

An Overview of Andaman and Nicobar Mangroves - Existing Day State of Affairs

Hari Nivas Asokan,¹ Iyyappan Jaisankar,¹ Nikil Lele,² Bosco Augustine Jerard³

1. Division of Natural Resource Management, ICAR- Central Island Agricultural Research Institute, Port Blair, Andaman and Nicobar Islands - 744 105, India
2. Space Application Centre (SAC), Indian Space Research Organization (ISRO), Department of Space (DoS), Ahmedabad - 380 015, India
3. ICAR - Central Plantation Crops Research Institute, Kasaragod, Kerala - 671 124, India
ijaisankar78@gmail.com

Abstract

This review provides an overview of biotic and abiotic components and a detailed studies on tropical mangrove ecosystem, existing in Andaman and Nicobar Islands, India. Mangrove ecosystem in these Islands is considered unique and wide-ranging among other mangrove systems in India owing to the unique biogeographical behaviours with diverse biological adaptable mechanisms, stabilizing the climatic conditions. Zonation of mangroves, application of remote sensing tools, physical characters and it's associated micro flora, fauna community with reported checklist of species are deals with in this review. It was revealed that 48 species of mangroves have been documented so far in Andaman and Nicobar Islands by various workers. There are 78 species of mangrove

associated fungi, 128 species of meiofauna, 277 species of fishes, saltwater crocodiles, and endemic birds, reptiles and mammals have been recorded and this list is setting added up every year by various organizations with new reports of flora and fauna from the mangrove ecosystems of these Islands.

1. Introduction

Mangrove ecosystem has been stated as one of the most productive ecosystems on the Earth, that occurs in the tropical and subtropical intertidal areas at the junction between terrestrial and marine ecosystem such as bays, estuaries, lagoons and creeks (Qasim, 1998). Mangrove forests are considered as unique plant communities of the critical biome

between terrestrial, estuarine, and shorelines of marine ecosystems in tropical and subtropical zones (Polidoro et al., 2010). They protect coastal zones from erosion, and supply food and shelter for a huge number of commercially valuable fin and shell-fishes. Perhaps, mangroves at different places are under serious threat due to range of misuse associated with deforestation and degradation practices. India has reportedly lost about 40% of its mangrove cover within this century as per estimates (Krishnamurthy et al., 1987). These mangrove habitats interact with a wide range of associated aquatic or terrestrial flora and fauna, enabling their growth and establishment. Considering their value for the ecological services and contribution to the coastal communities, conservation of

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mangroves has been postulated to be a priority activity and efforts have been stressed to find new and successful methods for conserving mangrove ecosystems (Bosold, 2012). Worldwide, approximately 46% of the mangrove forest area has reportedly vanished in the last 20 years (Romanach et al., 2018). With the exception of Antarctica region, mangroves exist on every continent and among them, Asia region has the highest quantity in terms of species diversity and richness which constitutes around 42% of world mangrove ecosystem. In Asia, approximately 7% of mangrove ecosystem is situated in India and mangroves of Andaman and Nicobar Islands covers 617 sq. km, which are considered as the most vulnerable coast of South East Asia (Giri et al., 2011). The mangrove ecosystem act as valuable guard and save lives and properties against destructive cyclones, violent storm surges and Tsunami (Danielsen et al., 2005; Selvam 2005). The mangrove ecosystem in Andaman and Nicobar Islands is considered as the best in India in terms of its density and growth (Dagar et al., 1991).

2. Methodology

2.1. Description of the study area

The study area, Andaman and Nicobar Islands (latitude 6° and 14°N and longitude 92° and 94°E) is located between the Bay of Bengal and Andaman Sea. The Andaman and Nicobar Islands consist of 572 Islands, among which only 38 are inhabited. Geomorphologically, Andaman and Nicobar Islands are

hilly and undulating, distributed in North–South direction in the Eastern Bay of Bengal. Located between the Burma and Sunda tectonic plates, the region is believed to have formerly been a part of the larger Eurasian plate. The Islands get most rains during May to early October (Southwest monsoon), while a weak Northeast monsoon also brings rain during November–December. The predominant winds are SW and NE with a recorded mean speed of 10.0 km h⁻¹ at Port Blair. The Andaman group forms the Northern part of the chain of Islands, while the Nicobar group in the South is separated from the main northern group by 160 km high seas around 10° channel. The major land mass occurs in North, Middle and South Andaman Islands which are separated from each other by narrow channels. Mangrove vegetations in Andaman and Nicobar Islands (Table 1) is wide spread in both groups of islands in seaward

fringes and creek areas and considered as one of the best in terms of density and growth (Vinithkumar et al., 2008).

2.2. Mangrove distribution in Andaman and Nicobar Islands

The mangrove flora of Andaman and Nicobar Islands has been studied by several workers Chengappa (1944), Banerji (1954, 1958), Sahany (1957) Mall et al., (1985) and Vasudeva Rao (1986). Mall et al., (1985) have listed 26 exclusive mangrove species and 10 non-exclusive mangrove species. But perusal of literature including the work of Vasudeva Rao (1986), consultation with the Botanical Survey of India, Port Blair Circle and personal observation in different mangrove areas of these islands has revealed the presence of 37 species of mangroves and their associated vegetation. Dagar & Sharma (1989) have classified the mangrove types into 19 communities

Table.1: Distribution and Location of Mangroves in the Andaman and Nicobar Islands

South Andaman	Chidiya tapu, Burmanallah, Bedonabad, Carbyn’s cove, Sippighat, Manjeri, Guptapara, Manglutan, Wandoor, Ograbbranch, Bambooflat creek, Wright myo creek, Shoalbay creek, Jirkatang, Tirur, Chatham, Hut bay, Rutland Is, Twins Is, Boat Is, Jolly Buoy Is, North and South Cinque Is, Baratang, Passage Is, North & South Brother Is, West & East Sister Is, Neil Is, Havelock Is, Tarmugil Is, Viper Is, Petrie Is, Kyd Is, Henry Lawrance Is, Inglis Is, North & South Sentinel Is, Sir Hugh Ross Is
Middle & North Andaman	Mayabunder, Diglipur, Rangat, North, Middle & South Button Is, Long Is, Flat Is, Hump Is, North & South Reef Is, Interview Is, Snark Is, Point Is, Paget Is, Reef Is, West & East Is, Land fall Is, Smith Is, Sound Is, Saddle peak, Aerial Bay, Peacock Is, Cleugh Is
Nicobar Islands	Carnicobar Is, Kamorta Is, Katchal Is, Tillang Chang Is, Teressa Is, Nancowrie Is, Isle of Man, Bompoka Is, Camorta Is, Trinkat Is, Meroe Is, Trak Is, Treis Is, Mero Is, Pilo Milo Is, Menchal Is, Kabra Is, Kondul Is, Little Nicobar Is, Great Nicobar Is

and established associations on the basis of structure and species composition. Earlier, a total of 34 exclusive mangrove species among 17 genera and 13 families were recorded from the Andaman and Nicobar Islands (Dagar et al., 1991). More recently Debnath (2004) reported 59 species from both island groups. Dagar et al., (1991) have previously reported the distribution pattern of mangroves in the Andamans and the Nicobar group of islands. Singh & Garge (1993) and Dam Roy (1995) have discussed the mangrove ecology and distribution pattern for the South Andaman Island. Dagar & Dagar (1986) and Dagar (1989a; 1989b) have discussed several mangrove and coastal plant and tree species, listed seeds and fruits used by the tribal people from mangroves.

