

Study of mangrove environment of Maharashtra coast using remote sensing data

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Analysis of remote sensing data indicate approximately 210 km² of the mangrove area along the Maharashtra coast. The dominant species along the coast are *Rhizophora mucronata*, *Avicennia officinalis*, *A. marina*, *Sonneratia alba*, *S. apetala*, while *Excoecaria agallocha* and *Acanthus ilicifolius* are very common. However, *Kandelia candal*, *Bruguiera gymnorhiza*, *Ceriops tagal*, *Lumnitzera racemosa* are restricted to few localities. Relatively, luxuriant formations and more number of species, occur in Ratnagiri and Raigad districts. Scrubby and scanty vegetation dominated by *Avicennia marina*, along the Bombay coast, could be attributed to constantly increasing anthropogenic pressures.

Mangrove environments in the tropics have been recognised for their ecological and socioeconomic significance, and they are highly productive¹. However, in India this valuable ecosystem, has deteriorated to a great extent, mainly due to over exploitation and total lack of management. For effective management of mangrove ecosystem, basic information such as species composition, ecology, extent, forest inventories, land use, human intervention etc. is required. Mangrove forest cover in most of the coastal states of India has been estimated^{2,3} using remote sensing data. However, no authentic and comprehensive data exist on the mangroves of Maharashtra coast, except for some ecological information⁴⁻⁶. Various estimates⁷⁻¹¹ for mangrove area, ranging from 200-622 km², have been given for the mangroves of Maharashtra. None of the above estimates, are based on standard survey techniques. Therefore, during the present investigation, the extent and composition of mangroves along the Maharashtra coast have been studied using the remote sensing techniques¹²⁻¹⁴, which are more precise, rapid and economical.

Materials and Methods

Maharashtra coast extends for about 720 km along the central west coast of India (Fig.1). The coast is indented with number of beaches, 15 rivers, 5 major creeks and over 30 backwater regions. Soil is lateritic in the south while it is red, loamy and alluvial towards the north. Climate in general is warm and humid. Atmospheric temperature varies from 20°-35°C and humidity 60-90%. Maximum annual rainfall reaches up to 3000 mm. Aerial photographs (black and white)

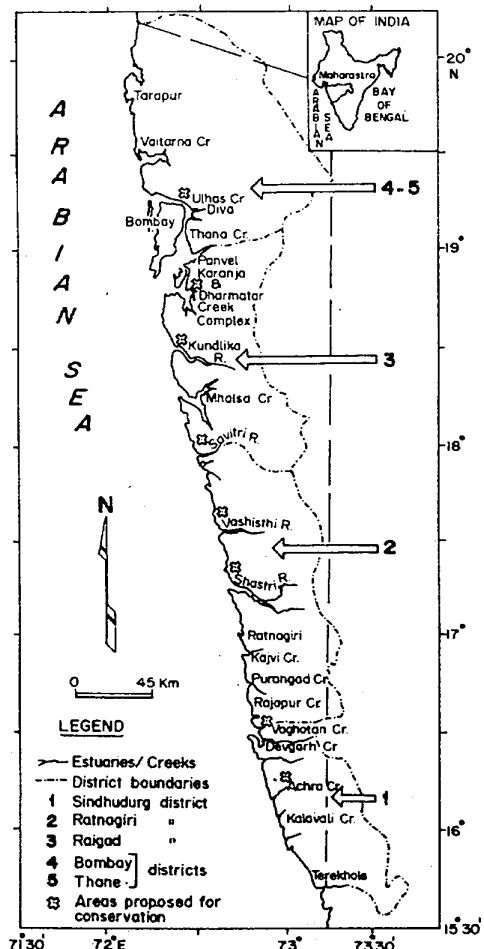


Fig. 1—Map of study area

taken during 1973 (scale 1:20,000 and 1:25,000) and Landsat TM data of 1987 (scale 1:2,50,000), of the study area (Fig.1) were used. The interpretation keys for the major mangrove species and associate parameters were prepared (Table 1) by observing remote sensing data visually as well as under mirror stereoscope (aerial photographs), and were delineated as described earlier¹²⁻¹⁴. The ground truth data was collected by visiting number of sites identified on the aerial photos and the satellite scene. Observations were also made on the impact of anthropogenic (human interferences) pressures on the mangrove ecosystem. The final vegetation maps for all the waterbodies, were prepared on the trace paper. The mangrove extent was estimated, using planimeter (Planix 5, Japan).

