Thane Creek

A Status Report on Species Diversity in Relation to Conservation

Naoroji Godrej Centre for Plant Research

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Contents

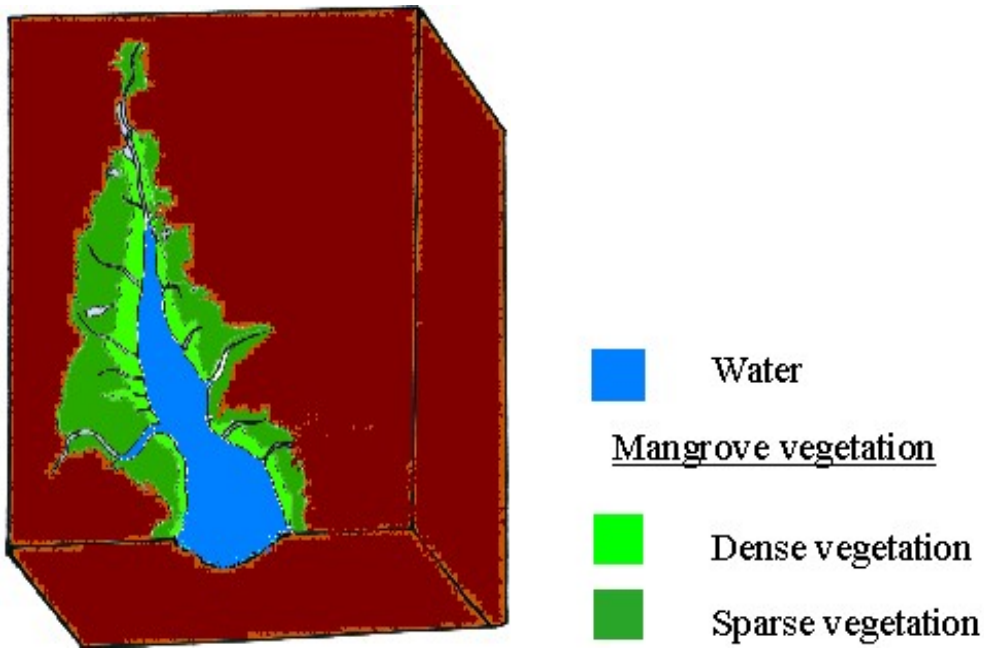
Chapter one

Introduction

Introduction

A creek is defined as an inlet of land where the seawater comes up regularly during the high tides and submerges vast areas known as inter tidal regions. Because of their unique physiography, creeks act as shelterbelts. The state of Maharashtra is very rich in having a number of creeks. There are about 58 such important creeks of different sizes present along the coast, on the western side of the state. Creeks play a vital role in the survival and livelihood of many human communities. Since immemorial times, the regions adjoining to creeks exhibited healthy and sustainable economies. Many factors contributed for such a scenario. One of the important factors that contributed from time to time for the well being of the human communities of adjacent regions of the creeks is a very fragile plant community, called mangroves.

Mangroves are an unique plant community, found in the inter tidal regions of tropical and sub tropical parts of the world. They grow luxuriant and attain maximum growth especially in the sheltered belts. A mangrove eco system does not necessarily mean a forest cover. In fact, it refers to various formations – arbores cent, bushy, and herbaceous and also the adjoining mud flats, which are devoid of any plant cover, but harbors many interesting forms of life. However, all these life forms share the ability to grow in saline and inundated environments and are adapted to multiple stresses that include high salinity and continuous flooding. In fact, the creeks with its mangrove formations represent one of the most complicated and highly evolved ecosystems of the world.



The Thane Creek

The mangrove ecosystems of creeks are complex as well as fragile and governed by different physical, chemical and biological elements. For a common man point of view, mangroves offer following useful roles. Many plant species are multipurpose. They are useful in boat preparation, honey production, local medicines etc. They are also habitat for many commercially useful species of fish, crabs, vertebrates and other fauna. The tree species are a major producer of detritus and a major contributor to offshore productivity. The roots of the plant community aids soil formation by tapping debris. Because of their unique root system and their habitat they selectively filters land runoff.

A comparison of the distribution of Indian mangroves reveals that more than 85% of the total mangrove areas are restricted to the West Bengal and Andaman & Nicobar Islands (Blasco, 1975). The East Coast has the advantage of having the major chunk of Indian mangrove areas as well as one of the richest mangrove diversity areas of the world. On the other hand, the West coast is less fortunate and left with lesser area under mangrove cover and less species diversity. Interestingly, Major mangrove cover of Maharashtra, which is also located on the West Coast, is distributed in the creeks.

The study conducted by Jagtap (1994) reveals that 79% of the mangrove cover of Maharashtra is distributed in 14 creeks, belongs to five districts of the state. Contrary to the West Coast, majority of the mangrove areas of East Coast are restricted to Delta regions of river mouths and estuaries. This is a very important information for planning purpose. Since the studies suggest that Creeks on the West coast and Delta regions on the East Coast are diverse regions as far as mangroves are concerned.

Whatever may be the location, mangroves are a unique community, impossible to match because of their adaptations. They are an indiscrete community belongs to unrelated genera and families. The most distinctive of all these features is the vegetation and the associated fauna of the substratum or mudflats.

The leaf architecture, the root system, the reproduction abilities and the salt balancing of this unique plant community is unparalleled and evolved in aeons of time.

The life forms of mangroves are functionally similar in many aspects. They are not randomly distributed. Species occupy specific habitats. Their distribution has a pattern. Inter dependent organisms form complex food chains & food webs. Their life scape structure and relationships are complicated and difficult to understand.

It is believed that this unique community might have been evolved 70 million years before sometimes in the Miocene period even before the continental drift took place. It may be remembered that this particular group of plants showed a reverse evolutionary trend of going back to the sea from where early plants were evolved. Their occupational niche in growing in the transitional zone between the land and the sea is highly appreciable.

Traditional human communities understood the structure of creek ecosystems and relationships among different organisms better. They practiced many prudent and sustainable methods while harvesting creek ecosystems. Eventually, they reaped better harvests.

In fact, the present day mangrove ecosystems of the creeks are not really a climax or a stable type. They are passing through a variety of depredations. Most of the creeks, which offered suitable habitats to for a number of species, can no longer do that because the resources were not sustainably utilized. They are in most cases functioning as the dumping grounds or the sinks for vast and fast growing cities. The human modification of the system altered the major components and factors related to their stability. As a consequence the mangrove related resource base dwindled. The creek ecosystems in general and the mangroves in particular are under threat. A look into the list of threatened flora & fauna will give us a better picture about their status.

The coastal Ocean monitoring and Prediction system (COMAPS), a division of Department of Oceanography is functional since the year 1990. One of its major observations based on the research data collected so far indicated that waters of the Indian sea are clean two km from the coastline except in the case of Mumbai where sea beyond five km clear.

In addition to this a recent CAMP (Conservation Assessment and Management Plan) exercise conducted at NIO (National Institute Of Ocenography), to identify the threatened species of mangroves (Ed. Rao, Molur & Walker -1997) recommended that majority of mangrove species (tree & shrubs) are facing some or other sort of threat and called for immediate conservation action. Groups of flora & fauna, number species assessed and number of threatened species assessed during the CAMP exercise is presented in Table-1.1

Table-1.1: Number of threatened species of mangrove ecosystems.

Group	Total no. of Species studied	Threatened species
Mangroves (Higher plants)	60	57
Mangrove Macro Algae	23	14
Mangrove Fishes	52	11
Mangrove Invertebrates	41	09

Source: Indian Mangrove Ecosystem Report Summary (Ed. T. Anand Rao, Sanjay Molur & Sally Walker , NIO, Goa 21-25 July 1997).

This is a serious concern to all of us. Many participants of the CAMP exercise felt that human interference and habitat loss are the two major threats to mangrove ecosystem and are a cause of concern.

Priority to this study another survey was conducted by NIO to identify the Marine Protected Areas (MPA) of Maharashtra & Goa states. The study was conducted under the stewardship of Dr. Untawale. A number of parameters (8) were studied to identify the MPA sites. Important criteria for identifying such sites is based on

1) Sensitivity of the ecosystem (How much it differs from rest of the areas)
2) Endemism
3) Economic importance & genetic variation
4) Human usage

At the end of the study, the following seven sites along the Maharashtra Coast (Map 1.1) were identified for MPA programme.

1) Vengurla rock & Malvan open coast,
2) Devgad, Vijaydurg & Achra,
3) Ratnagiri & Purangad,
4) Kundalika estuary & Alibag coast,
5) Colaba,
6) Vikroli and

7) Mumbra- Diva region.

A brief account of the importance and diversity of these seven sites of MPA are presented in Table – 1.2

Another study in relation to Conservation of Biodiversity of the West Coast between Mumbai & Goa was conducted by Ecological Society, Pune. The World Wide Fund For Nature (WWF- India) sponsored project identified five potential biosphere reserve regions and 12 sites of special interest along the coasts of Maharashtra (Gole, 1997).

Both of these surveys have many commonalties. Thane creek, especially the Vikhroli mangrove swamp area (owned by Soonabai Pirojsha Godrej Foundation) was identified as one of the well preserved & biodiversity rich areas of Maharashtra state.

A pioneering study conducted by Mr. Sanjay Deshmukh (1990) for his PhD work was actually created a base for assessing and identifying the Vikhroli mangrove swamp areas of Thane creek and other mangrove areas of Mumbai & Thane districts. It must be borne in mind that mangrove study of Mumbai coast dates back to early years of 20th century (Blatter, 1927 & 1928).

Conservation and sustainable utilization of an ecosystem is possible only when the structure and relationships are understood. All these years we forgot or conveniently ignored this basic principle. Most of the available research of mangrove ecosystem of creeks in India is group or taxon wise studies and therefore difficult for interpretation. A holistic approach is a need of the hour.

Keeping the existing needs in mind Naoroji Godrej Centre for Plant Research In collaboration with Soonabai Pirojsha Godrej Foundation promoted by Godrej group of industries and many other like minded organizations such as BNHS, Bandodkar college, Thane, Botanical Survey of India, Zoological Survey of India and many individual scientists and students from different colleges and Institutes, studied the life scape diversity and structure of Thane Creek mangrove ecosystem. The present study is aimed to quantify the diversity and understand the relationships of various groups organisms of Thane creek mangrove ecosystems. The details of the research studies are presented in the following chapters.

Map.1.1

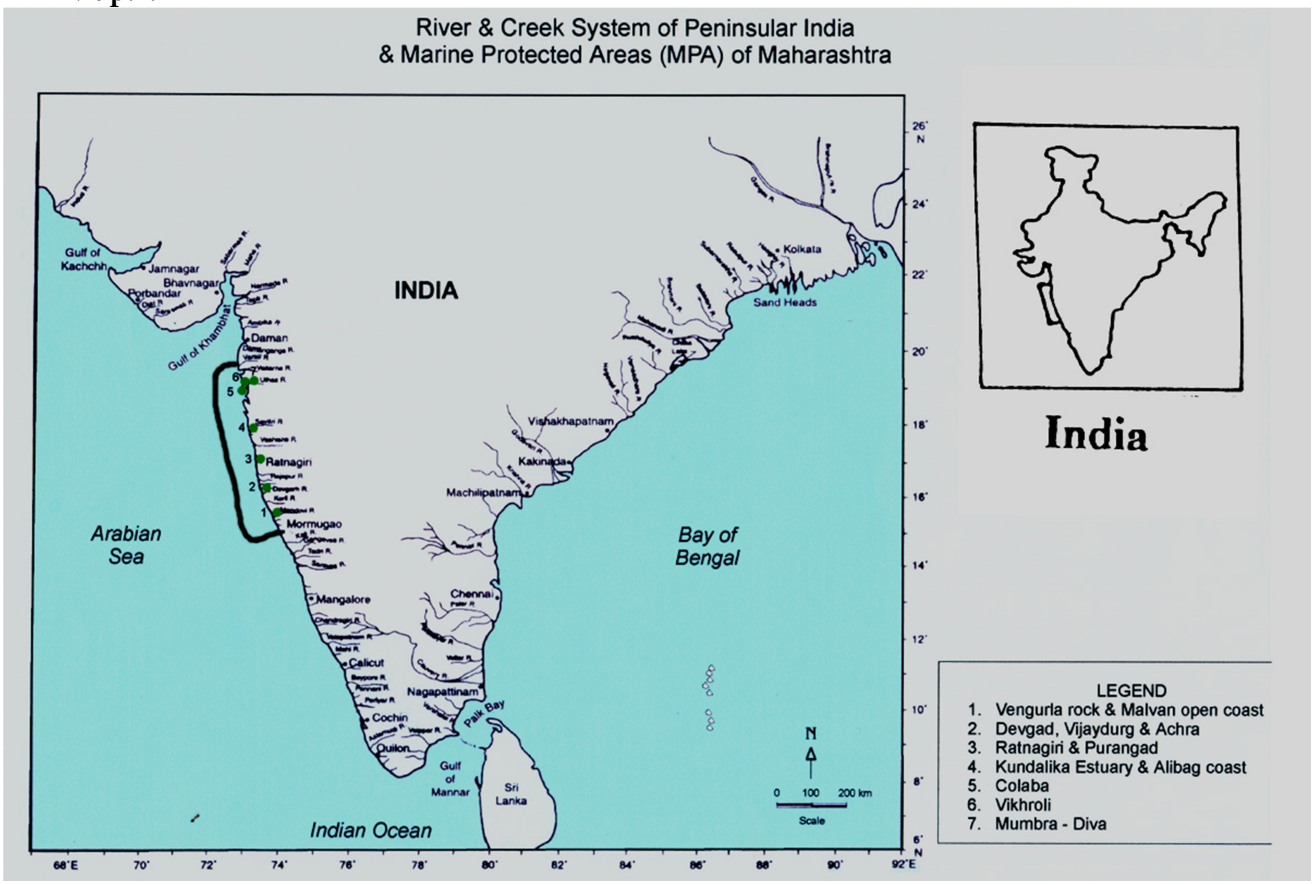

River & Creek System of Peninsular India
& Marine Protected Areas (MPA) of Maharashtra
INDIA
Arabian Sea
Bay of Bengal
Indian Ocean
Gulf of Kachchh
Gulf of Khambhat
Jamnagar
Bhavnagar
Porbandar
Daman
Ratnagiri
Mormugao
Mangalore
Calicut
Cochin
Quilon
Nagapattinam
Chennai
Machilipatnam
Vishakhapatnam
Kakinada
Kolkata
Sand Heads
Palk Bay
Gulf of Mannar
Sri Lanka
India
LEGEND
1. Vengurla rock & Malvan open coast
2. Devgad, Vijaydurg & Achra
3. Ratnagiri & Purangad
4. Kundalika Estuary & Alibag coast
5. Colaba
6. Vikhroli
7. Mumbra - Diva
N
0 100 200 km
Scale
68°E
70°
72°
74°
76°
78°
80°
82°
84°
86°
88°
90°
92°E
26° N
24°
22°
20°
18°
16°
14°
12°
10°
8°
6° N