The mangroves of the Bay Islands are noteworthy for their gregariousness and nearly uniform degree of dominance by the fewer number of species unlike on the mainland (Krishnamurthy, 1985). Two categories of mangroves, namely, core mangroves and associated and peripheral vegetation are also recognized. Among the Andaman mangroves, *Rhizophora mucronata* and *R. apiculata* are most dominant and grow on the outer seaward fringe of the swamp. Sometimes open mudflats, and rocky and coral reef flats are occupied by *Sonneratia alba*, *S. apetiaia* and *Avicennia marina*. In the tidal creeks are occupied by *Bruguiera gymnorrhiza* and *B. parviflora* are

abundant, of which tallest trees grow as high as 25 metres (Mall et al., 1985; Jagtap, 1985). In the tidal swamps, *Avicennia officinalis*, *Ceriops tagal*, *Kandelia candel*, *Xylocarpus granatum*, *X. moluccensis*, *Lumnitzera racemosa*, *L. littorea*, *Excoecaria agallocha* and *Aegiceras corniculatum* are found to grow. *Acanthus ilicifolius* forms dense prickly undergrowth generally near the creek. *Heritiera littoralis*, *Scyphiphora hydrophyllacea*, *Brownlowia lanceolata* and *Cynometra ramiflora* grow towards the landward fringe. Sometimes fern, *Acrostichum* spp and palms, *Nypa fruticans* and *Phoenix paludosa* are quite common in this zone. In the supralittoral zone of the disturbed mangrove forests *Acanthus ilicifolius* and *Acrostichum aureum* are occasionally abundant in Sippighat area, South Andaman.

Andaman mangroves exhibit a higher biomass of 214 t/h than any other mangroves of the world (Mall et al., 1991). The mixed mangrove forests have high soil respiration rate, faster decomposition rate, and high standing crop biomass (Mall et al., 1991). The litter biomass beneath *Rhizophora apiculata* in Andamans is significantly related to rainfall and wind velocity (Dagar & Sharma, 1991). A rare mangrove species, *Acanthus ebracteatus* has been recorded only from the Andaman and Nicobar Islands (Deshmukh, 1991). The Nicobar Islands of the Andaman Sea have 10 major species with the dominance of *R. stylosa* and

Bruguiera gymnorrhiza (Jagtap, 1992). In both Andaman and Nicobar Islands, members of the family Rhizophoraceae are pioneers in mangrove formation and the guardian of the soil builders. These forests along with their peculiar root system develop gregariously fringing the coasts or at the mouth of the creeks. Once *Rhizophora* colony becomes established other species grow gradually behind them. Mention may be made here that *Rhizophora* and its allied species have become rare or tended to be disappeared in other parts of India except in Cauvery delta and in the Andaman Islands due to strong biotic pressure (Deb, 1983). Ragavan et al., (2016) describes 38 true mangrove species belonging to 13 families and 19 genera are present in the Andaman and Nicobar Islands. The highlighted species of *Acrostichum*, *Acanthus*, *Pemphis acidula*, *Phoenix paludosa*, *Cynometra* and *Dolichandrone spathacea*, are globally considered as true mangrove species based on literatures (Duke, 1992; Polidoro et al., 2010; Dagar et al., 1991; Singh, 2003; Debnath, 2004; Dam Roy et al., 2009). Hybrids of some mangrove species are identified in Andaman and Nicobar Island such as *Rhizophora mucronata* x *Rhizophora stylosa*, *Acrostichum aureum* x *Acrostichum speciosum*, *Rhizophora*, viz., *R. x mohanii* (mutative hybrid between *R. stylosa* and *R. mucronata* and *R. mucronata* var. *alokii*, have been reported from mangroves of the ANI (Ragavan et

al., 2015b, c, Ragavan et al., 2014c). Based on the available literature and our survey we have found the mangrove plant population present in Andaman and Nicobar Islands broadly cover two major class, five sub class, six series, thirteen order, nineteen family, twenty-five genus with forty-eight species including two palms. In the list of mangrove plants present in Andaman and Nicobar Islands, forty-one species come under Least Concern (LC), three species are Near Threatened (NT), two species of Data deficient (DD) and each one of Not evaluated (NE) and Critical Endangered (CR) (Table 2).

Table.2: List of Mangroves in Andaman and Nicobar Islands

S. No	Class	Subclass	Series	Order	Family	Species	IUCN Status	Common Name	Habit		
1	Magnoliopsida	Gamoptalae		Scrophulariales	Acanthaceae	<i>Acanthus ebracteatus Vahl.</i>	LC	Holy Mangrove	Shrub		
2						<i>Acanthus ilicifolius L.</i>	LC	Holy Mangrove	Shrub		
3						<i>Acanthus volubilis Wall.</i>	LC	Holy Mangrove	Climber		
4					Bignoniaceae	<i>Dolichandrone spathacea (L.f.) K.Schumann</i>	LC	Trumpet Tree	Tree		
5				Bicarpellatae	Avicenniaceae Local Migrant Winter Migrant	Avicenniaceae	<i>Avicennia alba Blume.</i>	LC	White mangrove/ Gray Mangrove	Tree	
6							<i>Avicennia marina (Forsk.) Vierh.</i>	LC	White mangrove/ Gray Mangrove	Tree	
7							<i>Avicennia officinalis L.</i>	LC	White mangrove/ Gray Mangrove/ Common Indian Mangrove	Tree	
8				Gentianales	Apocynaceae	<i>Cerbera odollam Gaerth.</i>	LC	Sea Mango/ Poison nut of Madagascar	Tree		
9						Asclepiadaceae	<i>Sarcobolus globosus Wall.</i>	NE	Boali lata	Shrub	
10				Inferae	Rubiales	Rubiaceae	<i>Scyphiphora hydrophyllacea Gaertn.f.</i>	LC	Wild Ixora	Shrub	
11				Heteromerae	Primiales	Plumbaginaceae	<i>Aegialitis rotundifolia Roxburgh</i>	LC	Club Mangrove	Shrub	
12						Myrsinaceae	<i>Aegiceras corniculatum (L.) Blanco</i>	LC	River Mangrove/ Goats Horn Mangrove	Shrub	
13				Polypetalae	Disciflorae	Sapindales	Meliaceae	<i>Aglaia cucullata (Roxb.) Pellegrin</i>	LC	Solomon Island amoora/ Rose kamala/ Pacific maple/ New Guinea amoora	Tree
14								<i>Xylocarpus granatum Koenig</i>	LC	Cannon ball mangrove	Tree
15								Geraniales	<i>Xylocarpus mekongensis Pierre</i>	LC	Cannon ball mangrove

