

COASTAL AND MARINE PLANT DIVERSITY OF ANDAMAN AND NICOBAR ISLANDS

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ABSTRACT

The vegetation in Andaman and Nicobar Islands has immense potential both in terms of ecology and economy. The coastal vegetation plays a major role in maintaining the ecology of the coastal zone. The analysis of plant diversity in the islands revealed the presence of about 3552 species forming 76.5% of estimated species. Angiospermic flora constitute about 2000 species of which 80% are indigenous. The endemism in Angiosperms is about 14%. The flora in general has affinities to the Indo-Malayan region.

Littoral beach forests include about 400 species of trees, shrubs, herbs and climbers forming impenetrable thickets along the shore. The broad natural zonation is often disturbed by human activities in populated islands. The out-post species of the littoral forest include *Ipomoea pes-caprae*, *Vigna marina*, *Scaevola sericea*, *Vitex trifolia* etc. The inner littoral species are *Hernandia peltata*, the giant *Manilkara littoralis*, the massive *Calophyllum inophyllum* etc. Among the species thriving in the coastal zone about 100 species have economic value and are subjected to human pressure. Important coastal plant species, about 76 in number and their economic utility are given. Of these coastal plant species 7 are endemic while 60 species are common. There are 14 rare species and 2 species namely *Neisosperma oppositifolium* and *Xylocarpus moluccensis* are threatened with exploitation.

Tidal swamp forests in the islands are constituted by about 30 species. Large scale exploitation of germplasm i.e. seeds, fruits and associated macrofungi may endanger the natural regeneration capacity of these species.

The most important component of coastal vegetation is the occurrence of fringing mangroves in several islands. Occupying about 11.6% of the total geographical area, the mangroves of Andaman and Nicobar Islands are the third largest in India after Sunderbans and Gujarat on the mainland. There are about 50 species of mangroves, semi-mangroves and associate mangroves occurring in these mangrove forests. There has been a decrease in mangrove forests, which were cleared for human settlement, and for plantation of red oil palm in Little Andaman, besides extraction of timber and fuel wood. Between the years 1981-82 and 1984-85 a total of 73668 m³ of wood was extracted from mangroves for charcoal. This and other exploitative activities have reduced the mangrove cover from 1826 sq. km. in 1957 to 966

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sq. km. in 1998. The latest satellite figure is, however, to be verified by ground data. But some of the management practices such as cessation of wood extraction from mangroves, the process of regeneration in some areas and declaration of Wild Life Sanctuaries. National Parks have prevented mangroves from further degradation. The mangroves in the islands are still in a better condition than those on the mainland. The National Committee on Mangroves and Coral Reefs had recommended a Management Plan for the mangroves of North Andaman islands.

The marine algae and sea grasses were dealt in other reports of the project and hence those aspects which were not covered in them are dealt in this report. For the first time, through the efforts of this project, the species diversity of seaweeds and their utility have been projected. About 65.3% of the estimated algal diversity has been enumerated up to species level. But there are still gaps in our knowledge on their spatial distribution. Coralline algae are the least known group. Altogether 16 species of crustose corallines and 8 species of articulated corallines are known to occur in the islands. However, more studies are needed with reference to this group and capacity-building in taxonomy is essential. Mariculture potential of the islands was stressed by several committees but so far no attempt was made to start the culture of seaweeds. A pilot phase programme for the culture of seaweeds for sustainable coastal livelihood may form an important component of the full project.

INTRODUCTION

The Andaman and Nicobar Islands constitute a distinct island biogeographic zone characterized by rich heritage of biological wealth. The biodiversity profile encompasses over 6,500 species of fauna and 2,000 indigenous and non-indigenous vascular plant species and many non-vascular elements. Among the angiosperm species, about 14% are endemic to the Andaman and Nicobar Islands, while 40% of non-endemic species are not found in mainland India but occur in South East Asian countries including Myanmar, Thailand, Malaya and Sumatra. Of the total angiosperm species known from the islands 26% are common to both the Andaman and Nicobar islands, 47% occur in Andamans and the rest in Nicobars. Among these as many as 500 species are/or might be of economic value viz. about 40 commercially exploited species for plywood, saw mill, match and pencil industries,

15 mangrove species for fuel wood, 10 species for boat and canoe making, 15 species for construction and furniture making, 7 species for making artifacts, 20 species as a source of food and derivatives, 50 species (inclusive of orchids) of ornamental value, 14 species for wild edible fruits and several species of medicinal value (Rao 1999). They also include many species yielding minor forest produce such as fibres, gums, tannins, stimulants, vanilla, rotenone, alcohol etc. Plant taxonomic diversity of the islands is given in Table 1. A total of about 3552 species belonging to different groups were recorded from the islands. The indigenous elements (80%) in angiosperms are very conspicuous.

FLORISTIC DIVERSITY

The insular nature of the territory, and physical isolation between the islands and also from the neighbouring mainlands through millions of years have resulted in the evolution

Table 1. Plant Diversity of A & N Islands

Group	No. of Species	
	Recorded	Estimated
1. Angiosperms		
Indigenous	1,600 (appr.)	1,700
Non-indigenous	400 (appr.)	600
2. Algae: Fresh water	587	850
Marine	196	300
Mosses	66	90
Liverworts	53	100
Lichens	307	500
Ferns	183	200
3. Gymnosperms	5	5
4. Fungi (micro & macro)	155	300

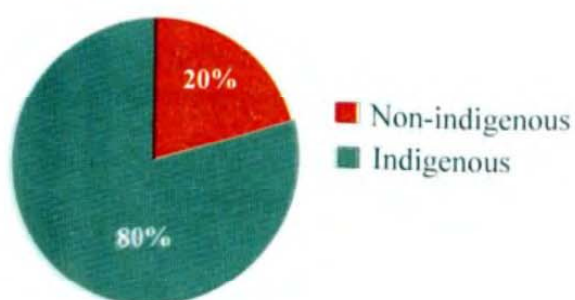


Fig. 1a
Indigenous & Non-indigenous
Angiospermic Flora in A & N Islands

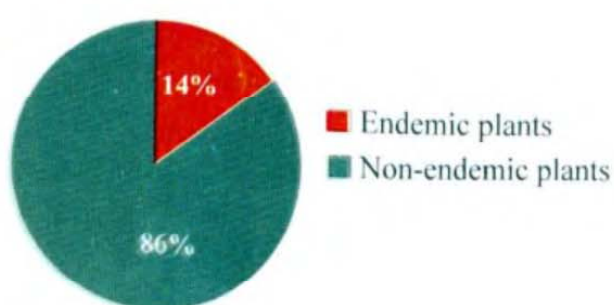


Fig. 1b
Endemism in Angiospermic Flora of
A & N Islands

of a rare and distinct flora, which though related to the mainland Indian flora, shows much closer affinity with the Myanmar, Malaysian and Indonesian floras. That is, the taxa of the Andaman islands show general affinities towards South-East Asia and India proper while those of the Nicobar islands have an affinity towards Malaysia.

The nearshore vegetation in the islands was studied by several authors, some of them as a part of general floristic studies and some with specific reference to coastal plant diversity. Some of the recent contributions were by Balakrishnan (1989), Dagar (1987), Dagar *et al.* (1991), Ellis (1987), Mall *et al.* (1985), Rajagopalan (1987), Sahni (1953, 1957), Srinivasan (1960) and Thothathri (1960, 1962).

The vegetation of the Andaman and Nicobar Islands is broadly classified as tropical evergreen. Balakrishnan (1989) while dealing with the insular flora and floristics has distinguished the vegetation into two types as littoral and inland forests based on the proximity to the sea and salinity of the soil.

- Littoral :
1. Littoral Beach forests
 2. Tidal and Swamp forests
 3. Mangrove forests
 4. Submerged vegetation
(Seaweeds and Seagrasses).

- Inland :
1. Evergreen forests
 2. Deciduous forests
 3. Grasslands
 4. Hydrophytic vegetation.

The coastal plant communities constituting the littoral forests of these oceanic islands are sometimes broadly divided into **Dry Coastal**

Plant Communities and **Wet Coastal Plant Communities**. The former includes both coastal and strand vegetation which are different from those of continental coastal communities while the latter includes Mangroves, Seagrasses and Seaweeds all of which are known to be luxuriant and abundant as compared to those of continental coastal communities. Although the dry coastal plant communities are divided into littoral beach forests and strand vegetation, the latter one is treated under the former as they are of less importance in the Bay islands. The continental shelf is narrow but it is compensated by the formation of numerous bays, lagoons, creeks, canals, and the indented coast facilitating the occurrence of various plant communities depending on the topography of the coast.

LITTORAL BEACH FORESTS

The beaches are fringed with luxuriant growth and remarkable variety of trees, shrubs and climbers. The insular climate and long coast-line have profound influence on the littoral vegetation (Table 2). The littoral beach forests are influenced by, but out of reach of the sea, occupying flat strips of land along the coast varying from a few to several meters in width together with the strand vegetation which constitutes the dry coastal communities.

Floristic composition : The herbaceous species occupying the foreground on the sandy beaches appear to be monotonously uniform and uninteresting but when these widely distributed species are closely examined they are found to be quite variable. Strewn on the ground above the sandy beaches we often find a twining growth of *Ipomoea pes-caprae*, goat-foot-creeper with lobed leaves and large purple flowers, *Vigna marina* with yellow flowers like those of the pea and the delicate

Table 2. List of Important Coastal Plant Species

C Common; E : Endemic; R : Rare; T : Threatened;			
Species	Life form	Status	
1	2	3	
ACANTHACEAE			
1. <i>Acanthus ebracteatus</i> Vahl	Shrub	C	
2. <i>A. ilicifolius</i> A. Gray	Shrub	C	
AMARYLLIDACEAE			
3. <i>Crinum asiaticum</i> L.	Shrub	C	
APOCYNACEAE			
4. <i>Cerbera manghas</i> L.(<i>C. odallum</i> Gaertn.)	Tree	C	
5. <i>Neisosperma oppositifolium</i> (Lam.) Fosb. & Sach	Tree	T	
ARECACEAE			
6. <i>Licuala peltata</i> Roxb.	Shrub	C	
7. <i>L. spinosa</i> Wurm.	Shrub	R	
8. <i>Phoenix paludosa</i> Roxb.	Tree	C	
BIGNONIACEAE			
9. <i>Dolichandrone spathacea</i> (L.f.) K. Sch.	Tree	C	
BORAGINACEAE			
10. <i>Cordia subcordata</i> Lam.	Tree	C	
11. <i>Tournefortia argentea</i> L.	Tree	C	
12. <i>T. ovata</i> Wall. Ex. G. Don.	Weak climber	C	
BURSEF ACEAE			
13. <i>Ganophyllum falcatum</i> Bl.	Tree	R	
CAESALPINIACEAE			
14. <i>Caesalpinia bonduc</i> (L.) Roxb. Emend Dandy & Exell [<i>C. bonducella</i> (L.) Fleming]	Climbing shrub	C	
15. <i>C. crista</i> L.[<i>C. nuga</i> (L.) Ait.]	Climbing shrub	C	
16. <i>Cynometra iripa</i> Kosterm. (<i>C. ramiflora</i> L.)	Tree	C	
17. <i>Intsia bijuga</i> (Coleb.) O.K. (<i>Afzelia bijuga</i> A. Gray)	Tree	C	

