

ISME Mangrove Ecosystems Technical Reports Volume 5

Two papers on Mangrove Ecosystems

Part I

Asian Pacific Mangrove Information Network (APMIN) - a Conceptual Model
by Vishwas S. Chavan, Tanaji G. Jagtap and Arvind G. Untawale

Part II

Atoll Mangroves and Associated Flora from Republic of Maldives, Indian Ocean
by Tanaji G. Jagtap and Arvind G. Untawale

Editor: M. Vannucci

June 1999

International Society for Mangrove Ecosystems

Atoll mangroves and associated flora from Republic of Maldives, Indian Ocean

T. G. Jagtap and A. G. Untawale

Biological Oceanography Division, National Institute of Oceanography, Donapaula, Goa-403004, India

Abstract

Coral islands from the Republic of Maldives were surveyed for their mangroves and feasibility of large scale mangrove afforestation to restore the coastal habitats and stabilize the shore. Extensive mangrove formations were observed from the islands of the north atolls. Male' atoll was totally devoid of mangroves due to their large scale reclamation mainly for urbanisation and tourism. Mangrove flora comprised of 12 species and was dominated by *Bruguiera cylindrica* followed by *Lumnitzera racemosa*, *Ceriops tagal* and *Rhizophora mucronata*. Many of these islands exhibited luxuriant and tall (7-20 m) forests of *B. cylindrica* with an average density of 7 trees 100 sq. m⁻¹. Production and establishment of mangroves seedlings was observed to be very high in all the members of Rhizophoraceae, as well as in *Avicennia marina*.

Associate mangrove flora was commonly represented by *Thespesia populnea*, *Hibiscus tiliaceus*, *Pandanus* spp., *Pemphis acidula*, *Scaevola taccada* and *Tournefortia argentea*. *Pemphis acidula*, was observed to act as a pioneer species on newly formed islands. Seagrass beds in the shallow lagoons and in the vicinity of mangroves were dominated by *Cymodocea rotundata* and *Thalassia hemprichii*. Seagrass meadows in the lagoons of southernmost Addu atoll were relatively more dense. Mangrove debris harboured 39 spp of manglicolous fungi. In general management status and awareness level of mangrove and adjacent ecosystems were observed to be very poor. Reclamation of mangroves, has caused severe erosion at a few of the islands particularly in the Haa Dhaalu in the north. *B. cylindrica* is commercially exploited for

fish sticks and wood for boat building and construction and cultivated on small scale. Islanders are well versed with plantation techniques and generally dense plantations particularly of *B. cylindrica* are practised in the intertidal swampy regions. There is good potential for developing mangrove nursery and afforestation, and aquaculture in the mangrove influenced environments. It is required to create necessary awareness regarding the ecological and socioeconomic importance of the mangroves and seagrass ecosystems among the islanders.

Introduction

Mangroves, an important constituent of the tropical and subtropical marine ecosystem, are of great ecological, socio-economic and commercial value (Odum and Heald, 1972). Various kinds of anthropogenic activities have resulted in the reclamation of lowlying coastal regions and particularly mangroves and salt marshes all over the world. Degradation and loss of these ecosystems have caused severe erosion and flooding of the land and adverse impact on the marine environment. Besides, low lying coastal areas and islands of recent origin could be the first victims of the increased sea level due to global warming (US EPA, 1983). Coastal zone management therefore, has become imperative in the overall land use planning.

Mangroves, salt marshes and seagrass beds being natural barriers, stabilize and protect the shoreline and sea bottom from erosion during adverse weather conditions. Similarly, they play significant role in land building by enhancing sedimentation and thus keeping the pace with sea

level rise (Untawale and Jagtap, 1992). Very recently, great efforts have been made for the assessment, conservation and management of the mangrove resources from Asia and Oceania (Malaya Univ. and UNESCO, 1984). Mangrove area in Asia and Oceania, had been estimated to be 478×10^5 hectares (Rodin *et al.*, 1975). However, it does not include the mangrove area from many of the oceanic islands. Lately, considerable amount of data have been generated on mangroves from islands in the Indian ocean (Untawale and Jagtap, 1984; 1989; Jagtap, 1992). However, many of the low lying oceanic islands, particularly, of Laccadive archipelago in the Indian ocean, which are more unstable and are threatened of possible sea level rise, have been very poorly known for mangroves (Hackett, 1971; Fosberg, 1976). Hence the mangroves from the Maldives atolls were evaluated for their status and feasibility of afforestation. The data would be of help to formulate conservation and management strategies on the basis of sustainable utilisation.

