# CHAPTER 2

# MATERIAL AND METHODS

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### 2.1 Introduction

Monitoring biodiversity can be defined as the process of documenting the qualitative and quantitative observations on the biodiversity by means of the standardised procedure in regular intervals. The process of monitoring essentially differs from the one time survey or inventorying, in its continuity. The inventorying is the documentation of the species observed with in a specified geographical area in a given time. Where the monitoring refers to the periodical surveys to check the noticeable changes against the past inventories made from the same area. Hence when we consider monitoring biodiversity in a long term perspective we have to adopt suitable methods and study area considering all the possible practical difficulties including financing and the availability of manpower etc.

All the taxa of taxonomic diversity can not be monitored at the same time due to obvious constrains. Therefore selection of the suitable sample is essential. The sample should be selected so as to address the entire range of objectives of biodiversity monitoring.

In general animals are the motile organisms, that make the monitoring of species population difficult. They occupy wide range of habitats and microhabitats. Therefore we cannot employ the same method to study the same genus or family. Even for one species. We may have to use more than one method of the sampling/census to get an idea of overall diversity. As most of they are moving the basic principle underlying in the delimitation of sampling unit is the restriction in space as well as time. Whether it is transact, or even the total count census, the principle is with in a specified area within the stipulated time how many species or individuals are observed.

Animals can be grouped into terrestrial vertebrates and invertebrate and aquatic vertebrates and invertebrates. Terrestrial invertebrates can be further grouped into soil invertebrates in the air and vegetation. Major methods generally used in



terrestrial vertebrates are, total count by all out search and transacts. The major aquatic vertebrates are fishes, which are sampled usually by standardised nets and efforts.

Broadly vertebrates can be classified into small and large animals. The total direct count by all out search is applicable to many conspicuous large animals. But many species are highly secretive and remain from the view (e.g. nocturnal, burrowing and aquatic mammals). Because of their hiding nature, in many surveys, Some animals go unnoticed and unrecorded. In general for the conspicuous animals sampling line and strip transacts are advisable. Bats and birds can be counted in the roosts. Many carnivorous sampling is done through indirect method like pug mark count, dung count etc. Many small mammals and birds can be studied only using traps and nets using capture or recapture method. In primates and many group living mammals like elephants, identifying groups and block counting will be the census method.

**Total Direct Count:** This method firstly, divide area into blocks then count the number of individual sighted in each of the block simultaneously by different group of the peoples, at the same time period. This is very good method for all conspicuous large animals like elephant, gaur, deer, or monkeys. Synchronisation of the period of the survey between the block is necessary for reducing the error due to the movement of the animal between the block Though it is not a one time block counting, for many groups of mammals which live in a specific home range can be censuses using this method.

**Line Transact :** This method involves travelling on a predetermined line and recording of all the species and number within the visible range on both side of the track. One basic assumption behind the line transact is the uniformity in the chance of encounter of any species it may not be true for many cases. The line transacts for large mammals can be done if the natural vegetation like forest were available in a large extent. The suggested transact length for mammals are one km. In man managed LSE's line transact for mammals are not advisable because the human interference will affect their distribution.

**Animal Roost Counting:** Bats and birds can be counted at their roost. In this process, first and all out search for locating the roost is essential. After mapping the roost, in each roost, individuals may be counted as they leave the roost or arrive at the roost.

**Capture Recapture Method:** Small terrestrial animals have been quieting extensively studied only by trapping method. There are large number different traps also can be very well used. Traps have to be visited twice a day. The animal falls in the trap were identified and then mark with some specific mark on the body and released. The number of the marked individuals in the next trapping will be used to calculate the actual population.

**Indirect Methods:** Counting footprints is another important secondary method. All on search for the foot prints in the area of soft soil particularly areas near the coast, mangroves, water bodies will give an approximate crude estimate of some animals, which are otherwise very much inconspicuous in a forested environment.

**Counting the Nests:** For the species like squirrels and other arboreal animals searching and counting the nests also can be done as an effective method of population counting.

