Plantae Scientia – An International Research Journal in Botany Publishing Bimonthly Open Access Journal

Plantae Scientia : Volume 04, Issue 03, May 2021

ISSN 2581-589X

RESEARCH ARTICLE

Mangroves of Maharashtra State (India): Diversity and Sustainability

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Manuscript Details

Manuscript Submitted : 08/04/2021
Manuscript Revised : 12/05/2021
Manuscript Accepted : 28/05/2021
Manuscript Published : 12/06/2021

Available On

https://plantaescientia.com/ojs

Cite This Article As

Kulkarni N. A. & L. J. Bhosale (2021). Mangroves of Maharashtra State (India): Diversity and Sustainability. *Pla. Sci.* 2021; Vol. 04 Iss. 03:178-207.

Indexed In

CrossRef, Scientific Indexing Services (SIS), Google Scholar, Index Copernicus International (ICI), Directory of Research Journal Indexing (DRJI), CiteFactor, Scientific Journal Impact Factor (SJIF), General Impact Factor, Journal Factor, Cosmos Impact Factor, PKP Index, AJIFACTOR Indexing, etc.

ABSTRACT

Mangroves are defined as tropical and sub-tropical forests with a diverse floristic composition bordering the sea on muddy or peaty low lands periodically submerged or influenced by the tides. Maharashtra is one of the coastal states of India, with many rivers emerging from Sahyadri ranges and meeting the Arabian Sea. The coast line available for Maharashtra state is 720 km. Ratnagiri, Sindhudurg, Raigad, Thane and Mumbai are the five coastal districts of the state of Maharashtra. All the districts together have more than 55 small, medium and large estuaries. It is found that estuaries like Vijaydurg shows maximum mangrove area of and estuaries like Kelye shows minimum area. It also reveals that the species like *E. agallocha*, *A. ilicifolius*, *R. mucronata*, *A. officinalis* and *A. marina* show maximum percentage of occurrence as compared to the species like *X. granatum*, *C. iripa*, *B. cylindrica*, *S. caseolaris*, *H.fomes* and *T. gallica*. The studies on mangrove biodiversity in five districts show the major variations. The study found 20 typical mangroves, 10 halophytic species, 13 border line mangroves and 15 mangrove associates from all these districts. Among these the uncommon and threatened greet pied Hornbill (*Buceros bicornis*) have been found at some sites. Some of the common crab species are *Uca roseus*, *Uca lactea annulipes* and *Uca vocans*. The species like *Scylla serrata* and *Portunus pelagius* are edible. In the present study 13 sp. of Molluscs, 25 species of edible fish, 9 species of Reptilia, 45 sp. of birds and 10 species of Mammalia are found. It is found that out of twenty-four species analyzed, some species are analyzed as Critically Endangered (CR), some are found Endangered (EN). From this study it is found that all sites being under human pressure the natural zonation pattern is not seen. The existing zonation pattern is a result of natural distribution and human disturbances.

Keywords: Mangroves, Maharashtra, Diversity, Threats, Sustainability, Conservation.

INTRODUCTION

Mangroves are typical group of plants which are adopted for survival in sheltered brackish water habitats along coasts of tropical and sub-tropical regions. Mangroves play a key role in maintaining the quality and productivity of coastal waters. Mangroves are known as primary producers, shoreline protectors, nursery grounds and habitat for variety of animals, bridging components and unique biological resources. They provide erosion control and shoreline stabilization; they are also involved in complex detritus food webs.

The Tsunami occurred on 26th Dec. 2004 along the East west of south India created a massive destruction in these areas and killed over thousands of people. It is also found that Tsunami has created greater destruction where there are no mangroves. On the other hand, it is found that the areas with thick mangrove forests have received least impact of Tsunami. It is also proved that mangroves can save us from natural disasters like Tsunami. It is the need of time that the present mangrove ecosystem is to be protected first and rehabilitation of destructed mangrove areas is to be undertaken.

STUDY AREA

The study area is the coastal Maharashtra which lies between 15°44' N to 20°08' N and 72°44' E to 73°39' E. Sindhudurg, Ratnagiri, Raigad, Thane and Mumbai are the five coastal districts of the state of Maharashtra. The study area has tropical climatic conditions. Three distinct seasons are observed as Monsoon (June to Sept.), Winter (Oct. to Jan.) and Summer (Feb. to May). The maximum annual rainfall that occurs along the coast is 2500 mm. The relative humidity ranges between 60 to 80%. The temperature varies from 20° C to 35° C.

The Mangrove Localities in the Study Area

Almost all the streams flowing in the study area are marked by drowned estuaries. The estuaries in the study area are disposing amount of fresh water received from the catchment area to the Arabian Sea. The rivers are rushing, short course and are almost empty during summer. The silt carried by surface runoff is trapped by the complex network of roots of mangroves on the bank of estuary.

Study of topo sheet maps published by survey of India (SOI) shows that there are more the 55 small and large estuaries along the five districts of Maharashtra. Out of these, Sindhudurg district have 16, Ratnagiri district have 13, Raigad district have 13, Thane district have 11 and Mumbai district have 4 major estuaries. These estuaries are listed below along with their Latitude and Longitude.(Table:1)

Fig.1. IRS – 1 Liss –II Image of the Some Part of Coast of Maharashtra Showing Various Study Sites (Courtesy – NRSA, Hyderabad) (1:25,000 scale)

MATERIAL AND METHODS

Survey of all estuaries in the five districts was undertaken by several field visits. A record of species occurring at each site was prepared. The field survey is based on maps of the area. The maps of all the estuaries were obtained from various sources. The latitude and longitude of the estuaries were obtained from the toposheet maps of SOI. Remote sensing is a technique recently followed for vegetation study. In the present study this technique is also taken into consideration. Mangroves show a distinct zonation/distribution pattern. It was studied for almost all the estuaries/creeks in the study area.

IUCN Categorization

Status of the species (Classification)

IUCN red list categories and criteria are used for assessing status of the species for conservation. These are **CR** : Critically endangered, **EN** : Endangered, **VU** : Vulnerable, **LR** : Lower risk, **DD** : Data Deficient, **NE** : Not Evaluated.

