towards right bank, extension to left bank.
5	E (46.92)	E (90.11)	Extension due to filling towards both the banks.
6	E (20.0)	E (26.92)	Extension due to filling towards both the banks.
7	-	-	-
8	-	-	-
9	C (-71.18)	E (96.72)	Cutting towards right bank extension to left bank.
10	E (528.42)	E (130.5)	Extension due to filling towards both the banks.
11	E (880.0)	E (86.81)	Extension due to filling towards both the banks.
12	E (50.1)	E (33.5)	Extension due to filling towards both the banks.
13	E (148.4)	E (273.41)	Extension due to filling towards both the banks.
14	E (180.1)	C (-11.49)	Extension to right bank and cutting towards left bank.
15	E (63.42)	C (-166.4)	Extension to right bank and cutting towards left bank.
16	E (85.0)	E (28.48)	Extension due to filling towards both the banks.

(E = Extension due to filling towards creek bank. C=Cutting towards island margin)

CHAPTER 4

SEDIMENTARY ENVIRONMENT OF CREEK ISLANDS

CHAPTER 4

SEDIMENTARY ENVIRONMENT OF CREEk ISLANDS

Sediments, particularly in estuaries, preserve a record of environmental change. Geochemical and physical characters of the sediments can provide a record of 'baseline' changes in natural and human activities within and outside river channel.

Sediment is any particulate matter that can be transported by water, which gets deposited as a layer of solid particles on the bed or bottom of water, and sedimentation is the deposition by settling of a suspended material. It is a continuous process, where settling velocity of a particle directly determines its reaction to flow. It depends on the size, shape and density of the particle and the density and viscosity of the fluid (water) also.

If the grains are closely spaced in fluid they will fall in a group within velocity that is higher than that of a particle falling alone. On the other hand if particles are dispersed throughout the fluid the interference is said to hinder the settling *(Embleton and Thornes 1979)*.

If the concentration of sediment on the bed increases the velocity of individual particles will fall. As the river flow decreases the sediment transport decreases and deposition takes place. Vegetation on these sediment helps to stabilize the bars in the channel and help to trap the fine material. Further this material is useful for extension of islands within the channel also.

In the creek mouth the sediments settle more slowly in turbulent water where seawater mixes with river water cut away from the creek mouth in upstream direction in calm water settling rate increases, as it is the ideal condition for deposition.

Properties of creek water:

Salinity, velocity of water, silt content and suspended sediment matter are the main properties of creek water. Sampling of creek water is required to provide a representative sample of the concentration at a particular point or zone within the channel. (Gregory and Walling, 1973). Therefore water samples collected at fixed distances **(Fig.4.1)** from the creek mouth were analyzed to know the salinity, silt content and suspended material. Velocity of water was measured by using current meter. From the amount of suspended sediment matter rate of sedimentation was calculated using

Mc Cave's formula (1982). RC =Cbw* 10^{-3} mg/cm/sec

(**RC** = rate of sedimentation, **cbw** = concentration of suspended sediment of settling velocity w/cm) ***Table 4.1*** gives variation in these properties in the upstream direction from creek mouth.

w1-SAMPLE SITE

WATER SAMPLE SITES IN KUNDALIKA CREEK.

Fig.4.1

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Table 4.1 Variation in the properties of creek water from mouth of the creek

Distance up Upstream (Km)	Salinity percentage		Silt mg/l		Velocity m/s		S.S.M mg/l	Rate of sedimentation mg/cm^2/sec
w1-w5	H.T	L.T	H.T	L.T	H.T	L.T	(Avg.) H.T- L.T	
0-5 (**w1**)	32.8	29.5	0.04	0.1	0.8	1.1	0.09	0.60*10^{-7}
5-10 **(w2)**	32.8	32.5	0.07	0.05	0.7	0.8	0.14	0.18*10^{-5}
10-15 **(w3)**	34.6	25.5	0.08	0.11	0.5	0.6	0.24	0.20*10^{-5}
15-20 **(w4)**	27.0	23.3	0.06	0.09	0.5	0.4	0.11	0.09*10^{-7}
20-25 **(w5)**	23.4	20.1	0.07	0.08	0.3	0.4	0.09	0.08*10^{-7}

(w1-w5) sample sites

Islands in the creek are clustered at various distances. Their individual distances and cluster distances are given in **Table 4.2 and 4.3.** On the basis of tidal impact total creek stretch was divided in 3 zones namely 1.Inner zone (Marine) 2. Middle zone (Mixed zone) 3.Outer zone (Fluvial). Inner zone is a zone of exclusively marine impact as it is submerged for a longer time in a daily tidal cycle. It was recognized up to a distance of 10 km from creek mouth. Island, 'A' which is a mud island, lies in this sector. Middle zone enjoys mainly marine impact with a slight riverine impact. In fact, this zone is a zone of mixed water, river water mixes with seawater. The dissolved salts react with the flocs neutralizing the positive charge. The flocs then coagulate and grow bigger, so that they could not remain suspended in water and are deposited on the channel floor. Due to the process of flocculation this zone acts as a sediment sink *(Pethic, 1984 /Kale 2001).*

This zone of Kundalika extends between 10 km to 25 km (24.86 km) in upstream direction. Islands 1 to 12 lie in this sector. Beyond this zone, the tidal water impact in the creek reduces considerably. The zone is controlled and influenced mainly by river flow. This zone is identified as outer zone and starts at a distance of 27 km (26.86 km) up to 34 km (33.75 km). Island group 'F' lies in this sector.

This zonation of creek is also shown in **(*Fig.4.2*). *Fig.4.2*** shows salinity variation in the creek at high tide as well as at low tide. At high tide salinity remains constant in the inner zone **(*Table 4.4*).** It increases slightly from 32.8 to 34.6 o/oo up to 15 km in sediment sink (middle sector). After this it rapidly decreases to 27.0 o/oo at the limit of tidal incursion. At 22.62 km distance it lowers to 25.0 o/oo as indicated by salinity curve. At the margins of outer zone water becomes brackish with a salinity of about 23.4 o/oo. At low tide more or less similar trend exists and salinity drops at 15 km and 20 km distance. The sedimentology and vegetation cover of island groups between 14.25 and 20 km (island Group B and C) are influenced by these salinity changes at high and low tide in the creek.

Table 4.2 Location of Islands from the creek mouth

Sr. No.	Distance from mouth of the creek (km)	Island No.
1	8.5	A (Mud Island)
2	14.00	1
3	14.50	2
4	18.9	3
5	19.65	4
6	21.65	5
7	22.15	6
8	23.35	7
9	23.35	8
10	23.90	9
11	24.30	10
12	24.40	11
13	26.86	12
14	29.25	13
15	30.20	14
16	31.00	15
17	33.75	16

Table 4.3 Island groups and their average distances from creek mouth

Sr. No.	**Distance from mouth (km)**	**Islands in island groups**	**Group**
1	8.5	Mud Island	A
2	14.25	(1,2)	B
3	19.15	(3,4)	C
4	22.62	(5,6,7,8)	D
5	24.86	(9,10,11,12)	E
6	31.05	(13,14.15,16)	F

SALINITY VARIATION IN THE CREEK

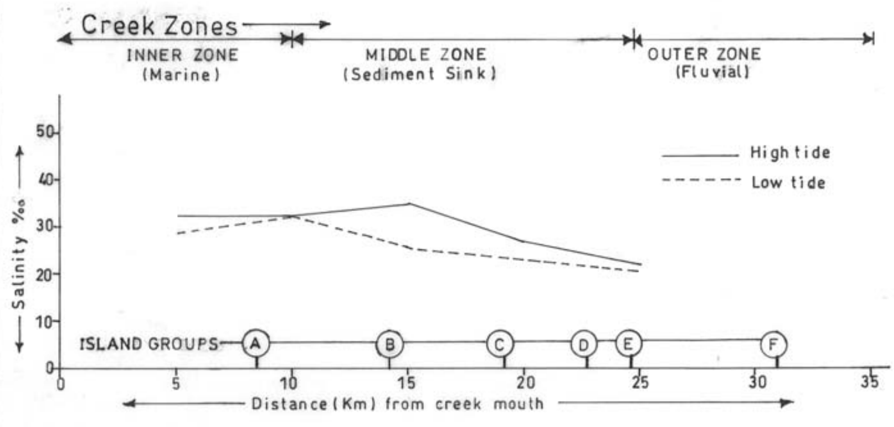

Fig. 4·2

VARIATION IN SILT PERCENTAGE IN THE CREEK

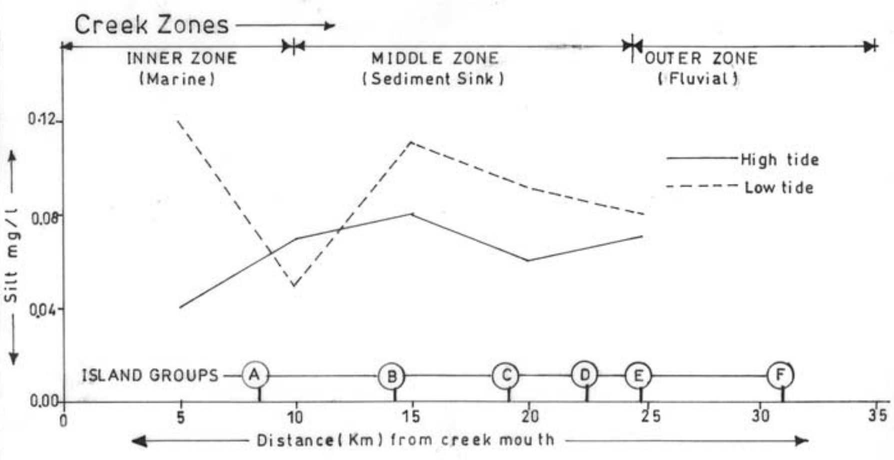

Fig. 4·3

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Table 4.4 Salinity variation in the creek

Sample site from the creek mouth (km)	Avg. Dist. of Island Group from creek mouth (km)	Island Group	Salinity Percentage at H.T	Salinity Percentage at L.T.
0-5	-	-	32.8	29.5
5-10	8.5	'A'	32.8	32.5
10-15	14.25	B	34.6	25.5
15-20	19.15	C	27.0	23.3
20-25	22.62-24.86	D and E	23.4	20.1

A stretch 15 km upstream from creek mouth seems to be more critical in the sedimentology of islands in group B, as far salinity variation is concerned.

Fig 4.3 and Table 4.5 shows variation in the amount of silt content in upstream direction. There is a significant decrease in the silt content of water up to 10 km distance at low tide. There after it suddenenly increases to 0.11 mg / l at 15 km distance. Here after it shows a slow decrease up to the limit of outer zone. At high tide silt content slowly increases up to 15 km distance, then it drops and again rises up to the limit of outer zone **(Table 4.5)Fig.4.4 and Table 4.6** show the variation in high tide-low tide average suspended sediment matter in creek. It is interesting to see that the amount of suspended sediment matter slowly increases and attains a peak at 15 km from mouth of the creek and thereafter decreases slowly up to the limit of the outer zone**. (Table 4.6)** The middle zone is thus an ideal sink for this suspended matter. It will be seen later that conspicuous island development in the creek is found at this distance and some distance upstream (Island groups B, C and D).

Rate of sedimentation is mainly a function of amount of suspended sediment matter. This is also reflected in ***Fig.4.5*** and ***Table 4.7*** showing variation in rate of sedimentation. The rate is highest between 12 to 15 km from mouth of the creek. It is substantially high in inner zone.

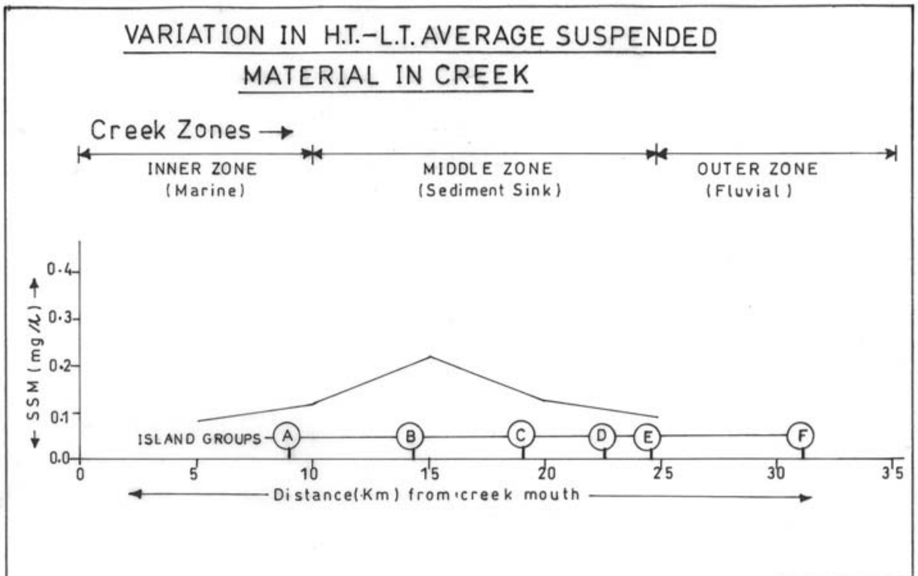

Fig. 4.4

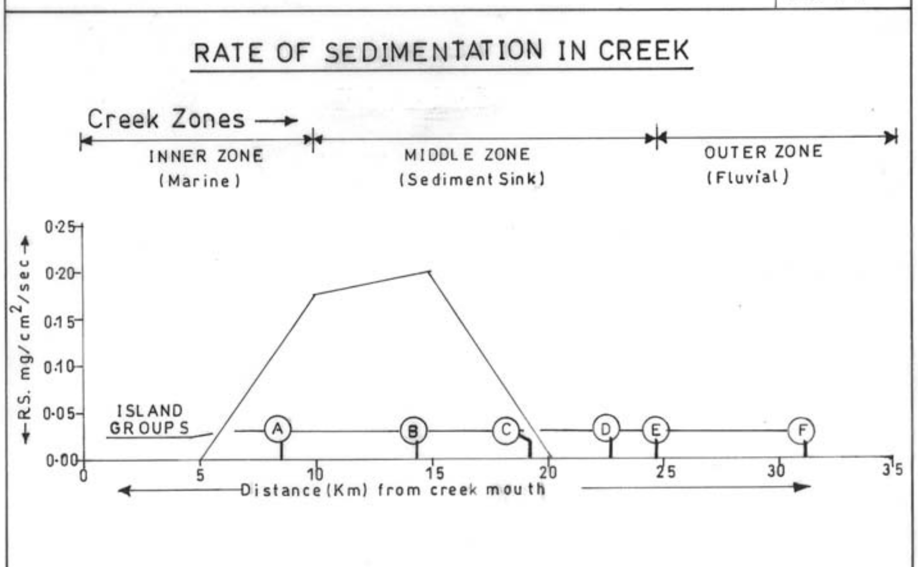

Fig. 4.5

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Table 4.5Variation in silt percentage in the creek

Sample site from the creek mouth (km)	Avg. Dist. of Island Group from creek mouth (km)	Island Group	Silt o/o at H.T	Silt o/o at L.T
0-5	-	-	0.04	0.1
5-10	8.5	'A'	0.07	0.05
10-15	14.25	B	0.08	0.11
15-20	19.15	C	0.06	0.09
20-25	22.62- 24.86	D and E	0.07	0.08

at 8.5 km distance, where Mud Island is developed and also at 19 km distance where islands in-group 'C' are developed.

Sedimentation in the creek is also governed by the velocity of tidal currents. Tidal velocity measurements at fixed intervals in high tide as well as low tide conditions are given in **Table 4.8.**

The velocity patterns are shown in **Fig. 4.6** and **Table 4.8.** It can be seen that the tidal current velocities are high inside the creek mouth at high tide as well as low tide. At high tide the velocity is 80 cm/sec whereas at low tide velocity is 110 cm/sec near mouth. Velocity decreases in upstream direction from 80 cm/sec in inner zone to 50 cm/sec at 20 km distance. At low tide also upstream areas are characterized by lower values of velocity, thus indicating a relative stagnation of water in the creek.

VELOCITITY VARIATION IN THE CREEK

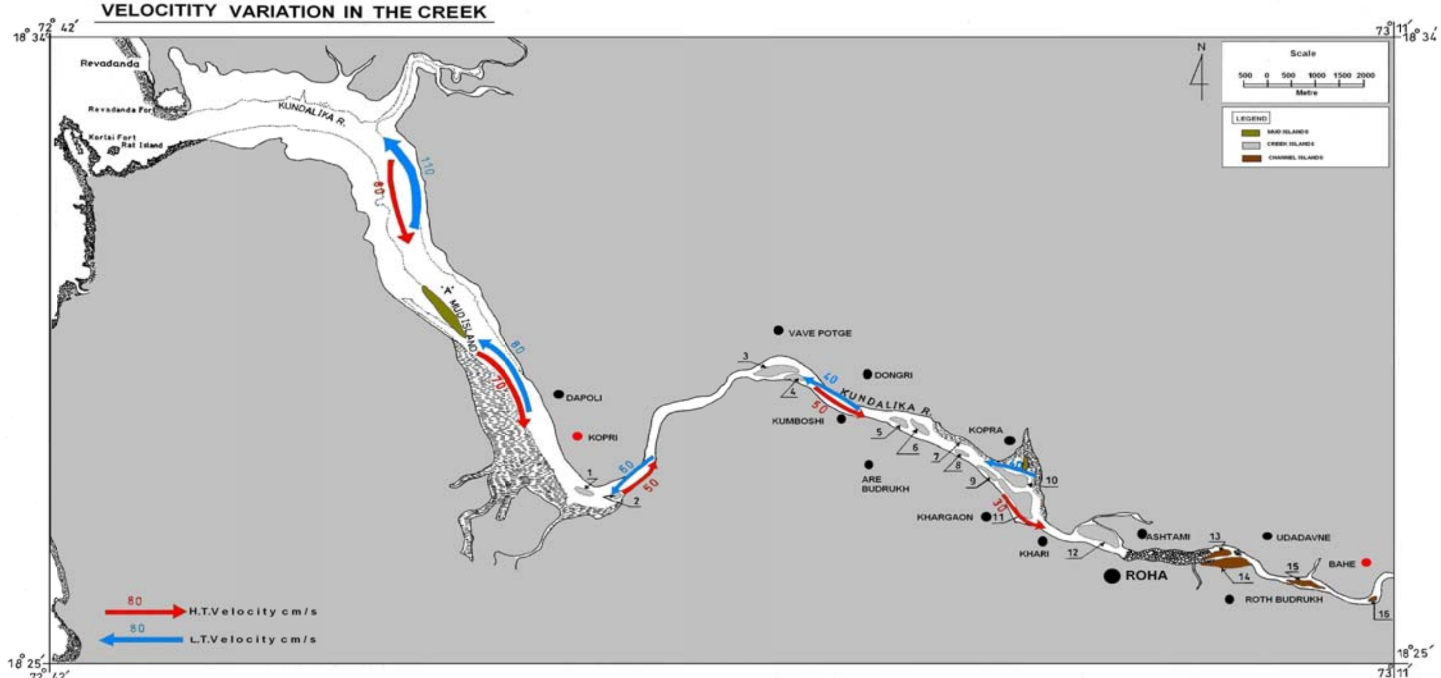


Fig.4.6

Table 4.6 Variation in H.T-L.T Average Suspended Material in creek

Sample sites from the creek mouth (Km)	Avg. Dist. From the Creek mouth (Km)	Island Group	S.S.M. Mg/L
0-5	-	-	0.09
5-10	8.5	A	0.14
10-15	14.25	B	0.24
15-20	19.15	C	0.11
20-25	22.62 –24.86	D and E	0.09

Table 4.7 Rate of sedimentation in creek

Sample site from the creek mouth (Km)	Avg.Dist.From creek mouth (km)	Island Group	Rate of Sedimentation	Calculated Values
0-5	-	-	$0.60*10^{-7}$	0.006
5-10	8.5	A	$0.18*10^{-5}$	0.18
10-15	14.25	B	$0.20*10^{-5}$	0.2
15-20	19.15	C	$0.09*10^{-7}$	0.0009
20-25	22.62 - 24.86	D and E	$0.08*10^{-7}$	0.008

Table 4.8 Velocity variations in creek.

