Report of
the Task Force on
ISLANDS, CORAL REEFS,
MANGROVES & WETLANDS
IN ENVIRONMENT & FORESTS

For the Eleventh Five Year Plan
2007-2012

Government of India
PLANNING COMMISSION
New Delhi

(March, 2007)
Report of the Task Force on
ISLANDS, CORAL REEFS, MANGROVES & WETLANDS IN ENVIRONMENT & FORESTS
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CONTENTS

Constitution order for Task Force on Islands, Corals, Mangroves and Wetlands 1-6

Chapter 1: Islands 5-24

1.1 Andaman & Nicobar Islands 5-17

1.2 Lakshwadeep Islands 18-24

Chapter 2: Coral reefs 25-50

Chapter 3: Mangroves 51-73

Chapter 4: Wetlands 73-87

Chapter 5: Recommendations 86-93

Chapter 6: References 92-103
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It has been decided to set up a Task Force on Islands, corals, mangroves & wetlands for the Environment & Forests Sector for the Eleventh Five-Year Plan. The composition of the Task Force will be as under:

1. Shri J.R.B. Alfred, Director, ZSI Chairman
2. Shri Pankaj Shekhsaria, Kalpavriksh, Pune Member
3. Mr. Harry Andrews, Madras Crocodile Bank Trust, Tamil Nadu Member
4. Dr. V. Selvam, Programme Director, MSSRF, Chennai Member

Terms of Reference of the Task Force will be as follows:

- Review the current laws, policies, procedures and practices related to conservation and sustainable use of island, coral, mangrove and wetland ecosystems and recommend correctives.
- Similarly review the institutional and individual capacities available to address issues related to conservation and sustainable use of island, coral, mangrove and wetland ecosystems and recommend how they may be adequately strengthened.
- Assess the current issues and systems of integrating concerns relating to fragile island, coral, mangrove, and wetland ecosystems into other sectors (ministries, departments) and to recommend required new or remedial measures.
- Review the current EIA laws, policies, procedures and practices as being applied in the island, coral, mangrove and wetland ecosystem context and recommend corrective measure to address significant issues that specifically arise in the context of these fragile ecosystems.
- Assess the potential impacts of climate change on island, coral, mangrove and wetland ecosystems and recommend required new or remedial measures of dealing with these impacts.
- Ministry of Environment & Forests will provide basic information and data input to the Task Force as and when required.
• The Chairperson of the Task Force will be free to co-opt any official / non-official as special invitee for its meeting.

• The non-official members will be paid TA/DA by the Planning Commission as per SR 190 (a) for attending meetings of the Task Force.

• The Task Force will submit its report to the Chairman, Working Group on Wildlife, Biodiversity, traditional knowledge and Animal Welfare by 31.10.2006.

• Shri M. Ravindranath, Joint Adviser (E&F), Room No. 301, Yojana Bhavan (Tel No. 2309 6536) will be the Nodal Officer for the Task Force for all further communications.

Copy forwarded to: All Members of the Working Group.

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* * * * *
Chapter 1: ISLANDS

1.1 The Andaman and Nicobar Islands

The Andaman and Nicobar Archipelago consists of over 345 islands, islets and rocky outcrops, with land area extending up to 8,249 km² and a coastline stretch of 1,962 km; the Andaman Islands constitute 6408 km² and the Nicobars 1841 km². The Andaman Islands are the extension of the submerged Arakan Yoma Mountain range of Myanmar and the Nicobars are the continuation of the Mentawai Islands to the south and southeast of Sumatra. These two island groups situated in the Bay of Bengal span 6°45′ N to 13°41′ N (740 km) and 92°12′ E to 93°57′ E (190 km). The nearest land mass to Great Nicobar Island is Sumatra, 145 km southeast; and the Myanmar coast is roughly 280 km north of Landfall Island, the northernmost island in the Great Andaman group.

The geology of both island groups has been described in detail (Oldham 1885; Gee 1925; Mahadevan & Easterson, 1983). The topography of the Andaman and Nicobar Islands is hilly and undulating, the elevation in the Andamans is from 0 to 732 m, Saddle Peak being the highest in North Andaman Island. In the Nicobars the elevation rises from 0 to 568 m, Mt Thuillier being the highest peak on Great Nicobar Island. The Andaman Islands support one of the world’s most extensive mangrove ecosystems, almost 101,172 ha (Balakrishnan, 1989). Due to their long isolation, these islands have evolved significant diversity of flora and fauna with a high level of endemism; including Andaman affinities to Indo-China and Nicobar affinities to the Indo-Malayan (Das, 1999).
Of the 306 islands in the Andamans and Nicobars, 33 are inhabited, 94 are designated as sanctuaries, including six areas as national parks, two of which are marine national parks, two areas and two islands as tribal reserves in the Andamans. The land area of 6408 km² in the Andamans constitutes 90% as reserves and protected areas of which 36% is tribal reserves. The entire Nicobar group is a tribal reserve and has four wildlife sanctuaries, two national parks and one biosphere reserve. The status, flora, fauna and profiles of all the protected areas for both island groups has been discussed in detail (Pande et al. 1991; Andrews & Sankaran 2002; ANET, 2003). Settlers from mainland India, numbering over 400,000, inhabit the Andaman Islands and the three original inhabitants; are marginalised to small areas in the Andaman Islands.

**Ecological Profile**

The Andaman and Nicobar Islands (ANI) consists of very fragile island ecosystems and some of the most pristine in the world. These ecosystems are very diverse and support very unique flora and fauna. Both these island groups are a distinct eco region and are classified as one of the 12 biogeographical zones of India by Rogers & Panwar (1988). These same authors in their biogeographic classification of India have classified these islands as 10A/B. The landscape for large islands emerges from sea grass beds, coral reef or rocky outcrops, to beaches, littoral forest, Andaman slope forests, hilltops, into valleys and streams. Some of the dominant tree species in these luxuriant forests reach heights of 40-60 m. In some areas in the Andamans along the west and the east coast, the landscape starts from reefs or rocky outcrops to steep rock faces with wind blown vegetation. The topography of all large islands in the Andamans, Little Andaman, Little Nicobar and Great Nicobar Islands, is mostly interlaced with perennial and seasonal freshwater streams and in some areas a matrix of mangrove creeks extending into marshes. Little Andaman Island has ecosystems that do not occur anywhere else in the Andamans or the Nicobars, mainly extensive fresh and saline water marshes and wetland.

Of the total forest cover, dense forests with crown density of 40 % and above constitute 85.9%, open forests with crown density less than 40% constitute 1.7%. The mangroves occupy 12% of the land area. The mangrove ecosystem are protected, in the Andaman Islands. Mangroves cover an area of 929 km² and in the Nicobar the extent is 37 km² (Balakrishnan, 1989; Andrews & Sankaran, 2002). Grasslands are unique to the central group the Nicobars and occur on low hillsides of Teressa, Bompoka, Nancowry and Camorta and in the central part of Trinket. Lowland grasslands are restricted to Great Nicobar Islands mainly on the inland riverbanks (Pande et. al., 1991; Sankaran, 1995; ANET, 2003).

The Andaman and Nicobars are fringed by one of the most spectacular reefs in the world and, currently they are not only significant for the Indian Ocean region, but are also globally significant (Kulkarni, 2000; 2001; Vousden, 2000; Turner et al., 2001; Andrews & Sankaran, 2002). These same authors have reported that the Andaman reefs consist of about 83% of maximum coral diversity found anywhere in the world and is equal to the “Coral Triangle” of Indonesia, and about 400 species could emerge after further surveys.
Species richness, diversity and site specifics

Fauna

The only primate, the Nicobar crab eating macaque (*Macaca fascicularis umbrasa*) occurs in the southern group of the Nicobar Islands. Miller (1902) was the first to list most of the mammals for both island groups. Since then, over 60 species have been reported; and these include several species of shrews that are endemic, rats and a palm civet (*Paguma larvata tyleri*). Others include bats of 32 species in the Andamans and Nicobars (Nath & Chaturvedi, 1975); Chakraborty, 1978; Saha, 1978; Das, 1997; 1998; Aul, 2003; Aul & Vijayakumar, 2003). Invertebrate groups represented include spiders (62 species); dragonflies (36 species), termites (26 species), holothurians (68 species), chitons (13 species), hermit crabs (38 species), copepods (172 species), amphipods (110 species), polychaetes (186 species) and nematodes (54 species). The butterfly diversity is very high and 298 species and 236 subspecies in 116 genera have been reported (Rao & Dev Roy, 1985; Khatri, 1989; 1993; 1994; 1995; 1997; 1998 Devy et al., 1994; Khatri & Chandra, 1995). Among the avifauna 270 species and subspecies have been reported for ANI so far, 126 within the Andamans and 56 for the Nicobars (Sankaran & Vijayan, 1993; Islam & Rahmani, 2004). 17 are ‘Globally Threatened’ and are Restricted Range species. ANI has also been designated as one of the ‘Endemic Bird Areas’ (EBA) of the world (Statterfield et al., 1998; Islam & Rahmani, 2004); (Sankaran, 1993, 1995, 1996). The giant robber crab (*Brigus latro*) occurs in the southern Nicobars, in South Bay in Little Andaman, and South Sentinel Islands (Davis and Altevogt, 1976; Andres & Sankaran, 2002; Jayaraj & Andrews, 2005). Seven species of freshwater fishes have been previously rejoined. Lim & Das (in prep.) are reporting several new species and new records from two national parks, Mount Harriet NP and Saddle Peak NP (Ali et al., 2002).