S. No	Class	Subclass	Series	Order	Family	Species	IUCN Status	Common Name	Habit
16	Magnoliopsida	Polypetalae	Disciflorae	Geraniales	Meliaceae	<i>Xylocarpus moluccensis (Lamk.) M. Roem.</i>	LC	Cedar Mangrove	Tree
17						<i>Xylocarpus gangeticus (Prain) C.E.Parkinson</i>	LC	Cannon ball mangrove	Tree
18						Calyciflorae	Magnoliopsida	Rhizophoraceae	<i>Bruguiera cylindrica (L.) Blume</i>
19			<i>Bruguiera gymnorrhiza (L.) Lamk.</i>	LC	Large leafed orange mangrove				Tree
20			<i>Bruguiera sexangula (Lour.) Poir.</i>	LC	Small leafed orange mangrove				Tree
21			<i>Bruguiera parviflora (Roxb.) Wight and Arnold ex Griffith</i>	LC	Large leafed orange mangrove				Tree
22			<i>Ceriops decandra (Griff.) Ding Hou.</i>	LC	Yellow Mangrove				Tree
23			<i>Ceriops tagal (Perr.) C.B.Robinson.</i>	LC	Yellow Mangrove				Tree
24			<i>Kandelia candel (L.) Druce.</i>	LC	Candel Mangrove				Tree
25			<i>Rhizophora mucronata Poir.</i>	LC	Long fruited stilted red mangrove/ White Candel Mangrove				Tree
26			<i>Rhizophora stylosa Griff.</i>	LC	Spider mangrove				Tree
27			<i>Rhizophora apiculata Blume.</i>	LC	Tall stilted red mangrove/ Twin flowered Mangrove				Tree
28			<i>Rhizophora x lamareckii Montr.</i>	DD	-				Tree
29			Combretaceae	<i>Lumnitzera racemosa Willd.</i>	LC				Black Mangrove
30				<i>Lumnitzera littorea (Jack) Voigt.</i>	LC	Black Mangrove	Tree		
31	Rosales	Fabaceae (Leguminosae)	<i>Cynometra ramiflora L.</i>	LC	Wrinkle pod mangrove	Tree			
32			<i>Cynometra iripa kostel.</i>	LC	Wrinkle pod mangrove	Tree			
33			<i>Derris trifoliata Lour.</i>	LC	Three leaved Derris	Climber			
34			<i>Derris heterophylla (Willd.) K.Heyne</i>		Common Derris	Climber			
35	Thalamiflorae	Malvales	Tiliaceae	<i>Brownlowia tersa (L.) Kosterm.</i>	NT	Durian of the sea	Shrub		

S. No	Class	Subclass	Series	Order	Family	Species	IUCN Status	Common Name	Habit																											
36	Magnoliopsida	Polypetalae	Thalamiflorae	Malvales	Sterculiaceae	<i>Heritiera littoralis</i> Cryand in Aiton	LC	Looking glass mangrove	Tree																											
37		Archichlamydeae				Lythraceae	LC	Shrubby coral Pemphis/ Small-leaved Mangrove	Shrub																											
38										Myrtiflorae	Sonneratiaceae	LC	Fire fly mangrove	Tree																						
39															Sonneratiaceae	LC	Mangrove apple	Tree																		
40																			Sonneratiaceae	LC	Mangrove apple	Tree														
41																							Sonneratiaceae	NT	Mangrove apple	Tree										
42																											Sonneratiaceae	CR	Mangrove apple	Tree						
43																															Geraniales	Euphorbiaceae	LC	Blind your eye/ Milky Mangrove	Tree	
44																																				Euphorbiaceae
45																															Filicopsida	Filicidae	Ptridales	Pteridaceae	LC	
46	Pteridaceae																																			LC
47		Monocotyledones	Calycineae		Arecaceae (Palmae)	LC	Water Coconut/ Mangrove Palm	Palm																												
48	Arecaceae (Palmae)								NT	Sea date	Palm																									

2.3. Floristic composition of Mangroves of Andaman and Nicobar Islands

Floristically, Mangrove ecosystem of Andaman and Nicobar Islands were studied by various authors (Kloss 1902; Parkinson 1923; Sahni 1958; Chapman 1976a, 1976b, b; Thothathri 1981; Dagar 1982; Singh & Garge 1993; Dagar & Dagar 1986; Mall et al., 1985; Rao & Chakraborti 1987; Mall et al., 1987; Singh et al., 1987a; Ellis 1987;

Dagar et al., 1991; Jagtap 1992; Sreekumar & Kala 1998; Hajra et al., 1999; Sinha 1999; Dagar & Singh 1999; Singh 2003; Debnath 2004; Sampath Kumar 2005; Damroy et al., 2009; Ragavan et al., 2014a, Goutham Bharathi et al., 2014) but little is known on the vegetation structure and the spatial patterns of mangroves of the Andaman and Nicobar Islands and information is almost restricted to few sites (Mall et al., 1982; Dagar

1982; Singh et al., 1986; Singh et al., 1987b; Dagar & Sharma 1989; Dam Roy 1995a, b; Mall et al., 1991; Singh & Garge 1993).

Forest survey of India (Table 3) reports over the three decades of mangrove ecosystem in Andaman and Nicobar Islands has showed periodical degradation. After the year 2001, FSI extensively utilized advanced technologies, including remote sensing and GIS-based techniques, for the classification of

mangrove ecosystems and land use/land cover. This approach allows the report to clearly explore categories of mangroves, such as very dense, moderate, and open mangrove classifications (FSI, 2001).

2.4. Zonation Pattern

The classification and zonation of the mangrove ecosystem can rely on the structural characteristics of mangrove forests (Specht, 1970). It has been characterized by the responses of individual species to variations in the degree of tidal inundation, salinity, pH, or other measurable edaphic gradients that consistently vary across the intertidal region (Snedaker, 1982; Smith, 1992). However, it may be, at least partially, influenced by biotic factors (Ball, 1980; Smith, 1987). Quantification or arithmetical testing of mangrove zonation patterns is rare, even with the availability of arithmetical tests for zonation (Dale, 1999). The studies on the influence of landscape over distribution exposed that the *Avicennia* spp, *Aegiceras* spp preferred low lying areas, the *Ceriops* – *Dalbergia* association preferred high land areas while *Ceriops decandra* and *Excoecaria* sp spread overall salinity ranges and topography types (Motilal et al., 1986). Various authors classified the mangrove areas into different zones based on the dominance of a specific factor. Watson (1928) and Thanikaimoni (1980) followed inundation and salinity as a basis; Untawale (1987) pH, salinity of soil and salinity of