Sample site from the creek mouth (Km)	Avg. Dist. From creek mouth (km)	Island Group	Velocity cm/s High tide	Velocity in cm/s Low tide
0-5	-	-	80.0	110
5-10	8.5	‘A’	70.0	80.0
10-15	14.25	B	50.0	60.0
15-20	19.15	C	50.0	40.0
20-25	22.62- 24.86	D and E	30.0	40.0

Sediment distribution on creek islands:

The sediments are important in relation to the geomorphology of the islands in two ways. Firstly these are the materials from which islands are created. Secondly their type, deposition and preservation provides clue to the process of their formation.

Grain size is an important petrological property of sediments. The size gives an idea about the nature of sediment. Sediment with a grain size ranging from 2 mm to 0.064 mm (i.e. -1 to 4 phi) is sand; from 0.064 mm to 0.002 mm (i.e. 4 to 9 phi) is silt and that with size less than 0.002 mm (≤ 9 phi) is clay. *(Gregory and Walling 1973).*

The mean grain size is often used to infer energy field. The extent to which a sediment sample is sorted (or composed of similar sized grains) is indicated by standard deviation. This is also called sorting index. It is used to infer the maturity of sediment deposit or sediment transport pathways. Skewness is a measure of the extent to which the distribution is symmetrical. This can indicate history of sediment movement. The material that is difficult to move always shows negative skewness. Fine sediment that is easy to move shows positive skewness. Kurtosis measures peakedness of distribution.

Coefficient of variation was also calculated to know the degree of variation in the samples collected. Coefficient of variation is used as a best measure of variation when the sample size is unequal. *(Karlekar et al 2006)*

Determining the environment of deposition is possible by sediment analysis. An attempt is made in this work to determine the depositional environment of each island on the basis of the analysis of sediments collected from these islands. To achieve this, sediment distribution profiles of coarse sand, fine sand and clay were prepared ***(Fig.4.7 to 4.17*** and **Table 4.9 to 4.19)** for all the creek islands.

The depositional environment on the each island is due to the deposition of coarse sand, fine sand and clay. Dominance of a particular grain size helps in its designation as Sand Island or Clay Island.

The mean grain size gives an idea of energy level required for its deposition. Standard deviation (sorting index) speaks for the maturity of sediment.

Young and immature sediments have high values of Std. deviation. Low values indicate their maturity. Negatively skewed distributions suggest inability of tidal currents to move the material from the island.

Island 'A' and a tiny island near by island 11 in this study area are exclusively mud islands. These are not easily approachable and thick mud on them does not assist the sample collection. Therefore samples could not be collected from these islands. River islands, island 15 and 16 are rocky, hardly covered with any sediment. Hence samples were not collected from these rock islands.

Sediment distribution on Island 1 **(Fig.4.7** and **Table 4.9)** shows distribution of coarse sand, fine sand and clay on island 1. Coarse sand on this island shows concentration in eastern, central and western parts of island towards northern and southern margins between (40 to 80 %). Fine sand and clay varies from 4 to 29 % and 10 to 40 % respectively. On an average coarse sand amount on this island is 59%. This island is situated 14.00 km inland from the mouth of the creek in the middle stretch of the study area. Since the dominant sediment type is sand, it is a sand island, formed by young sediments (Std. dev 12.6), which are coarse skewed (-0.030) **(Table 4.9)**

Island 2, 14.50 km away from mouth of the creek is at 500-meter distance from island 1. Sediments on island 2 are unevenly distributed**. Fig.4.8** and **Table 4.10** shows coarse sand, fine sand and clay distribution on this island. Here coarse sand proportion is nearly 70%. Fine sand is 8% and clay 39%.

Fine sand on island 2 varies from 0.5 to 16% and clay varies from 8 to 40 %. Maximum amount of coarse sand suggests that this island is a sand island. The negative values of skewness for coarse sand and clay represent coarse skewed and platykurtic distribution. Negative values of skewness suggest that many sites on the island have coarse sand less than the average.

Island 3 is approximately 4.40 km away from island 2. It is situated in sheltered zone of meandering channel in middle stretch of the study area. **Fig.4.9** and **Table 4.11** show clay percentage on island 3. The clay percentage is more than the percentage of coarse sand. Few pockets of clay are observed in central and western margins of the island. This is a clay island with skewness values -1.09 for coarse sand, - 0.19 for fine sand and - 2.25 for clay suggesting that this is a clay island with negatively skewed distribution of clay in different samples.

Island 4 is also situated in the protected zone of meandering channel. It is a very small island, area wise**. Fig.4.10** and **Table 4.12** show coarse sand, fine sand and clay distribution on this island. Island has more or less equal amount of sand and clay. So it is of sandy clayey nature. Clay percentage is maximum in few pockets on the eastern and central margins of the island. Sand percentage is maximum along central and eastern margin.

Island 5 and & 6 are 22 km (21.65 km) and (22.15 km) away from the mouth of the creek respectively. **Fig.4.11** and **Table 4.13** and **Fig.4.12** and **Table 4.14** show distribution of coarse sand, fine sand and clay on these two islands. Island 5 is a clay island and island 6 has more or less equal amount of coarse sand and fine sand. Clay % on island 6 is slightly more than 45%. North central margin of island 6 shows significant concentration of clay .It is a sandy clayey island.

Island 7 and 9 due to their very very limited extent were not considered for the collection of sediment samples.

Island 8. **Fig.4.13** and **Table 4.15** show coarse sand, fine sand and clay distribution. Here clay % varies from 37 % to 48 % and average coarse sand, fine sand % together is more than 59 %. The coarse sand, fine sand is maximum in central and southern margins of the island and clay % are more in northern, central and southern margins of the island. Coarse sand on this island is unevenly distributed, whereas % of clay is more in few pockets. In central and southern part as well as eastern margin it is slightly higher and shows more or less equal values suggesting that it is clayey island. **Fig.4.14** and **Table 4.16** show sediment distribution on island 10. It is a part of 'E' Group island. It is situated 24 km (24.30 km) away from the mouth of the creek in upstream direction. It is a cluster of 4 islands. Sizable islands i.e. island 10 and 11 are situated in sheltered zone of meandering channel. They are situated in the middle sector of the creek, closer to the northern bank of the River. **Fig.4.14** and **Table 4.16** show overall distribution of sediments on island 10. Clay % on this island is 54 %.

The values range from 48.3 % to 60 % of clay is concentrated in south eastern and northern part of the island 10, whereas sand % range from 10 to 20 % and fine sand % range from 19 to 39 %. Since the dominant sediment type is clay, it is Clay island with less % of sand on it.

Island 11 a part of group of islands in middle sector i.e. influx zone or sediment sink. It shows variation in distribution of sediment. It is closer to island 9 and located south east of Island 9.

Fig.4.15 and **Table 4.17** shows average % of clay to be 46 % and fine sand 38 %. The dominant sediment type is clay and fine sand. Island 11 is designated as a sandy clayey island.

Fig 4.16 and **Table 4.18** shows the distributional pattern of coarse sand, fine sand and clay on island 12.This island is 27 km (26.86 km) inland from the mouth of the creek in up creek direction. It is relatively bigger island except island 'A' near the mouth of the creek. Major part of the island is under cultivation of paddy. Major part of the island is covered by fine sand. Therefore it is a fine sand island with less % of clay. Coarse sand and fine sand is concentrated in few pockets along the north eastern, central and south eastern part of the island and some pockets of clay are observed in north and north western part of the island.

Fig.4.17 and **Table 4.19** show the distributional pattern of sediments on island 13 and 14, which are very close to each other. These two islands are situated in upper part of the middle sector of the creek. They are 29 km (29.25 km) and 30 km (30.20 km) away from the mouth of the creek respectively. They are elongated in shape. Their east west

Table 4.9 Sediment Distribution on Island 1

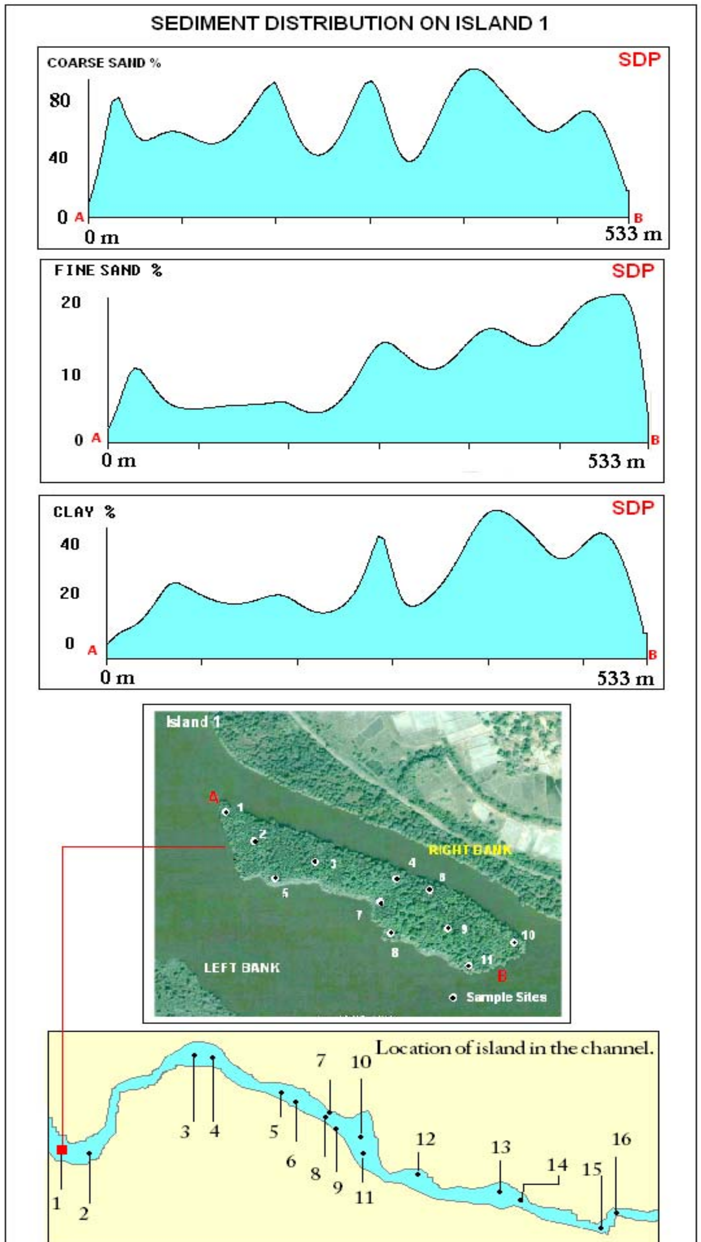
Sample site	C.S.% (2 to .064 mm)	F.S.% (.063 to .002mm)	Clay % (>.002 mm)
1	80.2	9.8	10
2	70.3	4.3	26.4
3	68.2	4.5	27.3
4	70.5	9.1	20.4
5	69.4	18.8	11.8
6	50.3	14.7	35.0
7	52.5	9.1	38.4
8	60.4	9.4	30.2
9	48.5	10.9	40.6
10	42.3	22.1	35.6
11	40.6	29.0	30.4
Avg.	59.38	12.88	27.74
Std.dev	12.6	7.26	9.7
S.k	- 0.03	1.19	- 0.5
C.V.	0.21	0.56	0.35

Table 4.10:Sediment Distribution on Island 2

Sample site	C.S.% (2 to .064 mm)	F.S.% (.063 to .002 mm)	Clay% (>.002 mm)
1	75.4	16.3	8.3
2	82.3	7.6	10.1
3	50.4	7.5	42.1
4	79.3	11.3	9.4
5	69.1	0.5	30.4
6	50.8	9.0	40.2
7	83.4	6.2	10.4
Avg.	70.1	8.34	39.22
Std.dev.	14.14	4.82	14.42
Sk	-1.88	0.07	0.56
C.V.	0.2	0.58	0.37

extension is larger than North South width. These two islands are more or less fragmented islands.

Island 13 and 14 show 78 % coarse sand and 19 % fine sand. Clay % is less than 5 %. Sand is concentrated in northern and central parts of island 14. Since the dominant sediment type is coarse sand it is a Sand island formed by young sediments (std. dev 15.77), which are coarse skewed (-0.78).


SEDIMENT DISTRIBUTION ON ISLAND 1
COARSE SAND %
SDP
80
40
0
A
B
0 m
533 m
FINE SAND %
SDP
20
10
0
A
B
0 m
533 m
CLAY %
SDP
40
20
0
A
B
0 m
533 m
Island 1
A
B
RIGHT BANK
LEFT BANK
Sample Sites
Location of island in the channel.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
SDP : SEDIMENT DISTRIBUTION PROFILE
Fig.4.7

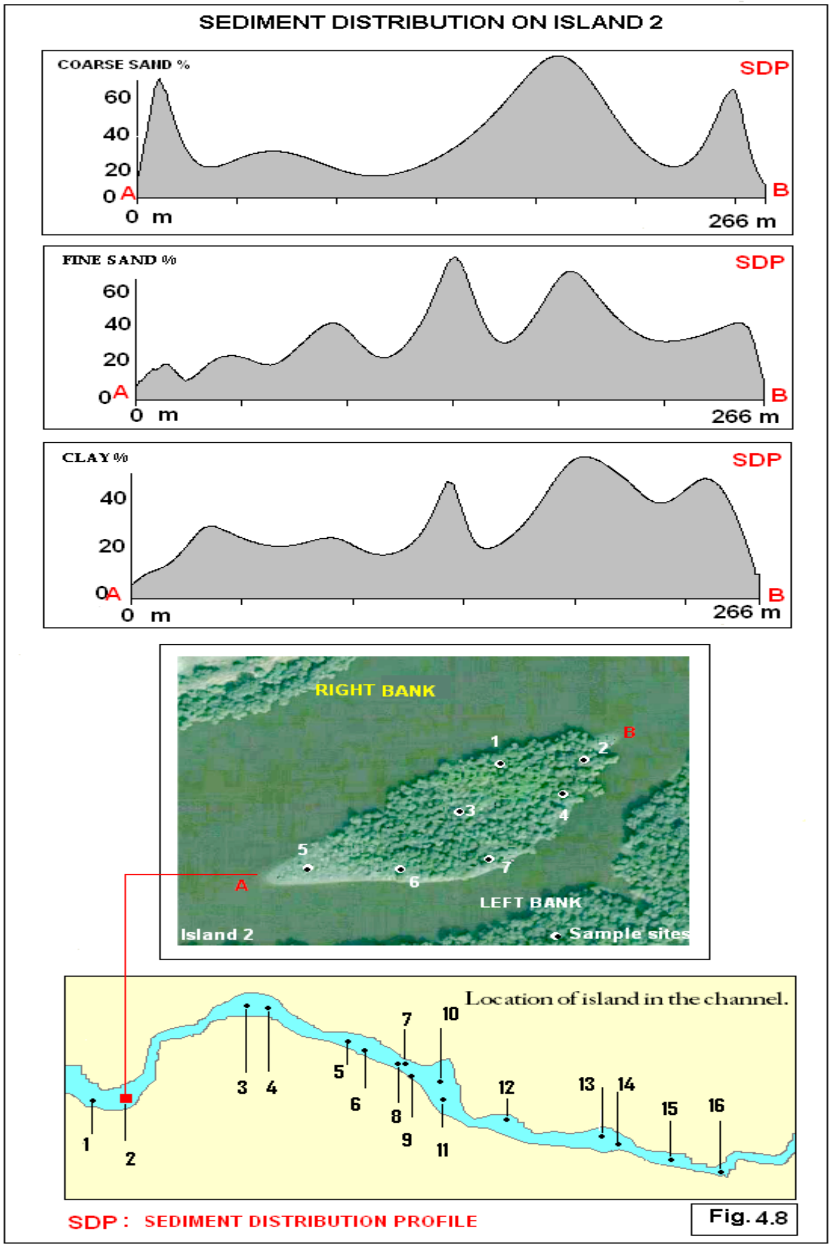

SEDIMENT DISTRIBUTION ON ISLAND 2
COARSE SAND %
SDP
60
40
20
0 A
B
0 m
266 m
FINE SAND %
SDP
60
40
20
0 A
B
0 m
266 m
CLAY %
SDP
40
20
0 A
B
0 m
266 m
RIGHT BANK
B
1
2
3
4
5
6
7
A
LEFT BANK
Island 2
Sample sites
Location of island in the channel.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
SDP : SEDIMENT DISTRIBUTION PROFILE
Fig. 4.8

Table 4.11: Sediment Distribution on Island 3

Sample site	C.S.% (2 to .064 mm)	F.S.% (.063 to .002 mm)	Clay % (>. 002mm)
1	30.6	10.1	59.3
2	30.4	9.2	60.4
3	49.1	2.6	48.3
4	56.1	3.7	49.2
5	48.3	6.4	45.3
6	50.4	3.8	45.8
7	30.4	9.2	60.4
8	50.7	7.2	42.1
9	40.3	9.4	50.3
Avg.	42.92	6.84	51.23
Std.dev.	9.6	2.7	6.62
Sk	- 1.09	-0.19	- 2.25
C.V.	0.22	0.39	0.13

Table 4.12: Sediment Distribution on Island 4

Sample site	C.S.% (2 to .064 mm)	F.S.% (.063 to .002mm)	Clay % (>. 002mm)
1	75.4	16.3	8.3
2	82.3	7.6	10.1
3	50.4	7.5	42.1
4	79.3	11.3	9.4
5	69.1	0.5	30.4
6	50.8	9.0	40.2
7	83.4	6.2	10.4
Avg.	70.1	8.34	39.22
Std.dev.	14.14	4.82	14.42
Sk	-1.88	0.07	0.56
C.v.	0.2	0.58	0.3