The reptile and amphibian fauna comprises over 125 species and is diverse with an assemblage of several species of frogs and toads. Reptiles include several species of lizards, geckos, snakes and four species of marine turtles. The mega species in the Andamans include the king cobra (*Ophiophagus Hannah*), the Andaman cobra (*Naja sagittifera*), water monitor lizard (*Varanus salvator*), and saltwater crocodile (*Crocodylus porosus*). In the Nicobars the mega herpetofauna includes the Malayan box turtle (*Cuora amboinensis*) on Great and Little Nicobar Islands, the sunbeam snake (*Xenopeltis unicolor*), the saltwater crocodile (*Crocodylus porosus*), the reticulated python (*Python reticulates*) in the southern Nicobar group, besides several species of pit vipers in the central Nicobars (Das, 1994; Krishnan, 2003; Vijaykumar, 2003; Whitaker & Captain, 2004). Four species of marine turtles, leatherback turtle (*Dermochelys coriacea*), hawksbill turtle (*Eretmochelys imbricata*), green sea turtle (*Chelonia mydas*), and the olive ridley turtle (*Lepidochelys olivacea*) also feed and nest around the Andaman and Nicobars (Bhaskar, 1993; Das, 1994; Daniels & David, 1996; Das, 1999b; Andrews & Whitaker, 1998; Andrews & Tripathy, 2003; Jayaraj & Andrews, 2005; Andrews & Vaughan, 2005).

Species richness and diversity are very high in areas and islands where intensive surveys and studies have been conducted. Of the 27 species of reptiles and amphibians recorded for Mount Harriet National Park, 12 are endemic and these represent 80% recorded for the Andaman Islands (Das, 1997). Chanda (1996; 1997) reported 120 species of moths for the same park with new additions to the moth fauna of India. The avifauna in Saddle Peak National Park is also diverse; of the 88 species recorded 49 are endemic (Chanda & Rajan,
Balachandran (1998) recorded 393 plant and tree species for Mount Harriet National Park of which 74 are endemic.

Aul (2003) reported 13 species of bats for the Rani Jhansi Marine National Park and this is 50% of the 26 species reported for the Andaman Islands and these included three new records and an endemic. Two freshwater fishes have been recorded from Saddle Peak National Park, a secondary freshwater fish *Sicyopterus microcephalus* could turn out as an endemic, the other species identified, *Belobranchus belobranchusa*, from the same park is a new record for the islands. Likewise, several other species have been from Mount Harriet National Park and some of these will be new species descriptions and new records for the islands (Lim & Das, in prep; Ali et. al., 2002). Turner et. al. (2001) also has reported high coral diversity for this park. They have reported 42-88 coral species around five islands in this national park. Kulkarni, et al., (2000) and Kulkarni, et al., (2004) have reported 222 coral species within the Mahatma Gandhi Marine National Park. Das (1996) has recorded the sea grass meadows in the Ritchie’s Archipelago to be the most extent in the Andamans, with meadow sizes ranging from 300-3000 m long and accounting for the highest species richness, when compared to the rest of the Andamans. Mall, et al., (1987) reported 16 of 34 mangroves species found in the Andamans from Rani Jhansi Marine National Park.

**Marine**

In all, over 1200 species of fishes have been reported from the surrounding seas of the islands and of these 300 are commercial species (Talwar, 1990; Rajan, 2003; Devi & Rao, 2003 b). Rajan, (2003) has reported on the 282 commercially important fish species and Devi & Rao (2003a) recorded 147 species of marine fishes belonging to 33 families as poisonous and venomous, found around the ANI. Rao (2004) has reported over 200 species of reef fishes for the islands and Rajan (2001) has previously reported 43 groupers and 42 species of snappers. Besides, Rao et al., (2000) have reported 539 species of ichthyofauna, including 53 new records for the islands; and Subba Rao & Dey 2000) have reported 1282 species of mollusca from 145 families and 372 genera for the Andaman and Nicobars. 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. Devi & Rao (2003b) have reported 21 species belonging to five genera of surgeonfish and the occurrence of 12 species of rabbit fish. Rao & Devi (2004) have also discussed 33 species of butterfly fish which is 27% of the world species and the same authors have recorded nine species of clown fish and four species of anemones making it one of the most diverse in the world.

Status surveys and studies in these islands have recorded India’s best nesting beaches for three species - leatherbacks, hawksbills and green turtles. The presences of green turtle and hawksbill feeding grounds have also been confirmed (Bhasker, 1993; Andrews et. al. 2001). The hawksbill population in the Andamans and Nicobars are the largest for India and most important for the Northern Indian Ocean region. The leatherback nesting population in the Nicobar is one of the last four large colonies that exceeds 1000 individuals in the Indo-Pacific, and hence of global significance (Andrews & Shanker, 2002; Andrews et. al. 2002).
Flora

The flora and the history of early botanical explorations of these islands was first described by Parkinson (1923), a classic which is now outdated. Floristically, the ANI show elements from the Indo-Chinese and Indo-Malayan and 3552 plants species have been so far reported (Hajra et al., 1999; Sreekumar, 2002; Padalia et al., 2004). Dipterocraps are represented in the Andamans group and are absent in the Nicobars (Chaudhuri, 1992). On the other hand, the Nicobars have tree ferns and other groups of plants that are of Indo-Malayan and Indonesian affinities (Lakshmi-narasimhan & Sreekumar, 1995).

Grant (1895) included some orchid species from the Andamans in his report on the orchids of Myanmar. 110 wild orchids are reported from these islands of which 19 genera with 25 species are endemic. Currently 40 plants species are extremely localized and not known from more than one locality. 85 species are recorded as rare, endangered and threatened, and the World Conservation Monitoring Centre (WCMC) has classified 365 as threatened (WCMC, 1994; Sreekumar, 2002; Andrews & Sankaran, 2002; Jayaran & Andrews, 2005). The IUCN Red List of ‘Threatened Species’ lists 397 animals and plant species for the Andaman and Nicobar Archipelago.

Of the 630 species of higher plants in the Red Data Book, 46 species occur in the ANI (Sinha, 1999). Aroids, ferns, mosses and climbers are mostly conspicuous in the semi evergreen and deciduous forests, besides six species of bamboo and 19 species of cane found in the islands. A recent survey has identified and recorded 406 medicinal plant species including introduced ones, many of which are used by the indigenous tribes (NBRI, 2003).

Ellis (1986) has reported the vegetation for several areas and islands in the Andaman group. Gopal (1990) reported 107 epiphyte species for two localities in South Andaman. Padalia et al., (2004) have discussed in detail the tree species diversity, density and distribution in the Andaman Islands. Srivatsava & Sinha (1995) have discussed 26 poisonous plants from the Andaman Islands. Ellis (1987c) reported 120 species of pteridophytic flora from 36 families for both island groups. Awasthi & John (1987) recorded 51 resource potential species from Great Nicobar Island as having 21 uses and Ellis (1988) and Ellis & Vishnoi (1989) reported some more exploitable plant species. Dixit & Sinha (2001) have reported 37 families representing the fern flora and divided them into three ecological groups; of which 58 are terrestrial species, 31 are lithophytes and 37 are epiphytes.