Description of the Study Area

Geology and geomorphology:

The Republic of Maldives consists of 26 atolls comprising, 1190 islands on the Chagos Laccadive Bank (approx. $0^{\circ} 42' S - 7^{\circ} 05' N$ Lat) along $73^{\circ} E$ Meridian (Fig.1). The length of the archipelago is ca 823 km and average width of ca 130 km. Atolls are mostly circular coral reefs enclosing lagoons (Hackett, 1971). Islands are for the most part transient, eroding rapidly and are enclosed by coral reefs with deep, natural channels and shallow lagoons (Stoddart, 1973). Most of the islands are 2 m above sea level and do not possess typical windward and seaward sides. Soil is generally young, vigorous and shallow, composed mainly of coral debris admixed with sandy loam with top layer containing humus. Due to excess of Ca, soil is alkaline and water retaining capacity is very poor (Fosberg, 1976).

Climatology (IMD, 1931-60):

Maldives's atolls lie outside the cyclone zone. The climate is warm and humid. Daily atmospheric temperature varies from $25.7-30.4^{\circ}C$. Though monsoon is not well defined, average annual rainfall is ca 1950 mm, mainly received from the south-west monsoon (May - October). North-east monsoons occur during November to April. Mean tide is about 0.7m and spring tide reaches to 0.9m

Materials and Methods

Nineteen islands of Male' (Central), Shaviyani and Haadhaalu (North) and Addu (South) atolls from Maldives (Fig. 1) were evaluated during September-October, 1991, for mangroves and adjacent ecosystem and their ecological status. Qualitative observations were made on the associated flora in the mangrove influenced regions. Floral specimens were preserved in 4% formaldehyde and also mounted on herbarium sheets. Specimens were identified by using standard literature mentioned elsewhere (Untawale and Jagtap, 1984; 1989; Jagtap, 1991; 1992.)

The quantitative data (density, DBH and height) of the dominant mangroves and their seedlings were collected along the transects. The transects were laid randomly, from seaward to landward and length varied from 20-1500m. The interval between sampling plots varied from 10-150 m, depending upon the quality and extent of mangroves. Densities of seedlings and trees were measured in triplicate, by using 10 sq. m and 1 sq. m quadrats, respectively. DBH was measured with a Vernier caliper by considering the trees with $DBH > 2.5$ cm only. Heights of the trees were measured approximately by comparing objects of known height. The results were expressed on an average basis. The concerned government and nongovernment personnel and islanders residing in the vicinity of mangroves were interviewed to know the awareness and utilisation levels of mangroves in various atolls.