**Birds:** Birds are the most popular and easiest animals in the censusing studies. Field techniques vary according to the taxa and the habitat understudy. For water fowls (aquatic habitats) generally a total count is suggested. For other terrestrial habitats like forests and plantation etc line transacts or point counts are the best methods. For the communal roosting birds like Mynas, egrets, parakeets roost counting is good. Other methods like territory-mapping mist netting, and capture recapture methods are not practicable on large-scale operations.

**Total Count Method:** This method is generally used in the population estimation of wetland birds, which is very much visible and easy for a direct count. Counting of total number of birds of different species in an area is referred to as total counts. Approximately area surveyed must be specified. In the case of very huge flocks of birds floating in the water or flying (as in case of migrating ducks) visual block counting of birds in a small square area and the approximation of the whole

flock size can be done. This technique can be perfected with a little practice. In the case of very large flocks, to avoid over estimation, it is always better to take the least approximate number agreeable to two or more observers at he same time. Very large birds and birds in comparatively smaller in number can be directly counted and recorded.

**Bird Roost Counting:** Many birds rest in communal roosts in the nights (e.g. Mynas, parakeets and herons). Roost counting of birds, also is done by direct total counting of birds. The counting is done generally during their departure from or arrival to the roost. Often the roost will be very large it will be very difficult for one or two peoples to count. In such cases four observers divide the roost into some sectors crudely ¼ th of the area. One person counts all the birds, which will fly into the roost through the respective sector only. The number counted by all the investigators are added to get the total number of birds in the roosts. Line transacts and point count is other useful methods.

**Herpato Fauna (Amphibians and Reptiles)**: Amphibians and reptiles are collectively referred to as herpato fauna. They are the cold-blooded terrestrial vertebrates. There are many similarities in their habits and habitats, even though reptiles and amphibians are ecologically very distinct. The most appropriate and simple methodology for the monitoring of these groups is the same the time limited, area limited all out search. Among the reptiles snakes are a bit risky unless the investigator is familiar with the snakes and their handling it without damaging them.

**Time Limited, Area Limited all out search:** In this method select one predetermined area of a fixed size and do a thorough all out search for these animals in all its possible micro habitats.

During the present investigation a mix of all the above conventional field methods was used in the four identified higher vertebrate taxa. The study primarily depended on time available, manpower, accessibility, and characteristic and size of the mangrove area to be surveyed. In most cases observations were made during morning and evening hours. The study was more of a rapid survey in nature and was based on visual observations in the field and feedback from the knowledgeable locals. .

## 2.2 Objectives

The main objectives of the current investigations were

- To study the identified mangrove habitats for four vertebrate taxa viz. Mammals, Birds, Reptiles and Amphibians.
- To study the human activities in the mangroves and adjoining areas.
- To study the human impact on the biodiversity of mangroves.
- To study the awareness among the local peoples about mangroves.
- To study local people's role in the conservation of mangroves.