Threats

The threats to the mangroves in the study area were recorded on the basis of threat categories given by IUCN such as habitat loss, fragmentation, human interference, Trade etc. The symbols for the threats are: Al: Artificial lighting, L: Loss of habitat, Lf: Loss of habitat due to fragmentation, D: Diseases, E: Edaphic factors, H; Harvest,

Hf : Harvest for food, I : Human interference, P : Predation, Ps : Pesticides, Pu : Pollution, R : Road kills, Sf : Fire as catastrophic event, Sn : Situation, T : Trade, Tp : Trade of parts.

Research Recommendations

G : Genetic management, H : Husbandry research, Hm : Habitat management, Lh : Life history studies, Lm : Limiting factor management, Lr : Limiting factor research, M : Monitoring, O : Other, P : PHVA pending further work, S : Survey search and find, T : Taxonomic and morphological genetic studies, Tl : Translocations.

Cultivation Recommendations

1. Captive breeding for conservation either only *in situ* and *ex situ* or both with the population maintaining 90% genetic diversity for 100 years.
2. Same as '1' but periodic reinforcement of captive stock with genetic materials from the wild.
3. Captive breeding only for research education or husbandry but not of conservation
4. Captive breeding for commerce.
5. Restrictive breeding.

RESULTS AND DISCUSSION

Mangrove Biodiversity

Mangrove ecosystem achieve the highest importance due to their biological productivity, diversity in adaptations, complexity in ecological processes and the diversity of bioresources. The components of mangrove diversity are an indication of the set of environmental conditions of the area. Indian mangroves have been described by Blasco (1975). The species composition of west coast of India has been compared with that of the east coast by Bhosale (1987), where 24 species of mangroves and associates occurring along the coast of Maharashtra are listed. In the present study the mangrove biodiversity of five districts of Maharashtra has been studied (Table-1). The mangrove biodiversity of all the districts are studied in detail for various facets of biodiversity, like typical mangroves, halophytic species, borderline mangroves and mangrove associates. Kulkarni (2006) and Kulkarni and Bhosale (2014) has given the detailed description of the mangroves of Ratnagiri and Sindhudurg districts.

Floristic Composition

The floristic composition is a reflection of environmental conditions and genetic flexibility of species (ecological amplitude). The occurrence of a species itself indicates the set of environmental conditions. For example, the species requiring low salinity represents the character. Therefore, species composition of a given place is of prime importance. The seral stages like *Porteresia coarctata* also play significant role in development of climax vegetation.

The floristic composition of mangroves is governed by various factors like the geographical position of the region, soil and water temperatures, tides, various chemical and physical parameters of soil and water. Saenger (1998) emphasized that evolutionary processes are also responsible for the global distribution of the mangroves. He also explained that there are several other factors like latitudinal limits, temperature, aridity, endemism, hybridizations, human-induced factors which also influence the Floristic setup of the mangroves.

The Floristic composition or the diversity of world mangrove has been reported by Tomlinson (1986), Bunt (1992), Farnsworth and Ellison (1997). Untawale (1985) has given distribution of mangroves along the west coast of India, recording 34 species from the west coast and 29 species from coast of Maharashtra. Bhosale (1987) has compared the species composition of west coast with that of the East coast. She has listed 24 species of mangroves and associates occurring along west coast of Maharashtra. Kotmire and Bhosale (1985) have given Floristic composition of Deogad estuary. More recently Bhosale (2005) has reported 24 typical mangroves, 11 halophytes and 9 mangrove associates from Maharashtra.

A. Ratnagiri District:

Ratnagiri district is the central district of coastal Maharashtra. It is important from mangrove diversity point of view. The district has wide network of rivers, estuaries, creeks and backwaters. The estuaries, namely from south to north are, Rajapur, Vetye, Purnagad, Pavas, Bhatye, Kalbadevi, Are, Kelye, Malgund, Jaigad, Dabhol, Harnai (Anjarle) and Savitri. The Savitri river forms boundary between Ratnagiri and Raigad districts and is the largest of all. The estuaries like Savitri, Purnagad,Jaigad, Dabhol

and Rajapur have a long course of tidal action and flows up to 50 kms. The dominant genera in the district are *Avicennia*, *Rhizopora* and *Sonneratia*.

Typical Mangrove Species

The species are distributed all along the banks of various estuaries, creeks and backwaters. It is evident that some of the estuaries like Rajapur, Kalbadevi, Purnagad, Are, Bhatye and Dabhol have greater diversity. Some species commonly distributed are, *Avicennia marina* var. *acutissima*, *A. officinalis*, *Rhizophora mucronata*, *Ceriops tagal*, *Sonneratia alba*, *Aegiceras corniculatum*, *Excoecaria agallocha* and *Acanthus ilicifolius.* The species like *Rhizophora apiculata*, *Lumnitzera racemosa* and *Avicennia marina* (dwarf) have a limited distribution in few estuaries. The uncommon species are *Bruguiera gymnorrhiza* and *Sonneratia apetala* recorded from Five estuaries, viz. Rajapur, Purnagad, Malgund, Jaigad and Dabhol. *S. apetala* is recorded from Vetye, Purnagad, Kelye, Dabhol and Savitri.

Bhosale (2002) has reported the most unique species *Xylocarpus granatum* from two estuaries, namely, Purnagad and Jaigad from the district. *X. granatum* has been observed during the present study with few numbers of individuals. Another uncommon species *Kandelia candel* has been recorded from three estuaries namely, Rajapur, Bhatye and Dabhol. *A. marina* var. *acutissima* is the most adaptive species recorded from all the sites in the district. It has a wide range of salinity tolerance. The species has shown different growth performances in the district. At the estuaries like Bhatye, Dabhol, Savitri the species has grown upto 8 to 10 m with bole size of 1 to 2 metres. But at other places like Kalbadevi, Are, Malgund, the *A. marina* has shown considerable reduction in its height. The *Avicennia officinalis* has also shown wide range of distribution all over the district. *Avicennia alba* has a restricted distribution in the district. It has been recorded from Rajapur and Pavas estuaries. The species is very much typical about the leaf shape and beaked fruits. The species *A. corniculatum*, *C. tagal*, *E. agallocha*, *R. mucronata*, *R. apiculata*, *S. alba* and *A. ilicifolius* are distributed at all the estuaries in the district. The presence of *Lumnitzera racemosa* is frequent with an exception of three estuaries viz. Dabhol, Harnai an Savitri.