Dagar and Sharma (1989) have classified the mangrove types into 19 communities and associations on the basis of structure and species composition. Earlier a total of 34 exclusive mangrove species among 17 genera and 13 families was recorded for the ANI (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 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, including seeds and fruits used by the tribal people. Awasthi (1987; 1988) reported over 86 species used by the various aboriginal inhabitants. Tigga & Sreekumar (1996) reported 76 species of wild edible fruits for the ANI and of these, 45 are known to be utilized by the indigenous people of both the island groups.
There are also several introduced species, besides agricultural crops and fruit trees, including Australian trees such as *Acacia auriculiformis* and *Eucalyptus*. Others include large palms, bamboos, fence plants, and ornamental garden plants. Dagar et al., (1989) identified 250 species and Dagar & Gangwar (1989) have reported about *Mikania cordata*, one of the world’s worst weed that has spread in agricultural lands and in forest areas. The same authors have reported 24 other deadly weeds introduced into the islands and their related problems. Balachandran (1998) during a floristic survey of the Mount Harriet NP reported 51 introduced species and more recently Karthikeyan et al., (2004) have discussed the extensive problems of *Limnocharis flava*, a South American species, which is now widespread in the Andaman Islands. The Central Agricultural Research Institute (CARI) has recorded over 600 introduced plant and tree species (Mohanraj et al., 1999).

Gopal (1990) reported 79 epiphyte species on 72 host tree on Mount Harriet; this is in comparison to two other sites sampled where the author found only 29 and 33 species. The same author also reported the maximum epiphyte species found on one host tree from Mount Harriet, of the 107 species recorded for South Andamans 79 were from Mount Harriet National Park.

Sinha (1999) has reported 422 floral genera for the Great Nicobar Island, belonging to 142 families of which 14 % is endemic. Ellis in 1987 reported 120 pteridophytes species for the Andaman and Nicobar Islands, 50% of which is from Great Nicobar Island alone. Of the reported 24 species of rare and six common orchids, eight are found only on Great Nicobar Island (Ellis, 1987) and Sinha et al. (1999) in their study of the great Nicobar Island recorded two more endemic and two genera and four species as new records for India. Currently Gupta et al., (2004) have reported four new records from Great Nicobar Island.

**Endemism**

The complex geological history of these islands and the submergence of land bridges leading to isolation have left the islands with high levels of endemism. The widespread distribution of certain species indicates that there was an early evolution and dispersal throughout the archipelago (Das, 1999). Endemism in reptiles and amphibians appears relative to species richness, islands with larger diversity have greater number of endemics (Das, 1999). This is also evident from recent herpetofauna studies conducted in the Nicobar group of islands (Vijayakumar, 2003).

Among the avifauna, 40% of the 244 species and subspecies of birds are endemic (Sankaran, 1996). In mammals, 60% of the 58 species are endemic; these include bats, shrews and rats. Seven amphibians and 16 reptile species are endemic to the Andamans and two amphibians and 15 reptiles are endemic to the Nicobars (Das, 1994, Andrews and Whitaker, 1998; Das, 1999; Andrews & Sankaran, 2002). The endemic Andaman cobra was only redescribed as a separate species in the 1990s (Wüster, 1996; 1998). More recently, Vijayakumar (2003) has reported three Ranidae as new to science from the Nicobar Islands. The two water monitor lizards found in the Andamans and the other in the Nicobars are being reported as two different species and these could be endemics (Das, *per. com.*). Several species of pit vipers found in the central Nicobar group are not found in the northern and southern groups and several of these could be endemic and are locality specific (Das, 1999; Vijayakumar, 2003).
Representing 700 genera and belonging to 140 families, 14% of the angiosperm species are endemic. The only vanilla, *Vanilla andamanica*, a climbing orchid found in the Andaman Islands is an endemic (Sreekumar, 2002). Of the 648 flora species on Great Nicobar Island, 13.11% are endemic (Sinha, 1999). In butterflies endemism is highly impressive, over 50% (Khatri, 1993). The Andamans have several species of freshwater fishes that are endemic and new to science and, are being reported from specific localities within the Andamans (Lim & Das, *in prep*; Ali, et al., 2003). Thus, considering the size and area of the islands, loss of habitat leading to extinctions will have far greater consequences in terms of the loss of genetic diversity (Andrews & Sankaran, 2002; ANET, 2003).

**Protected Areas**

Being an island archipelago, the designated protected areas in the Andaman and Nicobar Islands are very diverse and encompass unique habitats and complex ecosystems. Protected areas in the islands are as follows; tribal reserves, national parks, wildlife sanctuaries, reserve, protected and preserved forest; and a biosphere reserve. More recently in the year 2000 several areas and islands have been proposed as ‘Important Bird Areas’ (IBAs) and most of these IBAs are tribal reserves or are other protected area and islands.

**Tribal Areas**

An area of 513.70km² along the west coast of South Andaman Island is notified as a tribal reserve for the Jarawa people. This reserve extends north along the same coast into Middle Andaman Island, extending the reserve for another 338. 69 km². A 5 km distance into the sea from the high tide line right along the entire stretch of the Jarawa Reserve is also notified as part of the reserve. Strait Island, 6.01 km² in area, on the east coast of Middle Andaman Island supports a population of 29 of the last remaining Great Andamanese people.

To the south west of South Andaman Island is North Sentinel Island with an area of 59.67 km² and is inhabited by the Sentinalese people. The southern most island Little Andaman Island with a geographical area of 731.57 km² and of this, 706.49 km² with a distance of 3 km from the high tide line and into the sea along the coast has been notified as a tribal reserve for the Onge people.

The entire group of 24 Nicobar Islands is notified as tribal areas; only 1,499.65 ha along the east coast from Campbell bay and up to 35 km is outside the Tribal Area and is inhabited by ex-servicemen, traders, government departments and the residents. Great Nicobar has a total area of 1044.54 km² and of which 853.19 km² is the tribal reserve, for both, the 380 Shompen people and the Nicobarese people.

**Parks and Sanctuaries**

The Archipelago has four national parks in the Andamans, Mahatma Gandhi Marine, Mount Harriet, Rani Jhansi Marine and Saddle Peak National Parks. The Nicobars have two areas notified as national parks and an area in Great Nicobar designated as the Great Nicobar Biosphere Reserve. Within the area of 960.40 km² in Great Nicobar Island, 110 km² is the Galathea National Park, situated on the south east of the island. On the east coast an area of 476.73 km² is notified as the Campbell Bay National Park. An area of 885 km² includes the Nicobar Biosphere Reserve and all these parks are within the tribal area. These parks are unique, very diverse and are important biodiversity hot spots, besides being the last remaining
pristine areas in the archipelago. Some of these national parks needs to be recognised as world heritage sites and some should come under the Ramsar Wetlands.

**Threats and Impacts**

Several authors have reported various threats and impacts to the islands including impacts on the flora and fauna, including threats and impacts on the local indigenous tribal people and their reserves. Whitaker, (1985), Rodgers & Panwar (1988) and Pande, et. al. (1991) have discussed various threats and impacts in the Andaman and Nicobar group of islands, these include deforestation, sand mining, encroachments, bad land use practices leading to siltation and run off that destroy coral reefs. These authors have also discussed the extent of poaching and its effect on local flora and fauna. Saldanha (1989) and Balakrishnan (1989) during their impact assessments of the different ecosystems and habitats of both islands groups have reported impacts of illegal logging and habitat degradation; Sivaganesan & Kumar (1994), Sivakumar (2003) and Ali (2001; 2004) have reported the impacts of feral elephants on island ecosystems. Aul (2002), Sivakumar (2003) and Ali (2004) have discussed in detail on the effects and impacts on the flora and habitats by spotted deer (*Axis axis*) in the Andaman Islands.


The Andaman Islands are ecologically-unique, with high levels of endemism in both terrestrial and coastal ecosystems. The Islands are ecologically very different from the mainland of India. The Islands are home to indigenous tribal communities dating back as much as 20,000 years, remnant populations of which still have only limited contacts with mainstream society. These communities live within Tribal Reserves, which have faced increasing encroachment pressure. Contact with mainstream society has also exposed the tribal communities to a variety of threats including disease outbreaks and poaching of important food resources such as wild pigs.

- There has been a huge settler influx over the last sixty years, due to Government incentives to ‘populate’ and develop the Islands. As part of the settlement program Government provides subsidisation of as much as ninety percent of total costs in key areas including energy and transportation, agricultural inputs and infrastructure.
- Settlers come mainly from agricultural areas of the mainland, and have attempted to bring over traditional crops and agricultural practices (e.g. rice farming) which are not wholly suited to the ecological context of the Islands.
- Settlers generally see themselves as temporary migrants earning a livelihood, intending to return to their ancestral villages in the mainland. Thus they often have no
strong sense of identity with the Islands, or awareness of the uniqueness of the ecosystem they are living within.