1	2	3
18. <i>Peltophorum pterocarpum</i> (D.C.) Back. (<i>P. ferrugineum</i> A. Gray)	Tree	C
CASUARINACEAE		
19. <i>Casuarina equisetifolia</i> J. R. & G. Forst.	Tree	C
CELASTRACEAE		
20. <i>Glyptopetalum calocarpum</i> Prain	Tree	R,E
21. <i>Salacia chinensis</i> (L.)	Scandent Shrub	R
22. <i>S. latifolia</i> Wall.	Scandent Shrub	R
CLUSIACEAE		
23. <i>Calophyllum inophyllum</i> L.	Tree	C
CONVOLVULACEAE		
24. <i>Ipomoea pes-caprae</i> (L.) R. Br.	Creeper	C
25. <i>I. macrantha</i> R. & S.	Creeper	C
COMBRETACEAE		
26. <i>Gyrocarpus americanus</i> Jacq.	Tree	C
27. <i>Terminalia catappa</i> L.	Tree	C
CYCADACEAE		
28. <i>Cycas rumphii</i> Miq.	Tree	C
CYPERACEAE		
29. <i>Cyperus javanicus</i> Houtt.	Herb	C
30. <i>Fimbristylis cymosa</i> R. Br.	Herb	C
DATISCAEAE		
31. <i>Tetrameles nodiflora</i> R. Br. ex Benn.	Tree	C
FABACEAE		
32. <i>Canavalia cathartica</i> Thou.	Climber	C
33. <i>Clitoria ternatea</i> L.	Herb	C
34. <i>Dalbergia monosperma</i> Dalz	Scandent Shrub	C
35. <i>Dendrolobium umbellatum</i> (L.) Benth.	Shrub or tree	C
36. <i>Derris andamanica</i> Prain	Scandent Shrub	C
37. <i>Erythrina variegata</i> L. (<i>E. indica</i> L.)	Tree	C
38. <i>Mucuna gigantea</i> DC.	Climber	C

1	2	3
39. <i>Pongamia pinnata</i> (L.) Pierre	Tree	C
40. <i>Sophora tomentosa</i> (L.)	Tree	C
41. <i>Vigna marina</i> (Burm.) Merr.	Herb	C
GOODENIACEAE		
42. <i>Scaevola sericea</i> Vahl (<i>S. taccada</i> Roxb.)	Shrub	C
HERNANDIACEAE		
43. <i>Hernandia peltata</i> Meissn.	Tree	C
LAURACEAE		
44. <i>Cassytha filiformis</i> L.	Climber	C
LECYTHIDACEAE		
45. <i>Barringtonia speciosa</i> Forst.	Tree	C
LYTHRACEAE		
46. <i>Pemphis acidula</i> J.R. & G. Forst	Shrubby tree	C
MALVACEAE		
47. <i>Hibiscus tiliaceus</i> L.	Tree	C
48. <i>Thespesia populnea</i> Correa	Tree	C
MELIACEAE		
49. <i>Xylocarpus moluccensis</i> (Lam.) Roem.	Tree	T
MEMECYLACEAE		
50. <i>Memecylon pauciflorum</i> Bl.	Shrubby tree	C
MYRSINACEAE		
51. <i>Ardisia humilis</i> Vahl	Tree	C
NYCTAGINACEAE		
52. <i>Pisonia aculeata</i> L.	Shrub	C
OCHNACEAE		
53. <i>Ochna integerrima</i> (Lour.) Merr.	Tree	R
OLACACEAE		
54. <i>Ximenia americana</i> Willd.	Tree	R
PANDANACEAE		
55. <i>Pandanus andamanensis</i> Kurz	Tree	C, E

1	2	3
56. <i>P. leram</i> Jones	Tree	C, E
57. <i>P. tectorius</i> Soland.	Tree	C
RHAMNACEAE		
58. <i>Colubrina asiatica</i> (L.) Brongn.	Shrubby tree	C
59. <i>Smythea calpicarpa</i> Kurz	Straggling shrub	R
RUBIACEAE		
60. <i>Guettarda speciosa</i> L.	Tree	C
61. <i>Hydnophytum formicarum</i> Jack.	Epiphytic shrub	C
62. <i>Ixora brunnescens</i> Kurz	Tree	R, E
63. <i>Morinda citrifolia</i> var. <i>bracteata</i> (Roxb.) Hk. F.	Tree	C
SAPINDACEAE		
64. <i>Arytera littoralis</i> Bl.	Tree	R
65. <i>Cardiospermum helicacabum</i> L.	Climber	C
66. <i>Dodonea viscosa</i> L.	Shrub	R
67. <i>Lapisanthus senegalensis</i> (Poir.) Leenh.	Shrub	R
SAPOTACEAE		
68. <i>Manilkara littoralis</i> (Kurz) Dub. (<i>Mimusops littoralis</i> Kurz)	Tree	C
STERCULIACEAE		
69. <i>Firmiana colorata</i> (Roxb.) R. Br.	Tree	C
70. <i>Heritiera littoralis</i> Dryand. ex W. Alt.	Tree	C
71. <i>Sterculia rubiginosa</i> Vent. var.	Tree	C, E
TACCACEAE		
72. <i>Tacca leontopetaloides</i> (L.) O.K.	Herb	R
URTICACEAE		
73. <i>Pipturus argenteus</i> (Forst. F.) Wedd	Tree	R
VERBENACEAE		
74. <i>Clerodendrum inerme</i> (L.) Gaertn.	Straggling shrub	R
75. <i>Premna integrifolia</i> L.	Small tree/shrub	C
76. <i>Vitex trifolia</i> L.	Shrub	C

Clitoria ternatea with spoon-shaped deep blue and white flowers. *Ipomoea macrantha*, *Fimbristylis cymosa*, *Cyperus javanicus*, *Cassytha filiformis* etc. are also reported from some islands. *Phyla nodiflora* is another species commonly found among the creepers.

Lining the top of the beach and often reached by the waves, innumerable shrubs sometimes of pure patches are seen. *Scaevola sericea* with fleshy leaves and fan-shaped one-sided flowers, and which, on account of its light green foliage is easily spotted even from a long distance out at sea. Behind the dense growth of *S. sericea* are other shrubs such as *Ximenia americana*, *Hibiscus tiliaceus*, *Colubrina asiatica*, *Caesalpinia crista*, *C. bonduc*, *Canavalia cathartica*, *Dendrolobium umbellatum*, *Crinum asiaticum* etc. *Mucuna gigantea*, a climber with hanging pods is also commonly found.

Frequent along the seashore and found growing at the water's edge together with *Calophyllum inophyllum* is *Barringtonia speciosa*, a tree species (The Queen of the Seashores) which is conspicuous with large delicate pink flowers that look like powder-puffs. Associated species are *Guettarda speciosa*, *Pongamia pinnata* and shrubs like *Pemphis acidula*, *Messerschmidia argentea* and *Vitex trifolia*. Most common are the populations of *Pandanus lerram*, *P. andamanensium* and *P. tectorius* with their characteristic fruits. Owing to magnificent growth of *Pandanus* spp. these formations are often referred to as the 'Pandanus forests'. Other small and large trees behind the fringe of shrubs growth, and broken here and there, are *Thespesia populnea*, *Guettarda speciosa*, *Ixora brunnescens*, *Cycas rumphii*, *Neisosperma oppositifolium*, *Hernandia peltata*, *Erythrina* sp, *Heritiera*

littoralis, *Cordia subcordata* etc.

Lastly, towering above these tree species are the giants of the seashore, *Manilkara littoralis* with its deeply cracked stem and dense shady crown. *Calophyllum inophyllum* with beautiful veined leaves and delightfully fragrant flowers, *Gyrocarpus americanus*, and *Terminalia catappa* together with the species mentioned earlier comprise the littoral forest which confines itself to the zone immediately bordering the sea. Some islands, however, are known to have the species like *Intsia bizuga*, *Syzygium samarangense*, *Sophora tomentosa* and *Glochidion calocarpum*. Associated with such tree flora are *Ischaemum muticum*, *Acalypha indica*, *Euphorbia hirta*, *Centotheca lappacea*, *Ophiorrhiza mungos*, *Aerva lanata* and *Cyperus kyllinga*. Climbers found on the tree trunks are *Dischidia* ssp., *Pothos scandens* and *Hoya* species. Epiphytic orchids like *Dendrobium crumenatum*, *D. anceps*, *Luisia teretifolia*, *Bulbophyllum lepidum*, *Cymbidium aloifolium*, *Eria andamanica* and ferns like *Polypodium phymatodes* and *Drynaria quercifolia* are also commonly found. Epiphytic ferns like *Asplenium nidus*, *Phymatosorus scolopendria* and *Pyrrosia longifolia* are common on littoral trees, while *Vittaria elongata* occurs on mangrove plants (Ellis 1987). The ground layer is occupied by *Oplismenus compositus*, *Ophiorrhiza mungos* etc. *Mucuna gigantea* is a shrubby climber covering the trees completely. The disturbed areas are occupied by *Caesalpinia bonduc*.

Non-Extractive values : The coastal forests, although rich in species diversity and luxuriance are always under tremendous human pressure world over and those of Andaman and

Nicobar Islands are no exception to this dictum. The ecological role that they are naturally assigned is not measurable in terms of revenue. Every taxon has a role of its own and the cumulative effect of several taxa, be it a herb or shrub or tree, gets disturbed even if a single taxon is lost due to climatic change or human interference. The strand vegetation of the Bay islands replete with innumerable plant species occupying the interphase between the inland vegetation and marine ecosystem, therefore, plays an important role in soil conservation.

Several herbaceous plants such as *Ipomoea pes-caprae*, *Vigna marina*, *Phyla nodiflora* etc. play an important role in sand binding by creeping over the drift zone to the dike behind the reach of waves which area is often called 'zone of pes-caprae'. The dense growth of various shrubs such as *Scaevola sericea*, *Crinum asiaticum*, *Caesalpinia crista*, *Desmodium umbellatum* etc. behind the 'pes-caprae' formation minimises the erosion of sand as a second line of defence against the swelling tides. The woody elements next to shrubby growth are mostly represented by *Manilkara littoralis*, *Pandanus* spp., *Cordia subcordata*, *Hernandia peltata*, *Pemphis acidula*, *Calophyllum inophyllum*, *Barringtonia speciosa*, *Heritiera littoralis*, *Hibiscus tiliaceus*, *Thespesia populnea*, *Terminalia catappa*, *Gyrocarpus americanus* etc. These form almost impenetrable thickets around the islands serving as wind breakers during cyclonic weather and conserving the soil during high tide. *Manilkara littoralis* occupying the level lands just above the beach sometimes forms more or less pure forest known as 'Mohwa forest'. Likewise, the *Pandanus* spp. too form the 'fringe belts' just above high water mark, which are called 'Pandanus forests' in many islands. Further, the tree species in the strand vegetation

supporting innumerable epiphytic flora on the trunks and herbaceous flora such as *Ischaemum muticum*, *Acalypha indica*, *Euphorbia hirta*, *Centothea lappacea*, *Aerva lanata*, *Cyperus kyllinga* etc. on the ground add to the plant diversity while playing a protective role in the coastal ecosystem. Besides, the coastal forests as a whole protect the hinterland against the tidal surge.

Extractive values : Various littoral plant species are exploited for a variety of purposes in the Bay islands ever since the settlements have taken place. While some are made use of for sustenance, the others are exploited for economic returns on a commercial scale (Table 3).

Natural & human induced threats : The wild insular species are generally characterised by a small gene pool, reduced interspecific competition, inbreeding and small population size by virtue of which they become more vulnerable to habitat destruction. As many wild plants are exploited for food, fuel, medicines, clothing and shelter by settlers and tribes there have been significant changes in their composition during the last few decades. People who would like to exploit the plant resources encourage forest extractions. On the other hand, there has been a lot of apprehension among many that the unique and fragile island ecosystem would be irreversibly degraded by these anthropogenic and allied developmental activities resulting in the shrinkage of resource base. Because of this concern, of late, a genuine need has been felt by the policy makers for an objective and integrated approach for protecting these beautiful islands on a holistic level rather than sectoral. An environmentally sound strategy hinges on judicious and sustainable utilization of the forest wealth. Various developmental

Table 3. Extractive Values of some Coastal Plants

Species 1	Plant part 2	Uses 3
<i>Manilkara littoralis</i>	Roots	Ornamental pieces
	Wood	Girders and posts
	Flowers	Eaten by Andamanese
<i>Pandanus</i> spp	Fruits	Staple food for the tribes
	Leaves	Thatching, mat making, garland making by the tribes and other artifacts
<i>Dinochloa andamanica</i>	Cane	Cane furniture, earrings by tribes
<i>Morinda citrifolia</i>	Tender leaves	Supplementary food for some settlers, tribes
<i>Calophyllum inophyllum</i>	Hard wood	Boat building, house posts & beams, masts and sports
<i>Neisosperma oppositifolium</i>	Fruits	Extensively collected by felling the trees and transported to mainland
<i>Hernandia peltata</i>	Fruits	As above
<i>Cycas rumphii</i>	Leaves	Cooked and eaten by settlers & tribes
	Fruits	Eaten, large quantities exported to mainland
<i>Barringtonia asiatica</i>	Nuts	As fish-poison by the tribes
<i>Tetrameles nudiflora</i>	Trunk	For making dugout canoes by the Andamanese tribe
<i>Gyrocarpus americanus</i>	Wood	For making toys
<i>Tacca leontopetaloides</i>	Underground tubers	Edible, eaten by tribes
<i>Terminalia catappa</i>	Bark	For tannin extraction
	Nuts	Kernels edible
<i>T. bialata</i>	Wood	Beautifully mottled wood for planking in house-building and for making oars and furniture

1	2	3
	Fruits	Kernels eaten
<i>Cardiospermum helicacabum</i>	Whole Plant	Collected on large scale by traders/middlemen for transporting to mainland. Said to be of medicinal value
<i>Caesalpinia bonduc</i>	Seeds	Pharmaceutical importance
<i>Cerbera odallum</i>	Fruit	Collected on a large scale for transporting to mainland, medicinal value
	Seeds	Oil used for burning
<i>Barringtonia recemosa</i>	Fruits	Used as fish-poison by the tribes
<i>Derris scandens</i>	Pods	Used as fish-poison
<i>Dolichandrone rheedii</i>	Young flowers and fruits	Eaten as vegetable by Myanmarese
<i>Xylöcarpus moluccensis</i>	Fruits	Exported to mainland by the traders for chemical extraction

activities undertaken in the isles involving both the major and minor forest produce are bound to result in ecological imbalances unless they are on sustainable basis and conservation oriented.