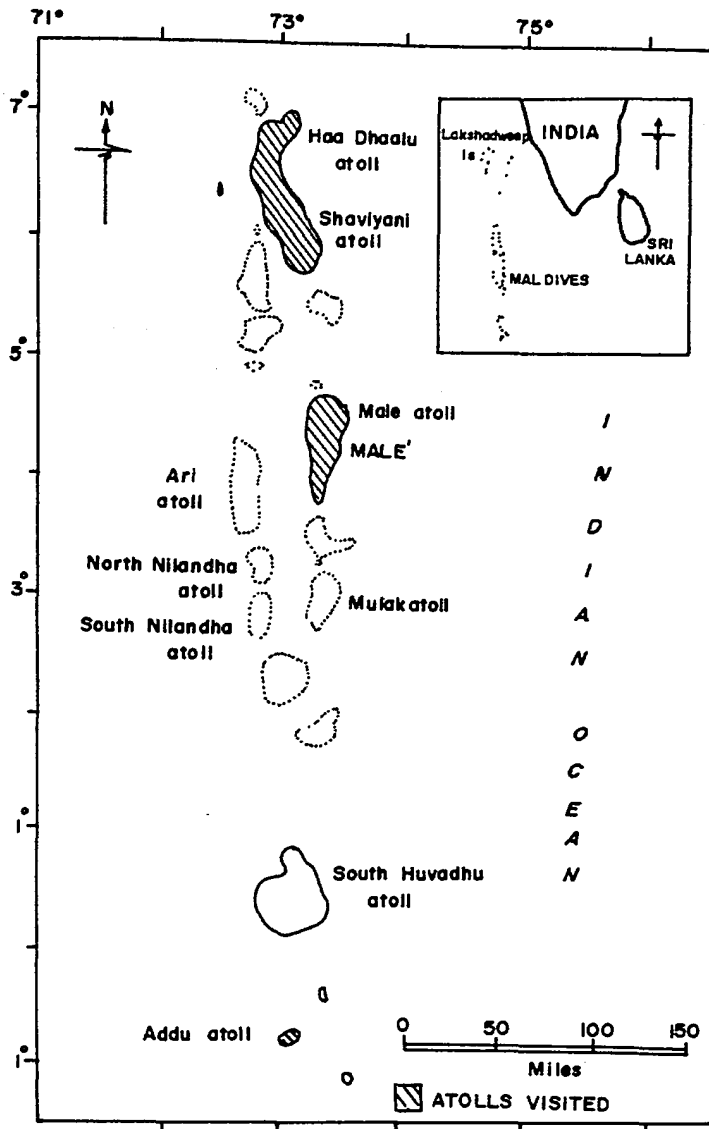


Figure 1 Geographical map of study area.

Results and Discussion

The composition of mangroves mainly depends upon the geomorphological and topographical features of landforms and the climatic conditions (Fosberg, 1976). The tropical belt between 32°N to 38°S, provides warm and humid climate which is quite ideal for the establishment and growth of mangroves. However, the best mangrove formations occur in the belt of 25°N to 25°S latitudes. Volcanic islands in the Indian ocean support qualitatively and quantitatively a

rich mangrove flora (Jagtap, 1985; 1992; Untawale and Jagtap, 1989). However, emerging islands of recent origin on Chagos Laccadive archipelago, in the Arabian Sea harbour relatively few number of species with a limited extent (Untawale and Jagtap, 1984; Jagtap, Chavan and Untawale, 1993). Most of these islands have limited land and natural resources and therefore, mangroves form an important asset of their ecosystem. Islands, particularly of Maldives atolls on Chagos Laccadive archipelago although old formations, are quite unstable (Ahmad, 1972) and

Table 1. Mangroves and major associate flora from republic of Maldives.

Species	Botanical Name	Local Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
<i>Rhizophora mucronata</i> Lamk		Thakarathi	-	-	-	-	-	VR	-	R	ST	C	-	-	-	D	-	-	-	-	D	ST
<i>Rhizophora</i> sp.			-	-	-	-	-	-	-	-	-	-	R	-	R	R	-	-	-	-	-	-
<i>Rhizophora</i> sp.			-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-
<i>Bruguiera cylindrica</i> (L.) Bl.		Khandu	-	-	D	-	D	ST	D	D	-	-	D	CD	D	-	-	-	-	-	-	R
<i>B. gymnorrhiza</i> (L.) Lamk		Bodavaki	-	-	-	-	-	-	-	-	R	-	R	-	D	-	-	-	-	-	-	-
<i>Bruguiera</i> Sp.			-	-	-	-	-	-	-	R	R	-	-	-	-	-	-	-	-	-	-	-
<i>Ceriops tagal</i> (Perr.) C. B. Robins		Khamana	-	-	-	-	-	-	D	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Avicennia marina</i> Vierh			-	-	-	-	-	-	-	-	-	-	-	-	D	-	-	-	-	-	-	-
<i>Lumnitzera racemosa</i> L. Gaertn.		Burehi	-	-	-	-	-	-	-	C	D	C	-	-	C	D	-	-	-	-	-	-
<i>Sonneratia caseolaris</i> (L.) Eng.		Kulhavah	-	-	-	-	-	-	R	R	C	R	R	-	-	-	-	-	-	-	-	-
<i>Excoecaria agallocha</i> L.		Thella	-	-	-	-	-	-	-	R	C	-	-	R	R	-	-	-	-	-	-	-
<i>Acrostichum aureum</i> L.		Maakeha	-	-	-	-	-	-	-	-	C	C	-	C	-	-	-	-	-	-	-	-
<i>Derris heterophylla</i> (L.) Merr.			-	-	-	-	-	-	-	-	C	C	C	-	C	-	-	-	-	-	-	-
<i>Thespesia populnea</i> Cav.		Hirundhu	C	-	VC	VC	VC	VC	VC	VC	VC	VC	VC	C	C	C	C	C	C	C	C	VC
<i>Hibiscus tiliaceus</i> L.		Dhiggaa	C	-	VC	VC	VC	VC	VC	VC	VC	VC	VC	C	C	C	C	C	C	C	C	VC
<i>Pandanus</i> spp.			-	-	C	C	VC	VC	C	VC	VC	C	C	C	C	VC	VC	C	C	C	C	VC
<i>Pemphis acidula</i> Forst		Kuredhi	-	R	C	D	D	C	C	C	C	C	C	C	D	D	D	D	D	D	D	D
<i>Scaevola taccada</i> (Gartn.)			C	R	C	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
<i>Tournefortia argentea</i> Roxb. L.f.			-	-	-	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C