## 2.3 Hypothesis

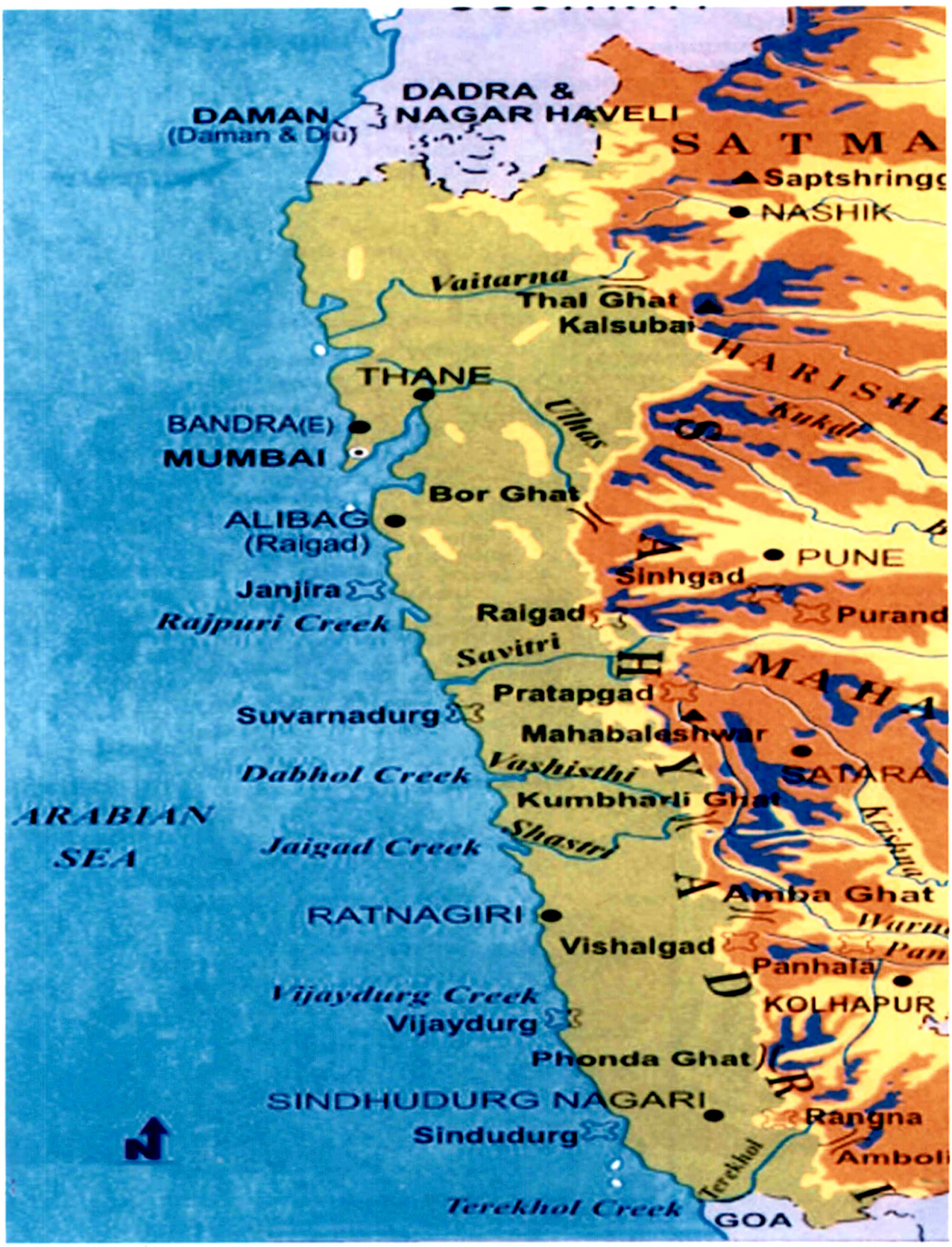
The hypothesis on which the investigations were based are as follows:

- Mangrove vegetation supports rich faunal diversity of small and large animals.
- The diversity and density of higher taxa in any natural habitat indicate the status of its health due to their hierarchy in the food chain.
- Fauna of mangrove plays important role in aquatic and terrestrial food web.
- Increase in coastal human population is the root cause for excessive and negative pressure on mangrove biodiversity.
- Industrialisation and developmental activities have further degraded mangroves.
- Lack of education and awareness among the local people is responsible for declining status of mangroves in Maharashtra.

## 2.4 Study Area

The Maharashtra coast lies between latitude $15^0 43'$ to $20^0$ N and longitude $72^0 49'$ to $77^0 41'$E. The coastline is 720 km long and is divisible in roughly three types i.e. 1) hills with steep entering the sea, 2) mudflats and 3) sandy beaches. Mangroves cover part of these mud flats, backwaters and mouths of estuaries.

Sindhudurg, Ratnagiri, Raigad, Mumbai and Thane are the coastal districts in Maharashtra State. Map 1 shows entire coastline of Maharashtra. Mangrove areas in Maharashtra as reported by Dept. of Forest (1997) is shown in Table No. 2.1 (a).




Map No. 1 Showing Coastline of Maharashtra. (not to scale)

Where as Table No. 2.1(b) gives the comparison between the district wise mangrove area reported by Dept. of Forest, Govt. of Maharashtra, Forest survey of India (1997), Upadhyay et.al.(2002)and Information collected from Forest Department during the present study (2001).