Table – 1.2**. Proposed Marine Protection Areas (MPA) & their biodiversity in Maharashtra.**

MPA locality	District	River	Important areas	Diversity
Vengurla & Malvan	Sindhudurg	Mandav	Kolamb creek Vengurla rock island Malvan open coast Kavya Dongar	Mangrove- 5 Algae – 49 Benthos -208
Devgad, Vijaydurg &Achra	Sindhudurg & Ratnagiri	Vaghotan	Achra creek Devgadh creek Vijaydurg open coast	Mangrove- 15 Algae – 25 Benthos -
Ratnagiri & Purangad	Ratnagiri	Muchkandi	Muchkandi river Shilwadi Purangad creek Shivgao creek Ratnagiri open creek	Mangrove- 12 Algae – 56
Kundalika & Alibag	Alibag	Kundalika	Kundalika estuary Revdanda fort	Mangrove- 5 Algae – 35
Coloba	Mumbai	--	Naval establishment TIFR area	Mangrove- 11 Algae – 64
Vikroli	Mumbai	Ulhas	Godrej & Boyce	Mangrove- 7 Algae – 2
Mumbra–Diva	--	Ulhas	--	Mangrove- 5 Algae – 3

* Source : Untawale et al, 1998 & Deshmukh, S, 1990.

Chapter Three

History

History

By pre history is generally meant pre-literate history (Kosambi, 1962). Pre history of the study area (Thane & Mumbai districts) is almost devoid of any documented facts. The documented history mostly reels around rulers, religion & commerce. Information on mangroves is scattered. Available interpretations are peace meal with much exaggeration and less clarity.

The earliest known fact in history of the area belonged to the third century before Christ (B.C.225). They are engravings of Ashokan edicts on Basaltic boulders. The present study area was part of Aparanta or *Sunaparanta* **(the behind or the Western land now known as Konkan).**

The next known evidence available is about the dynasty of *Satavahans* **or** *Andhra bhrityas* **who ruled the Konkan about B.C.100. The region witnessed the rise and fall of many dynasties. Notable among them were the** *Abhiras* **(A.D. 250),** *Trikuta* **or** *Traikutakas* **(name derived from three peaked mountain, A.D.415),** *Chalukyas* **(A.D.543),** *Rashtrakutas* **(A.D. 749) and** *Silharas* **(meaning food on rock).**

The mediaeval period witnessed the fall of a local king Bimb to Muslim invaders (A.D.1318), which followed an era of invasions and plundering. Marco Polos account (1290) clearly indicates that the seas were infested with pirates. The whole region was also regularly ravaged by *Siddis* **and Jesuits.**

In the recent past, the Marathas, the Portugese and the British ruled the region.

It is noteworthy to mention that since pre historic times, one coastal fishing community colonized these islands first and survived the ravages of time and many calamities and invasions. These sea loving people known as *Kolis* **are still intact without much cultural change. They worshipped natural objects such as trees and animals. Although, there are many interpretations about the origin of the word Bombay, to the study area, there is a strong evidence that the present name was originally derived from** *Mumba-ai* **or** *Mumba Devi***, the local goddess of** *Koli* **community. Infact all the names of** *vadas* **or hamlets of the past are derived from tree or forest groves or some deities.**

The Changing Pattern of Vegetation & wildlife of Thane creek and its surrounding areas.

The physical history of Bombay is the history of land reclamation. The early accounts of history reveals that the topography of the present day Thane creek and its surrounding areas is considerably modified. Topographically the region was in fact part of a two major groups of islands. The islands were lush green, full of trees.

Kolis

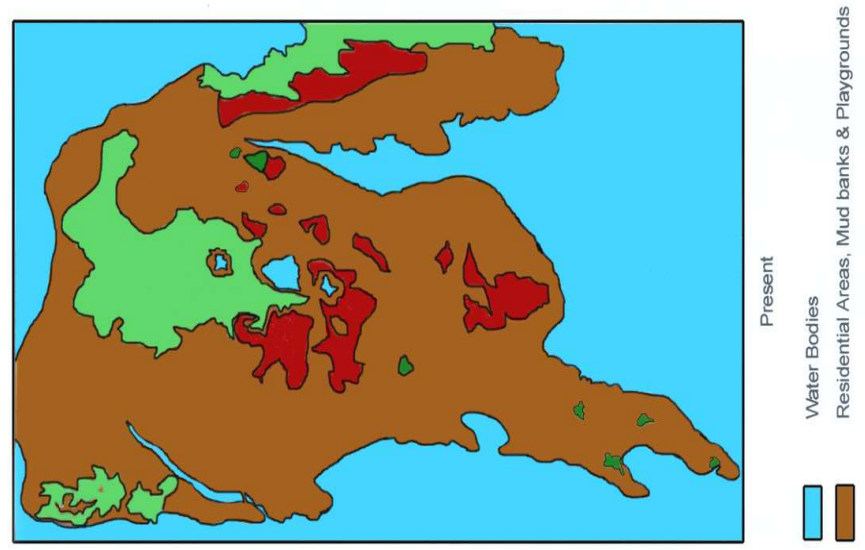
The islands were harboring many Coconut groves and Jack fruit trees. In fact the region was full of trees with tremendous species diversity (Jordanus & Odericus, 1321-1324 in Yules Cathay,I.68). The other common trees included *Mangifera indica* (mango), *Caryota urens* (forest palm), *Borasis* sp. (brab palm) and *Tectona grandis* (Teak). The reports also mentioned about the presence of a huge *Adansonia digitata* tree (baobab).

The inter tidal regions, the river banks and the lagoons were teemed with wild life. The shores of the islands were decorated with thick & luxuriant mangrove vegetation. Mangroves covered a larger part of the study area. There were many carnivorous animals such as black lions (needs confirmation, perhaps black leopards), leopards, lynxes roamed freely in the islands. The marshy habitat was home for rhinoceroses & crocodiles. There were numerous monkeys and baboons. There were also the reports (exaggerated) of bats as big as kites and rats (bandicoots) as big as dogs. There were no horses but oxen & donkeys. They were used in agriculture and in transportation. Best accounts of these translations were available in the Gazetteers of Bombay (1986) & Thane (1986).

The best of all descriptions about the past status of the island vegetation appeared not long ago in a relatively popular journal (Asiatic Journal, 1838). A curious writer presented a beautiful summary of the past status of these islands. Following is the replica of the letter.

" Bombay harbour presents one of the most splendid landscapes imaginable. The voyager visiting India for the first time, on nearing the superb amphitheater whose wood –crowned heights and rocky terraces, bright promontories and gem-like islands are reflected in the broad blue sea, experiences none of these disappointment which is felt by all lovers of the picturesque on approaching the low, flat coast of Bengal, with its stunted Jungle. A heavy line of hill forms a beautiful out line upon the bright and sunny sky; foliage of the richest hues clothing the summits of these towering eminencies, while below the fortress intermingled with fine trees and the wharves running out into the sea, present altogether, an imposing spectacle, on which the eye delights to dwell."

Land reclamation for agriculture and for defense purposes contributed to the maximum destruction of wildlife and vegetation of the past. In modern times, urbanization & industrialization contributed to the maximum destruction of mangrove areas of Thane creek. The destruction is so much so that many species, which were mentioned in the earlier literature or travelers diaries were, disappeared form these islands. A comparative list of wildlife mentioned in the ancient literature and its present status is presented in table- 2.1 and 2.2.


Present
Water Bodies
Residential Areas, Mud banks & Playgrounds

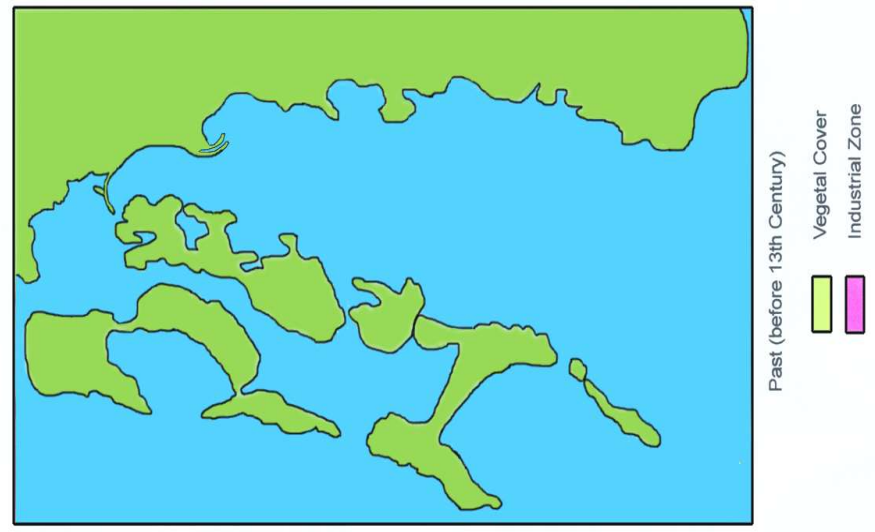

Past (before 13th Century)
Vegetal Cover
Industrial Zone

Table-2.1. Status of animals (extinct & threatened) of Thane creek and its neighbouring areas.

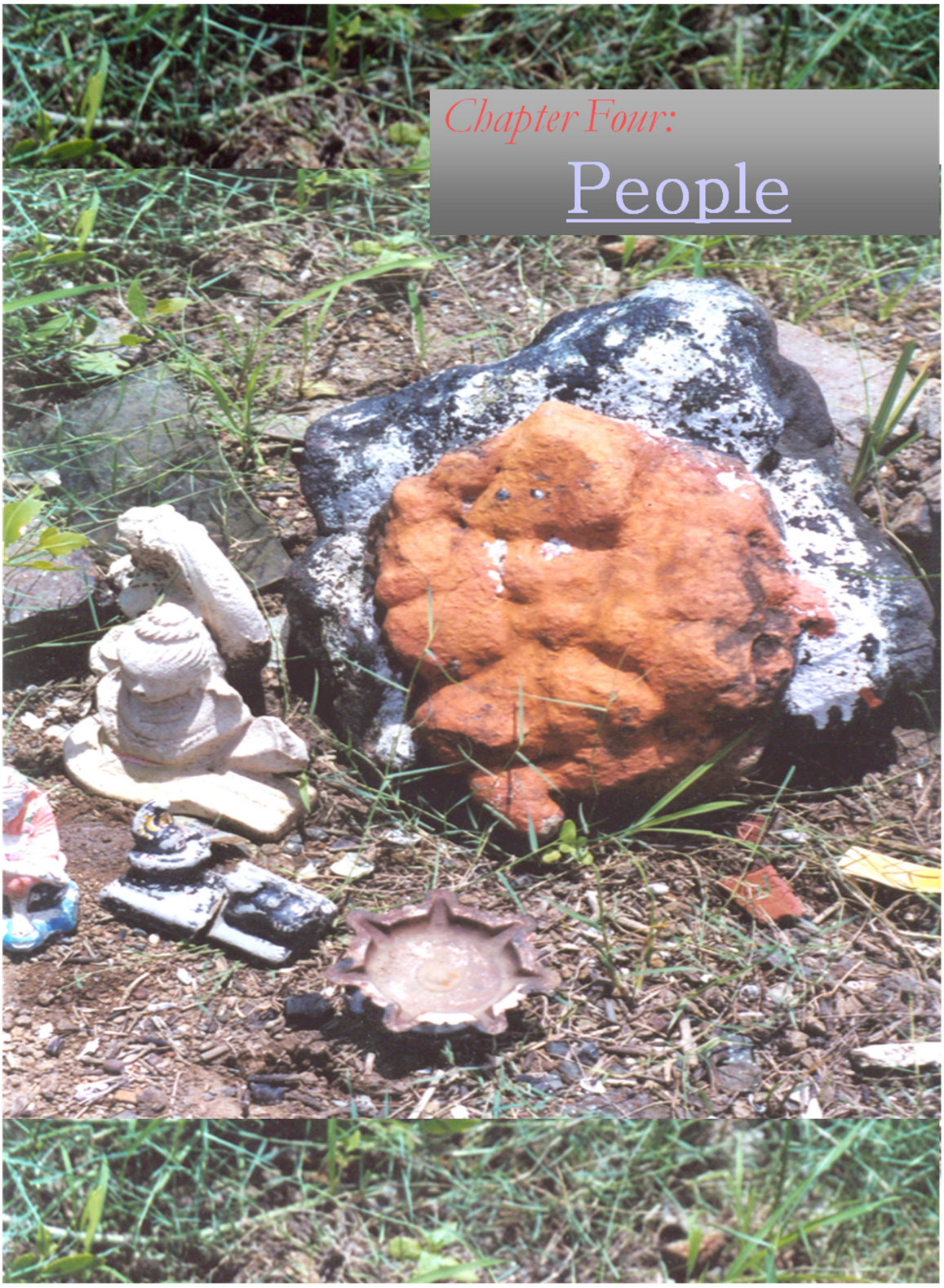
Common name	Scientific name	Past status	Present status	Reference
Rhinoceros	*Rhinoceros* sp.	Present	***Absent***	*Jordanus & Odericus, 1321 - 1324
Black lion	Not known (perhaps black leopard)	Present	Absent	*Jordanus & Odericus, 1321 – 1324
Leopard	*Panthera pardus*	Present	Common	*Jordanus & Odericus, 1321 – 1324
Linx	Felis *sp.*	Present	Absent	*Jordanus & Odericus, 1321 – 1324
Crocodile	*Crocadilus* sp.	Present	Absent	*Jordanus & Odericus, 1321 – 1324
Indian Python	*Pyhton molurus*	Present	Very rare	Vivek Kulkarni 1998.
Olive Ridely Turtle	*Lepidochelys Olivacea*	Present	Very rare	Giri, 2001
Green sea turtle	*Cheolonia mydas*	Present	Very rare	Giri, 2001

***Gazetteer of Bombay**

Table-2.2. Status of Plants (extinct & threatened) of Thane creek and its neighbouring areas.