LEGENDS:

1. Male' 2. Hulefulla 3. Kundhiurrd 4. Kurandhaa 5. Maaugaadhoo 6. Ariadhaa 7. Funadhaa
 8. Maakandhdhoo 9. Gooldhoo 10. Kulhudhufushoo 11. Kumundhoo 12. Keylakunu
 13. Neykurendhoo 14. Hithadhoo 15. Maradhoo 16. Peydho 17. Gan 18. Wilgill 19. Huthudhoo
 - Absent, VR- Very rare, R-Rare, C-Common, VC-Very common, D-Dominant.

Table 2. Ecological and socioeconomic aspects of mangroves from various islands of Republic of Maldives.

Islands	Dominant Sp.	Status	Number of Trees 100sq.m ⁻¹ (Seedling sq.m ⁻¹)	AV.height (m)	AV. BH (cm)	Coverage (%)	Farming	Soil type	Tidal flushing	Profile gradient	Awareness	Afforestation potential	Aquaculture potential
Male		VP	-	-	-	-	No	-	-	-	-	-	-
Hulehulle		VP	-	-	-	-	No	-	-	-	-	-	-
Konikhurra	Bc	P	3	4.5	3	80	No	SC	EH	DP	-	-	-
Kurendhoo		VP	-	-	-	-	No	-	-	-	-	-	-
Maaugoodhoo	Bc	P	10(08)	18	15	10	Yes	S	A	N	CU	G	NO
Ariadhoo	Bc	G	7(25)	-	-	-	No	S	A	Fr, Br	-	NO	NO
Funadhoo	Ct	VG	4(08)	3	-	-	No	SM	R	DP	-	VG	NO
Maakandhoo	Bc	G	20(30)	7.5	5	90	No	SC	EH	-	-	NO	NO
Gooldhoo	Lr	VG	15(28)	3	-	80	No	SC	EH	D, Br	CU	NO	NO
Kulhuhufusehu	Lr	VP	4(30)	3	-	80	Yes	SC	A	DP	-	G	VG
Kumundhoo	Bc	G	10(32)	20	15	80	No	SC	EH, SP	DP	CU	NO	NO
Keylakunu	Am, Bc	VG	20(30)	12	5	80	Yes	SC	EH, SP	DP	-	NO	NO
Naykurendhoo	Bc	VG	3	20	15	90	No	SC	R	DP	CU	NO	NO
Hithadhoo	Rm	P	-	6	-	90	Yes	-	R	Br	-	G	VG
Varadhan	-	VP	-	-	-	-	Yes	-	-	-	-	-	-
Feydho	-	VP	-	-	-	-	-	-	-	-	-	-	-
Gan	-	VP	-	-	-	-	-	S	-	-	-	-	-
Hulhuhoo	-	VP	-	-	-	-	-	S	R	-	-	G	-
Wiligill	-	G	-	-	3	-	-	SC	A, SP	D	-	-	-

LEGENDS:

BC- *Bruguiera cynnarica*, G-Good, SC- Sandy clay, A-Absent, DP- Depression, S- Sandy, Ct- *Ceriops tagal*, VG- very good, R- Regular, N-Normal, Lr-Lumnitzera recemosa, P-Poor, SM-Sandy muddy, EH- Extreme, Fr- Fringing, Am-Avicennia marina, VP-Very poor, High tide, Br-Brackish, Rm-Rhizophora mucronata, SP-Seepage, CU-Commercial.