- The thrust of economic development over the last half-century has been forestry and agriculture. Agriculture mainly consists of rice, bananas and other tropical fruits, and some spices. Some rubber and oil palm plantations have also been developed. Until recently forestry formed the backbone of the Islands’ economy.

- The Forestry sector has been one of the main sources of employment, livelihoods and Territorial Administration revenue in the Islands. It dates back more than a century and by the late 1990s more than 75,000 cu.m. of timber was being logged annually, approximately seventy percent of which was being exported as plywood.

- However in May 2002, to preserve the unique ecology of the islands, the Supreme Court of India ordered that commercial logging should cease and licenses of saw mills and all wood-based industries are to be revoked as of 31st March 2003.

The abrupt cessation of logging activity and closure of wood-based industries has forced the Administration to quickly identify new sources of jobs and economic development. The Island Development Authority has developed a strategy with four new thrusts of development for the Islands:

- Eco-tourism
- High-value agriculture
- Deep-sea fisheries
- Deep-sea oil and gas exploration
- Of these four sectors, the three that most directly impact the terrestrial and coastal ecology of the Islands are Deep-sea oil and gas exploration, eco-tourism and high-value agriculture.

**Research and information sharing**

The development of effective conservation strategies depends upon a sound understanding of the diversity, distribution, abundance and ecology of the islands’ flora and fauna. Apart from its research projects, the requirements and feelings of the islanders needs to be studied, to help develop practical and culturally acceptable means of sustainably utilizing the islands’ natural resources. This enables the partner organisations to share ideas. Expertise and equipment, and ensures that agencies are kept abreast of current research in this region.

**Alternative employment**

The rainforest flora and fauna of the Andaman and Nicobar Islands are both diverse and unique, with affinities to Assam to the north, the Malayan Peninsula to the east and Sumatra to the south. Propagation of rare and endemic plants to provide seedlings for villagers, school children, the Forest Department and environmental NGOs to reafforest degraded land and public areas. Nursery work can be chiefly undertaken by local women.

As the single largest collection of Andaman and Nicobar flora, the arboretum will also provide an opportunity for training local people and visiting scientists to identify plant
species, enabling them to assist with much-needed field surveys. It will be open to the public, to promote environmental awareness.

Collaboration

Networking with other scientists and environmental agencies, including: the Wildlife Institute of India (Dehra Dun), the Zoological Survey of India (Calcutta), the Indian Institute of Public Administration, the Indian Social Institute, Kalpavriksh, World Wide Fund for Nature, TRAFFIC-India, Development Alternatives (all in New Delhi), M.S. Swaminathan Research Foundation, Dept of Anthropology, Madras University (Chennai), the Auroville Index Seminum, Centre for Scientific Research (Auroville, Tamil Nadu). Within the Andamans, Save Andaman and Nicobar Islands Environment (SANE), Local Borns Society, Rotary Club, the Zoological Survey of India’s Island Museum and the Botanical Survey of India, Port Blair are some of the partner groups.

Environmental Education Programme

Conservation work in the islands is unlikely to succeed in the long term without the support of the local people. Recent studies by ANET researchers have revealed a worrying lack of understanding or appreciation for the islands’ natural ecosystems among the settlers, many of whom were raised in mainland cities. Some even consider that the presence of wilderness indicates a lack of progressive development. The objectives of the programme that will target schoolchildren, teachers, farmers and fishermen (primary target group) and administrators, the militia (including the Indian Navy), tourists and other islanders (secondary target group), are:

- To teach local people of the “workings” of the fragile island environment and help them understand the dangers of putting too much pressure on natural resources;
- To instil a greater level of environmental awareness; to encourage people to appreciate nature and take an active interest in conserving the islands’ wildlife and habitats;
- To support and train local teachers and naturalists so they can build upon the conservation efforts;
- Organise nature camps, walks and workshops for all age groups;
- Establish a network of environmental education activators and educators, especially women, throughout the islands;
- Educate students with the aid of innovative audio-visual materials, including purpose-made videos. ANET researchers and visiting biologists will be encouraged to share their knowledge of island habitats or species by participating in such presentations;
- Initiate street theatre, puppetry, media events and competitions;
- Organise seminars and formal get-togethers on environmental themes; for logistical reasons the main thrust of this programme will initially be directed at schools and villages in the Andamans, but will ultimately extend to the Nicobars as more educators become enrolled;
• Establish a special conservation fund to give small grants to support conservation projects by the local people.

Vegetation and wildlife mapping, systematic research

Rainforest and Mangrove Plants- The continuation of a detailed study of the distribution and abundance of tree species. This survey will later be extended to orchids and other herbaceous plants. Further investigation will also be made on systematics, phenology, biogeography, conservation, and exploitation of these plans by local communities, based on observations, interviews and market surveys.

Freshwater crustaceans, Molluscs and Fishes- There is little data available on the freshwater crabs, prawns and snails of the Andaman Islands, nor of the freshwater fishes found in hill streams. Information on patterns of exploitation is lacking as well, and many groups are of nutritional importance to the islanders of the highlands.

Giant Robber Crabs- The world’s largest land crab, the so-called Robber or Coconut Crab (Birgus latro) occurs in both the Andamans and the Nicobars. At certain sites, densities are very large (Bhaskar and Rao, 1992). Anecdotal remarks on its biology have been made based on studies on these islands by Daniel and Premkumar (1968) and Davis and Altevogt (1976). Exploited as food by the settlers, this species is not threatened at the moment, but will be if proposed road constructions (cutting through primary forests) take place, and if the influx of settlers continues. An autoecological study of this incredible species, which ascends coconut trees to break buts and then dehusk and eat the meat, is planned.

Sharks and Coral Reef Fishes- Harvesting shark fins, chiefly for export, is a relatively new but rapidly expanding industry in the A&N Islands. A survey on the exploitation of sharks is urgently required, as are comparative studies of the fish communities in coral reefs in different parts of the islands, and under differing levels of environmental pollution and human interference.

Reptiles and Amphibians- A large but neglected component of the rainforest fauna. Over a third of the known reptile fauna (currently 75 species) are endemic and further research is urgently required to document their distribution and abundance before formulating action plans to conserve the rarer species. Many new species of frogs, lizards and snakes were found during the first phase of the project, and the inventory of the herpetofauna of the archipelago is far from complete. The Andaman and Nicobar archipelago contains India’s best nesting beaches for the endangered leatherback, hawksbill and green turtles as well as important sites for the olive ridley turtle. Feeding grounds for the green and hawksbill turtles have also been reported. Several researchers will be involved in an ongoing study of these threatened animals, with special attention to the leatherback turtle. One of India’s largest surviving populations of saltwater crocodiles inhabits the islands’ mangrove creeks.

Endemic Birds- In all, 95 species (or nearly 40 percent of the fauna) of birds are endemic to the Andaman and Nicobar Islands, but few have been studied. ANET intends to coordinate studies on the ecology and distribution of the scarcer forest endemics, and has, in the past, conducted a study of the critically endangered Andaman teal (Anas gibberifrons albogularis), a denizen of wetlands within rainforests.
Bats- Bats play a crucial role in rainforest ecosystems as pollinators and seed dispersers, their activities valued at millions of dollars annually (Fujita, 1988). In all, 17 species of bats have been recorded in the Andaman and Nicobar Islands, of which eight are endemic. Few islands have been surveyed however, and a better understanding of the bat fauna is essential before conservation efforts can be implemented. Location and protection of major roosts and understanding the role of species in the ecosystem are a priority.

Pigs of the Andamans and Nicobars- The Andaman Pig (Sus scrofa andamanensis) is endemic to the islands’ forests. It is under serious threat from hunting and, possibly, competition with three species of introduced deer. A population census, an ecological study and an assessment of its human exploitation are activities that are planned. The Nicobarese Pig (Sus scrofa nicobaricus), on the other hand, is believed to be introduced, probably from the south-east Asian mainland for food. There are little data on wild populations, although population declines have been reported (Bhaskar and Rao, 1992). The dependence of the Nicobarese, the Shompens and the settlers on this species are subjects of ethno-zoological interest.

Endemic Small Mammals- Several species are endemic to the islands such as the Nicobar tree shrew (Tupaia nicobarica), an unusual primate found only in the islands’ rainforests; the Andamans spiny shrew (Crocidura andamanensis); Jenkins’ spiny shrew (C.jenkinsi) and the Rogers’ rat (Rattus rogersi). Studies of the distribution, ecology and conservation status of these small mammals are urgently required, as are systematic information on relationships. For instance, studies on the rats, shrews and bats undertaken in Mount Harriet have indicated serious problems with systematics of several groups, which have important practical consequences (such as species identification and species counts from these islands).