Common name	Scientific name	Past status	Present status	Reference
-	**Nypa fruticans**	***Present***	Extinct	Bonde, 1994
	Lumnitzera racemosa	Present	Absent	Navalkar, 1951
Pussur	*Xylocarpus granatum*	Present	Absent	Cooke 1901-1908
-	*Kandelia candel*	Present	Absent	Navalkar, 1956
-	*Sonneratia caseolaris*	Present (doubtfull)	Absent	Blatter, 1905 Backer, 1951
-	*Bruguiera parviflora**	Present	Very rare	Navalkar, 1941
-	*Rhizophora conjugata**	Present	Very rare	Navalkar, 1941
-	*Rhizophora mucronata**	Present	Very rare	Navalkar, 1941

* Re introduced



Chapter Four:
People

People

People play crucial role in **natural resource utilization**. The natural resources of creeks such as mangrove forests, fishes, crabs and other marine foods are a common resource. Despite the fact that they are common resources, our survey indicates clearly that selective communities of people only harvest these resources. Naturally, **creeks are primary resource base** for many local communities. Fishing is their major occupation.

Kolis are the major community traditionally dependent on the Thane creek ecosystem for their sustenance. The *Kolis* follow fishing as their hereditary occupation. They are directly dependent on the creek ecosystem for food, shelter, medicine and a gamut of other uses. It is also recorded during the study that there are many other people who indirectly dependent or benefit from the system. It is practically difficult to exactly estimate the number of people dependent on the Thane creek ecosystem. Rough figures prepared from a crude survey reveals that about 20,000 *Kolis* are dependent on the Thane creek for their livelihood. About another 30,000 people belongs to other communities are indirectly dependent on the natural resources of Thane creek. These indirect benefactors include slum dwellers who regularly use mangrove resources for fuel and other purposes and also labour involved in drudging operations. These figures exclude Government and industrial employs.

Kolis are mostly mangrove dwellers. The Thane creek region is represented by four sections of Kolis. They are a) Thalkars, b) Gaonkars, c) Christiahn Kolis and nava-Hindus.

During the survey we have recorded 14 *Koli* settlements in different parts of Thane creek. Most of the *Koli* houses are distributed in closely constructed houses. The 14 *Koli* localities are as follows.

1) Thane, 2) Vitava, 3) Airoli, 4) Diva, 5) Talwali, 6) Ghansoli, 7) Kanjur,
8) Mulund, 9) Balkumb, 10) Kharegaon, 11) Vikhroli, 12) Turbhu,
13) Belapur, 14) Kujur.

Kolis

It is estimated that in India alone, **about 2.5 million tones** of marine fish are available with in the 50m depth zone.

Documented history reveals that **fishing was one of the chief industries of Mumbai** during the pre-British period. Thane creek was one of the major fish and crab supply centers of Mumbai.

It is belatedly realized that Thane creek no longer yields commercially viable fish. The official records documented an alarming decline in fish catch, about **68% reduction** in the yield in a span of ten years ranging from 1980 – 1990. The natural resources of creek ecosystem are no longer renewable. They have been destroyed beyond the limit of sustainability. Experts opined many reasons.

The first explanation given is that all over the world, small scale fishing exceeds the sustainable capacity resulting in biological and economic over fishing in coastal waters (Ramakrishna, 1999). Thane creek is no exception.

The second opinion is that pollution is the major culprit for depleting fish, sea food and other natural resources.

In the present study we have tried to carefully look into the reasons and what is really responsible for depletion of natural resources. To understand this we made selective surveys, probed into the general lifestyles and interviewed fisher folks to understand their modes of fishing activities.

Sustainable utilization is the only option to ensure natural resources for future generations. The creek ecosystems have tremendous number of natural resources. All these resources are directly or indirectly dependent on the availability of mangroves. Many mangroves species and their associates are multipurpose species. It is very difficult to cover the resource utilization studies of all communities of people who are dependent on creek ecosystems with special reference to mangroves.

Kolis are one such community of people dependant on creek and mangrove ecosystems. Reaping the creek ecosystems is their heridetical occupation. For generations they are engaged to harvest creek resources. Many research documents are available about the Kolis of Mumbai (Wilson, 1876; Sorley, 1933; Sethna, 1949, Punekar, 1959)

Kolis are a very simple community with strong cultural bondages. Most of the *Koli* settlements are isolated. They are situated along the creek near the sea shore, very closely to mangrove forests. A substantial percentage (45%) of the *Koli* families is nuclear (Punekar, 1959). During the enquiries we understood Kolis changed with changing needs and adapted to modernization. Even in the present times, most of the *Koli* life styles are simple and their natural resource utilization can be categorized as sustainable type.

Fishing activity of Kolis

An interesting feature of *Kolis* is the nature worship. Worshipping a tree or a forest god is commonly observed. All the *Kolis* worship god and offer prayers before going on for fishing. Deities range from stone gods to the photographs of Christ. They are kept under some back mangrove trees, near the Jetty sites. During the discussion we were surprised to observe that many Kolis do not clearly recognize the different religions created by modern (primitive ?) man. The Christian *Koli*s prey to Hindu gods as well as Christ. They also celebrate all Hindu festivals.

Fishing is essentially a major employment generation occupation for *Kolis*. A variety of fishing techniques are used by Kolis.

The small and stunted mangrove forests of Thane creek are useless to provide wood for any type boat manufacturing. Boats are brought from other coastal regions.

The two most important requirements for fishing are a) boats, b) nets.
Kolis of Thane creek uses mostly three types of boats for fishing. Descriptions of the three types of boats used by the *Kolis* are as follows

1) ***Shipil***: It is a small hodi (boat), generally operated by two to three persons. A typical boat is elliptic - oblong shaped, 5.5-6m long X 1-1.2m wide. The boat is made from mango (*Mangifera indica*) wood. This variety of boat is the most common boat used by Kolis. It is a very useful boat for creek fishing and crab catching purposes. The present cost of the boat is about Rs. 20,000/- (It coasted Rs. 150-200 in late 1950's). The boat lasts for 15-20 years.

Shipil

2) ***Mothi Shipil*** : Large *hodi* (boat). This type of boat is operated by 6-8 persons (preferably 8 persons). A typical boat is broadly-elliptic in shape, 12-12.5m long X4-4.5m wide. This boat is exclusively made of teak wood (*Tectona grandis*). The boats are either fitted with sails or mechanized. The mechanized boats are fitted with diesel engine. This type of boats are used frequently for deep water fishing, mostly in creek waters. The present cost of the boat is about Rs.1,50,000/- (it coasted Rs. 400/- in late 1950's).

Mothi Shipil

3) ***Hora***: (Larger hodi (boat). This type of boat is opertated by 10-12 persons. They are fully mechanized. They are suitable for deep - water fishing. They are rarely found in creek waters. The price may vary depends upon the facilities. It is mostly made up teak wood. The cost ranges from Rs.12 lacks to 20 lacks.

The official estimates of the fishing boats in the Thane creek are 184. There are 17 mechanised and 167 non-mechanised boats operate in the creek. Table 4.1 presents regionwise distribution of fishing boats present in the Thane creek.

Other than fishing boats there are other boats, which are exclusively used for dredging in the Thane creek. Kashala-Gaimukh region is reserved for dredging. About 4,000-5,000 workers dependent on dredging operations and about 400-500 mechanical boats work for this purpose. The officially permitted daily turnover is about 400 brass sand. The region generates an annual royalty of Rs. 60 lacks for the Corporation. The workers on the dredging boats belong to many other communities.

Table 4.1 Fishing boats sensex of Thane creek (1998).

No.	Locality	Number of boats
1)	**Airoli**	30
2)	**Balkumb**	5
3)	**Diva**	41
4)	**Ghansoli**	33
5)	**Kanjur**	18
6)	**Kharegaon**	4
7)	**Mulund**	5
8)	**Talwali**	17
9)	**Thane**	3
10)	**Vitava**	28

- Source: Mumbai Port Trust (2000).

Another requirement for fishing is fishing-nets. We are amazed by the types of fishing and crab catching techniques used by Kolis and other communities. The type and shape of fishing nets are very important for type of fishing (a more detailed studies on types of boats and fishing nets are published by Gazetteers of Maharashtra). Generally fishing nets can be classified as two types. They are :

a**) fishing nets prepared from natural fibre from plants,**
b) synthetic nylon fishing nets.

A variety of plant materials were told, during the survey, were used for making fishing nets and other purposes. A list of plants suitable for fishing-nets is given below.

No.	Name of the species	Usage
1)	*Thespesia populnea*	fibre
2)	*Hibiscus tiliaceous*	fibre
3)	*Derris* sp.	rope
4)	*Dendrocalmus* sp.	erecting net & baskets
5)	*Lagneria* sp.	fish collection vessel

Using plant material for fishing was a thing of past. Except bamboo we have not noticed any other worth mentioning plant material being really used for fishing nets or any other related activity. Bamboos are costly. They are brought from far away places like Belapur. Each bamboo culm costs Rs.30/-. They are useful for only two years in saline waters. All types of nets made from natural fibre are taken over by synthetic nylon nets, locally called as *Pagara* or *vagara*. Bamboo culms are still used to erect the nets. As the water recedes fish that had come into creek are trapped in the net. Fish-catch of mechanized boats is carried out mostly during night apter 9pm. Torches made from tyres are burned to attract the fish. We have not recorded using of any plant material for stupyfying fish. A number of fish nets are used by the Kolis of Mumbai are listed below.

1) *Gholva*
2) *Khanda*
3) *Peri*
4) *Pongri*
5) *Vavri*

Another technique used for catching small fish is through a portable baited fish trap prepared with bamboo or cane. The trap is fixed at the inlet points of dug out ponds. During the high tide water with fish can enter through these traps. Once entered into the trap the fish cannot go out. The owner will catch the fish from the pond once in a ten days or fortnight.

Fish Trap

Fishing is a very studious job, demands patience and hard work. The *Kolis* believe that fishing operations are totally dependant on god. All fishing operations are conducted after offering prayers to gods. Two fishing periods of twelve days each occur every lunar month. Fishing requires united effort of many men. The division of labour is perfectly organized. Fishing with the mechanized boats lasts for eight days.

The general survey to find out the attitude of Kolis (of 70 *Koli* youth) towards their profession revealed that 75%of the youth felt that they are not happy with their profession because of the difficulties. Due to lack of choice they opted this job. They are happy at the same time because fishing is still a lucrative business as compared to their professional skills and educational background. Most of the *Koli* youth also realize the disadvantages of working as an unskilled laborer.

During the survey it is realized that many individual *Kolis* with small boats prefer to collect Crabs to fish, as fish are not available in sufficient quantities for commercial fishing. Many species of fish are almost disappeared from many parts of the creek. Even if they are available they are not fit for human consumption because of heavy metal pollution. Moreover, crab catch is easier and economically more fetching.

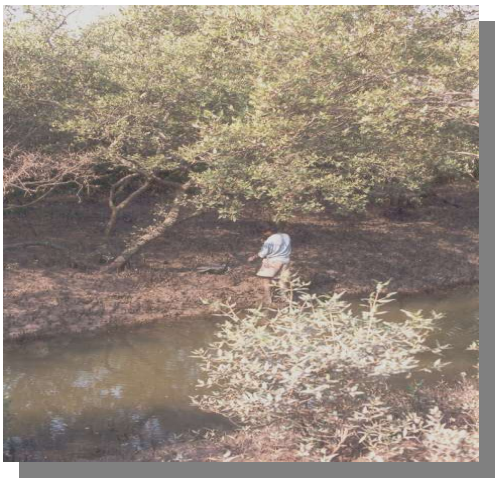
The mud crab is the most preferred crab because of good demand in the local markets. It is also one of the common crabs of Thane creek. A *Koli*, after a days hunt can manage Rs. 750 – 1250/- worth crabs. Three species of crabs from Thane creek are used for food purpose. Crab catching is generally done along the banks or confluence places. Crabs are caught mostly three ways. They are

1) Using *Tokre* : The technique involves digging a pot shaped hole of one meter size into the soil near mud flats. A bamboo basket is inserted into the hole. Butchered goat or sheep ears are released at the bottom of the basket or they are fixed on a bamboo stick at the center of the hole. Crabs attracted to the food fall into the basket trap. The trapped catch is collected easily with the basket after some hours or next day morning.

2) Using *Chadye* or *Chapate* (Crab hooks): The most common way of catching crabs is with the help of a hook attached to a bamboo stick. Pieces of eel or ears of butchered goats or sheep are used as bite to attract the crabs. Single individuals scout around mangrove forests looking for ideal crab holes. The bamboo stick is poked slowly into crab holes. The crabs attracted for food and gets trapped easily. Identifying the right crab hole is learned with experience. This type of crab catching is done mostly in *Avicennia* forests. The technique is mostly used to catch *Scylla serrata*. This type of crab catching is done mostly by other communities other than Kolis. Each individual can fetch 1-4kilos of crabs per day.

*Kathkar*i community mostly use this technique. The whole family engage in this sort of crab catching. The family gather at one place after collection of crabs. Individual collections are put at one place. The elder among them divides the catch and share is allotted on hierarchical basis to the members of the family to take the catch to the market for selling.