Table 3. Year-wise report of mangrove cover in Andaman and Nicobar Islands

Sl. No	Year of Assessment	Area under mangrove cover in Andaman and Nicobar Islands (in Sq. Km)			
		Very dense Mangroves	Moderate Mangroves	Open Mangroves	Total area (in Sq. Km)
1	1987	686	-	-	686
2	1989	973	-	-	973
3	1991	971	-	-	971
4	1993	966	-	-	966
5	1995	966	-	-	966
6	1997	966	-	-	966
7	1999	966	-	-	966
8	2001	709	-	-	789
9	2003	262	312	97	658
10	2005	255	272	110	635
11	2009	285	262	68	615
12	2011	283	261	73	617
13	2013	276	258	70	604
14	2015	399	168	50	617
15	2017	399	169	49	617
16	2019	399	169	49	616
17	2021	399	168	49	616

(Compiled from Forest Survey of India Reports)

water. Thanikaimoni (1980) definite that zonation in mangroves is disrupted mainly due to human interference and results in mixed zones. Bunt et al., (1982) observed that some species common at the mouth of an estuary were not present near the fresh and more riverine head water region. Yuvaraj (2017) stated that, it was observed that zones are classified from the seaward to the landward end, distributed as seaward fringes, tall and dense *Rhizophora-Ceriops* dense, *Xylocarpus* mixed, *Bruguiera* clumps and Lankward back mangroves. Although Dagar et al., (1991) reported about 30 mangrove

species from Middle Andaman, most of plants are belonging from true and saline tolerance species. The salinity of the soil water has long been recognised as an important factor in regulating growth, height, survival and zonation of mangroves (Macnae, 1968; Semeniuk, 1983). *Avicennia marina* is a pioneering mangrove species and is the most tolerant of extremely saline conditions. Maximum salinity tolerance for *Avicennia marina* is 90 ppt compared to between 55 and 60 ppt for *Rhizophora mucronata* and *Ceriops tagal* (Qureshi, 1996) (Table 4). Mangrove vegetation of Andaman shows a distinct zonation

pattern according to the degree of influence of tide, salinity, nature of soil, water table and drainage (Balachandra, 1988). Unlike in the mangroves of east coast estuarine areas where the species present a more or less uniform and characteristic zonation, the mangroves in these islands present no similarities and the zonation gets altered in different areas due to ecological conditions (Banerjee et al., 1989).

2.5. Precipitation

Precipitation records of Port Blair for the period of 1949 to 2006, showed the least precipitation (1541.4 mm) during the year of 1979 and the highest precipitation (4362.4 mm) during 1961. The average precipitation at Port Blair is 3180 mm. Analyses of the precipitation in the Andaman District from 1967 to

2006, revealed the lowest average precipitation (1774.3) mm during 1979 and the highest average precipitation (3651.1) mm during 1972. During 2007 to 2009, the lowest average precipitation in North & Middle Andaman district was 2849.8mm in 2007 and that in South Andaman District was 2325.3mm in 2009. Further the average precipitation was highest in both the district, during 2008. Similarly, in Nicobar District the lowest average precipitation (1335.8) mm during 1982 and the highest average precipitation (3923.8 mm) during 1975.

2.6. Temperature

The increase in the Global temperature in the past 10 decades has been more than 0.6 °C and it is predicted to be 2–6 °C by 2100 typically due to the anthropogenic

activities (Houghton et al., 2001). The impact of the predictable rises in sea temperature is not likely to affect mangrove ecosystem unfavourably (Field, 1995). Migration of some species of mangroves to higher latitudes is limited by temperature. Nevertheless, extreme cold temperatures are more likely to limit mangrove expansion into higher latitudes (Woodroof & Grindrod 1991; Snedaker, 1995).

The Temperature of Mean Maximum at Port Blair from 1949 to 2009, the lowest Mean Maximum Temperature was recorded as 29.10 °C during 1976 and 1985 and the highest Mean Maximum Temperature was recorded as 30.80 °C during 1958 and 1969. Similarly, lowest Mean Minimum Temperature was recorded as 20.40 °C during 1989 and the highest Mean Minimum Temperature was

Table 4. Zonation characteristics of Mangroves

Characteristics	Zones		Root system	Species
Proximal	Seaward zone	Frequent inundation, Water front, regular tidal	Specially adapted pneumatophores, stilt root and prop roots	<i>Rhizophora</i> sp. In muddy substrata. <i>Avicennia marina</i> and <i>Sonneratia alba</i> in rocky or coral reef substrata.
Middle	Towards the interior side	Sea water with more soluble salts and trees attaining maximum height.	Knee root	<i>Bruguiera gymnorhiza</i> , <i>Lumnitzera littorea</i> , <i>Ceriops tagal</i> and <i>Aegiceras corniculatum</i> . <i>Bruguiera cylindrica</i> and <i>Lumnitzera recemosa</i> also found.
Distal	Towards the landward side	Salinity is low and with more fresh water	<i>Heritiera</i> sp and <i>Xylocarpus</i> sp produce buttresses.	Presence of mangroves and mangrove associates such as <i>Thespesia populnea</i> , <i>Pongamia pinnata</i> , <i>Hibiscus tiliaceus</i> etc.,

Note: ANI, Mangroves are characterized by narrow strips along the creeks and often (Exclusively Island ecosystem type of mangroves habitat in India)

(Modified from Vinithkumar et al., 2008)

recorded as 24.50 °C during 2009. Due to regular tidal flushing in the estuaries the winter is cool but never cold, summer is warm but the day temperature rarely goes beyond 38 °C in May-June. The seasonal climate in Sundarban may be conveniently categorized into pre-monsoon (March to June), monsoon (July to October), post-monsoon (November to February). High humidity prevails all through the year with a pleasant winter from November-January. The average maximum temperature is 31.20 °C and average minimum temperature is 13.70 °C. Rainfall is of monsoon type, the monsoon generally starts from July and continues till October. Humidity goes up to 82 % (Mitra et al., 2002).

2.7. Salinity

Mangroves vary both in their salinity tolerance and in the degree to which salinity may be necessary to maintain their growth and competitive dominance (Ellison & Farnsworth, 2001), (Gilman et al., 2008) which jeopardises the survival of individual mangrove trees as well as mangrove forest. Globally, sea level is rise one of the consequents of inundation depth and salinity increase will results in degradation of seaward mangroves and migration of landward mangroves (Naidoo, 1983; Lewis, 2005; Eric et al., 2007). Further, the landward mangrove species such as *Rhizophora mucronata*, *R. apiculata* and mangrove associated species like *Acrostichum aureum*, *Fimbristylis littoralis*, *Nypa*

Table 5. Based on salinity of mangrove zonation

Zones	Salinity Range (psu)	Mangrove Habit and Habitat
Euhaline zone	40 to 30	Rocky and sandy area (mostly no mangroves)
Polyhaline zone	30 to 18	Mangroves on sandy area. (most of mangrove species survive with this salinity range) <i>Rhizophora</i> spp., <i>Avicennia</i> spp., <i>Bruguiera</i> spp., <i>Lumnitzera</i> spp., and <i>Acanthus</i> spp.
Mesohaline zone	18 to 5	Mangroves on silty clay. <i>Rhizophora</i> spp., <i>Avicennia</i> spp., and <i>Aegiceras</i> spp.
Oligohaline zone	5 to 0.5	Mixed zone mangroves on silt.
Lymnatic zone	<0.5	On dry sandy soil. Mostly salt marshes and <i>Avicennia</i> spp.