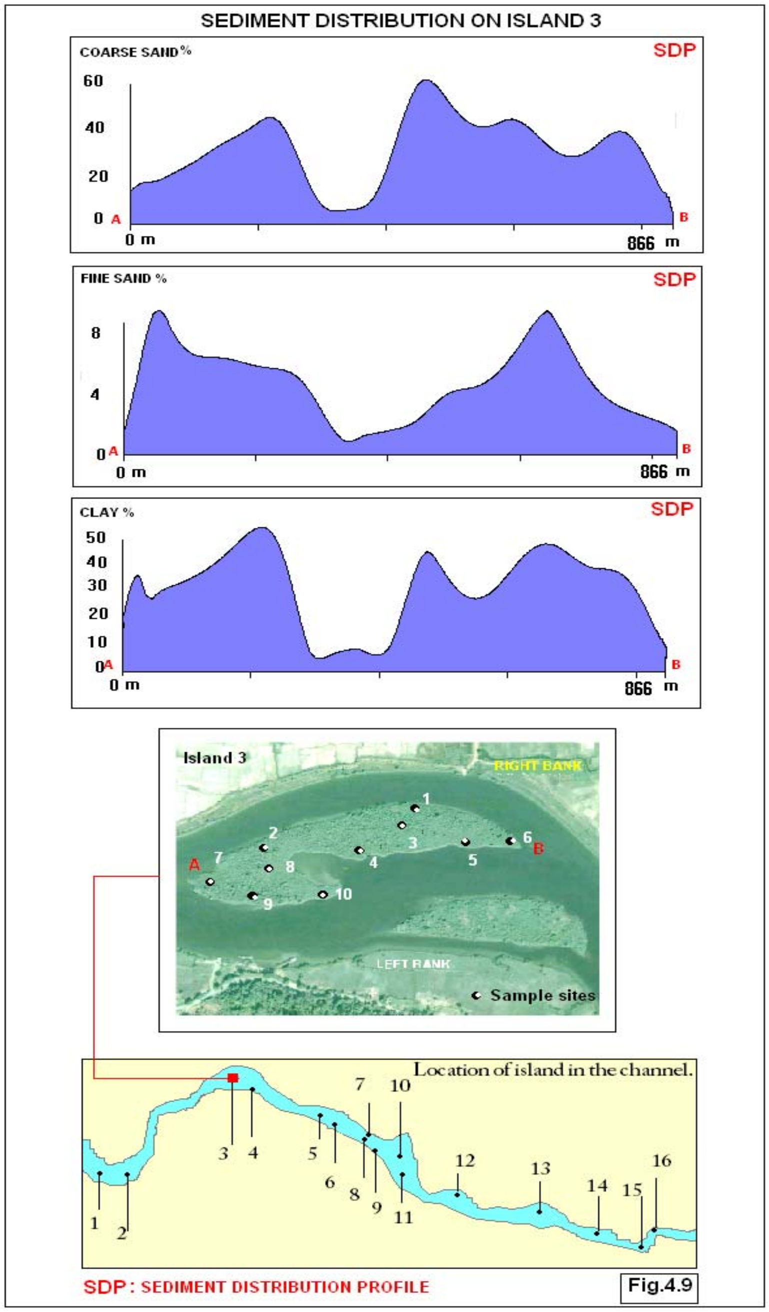
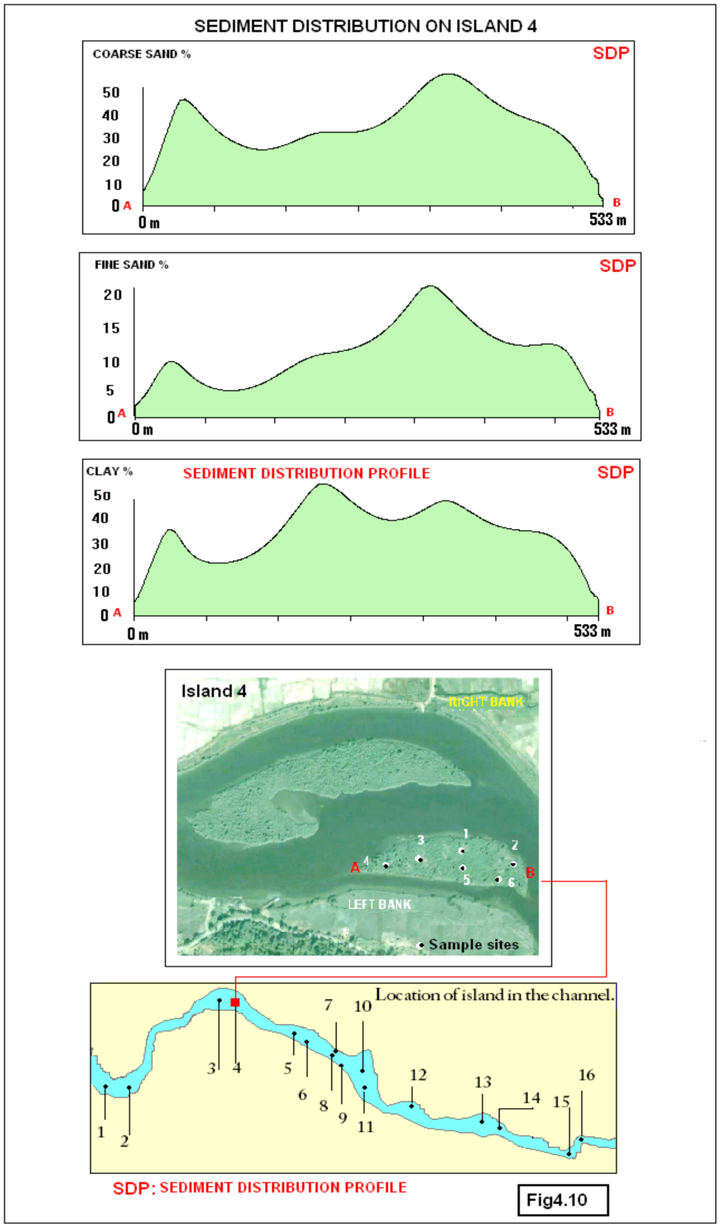

SEDIMENT DISTRIBUTION ON ISLAND 3
COARSE SAND %
SDP
60
40
20
0
A
B
0 m
866 m
FINE SAND %
SDP
8
4
0
A
B
0 m
866 m
CLAY %
SDP
50
40
30
20
10
0
A
B
0 m
866 m
Island 3
RIGHT BANK
LEFT BANK
Sample sites
Location of island in the channel.
SDP : SEDIMENT DISTRIBUTION PROFILE

Fig.4.9



SEDIMENT DISTRIBUTION ON ISLAND 4
COARSE SAND %
SDP
50
40
30
20
10
0 A
B
0 m
533 m
FINE SAND %
SDP
20
15
10
5
0 A
B
0 m
533 m
CLAY %
SEDIMENT DISTRIBUTION PROFILE
SDP
50
40
30
20
10
0 A
B
0 m
533 m
Island 4
RIGHT BANK
LEFT BANK
A
B
1
2
3
4
5
6
Sample sites
Location of island in the channel.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
SDP: SEDIMENT DISTRIBUTION PROFILE

Fig4.10

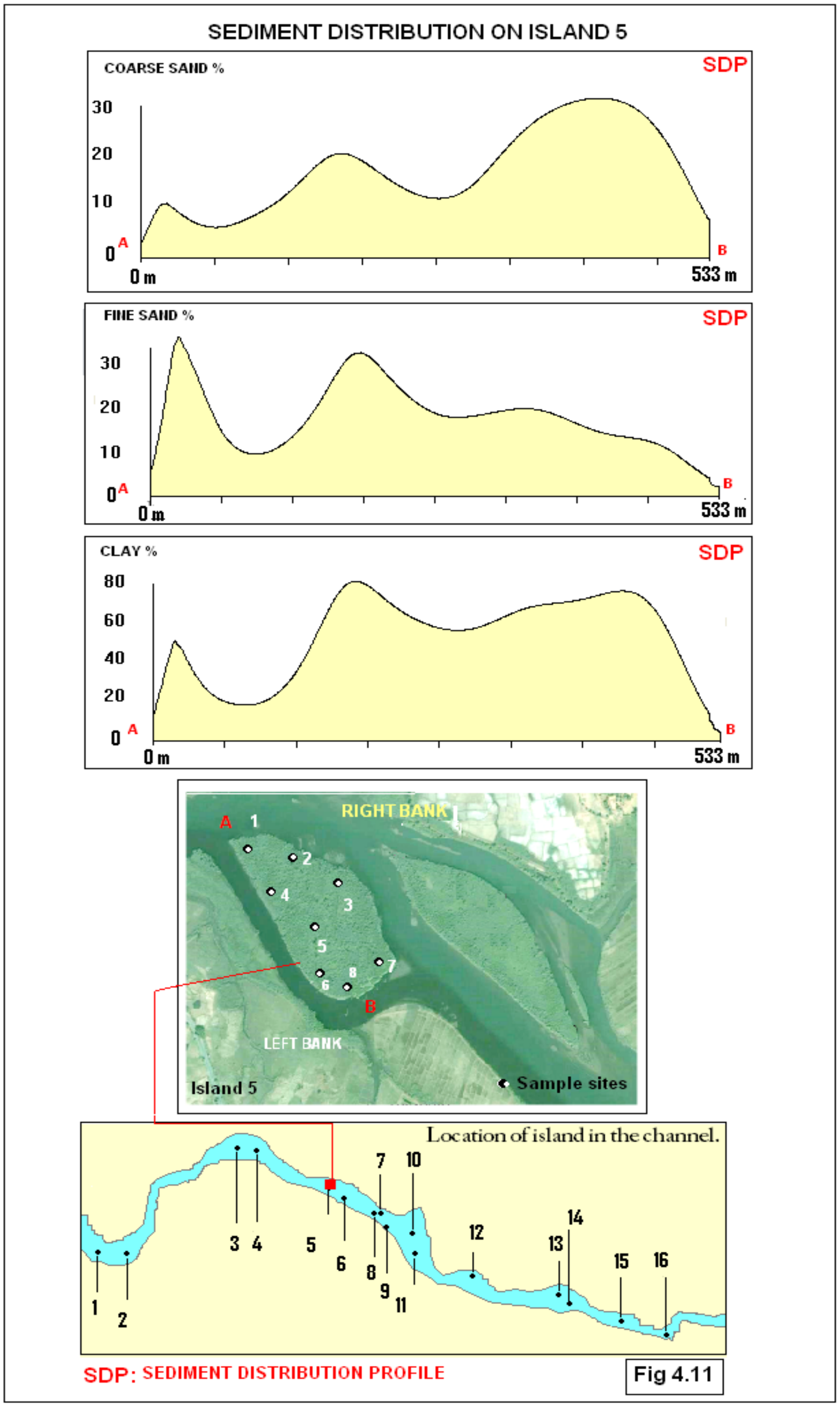
Table 4.13: Sediment Distribution on Island 5

Sample site	C.S.% (2 to .064 mm)	F.S.% (.063 to .002mm)	Clay % (>. 002 mm)
1	10.3	39.1	50.6
2	15.4	14.5	70.1
3	12.3	7.6	80.1
4	15.3	24.6	60.1
5	10.8	19.1	70.1
6	18.3	13.3	68.4
7	20.3	14.4	65.3
8	21.4	8.5	70.1
Avg.	15.51	17.64	66.85
Std.dev	4.23	10.24	8.63
S.k	0.14	1.47	- 0.64
C.V.	0.29	0.58	0.001

Table 4.14: Sediment Distribution 0n Island 6

Table 4.14: Sediment Distribution on Island 6

Sample Site	C.S.% (2 to .064 mm)	F.S.% (.063 to .002 mm)	Clay% (>. 002 mm)
1	12.3	17.2	70.5
2	15.4	4.5	80.1
3	20.5	39.4	40.1
4	25.4	35.1	30.4
5	26.2	43.3	39.5
6	30.4	35.2	30.5
7	32.5	32.1	34.4
8	35.0	32.9	35.4
Avg.	24.71	29.96	45.11
Std.dev.	8.11	12.79	19.14
Sk	- 0.37	- 1.37	1.37
C.V.	0.33	0.43	0.42



SEDIMENT DISTRIBUTION ON ISLAND 5
COARSE SAND %
SDP
30
20
10
0
A
B
0 m
533 m
FINE SAND %
SDP
CLAY %
SDP
80
60
40
RIGHT BANK
LEFT BANK
Island 5
Sample sites
Location of island in the channel.
SDP: SEDIMENT DISTRIBUTION PROFILE

Fig 4.11

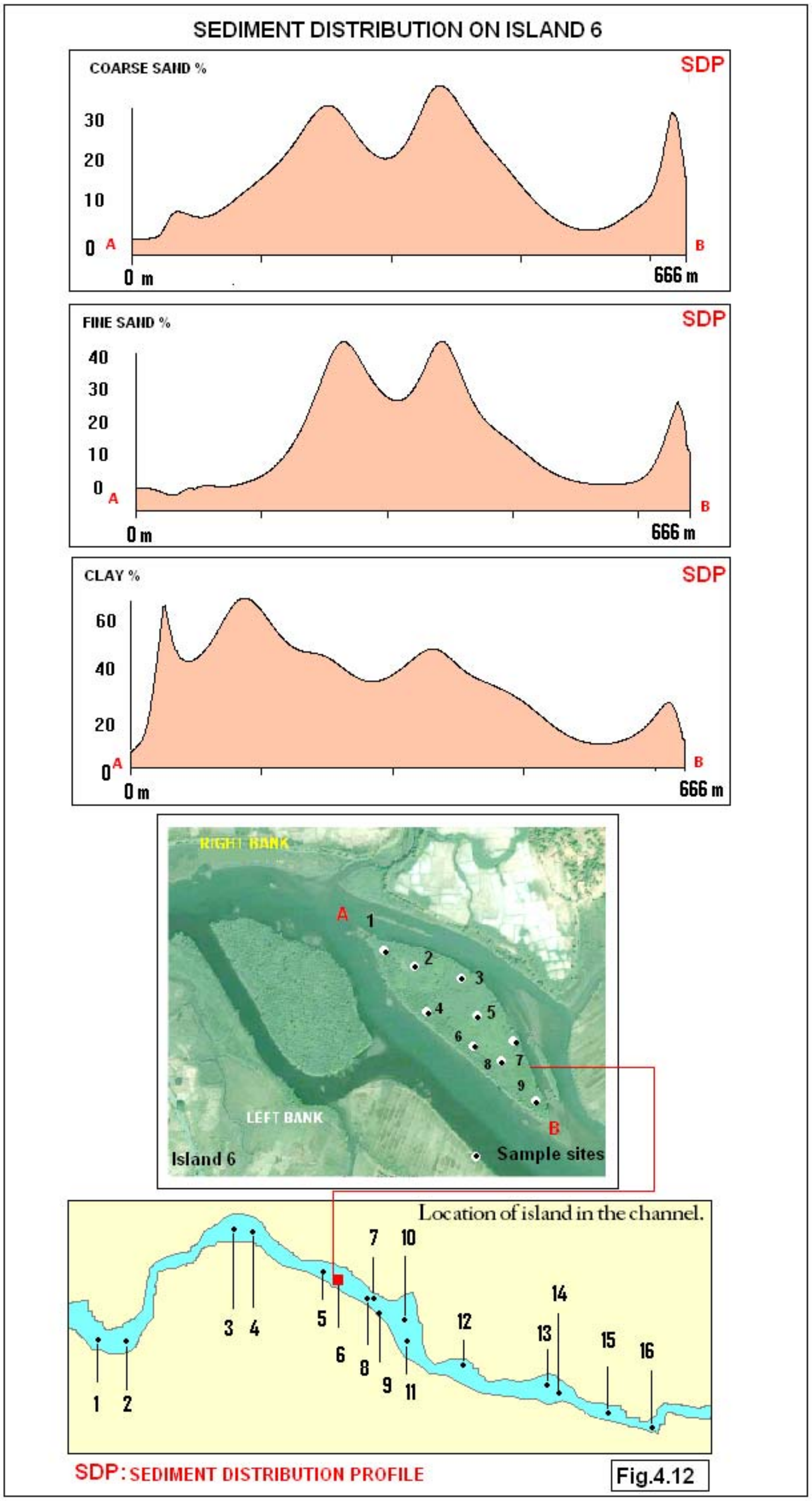
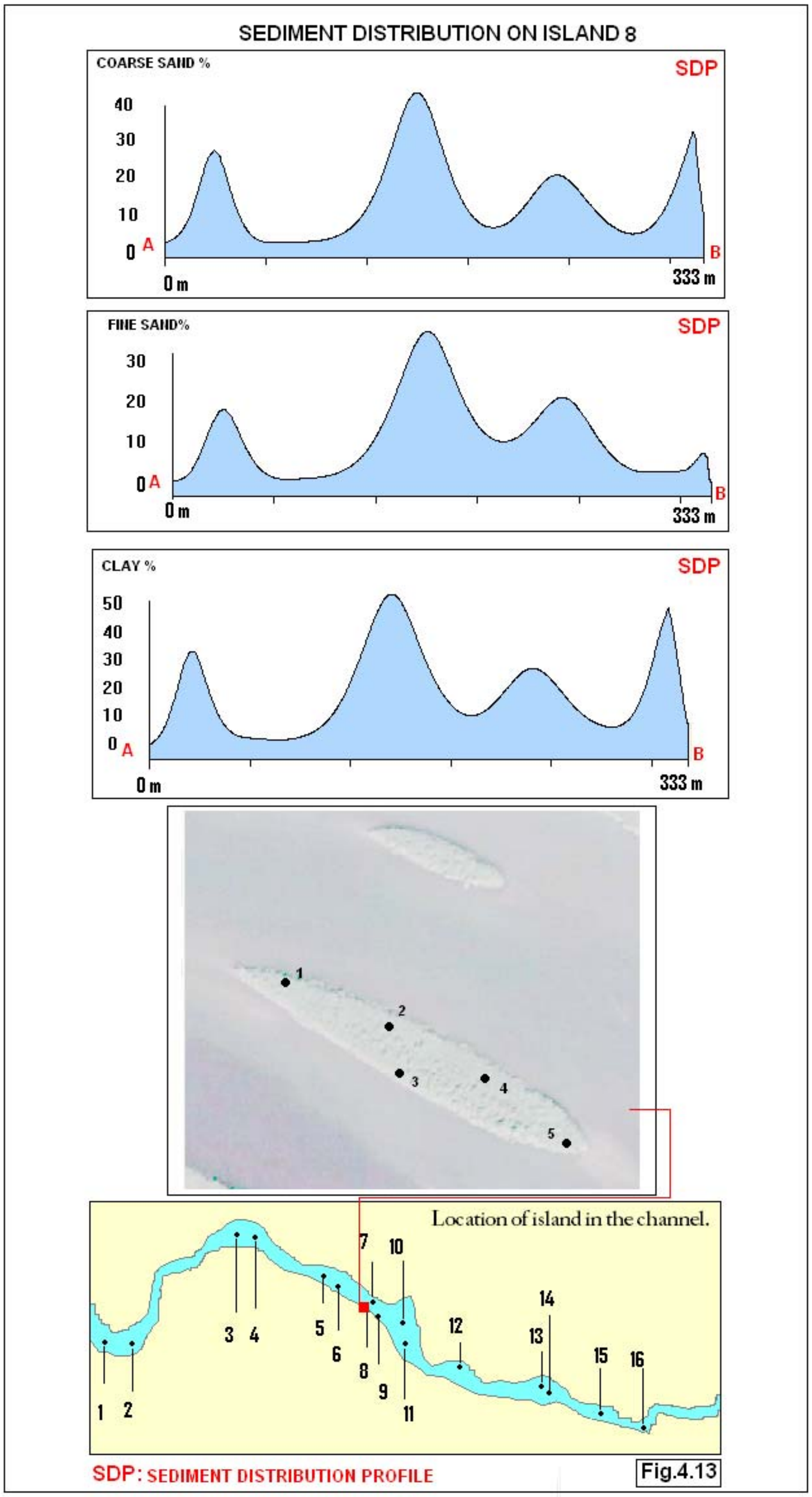

SEDIMENT DISTRIBUTION ON ISLAND 6
COARSE SAND %
SDP
30
20
10
0
A
B
0 m
666 m
FINE SAND %
SDP
40
30
20
10
0
A
B
0 m
666 m
CLAY %
SDP
60
40
20
0
A
B
0 m
666 m
RIGHT BANK
LEFT BANK
Island 6
Sample sites
A
B
1
2
3
4
5
6
7
8
9
Location of island in the channel.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
SDP: SEDIMENT DISTRIBUTION PROFILE
Fig.4.12