Marine Mammals - The status and occurrence of the large marine mammals (dugongs, dolphins, whales) off the waters of the Andaman and Nicobar Islands are poorly understood (see Bhaskar, 1994; Jones, 1967; Rao, 1990). Many species, such as the dugong (Dugong dugon), are actively hunted for meat as well as for fat; and have been locally extirpated in sites of former abundance (including Dugong Creek in Little Andaman Island). A population census and ecological study of the rare dugong or sea cow is required, in conjunction with an assessment of current hunting pressure based on interviews with islanders.

Coral Reefs- The Andaman and Nicobar Islands are fringed by numerous reefs, but many are under threat from siltation (by soil run-off due to deforestation), sewage pollution, effluents from the timber industry, and explosives (used in fishing and to create navigation channels). Once destroyed, these reefs will take hundreds of years to regenerate. Research and conservation programme will further examine the ecology of these reefs, including follow up studies of human impact.

Mangroves- The Andaman and Nicobar Islands together support 1,150 sq. km of mangroves, which protect the land from erosion and are essential for numerous species, including commercially and ecologically important fish and crustaceans. This programme will include a follow-up study of the effects of pollution on these fragile and threatened ecosystems.

Introduced species

Island biota which has evolved in isolation can be susceptible to even minor ecological interference, such as the introduction of exotic flora and fauna. Unfortunately, many
potentially destructive species have intentionally or unwittingly been introduced to a large number of the A&N Islands, including spotted deer, rats, giant snails, elephants, goats, common mynas and invasive weeds such as *Lantana*. The general objectives of the programme are:

- To document the distribution and abundance of introduced flora and fauna;
- To assess the impact of these species on the native wildlife;
- To assess the feasibility of selectively removing detrimental introduced species without further endangering native flora and fauna.

**Ecotourism**

Ecotourism can generate employment of residential people as park wardens, trackers, boatmen, interpreters and guides, thus creating a positive ‘vested’ reason for the protection of the area in its natural state for all time by the local populace. Resident people employed in reserves in preference to outsiders also help keep locally generated wealth within the community.

- Investigate appropriate avenues of ecotourism development for the island, keeping in mind the impact of tourism on the islands’ resources;
- Assess the potential for employing local people in ecotourism as naturalists, guards, guides, caterers, boat crew, etc and as they already have some infrastructure is not difficult to operations outside protected areas.

* * * * *
1.2 The Lakshadweep Islands

The Union Territory of Lakshadweep comprises of a group of islands in the Arabian Sea between latitude 8° and 12° 30’ N and between longitude 71° and 74° E. There are in all 27 islands, 3 reefs and 6 submerged sandbanks. Only 10 islands are inhabited (Agatti, Amini, Andrott, Bitra, Chetlat, Kadmat, Kalpeni, Kavaratti, Kiltan and Minicoy) and one island (Bangaram) has a tourist resort only.

Each island is fringed by coral sands, and is marked by huge, shallow, calm lagoon on the western side which separates it from incoming swells of the outer sea by the wall of a reef made-up of massive coral boulders and live corals.

A common feature of these islands is that a shallow lagoon exists invariably in their western side separating the outer reef rim from low-lying coral islands composed essentially of calcareous sand and soil. The total geographical area of the territory is 32 sq. km. All land is classified as agricultural land and the land use area is 28.5 sq. km. The lagoons cover 4200 sq. km. with 20,000 sq. km. of territorial waters and about 0.4 million sq. km. of Exclusive Economic Zone (EEZ). Length of coastline of UT of Lakshadweep is 132 km.

Recent study made by Centre for Earth Science Studies (CESS), Thrivunanthapuram, indicates that elevation of the Lakshadweep islands range from 0.5-7.0m above mean sea level. Considering the low elevation levels, it is imperative that the danger from storm tides is tremendous.
**Origin of Lakshadweep Islands**

The origin of Lakshadweep Islands is attributed to theory of Sir Charles Darwin, the renowned evolutionist according to whom the origin of these Islands can be traced to gradual submergence of some of the volcanic ridge into the Indian Ocean followed by accumulation of coralline deposits on the peaks and craters of these mountains. These deposits grew into coral islands resting on submerged mountaintops over a period of time. The islands are mostly coralline and their alignment appears to be in continuation of the Aravalli Strike of Rajasthan.

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**History and Background**

The Lakshadweep means a hundred thousand islands. This spectacular Island group is believed to have been discovered by shipwrecked sailors during the reign of Cherman Perumal, the legendary king of Kerala in the 4th century A.D. Before moving into the hands of the British, Tipu Sultan held sway in the Islands after defeating the oppressive rulers of Arackal.

The Union Territory was formed in 1956 and was named Lakshadweep in 1973. All the Islands now constitute one district for Administration with four Tehsils. The Administrative Head Quarters is at Kavaratti with the Administrator as the Head of the Union Territory. Each Island has a democratic set up with elected members. At Union Territory level, there is a District Panchayat with members elected from each village /Dweep Panchayat

**Location**

These Islands are located in the Arabian Sea between latitude 8° and 12° 30' N and between longitude 71° and 74° E at a distance ranging from 200 km to 400 km from Kochi-the mainland of Kerala coast.

The islands are grouped into clusters as follows:

**Aminidivi group:** (consisting of 5 inhabited islands)

1) Amini 2) Kadmat 3) Kiltan 4) Chetlat 5) Bitra

**Laccadive group:** (consisting of 4 inhabited)

Minicoy group: (consisting of 2 islands)

1) Minicoy, 2) Veiningili (only Minicoy is inhabited)

Submerged Reefs

1) Beliapani (Chebeniani) 2) Cheriapani (Byramgore) 3) Perumul Par

Submerged banks

1) Bassas de Pedro 2) Sesostris Bank 3) Cora Divh 4) Amini Pitti and 5) Kalpeni Bank

Geographic Features

There are in all 27 islands, 3 reefs and 6 submerged sandbanks. Only 10 islands are inhabited namely Agatti, Amini, Andrott, Bitra, Chetlat, Kadmat, Kalpeni, Kavaratti, Kiltan and Minicoy.

The total geographical area of Lakshadweep Islands is 32 sq. km and the land use area is 28.5 sq. km. Length of coastline of UT of Lakshadweep is 132 km. The lagoons cover 4200 sq. km with 20,000 sq. km of territorial waters and about 0.4 million sq. km of Exclusive Economic Zone (EEZ).

Lakshadweep Islands are located at a distance ranging from 200 km to 400 km from the mainland.

Geomorphology

The Lakshadweep Ridge approximately 800 km long and 170 km wide is a fascinating and conspicuous feature of Arabian Sea. It is inclined southerly (1/715-gradient) with a narrow strip (10 km) near Goa and widened to 170 km west of Cape Comorin. This domain is distinct with scores of islands, banks, and shoals, topographic rises, and mounts, intermount valleys and sea knolls.

Notable feature of the individual island of the ridge is that the relief of all the islands above MSL is uniformly low (4-5 m). However, height of the submerged banks and shoals varies considerably. Based on the structural features, trends of the individual islands, geophysical anomalies and related faults/ dislocations, Lakshadweep islands are classified into northern, central and southern blocks. All the important islands fall in the central block separated by Bassas de Pedro fracture in the north and a NNE-SSW trending valley in the south. The northern block is dominated by coral banks and southern by few islands and small banks.

The western slope of Lakshadweep Ridge is restricted to 2500-4000 m depth and foot of the slope increases from around 4000-4600 m in the south. Topographic rises of significant height (500-1300 m) are recorded in the slope domain. At many sections, the slope has a faulted contact with abyssal plain. Continental rise is present but only distinctly developed throughout the area.
Climate

Since these Islands are located within the tropics and extend to the equatorial belt, they have a tropical humid, warm and generally pleasant climate becoming more equatorial in the southern islands of the territory. Temperature varies from 28° to 32° C and relative humidity of 70-75%. From the point of view of temperature, the climate is equable and no well-marked distinct seasons are experienced.

Southwest monsoon is the rainy season, which extends from June to October with 80-90 rainy days a year. The average rainfall is 1640 ml. Annual rainfall decreases from South to North. Winds are light to moderate during October to March.