Halophytic Species

The species like *Halophila beccarii*, *Aleuropus lagopoides*, *Acrostichum aureum*, *Ipomea pes-caprae*, *Porteresia coarctata*, *Sesuvium portulacastrum*, *Stenophyllus barbatus*, *Sporobolus virginicus* and species of *Cyperus javanicus* and *Najas* species are distributed unevenly in estuaries of the district. Among all the species *Ipomea pes-caprae* is more or less commonly occurring. species like *P. coarctata* plays significant role as the seral stage in the development of mangrove ecosystem. *Derris heterophylla*, *A. lagopoides*, *H. beccarii*, *S. portulacastrum*, *Salvadora persica*, *Clerodendrum inerme*, *Premna integrifolia*, *Thespesia populnea*, *S. barbatus*, *Cyperus* and *Ipomea pes-caprae* are recorded from Ganapatipule (Malgund), Deogad, Mumbra and Bhatye estuaries.The *H. beccarii* has been recorded from three estuaries namely Bhatye, Kalbhadevi and Are.

Borderline Mangroves

The borderline mangrove species recorded are *Barringtonia racemosa*, *Caesalpinia nuga*, *Clerodendrum inerme*, *Derris heterophylla*, *Dolicandron spathecae*, *Premna coriaceae*, *Premna integrifolia*, *Pongamia pinnata*, *Salvadora persica*, *Tamarix gallica*, *Thespesia populnea* and *Vitis palida.*

Mangrove Associates

It shows *Acampae premorsa*, *Bauhinia racemosa*, *Calophyllum inophyllum*, *Fimbristylis ferrugenia*, *Flacourtia montane*, *Holiogarna antidysentrica*, *Hygrophila auriculata*, *Lindernia antipoda*, *Mimusops elengi*, *Nymphea nauchali*, *Paspalum vaginatum*, *Ruppia maritima*, *Scirpus littorali* and *Vitex nigundo.*

B. Sindhudurg District

It has the common border with state of Goa. Terekhol estuary is the boundary between two states, the north bank is in Maharashtra and the south bank is in Goa. On the northern side the district has a common boundary with Ratnagiri district, which is marked by the Vijaydurga estuary. The estuaries lying towards the north of Terekhol estuary in Sindhudurg districts are Shiroda, Vengurla, Mochemad, Khavane, Kalvi (Kelus), Vaingani, Nivti, Tarkarli, Kolamb, Kalavali, Achara, Mithbav, Mumbra, Deogad and Vijaydurg. Vijaydurg estuary is largest of all and has north boundary is in Ratnagiri district. The important feature of the district is Achara estuary having mouth region with estuarine delta.

Typical Mangrove Species

The species are *A. marina* var. *acutissima*, *A. officinalis*, *R. mucronata*, *S. alba*, *S. caseolaris*, *C. tagal*, *A. corniculatum* and *A. ilicifolius.* The species like *A. alba*, *C. iripa*, *L. racemosa* and *S. apetala* and *Kandelia candel* are uncommon and recorded from a few estuaries. The unique and rare species recorded from the district are *B. cylindrica* and *X. granatum.* Bhosale (2002) have reported the presence of *X. granatum* from few sites in the district after Cooke (1901). *B. cylindrica* is another unique

species reported from Vengurla (Manasi) estuary in the district. During the present study *X. granatum* has been recorded from Achara and Vijaydurg estuaries. *C. iripa* is another species reported by Bhosale (2002) from the district which is observed from Achara, Kalavali and Mithbav estuaries.

Halophytic Species

It shows the species like *H. beccarii*, *A. lagopoides*, *A. aureum*, *C. javanicus*, *I. Pes-caprae*, *Najas* Spp., *P. coarctata*, *S. portulacastrum*, *S. barbatus* and *S. virginicus.*

Borderline Mangroves

It shows the presence of species like B. *racemosa*, *C. nuga*, *C. manghas*, *C. inerme*, *Derris heterophylla*, *D. spathecae*, *P. coriaceae*, *P. integrifolia*, *P. pinnata*, *S. persica*, *T. gallica*, *T. populnea* and *V. palida.*

Mangrove associates

Species like *A. premorsa*, *B. racemosa*, *C. inophyllum*, *F. ferrugenia*, *Flacourtia montana*, *Holiogarna antidysentrica*, *H. auriculata*, *Lindernia antipoda*, *M. elengi*, *N. nauchali*, *P. vaginatum*, *R. maritima*, *S. littoralis* and *V. nigundo* show their occurrence in the district.

C. Raigad District

Raigad district is the connecting link between the Ratnagiri and Mumbai region. The major estuaries in the district are Panvel, Mora, Karanja, Rewas, Dharmatar, Alibag, Shrivardhan, Borli Mandala, Nandgaon, Murud Janjira, Rajpuri Dighi, Mandad, and Revdanda-Kundalika. The dominant species are *A. marina* var. *acutissima*, *A. officinalis*, *R. mucronata*, *S. alba*, *S. apetala*, *C. tagal*, *A. corniculatum* and *A. ilicifolius.* The dwarfism in the species like *Avicennia marina* on the very large areas is the unique feature of the district. The appearance of dwarfism in *A. marina* var. *acutissima* for several sq.kms. is the key feature of Raigad, Thane and Mumbai districts. Several reasons are given for this dwarfism habit. As we travel from Ratnagiri towards Raigad and Mumbai the extent of dwarf *A. marina* var. *acutissima* become more and more prominent. Another most important threat to mangroves of Raigad, Thane and Mumbai districts is 'Dredging.'It is activity due to which large amount of sand has been removed from the estuaries. Due to which the water is always in action and causes repeated precipitation. This causes no settlement of the substratum. Which is the very much need for spread up mangroves. This also cause removal of the soil from the banks of the rivers.