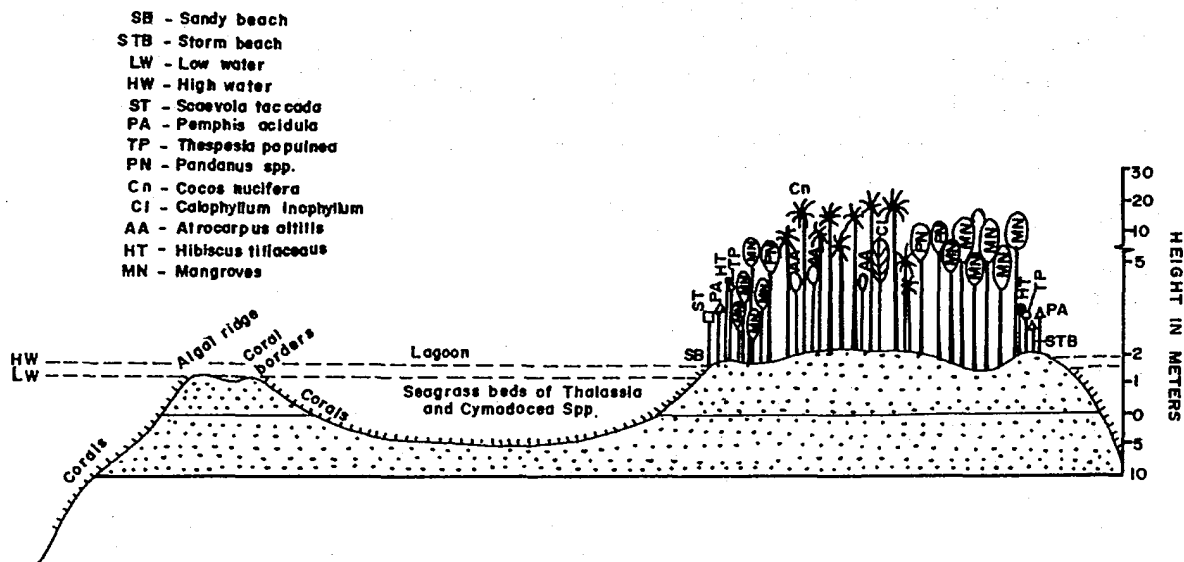


Figure 2 Schematic representation of the Island profile depicting major types of vegetation.

are of immediate concern from the possible sea level rise. Mangroves would be of considerable importance in providing stability to these islands, by enhancing sedimentation and avoiding erosion during adverse conditions. However, very little is known as regards the mangrove composition, extent and their status from these atolls.

Earlier (Fosberg, 1949, 1976; Hackett, 1971) stray reports of a few mangrove species have been made from Maldives. During the present investigations 12 species of mangroves were recorded from these atolls (Table 1). Islands of Shaviyani and Haa Dhaalu atolls, in the north, were represented by all the 12 species and the extent too was more, as compared to only three species and poor cover from Addu atoll, in the south. Male' atoll was totally devoid of mangroves, which could be attributed to large scale reclamation mainly, for urbanisation and tourism. Mangroves on the islands of Shaviyani and Haa Dhaalu atolls form pure stands of one or two species in the basins or shallow depressions, and mostly extends below the fluctuating water table (Fig. 2). Frequently the seawater enters and leaves through underground porous coralline debris. Mangroves were generally observed to grow

on hard substratum having large quantities of humus on the surface. Occasionally, few shrubs or trees of different mangrove species occur in the pure stands. In a few of the islands, like Funadhoo and Hithadhoo in the Shaviyani and Addu atolls, respectively, fringes of mainly, *Ceriops tagal* and *Rhizophora* spp. occur along the brackish water or lagoon shores.