Biodiversity

The Lakshadweep Islands have a vast expanse of the blue sea with precious heritage of ecology and environment. These Islands are rich in marine wealth and an abode of plethora of coastal and marine bio-diversity with pristine Coral Reef Ecosystem which support variety of ornamental and food fishes belonging to various species besides the sedentary and slow moving creature such as Sea Cucumbers, shelled animals (Molluscs) and Hermit Crabs, Lobsters and Shrimps.

The other marine organisms which are occasionally seen include Rays, Flying Fishes, Turtles and Dolphins. The common farm species which are tend by the people are Cows, Goats, Ducks and Hens. There are no dogs and snakes. A few Islands have Crows. Common Sea birds are Tarataihi (Sterna fuscata) and Karifetu (Anous folidus) the former being the state bird. Most of the birds nest on an Island called Pitty- a bird Sanctuary.

The flora of Lakshadweep mainly consists of palm trees with coconut as the only commercial crop. The other shrubs locally known as Kanni, Cholam, Chavok, Punna and Cheerani characteristically borders the base of coconut palms. Ipomea is a conspicuous ground runner, which place a strong role in preventing erosion of the Islands.

Bleaching event of 1998 due to El-Nino has been reported to have damaged 70% of corals in Lakshadweep Islands. The other potential threats to coral reef include marine
pollution due to oil slicks, disposal of untreated sewage and dumping of non-biodegradable solid waste into the marine ecosystem.

**Demographic Features**

According to 2001 Census, the inhabited Islands had a total population of 60595 covering 31,118 males and 29,477 females with a ratio of 947 females per 1000 males. The density of population per sq. km is 2253.

Socio-economic profile of these Islands indicates 885 families below the poverty line. The literacy rate is 87.52 which is higher in males (93.15) compared to females (81.56). Similarly, literacy rate is higher in the urban population compared to the rural population. The women of the Territory enjoy a higher social status and economic free than their counterparts elsewhere in the country. The matrilineal route of inheritance through the female keep the women folk independent. The predominance of women in every walk of life is a noteworthy feature in Minicoy.

The islands are directly in the trade route between Africa, Arabia and Malabar. The main livelihood of the people depends on coconut and fish. The traditional industry revolves around tuna, coir, vinegar, jaggery and copra making. Although boat-building industry has suffered, the traditional skills still exist. The people of Kavaratti have considerable skill as stonemasons and carpenters. Coir base industries are also one of the oldest areas of activity. Minicoy is an important center for tuna fishing and tuna canning factory is located there.

**Threats**

Coastal erosion is one of the serious problems being faced by the Lakshadweep group of islands. Studies on baseline data on erosion and the accretion cycle were carried out by the Center for Earth Science Studies (CESS), Thiruvananthapuram, in 4 islands viz. Kavaratti, Agatti, Amini and Bangaram during 1990-1993 and for other 4 islands viz. Kadmat, Chetlet, Kiltan and Bitra during 1997-2001. Major part of the Kiltan island has been undergoing erosion on the east coast. It is observed that South West and South East positions experience critical erosion whereas the North East position of the islands shows seasonal erosion/accretional behaviour.

Thunderstorms mostly occur in the months of April to June and October and November. Squalls though occasional, are more frequent in the northern islands than in the south. They occur in association with thunderstorms in May and during the southwest monsoon season. A few of the cyclonic depressions and storms, which form in the south Arabian Sea during April and May, affect the weather over the territory. During the post monsoon months of October to December also, a few of such systems originating in the Bay of Bengal and travelling westwards emerge into the south Arabian Sea, and occasionally affect these islands. In association with these, strong winds are caused and heavy rains occur. According to the available information for 115 years reveals that 27 storms and depressions have affected the Lakshadweep region during April -December.

Lakshadweep Islands are one of the low-lying small group of islands in the world and accordingly face the risks of inundation of sea water due to anticipated sea level rise, inundation of seawater due to storm surges as well as inundation of seawater due to Tsunami.
waves. These threats are associated with several uncertainties like the global warming leading to sea level rise, which is a slow and long-term process.

During 1998 the strongest El Nino was recorded in Lakshadweep islands leading to rise in temperature in a range of 3-5° C above normal which resulted into severe coral bleaching, with mortality rates as high as 90% in some parts of these Islands. Rising sea levels may also lead to potentially acute erosion.

The devastation by the cyclone in many areas in the island resulting in uprooting and twisting of coconut trees, blowing away of roof tiles, damages to the buildings, loss of domestic animals etc. was also noticed. The coir factory on the western side was submerged due to floodwater run-off.

The Lakshadweep islands are directly on the trade route between Africa, Arabia and Malabar. This has resulted into a dramatic increase in passenger and cargo traffic of sailing vessels. These passenger and cargo ships dump untreated waste into the sea around the islands as well as discharge waste oil leading to severe pollution and damage to the coral reef ecosystem.

Studies carried out by CESS under the project of Coastal Ocean Monitoring and Prediction System (COMAPS) indicate that the coral reef ecosystem is subjected to stress mainly due to anthropogenic pressures.

Assessment of vulnerability of Lakshadweep Islands to both the natural and man-made hazards becomes multifold mainly due to their insularity, remoteness and geographical isolation from the mainland. Similarly, small size of these islands also acts as a barrier leading to high levels of vulnerability.

As the islands lie scattered in the Arabian Sea, whenever a natural calamity occurs, the lifelines of these islands viz. communication and transportation are disrupted and the link between mainland and islands becomes non-functional. Since ship is the only mode of transportation for the local people it cannot ply between the islands during the period of disaster and the local people get stranded at their respective places. Similarly, the embarkation/disembarkation from ship to shore also gets disrupted because of the high seas and high-speed wind. The houses are also prone to damage caused due to the high-speed wind and falling of coconut trees on it.

Other factors which contribute to vulnerability of these islands to natural and man made hazards include social and economic backwardness of the indigenous population as well as fragile ecological, environmental and ecosystem status which directly affect their livelihood security due to hazards.

As per the recent Census Report (2001), Lakshadweep has the third largest population density in the country. This leads to limited carrying capacity of these Islands in terms infrastructure and their dependence on natural resources.

The main livelihood operations for the people of Lakshadweep are coconut cultivation and fishing, both these activities at the time of calamities get disrupted. The uprooting of coconut trees and loss of standing coconut crops sets back the economy of Lakshadweep immediately for a minimum period of 2 years. Since fishing is not possible during such times, the people suffer immediate losses to their day-to-day livelihood options. In the longer run losses to physical and social infrastructure sets back the pace of development.
Tourism is an important source of income for the islands population, and Lakshadweep is becoming increasing popular with both domestic and foreign tourist their numbers and activities need to be carefully monitored and controlled as they cause a threat to the ecology of the island. Carelessness by tourists can disturb the habitat of corals due to walking on the reefs, anchoring of boats as well as release of untreated sewage and disposal of garbage as well as non-biodegradable solid wastes. Similarly, tourism related infrastructure development may also affect carrying capacity of these islands leading to pressure on natural resources. In addition destructive practices such as coral mining, dredging of navigational channels, unsustainable fishing practices, coastal development and souvenir collection are some of the major causes of environmental degradation on Lakshadweep islands.

From the foregoing account, it is evident that Lakshadweep islands are at risk from the natural hazards like storms, cyclones, sea level rise, rainfall and the associated factors like winds, waves, atmospheric pressure, storm surges, tsunamis, etc. In such events, the islands are likely to be inundated due to these forces and because of their low elevation levels from MSL.

Hence a detailed, holistic study has to be taken up for assessment of the storm surge heights and the areas that are likely to be inundated based on historical and recent data on various parameters. It is therefore proposed that studies on Storm surge modeling, Tsunami wave propagation modeling, inundation mapping and areas of inundation at different scenarios may be taken up through the institutions actively involved in these activities.

* * * * *
Chapter 2: Coral Reefs

Coral reefs have long been recognized as one of the most spectacular ecosystems on Earth, forming a broad belt around the subtropical-tropical zone that is even visible from space. Any geologist or biologist knows that corals are found in shallow, well-lit, nutrient-poor tropical seas where the polyps are packed with symbiotic algae that provide them with energy, help them to grow and produce the calcareous skeletons that eventually form limestone when they die. Tropical coral reefs form complex habitats that act as centres of evolution in providing opportunities for species specialization. These coral reefs support some of the most diverse species assemblages in the marine realm. The survival of shallow-water tropical reefs is currently causing great concern internationally which may be linked to human-induced climate change, and other threats. To use tropical coral reefs as an example, it is estimated that 60 per cent of reefs are seriously at threat from human activities (Cesar et al., 2003).