Results and Discussion

Mangrove flora comprises 17 species belonging to 11 genera and 8 families (Table 2), dominated by *Rhizophora mucronata*, *Sonneratia alba*, *S. apetala*,

Avicennia officinalis and *A. marina*. Other commonly occurring species are *Acanthus ilicifolius*, *Excoecaria agallocha*. However, *Kandelia candel*, *Ceriops tagal*, *Bruguiera gymnorhiza* and *Lumnitzera racemosa*, are restricted to a few localities in Sindhudurg and Ratnagiri districts. *Sonneratia apetala* is dominant in Thane district and luxuriant (height 15-25 m) growth was observed along the Ulhas creek, and Diva Junction (Fig.2d). Rest of the regions along the coast are totally devoid of *S. apetala* except few stray plants in Ratnagiri district. As shown in Fig.1, Bombay and nearby coast, are mainly dominated by *Avicennia marina* and *Acanthus ilicifolius*. Around Elephanta Islands, off Bombay, few stray plants of *S. alba* have been observed.

Mangrove flora of India³ constitute 50 species, dominated by the genera like *Rhizophora*, *Avicennia* and *Sonneratia*. East coast harbours relatively higher number of species (37) as compared to the west coast (20). According to latest estimates^{2,3}, mangrove cover in India is 3150 km² of which 650 km² occur along the west coast. Relatively, poor extent of mangroves along the west coast compared to the east

Table 1—Interpretation keys for mangrove environment from remote sensing data

Parameters	Identifying features	
	Aerial photographs	Satellite (DCC and FCC)
Coastal vegetation		
Mangroves		
Dense/mature	Dark gray, coarse	Bright red
Sparse	Light gray, smooth	Light pink
Young	Light gray, smooth	Light red
<i>Rhizophora</i> spp	Dark gray, coarse	Bright red
<i>Sonneratia</i> spp	Dark gray, coarse	Bright red
<i>Avicennia</i> spp	Very light gray, wooly	Dark pink/red
Land forms		
Rocks	Black, coarse	Greenish/black, coarse
Dry sand	White, smooth	White, smooth
Wet sand	Light gray, smooth	Greenish smooth
Newly formed island	Light gray, smooth	Greenish, smooth
Sandy beach	White strips, smooth	White strips, smooth
Water bodies		
Estuary		
Deep water	Dark gray, smooth	Deep blue
Shallow water	Light gray, smooth	Light blue
Turbid water	Dark gray, patchy, smooth	Dark blue
Rivulets	Light gray, smooth	Dark/light blue
Mudflats	Light gray, smooth	Greenish, smooth

* DCC — Diazo colour composite

* FCC — False colour composite

Table 2—Composition and ecological status of mangroves in Maharashtra

Species	Districts				
	1	2	3	4	5
<i>Rhizophora mucronata</i> L.	D	C	C	R	R
<i>R. apiculata</i> Bl.	C	VC	C	R	A
<i>Ceriops tagal</i> (Perr.) C.B Rob.	LC	C	LC	LC	A
<i>Kandelia candel</i> (L.) Druce	C	VC	LC	R	A
<i>Bruguiera gymnorhiza</i> (L.) Lam.	R	R	R	R	A
<i>B. parviflora</i> (Roxb.) W. & A.	LC	C	C	R	A
<i>Sonneratia alba</i> J. Smith	C	VC	C	LC	R
<i>S. apetala</i> Buch. Ham.	R	R	C	C	R
<i>S. caseolaris</i> (L.) Engl.	C	R	A	A	A
<i>Avicennia alba</i> Bl.	LC	C	C	C	C
<i>A. marina</i> (Forsk.) Vierh.	LC	VC	C	C	VC
<i>A. officinalis</i> L.	C	C	VC	LC	C
<i>Lumnitzera racemosa</i> Willd.	LC	VC	C	R	A
<i>Aegiceras corniculatum</i> (L.) Bl.	LC	C	C	R	A
<i>Excoecaria agallocha</i> L.	C	VC	C	R	R
<i>Acanthus ilicifolius</i> L.	C	VC	C	C	VC
<i>Salvadora persica</i> L.	LC	LC	LC	LC	R
Associate mangroves					
<i>Acrostichum aureum</i> L.	C	VC	VC	R	A
<i>Derris heterophylla</i> Willd. Back.	C	VC	C	LC	R
<i>Clerodendrum inerme</i> (L.) Gaertn.	C	VC	C	LC	R