Based on the salinity, following zones have been identified by Banerjee et al., (1989).

fruiticans, etc, are affected and retarded in growth due to increased inundation depth and high salinity. The tolerance level is not the same for all mangrove species. *Rhizophora* sp. (Red mangroves) has low tolerances to high salinities and thrives best at the borders of coastal fringe forests and tidal creeks where salinity is low (10-20‰). They are however capable of forming forests in higher salinities (40-55 ‰). *Avicennia* sp. (black mangroves) have higher tolerances, and develop well in salinities of 60-65‰, but can survive salinities of up to 90 ‰ (Anonymous, 1991).

2.8. Mangrove associated Flora and Fauna

2.8.1. Fungi

The mangroves associated fungi reported from Andaman and Nicobar Islands in Table 5, total 78 fungi are isolated from various mangrove species from different authors (Chinnaraj, 1993; Hosagoudar, 2013; Jagadeesh Ram, 2014, 2016;

Thorati et al., 2016; Niranjana & Sarma 2018). The modified checklist of fungi Table 6 of mangrove associated fungi were collected (Niranjana & Sarma, 2018).

2.8.2. Lichens

Andaman and Nicobar Island emerge as lichen 'hot spot' ranking first in terms of endemic species with smallest area as compared to the rest of the lichen geographical regions in the country (Kulkarni, 1977). Makhija and Adawadkar (2007) studied about eighteen species in the lichen genera *Acanthothesis Clem* and *Fissurina Fee* (Graphidaceae) with colourless, trans septate ascospores from different places in India including Andaman and Nicobar Island. Some of the publications from Andaman Island are Patwardhan and Kulkarni (1977), Makhija & Nagarkar (1981), Makhija and Patwardhan (1985, 1987a, b, 1988a, b, 1989, 1990, 1992, 1993); Nagarkar & Patwardhan (1981); Patwardhan &

Table 6. Checklist of Mangrove associated fungi in Andaman and Nicobar Islands

S. No	Class	Order	Family	Species Name	Region	Hosted Mangroves			
1	Agaricomycetes	Cantharellales	Ceratobasidiaceae	<i>Rhizoctonia solani</i> Kuhn.	AI	<i>Sonneratia acida</i>			
2		Hymenochaetales	Hymenochaetaceae	<i>Hymenochaete</i> <i>adusta</i> Lev.	NI	<i>Pandanus</i> sp.			
3		Agaricales	Niaceae	<i>Halocyphina villosa</i> Kohlm & E. Kohlm	A&NI	<i>Avicennia marina</i> , <i>Avicennia officinalis</i> , <i>Bruguiera gymnorhiza</i> , <i>Rhizophora</i> <i>apiculata</i> , <i>Rhizophora mucronata</i> , <i>Sonneratia alba</i> .			
4		Arthoniales	Arthoniaceae	<i>Herpothallon granulosum</i> Jagadeesh & G.P. Sinha	MA	<i>Rhizophora</i> sp			
5				<i>Herpothallon globuliferum</i> Jagadeesh.	SA	<i>Heritiera littoralis</i> leaves			
6				<i>Cryptothecia elata</i> Jagadeesh & G.P. Sinha.		<i>Rhizophora</i> sp.			
7				<i>Cryptothecia elongata</i> Jagadeesh & G.P. Sinha.					
8				<i>Cryptothecia superphyllinica</i> Jagadeesh & G.P. Sinha.	SA	<i>Anacardium occidentale</i>			
9				<i>Herpothallon granulare</i> (Sipman) Aptroot & Lucking.	MA	<i>Rhizophora Mucronata</i>			
10				<i>Herpothallon coralloides</i> Jagadeesh.					
11				Dothideomycetes	Pleosporales	Fenestellaceae	<i>Lineolata rhizophorae</i> (Kohlm & E. Kohlm) Kohlm & Volkm-Kohlm.	NI	<i>Rhizophora mucronata</i> , <i>Xylocarpus granatum</i>
12							<i>Passeriniella savoryellopsis</i> K.D. Hyde & Mouzouras.	A&NI	<i>Avicennia marina</i> , <i>Avicennia officinalis</i> , <i>Bruguiera gymnorhiza</i> , <i>Rhizophora</i> <i>apiculata</i> , <i>Rhizophora mucronata</i> , <i>Sonneratia alba</i> .
13							<i>Quintaria lignatilis</i> (Kohlm) Kohlm & E.Kohlm.	SA	<i>Sonneratia alba</i>
14			<i>Monodictys pelagica</i> (T.W. Johnson) E.B.G. Jones.			NA	<i>Rhizophora mucronata</i>		
15			<i>Caryosporella rhizophorae</i> Kohlm.						
16			<i>Belizeana tuberculata</i> Kohlm & Volkm-Kohlm.						
17			Aigialaceae			<i>Aigialus grandis</i> Kohlm & S. Schatz.	A&NI	<i>Avicennia marina</i> , <i>Rhizophora apiculata</i> , <i>Rhizophora mucronata</i> .	