3) Using *Gela* : It is a floating net attached to ring typed steel rod. Mostly used in low lying waters to catch crabs. A long rope is attached to the other side of the ring. Floats made with thermo-coal are tied around the ring. Kolis mostly adapted this technique. Operations are done between rising and receding tides.



Crab catching with the help of Chadye

They take about 15-20 gelas on small boats. About two to three persons can catch about 30-150kg of mud crabs.

The Thane creek is also host for a number of people belongs to other communities. They are the people mostly living adjacent to the creek. They are casual visitors. Many of them come from near by slums. They use tubes of truck tyres as floats. Fishing and crab catching are done only for sustenance.

Gela

We did not record manufacturing of charcoal or debarking of mangrove trees for *cutch* in the mangrove areas of Thane creek. However, we observed serious exploitation of mangroves for fire wood. Interestingly, fire wood collection is regularly done by slum dwellers living in the vicinity of mangrove areas. Their harvesting technique is very destructive in nature. Men from the adjoining areas go to the mangrove areas and partially cut or injure the trunk or big branches of the tree with a sickle or knife. Those branches are marked with some identification marks. This type of marking on injured parts of trees with symbols indicates the ownership and reduces the conflict between rival collectors. The injured parts will soon dry up and die. Because of heavy pollution this process is faster in Thane creek. Women periodically monitor the marked trees and collect the dried or fallen fuel wood. Drying of stems and branches takes place 30 –40 days after they were injured.

Kolis generally do not engage in this type of fuel wood collection activities. In fact they bitterly complained about loose law enforcement agencies. They are not allowed to collect fuel wood while others steal freely. During the entire survey period we did not come across even a single technique adapted by fisher folks for fishing is destructive or unsustainable in nature.

Chapter two

Study Area

Study Area

The Thane creek is situated on the West coast of Maharashtra, between Mumbai and Thane districts. Geographically it is situated between 19^0 00′ - 19^0 15′ N latitude and 72^0 55′ - 73^0 00′ E longitude.

Thane creek is extended 26km northward from the Arabian Sea. The creek mouth is located on the South-West of Mumbai harbour where it joins Arabian Sea and its geomorphic head is located on the northern side near Thane, at the meeting point where Ulhas river joins the creek with a narrow connection.

Geology:

The entire study area is occupied by Deccan basalt flows. They are step-like or terraced type of geological formations. The basaltic flows are horizontally bedded. The traps attain their maximum thickness of 2,133 metres near Mumbai coast.

No minerals of economic importance are found in the study region. The rocks are generally used in construction. The important rock type quirred for construction work is granophyric trachyte (Gazetter of Mumbai & Thane, 1986).

Climate:

The climate of the study area is characterized by an oppressive summer , high humidity and heavy south-west monsoon. The mean annual temperature ranges from 22 ^{0}c to 30 ^{0}c. May is the hottest month. During summer days, the maximum temperature goes up to 40^0c. January is the coldest month. The temperature drops to 10 ^{0}c. The average rainfall of the district is 2293.4mm.

Humidity:

The creek harbours a humid climate in general. Mornings are more humid than the afternoons. Among the different months of the year, humidity is high between June – October. The relative humidity during these months is about 75 per cent. It even rises to 90% during rainy days. The humidity levels come down during other months. From November to February the relative humidity is between 50-65%.

Population:

The population of Thane district, as per the 1991 census, is 52,49,126, which ranks third in the state. Due to developmental activities, there is a great increase in the human population of the district. The percentage decadal increase in the human population of the district, which was around 8.5% during 1901-11, is increased up to 56.5% during 1981-91. The population of the Mumbai district, as per the 1991 census, is 12 million.

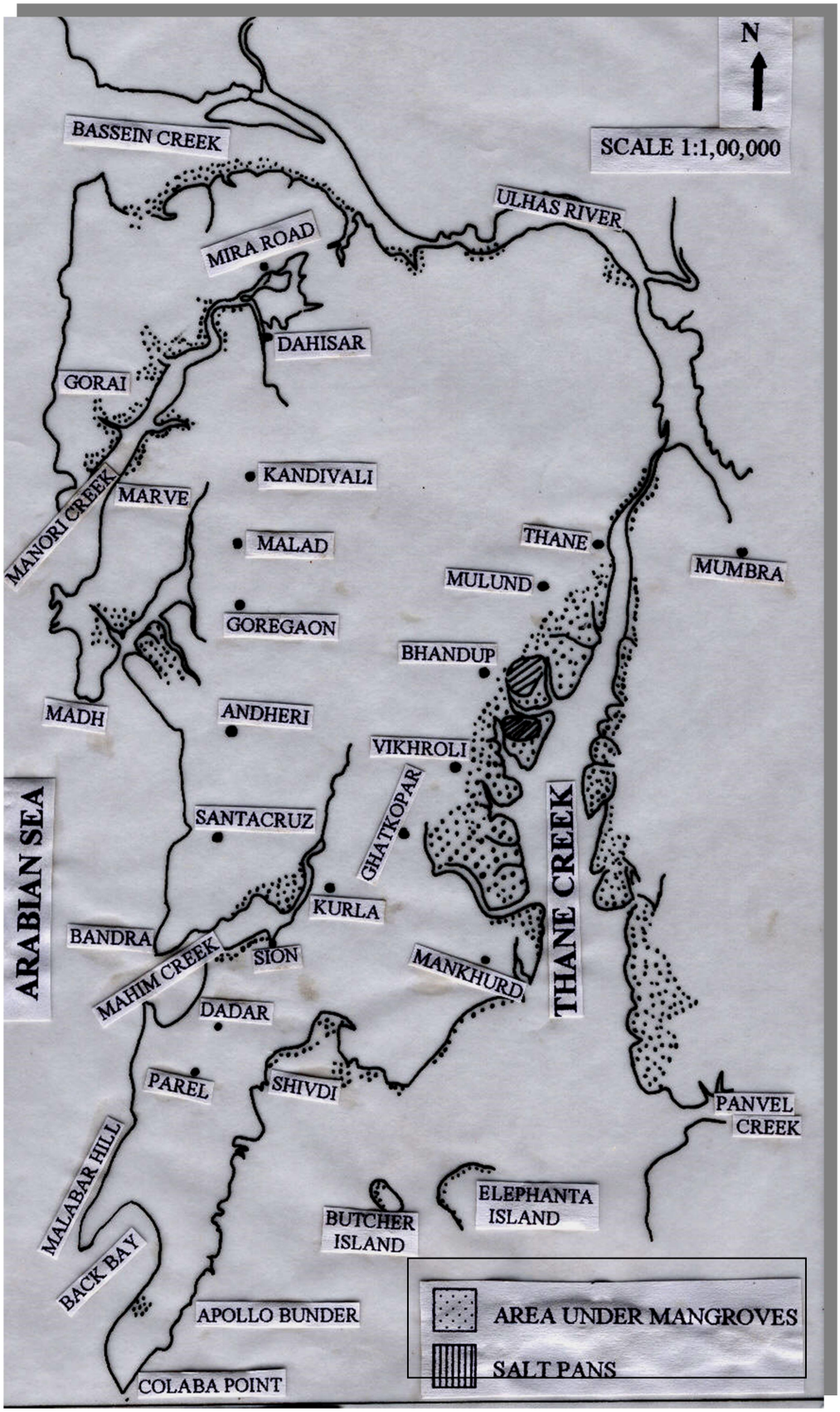
East bank of the creek represents Thane district while the west bank represents Greater Mumbai district.

Thane creek is one of the biggest creeks in Asia. Apart from Sanjay Gandhi National Park, Thane creek mangroves are the only forests that are surviving in the Mumbai city. There are many sources of fresh water for the creek. Ulhas river is the largest source, followed by numerous drainage channels coming from various suburban areas of the cities of Mumbai, New Mumbai and Thane.

The Thane creek is surrounded by a few of India's largest industrial areas, viz. Thane-Belapur, Ghatkopar, Kurla, Vikhroli etc. All these industries continuously pour their effluents in the creek. There are two very big solid waste dumping sites at Deonar and Shivajinagar (Govandi) located on the western bank of the creek. Along with numerous other small and scattered dumping yards, they dump a huge amount of solid waste, bio-degradable as well as non bio-degradable, into the creek, particularly after the spring tides. Hence today, Thane creek is considered as one of most polluted creeks of the country. The fish catch from the creek is reduced drastically because of marine pollution. Diversity of the fish catch is also reduced, as two to three species of fish are now available. The native fishermen of Mumbai used to depend on the creek for their livelihood. They are now looking for different business opportunities in the city because of decrease in the fish catch from the polluted Thane creek.

Areas selected for the study:

As the study should reflect the ecological status of the entire creek, various microhabitats, in the form of sampling stations were identified from the creek. Diversity of mangrove species varies according to their distribution as front mangroves and back mangroves with associate species. While selecting the stations, care has been taken to represent both the types. In addition to this, there is a consideration of arrays of pressure from natural and manmade processes while selecting the sampling stations.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BASSEIN CREEK
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DAHISAR
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MANORI CREEK
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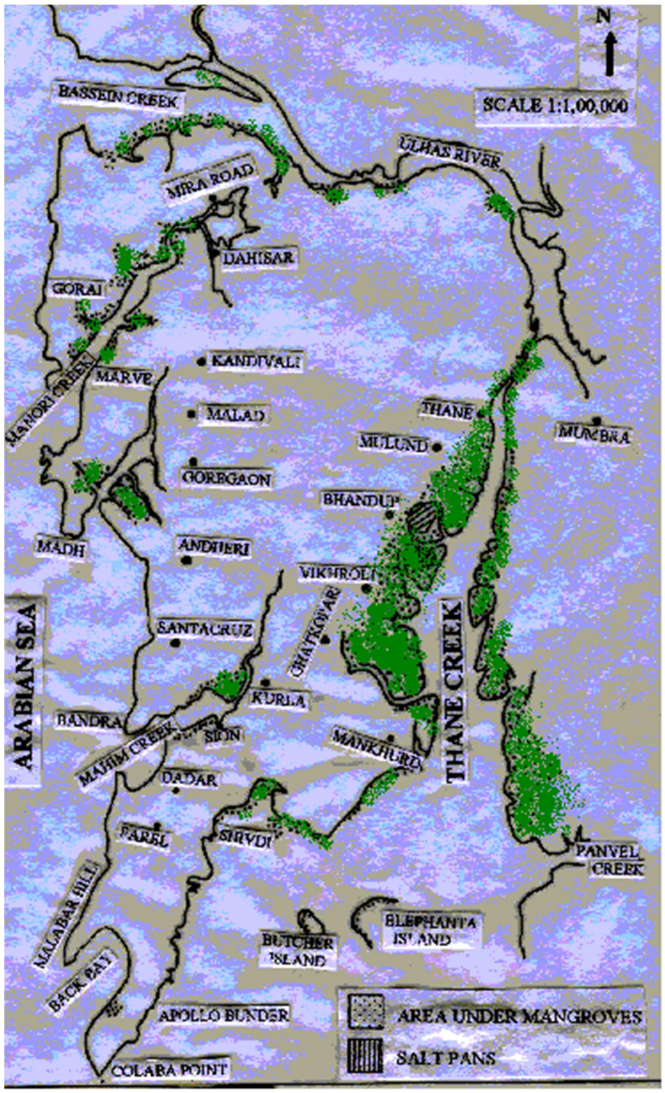
MUMBRA
MULUND
GOREGAON
BHANDUP
MADH
ANDHERI
VIKHROLI
ARABIAN SEA
SANTACRUZ
GHATKOPAR
THANE CREEK
KURLA
BANDRA
SION
MANKHURD
MAHIM CREEK
DADAR
PAREL
SHIVDI
PANVEL CREEK
MALABAR HILL
ELEPHANTA ISLAND
BUTCHER ISLAND
BACK BAY
APOLLO BUNDER
COLABA POINT
AREA UNDER MANGROVES
SALT PANS



Total area selected for the study is six hectares, spread over in six stations, each admeasuring one hectare (10,000m^2). Out of these six stations, three stations each have been selected from the mangrove areas is owned by Soonabai Pirojsha Godrej Foundation (SPGF) at Vikhroli and from the remaining areas are from the other parts of the Thane creek.

Names are given to sampling stations for the purpose of identification as well as the criteria for their selection which are presented in Table 2.1. The location map of these stations with reference to the creek is presented in Map 2.1

Table 2.1: Details of sampling stations.

Name of the Sampling Station	Criteria for selection
Vikhroli I: MMC Sewage Treatment Plant Site.	Partially protected, back mangroves.
Vikhroli II: Jetty site.	Partially protected, front mangroves.
Vikhroli III: Kanjurmarg nallah site.	Partially protected, front mangroves.
Mankhurd nallah site.	Disturbed area, front mangroves.
Talwali village site.	Disturbed area, back mangroves.
Vitava Island site.	Isolated island representing both the types of mangroves.

At each station, four permanent quadrates, each the size of 2,500m^2 were marked for the studies. Thus, a total of 24 permanent quadrates were laid down for purpose of study. In each sampling station, the stems of mangrove trees within the quadrat area were marked with a circular band of colour paint to demarcate the sampling area of the study area. Oil paint was used for marking the stems. Quadrates were drawn only in the areas covered by mangrove vegetation, i.e. in the supra-tidal region of the creek. Qualitative studies have been done by undertaking general surveys in the mangrove areas of the Thane creek.

The detailed description of each sampling station is presented in the proceeding text.

2.3 Description of the sampling stations

A] Stations from Vikhroli area

1] Vikhroli I: MMC Sewage Treatment Plant Site

The station is located on the west bank of the Thane Creek. This is a well protected old back mangrove patch, as evident from the tall trees with good canopy cover (Plate 2.1). This mangrove patch is surrounded by a number of *nallah*s. Estuarine water enters this area through these *nallahs* during high tides. During the other times these *nallahs* act as nothing but the drainage channels of decomposing sewage coming from the Vikhroli village. As a result biodegradable and non-biodegradable matter accumulates in these channels during the neap tide phases. These matters are flushed from channels by the gushing waters of spring high

tides. Total submergence of the area takes place only during spring high tides. Spring high tide waters are found to be anoxic.