D. Thane District - The major estuaries in the district are Kalyan, Nawapur, Satpati, Kelwa- Mahim, Arnala, Bassein, Uttan, Manori, Bhiwandi, Thane and Dahanu. The dominant species are *A. marina* var. *acutissima*, *A. officinalis*, *R. mucronata*, *S. alba*, *S. apetala*, *C. tagal*, *A. corniculatum* and *A. ilicifolius.*

E. Mumbai District - The major estuaries in the district are Trombay, Ulwa Belapur, Bandra, and Versova. Some species commonly distributed are, *Avicennia marina* var. *acutissima*, *Sonneratia apetala*, *A. officinalis*, *Rhizophora mucronata*, *Ceriops tagal*, *Sonneratia alba*, *Aegiceras corniculatum*, *Excoecaria agallocha* and *Acanthus ilicifolius.* The dwarfism in the species like *Avicennia marina* on the very large areas is the unique feature of the district.Most of the mangroves seen today in Mumbai are along the Vasai creek, Thane creek, Manori and Malad, Mahim- Bandra, Versova, Sewree, Mumbra-Diva and few more places. Mumbai mangroves are fastly disappearing in last few decades. The major reasons are reclamation for housing, slums, sewage treatment and garbage dumps. Growing industrial areas along the coastlines and discharge of domestic and industrial sewage are polluting these areas. Due to Godrej foundation some of the mangrove localities in Mumbai are still exists at the places like Vikroli. Mumbai mangroves mostly comprise of *Avicennia marina* as this species also tolerates pollution including heavy metals such as lead, mercury and chromium all found in significant concentration in the Mithi river. (G.Y.Shinde & Ram Sable,)(Year Not Given in the general article).

THREATS TO THE MAGROVE FORESTS

Threats to the species

The factors which adversely affect the vegetation directly or indirectly in a large or small scale are considered as threats. The mangrove ecosystems are under threat as they are affected by direct and indirect factors. Threats are classified into those affecting the taxon population and those affecting habitat. But some of the factors affect both habitat and taxon population.

Ahmad (1999) accounted the major human impacts on the mangroves of Arabian Gulf region include oil pollution, solid and liquid waste disposal, coastal development, marine dredging, recreation activities, over grazing, wood harvest, diversion of fresh water runoff and pest control. Similar threats are recorded in the study area.

During the field study some of the threats affecting the mangroves are recorded and explained as below. Kulkarni (2006) and Kulkarni and Bhosale (2014) has given the detail threats of the study area.

Natural Threats

Mangroves face problem in the course of natural processes leading to destruction. Such events are referred to as Natural Threats.

1) Diseases

At many places like Kolamb, Kalavali, Achara, Vijaydurg, Bhatye it is found that fruits of *S. alba*, *S. apetala* are infested by the fruit borer insects, which cause rotting of the fruits from inside. The leaves of *Avicennia* are favoured by Grasshoppers.

2) Wild Animals

In the estuaries like Achara, Vijaydurg, Purnagad, Kolamb, Tarkarli, the fruits of *S. alba*, *S. caseolaris* and *X. granatum* are much favoured by the monkeys. Half-eaten fruits are found under the tree in fruiting season.

Man made threats

These threats can be considered under following titles.

A) Affecting Taxon Population

i) Grazing : Heavy grazing in mangroves is observed during field survey. *Avicennia* are excellent feed for cattle. It is believed by the locals that the buffalos when fed by *Avicennia* leaves produce more milk. The grazing of *Avicennia* seedlings reduces regeneration rate.

ii) Fire wood : The mangroves have high calorific value and are used all over the study area as a fire wood. The species preferred are *Rhizophora*, *Avicennia*, *Aegiceras* and *Sonneratia.*

iii) Timber : Some species like *Rhizophora* yield good quality timber as they develop straight boles which are used for the construction purpose. Well grown *Aegiceras* is cleared for the fencing for the houses. Same is true for *Cynometra.*

iv) Siltation : Siltation is the indirect effect of cutting the mangroves. At many places like Kolamb, Achara, Terekhol, Shiroda, Vengurla the cutting of mangroves caused loosening and disturbance of the sediments.

v) Local medicines : Some species like *X. granatum* are used by the local people against child cough and fever at Achara, Vijaydurg and Purnagad.

B) Affecting Habitat and Taxon Population

i) Human interference: With the growing human population pressure, mangroves are cleared and the areas are used for construction purpose and for agriculture. The reclaimed areas are used for the rice, coconut and vegetable cultivation.

ii) Pollution: The mangrove lands are used as liquid and solid waste disposal sites. At many places like Dabhol the industrial effluents are discharged in the estuaries. The estuaries around the Ratnagiri city are affected by this problem.

iii) Reclamation of mangrove land: Mangrove areas are reclaimed for many purposes. The local people clear mangroves for their settlements. Now-a-days Kharland Development Board is active in bunding the mangrove area. Large areas are reclaimed by the Board at Achara, Deogad, Mumbra, Kolamb, Vijaydurg. This practice has been responsible to eliminate the rare and endangered species.

iv) Aquaculture ponds: The mangroves are also destroyed for the aquaculture ponds. Most of mangroves from Kolamb, Kalavali, Tarkarli, Achara, Deogad are cleared for this purpose. These ponds are constructed as small as 50 m^2 and as big as 31 ha. At Deogad an aquaculture pond of 8 ha is constructed by cutting the huge, pure stands of *B. gymnorrhiza.*

v) Dredging: Dredging is increasing water turbidity as the current patterns are not considered. Dredging on potential acid sulphate soils accelerates their acidification and salts are rising the surface rich in chlorides and sulphates, forming a whitish powder, at many places like Tarkarli, Kalavali and Savitri. It is observed that the dredging has been made at large scales for removing the sand for construction purpose. Huge amount of sand is continuously removed from the estuaries which result in continuous movement of sediments. The dredging sites are near to the mangroves like *S. caseolaris* and *K. candel.* Due to continuous dredging these species are exposed to highest degree of threat.

vi) Hypersalinity: The flushing of fresh water is essential for the germination, sprouting of seeds and seedlings in mangroves. But at many sites it is observed that flushing of freshwater is blocked by constructing bunds and the flow is diverted. This causes no mixing of fresh water into estuaries and causing elimination of fresh water loving mangroves due to hyper salinity.

vii) Tourism: Tourism near the estuaries like Tarkarli, Malgund, Kolamb creates the problems to mangroves in that area.