S. No	Class	Order	Family	Species Name	Region	Hosted Mangroves	
18	Dothideomycetes	Pleosporales	Aigialaceae	<i>Aigialus mangroviv B.D. Bose.</i>	A&NI	<i>Avicennia marina, Avicennia officinalis, Rhizophora mucronata, Sonneratia alba.</i>	
19				<i>Aigialus parvus Kohlm & S. Schatz.</i>		<i>Rhizophora mucronata, Sonneratia alba.</i>	
20				<i>Ascocratera manglicola Kohlm.</i>		<i>Avicennia marina, Avicennia officinalis, Bruguiera gymnorrhiza, Rhizophora apiculata, Rhizophora mucronata, Sonneratia alba.</i>	
21			Biatriosporaceae	<i>Biatriospora marina K.D. Hyde & B.D. Bose.</i>		<i>Avicennia marina, Avicennia officinalis, Rhizophora apiculata, Rhizophora mucronata, Sonneratia alba.</i>	
22		Cladosporiaceae	Cladosporiaceae	<i>Cladosporium oxysporum Berk & M.A. Curtis.</i>	AI	<i>Sonneratia acida Benth</i>	
23				<i>Cladosporium sphaerospermum Penz.</i>			
24				<i>Cladosporium spongiosum Berk. & Curt.</i>			
25			Didymellaceae	<i>Epicoccum sorghinum (Sacc.) Boerema.</i>			
26			Didymosphaeriaceae	<i>Julella avicenniae (B.D. Bose) K.D. Hyde</i>	MA, SA	<i>Rhizophora mucronata</i>	
27		Pleosporales	Leptosphaeriaceae	<i>Leptosphaeria australiensis (Cribb & J.W.Cribb) Hughes.</i>	A&NI	<i>Avicennia marina, Avicennia officinalis, Rhizophora apiculata, Rhizophora mucronata, Sonneratia alba.</i>	
28				<i>Lophiostoma mangrovei (Kohlm & Vittal) Kohlm & Volk-Kohlm.</i>		<i>Avicennia marina, Avicennia officinalis, Bruguiera gymnorrhiza, Rhizophora apiculata, Rhizophora mucronata, Sonneratia alba.</i>	
29				<i>Vaginatispora armatispora (Hyde, Vrijmoed, Chinnaraj & Jones) Wanas.</i>		<i>Bruguiera gymnorrhiza, Sonneratia alba.</i>	
30			Morosphaeriaceae	<i>Morosphaeria velatosporea (Hyde & Börse) Suetrong, Sakay, E.B.G. Jones & C.L. Schoch.</i>		<i>Avicennia officinalis, Bruguiera gymnorrhiza, Rhizophora apiculata, Sonneratia alba.</i>	
31					<i>Helicascus kanaloanus Kohlm</i>	SA, MA	<i>Rhizophora mucronata</i>
32				Periconiaceae	<i>Periconia prolifica Anastasiou.</i>	A&NI	<i>Avicennia marina, Avicennia officinalis, Bruguiera gymnorrhiza, Rhizophora apiculata, Rhizophora mucronata, Sonneratia alba.</i>

S. No	Class	Order	Family	Species Name	Region	Hosted Mangroves		
33	Dothideomycetes	Pleosporales	Periconiaceae	<i>Periconia lateralis</i> Ell. & Ev.	AI	<i>Sonneratia acida</i> Benth.		
34			Sonneratia acida Benth.	<i>Alternaria rumicicola</i> R.L. Mathur, Agnihotri & Tyagi.	AI	<i>Sonneratia acida</i> Benth.		
35			Salsugineaceae	<i>Acrocordiopsis patilii</i> B.D. Borse & K.D. Hyde.	A&NI	<i>Avicennia marina</i> , <i>Avicennia officinalis</i> , <i>Rhizophora apiculata</i> , <i>Rhizophora mucronata</i> , <i>Sonneratia alba</i> .		
36				<i>Salsuginea ramicola</i> K.D. Hyde.	MA, SA	<i>Avicennia officinalis</i> , <i>Bruguiera gymnorrhiza</i> , <i>Sonneratia alba</i> .		
37			Testudinaceae	<i>Verruculina enalia</i> (Kohlm) Kohlm & Volkm-Kohlm.	A&NI	<i>Avicennia marina</i> , <i>Avicennia officinalis</i> , <i>Bruguiera gymnorrhiza</i> , <i>Rhizophora apiculata</i> , <i>Rhizophora mucronata</i> , <i>Sonneratia alba</i> .		
38			Trematosphaeriaceae	<i>Halomassarina thalassiae</i> (Kohlm. & Volkm.-Kohlm.) Suetrong, Sakay, E.B.G. Jones, Kohlm. & Volkm.-Kohlm & C.L. Schoch.		<i>Rhizophora apiculata</i> , <i>Sonneratia alba</i> .		
39			Zopfiaceae	<i>Coronopapilla mangrovei</i> (K.D. Hyde) Kohlm & Volkm-Kohlm.	SA	<i>Rhizophora mucronata</i> , <i>Bruguiera gymnorrhiza</i> .		
40			Eurotiomycetes		Dactylosporaceae	<i>Dactylospora haliotrepha</i> (Kohlm & Volkm-Kohlm) Hafellner.	A&NI	<i>Avicennia marina</i> , <i>Avicennia officinalis</i> , <i>Bruguiera gymnorrhiza</i> , <i>Rhizophora apiculata</i> , <i>Rhizophora mucronata</i> , <i>Sonneratia alba</i> .
41			Mucoromycetes	Mucorales	Cunninghamellaceae	<i>Cunninghamella elegans</i> Lendner.	AI	<i>Sonneratia acida</i> Benth
42	Mucoraceae	<i>Mucor racemosus</i> Fries.						
43	Rhizopodaceae	<i>Rhizopus stolonifer</i> Ehrenb.						
44	Sordariomycetes	Phyllachorales		<i>Marinosphaera mangrovei</i> K.D. Hyde.	A&NI	<i>Bruguiera gymnorrhiza</i> , <i>Rhizophora mucronata</i> , <i>Sonneratia alba</i> .		
45				<i>Rhizophila marina</i> K.D. Hyde & E.B.G. Jones		<i>Rhizophora apiculata</i> , <i>Rhizophora mucronata</i> , <i>Sonneratia alba</i> .		
46				<i>Nigrospora oryzae</i> (Berk. & Br.) Petch.	AI	<i>Sonneratia acida</i>		
47		Hypocreales		<i>Trichothecium roseum</i> (Pers.) Link.				
48		Sordariales	Chaetomiaceae	<i>Humicola alopallonella</i> Meyers & Moore.	A&NI	<i>Avicennia marina</i> , <i>Avicennia officinalis</i> , <i>Sonneratia alba</i> .		
49		Diaporthales	Cytosporaceae	<i>Cytospora rhizophorae</i> Kohlm & E. Kohlm.	SA	<i>Avicennia marina</i> , <i>Rhizophora mucronata</i> ,		

S. No	Class	Order	Family	Species Name	Region	Hosted Mangroves				
50	Sordariomycetes	Torpedosporales	Diaporthaceae	<i>Diaporthe mangrovei</i> K.D. Hyde.		<i>Rhizophora mucronata</i>				
51			Etheiophoraceae	<i>Swampomyces armeniacus</i> Kohlm & Volk- Kohlm.	A&NI					
52				<i>Etheiophora blepharospora</i> Kohlm & Volk- Kohlm	SA					
53		Microascales	Halosphaeriaceae	<i>Halosphaeriopsis mediosetigera</i> (Meyers and R.T. Moore) Dixon.	A&NI	<i>Avicennia marina, Avicennia officinalis, Rhizophora mucronata, Sonneratia alba.</i>				
54				<i>Eignicola laevis</i> Hohnk.						
55				<i>Saagaromyces ratnagiriensis</i> (Patil & Borse.) K.L Pang & E.B.G. Jones.	AI	<i>Rhizophora apiculata, Rhizophora mucronata.</i>				
56				<i>Cirrenalia pseudomacrocephala</i> Kohlm.	MA	<i>Avicennia marina</i>				
57				<i>Clavatospora bulbosa</i> (Anastasiou) Nakagiri & Tubaki.						
58						<i>Aniptodera chesapeakeensis</i> Shearer & Miller.		<i>Rhizophora mucronata, Sonneratia alba.</i>		
59						<i>Aniptodera mangrovei</i> K.D. Hyde.				
60						<i>Bathyascus grandisporus</i> K.D. Hyde.			SA	<i>Rhizophora mucronata</i>
61						<i>Halosarpeia minuta</i> W.F. Leong				<i>Avicennia marina, Rhizophora mucronata.</i>
62						<i>Antennospora quadricornuta</i> (Cribb & Cribb) T.W. Johnson.				<i>Rhizophora mucronata</i>
63		Microascales	Halosphaeriaceae	<i>Bathyascus avicenniae</i> Kohlm.		<i>Avicennia marina</i>				
64		Hypocreales	Hypocreaceae	<i>Trichoderma viride</i> Pers. ex Fries.	AI	<i>Sonneratia acida</i>				
65		Lulworthiales	Lulworthiaceae	<i>Hydea pygmaea</i> (Kohlm) K.L. Pang & E.B.G. Jones	A&NI	<i>Avicennia marina, Avicennia officinalis, Bruguiera gymnorhiza, Rhizophora apiculata, Rhizophora mucronata, Sonneratia alba.</i>				
66				<i>Lulworthia grandispora</i> Meyers.						
67	<i>Matsusporium tropicale</i> (Kohlm.) E.B.G. Jones & K.L. Pong.			NI	<i>Sonneratia alba.</i>					