The striking feature of this area is the abundance of Pagoda Ant nests. Quite interestingly, in spite of good canopy, very few bird nests were observed in the area. There might have been some relation of presence of pagoda ant nests and absence of bird nests, which needs to be investigated in detail.

Six mangrove species viz. *Avicennia*, *Sonneratia*, *Excocaria*, *Ceriops*, *Aegiceras* and *Acanthus*, and four mangrove associates viz. *Salvadora persica*, *Derris* sp., *Clerodendron* sp. and *Sesuvium portulacastrum* are common in the area.

Patches of *Aleurops lagopoidis,* a typical mangrove grass is a very prominent feature of this area.

The length and width of Mudflats in the area are very short. Mud is very sturdy. Number of pneumatophores per unit area are more than any other study area. This could be, possibly because of the anoxic conditions. During spring high tides, mollusks are found to climbing on tree trunks.

2] Vikhroli II (Jetty site) :

This station is located on the west bank of Thane creek. The creek channel is very narrow. This channel is the release point of drainage channels from different parts of Vikhroli Industrial belt through which various kinds of effluents continuously released into the creek waters. Water is extremely polluted, showing dark colour and emit smells of chemicals. Mangroves in this site are protected. They show a good canopy cover. The area gets submerged totally during the spring high tides.

Avicennia is the dominant mangrove species in this area. Besides, *Acanthus* belts are also common. A few plants of *Rhizophora*, which are introduced some time back, are growing well in this area. Except a few crow nests, bird nests are not observed in this area.

3] Vikhroli III (Kanjurmarg nallah site):

The station is located on the west bank of Thane creek. This area is situated at comparatively low level. Hence majority of the area gets submerged during neap high tides. Water level reaches two feet above the ground level during spring high tides. Black patches especially of oil and greese on the stems & branches of mangroves indicate tree height of submergence during the Spring high tide. Mud flats in this area are very soft, possibly because of longer water retention in the area.

Avicennia and *Acanthus* are the two species, which predominantly present in this area. So far, bird nests and pagoda ant nests are not observed in this area.

B] Stations from other areas of Thane creek

1] <u>Vitava Island Site</u>

The station is located on the east bank of Thane creek. At least two sewage outlets of Thane Municipal Corporation are located near the study area. Mangrove trees are very tall with good canopy cover. Cutting ofwood for fuel is rampant in the area, which is evidenced by the presence of dried branches and wood logs spread all over the area. Mud flats are very long with extremely soft mud. According to local fishermen, widening of mudflats coupled with shallowing of the channel took place in last ten years because of solid waste dumping and siltation resulted from the construction of bridges on the creek.

The entire area gets submerged only during spring high tides. *Avicennia*, *Sonneratia* and *Acanthus* are the dominant mangrove species of this area. Bird nests are more in this area as compared to other sites.

2] <u>Talwali Village site</u>

The area is located at village Talwali near Ghansoli in the Thane – Belapur Industrial Zone, opposite National Organic Chemical Industries Limited (NOCIL) and Indian Petrochemical Corporation Limited (IPCL) factories, on the east bank of Thane creek. The Thane – Belapur Industrial Zone is one of the biggest chemical industrial zone of Maharashtra state. All along this zone, huge *Acanthus* belts have been formed due to the destruction of mangrove vegetation. Mud flats are long with soft mud. Front mangrove area is not accessible from land ward side because of thick belts of *Acanthus*. The area gets submerged during spring high tides only.

The Eastern side of the creek is reclamated for industries and housing. Mangrove areas are used for constructing crematorium.

3] <u>Mankhurd nallah site</u>

The station is located at village Mankhurd near Vashi creek bridge on Mumbai – Pune National High way, on the west bank of Thane creek. The area is located near High way near abandoned saltpans. The area is easily accessible by road, hence extremely degraded. Cutting of trees for fuel wood is maximum as compared to other stations. As a result, mangrove species show extensive branching.. Trees are stunted. The area gets submerged totally during spring high tides. Bird nests are very rare.

The study area is located near Deonar Solid Waste Dumping Depot, biggest of its kind in India. During spring high tides enormous quantity of solid waste in the form of plastic bags, plastic bottles, electric bulbs and tubes, thermocol etc. enters the

creek and gets trapped in mangrove bushes. *Avicennia* is the dominant species of this area.

Methodology

In the present work, various components of the mangrove ecosystem have been studied in order to know the structure and diversity of mangrove ecosystem in a holistic way. This was done by conducting quadrate study in the selected sampling stations.

Diversity of individual component has been studied by using standard ecological methodologies. Out of the selected biodiversity components, a few components have been studied quantitatively while a few components have been studied qualitatively. The methodologies adapted for respective studies are described below.

Physico-chemical studies

Brackish water, soil and sediments are the most important components of the mangrove ecosystem. They indicate the pollution levels and the health of the creek ecosystem in general. In the present work, seven parameters of the brackish water and six parameters of the mangrove sediments have been analysed.

Brackish water chemistry

All the mangrove areas selected for quadrate study gets submerged in the tidal waters only during spring high tides. At four sampling stations part of the quadrate study areas gets submerged during neap high tides. In the other two stations, water does not reach up to the mangrove zone.

To study the quality of brackish water reaching at selected mangrove quadrate study areas, surface water samples were collected during the spring and neap high tides. One representative sample was collected from each mangrove quadrate in one-litre pre-washed plastic containers. For the estimation of dissolved oxygen, samples were collected separately in BOD bottles of 300 ml capacity. For the estimation of oil and grease content of the water, separate samples were collected in plastic bottles of 250 ml capacity.

In the laboratory, samples were filtered before analysis to remove the visible impurities. Standard methods, as described in APHA, AWWA and WPCF (1981) and Trivedi and Goel (1984) were used for the analysis. The methods are summarized below.

pH: **pH was recorded by using digital pH Meter. Before taking the readings, the machine was calibrated by using standard solutions. These solutions were prepared in the laboratory by dissolving the buffer tablets 4, 7 and 9.2 pH, into 100ml of distilled water.**

Salinity: **Water salinity was calculated from the chloride contents of the sample. Chlorides were estimated by gravimetric method. 50 ml sample was taken**

$$\text{Chlorides} = \frac{\text{ml of titrant x Normality of } AgNO_3 \text{ x } 1000 \text{ x } 35.5}{\text{ml of sample taken for titration}}$$

in a 250 ml conical flask and 2ml K_2CrO4 was added as indicator. It was then titrated against 0.02N $AgNO_3$ until a persistent red tinge appears. Chlorides were then estimated by using following formula.

From the values of chlorides as obtained by the above formula, salinity values were calculated by using following formula.
Salinity = (chloride contents x 1.805) + 0.03
The results are expressed in terms of parts per thousand (ppt).

Dissolved oxygen (DO): **Sample was collected in 300ml glass BOD bottle and DO was fixed immediately by adding 2 ml each, of $MnSO_4$ and alkaline KI solution. After the precipitate gets settled, 2ml concentrated H_2SO_4 was added to it to dissolve the precipitate. Then, 100ml solution was taken from the bottle and titrated against 0.025N Sodium thiosulphate solution using starch indicator. Colour change from dark blue to colourless was the end point. DO was estimated by using the following formula.**

where, V = Volume of MnSO4 and KI added
V1 = Volume of BOD bottle,
V2 = Volume of sample taken for titration

$$\text{DO (ppm)} = \frac{\text{ml x normality of titrant) x 8 x 1000}}{\text{V2 x } \frac{\text{V1 – V}}{\text{V1}}}$$

Phosphates (PO_4 – P): **Phosphates were measured by using spectrophotometric method. In 50 ml sample, 2ml Ammonium molybdate and 5 drops of $SnCl_2$ were added. Blue colour appeared was measured on spectrophotometer at 690nm wavelength. Phosphate concentration was calculated by comparing the absorbance with the standard graph.**
The results are expressed in terms of parts per million (ppm).

Nitrates (NO_3 – N): **Nitrates were measured by using spectrophotometric method. In 50ml sample, silver sulfate equivalent to chloride contents of water was added to remove the chlorides. Precipitate of AgCl was filtered after gentle heating. Filtrate was evaporated to dryness in a porcelain dish. After cooling, 2ml Phenol disulphonic acid was added to dissolve the precipitate and contents were diluted to 50ml. After adding 6ml liquid Ammonia, yellow colour was developed which was measured at 410nm wavelength. Concentration of nitrate in ppm was estimated by using standard curve.**

Silica: **Silicates were measured with the help of spectrophotometric method. In 50 ml filtered sample, 1ml 1+1 HCl was added, followed by 2ml of ammonium molybdate. After about 15mins, 20ml of stannous chloride was added to the solution. Colour developed was measured with the help of spectrophotometer at**

815nm wavelength. Silica concentration was measured with the help of standard graph. The results are expressed in terms of parts per million (ppm).

Oil and grease: **Oil and grease content was estimated by using gravimetric method. 250 ml sample was taken in a separating funnel. It was mixed with 10ml sulphuric acid and 50ml petroleum ether. After formation of two layers, lower layer of sample was discarded through separating funnel. The residual oil and grease present in the upper layer was taken into pre-weighed porcelain dish and petroleum ether was evaporated by heating on a water bath. Final weight of the dish was taken and oil and grease content was estimated by using following formula. The results are expressed in terms of mg/L.**

Where, A = Final weight of dish in gm,
B = Initial weight of the dish in gm and
V = Volume of sample taken in ml.

Sediment chemistry

To study the chemical quality and nutritive value of mangrove sediments at selected mangrove quadrates, sediment samples were collected from all the quadrates from the depth of around 30cms. Four samples were collected from each

$$\text{Oil and grease mg/L} = \frac{(A - B) \text{ X } 1000000}{V}$$

quadrate area. Samples were collected in clean and marked polythene bags. In the laboratory, samples were kept in the open space for air-drying. After drying, the samples were pounded with the help of mortar and wooden pastel after which, they were sieved through a 2mm sieve. Sieved samples were stored in clean polythene bags and analysed by using standard analytical methods (Trivedi and Goel, 1986).

The methods adopted are presented below.

pH: **1 : 5 soil solution was made by mixing 20 gm dried soil in 100ml of distilled water. The pH of this solution was measured with the help of digital pH Meter.**

Soil salinity: **Soil salinity was estimated from the chloride contents of the sample. To estimates chlorides and salinity in the soil, 1:5 soil solution was analysed gravimetrically by using the same method as used for the estimation of brackish water salinity.**

The results are expressed in terms of parts per thousand (ppt).

Organic matter: **The organic matter content of sediments was calculated empirically from the values of organic carbon. Organic carbon was estimated by using modified Walkley and Black method . In a conical flask containing 10g of**

dried soil, 10ml of 1N K_2Cr2O7 solution and 20ml concentrated sulfuric acid was mixed by gentle swirling. The mixture was kept for reaction for about half an hour. After that, it was diluted to 200ml and 10ml phosphoric acid and diphenylamine indicator were added to it. The solution was titrated against 0.4N ferrous ammonium sulfate to the colour change of brilliant green.

Simultaneously blank titration was also run. Organic carbon was estimated by using following formula.

$$\text{Organic carbon} = \frac{3.951}{\text{wt. of soil}} \text{ X } 1 \frac{\text{ml of ferrous sol. for sample titration}}{\text{ml of ferrous sol. for blank titration}}$$

The values of organic carbon were converted into organic matter values by using following formula.

Organic matter = Organic carbon (%) x 1.724

The results are expressed in terms of percentage.

Total nitrogen: **The total nitrogen from the sediments was estimated by using Kjeldalh Digestion Method. The soil was digested with concentrated sulphuric acid in the presence of a catalyst. After digesting at high temperatures, sodium sulfate was added to raise the boiling point of sulphuric acid. Nitrogen was converted into ammonium sulfate, which was determined after distillation in alkaline condition by titrating with 0.1N hydrochloric acid.**

Total phosphorous: **A thin paste of 0.5gm powdered soil was taken in a Kjeldahl flask and 2ml conc. Nitric acid and 2ml concentrated perchloric acid was added to it. The mixture was heated on a hotplate till it dries. After cooling the flasks, again 1ml perchloric acid was added and again heated until dry. After cooling, 21ml diluted sulfuric acid was added to it and boiled slowly for 10minutess. After cooling, the mixture was filtered through Whatman No. 42 filter paper and distilled water was added to it till the volume becomes 250ml. From this solution, total phosphorous was estimated by employing the same procedure as discussed in estimation of phosphates from brackish water.**

The values are expressed, as percent total phosphorous. The results are converted into mg/100gm soil by multiplying with 1000.

Sediment texture: **The sediment texture was analysed by using Buchanan's (1984) method. About 5 gm of unpounded soil was weighed and soaked over night in 25 ml of 6% hydrogen peroxide solution to digest all the organic matter present in the soil. The following day another 10 ml of the 6% of the hydrogen peroxide was added to the soil and kept on a steam bath till the frothing completely stops. This digested soil was then passed through a 62 μm sieve in a trough by passing water**

and thoroughly agitating the sieve. After ensuring that all the fine grained sediments have passed through, leaving only the sand in the sieve, the sieve was then oven dried and the contents were weighed for sand. Next, the contents of the trough (containing the fine grain sediment) were transferred to a 1000 ml stoppered measuring cylinder, and the final volume was made to one litre. The measuring cylinder was agitated and 20 ml of the solution was removed immediately at a depth of 10 cm from the surface of the solution. This solution containing silt and clay was passed in a pre-weighed evaporating dish and dried in an oven. The measuring cylinder was again agitated and allowed to stand, after 2 hours and 3 minutes; another 20 ml solution was taken at 20 cm depth by using a pipette. This solution contains only clay, which was oven dried. After drying, the weights of both silt and clay were obtained for the 20 ml of solution. The clay portion from the silt and clay reading was subtracted and the values were calculated for 1000ml of the soil suspension. The values obtained for sand, silt and clay were then totaled to get the approximate initial weight (i.e. 5 gm). Finally the estimates obtained for the 5 gm of soil were converted to percentage.