Table 4.15: Sediment Distribution on Island 8

Sample Site	C.S.% (2 to .064 mm)	F.S.% (.063 to .002mm)	Clay % (>.002 mm)
1	32.1	27.8	40.1
2	33.4	27.3	39.3
3	35.4	24.3	40.3
4	30.1	32.1	37.8
5	33.3	18.6	48.1
AVG.	32.86	26.02	41.12
Std.dev	1.94	4.99	4.02
S.k	- 0.27	- 0.6	1.89
C.V.	0.06	0.19	0.09

Table 4.16: Sediment Distribution on Island 10

Sample site	C.S.% (2 to .064 mm)	F.S.% (.063 to .002 mm)	Clay% (>.002mm)
1	10.3	39.4	50.3
2	12.4	27.2	60.4
3	14.5	37.2	48.3
4	16.3	33.4	50.3
5	18.4	29.2	52.4
6	20.4	19.3	60.3
Avg.	15.38	30.95	53.66
Std.dev.	3.76	7.34	5.34
Sk	- 0.02	- 0.59	0.72
C.V.	0.24	0.24	0.09



SDP: SEDIMENT DISTRIBUTION PROFILE

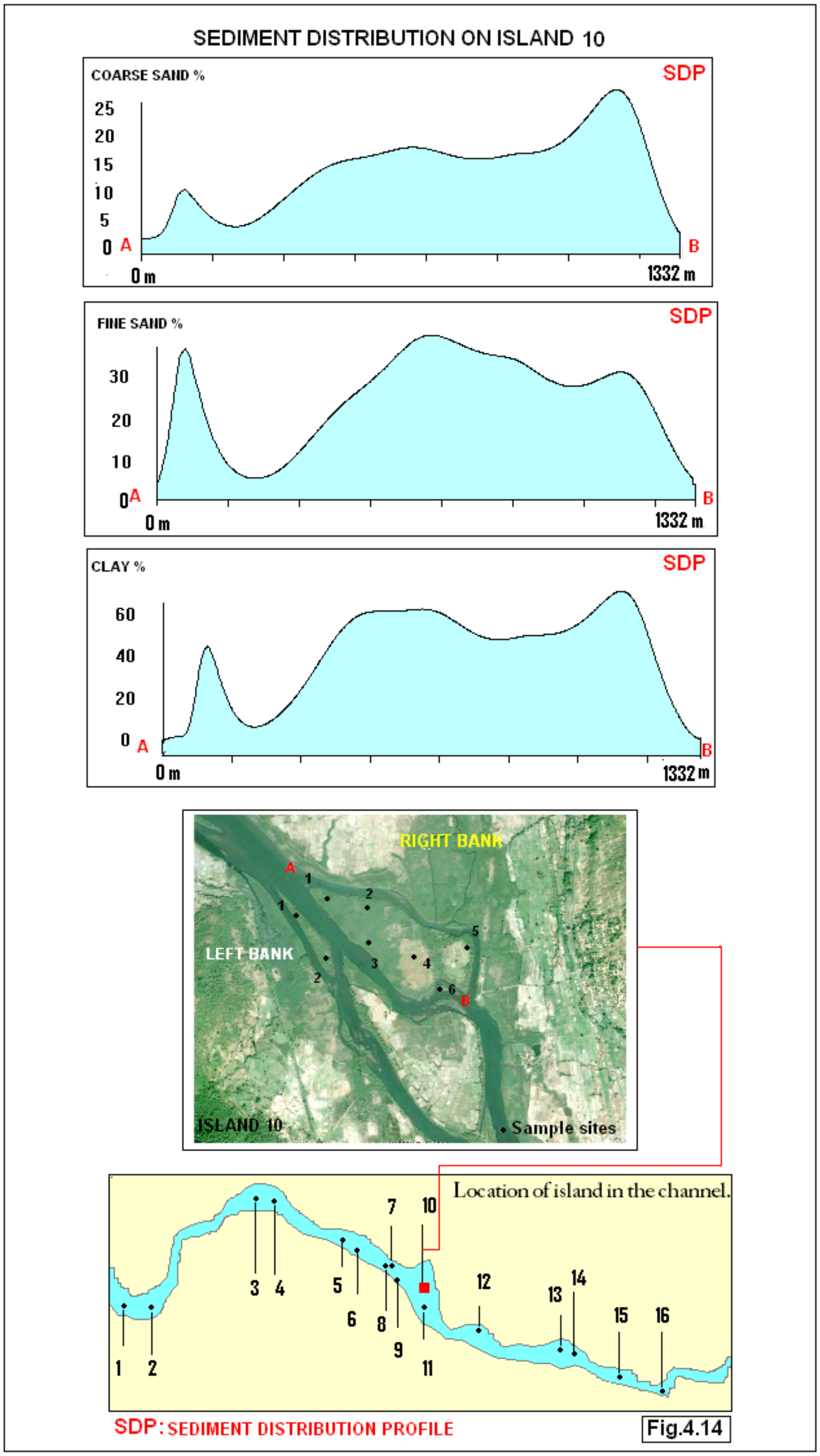
Fig.4.13

Table 4.17: Sediment Distribution on Island 11

Sample site	C.S.% (2 to .064 mm)	F.S.% (.063 to .002mm)	Clay % (>. 002 mm)
1	09.3	42.5	48.2
2	07.4	47.3	45.3
3	11.4	48.0	40.6
4	15.4	42.2	42.4
5	18.3	33.4	48.3
6	20.4	30.4	40.2
7	22.7	27.0	50.3
8	10.1	34.5	55.4
Avg.	14.36	38.16	47.48
Std.dev	05.65	07.89	04.67
S.k	0.30	- 00.58	00.12
C.V.	0.3977	00.21	00.09

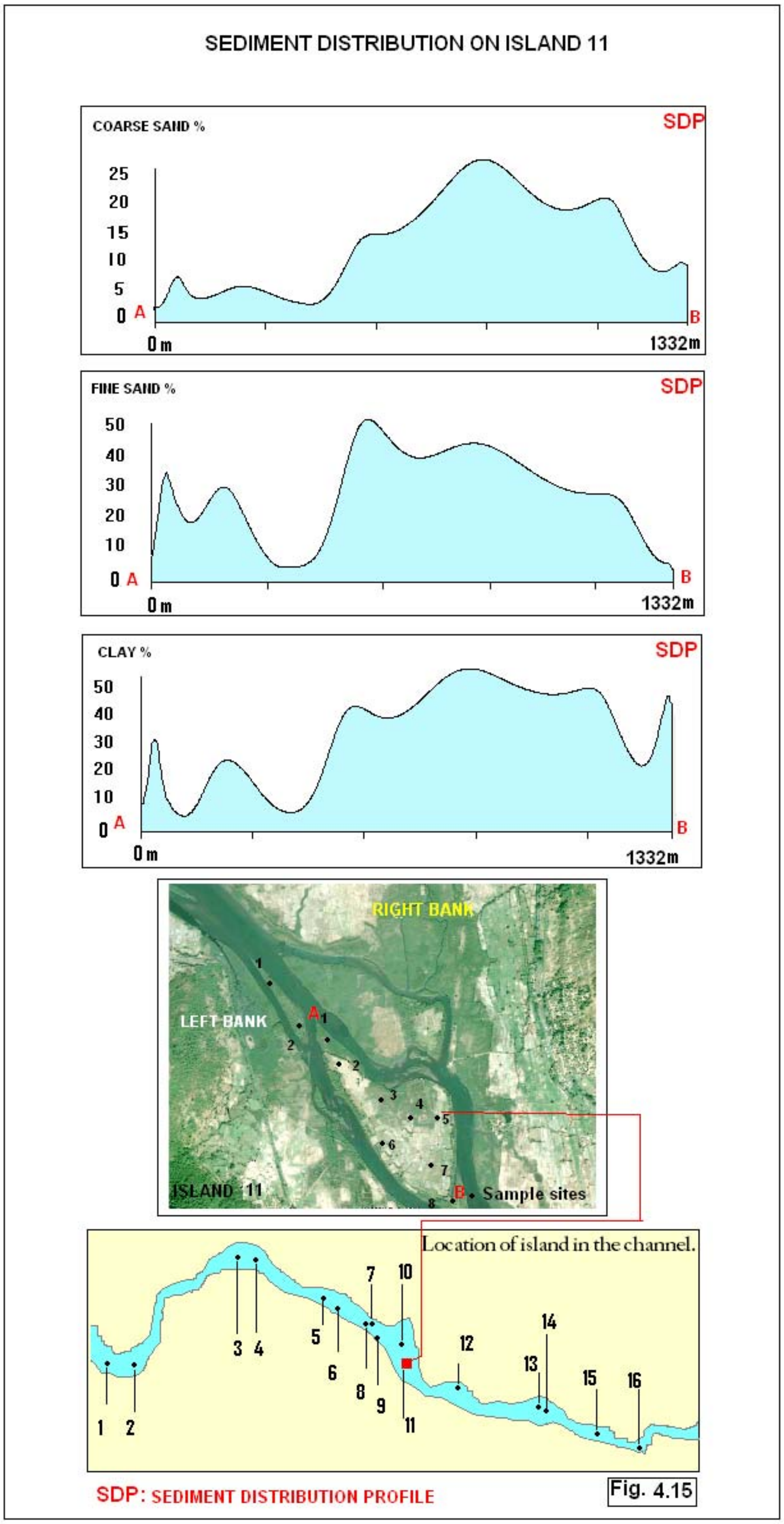
Table 4.18: Sediment Distribution on Island 12

Sample site	C.S.% (2 to .064 mm)	F.S.% (.063 to .002 mm)	Clay% (>.002 mm)
1	29.2	60.4	10.4
2	28.3	59.4	12.3
3	34.0	50.3	15.7
4	27.9	55.3	16.8
5	19.5	60.3	20.2
6	18.3	70.4	11.3
7	18.3	69.3	12.4
8	30.3	59.4	10.3
9	39.2	50.4	10.4
10	31.2	58.3	10.5
11	25.3	62.4	12.3
12	29.0	60.5	10.5
Avg.	27.54	59.7	12.78
Std.dev.	06.36	06.12	03.17
Sk	- 00.07	00.19	01.5
C.V.	00.23	00.1	00.25



SEDIMENT DISTRIBUTION ON ISLAND 10
COARSE SAND %
SDP
25
20
15
10
5
0
A
B
0 m
1332 m
FINE SAND %
SDP
30
20
10
0
A
B
0 m
1332 m
CLAY %
SDP
60
40
20
0
A
B
0 m
1332 m
RIGHT BANK
LEFT BANK
ISLAND 10
Sample sites
Location of island in the channel.
SDP: SEDIMENT DISTRIBUTION PROFILE

Fig.4.14


SEDIMENT DISTRIBUTION ON ISLAND 11
COARSE SAND %
SDP
25
20
15
10
5
0
A
B
0 m
1332m
FINE SAND %
SDP
50
40
30
20
10
0
A
B
0 m
1332m
CLAY %
SDP
50
40
30
20
10
0
A
B
0 m
1332m
RIGHT BANK
LEFT BANK
ISLAND 11
Sample sites
Location of island in the channel.
SDP: SEDIMENT DISTRIBUTION PROFILE
Fig. 4.15

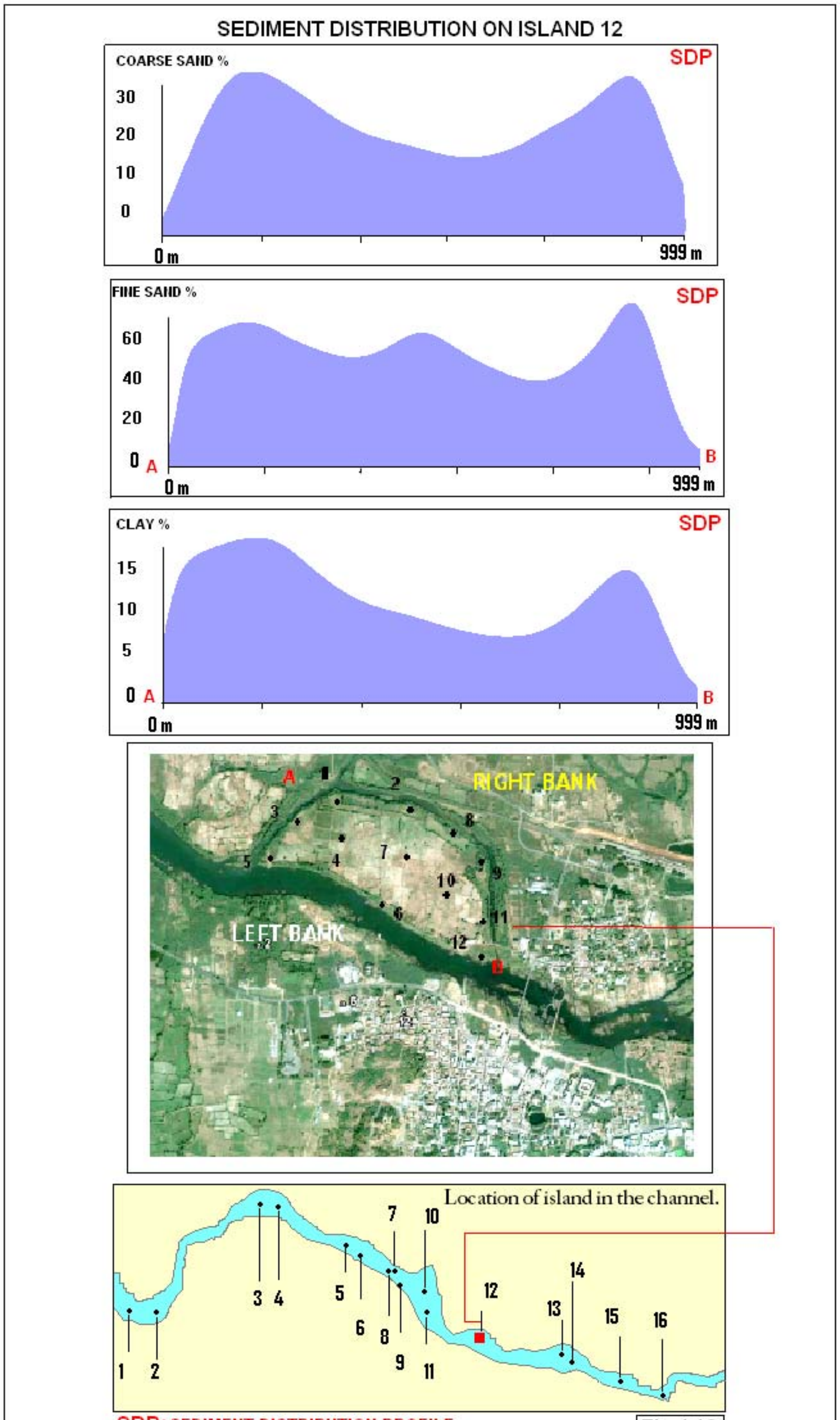
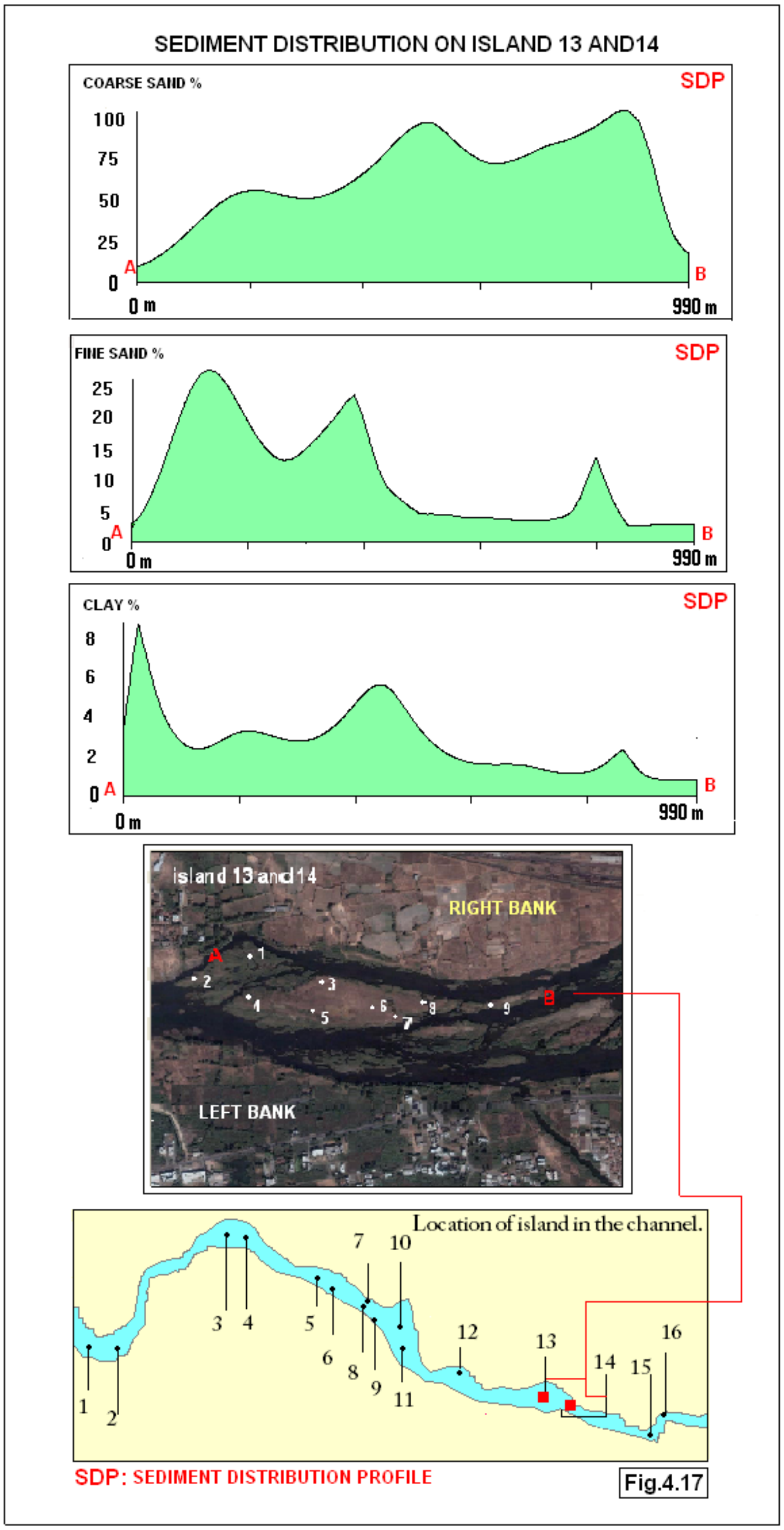

SEDIMENT DISTRIBUTION ON ISLAND 12
COARSE SAND %
SDP
30
20
10
0
0 m
999 m
FINE SAND %
SDP
60
40
20
0
A
B
0 m
999 m
CLAY %
SDP
15
10
5
0
A
B
0 m
999 m
A
RIGHT BANK
LEFT BANK
B
Location of island in the channel.
SDP: SEDIMENT DISTRIBUTION PROFILE

Fig.4.16

Table 4.19: Sediment Distribution on Island 13 and 14

Sample Site	C.S.% (2 to .064 mm)	F.S.% (.063 to .002mm)	Clay % (>.002 mm)
1	50.8	40.1	9.1
2	60.3	30.8	8.9
3	70.4	25.1	4.5
4	80.3	18.3	1.4
5	89.3	10.1	0.6
6	90.3	8.3	1.4
7	95.1	3.4	1.5
8	85.3	12.4	2.3
Avg.	77.73	18.56	3.71
Std.dev	15.77	12.54	3.46
S.k	- 00.78	0.64	1.04
C.V.	00.2	0.67	0.93



SEDIMENT DISTRIBUTION ON ISLAND 13 AND14
COARSE SAND %
SDP
100
75
50
25
0
A
B
0 m
990 m
FINE SAND %
SDP
25
20
15
10
5
0
A
B
0 m
990 m
CLAY %
SDP
8
6
4
2
0
A
B
0 m
990 m
island 13 and 14
RIGHT BANK
LEFT BANK
A
B
Location of island in the channel.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
SDP: SEDIMENT DISTRIBUTION PROFILE

Fig.4.17

Range of sediments on each island:

The average amount of sediment in each island is shown in **Table 4.20.** From this it is seen that island 1,2,13 and 14 are coarse sand islands. Island 3, 5 and 10 can be called as ‘Clay islands’. Island 4 and 11 show more or less equal percentage of sand and clay and hence they are Sandy Clayey islands. Island 6 and 8 are coarse, fine sand islands. They show 55.0 to 60% of coarse sand and remaining of clay%. Island 12 shows more percentage of fine sand. So this is designated as ‘Fine sand island.