1-Sindhudurg, 2-Ratnagiri, 3-Raigad, 4-Thane & 5-Bombay
C = common, LC = less common, VC = very common, R = rare, A = absent

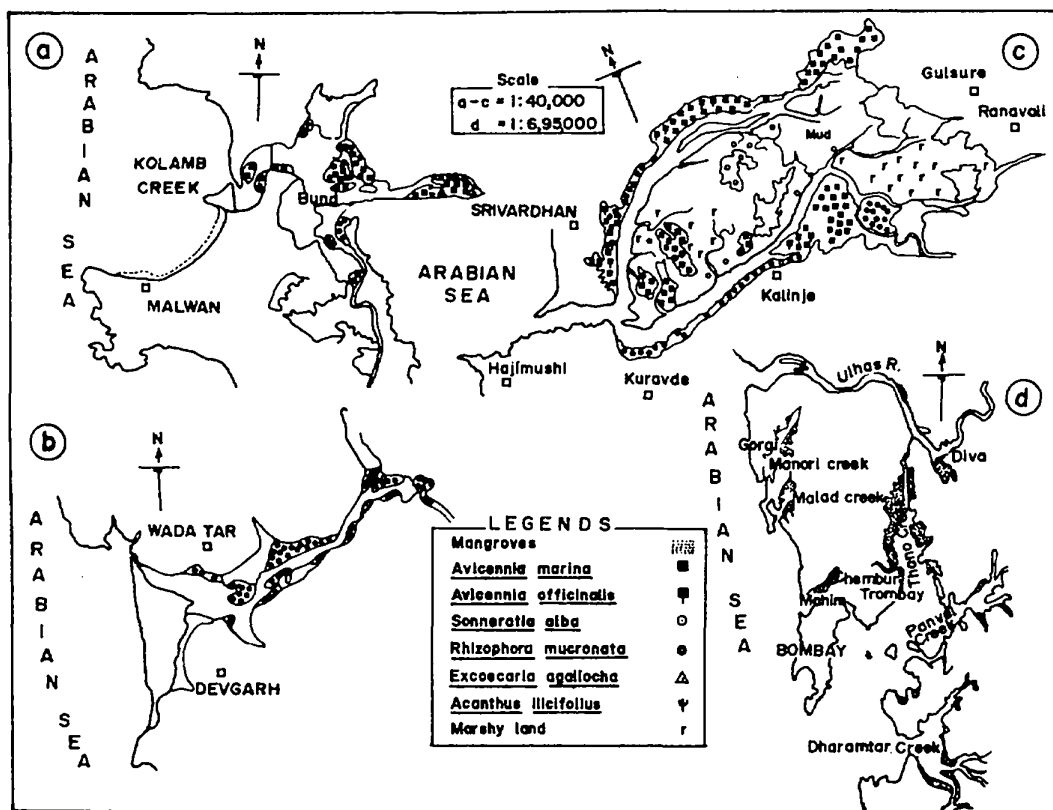


Fig. 2—Mangrove vegetation maps for few areas: (a) Malvan, (b) Devgarh, (c) Shrivardhan, (d) Bombay and nearby coast