The mangrove flora of the north was dominated by *B. cylindrica* and *C. tagal*, while *Rhizophora* spp. were dominant at Addu atoll in the south. However, *L. racemosa* was dominant at few islands of north and south atolls. Many of the islands in the north were represented by tall (height 7-20 m) thickets of *B. cylindrica* with average density of 7-10 trees 100 sq. m⁻¹ with DBH ranging from 3 - 15 cms, respectively (Table 2). The seedling establishment was higher in *B. cylindrica* and *C. tagal* and densities varied from 20-40 sq. m⁻¹ (Table 2). *Avicennia marina*, was restricted only to Keylakunu island in the north and mixed with stray *B. cylindrica* plants. Stray and tall (20-30 m) trees of *Sonneratia caseolaris*, occurred towards the land in the thickets of *B. cylindrica* and *L. racemosa*. *Acrostichum aureum*, *Excoecaria agallocha* and *Derris*

heterophylla, were common to most of the islands in the north. General distribution pattern of mangroves from these atoll, revealed that, *Bruguiera* spp. and *A. marina*, occurred in the depression which get regularly flushed with mean (0.7 m) tide. *Ceriops tagal* and *L. racemosa*, grew in the supratidal landward regions (salt encrusted) of high salinities. Intertidal zones under daily inundations harboured *Sonneratia caseolaris*, *E. agallocha* and *A. aureum*, which grew landwards mixed with terrestrial flora (Fig. 2), indicating their preference for lower salinity.

Islands of Maldives atolls on Chagos Laccadive archipelago are relatively older formations than those of Lakshdweep islands which are of very recent origin and emerging (Ahmad, 1972). The pattern of mangrove formations from Lakshdweep (Untawale, and Jagtap, 1984; Jagtap, Chavan and Untawale, 1993) and Maldives group of islands were compared and found to be very similar. However, mangroves in Lakshdweep have been established recently and are still in the process of genesis; they are limited to the southernmost (Minicoy) islands, in a very small patch (Untawale and Jagtap, 1984). Seedlings might probably be transported from the northernmost Haa Dhaalu islands of the Maldives to the Minicoy island of Lakshdweep, which are at a distance of ca 110 km. The mangroves at Minicoy are dominated by *Bruguiera cylindrica* and stray plants of *C. tagal* and *A. marina*. Number of species reported during present investigations commonly occur in the countries bordering the Arabian Sea (Untawale, Wafar and Jagtap, 1992). The surface current pattern (US Navy, 1976) and the similarity in the floral constituents, suggest close proximity of Maldives atolls to the coasts of Sri Lanka, India, Gulf countries, as regards the transport of early seedlings of mangroves.

Other coastal flora, above high tide level, was dominated by *Pemphis acidula*, and *Scaevola taccada* growing on coral debris and sand mixed with clay and humus (Table 1 and 2). The same species occur in a few islands of Lakshadweep

above highest high tide level, though growing to a lesser, extent. Sand dunes were dominated by *Ipomea pes-caprae*, *I. macrantha* and *Sesuvium portulacastrum*. *Pemphis acidula* was commonly observed to be pioneer on newly formed rocky islands. Associated mangroves like *Thespesia populnea* and *Hibiscus tiliaceus*, commonly occurred in the landward mangroves. Seagrass beds were dense and extensive in the shallow (0-4 m) sandy lagoons at Addu atoll. *Thalassia hemprichii* and *Cymodocea rotundata*, dominated the seagrass flora, while *Thalassodendron ciliatum*, was rarely observed beyond 2.5 m depth. The seagrass ecosystem from Addu atoll was more prominent than the mangrove ecosystem, as in Lakshdweep and Seychelles groups of islands (Untawale and Jagtap, 1984; 1989; Jagtap, 1987; 1991). Manglicolous fungi, responsible for converting detritus into organic matter, was represented by 39 spp in the atoll mangroves and were dominated by *Dactylospora haliotrepha*, *Lineolata rhizophorae*, *Lophiostoma mangrovei*, *Massarina thalassiae* and *Verruculina enalia*.

Maldives, particularly in the north atolls, have luxuriant mangroves, however the islanders by and large are unaware of the importance of these ecosystem. *Bruguiera cylindrica* is exploited commercially for wood and fishing poles, and dense plantations of this species has been practised for ages. Tender propagules of *Bruguiera* spp. and *C. tagal*, are consumed as vegetable after drying. Many of the islands, particularly from Male' atoll, have been totally reclaimed of mangroves, mainly for urbanisation and tourism developments. Reclamation has resulted in severe erosion at many of the islands, however, it is more prominent in Haa Dhaalu island in the north. These atolls which are emerging and unstable are likely to suffer immediate impacts from adverse conditions of the sea. Therefore, natural flora such as mangroves, seagrass meadows, sand-dunes flora forms an asset of the country from the ecological point of views. Mangroves of poorly inhabited and uninhabited islands are still in their pristine glory which need to be protected and conserved immediately. Brackish and shallow

water regions at Funadhoo, Kulhudhoofushu and Hithadhoo islands of Shaviyani, Haadhaloo and Addu atolls, respectively, have a great potential for the development of mangrove nurseries, afforestation and aquaculture.