Island 15 and 16 are ‘Rock islands’ as they are rocky in nature. It is clearly seen from **Table 4.20** that island types are recognized on the basis of average amount of sediments constituting these islands. **(Fig. 4.18)**

Since the sediment samples collected from all the islands were unequal in size, the coefficient of variation (CV = $\sigma / \bar{x}$) was calculated for all the samples. The C.V is effectively used to compare the variation in data sets. It can be seen from the values of C.V. that the C.V. is higher for all fine sand fraction, except for island 11 and 12 where variation is more in coarse sand fraction.

The clay fraction on island 5 hardly shows any variation in the proportion of clay. (CV = 0.001), same is the case with island 8, 10 and 11 where C.V. is 0.09**. Fig.4.18 and Table 4.21** show island types on the basis of average amount of sediments on each island.

Preferred locations for settling of sediments:

From this it is clear that the coarse sand, fine sand and clay is deposited on all these islands at preferred locations. These locations are dictated by velocity and direction of tidal currents and also the type of sediment.

Coarse sand has a large grain size. The areas dominated by coarse sand are due to winnowing of clay and fine sand from it by strong tidal currents. Due to strong low tide currents in lower region of the middle sector island 1 and 4 show more concentration of coarse sand on their downstream edges. Fine sand and clay moves easily with high tide and settles where velocity of current is less.

Table 4.20 Range of sediments on each Island (%)

Island No.	Coarse sand	Fine sand	Clay	Type
'A'	MUD ISLAND			
1	**40-80**	4.3-29	10-40	Coarse Sand
2	**51-83**	2.5-16.30	08-42	Coarse Sand
3	30-56	2.6-10.00	**40-60.4**	Clay
4	**30-50**	2.1-10.00	**30.7-60.4**	Sandy Clayey
5	10.3-21.4	7.6-39.0	**50.6-70.0**	Clay
6	12.3-15	**4.5- 43.0**	**30.5-80.0**	S.C (Coarse- Fine)
8	**15.4-30.1**	18.6-27.8	**37-40**	S.C (Coarse-Fine)
10	10.3-20.4	19.0-39.4	**48.0-60.4**	Clay
11	7.4-22.7	**27- 48**	**40.6-55**	Sandy Clayey
12	**18.3-39.2**	**50.3-70.4**	10.3-20.0	Fine Sand
13 and 14	**50-95**	3-40	1.4-9.1	Coarse Sand

- C.S.: Sand island with dominance of coarse sand (50-95)
- S.C.: Sandy-clayey island
- F.S.: Sand island with dominance of Fine sand (50-70)
- Clay: Clay island (30-80)

(Samples could not be taken from Island 7 and 9 due to their small sizes)

ISLAND TYPES ON THE BASIS OF AVERAGE AMOUNT OF SEDIMENTS (%)

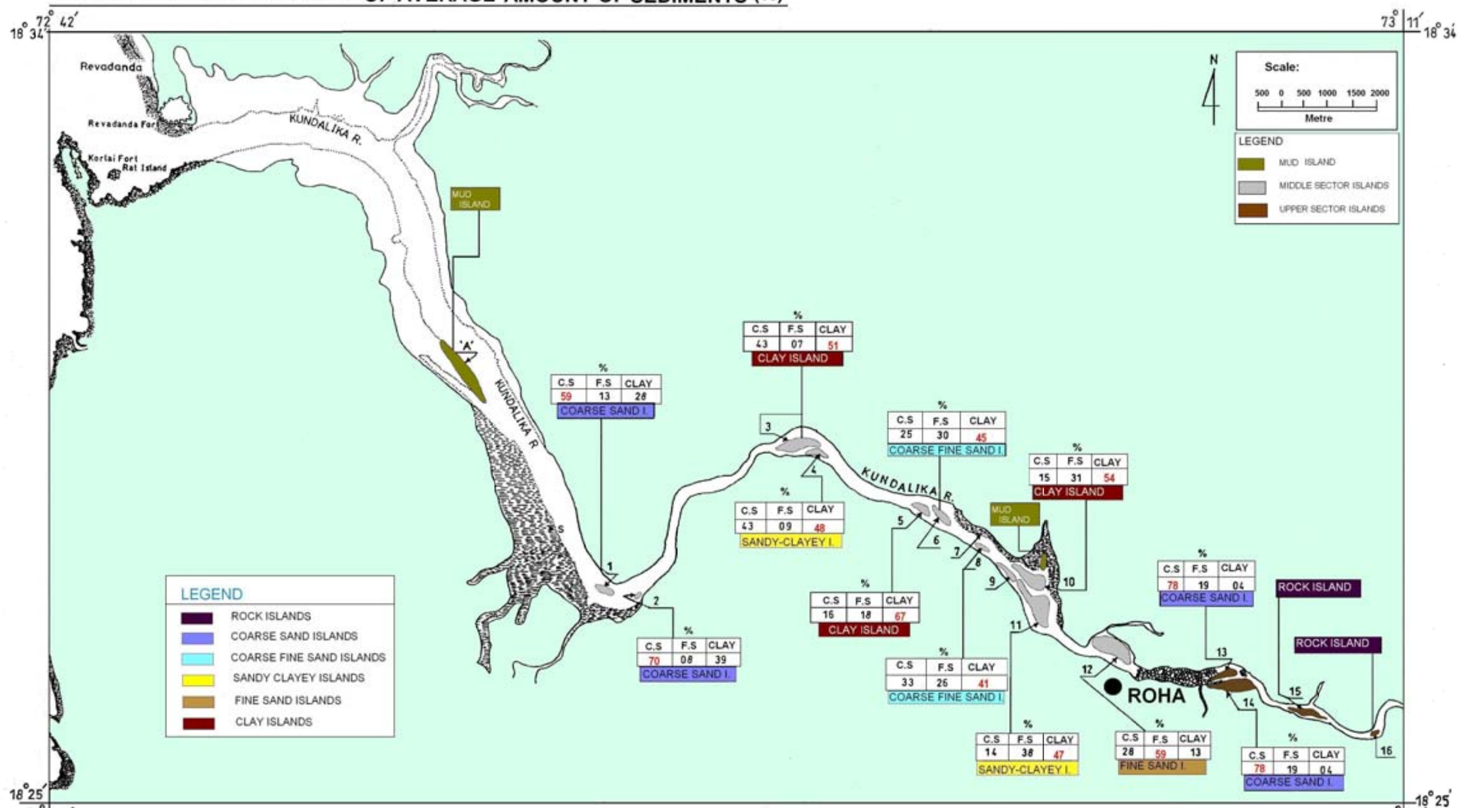


Fig.4.18

Table 4.21 Island types on the basis of average amount of sediments

Island No.	Coarse sand	Fine sand	Clay	Island Type	Specific Type
'A'	Mud Island			Mud Island	Mud
1	59.4	12.88	27.73	Sand Island	Coarse Sand
2	70.1	8.34	39.22	Sand Island	Coarse sand
3	42.92	6.84	51.23	Clay Island	Clay
4	43.08	9.35	47.56	Sandy Clayey	Sandy Clay
5	15.51	17.65	66.85	Clay Island	Clay
6	24.71	29.96	45.11	Sandy Clayey	Coarse Fine
8	32.86	26.02	41.12	Sandy Clayey	Coarse Fine
10	15.38	30.95	53.66	Clay	Clay
11	14.37	38.16	47.46	Sand Island	Sandy Clay
12	27.54	59.17	12.76	Sand Island	Fine Sand
13 and 14	77.42	18.56	3.71	Sand Island	Coarse Sand
15	-----------	------------	------	Rock Island	-----------------
16	------------	------------	-------	Rock Island	-----------------

Clay is found to be deposited more preferentially and in greater amounts on the downstream part of islands. These are the general patterns in preferred location. Fine sand, coarse sand and clay can get deposited in other areas of islands also according to change in energy level and morphology of islands.

Table 4.22 shows various areas on islands preferred by sediments, for settling. Preferred locations were identified from (**Fig.4.7 to Fig.4.17)** showing distribution of sediments on each island **Fig.4.7and Table 4.9** shows that maximum amount of coarse sand 80.2 % is found in sample 1 located near down stream region of island (seaward), whereas maximum clay is found in sample 9 on same island, located in the upstream direction.

Up creek variation in sediments on island clusters:

As explained earlier all the islands in the study area are grouped as clusters in B, C, D, E, and F groups. Group 'A' comprises of only one island, which is a mud island, where samples could not be collected.

Sediment properties such as mean grain size, Std. deviation and skewness are discussed earlier. The variation in proportion of coarse sand, fine sand and clay, on each island is also discussed. The variation in amount of sand and clay in groups or clusters of islands is given in **Fig.4.19.**

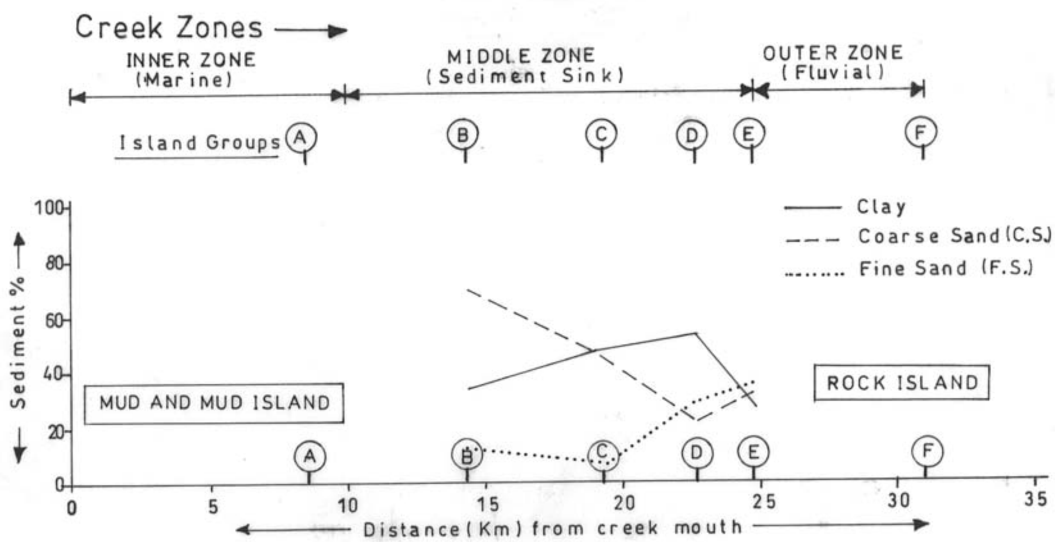
It can be seen from the **(Fig.4.19)** that the amount of coarse sand rapidly decreases from inner zone boundary islands to middle area of the sink zone. Hereafter it increases again. Fine sand decreses till 19 km distance and then increases slowly. Clay increases up to a distance of 20 km inland.

As regards the sorting of sediments in grouped islands **Fig.4.20** shows that coarse sand is less consistently distributed on group 'B' islands and well distributed on group 'D' islands. Clay distribution is poor on 'D' group islands there by suggesting the irregular deposition of clay (Tucker, 1988).

Fig.4.21 gives variations in skewness. Coarse sands on all islands are negatively skewed. Fine sands on group 'D' and 'E' islands are negatively skewed.

The negative skewness suggests the inability of tidal currents to move the coarser grains from specific locations. Thus the island groups in the creek show specific tendencies in the depositional environment. The distributional patterns in coarse and fine sand and clay give sediment-settling tendencies on these islands.

UPCREEK VARIATION IN PROPORTION OF SEDIMENTS ON ISLANDS



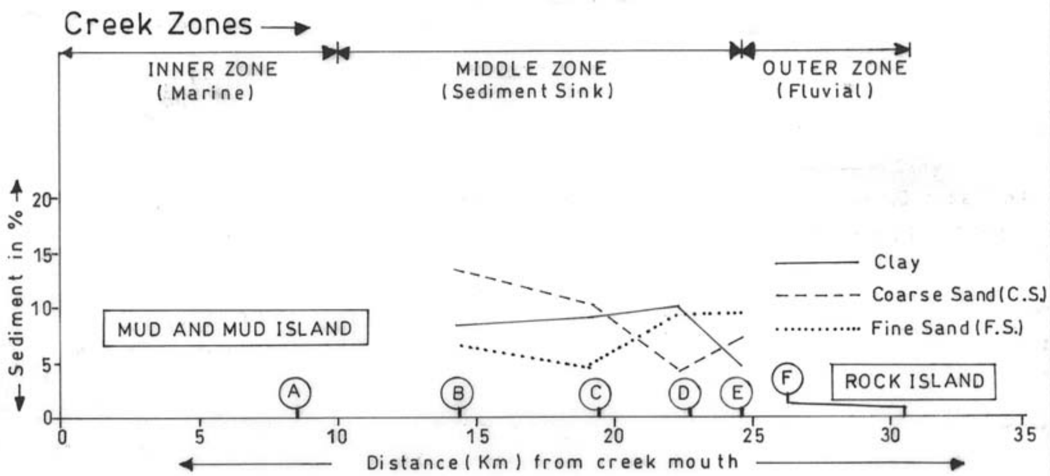
Proportion of Sediments on Islands

Distance from creek mouth (km)	Island Groups	C.S %	F.S %	Clay %	Island No.
8·5	A	M U	D I S	L A N	D
14·25	B	64·74	11·54	33·47	(1,2)
19·15	C	43·00	08·09	49·39	(3,4)
22·62	D	21·41	26·44	52·17	(5,6,7,8)
24·86	E	33·75	36·84	29·39	(9,10,11,12)

Fig. 4·19

113

VARIATION IN SORTING (STANDARD DEVIATION) OF SEDIMENTS ON ISLANDS



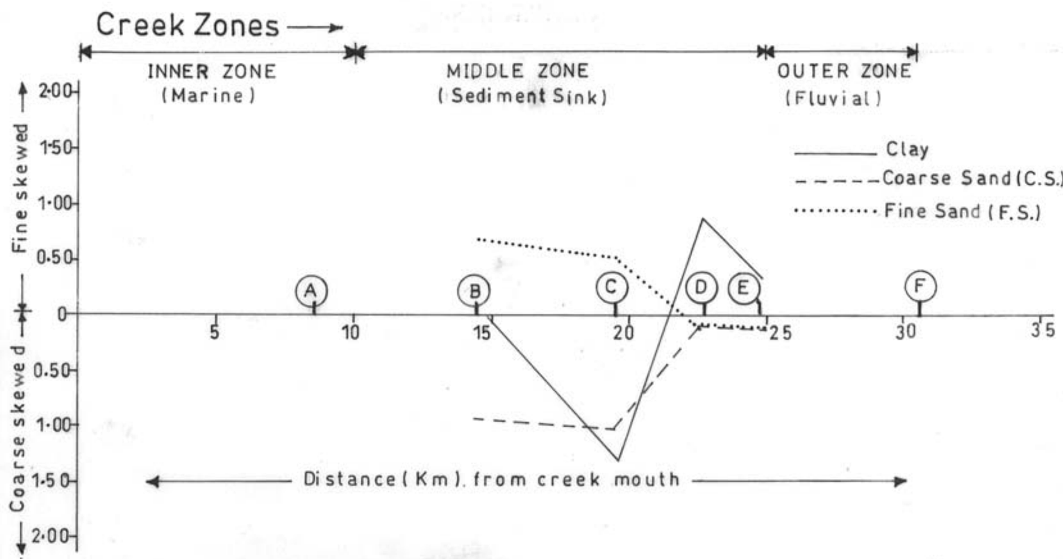
Standard Deviation of Sediments

Distance from creek mouth (km)	Island Groups	C.S	F.S	Clay	Island No.
8·5	A	M U	D I	S L A	N D
14·25	B	13·37	06·03	07·71	(1, 2)
19·15	C	09·66	04·58	08·88	(3,4)
22·62	D	04·18	08·12	09·17	(5,6,7,8)
24·86	E	07·88	08·47	04·16	(9,10,11,12,13 14)

Higher values of Std.dev. mean less consistantly distributed around mean and low values mean, more consistantly and well distributed around mean.

Fig. 4·20

VARIATION IN SKEWNESS OF SEDIMENT DISTRIBUTION ON ISLANDS



SKEWNESS OF SEDIMENT ON ISLANDS

Distance from creek (Km)	Group	C.S.	F.S.	Clay	Islands
8·5	A	M U	D I S	L A N	D
14·25	B	−0·96	0·63	00·03	(1,2)
19·15	C	−1·01	0·51	−1·25	(3,4)
22·62	D	−0·166	−0·16	0·87	(5,6,7,8)
24·86	E	−0·288	−0·20	0·39	(9,10,11,12)

Fig. 4·21

It can be therefore concluded that the islands in group D at 23 km (22.62 km) distance are more clayey, where clay is less consistently distributed. Clay distribution in these islands is highly positively skewed. Islands in group 'B' and 'C' are sandy. Here also sand is irregularly distributed on the islands.

Table 4.22 Preferred areas for deposition of coarse sand, fine sand and clay.

Island No.	Upstream edge	Left Bank	Right Bank	Downstream edge	Mid stream Edge
1	29.0,40.6	-	-	80.2	-
2	-	-	82.3,16.30	-	42.1
3	-	-	10.1	60.4	56.1
4	-	-	-	50.4	21.0,60.4
5	-	21.4	-	-	39.0
6	35.0	-	-	80.1	43.0
8	48.1	35.4	32.1	-	-
10	20.4	-	-	39.4	60.4
11	22.7,55.4	-	48.3	-	-
12	39.2	70.4	-	20.2	-
13 and 14	40.1	95.1	9.1	-	-
(Coarse sand, Fine sand, Clay- Amount in percent)					

CHAPTER 5
VEGETATION ON ISLANDS OF KUNDALIKA

CHAPTER 5

VEGETATION ON ISLANDS OF KUNDALIKA

A variety of plants are found on the islands in study area but mangroves are one of the most frequent forms of vegetation that occur in inter tidal zones along Kundalika River up to Roha.

Mangroves are highly productive eco-systems and are a natural renewable resource also. The mangrove environment is basically saline in nature. The vegetation grows and flourishes on islands coping with excess salt.

Mangroves occur in areas where strong wave actions are absent. The most extensive growth of mangroves can be seen in estuaries of rivers and protected lagoons and coastal lakes. Mangroves occur in areas of high humidity and their luxuriant growth is often associated with high rainfall.