**Table No 2.1 (a) District wise mangrove areas in Maharashtra.**

| District | Area ($Km^2$) |
|---|---|
| Mumbai | 34.00 |
| Thane | 24.00 |
| Raigad | 38.00 |
| Ratnagiri | 12.00 |
| Sindhudurg | 15.06 |
| **Total** | **123.06** |

**Table No.2.1 (b) Comparison of district-wise change in the Mangrove covers in Maharashtra.**

| District | Area in $km^2$ | | | |
|---|---|---|---|---|
| | 1991 | 1997 | 1999 | 2001 |
| Mumbai | 26.97 | 48 | 34 | 17.28 |
| Colaba | - | 34 | - | - |
| Thane | 48.12 | 42 | 24 | 3.47 |
| Raigad | 85.52 | - | 38 | 40.20 |
| Ratnagiri | 33.50 | - | 12 | 21.90 |
| Sindhudurg | 15.06 | - | - | 2.63 |
| **Total** | **209.17** | **124.0** | **108.0** | **85.48** |

(Note: '-'indicate data not available)

It can be seen from the above tables that the values of mangrove area for some districts do not tally. Also mention of Colaba district in 1997 and absence of values for Raigad, Ratnagiri and Sindhudurg districts is incorrect. The values of the year 2001 indicate the trend set in negative change in mangrove area in the state. Thus according to these reported values there is phenomenal and drastic negative change in the mangrove area in the state from 330 sq. km (1987) to 85 sq. km in (2001) i.e a



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total loss of 244.5 sq. km (74%) in just two decades. This urgently needs to be confirmed by using latest remote sensing data for the region.

The westward flowing rivers in Konkan play a significant role in the ecology of mangroves, which are located in the lower reaches of these rivers and opening of their estuaries. These estuaries and backwaters support mangroves with the required nutrient load and fresh water to maintain euryhaline conditions, water movement and water level fluctuations. According to Wafar and Untawale (2000) there are 15 main rivers and five main estuaries on the coast of Maharashtra. Table No. 2.2. gives the list of rivers on the coast of Maharashtra with mangrove area in them.

**Table No. 2.2. Rivers on Maharashtra coast and mangrove area in them.**

| Sr.No | Rivers | Mangrove Area |
|---|---|---|
| 1 | Kundalika | 9.36 |
| 2 | Sawitri | 16.34 |
| 3 | Shastri | 4.88 |
| 4 | Vasai | 20.00 |
| 5 | Vaitarna | 13.75 |
| 6 | Thane | 14.37 |
| 7 | Panvel | 11.25 |
| 8 | Dharmatar | 14.37 |
| 9 | Karanja | 4.37 |
| 10 | Mhalasa | 21.45 |
| 11 | Kajavi | 1.26 |
| 12 | Purangad | 3.14 |
| 13 | Rajapur | 3.47 |
| 14 | Vaghotan | 5.39 |
| 15 | Deogad | 2.08 |
| 16 | Kalvali | 4.90 |
| 17 | Karli | 0.12 |

During the present study village wise information on existing mangrove area in the identified field sites was collected from different sources, which is given in

Table No.2.3. Thus the total mangrove area studied during the present rapid survey is around 36 sq. km.

**Table No. 2.3 Village wise mangroves in the study area.**

| No. | Village | Area In Ha. | Source |
|---|---|---|---|
| 1 | Ubhadanda | 7.87 | Forest Dept. |
| 2 | Kelus | 59.00 | Kharland Dept. |
| 3 | Kandalgaon | 5.35 | Grampanchayat |
| 4 | Kolamb | 1.26 | Grampanchayat |
| 5 | Achara | 65.00 | Grampanchayat |
| 6 | Tirlot | 23.05 | Forest Dept. |
| 7 | Jamsande | 15.39 | Forest Dept. |
| 8 | Girye | 1.79 | Forest Dept. |
| 9 | Rameshwar | 47.15 | Forest Dept. |
| 10 | Jaitapur | 78.89 | Grampanchayat |
| 11 | Nate | 80.00 | Grampanchayat |
| 12 | Purngad | 6.00 | Kharland Dept. |
| 13 | Gaonkhhedi | 107.00 | Grampanchayat |
| 14 | Pawas | 2.50 | Grampanchayat |
| 15 | Golap | 7.67 | Grampanchayat |
| 16 | Kolambe | 4.50 | Grampanchayat |
| 17 | Kalabadevi | 100.00 | Grampanchayat |
| 18 | Shirgaon | 92.00 | Grampanchayat |
| 19 | Bhatye | 10.00 | Kharland Dept. |
| 20 | Phansop | 3.00 | Grampanchayat |
| 21 | Kasari | 284.00 | Grampanchayat |
| 22 | Veldur | 15.73 | Grampanchayat |
| 23 | Anjarle | 7.55 | Grampanchayat |
| 24 | Adkhal | 16.50 | Grampanchayat |
| 25 | Kelashi | 28.77 | Grampanchayat |
| 26 | Veshai | 60.00 | Kharland Dept. |
| 27 | Harihareshwar | ---- | ----- |
| 28 | Agardanda | 37.80 | Grampanchayat |