Floristics

Floral components of the mangrove ecosystem studied include vascular plants, associated macroalgae, phytoplanktons, marine fungi and lichens. Out of these, phytoplankton and vascular plant diversity was studied quantitatively while associated algae, marine fungi and lichens were studied qualitatively. Plant specimens (mangroves, mangrove associates and halophytes), collected during the study were pressed, poisoned and Herbarium sheets were prepared.

Ecology of vascular plants

Vegetation studies were conducted for all the six sampling stations by quadrate method. All the mangrove species in the quadrats were identified with the help of standard keys (Banerjee et al, 1989 and Tomlinson, 1986).

For confirmation of field identification of mangrove as well as associate flora, herbarium sheets of all the species have been prepared and stored in the herbaria of Naoroji Godrej Centre for Plant Research.

For the estimation of biomass, diameter at breast height (DBH, ~1.32mt high from the ground level) was recorded for all such plants showing DBH more than 2.5cm. The height of the plant was recorded for all such plants showing DBH > 2.5cm. For the plants showing multiple branches, number of branches on the main stem and DBH of all the branches (if DBH exceeds 2.5cm) were recorded.

Based on these observations, frequency, abundance, density, Importance Value Index (IVI) and biomass of the individual species have been calculated by using following formulae.

Frequency: Frequency indicates distribution of a particular species in a community. Frequency was calculated by using following formula, and expressed in percentage.

Abundance and density: **These values represent numerical strength and distribution of species in a unit area. They were calculated by using following formulae.**

$$\text{Frequency (\%)} = \frac{\text{Number of sampling units in which species occurs}}{\text{Total number of units studied}} \times 100$$

$$\text{Abundance} = \frac{\text{Total number of individuals}}{\text{Total no. of quadrates in which the species occur}}$$

Basal area: **In the calculation of above ground biomass or wood volume, basal area**

$$\text{Density} = \frac{\text{Total number of individuals}}{\text{Total no. of quadrates studied}}$$

and canopy height are the important factors. In diversity studies of terrestrial vegetation, diameter of the trunk at the base is generally used to compute the basal area. However, in case of mangrove forests, the habitat is inhospitable. The substrate is loose, sticky mud. Also, many a times, the mangrove trees develop modified roots in the form of buttresses. Hence, it becomes difficult to take the measurements of the basal area exactly at the base. Under such circumstances, to get better results, the methodology was slightly modified. In the present study, DBH was used to calculate the basal area by using the following formula.

Basal area (cm^2)= r^2, where r = 1/2 (DBH)

Importance value index (IVI): **IVI indicates the dominance as well as ecological success of the species. As it is the summation of relative density, relative frequency and relative dominance it considers the number, occurrences and area occupied by that species.**

I.V.I. = Relative frequency + Relative Density + Relative Dominance.

where,

Diversity indices: **It is the statistical expression of diversity, which includes species richness and evenness within the community.**

Species diversity can be measured by using species richness model, species abundance model or proportional abundance model. In the present study alpha

$$\text{Relative Density} = \frac{\text{Number of individuals of the species}}{\text{Number of individuals of all the species}} \times 100$$

$$\text{Relative Frequency} = \frac{\text{Number of occurrences of the species}}{\text{Number of occurrences of all the species}} \times 100$$

$$\text{Relative Dominance} = \frac{\text{Total basal area of the species}}{\text{Total basal area of all the species}} \times 100$$

diversity of vascular plants has been measured. As the plants are delimited in habitat and effect of these habitats is significantly expressed in terms of species richness, in the present study, Margalef's index (1958) and Menhinick's index (1964) have been used to represent the diversity. These indices were calculated by using following formulae.

Margalef's index D_{Mg} = (S-1) ln N

Menhinick's index D_{Mn} = S/√ N

Margalef Index comes to zero if the area is having only one species while Menhinck's Index gives some value in every case. Hence in the present study, both the indices have been computed.

Diversity for the vegetation was calculated by using Shannon's diversity index (H'). It measures the average degree of uncertainty for S number of species and N number of individuals of the species. The index comes to zero when there is only one species in the community and it is maximum when all the species are equal in number.

$H' = \sum (Pi \ln Pi)$
$Pi = ni / N$
where, ni = Total number of individuals of a species
N = Total number of individuals of all the species

Wood volume: **For mangrove plants, estimation of wood volume is important as they are mainly utilised for fuel purpose.**
It was calculated by using following formula and is expressed as m^3/ha.
Wood Volume = 0.719 + 0.4149 (D^2H)
Where H = canopy height and D = DBH

Phytoplankton

Phytoplanktons are mostly unicellular autotrophic organisms, which lack locomotary mechanism. They form the food-base for fishes and crabs. Their occurrence in the mangrove ecosystem is only during the high tides.

Phytoplankton diversity was studied qualitatively as well as quantitatively. One brackish water sample was collected from each quadrate for plankton analysis in every season. For qualitative studies, i.e. species identification up to genus level, sample collection was done as follows:
500 ml of brackish water was collected during spring tide by dipping the bottle. The sample was preserved, first in Lugol's solution for instant fixation and then, in 4% Formaldehyde for long term preservation. The planktons were allowed to settle down, to collect 100ml of concentrate. This sample was analyzed by using Haemocytometric method for cell counting. Counting was done by using the formulae,

$$\text{Phytoplankton , units/ml} = \frac{\text{No. of phytoplankton in central chamber x 10}}{\text{concentration factor*}}$$

These observations were used for quantitative estimation of algae and for calculation of various diversity indices. Evenness Index explains the abundance of species in the community. It was found to be maximum where all the species

$$\text{concentration factor} = \frac{\text{Total volume of water concentrated}}{\text{Final vol. made after concentration}}$$

are equally abundant and decreases towards zero. Within five different evenness indices Hill's index was used as it was relatively unaffected by species richness. It was calculated by using following formula,

$$E = (1/\lambda) - 1 / e^{H'} - 1$$

where, H′ = Shannon's index value

Planktons were identified by examining the sample concentrate drop-wise under the microscope and comparing the specimens with standard keys (Hendy, 1964; Palmer, 1980; Sarode and Kamat, 1984; Santhanam et al, 1987; and Bellinger, 1992).

For computing the phytoplankton biomass, chlorophyll estimation method was used. The methodology adapted for chlorophyll estimation was as follows:

100 L of brackish water was filtered through plankton net (30 mesh size). Phytoplanktons were concentrated to make the volume of the solution 100 ml.

Phytoplanktons were filtered through cellulose filter paper (45μm pore size, 47mm diameter) by using the Buckner funnel. During the final stage of filtration, 0.2ml of magnesium carbonate suspension was added to elute the pigments.

The concentrated sample was centrifuged at 5000 rpm for 20 minutes. After decanting the water, the filtrate was macerated in mortar and pestle with the addition of a few millilitres of 90 % acetone. Acetone solution was used to rinse mortar and pestle.

The sample was then kept at 4^0 C for 4-6 hrs to elute the pigment.

The macerated sample was then centrifuged at 5000 rpm for 10 minutes by making the volume 10ml with distilled water.
After centrifuging, the extract was decanted.

After making the volume to 10ml with 90% acetone, the optical density of the extract was measured on spectrophotometer at 663, 645 and 630 nm wavelengths.

Based on the optical density values, chlorophyll *a* estimation was done by using following formulae.

Chlorophyll *a* = [(11.64 x E663 – 2.16 x E645 + 0.10 x E630)
where E663, E645 and E630 were the optical density values of the extract at these respective wavelengths.

Associated algae

Qualitative studies were carried out for,
Algae found on the mangrove soils
Algae observed on the pneumatophores and bark of mangrove species, especially *Avicennia marina*
Algae observed on the surfaces of the broken branches of mangroves or plastic or other material accumulated in the mangroves

Samples were collected and preserved in 4% Formaldehyde solution in plastic bottles according to category and labeled. Identification was done by using the standard keys (Chapman, 1977; Humm and Wicks, 1980).

Various algal groups, their pattern of association with ecological gradients and relationship with climatic and physical parameters were recorded.

Marine fungi and lichens

General qualitative survey was done in Thane creek mangrove areas to locate the presence of any epiphyte, fungi or lichen. The specimens were collected and identified by using standard key (Kohlmeyer and Kohlmeyer, 1979).

Faunal components

Faunal components studied in the present work include macrobenthos, meiobenthos, zooplankton, insects and plant galls, reptiles, avifauna and mammals associated with the mangrove ecosystem. Out of these components, macrobenthos, meibenthos and zooplankton were studied quantitatively while other components were studied qualitatively.

Macrobenthos

For studying the diversity of macrobenthos, mud samples from all the quadrate study were collected. For sample collection the shovel method suggested by Kicenink and Williams (1987) was employed. A specially designed metal shovel of size 10x10x10cm was used. From each mangrove quadrate, five scoops of mud was collected by random sampling method.

Collected samples were drained through a sieve of mesh size 0.5mm, and organisms were separated and preserved in 10% Formaldehyde solution. From the preserved samples, organisms were identified, counted and biomass was recorded for individual organism.

The results are expressed in terms of number of organisms per square meter.

Meiobenthos

Soil samples were collected up to a depth of 10 cm using a core of 2.5 cm diameter in the field. The samples collected were then fixed in 1: 500 Rose Bengal : Formalin. Later the samples were passed through two sieves, first through 0.5 mm followed by 0.62 μm sieve to separate the meiobenthos. The organisms were separated, preserved in Formaldehyde and then identified. The organisms were counted for the individual groups and per square meter biomass was estimated.

Zooplankton

The sample collection for the quantitative study of zooplankton was done by using 30 mesh plankton net. As it was impractical to tow the plankton net through the mangrove quadrates, 100 litres of brackish water was filtered through the plankton net and the filtrate containing zooplankton was collected and preserved in 10% Formaldehyde solution.

The entire sample was observed for rare and common groups, while the zooplanktons were counted for abundance using subsamples by observing under the microscope. Species were identified by using standard keys (Wimpenny, 1966; Krishna Pillai, 1986; Battish, 1992 and Santhanam and Srinivasan, 1994).

Insects and plant galls

Regular field visits were conducted to observe the insects present on mangrove plants. Hand picking and collection of insects using insect nets was done to collect the insects. Insect specimens collected have been handed over to insect museum of Bombay Natural History Society for correct identification. Insects were also collected during the night time by using light traps. However, due to unavailability of electricity on the creek side, modified light trap have been used. This light trap consisted of a pair of tube lights, a portable generator set and white coloured cloth curtain. The trap was operated during 6.00 p.m. to 1.00 a.m. and insects were collected.

Similarly, a general survey was conducted to collect the infected plant parts showing galls by insect or mite. This is a first attempt to study plant galls of the mangroves from Mumbai area.

Avifauana associated with mangrove ecosystem

Field surveys were carried out on both, landward side as well as seawards and in the intertidal regions to count the birds in every possible niche. Surveys were conducted both on foot as well as from the boat. Due to legal constraints actual capturing of the birds was not undertaken and identification was done

through field observations only. Dr. Salim Ali's `Hand Book of Birds of India and Pakistan' was used for identification purpose.

Mammals associated with mangrove ecosystem

Most of the inferences are based on visual observations in the field. Excepting for the rodents and the smaller bats, no captures were involved for identification purposes. For classification, general characteristics and colouration was considered. Due to limitation of time and resources, identification at species level was only undertaken. Identification to the sub species and racial level was not considered. Capture and identification was carried out in all seasons. Identification was done by referring to Prater (1971), Gee (1955) and Sandersan (1955).

Reptiles associated with mangrove ecosystem

Most of the inferences are based on visual observations in the field. Excepting for the *Enhydrina schwastosa*, *Hydrophis cyanocinctus* and *Acrochordus granulatus* where, the dead specimens were used for identification, in most cases, the specimens were captured live and released after identification. For classification, general characteristics, colouration and rarely, the scales were considered. Due to limitation of time and resources, identification at species level was only undertaken. Identification to the sub species and racial level was not considered. Capture and identification was carried out in all seasons and both in water and on land. For identification purpose, books by Daniel (1983), Whitaker (1978) and Smith (1931) were used.

Chapter Seven

Mangrove flora

Angiosperms

Angiosperms are flowering plants.

Thane creek is rich in flowering plant diversity. Mangroves are salt tolerant flowering plants. Floristically, Maharashtra coast is rich in mangrove species. About 60 species of mangroves, mangrove associates and salt tolerant species are reported from the state. Out of them, 27 species are mangroves (Deshmukh, 1996).

The present study revealed the presence of 16 mangrove species in the Thane creek area. They are represented by 10 genera and eight families. The study also listed about 60 more mangrove associates and salt tolerant species during the floristic surveys.

The present floristic studies strategically included all the species listed by Woodrow and Navalkar. However, many species listed by the earlier authors may not be found in the Thane creek and its surrounding areas. Some species are reintroduced in the creek in recent years.

A serious study is further required to find out what are the species disappeared from the Thane creek area. Interestingly the floristic composition of Thane creek mangroves is dominated by two genera – *Avicenia* and *Sonneratia*. Both these genera are represented by three species each . This present study confirms the presence of three more species in addition to the earlier described species from Thane creeks.

Botanical name: ***Acanthus ilicifolius*** L.

Vernacular name: *Marandi*
English: Sea Holly

Family: **Acanthaceae**

Habit: Shrub (up to 2m tall).

Description: Erect or sprawling, occasionally with a viny tendency. Leaves glabrous, shining above, elliptic, ovate-oblong, decussate, usually with spiny margins. A pair of spines is usually present at the insertion of each leaf. Flowers bluish or bluish-violet, two lipped, in densely strobilate spikes, 3-4cm long. Stamens-4, in two slightly unequal pairs; anthers with a thick line of hairs bordering the split. Fruit a capsule, ovoid-oblong, 2.5-3cm long. Dehiscence takes place by violent splitting of capsule in the dorsiventral plane.

Flowering: Throughout the year.

Pollinators: Birds (Sun birds) & insects (Bees).

Fruiting: Throughout the year.

Key characters for identification: Flowers blue or violet (rarely white), 3.5-4cm across. Leaves spinuous.