S. No	Class	Order	Family	Species Name	Region	Hosted Mangroves
68	Sordariomycetes	Meliolales	Meliolaceae	<i>Meliola melanoxylo</i> Hosag. & Pillai.	SA	<i>Acacia auriculiformis</i>
69		Hypocreales	Nectriaceae	<i>Payosphaeria minuta</i> Leong.	A&NI	<i>Avicennia marina</i> , <i>Avicennia officinalis</i> , <i>Rhizophora mucronata</i> , <i>Sonneratia alba</i> .
70				<i>Fusarium equiseti</i> (Corda) Sacc.	AI	<i>Sonneratia acida</i> Benth
71				<i>Fusarium oxysporum</i> Schltld.		
72				<i>Fusarium semitectum</i> Berk.		
73				<i>Fusarium solani</i> (Mart.) Sacc. & <i>Michelia</i> .		
74				<i>Fusarium verticillioides</i> (Sacc.) Nirenberg. (= <i>Fusarium moniliforme</i> Sheld.)		
75				<i>Fusarium microsera</i> Bilai, <i>Fusarii</i> .	Mangroove roots	
76		Savoryellales	Savoryellaceae	<i>Savoryella lignicola</i> E.B.G. Jones & R.A.Eaton.	SA	<i>Avicennia marina</i> , <i>Rhizophora apiculata</i> , <i>Rhizophora mucronata</i> , <i>Sonneratia alba</i> .
77				<i>Savoryella paucispora</i> (Cribb & J.W.Cribb) Jorgen Koch.		<i>Avicennia marina</i> , <i>Avicennia officinalis</i> , <i>Rhizophora mucronata</i> , <i>Sonneratia alba</i> .
78		Xylariales	Xylariaceae	<i>Halorosellinia oceanica</i> (S. Schatz.) Whalley, E.B.G. Jones, K.D. Hyde & Læssoe.	A&NI	<i>Rhizophora mucronate</i> , <i>Excoecaria agallocha</i> , <i>Avicennia officinalis</i> , <i>Aegiceras corniculatum</i> .

(Chinnaraj, 1992, 1993; Hosagoudar, 2013, 2014; Jagadeesh Ram, 2014, 2016; Thorati, 2016)

A&NI – Andaman and Nicobar Islands, AI – Andaman Islands, NI- Nicobar Islands,

SA – South Andaman, MA – Middle Andaman, NA- North Andaman

Kulkarni (1976, 1977a, b); Patwardhan & Nagarkar (1980). Adawadkar & Makhija (2004, 2006, and 2007), Makhija & Adawadkar (2005) carried out studies on the transversely septate species of *Graphis* from India. Sinha et al., (2018) published a list indicates that large number of taxa are reported

from the family Graphidaceae (106 spp.) where genus *Graphis* alone counts 34 species. Large number of taxa are also reported from order Arthoniales (52 species) with *Opegrapha* representing 17 species. In 2018, Joseph et al. compiled a bibliography of Indian lichens, providing a detailed

reference list for these organisms.

2.8.3. Other Microflora and Fauna

Dev Roy & Das (2000) have recorded 51 species of mangrove crabs belonging to 33 genera from 10 families and Wells & Rao (1987) have reported 128 species of meiofauna from both island groups.

In the mangrove ecosystem of Andaman and Nicobar Islands 277 species of fishes were reported (Rajan et al., 2012). Foraminiferal distribution in the mangrove environments of south Andaman revealed the dominance of agglutinated foraminifera species *Trochidrobia inflata* (Rajshekhar, 2010).

2.8.4. Mammals

One of India's largest surviving populations of saltwater crocodiles inhabits the islands' mangrove creeks. The salt water crocodile (*Crocodylum porosus*) and water monitor lizard (*Varanus salvator*) are found in the mangrove areas of Andaman and Nicobar Islands. The

Lohabarrack Salt Water crocodile sanctuary is declared to protect the saltwater crocodile population in the western coast of south Andaman. Rao et al., (2013) studied and documented the importance and role of endemic mangrove associated mammals of Andaman and Nicobar (Table 7).

Table 7. List of Endemic Mangrove associated fauna

Sl. No	Species	Common name	Locations	IUCN Status
Mammal				
1	<i>Rattus palmarum</i> (Zebebor)	Zebebor's Nicobar Rat	Great Nicobar	VU
Birds				
1	<i>Alcedo meninting rufigaster</i> Walden	Andaman Blue-Eared Kingfisher	Andaman Islands	LC
2	<i>Amaurornis phoenicurus insularis</i> Sharpe	Andaman White breasted Waterhen	Andaman and Nicobar Islands	LC
3	<i>Caprimulgus maerurus andamanicus</i> Hume	Andaman Long-Tailed Night jar	Andaman Islands	LC
4	<i>Centropus andamanensis</i> Beavan	Andaman Crow-Pheasant, Brown Coucal	Andaman and Nicobar Islands.	LC
5	<i>Ceyx erithacus macrocarus</i> Oberholser	Andaman Three-toed Kingfisher	Andaman and Nicobar Islands	LC
6	<i>Halcyon capensis intermedia</i> (Hume)	Nicobar Strok-billed Kingfisher	Nicobar Islands	LC
7	<i>Halcyon capensis osmastoni</i> (Baker)	Andaman Strok-billed Kingfisher	Andaman Islands	LC
8	<i>Halcyon chloris davisoni</i> Sharpe	Andaman White collared Kingfisher	Andaman Islands	LC
9	<i>Halcyon chloris occipitalis</i> (Blyth)	Nicobar White collared Kingfisher	Nicobar Islands	LC
10	<i>Halcyon coromanda mizirhina</i> (Oberholser)	Andaman Ruddy Kingfisher	Andaman Islands	LC
11	<i>Halcyon smyrnensis saturator</i> Hume	Andaman White breasted Kingfisher	Andaman and Nicobar Islands	LC
12	<i>Nectarinia jugularis andamanica</i> (Hume)	Andaman Olive backed Sunbird	Andaman Islands	LC
13	<i>Nectarinia jugularis klossi</i> (Richmond)	Nicobar Olive backed Sunbird	Nicobar Islands except Car Nicobar	LC
14	<i>Ninox affinis affinis</i> Beavan	Andaman Brown Hawk-owl	Andaman Islands	LC
15	<i>Psittacula alexandri abbotti</i> (Oberholser)	Andaman Red breasetd Parakeet	Andaman Islands	NT
16	<i>Psittacula longicauda nicobarica</i> (Gould)	Nicobar Red-Cheeked Parakeet	Nicobar Islands	VU
17	<i>Psittacula longicauda tytleri</i> (Hume)	Long-Tailed Parakeet, Andaman Red-Cheeked Parakeet	Andaman Islands	VU
18	<i>Spizaetus cirrhatus andamanensis</i> Tytler	Andaman Crested Hawk-Eagle	Andaman Islands	LC
19	<i>Zoothera citrina andamanensis</i> (Walden)	Andaman Ground Thrush	Andaman Islands	LC
Reptile				
1	<i>Trimeresurus Purpureomaculatus andersoni</i> (Theobald)	Andaman Mangrove Pit Viper	Andaman Islands	LC