Acknowledgements

Authors are grateful to Director, National Institute of Oceanography (C.S.I.R.), Dona Paula, Goa, India, for facilities and encouragement. Thanks are also due to, the Ministry of External Affairs, Govt. of India and Govt. of Maldives, for fundings.

References

- Ahmad, E. 1972. *Coastal Geomorphology of India*, Sangam Press, Poona, pp. x-222.
- Anon, 1976. *Marine Climatic Atlas of the World*, NAVAIR 50 - IC - 530, Vol. III, Pub. Director of the Commander Naval Weather Service Command, US Govt. Printing Office, Washington, DC.
- Chinnaraj, S. 1993. Manglicolous fungi from Maldives atolls, Indian Ocean, *Ind. J. Mar. Science*, 22: 141 - 142.
- Fosberg, F.R. 1949. Atoll vegetation and salinity. *Pacific Sci.*, 3 : 89 - 92.
- Fosberg, F.R. 1976. Coral Island vegetation In : O. A. Jones and R. Endeane (Editors) *Biology and Geology of Coral Reefs*, Academic Press, N. Y. Vol. III; Biol., 2: 256-279.
- Hackett, H. E. 1977. Marine algae known from Maldives island. *Atoll Res. Bull.*, No. 210.
- Hoffman, J.S. Keys, D. and Titus, J.G. 1983. *Projecting Future Sea Level Rise, Methodology, Estimates to the year 2100, and Research Needs*, US Environmental Protection Agency, Washington, USA.
- Jagtap, T.G. 1985. Studies on littoral flora of Andaman islands. In : V. Krishnamurty (Editor), *Marine Plants, their biology, chemistry and utilisation, Proc. All India Symp. Marine plants*, pp.45 - 50.
- Jagtap, T.G. 1987. Distribution of algae, seagrasses and coral communities from Lakshdweep islands, eastern Arabian sea. *Ind. J. Mar. Sci.*, 10: 402-404.
- Jagtap, T.G. 1991. Distribution of seagrasses along the Indian coast. *Aquatic Bot.*, 40: 379 - 386.
- Jagtap, T.G. 1992. Marine flora of Nicobar group of islands, Andaman sea. *Ind. J. Mar. Sci.*, 22: 56 - 58.
- Jagtap, T.G.; Chavan, V.S. and Untawale, A.G. 1993. Mangrove Ecosystems of India: A need for protection. *Ambio*, 22: 252-254
- Odum, W.E. and Heald, E.J. 1972. Tropic analysis of an estuarine mangrove community. *Bull. Mar. Sci.*, 22: 671 - 738.
- Rodin, L.E.; Barilevich, N.I. and Rozov, N.N. 1975. Productivity of the world's main ecosystem. *Natn. Acad. Sci.*, Washington.
- Stoddart, D.R. 1976. Coral reefs of the Indian Ocean. In : O.A. Jones & R. Endeane (Editors) *Biology and Geology of Coral reefs* Vol. 1 : Geology 1 : 51 - 92. Academic Press, N.Y.
- Untawale, A.G. and Jagtap, T.G. 1984. Marine macrophytes of Minicoy (Lakshdweep) coral atoll of the Arabian sea. *Aquat. Bot.*, 19: 97 - 103.
- Untawale, A.G. and Jagtap, T.G. 1989. Observation on marine macrophytes of Republic of Seychelles. *Bot. Mar.*, 32: 115 - 119.

Untawale, A.G. and Jagtap, T.G. 1991. Floristic composition of the deltaic regions of India. *Memoirs Geol. Soc., India* 22: 243 - 263.

University of Malaya and UNESCO. 1984. *Proc. As. Symp. Mangr. Env. Res. & Manag.* (Eds.

E. Ssoepadmo, A.N. Rao and D.J. Macintosh), organised by Univ. Malaya and UNESCO, Kuala Lumpur, 25 - 29 Aug. 1980, pp. i-828.