SUMMARY AND CONCLUSION

Mangroves are defined as tropical and sub-tropical forests with a diverse floristic composition bordering the sea on muddy or peaty low lands periodically submerged or influenced by the tides. These ecosystems are proved important for many reasons. By considering all these aspects the present study has been undertaken. The emphasis is given to understand the biodiversity component of mangroves in study area. The data has been collected by extensive field surveys. The data is further analysed for species composition, species distribution pattern, diversity indices, faunal components, phenological observations, height and girth analysis, analysis of mangrove soil, remote sensing studies, threats and the IUCN categorization of the species found in the study area.

The survey, mapping and remote sensing studies are carried out by collecting the data from ground visits and from various sources. The studies on remote sensing, data is carried out with the help of the data collected from the remote sensing Agencies like NRSA, Hyderabad and MRSAC, Nagpur. The study revealed that this data is useful in analysing the mangrove area of the concerned region. The data of IRS 1B Liss –II is used for the present study. It is found from remote sensing data that estuaries like Vijaydurg shows maximum mangrove area of 639.5 ha and Kelye shows minimum of 6.25 ha area. The mangroves of Achara show 94.5 ha area. The mangrove area analysed by the ground surveys in present study, at Achara equals to 150.96ha. The ground surveys are carried out in all the estuaries. It is found that ground surveys are essential to record the ground facts which are not known by the aerial device during the ground surveys. Attempts are made to collect the data required for various purposes including IUCN categorization. The study reveals that the mangrove vegetation in the study area is diverse with respect to and follows the normal pattern of species distribution / occurrence. It also reveals that the species like *E. agallocha*, *A. ilicifolius*, *R. mucronata*, *A. officinalis* and *A. marina* show maximum percentage of occurrence as compared to the species like *X. granatum*, *C. iripa*, *B. cylindrica*, *S. caseolaris* and *T. gallica.* The average canopy area is greater in the species like *A. alba*, *A. officinalis*, *S. alba* and *C. iripa* and lower in species like *K. Candel*, *C. tagal* and *L. racemosa.* The study also shows that the data collected during the ground surveys and RS studies shows considerable variations. It suggests that the high-resolution RS data can help in such type of studies.

The studies on mangrove biodiversity in both the districts show the major variations. The study gives importance to both the districts to investigate different mangrove species. The study found 20 typical mangroves, 10 halophytic species, 13 border line mangroves and 15 mangrove associates from both these districts. The mangrove biodiversity is also studied with the help of various diversity indices. The vegetation in the study area is analysed for various indices like species diversity index (D), diversity index (Di), alpha and beta diversity indices. It indicates that the Simpson's Index of Diversity (Di) is greater for the estuaries like Achara, Khavane, Purnagad, Dabhol and Savitri estuaries. The diversity index (Di) shows variation in values for the mangrove stands in the study area. The analysis of alpha and beta diversity indicates that these values are variable for different estuaries. These values are obtained by using the Jaccard's Index of species diversity. The alpha and beta diversity profile indicates that there is positive correlation between the estuarine area and the area occupied by the mangroves of concerned area.

Mangrove supports variety of animal life. These animals become a part of the energy flow in the ecosystem. The important animal groups which are associated with the mangroves are macro and meiobenthos, pisces, mammals, reptiles and birds. Some of the bird group observed in the study area are Herons, Egrets, Lapwings, plover, Gulls, Terns, Storks, Hawks, Kites, Hornbills and King fishers. Among these the uncommon and threatened greet pied Hornbill (Buceros bicornis) have been found at some sites. Some of the common crab species are *Uca roseus*, *Uca lactea annulipes* and *Uca vocans.* The species like *Scylla serrata* and *Portunus pelagius* are edible. In the present study 13 sp. of molluscs, 25 species of edible fish, 9 species of reptilia, 45 sp. of birds and 10 species of mammalia are found.

Mangroves exhibit specific zonation pattern. During the present study the mangrove zonation and distribution across and along the estuaries are studied. It is found that the species like *Avicennia* occur along the seaward zone flooded by all medium high tides. The second zone is dominated by *R. mucronata* and *S. alba.* The third zone or mixed zone is composed of *A. alba*, *S. apetala*, *A. ilicifolius*, *B. gymnnorriza*, *A. cornicnlatum* and *C. tagal.* The landward fringe is limited by *S. persica*, *C. inerme* and *I. Pes-caprae.* The study revealed that habitat adaptation and microclimate of species decides its zone and succession in the community. From this study it is found that all sites being under human pressure the natural zonation pattern is not seen. The existing zonation pattern is a result of natural distribution and human disturbances.

It is observed that in most of the species the early phenophases initiate in the early summer season. Members of family *Rhizophoraceae* show flowering throughout the year. The species like *R. mucronata*, *C. tagal* and *K. candel* show early stages in the month of April and May and blooming is observed from September to November. The mature propagules are found upto May and June. The species like *Avicennia* show flowering from March to July and matured fruits are formed in June – July. It is found that some phenophases overlap in the species like *C. tagal*. The present study differs from that for Ratnagiri because of latitudinal difference. It is observed that flowering is delayed from lower to upper latitude. The period of delay depends upon the distance between two locations.

IUCN has given Red list criteria. These criteria are used for assessing the status of mangroves in the study area. The categorization process requires the data like number of mature individuals, area under each species, threats affecting taxon population etc. this information is helpful to decide the status of the species. During the present study the data required for categorization of mangroves for both the districts has been collected. From these studies it is found that out of twenty four species analysed, some species are analysed as Critically Endangered (CR), some are found Endangered (EN). The study also reveals that all the mangroves from the study area are found under severe anthropogenic threats. The mangroves in the study area are threatened due to loss of habitat, due to fragmentation (LF), Harvest for Food (HF), pollution (Pu), loss of habitat (L), Human interference (I) and trade (T). These threats are listed as per IUCN (2000) version of red list guidelines.

It is another important aspect of study is to deal with conservation aspect. The threatened species indicate priorities for conservation. It is suggested that for conservation of mangroves there is need to implement the CRZ Notification (1991) quite effectively. Moreover, people's participation is a must and therefore, participatory management of mangrove areas is suggested.