The threatening processes identified in the case of vegetation are both natural and man-made. Frequent cyclonic storms during South-West, May to October and North-East monsoons, November to December many a time have a devastating effect, uprooting several hundreds of trees each year. Even *Manilkara littoralis*, a woody element, so strong among the coastal communities also gets uprooted. Coupled with this, rampant sand mining and quarrying along the coastal belt pose a serious threat to 'Mohwa forests' in several islands such as Rutland, South Andaman and Little Andaman. Large scale felling of economically important tree species such as *Neisosperma oppositifolium*, *Calophyllum inophyllum* etc.

makes a dent in the otherwise impenetrable thickets making them an easy prey to cyclonic winds. Indiscriminate collection of the foliage of various coastal plants results in the thinning of canopy thereby allowing the rainwater splashing on the forest floor which in turn causes soil erosion. Various developmental and anthropogenic activities in the hinterland too accelerate the deterioration of coastal ecosystem owing to flooding of low-lying areas thereby affecting the vegetation. The dependence of settlers, and the tribes to some extent, on the forest resources for fuel wood is yet another factor contributing to the loss of vegetation.

Conservation measures for sustainable utilization : The tropical rain forests harbouring innumerable species with limited distributional range have been considered by environmentalists as one of the most complex terrestrial ecosystems in the world.

As the coastal forests are more prone to both biotic and abiotic threats as indicated earlier, they however, require rather more emphasis for sustainable utilization. To ease the increasing human pressure on the forest resources of the littoral habitats, following suggestions are made:

- Indiscriminate felling, and illegal timber extraction or logging from littoral forests should be checked by the local forest department to prevent species depletion and soil erosion, as well as to protect the islands from cyclones.
- Agroforestry, social forestry or fuelwood plantations initiated by the Forest department must be continued in unutilised areas to meet the fuel demands of the islanders.
- Tourism related activities which require additional timber should not endanger the luxuriance and species diversity of the coastal forests to any extent.
- Prior to induction of further settlement along the coastal belt, the carrying capacity of the island ecosystem should be evaluated.
- *In-situ* and *ex-situ* conservation of rare and threatened species should be taken up on priority basis.
- Introduction of aggressive exotic weeds, such as *Mikania cordata*, and *Chromolaena odorata* which overpower the natural flora should be stopped.
- Extraction of minor forest produce viz. underground tubers, tender leaves of *Cycas rumphii*, *Pandanus* fruits, leaves of *Licuala* spp, boles of *Tetrameles nodiflora* and *Calophyllum inophyllum* for boat building, canoe making, fruits and flowers of *Barringtonia* spp for fish-poisoning etc. from the coastal zone should be regulated.
- Growing the plants of tribal food value viz.

Tacca leontopetaloides, a native plant of sandy coasts on a large scale should be thought of by local Agriculture Department for sustainable utilization and conservation.

- Sand mining and quarrying from the vulnerable coastal habitats should be stopped to protect the Mohwa forests and the sand binding plants from the cyclonic storms.

TIDAL (SWAMP) FORESTS

These are closed evergreen forests of medium size trees which have adapted in various ways to thrive on tidal mud which is permanently wet with salt water and remain submerged during high tide. The swamps are sometimes secondary succession stages of the mangrove forest as they are often found along the landward fringes of mangroves. A peculiarity of the tidal forest trees is the occurrence of special root formations such as stilt roots supporting stem base, plank buttresses root formations and conically thickened stem bases of small erect aerial roots emerging from the mud. These help to improve the air supply to the root system or to support and project the trees against strong winds.

Floristic composition : Trees like *Cerbera odollam*, (Plate 1) *Heritiera littoralis* and *Barringtonia racemosa* are common in association with *Ficus retusa*, *Cynometra ramiflora*, *Scyphiphora hydrophyllacea*, *Excoecaria agallocha*, *Lumnitzera racemosa*, *Xylocarpus granatum*, *Sonneratia acida* and *Dolichandrone rheedii*. *Phoenix paludosa*, a slender erect palm is also common. *Caesalpinia crista*, *Derris scandens*, *D. heterophylla* and *Flagellaria indica* are common woody climbers and stragglers.

Sarcolobus carinatus, *Hoya parasitica* and *Dischidia bengalensis* are other climbers. Epiphytic orchids like *Dendrobium*, *Bulbophyllum*, *Eric* etc and fern species of *Drymoglossum*, *Lepisorus* and *Asplenium* grow on the tree trunks.

Almost all the plant species play an important role in soil conservation by lowering the pace of run-off water from the interiors, and offering an ideal habitat for numerous bird species. Various root adaptations facilitate soil conservation while keeping the habitat wet throughout.

Human interference & suggested conservation plans : Swamps are perhaps second most important wetlands after the mangroves in the Bay islands which seem to be vulnerable, of late, due to various anthropogenic activities such as forest extraction and laying of Andaman Trunk Road through Austin islands where extensive swamps are found. Any human pressure either on inland forests or mangroves is responsible for flooding and soil erosion of the swamps where the salinity of the soil is the determining factor for the floristic composition. The absence of an epiphytic herb *Hydnophytum formicarium* (in whose swollen irregular tuber-like stems ants make their dwellings) in these forests may be construed as one of the indications of degrading swamp forests. The conservation of swamps is, therefore, possible only when logging operations in the nearby forests are minimized and the construction of roads, bridges, jettys etc. are relocated away from the swamps and mangrove wetlands. Also the large scale collection of germplasm viz fruits, seeds and

flowers of important species by traders should be discouraged through legislation and awareness programmes.

MANGROVE FORESTS

Mangroves are a group of plant species which occur in the tropical and subtropical intertidal estuarine regions, sheltered coastlines and creeks. Mangroves constitute a dynamic ecosystem with a complex association of species of both flora and fauna of terrestrial and aquatic systems and the vegetation presents an evergreen type with varied life forms. Mangroves occur behind coral reef fronts or at the back of beach zones with cemented or non-cemented coral detritus. These are generally fringing in nature except in river flood plains where they penetrate deep into the inland areas. The best mangrove formations are seen where the tidal regime is normal with a constant mixing of sea water and fresh water and the minimum optimum temperature is around 20°C. Typical mangroves are plants which have partly reached the sea-estuarine interphase on stilts and props with adaptations like viviparous germination and pneumatophores for survival in the partly saline and partly submerged coastal ecosystem. The mangrove vegetation constitutes nearly 13% of the total forest cover that is about 1,000 sq. km. of the wood land in the islands.

Floristic composition : The popular name 'mangrove' is indiscriminately given to many kinds of trees found growing in swamps and along the seashore while only the species of RHIZOPHORA, BRUGUIERA, KANDELIA and CERIOPS belonging to the family

Table 4. List of Important Plant Species in Mangrove Forests

A : Abundant; C : Common; R : Rare; T : Threatened;			
Name	Life form	Status	Occurrence
1	2	3	4
ARECACEAE			
1. <i>Nypa fruticans</i> (Van.) Wurm.	Tree	C	Landward
2. <i>Phoenix paludosa</i> Roxb.	Tree	C	Landward
AVICENNIA CEAE			
3. <i>Avicennia marina</i> (Forsk.) Vierh.	Tree	C	Seaward
4. <i>A. officinalis</i> L.	Tree	C	Seaward
COMBRETACEAE			
5. <i>Lumnitzera littorea</i> (Jack.) Voigt.	Tree	R	Landward
6. <i>L. racemosa</i> Willd.	Tree	R	Landward
RHIZOPHORACEAE			
7. <i>Bruguiera gymnorhiza</i> (L.) Lamk.	Tree	C	Seaward
8. <i>B. parviflora</i> (Roxb.) Wt. & Arn. Ex Griff.	Tree	C	Landward
9. <i>Ceriops decandra</i> (Griff.) Ding Hou	Tree	R	Backwater
10. <i>C. tagal</i> (Perr.) Robin.	Tree	R	Backwater
11. <i>Kandelia candal</i> (L.) Druce	Shrub	C	Landward
12. <i>Rhizophora apiculata</i> Bl.	Tree	A	Seaward
13. <i>R. mucronata</i> Lamk.	Tree	A	Seaward
14. <i>R. stylosa</i> Griff.	Tree	R	Seaward
SONNERATIACEAE			
15. <i>Sonneratia alba</i> J. Sm.	Tree	C	Seaward
16. <i>S. caseolaris</i> (L.) Engl. (<i>S. acida</i> L.f.)	Tree	C	Seaward
SEMI MANGROVE SPECIES			
EUPHORBIACEAE			
17. <i>Excoecaria agallocha</i> L.	Tree	C	Landward

1	2	3	4
MELIACEAE			
18. <i>Xylocarpus moluccensis</i> (Lamk.) Roem.	Tree	T	Seaward, Landward
19. <i>X. granatum</i> Koen.	Tree	T	Seaward, Landward Creeks
MYRSINACEAE			
20. <i>Aegiceras corniculatum</i> (L.) Blanco	Tree	R	Backwater
PLUMBAGINACEAE			
21. <i>Aegialitis rotundifolia</i> Roxb.	Shrub	R	Middle
PTERIDACEAE			
22. <i>Acrostichum aureum</i> L.	Herb/fern	A	Landward
23. <i>A. speciosum</i> Wild.	Fern	C	Landward
RUBIACEAE			
24. <i>Scyphiphora hydrophyllacea</i> Gaertn.	Shrub	C	Middle
STERCULIACEAE			
25. <i>Heritiera littoralis</i> Dryand. Ex Ait.	Tree	C	Landward
ASSOCIATE MANGROVE SPECIES			
ACANTHACEAE			
26. <i>Acanthus ilicifolius</i> L.	Herb	C	Landward
27. <i>A. volubilis</i> Wall	Herb	C	Landward
APOCYNACEAE			
28. <i>Cerbera manghas</i> (L.)	Tree	C	By the side of creeks
ASCLEPIADACEAE			
29. <i>Finlaysonia obovata</i> Wall	Shrub	---	
30. <i>Sarcolobus carinatus</i> Wall	Scandant shrub	C	
31. <i>S. globosus</i> Wall	Scandant shrub	C	
ASTERACEAE			
32. <i>Pluchea indica</i> Less	Undershrub	C	Landward