| | | | |
|---|---|---|---|
| 29 | Diveagar | 32.40 | Forest Dept. |
| 30 | Revdanda | 51.40 | Grampanchayat |
| 31 | Akshi | 40.00 | Kharland Dept. |
| 32 | Navadarbeli | 104.67 | Forest Dept. |
| 33 | Vadakhal | 321.00 | Kharland Dept. |
| 34 | Diwa | 20.96 | Grampanchayat |
| 35 | Vikroli | 1750.00 | .Godrej Garden Dept . |
| 36 | Pam | 56.23 | Forest Dept. |
| 37 | Tembhi | 70.31 | Forest Dept. |

( **Note:** '-' Indicate information regarding area not known)

**Sindhudurg District**

The Sindhudurg district lies between $15^0$37'N and $73^0$19'E to $16^0$40' North latitude to $74^0$13' East longitude. Shuk, Deogad, Achara, Gad, Kurla, Terekhol, Kalawa and Tilari are the important rivers. The district is bounded by hilly region of Sahyadri in the east, Arabian Sea on the west, Goa State in the south and Ratnagiri district in the north. The district is the southern most coastal district in Maharashtra. The cost line of the district is about 121 kilometres from north to south.

Achara, Devgad (Vaghotan) and Vijaydurg area have good mangrove formations with rich biodiversity. Achara is a small village having estuarine area with 273 ha. mangrove. Achara mangrove is considered as 'sacred' since this mangrove belongs to the local deity of Shri Rameshwar, A satellite imagery showing Achare mangrove is given in Plate-1 which reveals good patch of mangrove vegetation at the centre. The destruction of mangroves due to developmental activities can be seen on the lower bank of the creek. Vijaydurg (Girye and Tirlot), and Devgad also have good mangrove cover. Map 2 Shows the field sites in Sindhudurg District.

**Ratnagiri district**

Ratnagiri district lies between $16^0$13'N and $73^0$02' E to $18^0$04'N and $73^0$53'E. The district has Savitri, Jog- Anjarle, Jagbudi, Vasishthi, Shastri, Kajali, Muchakundi and Shuk as major rivers. Ratnagiri district is one of the most important maritime districts of the state with the coastal belt expanding up to approximately 167 km.