The growth and development of mangroves occurs where the seasonal temperature variation does not exceed 10^{0}C. These species have aerial root systems called Pneumatophores. They are slender, spreading horizontally in every direction in the soil. The length of root is variable from less than 1 m to over 20 m depending on the tree size and age. The aerial roots of Pneumatophores are more in younger trees than in older trees, as big trees are aged and prone to be influenced and deformed by long-term external stresses *(Nakamura 2000).*

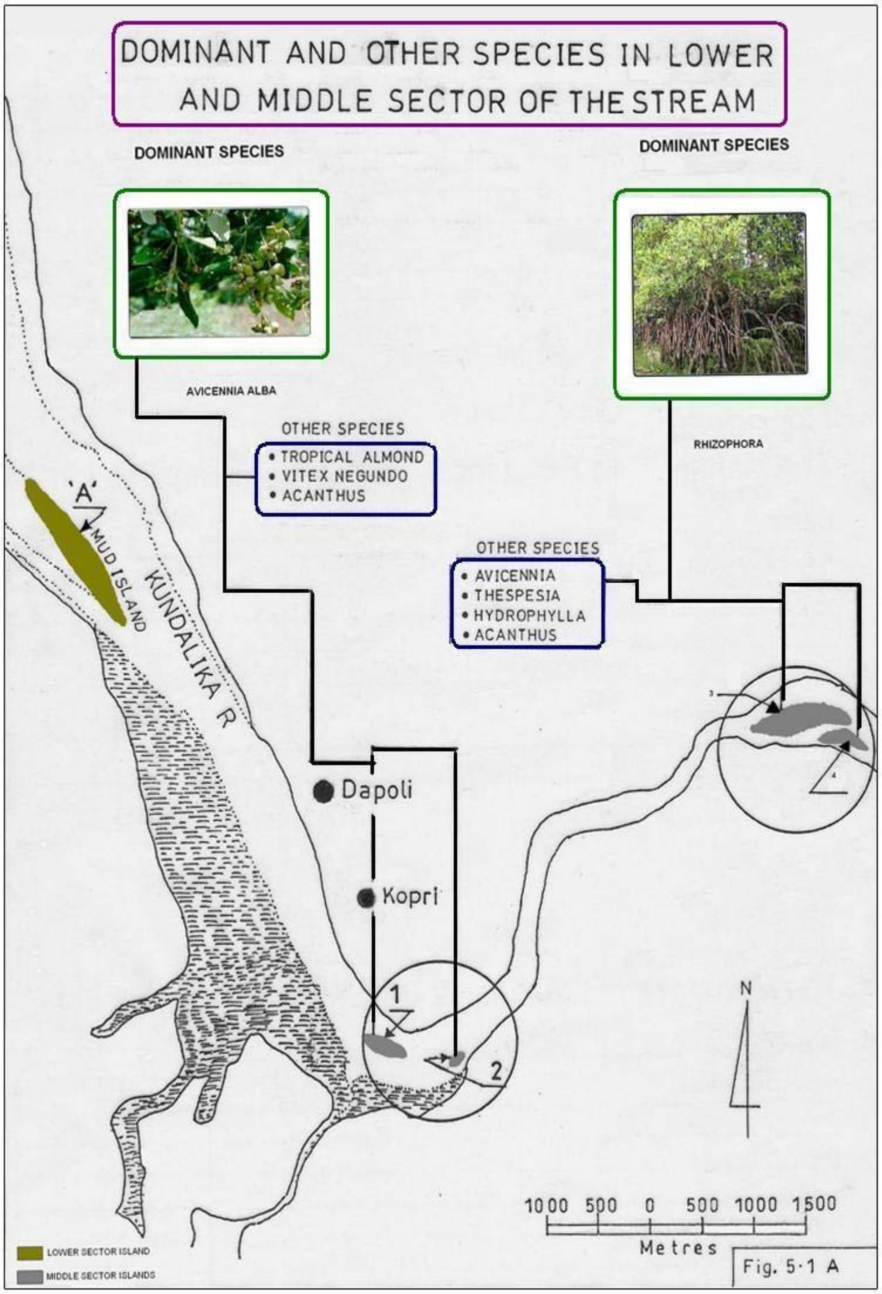
Mangrove substratum is characterised by high salt and water, low oxygen and high hydrogen sulphide content and contains a high proportion of humus. *(Macnae 1968)*. The best growth and development of mangrove takes place on muddy sediments, which are generally formed by deposition of water-borne, sediment particles. Many investigators believe that the roots and trunks of these species serves as sedimentary trap (weir). (Rhodes Fairbridge1968), which plays important role in the accretion of the islands from their left and right bank in the study area. Mangrove soils are mostly anoxic except for the surface layer in which their roots spread.

As a result mangrove generally have shallow root systems and cannot withstand strong winds and grow better in sheltered habitat on islands like one in the study area **(Fig 5.1A).** Seeds of Mangroves are dispersed by water and their distribution is therefore greatly influenced by tides, which carry them both upstream and downstream. The tidal range, together with the topography of an area regulates the lateral extent of mangroves development.

The tides also bring about change in the salinity concentration of water in mangrove areas. Mangroves have an efficient mechanism for natural regeneration, particularly in areas within mangroves where tidal water helps for deposition of waterborne sediment particles and due to this bed remains soft and always suitable for regeneration of mangroves. All the mangrove species produce buoyant seeds, which are dispersed by water and reach any corner of the creek. The deposition of silt by subsequent high tides helps the seeds or seedlings to secure a better substratum.

If seeds or seedlings drop during high tides they continue to float in the water until they come into contact with sediment substratum and strike roots if suitable saline conditions are available. Mangrove species are important for many uses. They can be used as fuel wood, as a thatching material, for construction, boat building, as a timber and as a source of tannin also.

The islands in the Kundalika creek show a variety of mangroves like Acanthus Ebracteatus (Black mangrove), Avicennia Officinalis (Grey Mangrove), Derris Trifoliata, Rhizophora Mucronata (Red mangrove), Avicennia Alba (Grey mangrove), Rhizophra Apiculata and Avicennia Maria.



DOMINANT AND OTHER SPECIES IN LOWER AND MIDDLE SECTOR OF THE STREAM
DOMINANT SPECIES
DOMINANT SPECIES
AVICENNIA ALBA
RHIZOPHORA
OTHER SPECIES
• TROPICAL ALMOND
• VITEX NEGUNDO
• ACANTHUS
OTHER SPECIES
• AVICENNIA
• THESPESIA
• HYDROPHYLLA
• ACANTHUS
'A'
MUD ISLAND
KUNDALIKA R
Dapoli
Kopri
1
2
N
1000 500 0 500 1000 1500
Metres
Fig. 5·1 A
LOWER SECTOR ISLAND
MIDDLE SECTOR ISLANDS

In addition to these other plant species like Ipomoea fistula, Triloba, Hygrophillia, Coix Lacryma-jobi, Mimosa pudica, Caesulia axlillaries, Pongamia pinnata, Polygonum glabrum, Terminalia, Phyllanthus reticulatus, Vitex Negundo, Thespesia, Saccharum, Crynum also grow on the islands and along the channel **(Fig.5.1 B, C).** The species, which are widely distributed on the islands in Kundalika mainly, include the following**.**

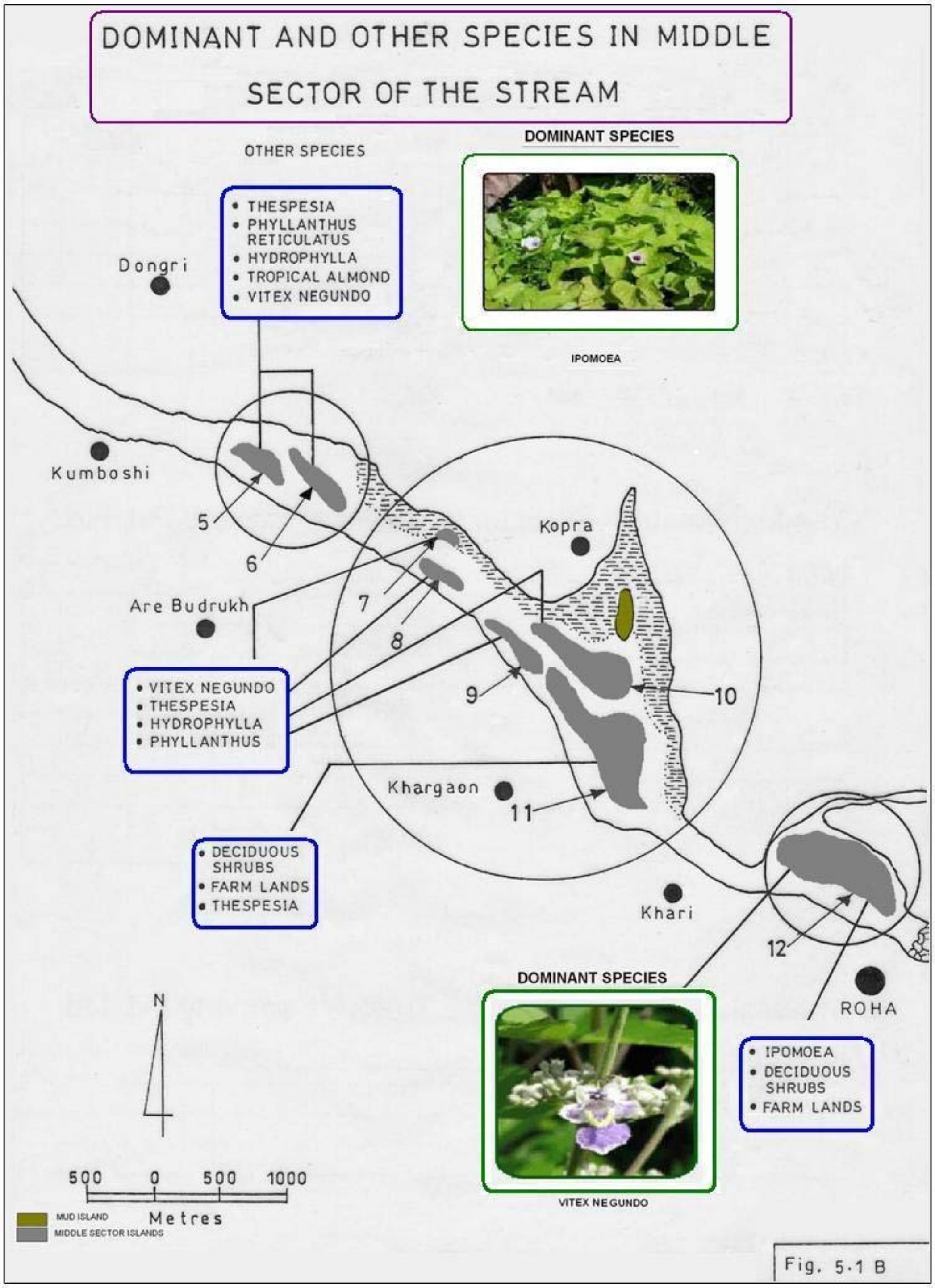
Dominant species found in Lower, Middle and upper sector of the stream:

1.Acanthus (Black Mangrove)/ Marandi:

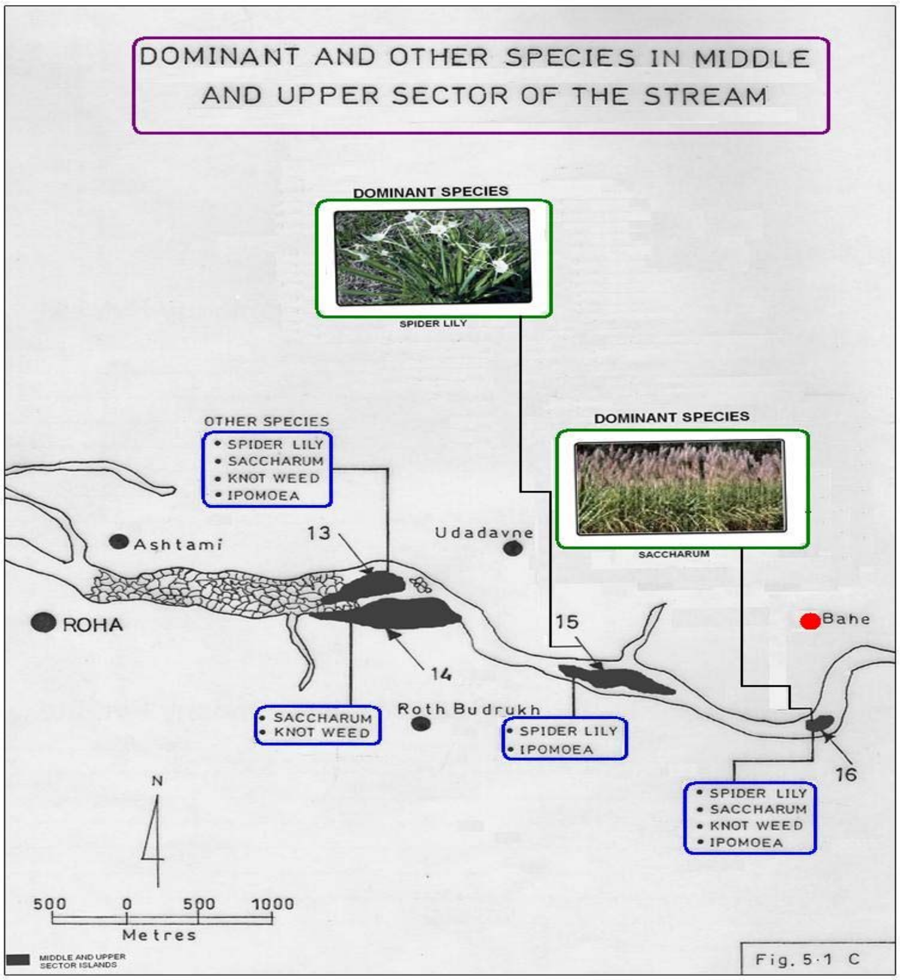
Acanthus is a variety of mangrove (Rhizophora). They are widely found in tropical tidal areas and can thrive in high degree of salinity. It is important and widely spread species in creek of Kundalika. The Acanthus is tolerant to tidal inundation and salinity. They protect coast from erosion and storms. Their root systems reduce the wave energy. The sediment is deposited with tidal incursion and is not re-suspended as the tide ebbs, except for fine particles.

As a result mangroves build their own environment. Because of the uniqueness of the mangrove ecosystems and their protection against erosion, they are often the objects of conservation programmes including national Bio-diversity Action Plans.

Wave energy is typically low or almost negligible in areas where mangroves grow. Mangroves support unique ecosystems especially on their intricate root systems. In areas where roots are permanently submerged, they may host a wide variety of organisms, including algae, barnacles, bryozoans, crabs which all require a hard substratum for anchoring themselves. Mangrove crabs improve the nutritional quality of the muds by mulching the mangrove leaves. The mangrove habitat also host several commercial important species of fish and crustacea.


DOMINANT AND OTHER SPECIES IN MIDDLE SECTOR OF THE STREAM
OTHER SPECIES
• THESPESIA
• PHYLLANTHUS RETICULATUS
• HYDROPHYLLA
• TROPICAL ALMOND
• VITEX NEGUNDO
DOMINANT SPECIES
IPOMOEA
Dongri
Kumboshi
Kopra
Are Budrukh
Khargaon
Khari
ROHA
5
6
7
8
9
10
11
12
• VITEX NEGUNDO
• THESPESIA
• HYDROPHYLLA
• PHYLLANTHUS
• DECIDUOUS SHRUBS
• FARM LANDS
• THESPESIA
DOMINANT SPECIES
VITEX NEGUNDO
• IPOMOEA
• DECIDUOUS SHRUBS
• FARM LANDS
N
500 0 500 1000
Metres
MUD ISLAND
MIDDLE SECTOR ISLANDS
Fig. 5.1 B

122


DOMINANT AND OTHER SPECIES IN MIDDLE AND UPPER SECTOR OF THE STREAM
DOMINANT SPECIES
SPIDER LILY
DOMINANT SPECIES
SACCHARUM
OTHER SPECIES
• SPIDER LILY
• SACCHARUM
• KNOT WEED
• IPOMOEA
Ashtami
13
Udadavne
ROHA
15
Bahe
14
• SACCHARUM
• KNOT WEED
Roth Budrukh
• SPIDER LILY
• IPOMOEA
16
• SPIDER LILY
• SACCHARUM
• KNOT WEED
• IPOMOEA
N
500 0 500 1000
Metres
MIDDLE AND UPPER SECTOR ISLANDS
Fig. 5·1 C

Acanthus grows on higher ground and makes many pneumatophores. These breathing tubes reach height of up to 30 cm and in some species over 3 meters. On the lower sector islands where the substratum is perpetually waterlogged, there is little free oxygen. Anaerobic bacteria liberates nitrogen gas, soluble iron, inorganic phosphates, sulphides and methane, which give pungent odour. Prop root systems of mangroves allow them to take up air directly from the atmosphere.

Acanthus is viviparous i.e. their seeds germinate while still attached to the parent tree. Once germinated the seedlings grow either within the fruit or out through the fruit to form a seedling ready to disperse. (Davies, 1972). When propagule is mature it drops into water where it can then be transported to over long distances. Propagule can survive desiccation (dry conditions) and remain dormant for weeks, months or even over a year until they arrive in a suitable environment. Once a propagule is ready to root, it changes its density so that the elongated shape can floats vertically rather than horizontally. In this position it is more likely to become logged in the mud and roots. If it does not root it can alter its density so that it floats off again in search of more favourable conditions.

2. Avicennia Alba (Grey Mangrove) (Tivar):

Avicennia Alba occurs in the intertidal zones of estuarine areas and has aerial roots of mangroves. Avicennia is one of the fast growing mangrove species and can attain height of more than 20 m. Therefore it is used in plantation to protect coastlines. It produces low quality firewood. It provides food for small creatures. It is locally abundant in the creek islands of Kundalika (Island 1, 2, 3 and 4)

3. Rhizophora Apiculata (Garjan):

Rhizophora Apiculata is a shrub and may attain height of 3 to 6 m. Rhizophora species generally live in inter-tidal areas, which are inundated daily by the saline tidal water. They show a number of adaption to this environment, including stilt roots that elevate the plant above the water and allow them to respire oxygen even while their lower roots are submerged. Rhizophora prefers deep soft mud and flooding by high tides. All these mangrove types are recorded on the creek islands in Kundalika. Their number and density varies from creek islands i.e from island ‘A’ mud island to island 11 in the study area.

Other vegetation types in the creek and Channel islands:

Besides the above mangrove species other species are found on the island 1 to island 16. They are as follows.

4. Pongamia pinnata (Karanj)

It is called as Indian beech tree. It is an important plant found in tidal zone in the creek of Kundalika. It is a deciduous plant commonly found in littoral forest in tropical and sub tropical lands. The species tolerate 27^0c to 38^0c maximum and 1^0c to 16 ^{0}c minimum range of temperature. It can thrive 500 mm to 2500 mm of rainfall conditions. The mature trees can withstand water- logging conditions.

Pongamia can grow on moist soil types ranging from stony to sandy and sandy to clayey soils. It can tolerate high saline water conditions. It can be easily grown in fresh or highly saline water conditions. It is commonly found along the river channel and creek islands of Kundalika. These species have a great environmental importance as they are planted against the soil erosion. As the dense network of lateral roots bind the sediment particles together and arrest the soil erosion.