1	2	3	4
BIGNONIACEAE			
33. <i>Dolichandrone spathacea</i> (L.f.) K. Sch.	Tree	C	
CAESALPINIACEAE			
34. <i>Caesalpinia bonduc</i> (L.) Roxb. emend. Dandy Exell	Climbing shrub	C	Landward
35. <i>Cynometra iripa</i> Kosterm.	Tree	C	Landward
36. <i>Intsia bijuga</i> (Coleb.) O.K.	Tree	C	Landward
CELASTRACEAE			
37. <i>Salacia chinensis</i> L.	Scandant Shrub	C	Landward
CYPERACEAE			
38. <i>Fimbristylis ferruginea</i> (L.) Vahl.	Herb	C	
FABACEAE			
39. <i>Derris trifoliata</i> Lour.	Climber	C	Landward
40. <i>Mucuna gigantea</i> (Willd.) DC..	Climber	C	Landward
LECYTHIDACEAE			
41. <i>Barringtonia racemosa</i> (L.)	Tree	C	Landward
MALVACEAE			
42. <i>Hibiscus tiliaceus</i> L.	Tree	C	Landward
43. <i>Thespesia populnea</i> Correa	Tree	C	Landward
MELIACEAE			
44. <i>Aglaia cucullata</i> Roxb.	Tree	C	Landward
PANDANACEAE			
45. <i>Pandanus odoratissimus</i> L.f.	Tree	C	Landward
TILIACEAE			
46. <i>Brownlowia tersa</i> (L.) Kosterm.	Shrub	R	
VERBENACEAE			
47. <i>Clerodendrum inerme</i> (L.) Gaertn.	Shrub	C	Along mangroves

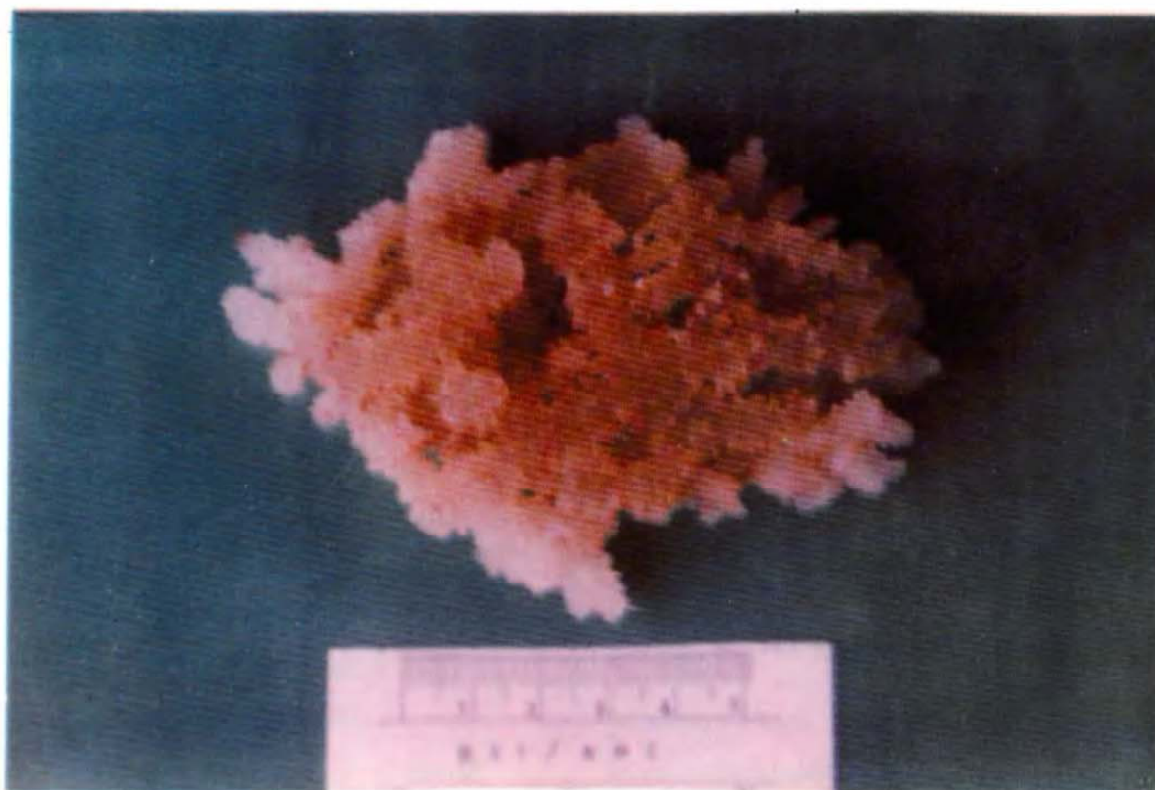


PLATE I

1. Confiscated and stored *Cerbera odallam* fruits at a Forest camp germinating after the rains
2. *Kappaphycus cottonii* – an economically important sea weed collected from the Andaman coast.

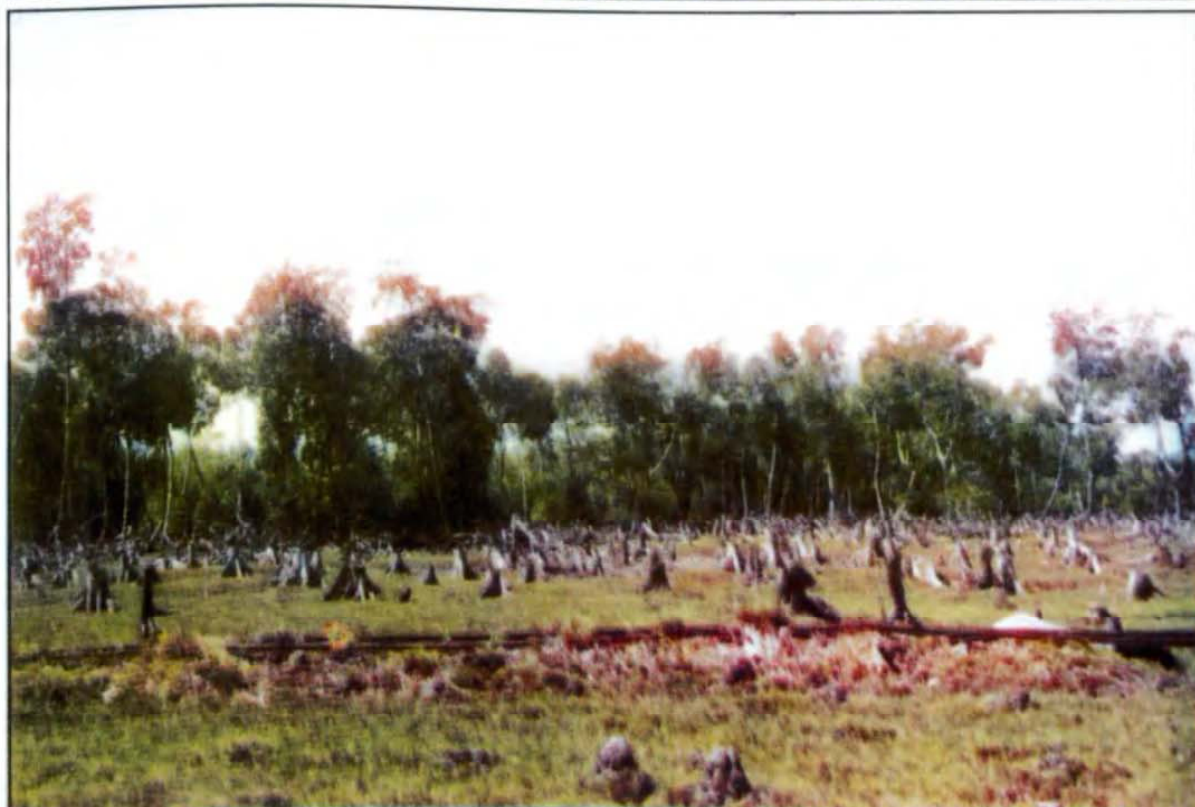


PLATE 2

1. Mangrove forests in Andaman islands
2. Degraded mangrove forests in Andaman islands.

Rhizophoraceae are the true mangroves. *Carallia brachiata* of the same family and the species of XYLOCARPUS, SONNERATIA, AVICENNIA, SCYPHIPHORA and others are treated as back mangroves or mangrove associates as they do not exhibit the characteristics of the true mangroves. A number of other species are also seen coming up in the mangrove degraded areas which are, however, ecologically important. Altogether, about 47 species inclusive of the species growing in degraded mangrove forest are recorded from the Bay islands (Table 4). *Rhizophora mucronata* and *R. apiculata* are considered as the most predominant of all while *Bruguiera gymnorhiza* is the largest of all the mangroves recorded from the Bay islands. The mangroves of Andaman & Nicobar islands are considered perhaps the best formations in the entire South Asia both in terms of diversity as well as luxuriance.

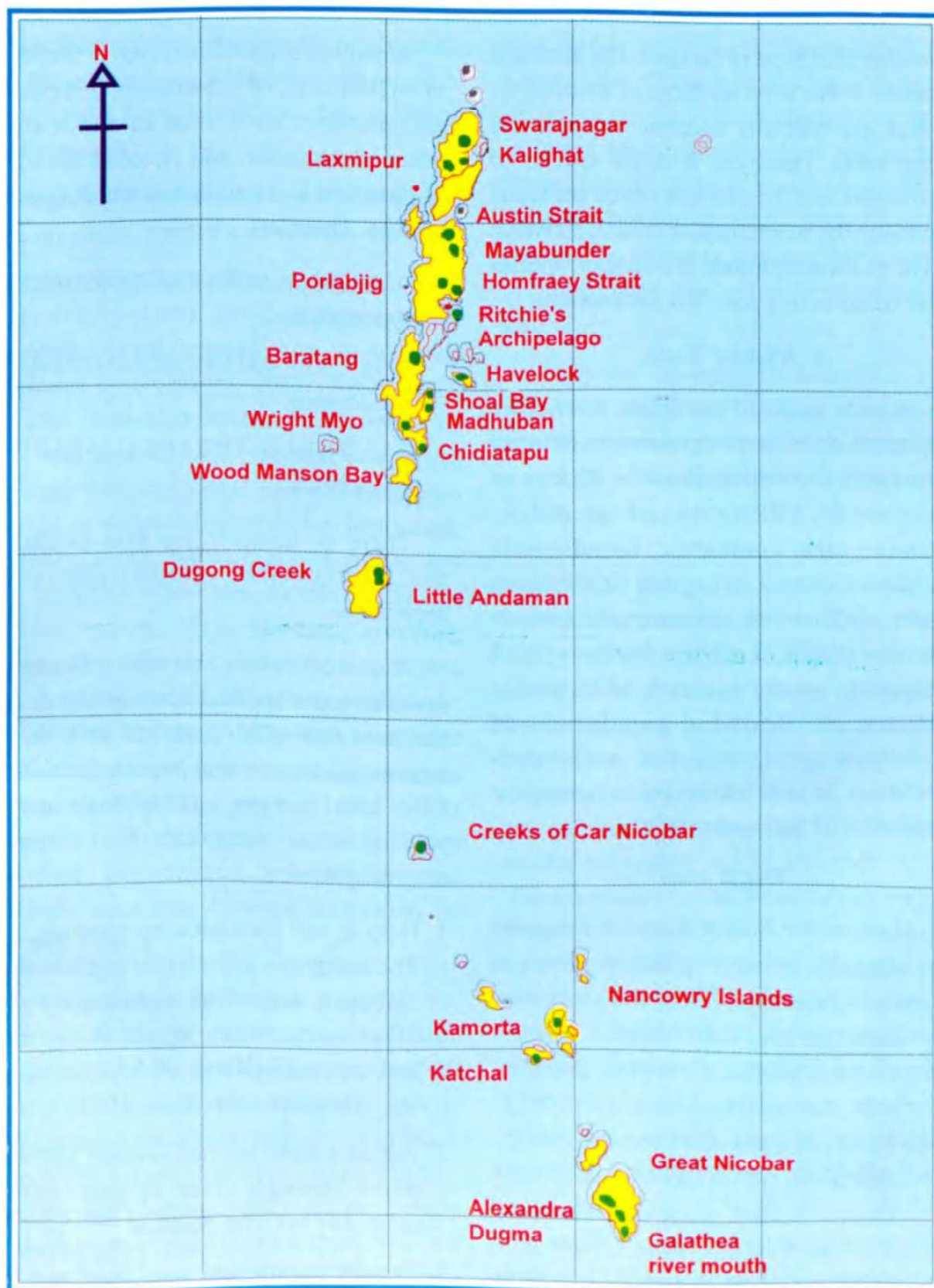
Mangrove rich areas : The irregular and deeply indented coastline of these islands resulting in innumerable creeks, bays and estuaries are characterised by excellent freshwater runoffs and large intertidal mud flats that facilitate the development of rich and extensive mangrove forests. These mangroves are seen coming up well in areas which are covered with brackish water during high tides, protected against heavy wave action and somewhat sheltered from high winds. Extensive mangrove forests (Plate 2) in Andaman group of islands are found in large areas in Austin, Strait, Ganesh nagar (North Andaman), Bomlungta and Charulungta (Middle Andaman), Baratang, Havelock and Wrafter creeks (South Andaman) and Little Andaman while moderate