We live in a complex world where change is happening at ever increasing speeds and nothing can be dealt with in isolation from the forces that affects it. Increasing globalisation has meant that what happens in one place of the world affects other parts far away. Climate change is one example of the outcome of these global forces, which threatens to disrupt and alter much of the world around us.

Coral reefs are one of the early indicators of this change; they are fragile and respond quickly to adverse pressures. These pressures are increasing and coral reefs are coming under greater threat. Their decline is a warning to us all.

<table>
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<tr>
<th>High biodiversity and productivity</th>
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<tr>
<td>Coral reefs support high levels of biodiversity and biomass in tropical regions where the surrounding ocean is comparatively barren. The productivity associated with coral reefs is estimated to be higher than any other ecosystems, but varies according to the health of the reef and the reef area and region in question.</td>
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</tbody>
</table>
Coral reefs are not just valuable as indicators of change; they have intrinsic value and contribute to local and global economies. Recently this has been widely studied and reported, improving our perception of the significance of reefs. While we may value coral reefs as an important part of our global environment, many people depend upon reefs for their very survival. These people include some of the poorest in the world and they derive many benefits from coral reefs that enable them to sustain their impoverished livelihoods in spite of great difficulties. They benefit, not just from the food the reef provides, but also in many other ways that contribute to the physical, social, economic, spiritual and cultural aspects of their lives. These benefits are complex and we are only just beginning to fully appreciate their relationships with and importance for the poor.

**Andaman Islands**

On the Andaman Islands during the rough weather season months, from June to October, distant fishing grounds and offshore areas are inaccessible. However, nearby reefs can still be reached and assure a source of income, and protein, throughout the year, providing an important alternative to vegetable protein sources which increase in price during the rough weather season.  
(Singh and Andrews, 2003)

Whilst we all agree that coral reefs need to be protected, we also need to improve our understanding of the complex relationships between the poor and reefs and to ensure that conservation is carried out in equitable ways. Much attention has been given to coral reef conservation, but at times this has taken place with the exclusion of the local people, who depend on coral reefs. As acknowledged everywhere, if we are to achieve our common goal of equitable and sustainable development it is now imperative that greater emphasis is placed on the increasing inequalities and importance of human and social development. The poor have much to teach us about the environment that they live in and we can benefit greatly from working in partnership with them.

**Gulf of Mannar**

The husband of a local woman was a fisherman. He was forced to give up fishing because of abdominal cancer of which he died. Since then all the four children in the household had to depend upon the sole income of their mother. When her husband was active and alive, there was no need for her to go to the sea. When her husband was diagnosed as a cancer patient, for a month she could not do anything. She thought of committing suicide. But the mother sea consoled her by saying ‘Come, I am here to take care of your family’. She decided to work in the sea. She harvests seaweed and shells from the reef flats, she is knowledgeable about the various types of species and which can be exploited for income.  
(From: Rengasamy et al., 2003)

Reefs are mainly found in developing countries where a substantial proportion of the population is living in poverty. Dependence on coral reefs, particularly subsistence fishing, is often quoted as being vital to the livelihoods of many poor indigenous coastal communities but what that dependency consists of is unclear.

Coral reefs differ from many other coastal resources used by the poor in that they can not so easily be ‘occupied’ and alienated from public access for purely economic motives in
the same way as many other coastal resources. Their shallow and complex physical structure and high biodiversity do not lend themselves to intensive exploitation and economies of scale, so they often remain ‘open-access’ even when other coastal resources have been ‘privatised’. This, however, is changing as tourism and conservation laid claim to large areas of reef. The accessibility of coral reefs provides important opportunities for the poor, including the young, old and women, to directly harvest resources on foot and by hand, or using simple, cheap and locally available technology. For female-headed households and widows, who are frequently some of the poorer and more marginalized households in the communities, the accessible reef resources provide a vital source of food and income. Significantly, the principle threats to poor people’s access to coral reefs are the degradation and disappearance of the reefs themselves.

<table>
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<tr>
<th>Coral reef products</th>
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<tr>
<td>Coral reef resources provide a diversity of products for consumption, both for those living on the coast, inland communities and increasingly by people in developed countries, living far away from the reef itself. In many coastal communities adjacent to coral reefs, the reef provides the only accessible source of protein for the poor. Small discards and damaged fish are often crucial sources of cheap or free protein for the elderly and poor female-headed households. Dried reef fish are often an important trading commodity between the coast and inland communities and provide valuable protein sources to households inland.</td>
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A diversity of different people worldwide depends on coral reefs for many different reasons. Many millions of these people are poor and for them the coral reef represents an important resource which contributes to many aspects of their livelihood. However, the ability of the reefs to provide income and food security and buffer seasonal and periodic hardships is being eroded. Coral reef ecosystems are extremely sensitive to change and easily suffer from disturbance. Reef degradation is removing many of the benefits on which the poor depend, climate change threatens further loss, and well-meaning polices aimed at conserving threatened reefs are often excluding the poor from access to benefit flows. The impact of these changes varies between different stakeholders, but in general the poor are finding that their livelihoods are being stressed more than most and they are the least able to respond.

The policy formulation and implementation environment surrounding reef-dependent people is only partially focused on those people; the main emphasis is on reef conservation. Many of the key national institutions and initiatives concerned with coral reefs are those whose primary objective is nature conservation. There is a considerable short-fall in the required skills, awareness, attitudes and institutional orientation required to respond effectively to reef-related poverty. However, there is a growing awareness of this deficiency and recognition that coral reef conservation cannot meet its desired objectives without better consideration of poverty issues and the sustainable livelihoods of the reef-dependent poor. This change in thinking has also been encouraged by the shifting priorities of international donor agencies and governments towards poverty alleviation.

There is an urgent need for guidance and support amongst coral reef scientists, agencies and initiatives to assist the changes needed to address poverty and reef-related issues more effectively. Unless this is achieved in the near future many poor people will confront greater levels of hardship than they have faced before and many coastal communities above
the poverty line will start to fall into poverty. There is a need for a major drive to re-orient the current approaches to reefs and reef-dependent people.

At the macro-level there is a need for a change in the national policy framework that shifts the focus from reef conservation to the sustainable and equitable use of reef ecosystems where poverty reduction is a central theme rather than a means towards an end. This requires a large degree of awareness raising, consensus building, policy reform and the uptake of a new array of policy instruments. These need to be based on a much better understanding of the issues facing the reef-dependent poor. There is a growing willingness to accept this kind of reform but a lack of coordinated understanding about how to achieve it. Support at the macro-level is also required to reflect the interconnected nature of reef problems and to deal with the interstitial and dispersed nature of reef-dependent poverty.

**Gulf of Mannar**

In the Gulf of Mannar, coral reefs fringe a chain of 21 coralline islands, sheltering mangroves, lagoons and a shallow ‘trapped sea’ with extensive seagrass beds. This mosaic of coastal ecosystems forms the basis for sea-based livelihoods among the coastal communities, including the extraction of seaweed, shells, lobsters, sea cucumbers and reef fish from the reef flats and lagoons; and the harvest of crabs, squid, fish and shells from the seagrass beds and ‘trapped sea’ between the islands and the mainland coast.

For the coastal people of the Gulf of Mannar coral reefs are perceived as part and parcel of the ocean, as expressed below:

- ‘It is the reef from where everything sprouts and spreads throughout the entire sea’.
- ‘The reef is a natural nursery’.
- ‘It is because reefs are there and its fertility, we get different varieties of fish to catch and we have to keep different nets’.

(From: Rengasamy et al., 2003)

**Lakshadweep**

On the Lakshadweep Islands, the shallow reefs and lagoons provide a constant and stable food and income source all year around, even during bad weather, and provide the only protein source for the poorest households, who are unable to stock up with food prior to the monsoon (Hoon, 2003).

At the meso-level there is a need for substantial capacity building in coastal community development and poverty reduction approaches. This applies not only to governments in states where reef dependence is an issue, but also to local panchayat/intergovernmental and NGO agencies concerned with these issues. Many of the approaches that need to be applied have still to be developed, some are currently being developed and others exist but need to be brought together and applied to reef issues.