5. Polygonum Glabrum (Gulabi):

Polygonum is commonly called as knotweed plant. It is a perennial herb found in tropical lands. It is commonly distributed along riverbanks, streamsides, and marshy areas and can be found from sea level to100 m of height. It can grow in moist soil and prefers light (sandy), medium (loamy) and heavy (clay) soils. It is well distributed on island ‘A’ (mud island) to island 16 in the study area.

6. Derris Trifoliata (Pan lata/Karanjvel):

Derris is the only common climber that grows in mangrove habitat. It is a creeper with woody stems.

Role in habitat: Like other climbers, Derris provides shelter for the smaller creatures of the mangroves. Plant also form an interlocking framework of its branches and makes canopy which gives strength in coastal storms.

7. Terminalia catappa (Jangali Badam):

Terminalia catappa is called Tropical Almond. It is commonly found in tropical lands and in coastal areas. It is a salt tolerant and grows in temperature conditions between 30^0 c to 40^o c. It grows up to 25 to 30 feet and can attain more height also. It is shade tolerant and hard wooded tree. The seeds of Tereminalia are dispersed by water. The corky fiber, which surrounds the nut, helps the fruit to float and germinate with suitable environmental conditions. The tree adapts medium or coarse textured sediments. It tolerates high amount of calcium carbonate in saline water. As well as it tolerates minimum 6 ph to maximum 7.5 ph conditions of soil.

Role in habitat: Various species of biting and stinging ants have been found inhabiting hollow twigs of the tree. While the tree provides these creatures a home. The ants in turn may protect the tree from insects predators.

8. Ipomoea Fistula (Besharam):

It is called Salt marsh morning glory vine. It is a perennial plant in tropical coastal areas and brackish swampy areas. These species are salt tolerant (Halophytic) species. The high alkaloid content makes this plant unpalatable. In the tidal zones of Kundalika creek, tides bring nutrients and due to this reason Ipomoea can establish all over the banks and islands in its channel especially all middle sector islands 1,2,3,4, 5, 6, 7, 8, 9, 10, 11, and 12.

Role in habitat: The flowers of Ipomoea attracts the pink spotted Hawk moth, butterflies and humming birds which shows this perennial vine plays an important role in the ecosystem on the islands of Kundalika.

9. Thespesia (Ran Bhendi /Jangli Bhendy):

Thespesia is called Indian Tulip tree. It is basically exist in tropical coastal lands. It grows luxuriantly on shores. The species grow on soils ranging from mildly alkaline to strongly acid with texture ranging from sandy loam to clay. It can be grown in 125 cms to 250 cms of rainfalls annually and tolerates temperature conditions 20^0c to 27^0c. The growth of this plant is fast. Within six months of span it attains the height of nearly 40 cms. The main feature of this plant is it always associates with mangrove habitat. The fruits and seeds are buoyant and adapted to long distance dispersal by the tides and ocean currents.

Role in habitat: This plant provides shelter and food to many creatures of the mangroves. It is commonly planted in coastal areas to minimize the wind speed.

10. Saccharum (*Jangli Uus/sugarcane):*

This weed is widely spread in the rocky islands especially Island 13, 14, 15 and 16 which are situated in the middle and upper stretch of the Kundalika river. It is an aquatic and terrestrial noxious weed. It may grow in a variety of soil types. The plant may grow in deep rich well-drained soils from sea level to 1600 meters. It requires moist climate and can tolerate atmospheric pollution. Saccharum is also commonly found on the islands, which are situated in the middle stretch of the Kundalika where the polluted water (effluent from nearby chemical industry) mixes with river water, near Roha in Raigad District.

11. Vitex Negundo (Nirgundi):

Vitex Negundo (Heterophylla) is called chaste tree. It is deciduous tree, which requires loose moist well-drained soil. It may attain height 10 to 15 feet and requires clayey, sandy or loamy slightly alkaline, acidic, well-drained soil. It may grow 1 m to 35 m tall. Vitex can tolerate hot weather, moderate salt air exposure and alkaline soils.

Role in habitat: Its lavender bloom attracts butterflies and bees.

12. Hygrophila (Ran Tevan):

Hygrophila is known as the temple plant. It is aquatic and semi aquatic plant called as amphibious herb. It is also called polysperma or swamp weed plant or marsh carpet. It requires tropical climatic conditions. It grows very fast in aquatic conditions. It has height of 25 cms to 40 cms. It can grow well in 18^0c to 30^0c temperatures. It tolerates water of 5 to 9 ph condition. It may be found in streams and in slow moving waters. This plant may grow in coarser soil or sediments on river islands of Kundalika. Without any nutrients hygrophila grows faster. The plant requires bright light for its growth. Stem fragments of hygrophila are able to develop new plants easily. The plant grows in deeper moving water as well as along the riverbanks. In the study area it is widely distributed along the channel and mostly on islands of Kundalika.

13. Coix Lacryma - Jobi:

It is a tall grain bearing tropical plant. Coix may grow in swampy places and near streams and tolerate the tidal inundation. It needs reasonably high rainfall of 1500 mm. Coix spreads very slowly in favourable environments. It is a perennial plant and can attained height of 1m to 2 m. The plant prefers light (sandy) medium, (loamy) and heavy (clay) soils. It can grow in very acidic soils having ph values ranging to 4.5 to 8.4. This tropical coix may grow in 9.6^0 c to 27.8^0c temperature conditions and can withstand temperature above 35^0c.

14. Crynum Oliganthum / (Bombay lily):

Crynum is also called spider lily. This plant is widely distributed on upstream rocky islands of Kundalika. Island 13, 14, 15, and 16 and along the channel itself where the water is purely fresh. Crynum plant has fleshy thick and elongated leaves. It has large and long lasting white flowers, which attract honeybees and many butterflies.

15. Phyllanthus Reticulatus:

Phyllanthus is a tropical deciduous shrub; throughout India it may occur either in deep water, wastewater places or along the streams and canals. Phyllanthus is spread along the channel of Kundalika and in the middle stretch islands i.e. Island 6, 7, 8, 9 and 10 of the study area. It commonly exists in the middle stretch where the soil is clayey and sandy in nature and water is brackish i.e. partly fresh and partly saline. This plant may attain the height of 4m to 6m and grows fast.

Some striking features of vegetation on islands:

Vegetation on the islands shows some striking features.**1.** Everywhere it is a mixed type of vegetation. Its growth is controlled by its location on the island **2.** Vegetation is not completely tidal. **3.** Islands in lower sector show mangrove as the main variety of vegetation and the islands in the upper sector consists of fresh water variety of vegetation and the islands in the middle sector invariably show brackish as well as fresh water varieties. The limit of the mangrove can be drawn up to “Khare” village, (24 km upstream) where a single occurrence of “Vitex Negundo” variety is recorded. In the lower islands however a variety of mangrove such as Rhizophora Apiculata, Avicennia Alba etc can be found.

Lower islands are dominated by mangroves. The other varieties which grow along with mangroves include Ipomoea, Hygrophila, Derris Trifoliata, Mimosa Pudica, Coix lacryma - jobi, Pongamia pinata, Terminalia, Phyllanthus Reticulatus, Thespecia, Saccharum, Blumia Terpenal, Crynum, etc. Satellite image of middle sector islands 1and 2 clearly shows thick vegetative cover on these creek islands**.** **(Fig 5.2A)** The islands are bordered by sand and silt which is exposed at low tide. Some islands especially island 3,6 and 10 show white barren patches without any growth of vegetation. In most of the cases these patches are saline in nature**. (Fig.5.2).**

Considering the complexity of the vegetation on the islands their boundaries could be demarcated by using an image analysis technique**.** The various boundaries thus obtained for some islands are shown in images of island (3 and 4) and island (9,10 and 11) in **(Fig. 5.3).** The digitally enhanced images can be used to identify the areas of reach growth, devoid of vegetation and the patches of scattered growth of vegetation.

Out of 17 islands, islands 9 to 11 located in middle sector of the creek are at a critical distance and at an inflextion point. Therefore they show a totally different pattern of sedimentation, morphology and vegetation growth. Vegetation found on the island tolerates high salt concentrations, periodical submersion and experience low and dry nutrient conditions. These islands are sandy clayey or clayey in nature.

THICK VEGETATIVE COVER ON ISLANDS IN THE CREEK

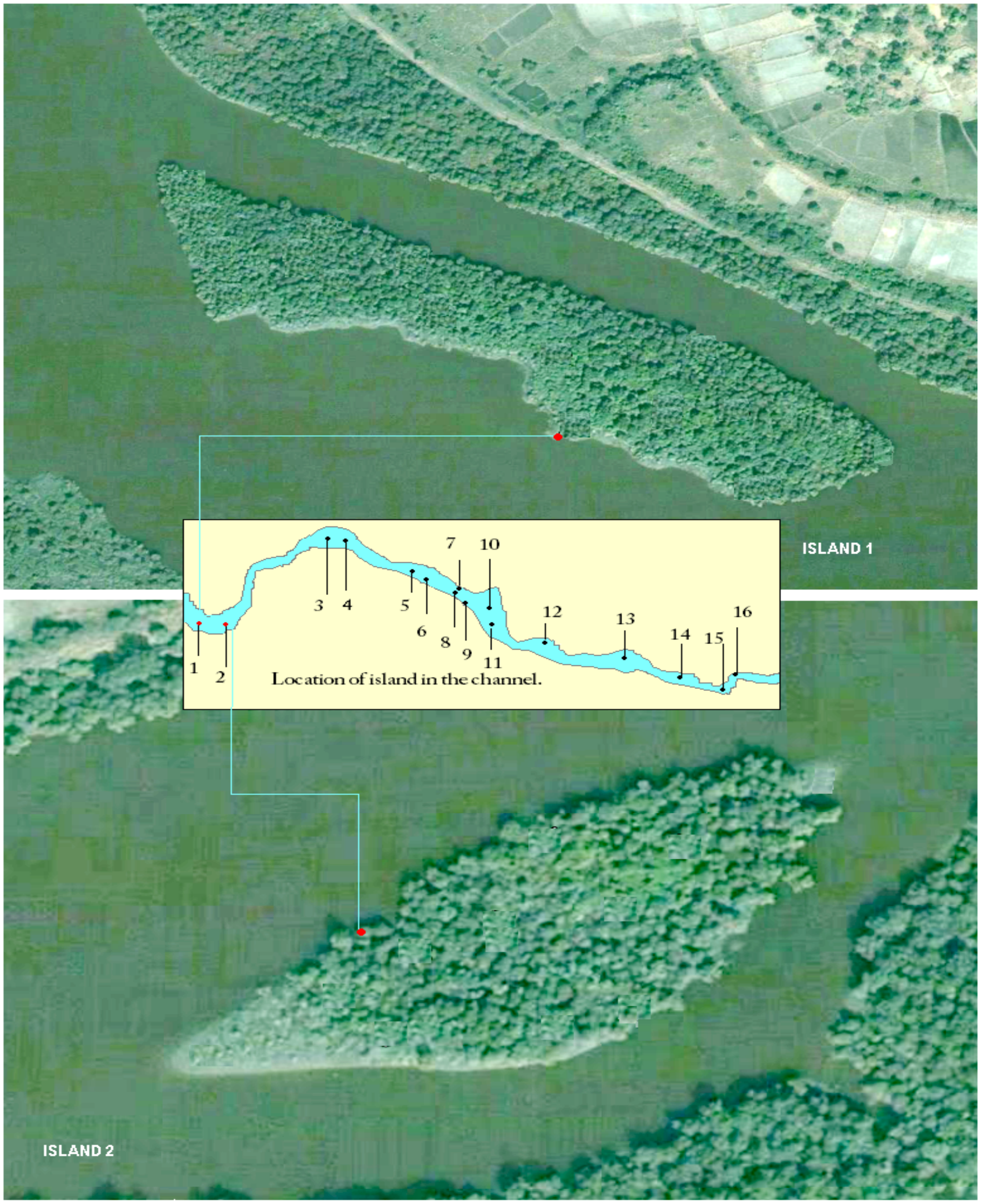


Fig.5.2 A

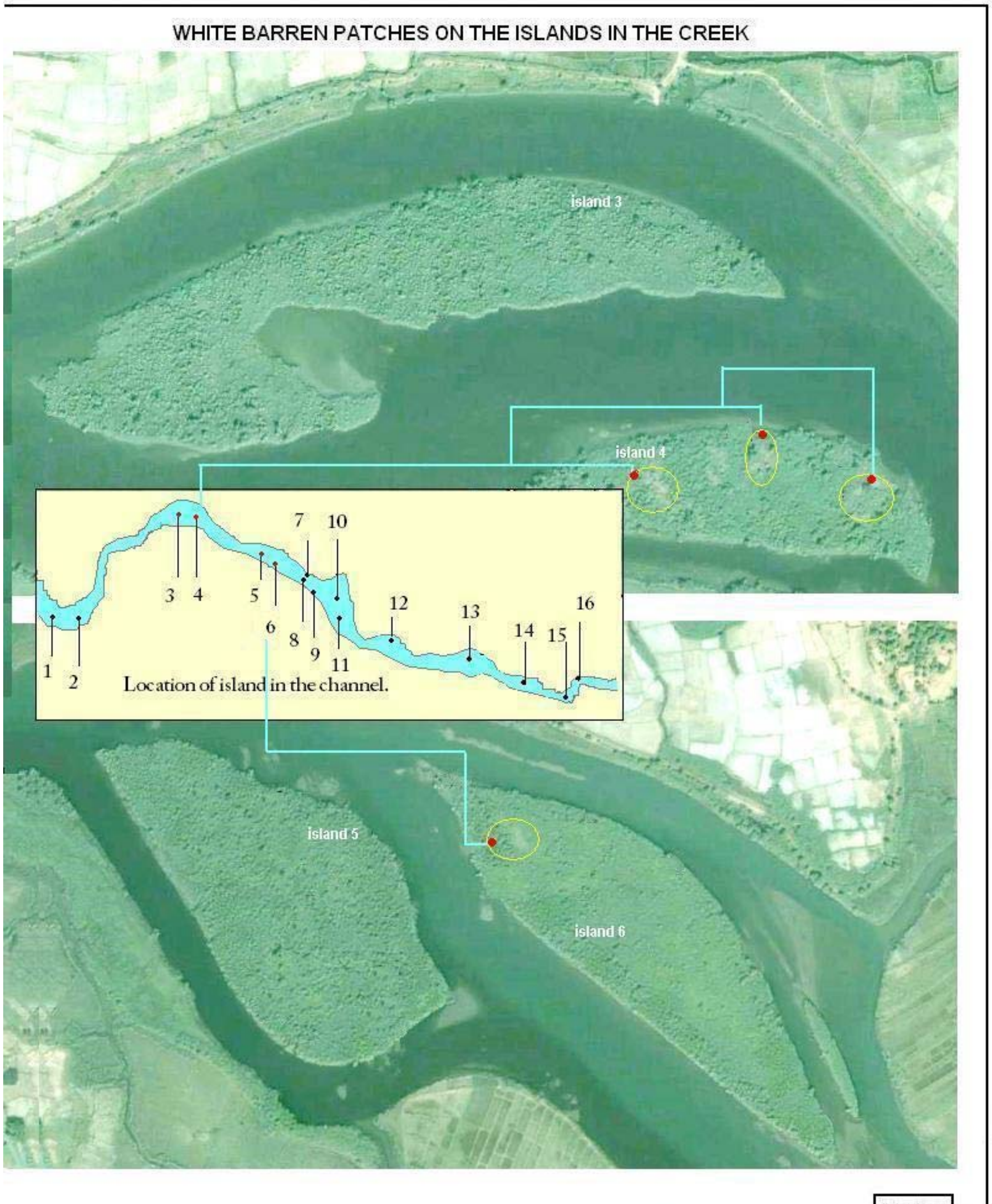

WHITE BARREN PATCHES ON THE ISLANDS IN THE CREEK
island 3
island 4
island 5
island 6
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Location of island in the channel.

Fig.5.2

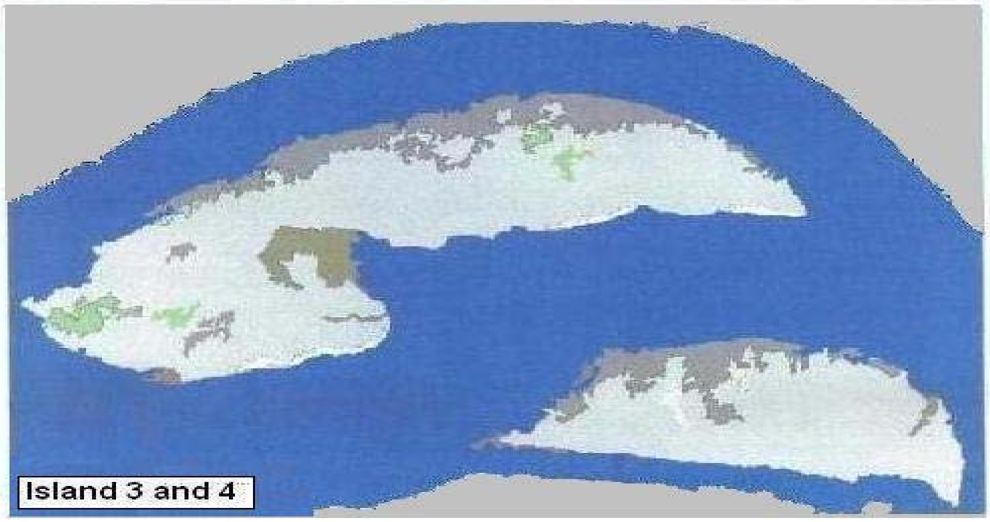


FIG. 5.3 OPTICAL COLOUR MONITOR IMAGE SHOWING VEGETATION BOUNDARIES

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Vegetation types on Islands 1 to 16:

Lower part of the Middle sector Islands 1 to 4 shows dominant species of mangroves e.g. Aviceinnia Alba and Rhizophora, whereas other species include Vitex Negundo, Thespecia, Hydrophylla and Acanthus which are well distributed on these middle sector islands.

Middle sector Islands 5 to 14 show Ipomoea as a dominant species which is salt tolerant and other species of Thespecia, Tropical Almond (Terminallia catappa), Deciduous Shrubs, Phyllanthus Reticulatus and Vitex Negundo. These are distributed unevenly on the islands. Islands 10,11 and 12 show some cultivated areas also**. (Fig. 5.4)**

Islands beyond Roha e.g. (13, 14, 15 and 16) show spider Lilly and Saccharum as dominant species, observed in high density and other species like knotweed (Polygonum Glabrum, Derris Trifoliata and Coix Lacryma-Jobi).

Middle sector islands (1 to 12) show species like Ipomoea, which can tolerate brackish water in the creek. Upper sector islands show Saccharum and Spider lily as dominant species, which can grow in fresh water. **Fig.5.5 and Table 5.1** show vegetation types on island 1 to 16.