growth of mangroves is observed in many other areas such as Wright Myo and Sippighat in South Andaman. *Rhizophora* spp. and *Bruguiera gymnorhiza* are known to attain a size of 50 cm in diameter and 50 m in height in some places like Baratang, Austin and Strait islands. The most common species are *Rhizophora mucronata*, *R. apiculata*, *Bruguiera gymnorhiza*, *B. parviflora* and *Ceripos tagal*. *Avicennia marina* is frequent forming small patches. Some of the less common species are *Lumnitzera littorea*, *L. recemosa*, *Aegiceras majus*, *Excoecaria agallocha* and *Xylocarpus granatum*. A mangrove palm *Nypa fruticans* is also found in some of the creeks while the mangrove fern *Acrostichum aureum* is associated with *Acanthus ilicifolius*. In Nicobar group of Islands, luxuriant and impenetrable mangrove forests are found in West Katchal Bay, the harbour of Kamorta and Nancowry islands, Little Nicobar and Ganges Harbour, Mouths of the river Galathea, Dogmar and Alexandra in Great Nicobar (Map 1). The dominant species are *Rhizophora mucronata*, *Bruguiera gymnorhiza*, *Excoecaria agallocha*, *Carallia brachiata*, *Sonneratia acida*, *Timonius jambosella* and *Nypa fruticans*.

Mangrove Zonation Pattern : There are three conspicuous zones identified with the mangroves of Andaman and Nicobar Islands depending on their proximity to the sea :

1. Proximal zone facing the sea

These constitute the mangal formations in the creeks and river mouths where they have extended into sea so that, there is no foreshore and a part of the community is



Map 1. Mangrove areas in Andaman and Nicobar Islands

inundated for most of the time. The dominant species in this zone are those of RHIZOPHORA which are specially adapted with stilt and prop roots. However, it is the species of AVICENNIA and SONNERATIA which are found on rocky flat substratum or coral reefs which have pneumatophores. BRUGUIERA species also occur in this zone but occasionally.

2. Middle Zone

A wide range of mangrove species are represented in this zone growing on different types of substratum. Besides, species of RHIZOPHORA, BRUGUIERA, LUMNITZERA, CERIOPS are commonly found while *Aegiceras corniculatum* and *Scyphiphora hydrophyllacea* are occasionally seen. In Nicobar islands, it is *Nypa fruticans* which frequently occurs particularly on muddy substratum. Scattered populations of *Xylocarpus granatum* and *X. moluccensis* are also found while *Dolichandrone spathacea* is not uncommon.

3. Distal zone

Most of the species found in this zone are generally mangrove associates such as *Heritiera littoralis*, *Thespesia populnea*, *Pongamia pinnata*, *Hernandia peltata*, *Manilkara littoralis*, *Pandanus tectorius*, *Cerbera manghas*, *Licuala spinosa*, *Colubrina asiatica*, *Hibiscus tiliaceus*, *Calophyllum inophyllum*, *Phoenix paludosa*, *Excoecaria agallocha*, *Intsia bijuga*, *Cynometra* spp, *Xylocarpus molluccensis* etc. As this zone is towards the inland forests, many littoral species are encountered here.

Mangrove associations : Depending upon the nature of substratum, three different associations were seen in the mangrove areas of Andaman and Nicobar archipelago as observed by Gopinathan and Rajagopalan (1983). These are :

AVICENNIA-SONNERATIA-RHIZOPHORA Association.

BRUGUIERA-EXCOECARIA-BARRINGTONIA Association.

PANDANUS-THESPESIA-HIBISCUS Association.

There is, however, no data available on the interspecific competition in these formations.

Non-extractive values : Mangroves stabilize loose soil and detritus, act as a filter for land run offs, function as a bulwork against sea erosion and protect the hinterland from tidal surges and cyclone and high velocity winds. Altogether, four major roles are recognized :

1. Help in soil formation by trapping debris. The mangrove substratum is constituted by carbonate deposition contributed by shells of molluscs, corals, spines of sea urchins and encrusting form of bryozoans, algae etc. (Bhattacharya *et al.* 1991).
2. Act as a sieve for rich organic soil washed down through river systems into sea especially in Great Nicobar.
3. Provide appropriate ecosystem and refuge for fish, crocodiles, birds, marine invertebrates such as molluscs and crustaceans.

4. Contribute detritus enhancing the productivity of the ecosystem. Mangroves grow in a relatively high turbulent depositional environment.
5. Mangroves also function as a buffer against the oil-slicks washed ashore from the sea.

Extractive values : The important role of mangrove systems for commercial and economic development has been well recognized by UNESCO, UNDP, IUCN, FAO, WWF etc. and also by the Government of India, which constituted National Committee on Mangroves and Coral Reefs. Mangroves are used as potential sources for fuel wood, charcoal, timber, particle board, house and boat building materials, synthetic fibers, viscous rayon, dye, tannin, alcohol, condiments, adhesive, incense, paper and pulp, packing boxes, thatching materials, match sticks, toys etc. Mangroves also serve as rich nursery grounds for many estuarine fishes, shellfishes, prawns and other crustaceans. Many birds, crocodiles, honey bees and endangered animals depend constantly upon this dynamic ecosystem for food and shelter.

A wide range of minor uses of the mangrove seeds have been reported from various parts of the world. They are used for treating various ailments, diseases such as boils, rheumatism, ulcers, tumours, diarrhoea, leprosy and many others. Medicinally important oils, illuminant oils and high proteins are also obtained from certain species. Some toxic substances are usually associated with the carbohydrates, proteins and oils of many mangrove seeds and these toxic constituents

are used as drugs, insecticides and nematicides. Obviously, the services provided by the mangroves which can not be measured in terms of monetary values are of various types for protection and conservation as natural "border security forces" with self repairable capacity against high wind and storm. These are often termed as 'coast guard'.

Temporal changes in mangrove cover : The total mangrove cover in Andaman and Nicobar Islands as reported by Sahni (1957) was 22% of the geographical area i.e. about 1,826 sq. km. In the last 50 years or so, significant changes affecting the forest resources, mangrove forests in particular have taken place due to which the mangrove cover was down to 11.6% (Kathiresan, 1998). The decrease (Plate 2) would have been much more but for the cessation of extractions and natural regeneration of the degraded mangroves. This is confirmed by the satellite data showing 25.45% increase in the mangrove cover between 1993-97. These changes are in the nature of large scale human colonization of the islands beyond the carrying capacity, conversion of forest areas into revenue and agricultural lands, large scale commercial plantations, forest extractions to meet the fuel wood requirement (Table 5) and supply to the forest based industries etc. For example, vast areas of mangrove forest in Little Andaman itself appear to have been cleared for Red Oil Palm plantations since the acid sulphate/potential acid sulphate soils of the mangroves offer a wide potential for cultivation of red oil palm. Recent anthropogenic activities such as

tourism in Sippighat and Wright Myo areas in South Andamans have further aggravated the situation resulting in more demands for fuel wood etc. in the islands especially where there is no supply of cooking gas. All these changes have directly and indirectly affected the mangrove resources until they were regularized in the nineties. The impact of colonization in the islands has apparently led to the shrinkage of mangrove zone as shown in the Fig. 2.

Human induced threats to mangrove ecosystem :

Exploitation for fuel wood :

As the species, especially of *RHIZOPHORA* and *BRUGUIERA* are of high calorific value, the wood

is extensively used as chief fuel wood by the rural people in coastal areas. Extraction of wood from mangroves during the eighties from different divisions in Andaman and Nicobar islands given in Table 5 indicating the extent of damage already done following which the extraction was stopped or minimized. The bark gives useful tannin and dye which are used for dyeing and strengthening fishing nets etc. As long as there is no alternative source of fuel, mainly the natural gas, the problem remains unresolved for a long time. About 13,000 ha. of mangrove area is probably destroyed in Little Andaman. A provision for electric crematorium in major inhabited islands should be thought of for relieving the pressure on the mangroves for fuel wood.

Fig. 2 Degradation of Mangrove forest cover between fifties and nineties

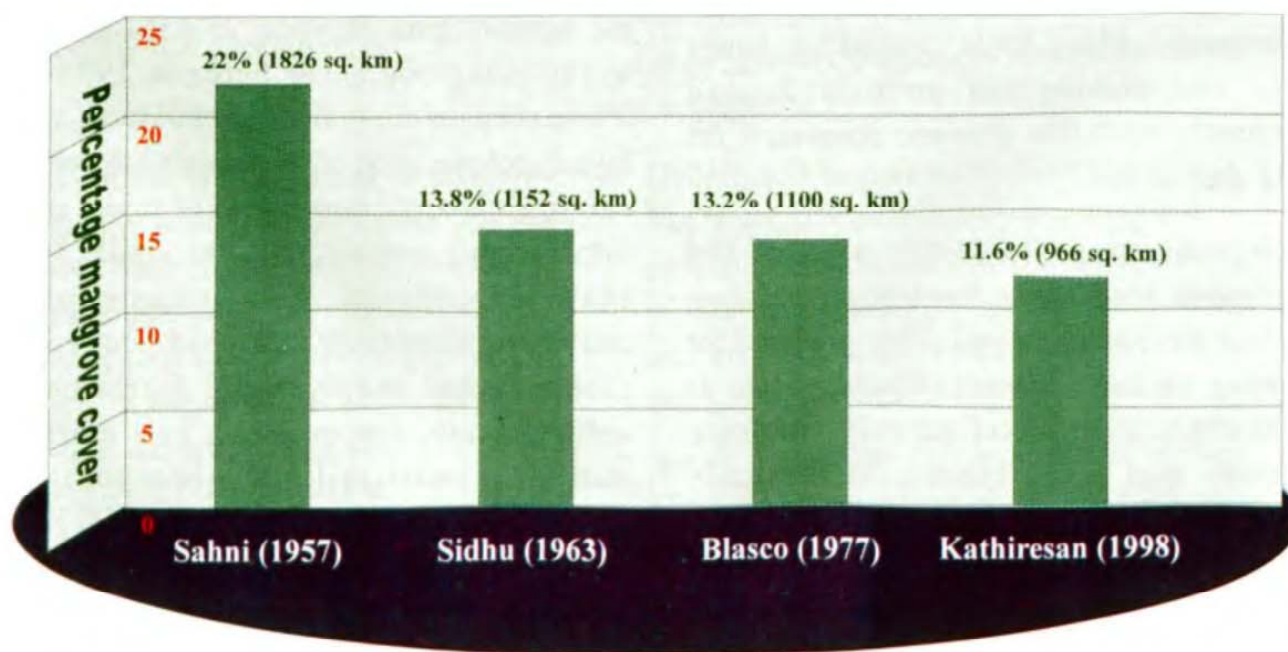


Table 5. Extraction of Wood from Mangroves of different Divisions

Forest Division	Volume of wood (m ³)			Charcoal (tons)
	Govt. Agency	On payment of royalty	Total	
1981-1982				
North Andaman	---	472	472	0.96
Middle Andaman	157	4,405	4,562	7.56
Baratang	130	207	337	3.92
South Andaman	---	20,586	20,586	---
Nicobar	---	104	104	---
Total	287	25,774	26,061	12.44
1982-1983				
North Andaman	---	1,739	1,739	0.71
Middle Andaman	150	567	727	9.55
Baratang	100	65	165	3.61
South Andaman	---	15,314	15,314	---
Nicobar	22	---	22	---
Total	272	17,685	17,957	13.87
1982-1983				
North Andaman	---	545	545	---
Middle Andaman	1,392	1,285	2,677	7.12
Baratang	127	70	197	4.34
South Andaman	---	12,277	12,277	---
Nicobar	---	---	---	---
Total	1,519	14,177	15,686	11.46
1982-1983				
North Andaman	11	2,639	2,720	1.27
Middle Andaman	8	---	8	8.51
Baratang	130	19	149	4.69
South Andaman	---	11,059	11,059	---
Nicobar	---	28	28	---
Total	219	13,745	13,964	14.47

Siltation and chocking of the creeks

The siltation of creeks is a perennial problem in the islands due to top soil erosion in the hinterland owing to various agricultural practices. Large scale siltation and chocking are detrimental to the health of the mangroves and to the nursery grounds. This will have adverse impact on the reef ecosystem.