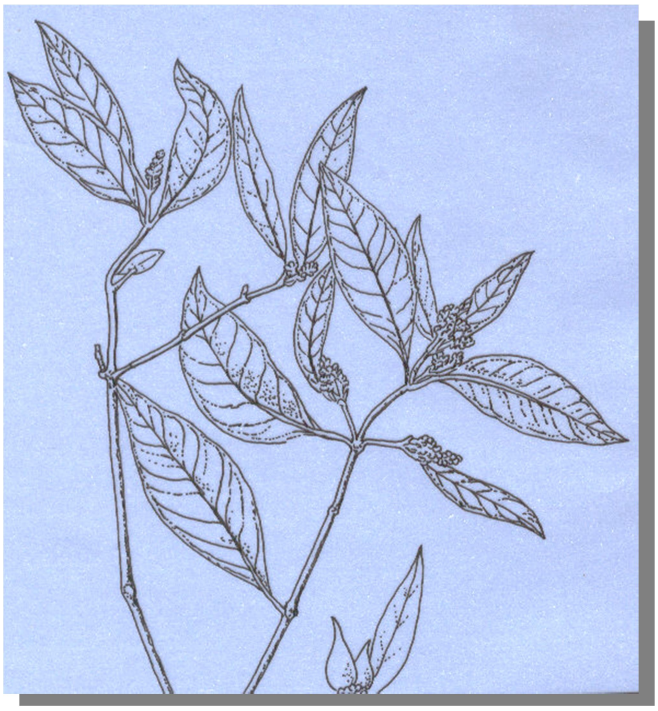
Ecology: Salt is secreted through epidermal glands. Abundant in back mangrove areas. Its presence along the swamps indicates secondary formation**.**

Distribution: Asia, Australia & South-East Africa.

Uses: A decoction of the stem & leaves with sugar candy and cumin is given dyspepsia with acid eructations
Leaf paste is applied to parts to cure rheumatic pains and neuralgia.
Fruit pulp is taken internally to purify blood.
Stray cattle graze flowers.

Threatened category: Endangered.

	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Frequency	100	100	--	100	100	--
Density	360.25	137.8	--	221	2010.5	--
Abundance	360.25	137.8	--	221	2010.5	--
Average height (m)	--	--	--	--	--	--
Number of plants/hectare	1441	551	--	884	8,000	--



Botanical name: ***Avicennia alba*** Bl.

(= *Avicennia officinalis* L. var. alba (Bl.) Bakh.)

Vernacular name: *Tivar*

Family: **Avicenniaceae**

Habit: Small tree (up to 5m tall).

Description: Buttressed (not so prominent), bark lenticelled, brownish-black. Leaves 8-13 X 2-3.5cm, lanceolate, pointed at the apex, green above, silvery papillose or whitish below. Flowers in terminal or axillary spikes, fragrant, yellow, resembles *A. marina*. Ovary 2mm long, middle of the ovary is hairy and the lower part consists of glandular hairs. Style absent. Fruits 4cm, conical, narrowly curved at the apex, tomentellous.

Flowering: June – August.

Pollinators: Insects (Bees)

Fruiting: July-October.

Key characters for identification: Bark grayish green.
Leaf lanceolate-acute, under surface silvery-grey or white.
Fruits narrow-ellipsoid (almond type).

Ecology: Common in riverine and estuarine mangrove swamps. It forms a second zone species mostly behind *A. marina.*
*Doubtfully present in the creek

Distribution: Asia and North Australia.

Uses: Unripe seed powder is made into a paste and used externally as a poultice to hasten suppuration of boils and abscesses and to cure small-pox.
Sap from bark taken internally as a contraceptive.
When in flower the species is a good source of food for honey- bees.
Fruits are edible and consumed by humans.
The species is extensively used as fuel wood.
The leaves are used as fodder and fish-food.

Threatened category: Critically endangered.

Botanical name*: Avicennia officinalis* L.

(= *A. tomentosa* Jacq.)

Vernacular name: *Tivar*
English name: White mangrove

Family: **Avicenniaceae**

Habit: Moderate sized tree (up to 20m tall).

Description: Pneumatophores simple or forked, frequently hooked at apices, spongy. Bark whitish-grey, peels off as papery flakes. Leaves elliptic, ovate-oblong, shining above, densely brownish pubescent beneath, black on drying, 6-10 X 3-6cm. Description of flowers varies from Manuel to Manuel. Flowers aromatic (rancid or fetid smell), large, orange- yellow, 10-15mm diameter. In Mangroves in India – Identification manuel by Banerjee, Sastry &Nayar,1989 the following description was made. " flowers in trichotomous cymes, yellow, small, 5-6mm" (considered wrong description). The corolla is the largest and shallowly bilobed. Stmens 3-4mm long, exerted. Ovary shortly hairy except the tip of the well developed style, stigma lobes unequal. The bracts and bracteoles are black tipped with a fringed margin. The fruit is densely hairy, almond shaped, ovoid, about 3-4cm long, beaked at apex.

Flowering: June - August

Pollinators: Insects (flies & bees).

Fruiting: June – October.

Key characters for identification: Obovate or ovate-oblong leaves. Largest flower among *Avicenia* spp (?).
Almond shaped fruits.

Ecology: Back mangrove. Never forms a pure strand.

Distribution: Asia, Africa, Australia & Pacific islands.

Uses: The wood is used to prepare Dugout canoes.
It is also considered good and preferentially used as boat keels.
The wood is considered as best firewood.
The leaves and stem contains steroid sapogenins and used for a variety of purposes.
The unripe seed powder taken internally to **cure ulcers**. Crushed paste of the bark is used to cure leprosy.
Leaves and fruits are recognized as diuretic.
Dried leaves are smoked by the people of Gujarat & Rajasthan for relief from **Asthma**.
The decoction of the leaves & bark taken internally to cure **diarrhoea.**
Ash from its wood is used for washing and reportedly removes **stains & blotches**.
The bark yields a dye
The flowers & unripe fruits are edible.
Sprouts and fruits are used as cattle fodder. The fodder is believed to **increase milk** in cattle.
In many regions particularly in Konkan region all *Avicenia* sp. are used as green manure.
The roots of the species are considered as **aphrodisiac**.

Threatened category: Endangered.

Botanical name: ***Avicennia marina*** (Forssk.) Vierh.
var. marina (Forsk.) Vierh.
var. acutissima Stapf & Mold.

Vernacular name: *Tivar*

Family: **Avicenniaceae**

Habit: Variety marina: Shrubs or small tree (4-5m high)
Variety acutissima: Shrubs or small trees (5-10m high).

Description: Bark yellowish brown, lenticellate. Leaves elliptic –ovate or elliptic-oblong (3-6 X 2-2.5cm), pale green above, tawny-tomentose beneath, acute apex. Flowers in condensed cymes, orange-yellow, scented, about 6mm in diameter. Flowers of Indian varieties 2-4mm across, generally pale yellow. Corolla glabrous within except the presence of minute glandular hairs. Stamens short, 2mm long, not exserted. Style short, stigmas two. Capsule 1.2-2cm long, ovoid, apiculate, grayish toementose. Capsule viviparous.

* Several varieties have been recognized in this species.

Flowering: April - August

Pollinators: Insects (Bees)

Fruiting: April - September

Key characters for identification:
var. marina: Leaves elliptic-oblong or elliptic-ovate, petiolate
Fruits apiculate.
var. acutissima: Leaves sessile or sub sessile
Leaves sharply acuminate.

Ecology: Gregarious. Commonly found in inter tidal areas. Present in pure stands. Back mangrove.

Distribution: Asia, Africa & Australia.

Uses: When in flower the species is a good source of food for honey- bees.
Leaves are edible and consumed by humans as vegetable as well as used as a cattle feed.
The species is extensively used as fuel wood.
Roots are used to cure fish sting.

Threatened category: Endangered.

	Station 1	*Station 2*	**Station 3**	**Station 4**	**Station 5**	**Station 6**
Frequency	100	100	100	100	100	100
Density	268	708	194.25	343.5	9.5	2294.5
Abundance	268	708	194.25	343.5	2010.5	2294.3
Average height (m)	5.71	4.09	5.2	4.49	1.25	1.5
Number of plants/hectare	1072	2832	777	1374	38	9177

Botanical name: ***Derris trifoliata*** Lour.

(= *D. uliginosa* (Willd.) Benth.; *Dalbergia heterophylla* Willd.; *Pongamia uliginosa* DC.).

Vernacular name: Kajarvel.

Family: **Fabaceae**

Habit: Erect shrubs or large climbers (about 15m tall).

Description: Bark dark gray, covered with lenticels and spreads by root suckers. Leaflets 3, 5 or 7, glabrous on both sides, highly polished on the upper side and reticulately veined beneath, ovate or ovate-oblong, 10-12 X4-5cm. Flowers in axillary racemes, about 20cm long. Flowers white, pale pink or rose-coloured. Standard broader than long. Stamens monadelphous. Fruit elliptic, flat, reticulately veined, narrowly winged on the upper suture, pale yellow when ripe, 3-4X2cm. Seeds 1,2 or 3.

Flowering: December – March.

Pollinators: Insects.

Fruiting: February – May.

Key characters for identification: Stems strongly ridged, dark red. younger stems with lenticels. Stamens monadelphous, Standard without callosities at the base of the limb. Pod exceeding more than 3cm long.

Ecology: Occasional along the muddy & salt water creeks.

- Doubtfully present in the creek.

Distribution: Asia & Australia.

Uses: Roots are a potential source of an insecticide.
The bark is a fish poison and also used in rheumatism.

Threatened category: Endangered.

Botanical name: ***Derris scandens*** Benth.

Vernacular name: *Mota sirili*

Family: Fabaceae

Habit: Large climber (up to 30 m tall).

Description: Stems dark purple. Young parts pubescent. Leaves7-20cm long. Leaflets opposite, 7-15. Rachis deeply channeled. Flowers many in axillary racemes, 10-25cm long. Flowers pale pink, pinkish, 1-1.3cm long. Calyx grey-silky. Stamens monodelphous. Pods winged, appressedly pubescent, 2.5- 5cm long.

Flowering: May – September.

Pollinators: Insects.

Fruiting: May – January.

Key characters for identification: Leaf lets 7-15. Stamens monodelphous. Pod winged.

Ecology: Very common in back mangrove areas.

Distribution: Asia, Australia.

Uses: --

Botanical name: ***Excoecaria agallocha*** L.

Vernacular name: *Geva, Phungali, Surund*

English name: Blinding tree

Family: **Euphorbiaceae**

Habit: Large shrub or small tree (up to 15m high).

Description: Ever green. Plant parts with milky latex. Bark gray, fissured. Leaves light green, coriaceous, some what fleshy, spirally arranged, turns red before shedding, ovate, ovate-oblong, ovate-elliptic, basal glands 2 (-4), sometimes one, present at the beginning of the petiole on each side, 3-8X1.5-3cm. Inflorescence axillary, resembles catkin type. Flowers unisexual, fragrant. Male flowers yellow, 2-3mm. Stamens-3, anthers yellow, 5mm at maturity. Female racemes usually shorter than male, bracts glandular, flowers pedicillate, tepals-3. Fruit depressed, globose, 3-lobed, 1-1.5cm across.

Flowering: March – July.

Pollinators: Insects (flies).

Fruiting: March – November.

Key characters for identification: Light green leaves. White latex. Catkin type inflorescence.

Ecology: Common in inter-tidal forests and muddy seashores.

Distribution: Tropical & subtropical Asia & Australia.

Uses: It is considered one of the potential petro-crops.
The wood is used as incense as well as for paper-pulp, matchbox, boards and splint manufacture.
* The milky juice of the plant is harmful and causes blisters on skin and blindness when fallen in eyes.

Threatened category: Vulnerable.

	Station **1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**
Frequency	75	25	--	50	--	--
Density	87	1	--	1	--	--
Abundance	65.25	0.25	--	0.5	--	--
Average height (m)	3.26	3	--	2.93	--	--
Number of plants/hectare	261	1	--	2	--	--

Botanical name: ***Bruguiera cylindrica*** (L.) Bl.

(*Rhizophora caryophylloides* Burm, B. *malabraica* Arnold, *B. caryophylloides* (Burm.f.) Bl.)

Vernacular name: --

Family: **Rhizophoraceae**

Habit: Medium sized tree (up to 20m tall).

Description: Evergreen. Bark bronze or grayish. Stem-base short buttressed. Roots- oval shaped knee-bent roots. Leaves elliptic, oblanceolate, 7-17 X 2 - 8cm, acute apex. Petioles green or reddish, 4cm long. Young twigs and bark with many stipular scars. Inflorescence mostly 3-flowered cymes, flower colour mentioned differently in different books, either green or white, 1-1.5cm long. Calyx tube cup shaped, smooth, about 8-10 lobes, slightly reflexed. Petals shortly bilobed with a bristle in the sinus and each lobe with 3 apical cilia, margins hairy. Each petal encloses 2 stamens. Hypocotyl up to 15 cm long, cylindrical, grooved or angled, slightly curved.

Flowering: May - August

Pollinators: Small insects (flies & bees).

Fruiting: May – September.

Key characters for identification: Flowers small, 10-12mm long.
Bronze coloured twigs. Calyx lobes 8, reflexed in fruit.

Ecology: Common along estuarine mouths. Pioneering species. Back mangrove. The species cannot with stand prolonged submersion. Commonly found growing behind *Avicenia* sp.

Distribution: South-East Asia & Australia.

Uses: Main stem is used as poles and for fuel.
Bark is used as condiment.
Bark is used as tan. It consists 18.9% tannin.

Threatened category: Endangered.

	Station 1	*Station* **2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**
Frequency	100	--	--	--	--	--
Density	33.75	--	--	--	--	--
Abundance	33.75	--	--	--	--	--
Average height (m)	3.76	--	--	--	--	--
Number of plants/hectare	135	--	--	--	--	--

Botanical name: ***Bruguiera gymnorrhiza*** (L.) Savigany

(= *Rhizophora gymnorhiza* L.)
Vernacular name: Kakra.

Family: **Rhizophoraceae.**

Habit: Large tree (up to 30m tall).