AREA UNDER CULTIVATION ON ISLANDS 10,11 AND 12

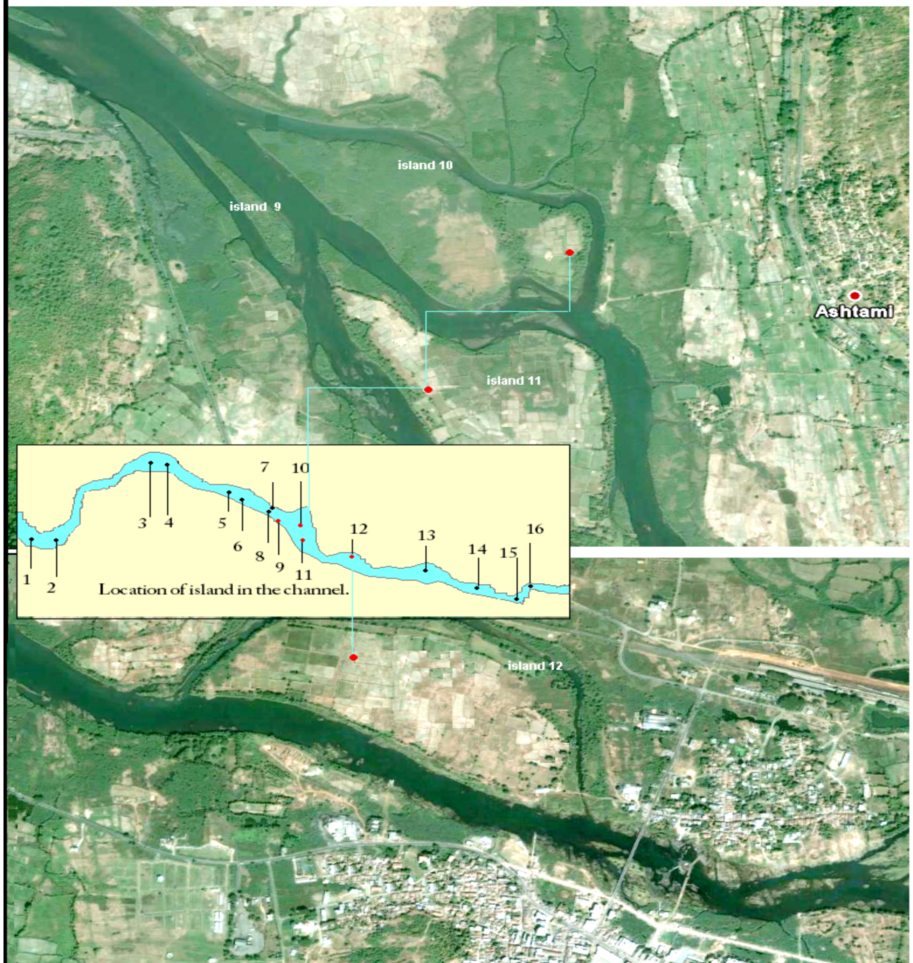

Fig.5.4

VEGETATION TYPES ON ISLANDS 1 TO 16

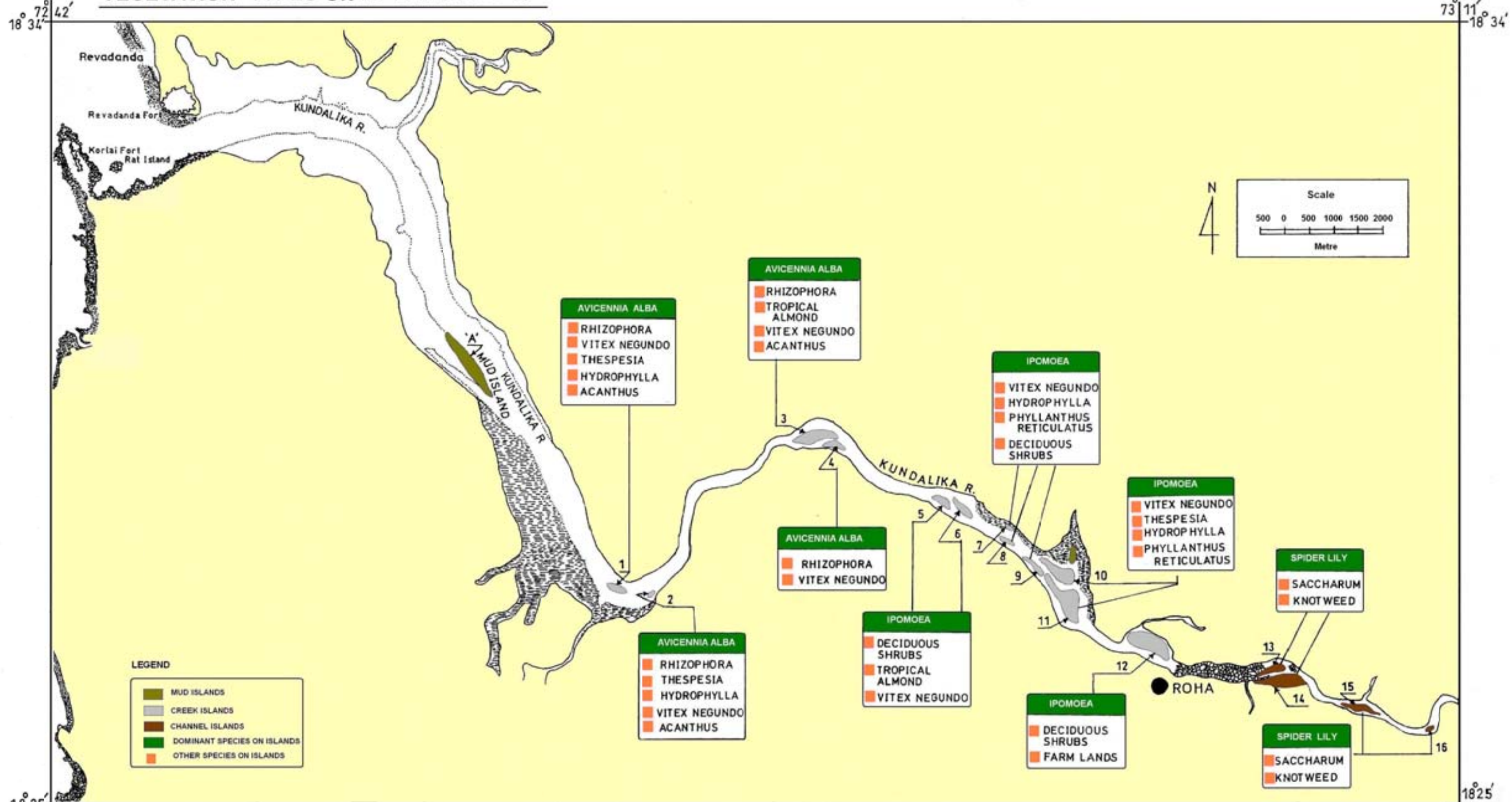

Fig.5.5

Table 5.1 Vegetation types On Islands 1 to 16

Island 1	Island 2	Island 3	Island 4	Island 5	Island 6	Island 7	Island 8
Avicennia-Alba (Gray Mangrove)	**Avicennia-Alba**	**Avicennia-Alba**	**Avicennia-Alba**	**Ipomoea**	**Ipomoea**	**Ipomoea**	**Ipomoea**
Rhizophora Acanthus Vitex - Negundo Thespesia Hydrophylla	Rhizophora Tropical - Almond Vitex - Negundo Acanthus	Rhizophora Thespesia Hydrophylla Vitex - Negundo Acanthus	Rhizophora Vitex-Negundo	Deciduous - Shrubs Tropical - Almond Vitex - Negundo	Deciduous-Shrubs Vitex - Negundo Thespesia Hydrophylla	Vitex - Negundo Hydrophylla	Vitex - Negundo Phyllanthu Reticulatus Deciduous Shrubs

Island 9	Island 10	Island 11	Island 12	Island 13	Island 14	Island 15	Island 16
Ipomoea	**Ipomoea**	**Ipomoea**	**Ipomoea**	**Spider lily**	**Spider lily**	**Spider lily**	**Spider lily**
Vitex - Negundo Hydrophylla	Vitex - Negundo Thespesia Hydrophylla Phyllanthus Reticulatus	Deciduous Shrubs Farm Land	Deciduous-Shrubs Farm Land	Saccharum Knotweed Polygonum - Glabrum Coix - Lacryma – Jobi	Saccharum Knotweed Derris-Trifoliata Coix-Lacryma-Jobi	Saccharum Knotweed Derris-Trifoliata Coix-Lacryma-Jobi	Saccharum Knotweed Polygonum Glabrum Coix-Lacryma-Jobi
Island No. 'A' Lower secto	**1 2 3** ←——	**4 5** ←——	**6 7 8** Middle	**9 10 11** sector——→	**12 13 14** ——→	**15 16** Upper	Sector
Dominant Species **Avicennia Alba**,**Ipomoea**,**Spider lily**				Other Species Vitex Negundo , Hydrophylla			

(Continued Table 5.1)

Plants and their association with substratum where they grow:

Table 5.2 shows association of plants with type of substratum in which they grow. From this table we can see that the mangrove species are well distributed on island 1 to 3.They grow on inter tidal submerged areas flooded by daily tides. Mangroves grow well on silty, clayey and sandy substratum covered by deep soft mud whereas other species like Indian beech trees (Pongamia pinnata) local name 'Karanj,' are widely spread along shores where substratum is stony to sandy and sandy to clay.

Other plants like Saccharum, Derris Trifoliata, Spider lily, Knotweed (polygonum Glabrum), Coix Lacryma-Jobi can grow in brackish to fresh water. They can grow in sandy loamy as well as rocky substratum also.

Mangroves can be thought of as agents of geomorphic change (Davies, 1972). Same is true as far as islands in the study area is concerned. The vegetation cover on the islands have strong association between the substratum and terrain. Terrain and substratum are the determinants in the type and density of vegetation on the islands in study area.

TABLE 5.2 Plants and their association with Terrain and Substratum where they grow.

Sr.N	Plants	Terrain	Island No.	Water	Substratum
	Mangrove species				
1.	Acanthus (Black mangrove) Marandi	Higher ground (Intertidal Areas)	(1 to 4)	Saline water	Silty, clayey (water logge
2.	Avicennia Alba (Grey mangrove) (Tivar)	Lower ground (Intertidal zones)	(1 to 4)	Saline water	Deep soft mud
3.	Rhizophora Apiculata (Red Mangrove) (Garjan)	Lower ground (Intertidal zones) (Submerged and flooded by tides)	(1 to 11)	Saline water	Silty & clayey
	Other Species				
4.	Pongamia Pinnata (Indian Beech Tree) (Karanj)	River channel Along shores. Tidal-Zone in the creek.	(1 to 6)	More/High Saline water	Stony to Sandy, sandy to clayey, soil (can withstar water logging conditions
5.	Polygonum Glabrum. Knotweed plant (Gulabi)	River Banks/ Marshy areas	(13 to 16)	Fresh water	Light sandy ,loamy ,clay

6.	Derris Trifoliata (Associate with Mangrove)(Panlata)	Margins of Islands	(1 to 3)	Saline water	Sandy clayey
7.	Tropical Almond Tree (Terminalia catappa Jangli Badam)	Higher Ground River Banks	(5 to 9)	Brackish water	Sandy ,coarse texture substratum High Caco 6.0 to 7.5 ph
8.	Ipomoea Fistula (Salt marsh morning glory)(Besharam)	Tidal zones swampy areas River Banks	(5 to 12)	Brackish water	Sandy, Loamy to Clay
9.	Thespesia (Indian Tulip Tree)(Ranbhendi)	Shores. Always Associate With Mangrove Habitat	(1 to 9)	Brackish water	Sandy, Loamy to Clay
10.	Saccharum (Jangli sugarcane)	Higher Grounds Along the River Banks	(13 to 16)	Fresh water	Well drained soils

(Continued Table 5.2)

11.	Vitex Negundo (Chaste Tree) (Nirgundi)	Higher grounds	(1 to 4)	Brackish water	Loose, moist well draine Soil. Clayey, Loamy
12.	Hydrophila (Temple plant.) Swamp weed plant) (Ran Tevan)	Bordering the Islands / Swamp areas	(5 to 12)	Brackish water	Coarser soil.
13.	Coix -Lacryma -Jobi	River Banks Swampy Areas	(5 to 11)	Brackish water	Sandy Loam Substratur
14.	Spider lily (Crynum Oliganthum) (Bombay lily)	River Banks Higher Grounds , Marshy Areas.	(13 to 16)	Fresh wate	Rocky/marshy Substratum
15.	Phyllanthus Reticulatus	Along the river deep water.	(6 to 10)	Brackish water	Clayey and sandy substratum

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CHAPTER 6

OBSERVATIONS AND CONCLUSIONS

CHAPTER 6

OBSERVATIONS AND CONCLUSIONS

The geoenvironmental study of any area normally includes the identification of major land facets in the area e.g. relief, slope, soils, sediment composition, regolith, weathering and biotic aspects, mainly vegetation associated with it.

Ridges of detirtal sediments, islands, sand bars and sand lenses are important geomorphic features of modern tidal sectors of Konkan Rivers. (Karlekar 2009). Reduction in size, change in shape, linear growth in upstream and downstream direction are the salient features of these forms. The forms, which are not stable, are swept away by strong waves in monsoons. They are essentially sandbars in creeks. The islands are relatively stable and covered by vegetation, especially mangroves.

Detrital material giving rise to sand islands, bars and ridges is largely drawn from immediate terrigeneous sources. In many cases it is a coarse grained sand with good sorting. Tidal current usually induces poor grading. The material becomes fined grained away from the source. In Konkan, at majority of places these islands and bars are reduced in size or totally swept away (Karlekar 2009). They have started showing tendencies of shifting within inlets since last decade or so. Reduction in size, change in shape, elongated growth in upstream or downstream direction are some of the features of change. Now a days these changes can be easily detected on IRS images of tidal inlets.

Study area is a tidal stretch of river ‘Kundalika’ between Kopri and Bahe.It is a 26.5 km. stretch characterized by about 17 islands of varying sizes and shapes. They are comprised by mud, sand and silt.
The channel under study is divided into three sectors as lower, middle and upper. The lower sector is dominated by tides and has maximum period of tidal innundation. This period slowly goes on decreasing in the upstream direction, where the influence of daily tides decreses. The sector beyond 25 km is called the upper sector. The sector in between these two ends is identified as a middle sector. Island, ‘A’ which is

a mud island, lies in the lower sector. Island 1 to 14 are in the middle sector and remaining in the upper sector of the channel.

All these islands are basically very low in height. The height of any island hardly exceeds 4 m ASL.The elevation range of most of these islands is between 1 to 4 meters only. The island morphology and relief has specific pattern in longitudinal direction and not across their edges facing left or right bank. This is because these islands are mainly shaped by tidal incursion and excursion in the creek. The longitudinal component of tidal flow is more influential than the circulation across the channel.

Between 1927 and 2007 the very first island from the creek has shifted inside the creek by a distance of 161 m, whereas the second island has shifted closer to the first island by a distance of 45 m. Although, the Island 3, 4 and 5 have drifted inside the creek, island 6 has drifted towards the mouth. Overall tendency of forming clusters seems to have prevailed till 2007. All these islands are pushed in the creek towards the upstream direction. The islands especially in the lower and middle sector have moved upstream, whereas islands in the upper sector have moved in the downward direction towards the mouth of the creek. Islands 1,3,4 and 5 in lower part of the middle sector show landward shift. Whereas Islands in the upper part of middle sector, Islands 9,10,11,12,13,14 and upper sector islands 15 and 16 show downward (seaward) shift.

The creek islands in the area show tendency of cutting and growth especially, along their cross sectional axis. This has resulted in the increase or decrease in distance from left and right bank of the tidal creek.

There is a pronounced extension of right margins of islands in the upper part of the middle sector, which shows a downstream shift. Although extension due to filling is a dominant tendency seen in all islands, it is less pronounced in islands in lower sector, which are shifting upstream. Right bank of upper sector islands seems more prone to filling than the left bank. Cutting and extension tendencies are relatively more balanced in Middle Islands 3,4,5,6 and 9.Maximum extension by 880 m in case of island 11 in last 80 years indicates an extension rate of around 11 meters per year towards northern bank of the creek. Extension due to filling is clearly a dominant process in most of the islands.

The islands in-group 'D'at 23 km (22.62 km) distance are more clayey, where clay is less consistently distributed. Clay distribution in these islands is highly positively skewed. Islands in group 'B' and 'C' are sandy. Here also sand is irregularly distributed on the islands. The middle zone is an ideal sink for suspended matter. And therefore between 40 years of span from 1967 to 2007 development of conspicuous island in the creek is found at this distance and some distance upstream (Island group B, C and D) also.

Out of 17 islands, islands 9 to 11 located in middle sector of the creek are at a critical distance and at an inflextion point. They show a totally different pattern of sedimentation, morphology and vegetation growth. Vegetation found on these islands tolerates high salt concentrations, periodical submersion and experience low and dry nutrient conditions.

A variety of plants are found on the islands in study area, but mangroves are one of the most frequent forms of vegetation occurring in intertidal zones along Kundalika River up to Roha.

The vegetation cover on the islands has strong association between the substratum and terrain. Terrain and substratum are the determinants in the type and density of vegetation on the islands in study area. Along 30 km tidal stretch of the river, the stretch between 15 and 25 km distance inland from mouth has all the characteristics of a sediment sink. Sand, that too, coarse sand is a major sediment size on most of the islands. Clay found on these islands shows patchy distribution and is less consistently distributed, except in case of a mud island 8.5 km inland from the mouth of the creek.

Channel bank shows thick mud deposits at a few places but the islands within the channel are sandy. The sediment distribution pattern and profile for all islands suggest winnowing of finer sand and clay particles by tidal currents. Preferred locations for the deposition of various size particles are also decided by tidal currents. The landward and seaward shift of islands may be attributed to fluctuations in sea level.

Luxurious growth of the vegetation is found on the lower part of the middle sector islands near Kumboshi 20-22 km inland. Anthropogenic activities like dredging (sand mining) is observed near Kumboshi through out the year within the channel, which disturbs the natural geomorphic processes within the channel.

The islands in Kundalika creek are thus peculiar as regards their geoenvironment, as well as sedimentary environment and are unlike sandbars and islands in other creek and estuaries of konkan. They preserve many bio and geo indicators of environment and need more detailed investigation to understand Holocene sea levels in the area.

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PHOTO PLATE : 9

THICK VEGETATION ON ISLAND NEAR KUMBOSHI

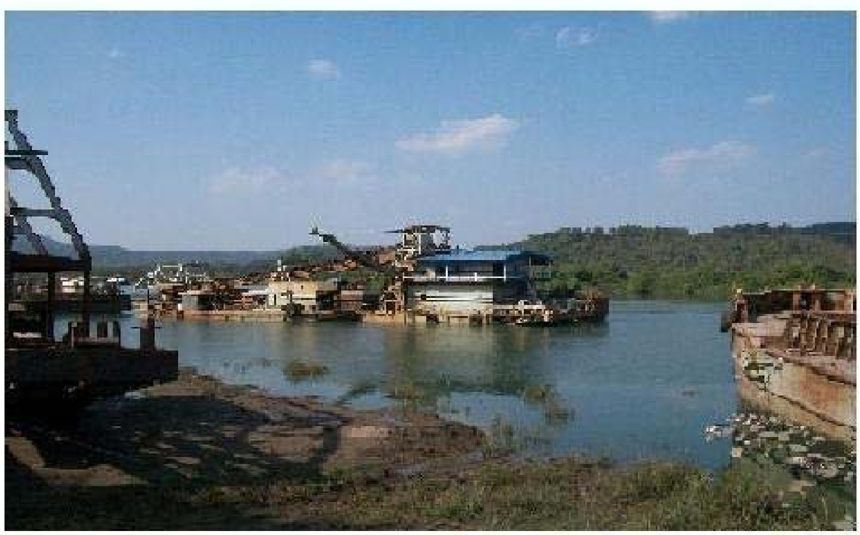

PHOTO PLATE :10

DREDGING ACTIVITY WITHIN THE CHANNEL NEAR KUMBOSHI

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