Navigational activities : Shipping is the lifeline in the islands for the last few decades whose importance has increased, of late, due to population influx from the mainland beyond the carrying capacity. The creeks are invariably the navigational routes for medium sized vessels whose movement has certainly affected the breeding ground of many creek inhabiting aquatic fauna. Besides, the unseen and mostly ignored oil slick in the creeks due to ferrying activities have added to the degradation of mangrove ecosystem slowly but surely. The construction of harbour and jetty structures in some of the islands for facilitating the ferrying activities in the vicinity of creeks, though marginally, is likely to be detrimental as a result of cumulative effect of various anthropogenic activities.

Unplanned fishing : Fishing is the backbone of economy in most of the islands as the settler population largely depends on the income generated by fishing related activities. This needs to be regulated in the reefs so as to offset the ecological imbalance caused by the inadequate fish seed during lean months.

Poaching and crocodile hunting : Poaching activities involving the mangrove

resources such as fuel wood, crocodile skin etc. both by the natives, and foreigners from Myanmar will seriously impair the ecology leading to the deterioration of mangrove ecosystem.

Large scale collection of germplasm : A serious problem that has been witnessed in the recent years is the large scale collection of mangrove germplasm viz. radicles of RHIZOPHORA, BRUGUIERA etc., and fruits of XYLOCARPUS by unscrupulous traders for exporting to various firms in the mainland. Owing to these activities, the regeneration capacity of the dominant mangrove species is likely to be affected in future, if not now.

Conservation and sustainable utilization : The total area of Indian mangrove forest cover as estimated by Blasco (1977) is around 356,500 ha of which nearly 110,000 ha are in the Andaman and Nicobar islands alone. Mangrove ecosystem being the only major wetland in the Bay islands occupying the estuarine interphase, plays an important role ecologically thus necessitating wetland conservation and wise use policies. There has already been an increasing awareness among policy makers, NGOs, the private sector and the public at large of the values of the mangrove wetlands. Keeping in view the various threats preceived, sound and viable conservation strategies need to be evolved before it is too late so that the mangrove resources are made use of on sustainable basis. The dominant RHIZOPHORA population together with other mangrove species constitute the major framework in the ecosystem, and the removal of

such keystone species wittingly or unwittingly will result in the disappearance of various other dependent species, both aquatic and terrestrial, eventually leading to the collapse of the dynamic and productive ecosystem which is indispensable in the island scenario.

Mangroves constitute a nature bank from which unlimited supplies of capital cannot be drawn without deposits being made. The disastrous effects of lack of policy in this regard are reflected in the general deterioration of mangrove ecosystem in the isles but less visible. The following few guidelines can be thought of for effective management :

- Timbering of mangrove species such as RHIZOPHORA, SONNERATIA, AVICENNIA, BRUGUEIRA etc. must be accompanied by reforestation in order to maintain the longterm viability of coastal systems.
- Protocols for germination, planting, irrigation, and rotational forestry of native mangrove species should be developed.
- Genetic diversity of mangrove plants must be better understood and preserved.
- Native mangrove species should be used whenever possible, and forest growth and the subsequent recruitment of native marine invertebrates, fish, and terrestrial birds and mammals should be monitored carefully, and assisted if necessary.

The above steps are meant for restoration of degraded zones by reforestation programme. Developing a workable plan entails an abiding appreciation for the mangrove resource and a comprehensive understanding of the links among

mangroves, neighbouring natural ecosystems, and nearby human settlements. However, public education of both local users and policy makers is essential to ensure that mangroves are protected for future generations. The principal threats as pointed out should be understood and the mangroves be designated as a genuine administrative priority.

Management plans for mangrove protection : Useful data on the extent of mangrove area and the rate of their decline in any area are essential for planning and resources management especially in the context of various human impacts on the fragile mangrove ecosystem in Andaman and Nicobar Islands as is the case in the rest of India. The Ministry of Environment and Forests, New Delhi, therefore, initiated several measures in conservation and management of mangrove forests in the country by declaring them as ecologically sensitive areas under the Environmental Protection Act, 1986. This has banned exploitation and development activities in the mangroves and has prohibited waste disposal from industries through mangroves all over the country. The Ministry has been effectively managing the mangroves by constituting committees at National and State levels. Further in Andaman and Nicobar Islands, all mangroves with an area of 1,000 sq. m. or more are classified as CRZ 1 with a buffer zone of at least 50 m. It is also monitoring the mangrove areas by remote sensing with land surveys and time series data.

The extent of mangrove area keeps on changing over a period of time in different states of India as known from the satellite

data. However, as far as the Andaman and Nicobar Islands are concerned, there have been some draw-backs noticed in the satellite data : 1. Mangrove areas smaller than 25 ha could not be mapped and 2. Mixing of mangroves with adjoining forest area in some island could not be resolved. In spite of the efforts made by the Forest Department from time to time, degradation appears to still continue in some islands due to natural and anthropogenic pressures.

SEAGRASS MEADOWS

Seagrasses, mangroves and salt marshes have important functions in maintaining the richness of coastal environment. Seagrasses, believed to have originated from related terrestrial grasses in the Cretaceous either directly from the beach or indirectly from freshwater into the shallow waters of the Tethys sea, have evolved into several genera, spreading to the Pacific and Atlantic as continents drifted during the Eocene. They are the only angiosperm species, belonging to two families and twelve genera, which have adapted so successfully to the marine environment and completing their entire life cycle under water. Being widespread in their distribution, seagrass meadows play a significant role in the processes and resources of near shore coastal ecosystems, as they have physical, chemical and biological effects on habitats where the species entrench firmly with the help of true roots.

The Andaman and Nicobar Islands, topographically, are endowed with varied landscapes and coastal wetlands. They exhibit diverse geomorphic features in the

form of inter tidal mudflats, shallow sandy bays, mangrove flats, rocks and coral reefs. Along the coast can be seen luxuriant growth of seagrasses at certain places especially where the coastline is broken irregularly by numerous small and large indentations, some of which form spacious, deep and well sheltered natural harbours.

Floristic composition : The intertidal mudflats characterized by soft sediments and dead corals support the mangroves and seagrasses as the water in these sites is less transparent. The dominant species recorded here are *Enhalus acoroides*, *Thalassia hemprichii*, *Halodule pinifolia*, *Cymodocea serrulata* and *Syringodium isoetifolium*.

The shallow sandy bays with less turbid water are found to be ideal for luxuriant growth of *Cymodocea rotundata*, *Halophila* spp. and *Thalassia hemprichii*.

Mangrove flat of fine mud, loose coarse sand, coral rubble are seen exhibiting extensive mixed seagrass meadows of *CYMODOCEA*, *THALASSIA*, *SYRINGODIUM* and *ENHALUS*. Thus a total of 9 species out of 14 species known from the Indian coast are reported from Andaman & Nicobar Islands. For more details on sea grasses report by Umamaheswara Rao, and also by Kannan may be consulted.

Non-extractive values :

- Seagrass meadows are the rich productive zone in the marine ecosystem supporting diverse faunal communities. Animal communities in seagrass beds primarily use the habitat for shelter and food.

Table 6. Seagrass Rich Areas and Associated Fauna

SEAGRASS SPECIES	ASSOCIATED FAUNA
1. Camorta East and Camorta West : <i>Enhalus acoroides</i> , <i>Thalassia hemprichii</i> , <i>Halodule pinifolia</i> , <i>Cymodocea serrulata</i> , <i>Syringodium isoetifolium</i>	Sea cucumbers, star fishes and oysters
2. Little Nicobar & Havelock : <i>Cymodocea rotundata</i> <i>Halophila</i> spp. <i>Thalassia hemprichii</i>	Staghorn corals, jelly fishes Sea cucumbers, brittle stars
3. English & Katchal Westbay : <i>Cymodocea</i> , <i>Thalassia</i> , <i>Enhalus</i> , <i>Syringodium</i>	Crab, prawn, oyster, sea Cucumber, starfish and fishes
4. Camorta harbour : Mixed meadows of seagrasses	Coral coelenterates, molluscan shells. echinoderms, fishes and turtles
5. Great Nicobar West & Cinque : All nine spp. both in mono-specific (<i>Thalassia</i> or <i>Cymodocea</i>) or mixed beds	Corals, coelenterates, molluscan shells. echinoderms, fishes and turtles
6. Teresa, Car Nicobar & Interview island : Species such as <i>Thalassia hemprichii</i> , <i>Cymodocea rotundata</i>	Brittle star, rock crabs, and other crustaceans.

- Submerged seagrass vegetation increases the available surface for epiphytic algae and associated fauna.
- Dense vegetation softens the water movement by currents and waves.

- Seagrasses produce oxygen and consume carbon dioxide dissolved in the water during the daytime and high oxygen concentrations support high densities of various animal forms.

- Excessive illumination in the daytime is diminished by the leaf canopy, protecting the bottom and permitting a shaded micro environment at the base of the vegetation.
- Interaction of several or all the above factors is responsible for the seagrass bed functioning as spawning site or nursery ground of fishes and other animals.
- Marine turtles and dugongs are probably the main vertebrate grazers and only a few of invertebrates graze on the seagrasses. Seagrass being its staple food, dugong is intimately associated with the seagrass habitat. Most of the tribes are said to be traditionally hunting dugong and consume dugong meat.
- Seagrass meadows are known to be ideal habitats for many economically important marine fauna viz. Staghorn corals, soft corals, brain corals, reef building corals and plate corals.
- Edible oysters are collected by the tribals from seagrass beds in Nicobar.
- Most suitable habitats for sea cucumbers and sea urchins are found in the seagrass meadows many of them being economically important.
- Seagrass beds also contain a variety of juvenile fish and economically important shrimps, often in abundance.
- Endangered species of turtles and other animals are known to occur in seagrass beds.

Extractive values : The seagrasses are

known to play an important role in the process and resources of near shore coastal ecosystems in various ways. No direct use of seagrasses by the islanders is known though some species are used in Indian mainland for their medicinal and food value.

Threats to natural habitats : All the known seagrass meadows in the Bay islands can be broadly classified as (a) Pristine : least disturbed (b) Disturbed : already degraded due to regular exploitation by human activities near the inhabited islands and (c) Highly Disturbed : where the degree of exploitation is comparatively high causing irreparable change in habitat.

The seagrass habitats of Andaman & Nicobar groups of islands, thus, are being threatened by both natural and human induced disturbances. As stated by Das (1996) some of the sites in North Reef and Little Nicobar islands are found to be pristine with least disturbance while those of English, Henry Lawrence of Rani Jhansi Marine National Park in South Andaman, Camorta harbour in Nancowry islands and Great Nicobar west are treated as disturbed. However, some of the seagrass habitats in Havelock region, Camorta east and Nancowry-Champion are categorized as highly disturbed as they are in the vicinity of inhabited areas.

Natural threats : As elsewhere in the world the natural threats in the Bay islands include those caused by cyclonic storms, tidal waves and population and community interactions such as grazing, pests and diseases. It is also known that the plants are severely damaged when outbreak of grazers

occur but the problem is localised. Increased wave and current energy are likely to increase sediment erosion leading to the fragmentation of seagrass beds and loss of submerged rhizome mats. It is also reported that the seagrass beds near the jettys in Teressa, Katchal and Camorta are of this category.

Human induced threats : The following threats caused by human activities are also known to play major role in the deterioration of the seagrass rich habitats. The timber extraction and logging operations carried out in the inland forests increase the sediment load in coastal waters and adversely affect the distribution and density of seagrass populations. The sediment from the construction sites washed out by the rainwater deposits on the seagrass leaf lamina which phenomenon changes the wave energy regime.