(Compiled and modified data from Rao et al., 2013)

3. Mangrove Mapping of Andaman and Nicobar Islands

Mapping of mangroves using remote sensing tools has been attempted by several workers. Bagla & Menon (1989) have estimated mangrove area of around 66,261 ha in the Andaman and Nicobar Islands. Krishnamoorthy et al., (1993) have studied the mangroves and coral reef of south Andaman Islands through Remote sensing. Ranganath et al., (1989) used satellite data to map the mangrove distribution in 8 Islands (Havelock, Peal, Nicholson, Wilson, John Lawrence, Henry Lawrence, English and Outram) in the Middle Andaman. Mangroves and coral reef of South Andaman Islands have been mapped through remote sensing to identify the degraded areas due to human activities (Krishnamoorthy et al., 1993). Swaminathan and Ramesh (1993) have used the satellite data of 1993 SPOT FCC image on 1:50,000 scales to map the mangroves and coral reefs of South Andaman Islands. The Andaman and Nicobar Islands, located in the northeast Indian Ocean, occupy 966 sq. km of mangrove cover (Krishnamoorthy, 1997; FSI, 1997).

According to Upadhyay et al., (2002) no change of mangrove vegetation was observed during 1997 to 1999, both in the Andaman and Nicobar groups of Islands. The Department of Space has mapped the areas under mangroves using satellite data, with 83-90% accuracy and mixing of mangroves with adjoining forest area especially in the Andaman-Nicobar group of

islands has been noted. (RSAM, 1992). There are very few attempts to classify different vegetation types in the Andaman and Nicobar Islands. IRS-1C LISS III data and Landsat TM data were effectively used to map the vegetation types. In the south Andaman Islands, mangroves formed 10% of the area. The study brought out a better separation of mangrove vegetation in Landsat data. Forest density mapping and landscape analysis have been well brought out in the study (Barnali, 2006).

As per the FSI (2001) reports, a total of 709 km² of dense and 80 km² of open mangroves have existed in the entire Andaman and Nicobar Islands before tsunami. But the tsunami of December 26, 2004 has caused considerable damage to the mangroves and low-lying habitats of Andaman and Nicobar group of islands including the Great Nicobar Island. Navalgund (2005) detailed about the tsunami of the Sumatra Island. Ramachandran et al., (2005) who estimated the mangroves of four islands have noticed the following reductions in the mangrove areas. 335.7 ha (51%) in Kamorta, 339.03 ha (69 %) in Katchal, 152.53. ha (100%) in Nancowry and 240.06 ha (68%) in Trinket. Sridhar et al. (2006), assessed the impact of tsunami on the mangroves of the Great Nicobar Island using IRS 1C LISS III digital data and estimated that about 61% of the mangroves were severely affected, leading to a loss of 531.70 ha of mangroves in the island. Better separation of land cover classes was

studied for the Pre and Post Tsunami images in the South Andaman Islands and a decline in the spatial extent of the mangroves of 7.5 % was found after the tsunami (Barnali, 2006). FSI (2005) has also indicated that only 21 km² of the mangroves were found distributed in the Andaman and Nicobar group of islands with a loss of 6 km² in Andaman groups of Islands and 15 km² Nicobar groups of islands noticed in the previous assessment of 2003, because of the tsunami that hit Andaman & Nicobar Islands on 26 December 2004 using the tool of Remote Sensing and GIS.

4. Conclusion

The mangrove ecosystem in the Andaman and Nicobar Islands is a vast and dense tropical forest in India, in comparison to other regions. From the period of British era and various colonies in Andaman and Nicobar Islands a wide study of classical work was conducted about mangroves. Presently the documentation and record of the Mangrove ecosystem area cared out by Zoological Survey of India, Botanical Survey of India, and other institutes in Andaman and Nicobar Island A total of forty-eight mangrove species have been recorded and documented, with numerous literatures detailing their taxonomy and floristic composition. According to the authors, mangrove associates were not addressed in the aforementioned reviews. The variation in mangrove associates is observed across different regions is influenced by factors such as

adaptation, climate, biogeographical system, temperature, geomorphological range, soil conditions, tidal variations, and water salinity. While the Zoological Survey of India and Botanical Survey of India every year documents micro flora and fauna community in Andaman and Nicobar Islands and describing new species. Still need exists for studying mangrove associated micro flora and micro fauna of Andaman and Nicobar Islands at advance levels as it may be useful to formulate strategies for better management of mangrove systems. Application oriented study of Remote Sensing and GIS approach has been used by various authors and institutes. After 1999, FSI also contributed their reports about mangrove cover using Remote Sensing and GIS. Further biotechnological, nanotechnological and other advanced methods are hither to untouched area pertaining to mangrove ecosystem of Andaman and Nicobar Islands which are suggested to generate newer information on status of mangroves of Andaman and Nicobar Islands.

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Hari Nivas Asokan

Division of Natural Resource Management,
ICAR- Central Island Agricultural Research
Institute, Port Blair, Andaman and Nicobar
Islands, India - 744 105



Iyyappan Jaisankar

Division of Natural Resource Management,
ICAR- Central Island Agricultural Research
Institute, Port Blair, Andaman and Nicobar
Islands, India - 744 105



Nikil Lele

Space Application Centre (SAC),
Indian Space Research Organization (ISRO),
Department of Space (DoS),
Ahmedabad, India - 380 015



Bosco Augustine Jerard

ICAR - Central Plantation Crops Research
Institute, Kasaragod, Kerala, India - 671124