The study concludes that -

a) the ground surveys lead to record of 20 typical mangroves along with 10 halophytes12 borderline species and 15 associates;
b) the data from remote sensing though is very useful is far from ground surveys;
c) though the faunal components do not represent complete list, but added dimensions to biodiversity;
d) distribution and zonation pattern is indicative of disturbances in the original structure;
e) all the mangrove species are threatened to a great degree;
f) for conservation of mangroves participatory approach and effective implementation of CRZ regulation are required.

REFERENCES

Ahmad, A. (1990). Impact of human activities on marine environment and guidelines for its management: Environmentalist viewpoints. In : Recent Trends in Limnology (eds.) Agrawal, V. P. and P. Das, Muzaffarnagar, India Soc. of Bio. Sci. 49-60.

Bhosale, L. J. (1987). The Mangrove Ecosystems of India. In: C. D. Field and A. J. Dartnall (eds.) Mangrove Ecosystems of Asia and The Pacific. Status, exploitation and management. Proc. of the Res. for Development Seminar, Australian Institute of Marine Science, Townsville, Australia, 18-25 May, 1985, 24-29.

Bhosale, L. J. (2002). Categorization of Mangroves of Maharashtra based on IUCN Red list guideline and germplasm preservation of threatened species. Final report submitted to Ministry of Environ. and Forest, Govt. of India, New Delhi. 155 p.

Bhosale, L. J. (2005). Field Guide to Mangroves of Maharashtra. Shivaji University, Kolhapur. 315 p.

Blasco, F. (1977). Outline of ecology, botany and forestry of the Mangals of the Indian subcontinent. In : V. J. Chapman (ed.) *Ecosystems of the World 1 : Wet Coastal Ecosystems.* Elsevier Scientific Publ. Co., New York, 241-260.

Bunt, J. S. (1992). In : Coastal and Estuarine Studies : tropical mangrove ecosystem (eds.) A. I. Robertson and D. M. Alongi American Geophysical Union, Washington DC, USA, 101-136.

Farnsworth, E. J. and Ellison, A. M. (1997). The Global Conservation Status of Mangroves. *Ambio*, 26 (6) : 328-334.

IUCN/SSC (2000). criteria review working group (version 3.1), IUCN, Gland, Switzerland.

Kotmire, S. Y. and L. J. Bhosale (1985). A study of Mangrove vegetation along Deogad estuary. In : V. Krishnamurthy and A. G. Untawale (eds.) *Marine Plants.* Seaweed Research and Utilization Association, Madras, 225-230.

Kulkarni N.A.(2006). Ph.D.Thesis Submitted to Shivaji University, Kolhapur.

Kulkarni N.A.and L.G.Bhosale (2014). Ecological Studies on the Mangroves Along the Coast of Maharashtra State With Respect to Their Conservation. Pp 1-109. In: Microbial Applications and Environment. Discovery Publishing House.Ltd. New Delhi.pp 188.

Saenger, P. (1998). Mangrove Vegetation: an evolutionary perspective. *Mar. Freshwater Res.*, 49 : 277-286.

Tomlinson, P. B. (1986). The Botany of Mangroves. Cambridge Univ. Press. Cambridge, England. 413 p.

Untawale, A. G. (1985). Mangroves of Asia and the pacific: status and usage. The final document of the UNDP, UNESCO Regional Research and Training Pilot Programme on Mangrove Ecosystem in Asia and the Pacific NIO. Dona, Paula, Goa, 20 p.

Untawale, A. G. (1985). Status of mangrove research in India. In : Bhosale L. J. (ed.) *The Mangroves : Proc. Nat. Symp. Biol. Util. Cons. Mangroves.* Shivaji University, Kolhaour. Nov. 1985. 127-134.

Table : 1. Estuaries and Creeks present in the five districts along the coast of Maharashtra

Sindhu durg	Geo. Position	Ratnagiri	Geo. Position	Raigad	Geo. Position	Thane	Geo. Position	Mumbai	Geo. Position
Terekhol	15°42'N 73°40'E	Rajapur	16°36'N 73°19'E	Panvel	18°98'N 73°04'E	Dahanu	19°96'N 72°71'E	Versova	19°14'N 72°75'E
Shiroda	15°45'N 73°37'E	Vetye	16°38'N 73°19'E	Mora	18°90'N 72°91'E	Nawapur	21°16'N 73°79'E	Ulwa Belapur	19°01'N 73°02'E
Mochemad	15°47'N 73°38'E	Purnagad	16°48'N 73°18'E	Karanja	18°85'N 72°93'E	Satpati	19°72'N 72°69'E	Bandra	19°05'N 72°81'E
Vengurla	15°51'N 73°36'E	Pavas	16°53'N 73°17'E	Rewas	18°79'N 72°92'E	Kelwa-Mahim	19°54'N 72°79'E	Trombay	19°01'N 72°87'E
Vaingani	15°54'N 73°35'E	Bhatye	16°58'N 73°17'E	Dharmatar	18°81'N 72°95'E	Arnala	19°45'N 72°74'E		
Kalvi	15°56'N 73°32'E	Kalbadevi	17°01'N 73°16'E	Alibag	18°63'N 72°88'E	Bassein	19°32'N 72°81'E		
Khavane	15°58'N 73°33'E	Are	17°04'N 73°17'E	Revdanda-Kundalika River	18°54'N 72°93'E	Uttan	19°24'N 72°80'E		
Nivti	15°59'N 73°29'E	Kelye	17°05'N 73°17'E	Borli Mandala	18°51'N 72°91'E	Manori	19°22'N 72°80'E		
Tarkarli	16°00'N 73°28'E	Malgund	17°06'N 73°15'E	Nandgaon	18°38'N 72°91'E	Bhiwandi	19°33'N 72°97'E		
Kolamb	16°02'N 73°27'E	Jaigad	17°18'N 73°12'E	Murud Janjira	18°29'N 72°98'E	Thane	19°21'N 72°93'E		
Kalavali	16°05'N 73°27'E	Dabhol	17°34'N 73°09'E	Rajpuri Dighi	18°30'N 72°96'E	Kalyan	19°24'N 73°09'E		
Achara	16°11'N 73°25' E	Harnai	17°50'N 73°05'E	Mandad	18°29'N 73°02'E				
Mithbav	16°16'N 73°24'E	Savitri	17°59'N 73°01'E	Shrivardhan	18°04'N 73°02'E				
Mumbra	16°21'N 73°22'E								
Deogad	16°23'N 73°21'E								
Vijaydurg	16°33'N 73°20'E								

Table: 2. Biodiversity of Mangroves of Maharashtra in relation to World.