CONSERVATION

The pristine seagrass meadows identified in the smaller islands, especially those in clusters having long coastline need to be conserved by curbing human activities as suggested below :

- Coral reefs and seagrass beds provide a major impetus for tourism development in the islands. The effect of tourism related activities such as development of coastal habitats, coastal urbanisation, increased traffic, sewage disposal and sediment from the construction sites should be carefully regulated and the policy taken in allowing the coastal aquaculture need to be redefined.

- Removal of sand and dead corals from the beach for construction work has already affected the near shore coastal habitats which must be controlled by exploring alternative resources. Besides, legislation prohibiting the activities of disastrous nature such as over fishing and anchoring of boats etc., should be reviewed and refined.
- Declaration of seagrass rich habitats as marine park is suggested in Great Nicobar and Nancowry group of islands in addition to Mahatma Gandhi Marine National Park and Rani Jansi Marine National Park in South Andaman which were already declared earlier.

MARINE ALGAE

The marine vegetation that bedecks the long stretches of seacoast is no less important than the verdure of the terrestrial habitats. The marine algae, popularly known as seaweeds, are little known and least appreciated as compared to the land plants. Obscurity of the natural places of their growth and the risks involved in reaching those places are perhaps some of the factors for their being not appreciated. Many of the islands remain unexplored or under explored.

The open coral reefs and extensive low lying protected areas of the Andaman and Nicobar Islands are congenial natural substratum for a number of seaweeds. Microscopic algae survive inside the coral polyp's translucent tissues. When the hard corals are under stress they discard their colourful algae and turn 'unadorned' white, a happening called 'coral bleaching'

Nearly 189 species of marine algae are recorded (Fig 3) from these islands while the estimate is above 300 species. Representatives of various groups recorded from Bay islands are as follows (detailed in the Umamaheswara Rao's Report) :

Chlorophyceae	63 species (33.3%)
Xanthophyceae	1 species (0.5%)
Phaeophyceae	41 species (21.7%)
Rhodophyceae	81 species (42.9%)
Cyanophyceae	3 species (1.6%)

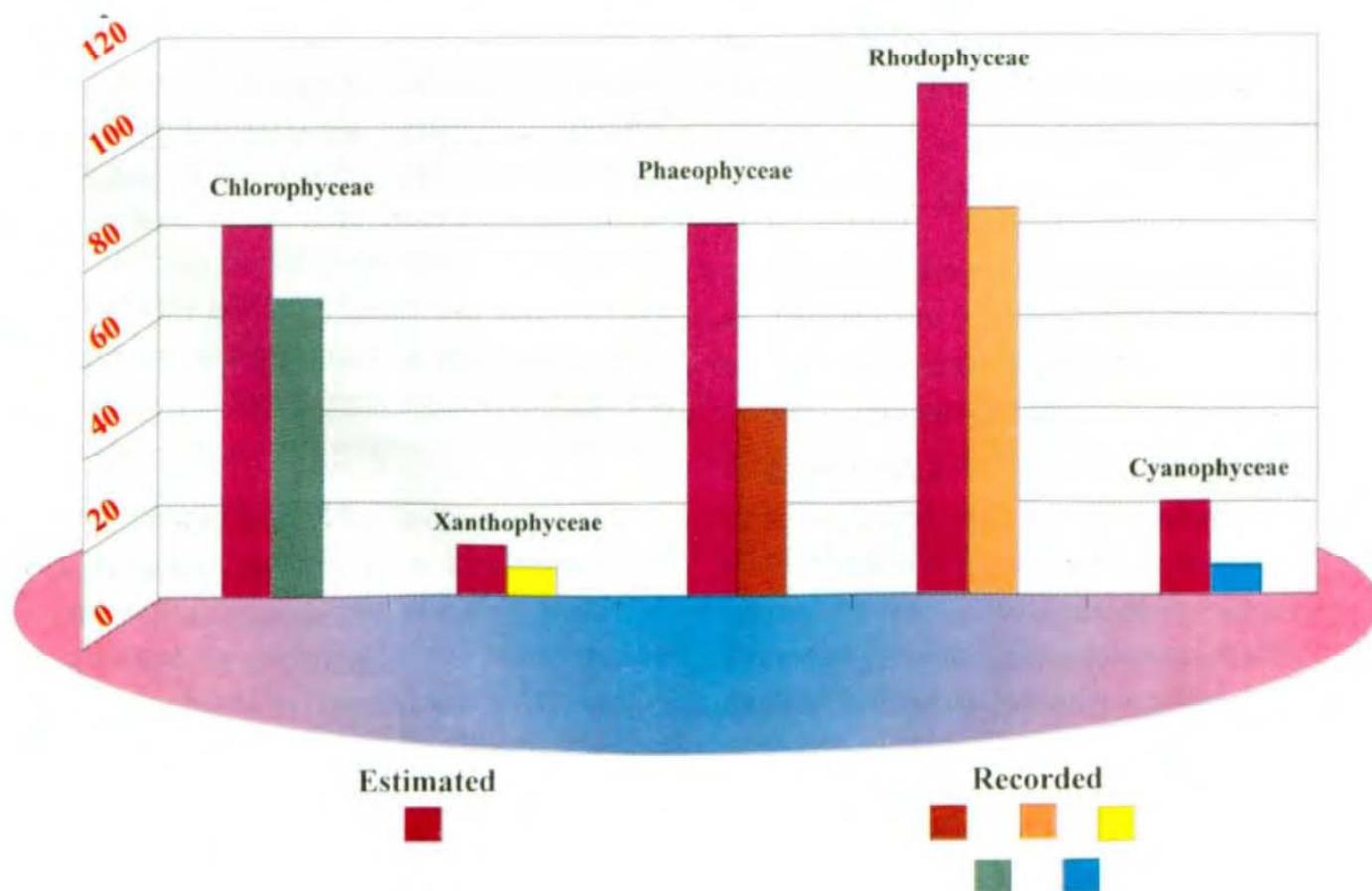
Floristic diversity is more in Rhodophyceae while luxuriance is observed in case of Phaeophyceae. The least explored divisions are

Cyanophyceae and Xanthophyceae with 1 and 3 species respectively reported.

CHLOROPHYCEAE

Among various genera recorded from the islands, the genus *CAULERPA* is the most represented (10 species) followed by *HALIMEDA* (7 species) and *ENTEROMORPHILA*. *ULVA* and *CLADOPHORA* (5 species each) while remaining 22 genera are represented by 1-4 species each thus making a total of 63 species. Although the genus *CAULERPA* is dominant numerically the genera *HALIMEDA* and *ULVA* are found to be predominant in terms of biomass and luxuriance on the coasts of Bay islands. The species of *ACETABULARIA*.

Fig. 3. Marine Algal Diversity in Andaman and Nicobar Islands



NEOMERIS, AVRAINVILLEA, BOERGESENIA, VALONIOPSIS, DICTYOSPHERA and TYDEMANIA are extremely rare.

A few species among the green algae, however, are known to show restricted distribution in the islands. While *Tydemania expeditionis*, *Acetabularia crenulata*, *A. calyculus* and *Boergesenia forbesii* occur only in Andaman group of islands, *Aurainvillea erecta* is recorded from Nicobar islands. All other species have common distribution in both the groups of islands. However, a clear picture regarding the distributional range will emerge only when extensive and systematic exploration is carried out in all the isles.

XANTHOPHYCEAE

The only species, hitherto, recorded in this family is *Vaucheria clavata* whose distribution range in the Bay islands is not known.

PHAEOPHYCEAE

A total of 41 species belonging to 15 genera are enumerated from the Bay islands. As in case of the mainland coast, the abundance and luxuriance of growth of brown algae is higher when compared to other groups in almost all the islands.

Represented by 10 species the genus *SARGASSUM* is dominant both in terms of abundance and growth. Although *TURBINARIA* is represented by 7 species, its availability is less but certainly more than other brown algae excepting *SARGASSUM* and *HORMOPHYSA*. The genera *GIFFORDIA* and *PADINA* representing 5 and 3 species respectively are generally less abundant. Almost all the brown algae

recorded have common distribution in both Andaman and Nicobar groups of Islands.

RHODOPHYCEAE

The economically important Rhodophyceae is well represented by about 43 genera and 81 species in the Bay islands among which the genus *GRACILARIA* has maximum number of species i.e. 15, many of which are known to yield the phyco colloids used in various industries in India and abroad. The genus *GRACILARIA* is represented by 6 species, followed by the genera *LIAGORA*, *AMPHIORA* and *HYPNEA* with 5 species each. Remaining 36 genera are represented only by 1-4 species each. Although floristically rich and distributed in many areas the biomass availability of all the red algal species is far less as compared to green and brown algae in the islands.

Among the red algae, the species of *GRACILARIA* and *AMPHIORA*, attached to the coralline rocks in fair quantities are known to be dominant in a number of islands. The species such as *Halymenia venusta* are highly attractive in the field as compared to others. *Kappaphycus cottonii* (Platel) recently collected from Mahatma Gandhi Marine National Park is phyto geographically important besides its economic potential. if cultivated mariculturally.

CYANOPHYCEAE

So far, only 3-4 species of *OSCILLATORIA*, *PHORMIDIUM* and *NOSTOC* are recorded from these islands while many are yet to be collected and identified.

Extractive values : Seaweeds are harvested by man for centuries particularly in

Japan, China etc. where they form a part of the staple food. The uses of many seaweeds are well known as fodder and manure in mainland India too but mostly as a source of agar-agar, agarose, sodium alginate, iodine, protein, vitamins, mannitol etc. The use they are put to in the Bay islands is as biofertiliser. The drift *SARGASSUM* is used as fertiliser, although in a limited way, in plantations by Tamilian settlers in some of the islands. Mostly the drift seaweed after it is leached of salts by rain water is used as green manure.

Chauhan *et al.* (1987) stressed the need for assessment of seaweed resources and the potentiality for establishing seaweed industries in the islands. They had analysed the percentage yield of commercial seaweeds, methods for agar manufacture and alginates in a commercial scale and their industrial uses. A prerequisite for setting up of any seaweed industry in the islands is quantitative assessment and harvestable quantities of different seaweeds. There were many recommendations suggested for seaweed culture in the islands but so far no organisation has initiated any programme to culture seaweeds. A full project may have a component to study on the prospects of starting seaweed culture in the islands and its impacts on the environment. Some of the National Laboratories viz Central Salt & Marine Chemicals Research Institute and National Institute of Ocean Technology under the aegis of CSIR and DOD have requisite expertise for taking up such research projects to bring economic dividends to the isles.

The methods given by Chauhan *et al.*

(1987) for extraction of agar-agar and alginates are given in Fig. 4 and 5 and their industrial uses in Table 6.

Non-extractive values : The seaweeds were earlier considered as least attractive or useful. But now, the ecological role of several seaweeds is recognized besides their commercial value. Dense growth of seaweeds, especially the brown seaweeds attaining great sizes and growing in profusion offer shelter and necessary habitat for several marine animals in the sea. The major use of seaweed is as source of nutrient for a large number of marine animals in the sea which feed directly on them and prey on other animals as well. Many microscopic forms too serve as chief source of food, especially for molluscs, crustaceans, tunicates, fishes etc. Several species of molluscs, however, aid the growth of a few seaweed species, as their dead and broken shells offer very good substratum and anchorage.

Profuse growth of seaweeds is believed to be detrimental to the growth of coral reefs, but also known to play an important role in consolidating the substratum.

Conservation of seaweeds for sustainable utilization : Exploration and intensive survey of a large number of islands and long coastline is rather a formidable job taking into account the logistics involved. If the resources are to be exploited on a sustainable basis in order to generate employment, efforts should be initiated as suggested below :

- All the islands and islets need to be explored

to get quantitative estimates of raw material available especially of economically important red seaweeds viz. *GELIDIUM*, *GELIDIELLA*, *GRACILARIA*, *KAPPAPHYCUS* etc.

- The islands with more potential may be

targeted for harvesting from natural beds on a sustainable basis and necessary steps for growing them on a large scale through mariculture in the field should be initiated

- Rural people in the respective islands need to be involved by offering training.