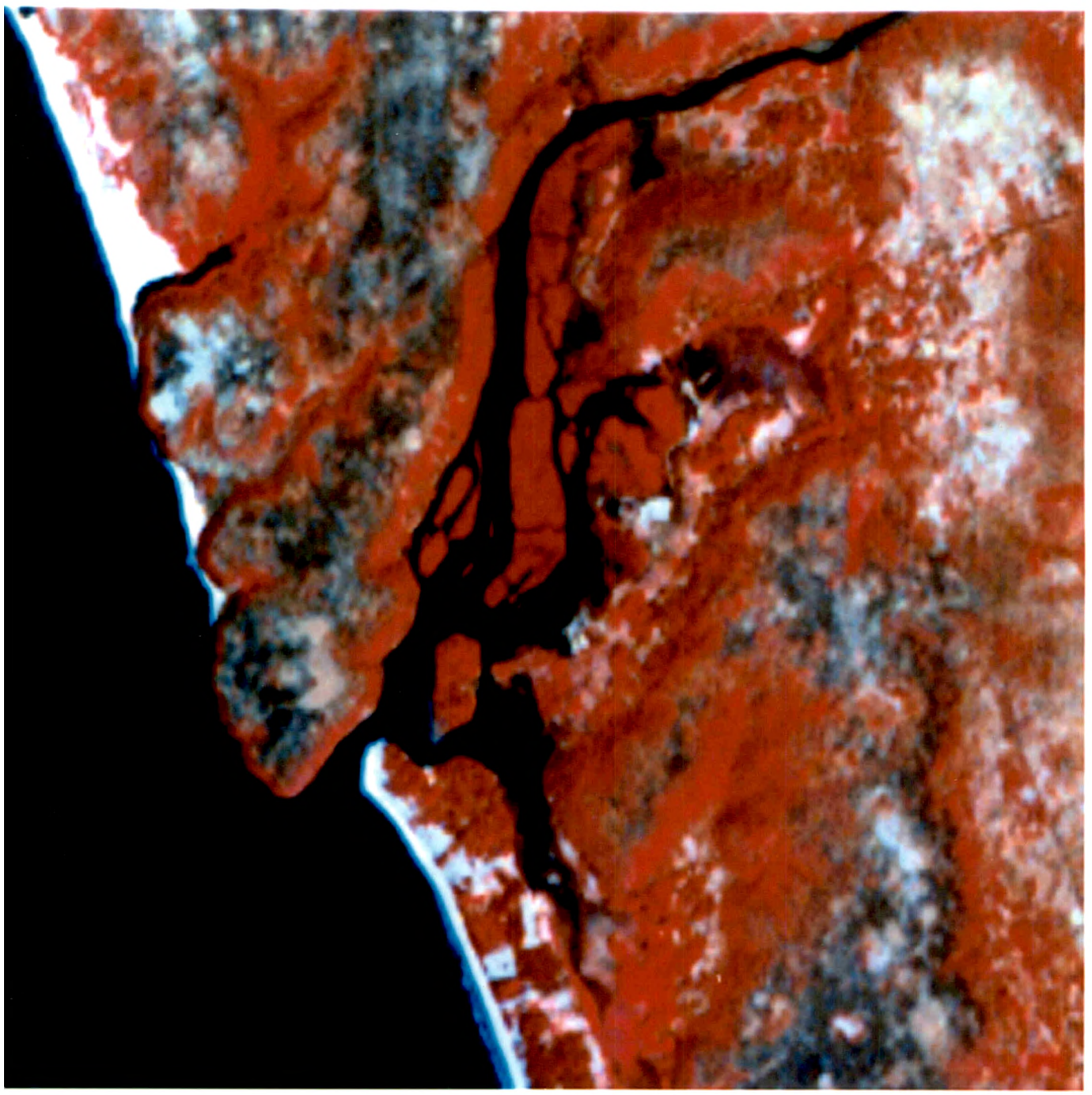

Plate 1 Satellite imagery showing Achara mangroves, sea coast and beach.


Map No. 2 Showing study sites in Sindhudurg District.

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Fishing industry is mainly dependant upon the exploitation of marine resources as the fish fauna of Ratnagiri is very rich.

In Ratnagiri district Jaitapur, Pawas - Gaonkhadi, Phansoap, Bhatye, Shirgaon, Kasari, Veldur, Dabhol, Adakhal, Anjarle and Veshavi villages have good mangrove ecosystems. The Shirgaon creek north of Ratnagiri has much intact and healthy mangrove ecosystem. Social Forestry Department had planted *Sonneratia alba* and *Rhizophora mucronata* during 1986 resulting in the dominance of these species. Kasari Veldur villages also have diversified mangrove patch. Map 3 shows sites in Ratnagiri district.

A satellite image showing mangrove at Bhatye is given in Plate-2, the Ratnagiri township is clearly seen with the airstrip. Mangrove vegetation is seen in bhatye creek at the bottom. Part of Sheergaon mangroves are seen on the top side of the plate.

**Raigad District**

Raigad district lies between $17^0$51'N and $73^0$40' E. and $18^0$53'N 74025' E. It is bounded by Thane to the north and Ratnagiri to the south, Pune district and Satara to it's east. Raigad has Ulhas, Kalu, Patalganga, Bhogavati, Amba, Kundalika, Sawitri, and Gandhar as important rivers. Shrivardhan creek, Harihareshwar, Agardanda and Diveagar, are the important mangrove locations in the district. The Length of the district coastline is approximately 118 km. The Map 4 Shows field sites in Raigad district.