coast and Andaman and Nicobar Islands, can be attributed to the coastal geomorphology. Rising¹⁵ coast has resulted into the narrow intertidal belts which support fringing mangroves along the west coast of India. Maximum (370 km²) extent of mangrove has been reported³ from Gujarat state, however, the flora was represented² by only nine species. On an average 28% (ca. 210 km²) of estuarine and brackish water regions of Maharashtra, have been covered by mangroves. Maximum of about 87 km² and minimum of 15 km² of the mangrove extent are estimated in the Raigad and Sindhudurg districts, respectively (Table 3). Bombay and nearby coasts, have relatively greater (36%) mangrove cover, however, flora is mostly scrubby, stunted and dominated by *Avicennia marina* and *Acanthus ilicifolius*. The southern coast (Sindhudurg, Ratnagiri and Raigad districts) has relatively more number of species and larger extent of mangroves. The luxuriant formations occur along few creeks like Vaghotan, Rajapur, Dharmatar and Vasai (Ulhas) and rivers like Shastri, Vashisthi, Savitri and Kundalika (Table 4).

Table 3—Mangrove and estuarine area (km²) in various districts of Maharashtra

District	Estuarine area	Mangrove area	% Mangroves
Sindhudurg	074.60	15.06	20
Ratnagiri	145.38	33.50	23
Raigad	272.51	85.52	32
Thane	171.87	48.12	28
Bombay	073.77	26.97	36
Total	738.15	210.17	28

In general, the Maharashtra coast represents relatively better extent and composition, compared to other coastal regions² along the central west coast. However, like in other coastal states, mangroves of Maharashtra too have suffered great damage and continue to be under constant anthropogenic pressures. It is estimated that almost 40% of the mangrove area of Maharashtra has been reclaimed during the last 30 years for various developmental activities, and lately, more reclamation is made for

Table 4—Physical data for major coastal waterbodies of Maharashtra

Waterbody	Length (km)	Estuarine area (km ²)	Mangrove area (km ²)	Mangrove (%)
Kundalika	21.0	29.63	9.36	31.6
Savitri	51.0	46.87	16.34	35.1
Shastri	42.0	21.94	4.88	23.8
Vasai	41.0	84.37	20.00	23.5
Vaitarna	15.0	46.25	13.75	29.9
Thane	22.5	41.25	14.37	34.8
Panvel	08.5	30.0	11.25	37.5
Dharmtar	40.0	60.62	14.37	23.8
Karanja	10.0	20.0	4.37	22.5
Mhasla	22.5	59.96	21.45	35.8
Kajvi	12.0	05.48	1.26	25.0
Purangad	13.5	12.88	3.14	23.0
Rajapur	22.5	15.73	3.47	21.9
Vaghotan	23.0	37.88	5.39	14.5
Devgarh	16.5	18.70	2.08	10.5
Kalavali	16.5	17.53	4.90	27.8
Karli	10.5	11.68	0.12	0.9
Total	595.77	157.64	26.25	16.65

agriculture. At certain localities, mangroves have also encroached agricultural areas to smaller extent.

Continuously mounting pressures, mainly for civil and agricultural developments have deteriorated mangrove ecosystem all over the region and particularly, in India to a large extent. The degradation of mangroves at the present rate, may result into a great loss of its cover as well as biodiversity. Number of taxa like *Xylocarpus*, reported earlier¹⁶ from the west coast have totally disappeared. Similarly, *Lumnitzera racemosa* reported⁴ during 1934 from Bombay coast is no more seen. Other species like *B. gymnorrhiza*, *K. candal*, *C. taga* etc. have restricted, rare or patchy distribution. Various kinds of pollutants also cause severe loss of genetic material. In the coastal regions of Bombay, ca. 2230 mld of domestic and industrial effluents is discharged¹⁷. The gross BOD production in the marine waters has been reported¹⁸⁻²⁰ to be 40-50 g per capita per day. Scrubby vegetation and the limited number (2) of species dominated by *Avicennia marina* along Bombay and nearby coast can be attributed to such high levels of pollution in the marine environment.

Over 30% of the mangrove area have been reduced³ from the country, during last 3 decades. The maximum reduction of 44% in the area has occurred along the west coast. However, so far no constructive efforts have been made to manage these resources on

sustainable basis. Recently, management plans²¹ for the conservation and preservation of mangroves of Maharashtra have been prepared, where in few localities with luxuriant mangroves and rich biodiversity, have been proposed to be conserved immediately, for mangrove germplasm.

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