Fig. 4. Methods for Extraction of Sodium alginate, Calcium alginate and Alginic acid

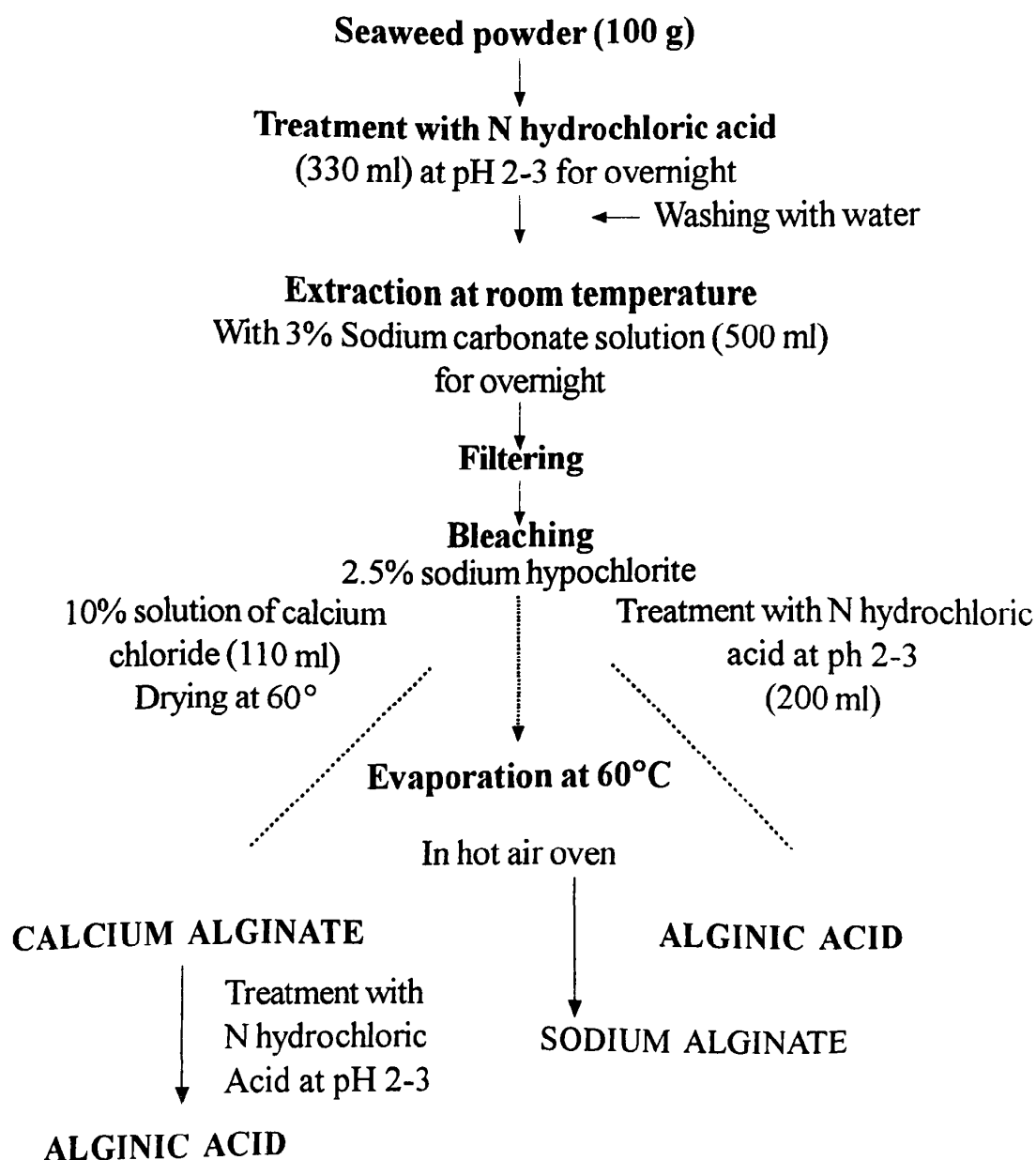


Fig. 5. Methods for extraction of Sodium alginate, Calcium alginate and Alginic acid

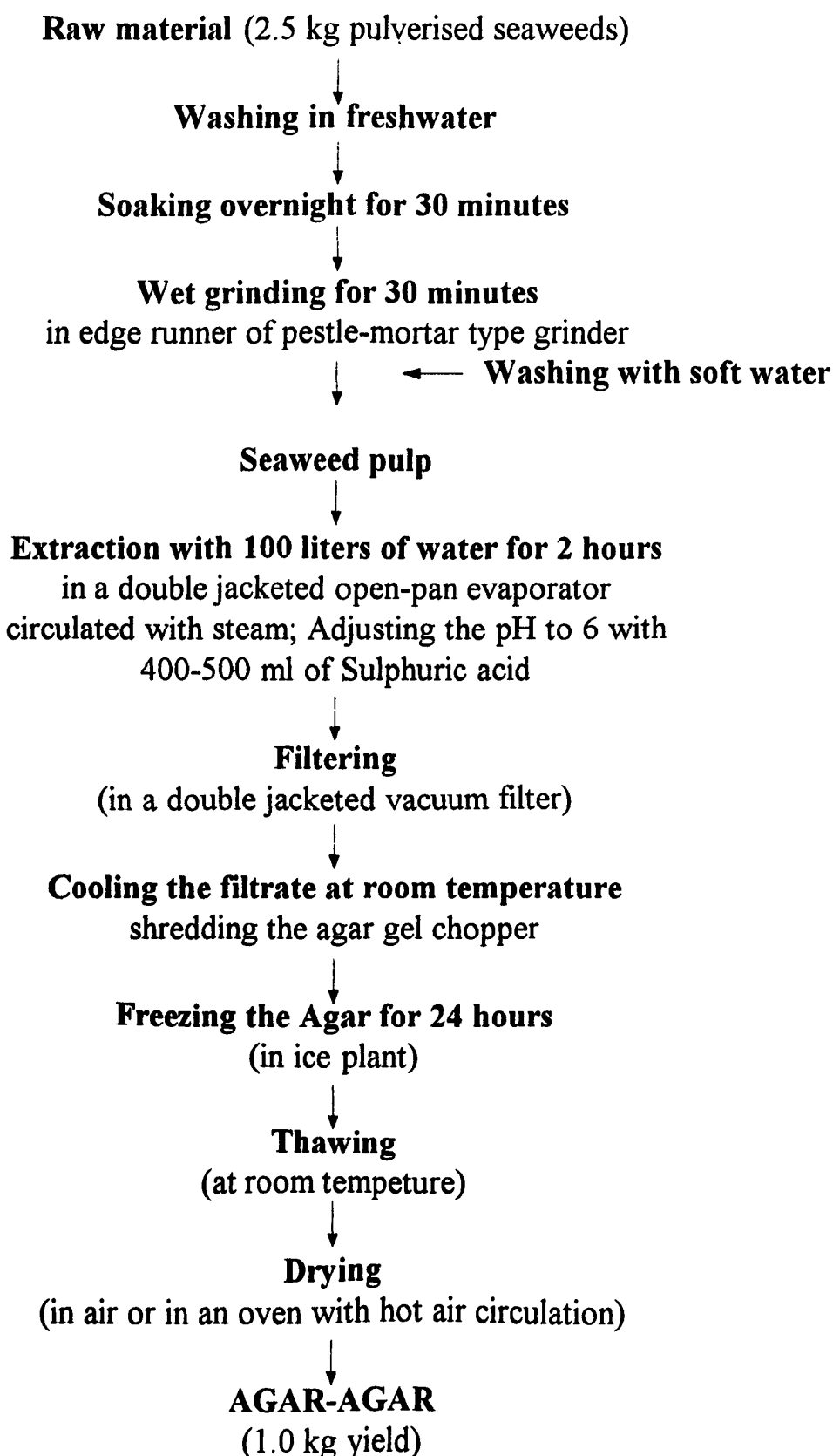


Table 7. Industrial uses of Agar, Carrageenan and Alginates

Sl. No.	Uses	Agar	Carrageenan	Alginates
1.	Dairy products	+	+	+
2.	Beverages	+	+	+
3.	Bakery	+	+	+
4.	Confectionary	+	+	+
5.	Dressings, Sauces		+	+
6.	Dietetic foods	+	+	+
7.	Meat, Fish	+	+	+
8.	Adhesives		-	+
9.	Pharmaceutical products	+		-
10.	Rubber			+
11.	Textile products			+
12.	Paper products		-	+

incentives and infrastructural facilities.

- Research organisations like BSI, NIOT, CARI etc. based in the islands can extend available expertise and the local administration the required financial assistance.
- As the transportation of raw materials to mainland India or adjoining countries is expensive due to the long distances involved, only the finished products should be transported.
- As the overgrowth of seaweeds is detrimental to reef formation, harvesting and economical exploitation assume paramount importance. However, total denudation of the habitats should be prevented so as to provide natural habitats for innumerable marine fauna which seek shelter and food in the algal beds.

- As the increasing level of siltation in the coastal waters is not conducive for many seaweeds and microalgae which play vital role in coral reef formation, sand mining in the coastal belt should be minimised.
- Pollution of coastal waters especially in the vicinity of the seaweed rich areas is to be checked so that the regeneration of seaweeds is not affected.

REEF-BUILDING CORALLINE ALGAE

Coral reefs are formed by the limestone skeletons of thousands of tiny anemone-like animals. True reef-building corals are the hermatypic polyps with symbiotic algae (zooxanthellae) within their bodies. The algae process the coral's waste, thereby recycling vital nutrients to make a significant contribution to the high productivity of the system. While the microscopic algae

contribute significantly in the reef-building depending on the availability of light, oxygen, suspended sediments and the temperature regime between 22° and 28°C, the macroscopic seaweeds which overgrow due to eutrophication smother the corals and weaken the reef structure. Similarly, overgrowth of algae on coral surface causes extensive degradation by smothering.

Floristic composition : The studies made, hitherto, on the coralline algae of Bay islands are very meagre and mostly confined to fossil forms. Chandra *et al.* (1999) have recently summarized the work of earlier workers on fossil forms and their own work in the Kakana formation of Car Nicobar island. They reported the occurrence of 10 genera and 24 species of both crustose and articulated corallines (Table 8) belonging to red algae which, also included the present day living forms such as the species of LITHOTHAMNION, LITHOPHYLLUM, LITHOPORELLA, POROLITHON, SPOROLITHAN, MESOPHYLLUM, AMPHIROA, CORALLINA and HALIMEDA. As against this 10 genera and 31 species of crustose algae were recorded from the coast of mainland India. However, more species are likely to be recorded from these islands if extensive survey is made. Same is the case with the articulated corallines of these islands.

Possible threats and conservation measures: As already stated several threatening processes are identified in the Bay islands which are responsible for the degradation and bleaching of coral reef, some of which are :

- Eutrophication of coastal waters because

of pollution caused by various developmental activities in the hinterland.

- Coastal, agricultural or agrarian development or agriculture bordering watersheds too have been responsible for the deterioration of reefs especially near the inhabited islands.
- Sand mining and sand quarrying along the coast and siltation caused thereby affect the health of corals by preventing survival of the coral-associated microalgae.

Unless the impact of these threats is reversed and neutralized through awareness and conservation programmes and by the involvement of both people and policy makers in such endeavours, the deterioration of natural habitats of coral and the associated coralline algae will continue unabated. Moreover, the existing legislation in curbing the bulk collection and trade of coral is inadequate as it takes care of corals wealth only in protected areas and not outside the protected area.

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Crustose and Articulated Forms

CRUSTOSE CORRALLINES (MELOBESIOIDEAE) (66.6%)

Lithoporella sp.
Lithophyllum kotschyannum
Lithothamnion aggregatum
L. andamanensis
L. andrusovii
L. aucklandicum
L. flexuosa
L. geei
L. prelichenoides
Lithothamnion sp
L. wallisium
L. wilsonensis
Mesophyllum iraquense
Porolithon marshallense
Sporolithon chamorrosum
S. oulianovii

ARTICULATED CORRALLINES (CORALLINOIDES) (33.3%)

Amphiroa fragilissima
A. prefragilissima
A. medians Johnson
Amphiroa sp.
Arthrocordia sp.
Corallina eniwetokensis
C. raoi
Halimeda chiplonkarii

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