**Thane District**

This is the northernmost coastal district of Konkan in Maharashtra. It lies between $18^0$42' N and $72^0$45'E and $20^0$20'N latitude and $73^0$45'E longitude. The cost line of the district is 114 km. Surya, Kalu, Penjal, Vaitarna, Bhatsai, Damanganga, Tansa, Ulhas and Murbadi are the important rivers in the district. Mumbai is having Dahisar, Poisar, Oshiwara and Mithi rivers. Map 5 show field sites in Thane district.



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Map No. 3 Showing study sites in Ratnagiri District.

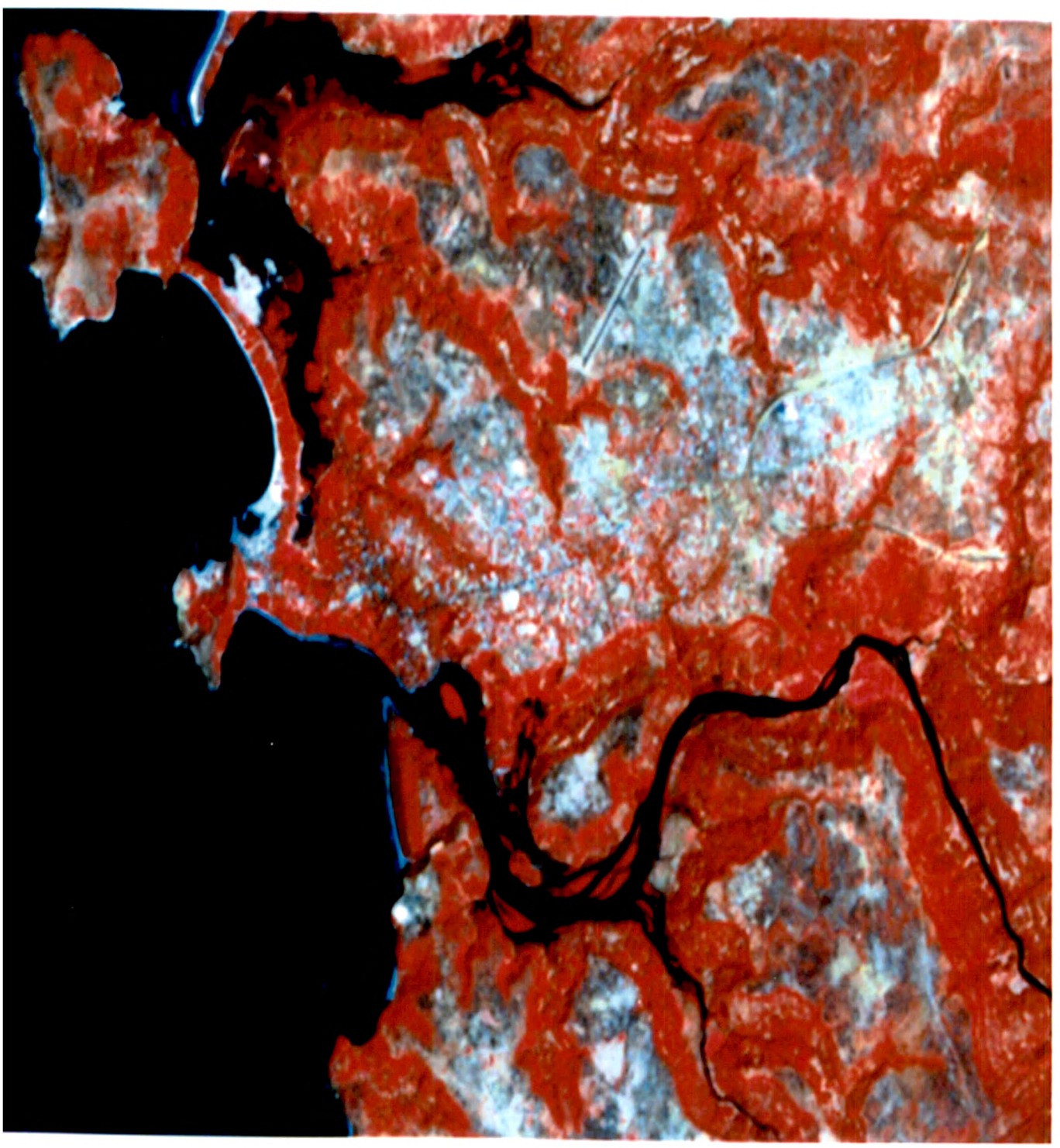

Plate 2 Satelite imagery showing Bhatye mangrove south of Ratnagiri, the extreme north is the opening of Shirgaon creek and the mangroves.

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Map No. 4 Showing study sites in Raigad District.


Map No. 5 Showing study sites in Thane District.

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**Justification for Site Selection**

Though mangrove ecosystem is one of the important ecosystems and acts as an ecotone between terrestrial ecosystem and aquatic ecosystems, there is acute paucity of information on the faunal diversity of mangroves, particularly higher vertebrate taxa, in the state. Similarly there is scanty data on the current status of mangroves, and threats faced by it, on the coast of Maharashtra.

By literature survey, and particularly review of the earlier available reports on mangroves by NIO (1987), Ecological Society (vol-9, 1996), it was decided to undertake the present study. The following sites were finally selected for the field study on the basis of the primary survey of the coastal area and the literature survey. Mumbai area was excluded due to logistic reasons. Sites selected (n = 30) for field study in the four coastal districts are as follows

**Table No. 2.4 Field sites selected in each of the four coastal districts in Maharashtra.**

| Sindhudurg | Ratnagiri | Raigad | Thane |
|---|---|---|---|
| Vengrla | Jaitapur | Shirivardhan | Thane |
| Kelus | Purnagad | Murud Rajpuri | Diwa |
| Kolamb | Pawas | Revdanda | Mumbra |
| Achara | Ratnagiri(Bhatye) | Alibag | Vikroli |
| Deogad | Ratnagiri(Shirgaon) | Uran. | Vasai |
| Vijaydurg | Jaigad | | Vaitarna |
| | Veldur | | Dahanu |
| | Dabhol | | |
| | Adakhal | | |
| | Anjarle | | |
| | Kelasi | | |
| | Veshavi | | |