Description: Evergreen. Stem base with many knee-like bent roots. Young branches marked with scars of fallen leaves. Leaves opposite, bright green above , paler and a prominent midrib beneath, glabrous, elliptic or elliptic-oblong, tip acute or acuminate, obtuse base, 7.5 – 15 X 4-6cm. Stipules and petioles reddish, 2-5cm long. Flowers solitary, orange-yellow, scarlet, 2.5-5cm across. Calyx lobes pinkish-green to reddish- brown or orange-yellow, campanulate, ribbed, 10-16 lobed, lobes divided half way down. Petals, white, stiff, bilobed with a bristle in the sinus, outer margins of petals fringed with wight silky hairs. Stamens 2 opposite to each petal. Filments of each pair alternately long and short. Hypocotyl obscurely ribbed, 10-15cm long.

Flowering: Throughout the year.

Pollinators: Insects.

Fruiting: Throughout the year .

Key characters for identification: Red coloured petioles. Solitary flowers. Large flowers (2.5-5cm across.)

Ecology: Rare. Distributed in interior parts of mangrove forests.

Distribution: Tropical Asia, Africa & Australia

Uses: Leaves are used as fodder.
Wood is used for fishing boats, electric poles and house construction.
The tree is largely exploited for charcoal and fuel wood.
The bark is used as tan. The bark contains 35.2% tannin and 15.3% soluble non-tannin.

Threatened category: Critically endangered.

Botanical name: ***Ceriops tagal*** (Perr.)C.E.Rob.

(= *Ceriops candolleana* Arn., *C. timoriensis* Domin, *C. boiviniana* Tulasne)

Vernacular name: *Chauri*, *Kirrari*

Family: **Rhizophoraceae**

Habit: Small tree (up to 6m tall).

Description: Evergreen. Roots- Stilt roots, Pneumatophores some times developed as looped surface roots. Stem base short, buttressed. Leaves leathery, obovate, ovate – oblong, 6-12 X 3-6. Inflorescence axis longer than C. decandra, slender, 10-20mm. Flowers in condensed cymes, 5-7mm across, white, resinous. Calyx 5-lobed, lobes linear. Petals-5, enclosing the stamens in pairs, 3-3.5mm long. Stamens 10, filaments long, slender. Fruit slightly conical. Hypocotyls up to 25mm long, reddish brown, warty, grooved and ribbed.

Flowering: March – August.

Pollinators: Insects (bees)

Fruiting: March – November.

Key characters for identification:
Petals enclosing anthers at the time of anthesis. The apex of the petal with three clevage appendages. Hypocotyl terete or slightly ridged, long, above 25mm.

Ecology: more common in the areas under estuarine influence.

Distribution: Asia, East Africa, Australia & Pacific islands.

Uses: One of the most important mangrove genera of India.
Flowers are rich source of food to honey bees.
Wood is used for fuel and also in constructing small houses.
The bark & leaves of the tree are excellent source of tannin. Bark contains 29% tannin.
The fisher men extract a reddish coloured liquid from the bark after boiling in water in which fishing nets are dipped and soaked to improve the quality and life span.
The decoction of the bark is taken internally
The decoction of the bark is applied to cure hemorrhages and malignant tumors.
A decoction of the shoots is used as a substitute for quinine(anti malarial drug).

Threatened category: Endangered.

	Station 1	*Station* **2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**
Frequency	100	--	--	--	--	--
Density	5.25	--	--	--	--	--
Abundance	5.25	--	--	--	--	--
Average height (m)	4.39	--	--	--	--	--
Number of plants/hectare	21	--	--	--	--	--

Botanical name: ***Rhizophora apiculata*** Bl.

(= *Rhizophora conjugata* auct.non L.)
Vernacular name: *Kandal, Kamo, Dumbi*.

Family: **Rhizophoraceae**

Habit: Moderate sized tree (up to 30m tall).

Description: Front mangrove. Stme are supported by stilt-roots. Stems and young branches marked with scars of fallen leaves, ascending. Crowns pyramidal. Leaves dark green- above, paler, rugulose and minutely dotted beneath, elliptic-oblong, elliptic-lanceolate, cuneate at base, 10-20 X 5-8cm. Flowers white or cream coloured, in pairs of 2- flowered cymes. Calyx 4-lobed, concave, externally rugose, reflexed in fruit. Corolla lobes fleshy, glabrous, caduceus. Stamens 11-12. Hypocotyl, cylindrical, obclavate, clavate, 30-50cm long.

Flowering: August – November.

Pollinatiors: Insects.

Fruiting: August – December.

Key characters for identification: Acute leaf tip. Cymes 2-flowered. Petals glabrous. Stamens 12.

Ecology: Extremely rare. Planted along the inter tidal regions of creek.

Distribution: South Asia, Australia & Africa.

Uses: The leaves are used as a fodder and in medicine.
The tree is highly exploited for charcoal & fuel wood.
Wood is used for heavy construction. Wood pulp is used for blotting and corrugating paper. It is find application in ply wood, adhesive, dye bark, cellophane, rayon, ferro-alloys, cellulose acetate industries and as a substitute for petroleum coke for calcium carbide.
The tree bark is used for tanning material. The bark contains 33.8% tannins and 13% soluble non-tannins.

Threatened category: Endangered.

Botanical name: *Rhizophora mucronata* Poir.

(= *Rhizophora mangle* Roxb., non L.)
Vernacular name: *Kamo, Dumbi, Kandal*

Family: **Rhizophoraceae**

Habit: Moderate sized tree (up to 20m tall).

Description: Front mangrove species. Stems are supported by many stilt-roots (often branched. Leaf-scars are prominent on stems and branches. Leaves bright green, glabrous on both sides, broadly elliptic, ovate-oblong, 10 –18 X 4-10cm. Flowers fragrant, white or cream coloured, present in axillary cymes, 3-8 in number, pedicellate. Calyx ovate, 12-14mm long. Petals fleshy, long, hairy, 9-10mm long. Stamens 8. Style 1-2mm long, stigma sessile. Hypocotyl cylindrical, 30-65cm long.

Flowering: February – May; July – December.

Pollinators: Insects

Fruiting: July – December.

Key characters for identification: Leaves broadly elliptic, cymes 3 flowere, petals fleshy, villous on inner faces and margins. Hypocotyl 30-65cm long.

Ecology: Extremely rare in swamp forests. Gregarious along inter tidal banks.

Distribution: South Asia, East Africa, and Northeast Australia.

Uses: Fruits and young shoots are edible.
Timber is good for heavy construction. Wood is used for temporary bridges, buffers, brake blocks, tool handles.
The trees are cut mostly for charcoal & fuel wood.
The bark of the tree is considered very powerful and is believed to cure a variety of ailments. Bark is a powerful astringent and is taken internally to treat hemorrhage, haaematuria and angina. It is also taken internally to control diabetes.
The bark supplies a useful tanning material. It contains about **24% tannin and 11% soluble non-tannins.**

Threatened category: Vulnerable.

Botanical name: ***Aegiceras corniculatum*** (L.) Blanco

(= *Aegiceras. majus* Gaertn.; *A. fragrans* Konig, *Rhizophora corniculata* L.)

Vernacular name: *Cheep, Kajla*

Family: **Myrsinaceae**

Habit: Large shrub or small tree, up to 6m .

Description: Evergreen. Roots slender, stilt – roots. Bark smooth gray. Leaves 4-8 X 2-4cm, ovate-oblong or obovate, petiole short, laterally two keeled (slightly), alternate, spirally arranged, occasionally subopposite, surface glabrous with minute pistules, turning black with age and reddish punctate glands on the margin. Inflorescence constantly an umbel with a short peduncle (5mm long). Flowers white, fragrant, 1.5-2cm long. Calyx,5, imbricate (left handed twist) with surface glands. Petals,5, contorted, pointed, fused basally to form a short tube, reflexed at maturity. Dense weft of hairs at the mouth of the tube and capitate hairs are present at the base of the tube. Fruits 6-8cm long, green, turns yellow, curved, tapering, pointed.

Flowering: April – November.

Pollinators: Insects (Bees especially honey bees).

Fruiting: April – December.

Key characters for identification: Umbel inflorescence, Reddish punctate glands on the leaf margins. Presence of dense weft of hairs at the mouth of the corolla. Curved fruits.

Ecology: Generally distributed along the sheltered inter tidal banks. Commonly associated with *Rhizophora* spp. and *Ceriops decandra*.

Distribution: Asia, Northeastern Australia.

Uses: Flowers **fragrant.**
When in flowering it attracts lot of honey bees. The flowers are believed to be a good source of food for honey bees.
Seeds & bark are used to poison fish.
Wood is used as fuel and as frame-work for huts.
Bark contains about **6.6% tannin**.
Leaves & bark boiled in water taken internally to cure Asthma, diabetes & rheumatism.

Threatened category: Endangered.

	Station **1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**
Frequency	75	50	--	25	--	--
Density	27.0	1.5	--	2	--	--
Abundance	20.25	0.75	--	0.5	--	--
Average height (m)	3.29	1.28	--	3.88	--	--
Number of individuals/hectare	81	3	--	2	--	--

Botanical name*: Sonneratia apetala* Buch.-Ham**.**

Vernacular name: --

Family: **Sonnerratiaceae**

Habit: Moderate sized tree (up to 30m tall).

Description: Evergreen. Bark, thin, light-brown. Root type - pneumatophores (50-160cm long), forked.
Branches drooping. Leaves narrow, thick, elliptic, oblong, tapering at apex, 4-10 X 2 – 3cm. Flowers cream coloured, in 3or 7 flowered dischasial cymes, 1.5-2cm across. Calyx 4-merous. Petals absent. **Stigma is broad, mushroom shaped** at the anthesis. Fruit small, globose, 1-2 X 2cm.

Flowering: February – September.

Pollinators: Insects (bees, flies)

Fruiting: February – November.

Key characters for identification: Leaves narrow-elleptic, apetalous flowers, mushroom or umbrella shaped stigma.

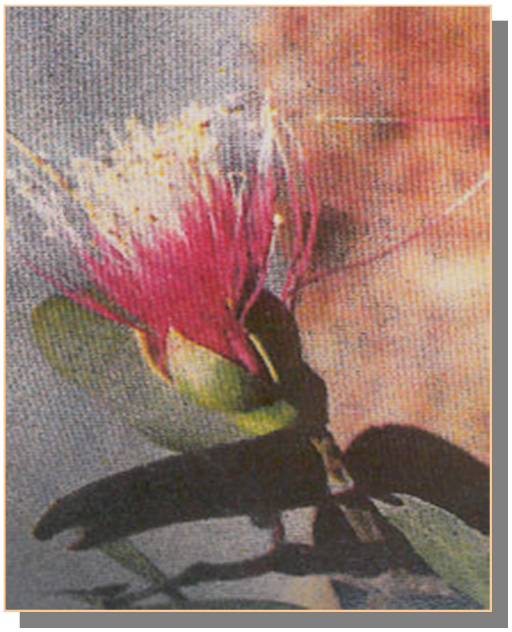
Ecology: Common along the intertidal regions. Pioneer species.

Distribution: India, Sri Lanka & Burma.

Uses: The brown coloured wood is used in building construction and for making packing cases. Stem is used for paper pulp, matches and as poles.
Over exploited for firewood.
Fruits are edible and used as vegetable.
Leaves are used as fodder.
Bark is used as tan. It consists 11.3% tannin.
It is believed that leaf paste taken internally will cure hepatitis.

Threatened category: Endangered.

	Station **1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**
Frequency	--	--	--	25	25	--
Density	--	--	--	22.67	1	--
Abundance	--	--	--	17	4	--
Average height (m)	--	--	--	3.49	2	--
Number of individuals/hectare	--	--	--	68	4	--



Botanical name: ***Sonneratia caseolaris*** (L.) Engl.

(= *S. acida* L.f.)

Vernacular name: *Kandal.*

Family: **Sonneratiaceae**

Habit: Small tree (up to 15m tall).

Description: Inner or back mangrove. Evergreen. Respiratory roots are **Pneumatophore**s. Bark white. Leaves thick (fleshy), obovate or elliptic oblong 5-10 X 3-5cm, with a blunt apex and minute recurved spicules. Petiole red.
Flowers solitary, 4-6cm across, with a shallow, green calyx tube. Petals inconspicuous reddish-purple. Ovary globose, flattened or depressed above. Stigma capitate. Fruits 4-6 in diameter.

Flowering: March-July

Pollinators: Bats & Hawk moths. Flowers open during nighttime.

Fruiting: March - November

Key characters for identification: Petiole short, reddish. Larger flowers & fruits among different species of the genus. Filaments reddish below & white above.
Ecology: Common along the tidal creeks. Thrives well under fresh water inundation.
*Doubtfully present in the creek.

Distribution: Asia & Tropical Australia.

Uses: Mucilaginous fruits are edible.
Pneumatophores are used as a substitute for cork.
Pith is used as floats for nets, for inner soles of shoes, artificial flowers.
Stem bark yields tannin. **It contains 10.1% tannins**.
The fermented juice of the fruit is believed to be useful in arresting hemorrhage.
The fruit is used as poultice in sprains and swellings.

Threatened category: Endangered.

Botanical name: *Sonneratia alba* J. Sm.

Vernacular name: *Tiwar*

Family**: Sonneratiaceae**

Habit: Small tree (up to 5m tall).

Description: Evergreen. Arial roots - Pneumatophores**. Leaves glabrous, elliptic, oblong, suborbicular, obtuse at apex, 5-7.5 X 4-6cm. Calyx ribbed, cupular, lobes reflexed. Petals white, tinged red apically. Ovary globose, style up to 4cm long, stigma capitate. Fruit 3cm in diameter.**

Flowering: April - September

Pollinators: Bats

Fruiting: April – December.

Key characters for identification: Numerous white petals tinged with red at the apex. Calyx ribbed with obconical base.

Ecology: Occasional in inter tidal areas.

Distribution: Asia, North Australia & Africa

Uses: Fruits are edible. Wood is used as timber & fuel.
Stem bark is a good source of tannin.

Threatened Category: Endangered.