No.	Family	Genus	Number of species / varieties							
			World*	India	Maha	Ratn	Sind	Raig	Than	Mum
1.	*Avicenniaceae*	*Avicennia*	8	3	2	1	2	2	2	2
2.	*Combretaceae*	*Lumnitzera*	2	2	1	1	1	1	1	1
3.	*Rhizophoraceae*	*Bruguiera*	6	4	2	1	2	2	2	2
		Ceriops	2	2	1	1	1	1	1	1
		Kandelia	1	1	1	1	1	1	1	1
		Rhizophora	9	5	2	2	2	2	2	2
4.	*Sonneratiaceae*	*Sonneratia*	5	4	3	2	3	3	3	3
5.	*Euphorbiaceae*	*Excoecaria*	1	1	1	1	1	1	1	1
6.	*Meliaceae*	*Xylocarpus*	3	3	1	1	1	1	1	1
7.	*Myrsinaceae*	*Aegiceras*	2	1	1	1	1	1	1	1
8.	*Acanthaceae*	*Acanthus*	2	2	1	1	1	1	1	1
9.	*Pteridaceae*	*Acrosticum*	1	1	1	1	1	1	1	1
10.	*Tamaricaceae*	*Tamarix*	4	4	1	1	1	1	1	1
11.	*Leguminoceae*	*Cynometra*	2	2	1	1	1	1	1	1
12.	*Apocynaceae*	*Cerbera*	2	2	1	1	1	1	1	1
13.	*Palmae*	*Nypa*	1	1	---	---	---	---	---	---
14.	*Combretaceae*	*Languncularia*	1	NR	---	---	---	---	---	---
15.	*Bombacaeae*	*Camptostemon*	2	NR	---	---	---	---	---	---
16.	*Lythraceae*	*Pemphis*	1	1	---	---	---	---	---	---
17.	*Myrtaceae*	*Osbornia*	1	NR	---	---	---	---	---	---
18.	*Pellicireaceae*	*Pelliciera*	1	NR	---	---	---	---	---	---
19.	*Plumbaginaceae*	*Aegialitis*	2	1	----	----	---	---	---	---
20.	*Rubiaceae*	*Scyphiphora*	1	1	---	---	---	---	---	---
21.	***Sterculiaceae***	***Heritiera***	**4**	**3**	---	---	**1**	---	---	---

*Tomlinson (1986), Maha : Maharashtra, Ratn : Ratnagiri, Sind : Sindhudurg, Raig : Raigad, Than : Thane, Mum : Mumbai.

Table: 3. Mangrove Status and Diversity along the Coast of Maharashtra

Sr. No.	Family	Genus	Species	Ratn	Sind	Raig	Than	Mum	IUCN Status
1.	*Avicenniaceae*	*Avicennia*	*marina* var. *acutissima*	+	+	+	+	+	EN
2.	*Avicenniaceae*	*Avicennia*	*alba*	+	+	+	-	-	EN
3.	*Avicenniaceae*	*Avicennia*	*officinalis*	+	+	+	+	+	EN
4.	*Combretaceae*	*Lumnitzera*	*racemosa*	+	+	+	+	+	EN
5.	*Rhizophoraceae*	*Bruguiera*	*gymnnorriza*	+	+	+	+	+	EN
6.	*Rhizophoraceae*	*Bruguiera*	*cylindrica*	+	+	+	+	+	CR
7.	*Rhizophoraceae*	*Ceriops*	*tagal*	+	+	+	+	+	EN
8.	*Rhizophoraceae*	*Kandelia*	*candel*	+	+	+	+	+	EN
9.	*Rhizophoraceae*	*Rhizophora*	*mucronata*	+	+	+	+	+	EN
10.	*Rhizophoraceae*	*Rhizophora*	*apiculata*	+	+	+	+	+	EN
11.	*Sonneratiaceae*	*Sonneratia*	*alba*	+	+	+	+	+	EN
12.	*Sonneratiaceae*	*Sonneratia*	*apetala*	+	+	+	+	+	EN
13.	*Sonneratiaceae*	*Sonneratia*	*caseolaris*	+	+	+	+	+	CR
14.	*Euphorbiaceae*	*Excoecaria*	*agallocha*	+	+	+	+	+	EN
15.	*Meliaceae*	*Xylocarpus*	*granatum*	+	+	-	-	-	CR
16.	*Myrsinaceae*	*Aegiceras*	*corniculatum*	+	+	+	+	+	EN
17.	*Acanthaceae*	*Acanthus*	*ilicifolius*	+	+	+	+	+	EN
18.	*Pteridaceae*	*Acrosticum*	*aureum*	+	+	+	+	+	EN
19.	*Tamaricaceae*	*Tamarix*	*gallica*	+	-	+	+	+	CR
20.	*Leguminoceae*	*Cynometra*	*iripa*	+	+	-	-	-	CR
21.	*Apocynaceae*	*Cerbera*	*manghas (odollum)*	+	+	-	-	-	CR
22.	*Sterculiaceae*	*Heritiera*	*fomes* (Recent report)	+	-	-	-	-	CR

- Ratn : Ratnagiri, Sind : Sindhudurg, Raig : Raigad, Than : Thane, Mum : Mumbai.
- Data quality – Census & Field Survey, EN : Endangered, CR : Critically Endangered
- Population restricted in area of occupancy of less than 100 km^2. 1 ‹ 10 km^2 (CR) 2. ‹ 500 km^2 (EN).

Plate I - Mangrove Biodiversity of Maharashtra: Typical Mangrove Species Recorded.