| **Six Sites** | **Twelve Sites** | **Five Sites** | **Seven Sites** |

The study was carried out from August 2002 to January 2004 with the main field work from October 2002 till May 2003 covering winter and summer months as it

was not possible conduct field work during monsoon due to heavy rains and poor visibility.

**2.5 Methodology**

The initial pilot survey was conducted in the Ratnagiri district at two sites, Bhatye and Shirgaon creeks, where mangrove forest is in reasonably good condition. Methodology was field tested in the pilot field study and improved wherever necessary. The questionnaire was also field tested in this preliminary survey.

Secondary information for the study was collected from the concerned government departments such as Revenue, Forest, Kharland development offices etc. Visits were made for bird watching and to collect information on other study taxa viz. reptiles, mammals and amphibians. Awareness among the local peoples about the mangroves and its biodiversity was studied through questionnaire and personal interaction.

On the basis of pilot survey field data sheets were prepared for the main study. Detail survey of selected sites in each district was done as soon as monsoon period was over. Bird observations were made during in the morning during 6:30 – 9:00 am and at evening 4:00 – 6:00 p.m. So that post monsoon and early winter months could be covered to observe local and migratory birds. The visual observation were made with help of 10X 50, centre focus binocular with $6^0$ angle. Observations were made for reptiles, mammals and amphibians during the field visits to mangroves and the adjacent areas.

During the field visits, discussion with the local people and Grampanchayat officials revealed information about total area of mangrove in the village and the dependence of the locals, for their daily needs, on mangroves. Awareness among them about mangroves was also recorded through a questionnaire.

Non availability of the satellite imageries, restricted the use of reliable advance information in comparing ground truth in ascertaining the present status and change in mangrove area in the recent past. Duration of the project was limited. Similarly the three and half months of monsoon period was not suitable for field study in the coastal areas due to non-accessibility and poor visibility.