Acanthus ilicifolius

Acanthus ilicifolius (close up)

Avicennia marina* var. *acutissima

Avicennia officinalis

Bruguiera gymnorrhiza

Bruguiera cylindrica

Ceriops tagal

Kandelia candel

Rhizophora mucronata

Lumnitzera racemosa

Sonneratia apetala

Sonneratia caseolaris

Avicenia marina

Cynometra iripa

Excoecaria agallocha

Sonneratia alba

Plate II - Fruiting Pattern in Typical Mangrove Species

Viviparous Seedlings of *Rhizophora mucronata*

Viviparous Seedlings of *Ceriops tagal*

Viviparous Seedlings of *Kandelia candel*

Viviparous Seedlings of Bruguiera gymnorrhiza

Viviparous Seedlings of Bruguiera cylindrica

Cryptoiviparous Seedlings of *Aegiceras corniculatum*

Sonneratia alba Fruits

Sonneratia apetala Fruits

Avicennia officinalis Propagules

Avicennia marina var acutissima Propagules

Cynometra iripa Fruits

Xylocarpus granatum Fruits

Plate II A – Mangrove Associated Species

Cerbera manghas

Tamarix gallica

Sesuvium portulacastrum

Thespesia populnoides

Pongamia pinnata

Ipomea pes-caprae

Porteracia coarctata

Salvadora persica

Halophilla bacarrai

Acrosticum aureum (The only Fern)

Acampae premorsa

Plate III - Rooting Pattern in Mangrove Species

Pencil like Pneumatophores of *Avicennia marina*

Young Pneumatophore Development of *Avicennia marina*

Knee Pneumatophores of *Bruguiera gymnorrhiza*

Exposed Roots of *Excoecaria agallocha*

Coiling Roots of *Acanthus ilicifolius*

Butteresses or Plate like Roots of *Kandelia candel*

Tall pneumatophores of *S. caseolaris* recorded upto 5 feets at Nerurpar site of Tarkarli estuary.

Roots of *Lumnitzera racemosa*

Pneumatophores of *Sonneratia alba*

Prop roots of *Rhizophora mucronata*

Plate IV - Zonation Pattern in Mangrove Vegetation

A big pure patch of *A. ilicifolius* recorded at Dongarwadi site of Achara estuary.

Development of *Rhizophora* plants in stable water at Purnagad

Growth of *Excoecaria* plants at Nivati

Development of *Rhizophora* plants in stable water at Khavane

Accumulation of the new bourn soil by *Rhizophora* at Deogad

Spreading of the pneumatophores by *Sonneratia* at Malvan

Growth of *Cerbera* plants along with *Aegiceras corniculatum* at the drier soils at Vengurle

Full grown *A. officinalis* tree with *A. aureum* as understorey at Kalavali.

Cutting of the estuarine water for the construction of Prawn culture ponds has hampered the growth of Bruguiera gymnorrhiza at Deogad

A. corniculatum, *C. tagal*, *P. coarctata*, *A. ilicifolius* and *A. marina* in the background at upstream site of Kalavali.

Mix growth of *Rhizophora*, *Aegiceras* and *Acanthus* at Pavas

Well grown stands of *Rhizophora apiculata* at Bhatye - Ratnagiri

T. gallica along with *C. javanicus* at the Kasheli site of Purnagad estuary.

Growth of *Rhizophora* and *Avicennia* at Purnagad

Performance of *Avicennia marina* along with *Acrosticum* on the drier soils at Deogad

Well grown stands of *Sonneratia apetala* at Savitri Estuary

Disappearing mangrove stands due to drier soils at Kolamb

Cutting of the estuarine water for the construction of Prawn culture ponds has hampered the growth of Bruguiera gymnorrhiza and encroachment of Acrosticum at Deogad

Plate V - Benefits of Mangroves for Livelihood

Coir production in the mangrove soils at Mumbra

Small scale fishing in the mangroves of Kolamb.

Small scale use of S. alba as a fuel is seen at Achara

Grazing animals in the mangroves as at Achara

Plate VI - Satellite Images Showing the Mangrove Vegetation in Various Estuaries and Creeks of Along the Coast of Maharashtra (Courtesy – Google Earth)

Achra Estuary - Sindhudurga District

Devgad Estuary – Ratnagiri District

Kolamb Creek - Sindhudurga District

Mumbra Estuary Ratnagiri District

Sarjekot Kalavali Estuary Sindhudurga District

Shiroda Estuary Malvan Sindhudurga District

Tarkarli Estuary Malvan Sindhudurga District

Terekhol Near Mouth Mangroves - Sindhudurga District

Terekhol Kiran Pani Mangroves - Sindhudurga District

Terekhol Gavtale Mangroves - Sindhudurga District

Ade Raigad Mangroves

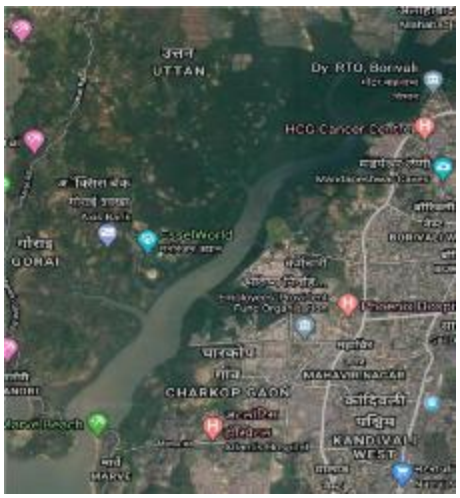
Adi Savitri River Raigad Mangroves

Agardanda Murud Mangroves

Anjarle Dapoli Raigad Mangroves

Bhatye Estuary Ratnagiri Mangroves

Gaokhadi Kondsur Punagad Ratnagiri Mangroves



Mumbai - Gorai Uttan Mangroves

Jaigad Estuary Ratnagiri Mangroves

Kelashi Sakhari Nate Raigad Mangroves

Kodjai Tributory of Vashishthi River Mangroves

Mandad Khajanivadi Murud Mangroves

Vijaydurga Estuary (Vaghothan River)Ratnagiri Mangroves

Mandava Revas Raigad Mangroves

Mumbai Versova Daravali Mangroves

Mumbai Mangroves Mandava Revas Bori (Karanja Creek)

Mumbai Mangroves Trombay

Pangar Tarfe Haveli Mangroves Dabhol (Vashishthi River)

Parchuri Dabhol Raigad Mangroves (Vashishthi River)

Panvel Belapur Mumbai Mangroves

Rajapur Jaitapur Ratnagiri Mangroves

Rajapuri Dighi Raigad Mangroves

Revdanda Alibag Mangroves

Shrivardhan Kalinge Raigad Mangroves

Vasai Virar Creek Mangroves