At the micro-level there is much to be done in understanding the nature of reef-dependent poverty. There is already a large amount of information out there but this has rarely been brought together to provide a cohesive body of knowledge that can inform policy. The poor have even more to teach us about the way they live with, use and manage their reefs.
**Gulf of Mannar**

‘Take for example the lobster that we catch in the reef area. People associated with the production, marketing and mending of the gears and nets, fishermen, merchants, processors, people managing cold storage, export and inland distribution, it is unimaginable to comprehend all these people and their activities. Before a piece of fish is taken by a consumer, it generates a chain reaction, it creates social relations, it throws open lots of opportunities for various groups of people; a fish sacrifices itself to sustain the human life.’ (From: Rengasamy et al., 2003)

From this, new approaches in XI Five Year Plan to sustainable livelihoods, livelihood enhancement, poverty reduction, and reef management can begin to be developed.

India is one of the lower ranking Medium Human Development countries, with over a third of its population living on less than 1 US$ a day. Coastal areas are heavily populated, but coral reefs are limited to two main areas off the mainland coast: the Gulf of Mannar, in the south; and the Gulf of Kutch, in the northwest, with the remaining reefs associated with the remote islands of Lakshadweep off the west coast and the Andaman and Nicobar Islands off the east coast. Reef fisheries have been estimated to contribute to 5–10% of the total marine landings (Pet-Soede et al., 2000; White and Rajasuriya, 1995, respectively), and contribute significantly to the subsistence and income of coastal fishing communities in the four reef areas. Estimates of the numbers of small-scale fishers, amount to 21,000 in the Gulf of Mannar and 20 000 in the Andaman and Nicobar Islands (Rengasamy et al., 2003; Singh and Andrews, 2003). On Lakshadweep where the reefs form the foundation of the lowlying coralline islands and home to 60,595 people, tuna fishing relying on bait fish from the reef constitutes a major part of the local economy and reef harvest is the main source of subsistence for poor households (Hoon, 2003.)

**Lakshadweep**

On Agatti Island, Lakshadweep, the practice known as *Kal moodsal* is a simple activity carried out by children and adults close to shore, at low tide, throughout the year in the shallow eastern lagoon. A simple small cast net, a leaf bag and plastic slippers are all that are required to undertake this activity, which can yield 10–12 small fish (approximately 1 kg) for household consumption. Cast nets, known as *Beesh Bala*, are not expensive and all the households in Agatti own at least one. The boats operated in the lagoon and near shore reef are small non-mechanized traditional wooden rowing boats, known as *Dhonis*, or rafts, known as *Tharappam*. These are constructed locally and have low running costs.

(From: Hoon, 2003)

The coral reefs are classified depending on their locations into fringing, patch, barrier and atoll. All the three major reef types occur in India (atoll, fringing and barrier). Within these habitats some of the most diverse, extensive and least disturbed reefs exist in and around the Indian subcontinent. To this day, many of these reefs are largely unstudied. The mainland coast of India has two widely separated areas containing reefs: the Gulf of Kutch in the northwest, which has some of the most northerly reefs in the world, and Palk Bay and Gulf of
Mannar in the southeast. In addition to these, there are patches of reef growth on the West Coast, for example coral reefs at Malvan. The Andaman and Nicobar Islands have fringing reefs around many islands, and a long barrier reef (329 km) on the west coast. Little is known about these reefs, which may be the most diverse and pristine reefs in India. The Lakshadweep also has extensive reefs but these are also poorly explored.

The fringing reefs are contiguous with the shore and they are’ the most common –by occurring reef form, found in Andamans. Patch reefs are isolated and discontinuous patches, lying shoreward of offshore reef structures as seen in the Gulfs of Mannar and Kutch. Barrier reefs are linear offshore reef structures that run parallel to coastlines and arise from submerged shelf platforms. The water-body between the reef and the shore is termed as lagoon. Barrier reefs are seen in Nicobar and Lakshadweep. Atolls are circular or semi circular reefs that arise from subsiding sea floor platforms as coral reef building keep ahead of subsidence. The examples are the atolls of Lakshadweep and Nicobar. When the reef building does not keep pace with subsidence, reefs become submerged banks as seen again in Lakshadweep.

Indian coral reefs are mainly in the Andaman & Nicobar and Lakshadweep Islands. On the main land, coral reef formations are found in the Palk Bay, Gulf of Mannar, Gulf of Kutch and Malwan coast. When sea grasses grow on Kavaratti atoll, mangroves are prevalent on Andaman and Nicobar coral reefs. Primary productivity of Indian coral reefs is comparable with that of the reefs of the rest of the world.

The total coral reef area in India is 5,790 sqkm, distributed between 4 major regions: Lakshadweep; Gulf of Mannar; Gulf of Kutch; and Andaman and Nicobar Islands. Reef structure and species diversity vary considerably between the areas due to differences in size and environmental conditions.

The Lakshadweep islands lie scattered in the Arabian Sea about 225 – 450 km from Kerala coast. Geographically, the islands lie between 8°N- 12°N lat. and 71° 7.4°E longitudes. The islands consists of coral formations built up on the Laccadive – Chagos submarine ridge rising steeply from a depth of about 1500 m to 4000 m off the west coast of India. The Union Teritory of Lakshadweep along with the Maldives and the Chagos Archipelagoes from an interrupted chain of coral atolls and reefs on a contiguous submarine bank covering a distance of over 2000 km. This ridge is supposed to be a continuation of the Aravali Mountain, and the islands are believed to be remnants of the submerged mountain cliffs.

There are six tiny islands, 12 atolls, 3 reefs and 5 submerged banks, covering an area of 32 km² with lagoons occupying about 4200 km². Only 11 of the 36 islands are inhabited. Almost all the atolls have a NE–SW orientation with the island on the east, a broad well shaped reef on the west and a lagoon in between. They are Andrott, Amini, Agatti, Bangaram, Bitra, Chetlat, Kadmat, Kalpeni, Kilten, Minicoy and the headquarters at Kavaratti. The Minicoy Island is separated from the rest of the islands by a 180 km wide stretch of sea known as the nine-degree channel.

The islands are flat and scarcely rise more than two meters. They are made up of coral sand and bounders that have been compacted into sandstone. Coral reefs of the islands are mainly atolls except one platform at Andrott. Bahuguna and Nayak reported that the reef flat occupies 136.5 km area, sea grass occupies 10.9 sq. km and lagoon occupies 309.4 sq. km.
The depth of the sea increases outside the coral reef and can reach up to 1500-3000 m. Andrott is the largest island with an area of 4.84 sq. km and the only island that does not have a lagoon. Birta with an area of 0.10 sq. km is the smallest in land area but perhaps has the most magnificent lagoon. All the islands lie north to south, excepting Andrott that lies east to west. The distance between them varies from 11 km to 378 km.

**Lakshadweep**

Exploitation of the reef flat on foot and by hand, or reef gleaning, is commonly the domain of women and children. On a daily basis reef gleaning in many communities provides a regular supply of protein and may significantly enhance the nutritional status of households (Gina-Whewell, 1992). In certain seasons when weather limits access to more exposed parts of the reef, it may also be the only source of food or income.

These lagoons are protected by the reefs on the outer edge, and provide a safe anchorage for small vessels. The reef on the eastern side is closer to the island and the lagoon is very shallow. The coral patches in the eastern lagoon are exposed during low tide. The eastern reef flat faces the highest stress from trampling by reef gleaners and net operators since it is easily accessible by foot. The reef flat occupies an area of 136.5 km², seagrass occupies 10.9 km² and the lagoon occupies 309.4 km² (Bahuguna and Nayak, 1994). The depth of the sea increases outside the coral reef and can reach up to 1500–3000 m. On the leeward side the reef slopes into the sea. The first plateau is found around a depth of 5–6 m. The second plateau with sandy patches is found around 25–30 m (Hoon, 1997). This area is locally called the bar area and is favoured by fishermen for harpooning and spearing specific kinds of rays and big fish. During high tide, water exchange takes place between the lagoon and the open sea over the reef. The lagoons have sand bottoms with scattered coral boulders and pinnacles followed by extensive seagrass beds at the landward side. The lagoon opens to the sea through one or more natural entrance points.

**Lakshadweep**

On the Lakshadweep Islands, not only does reef gleaning provide a supplementary source of income, which the women can control, it is also the source of a wealth of knowledge about the reef resource, which women accumulate from a young age. For elderly and households lacking formal education, who cannot access jobs in the government sector, and live by subsistence means alone, reef gleaning forms an important share of household income. While for others, although the financial dependence on reef gleaning has diminished, its importance for women as a recreation, a break from household duties and a chance to chat together away from the men, is still of great value (Hoon, 2003).

These include natural breaks in the reef that allow boats to ply between the ocean and the lagoon, as well as other small shallow entrances, locally known as *chals*. The *chals* are important since these are the points where the fish shoals enter and leave the lagoon with the tidal change. These *chals* are therefore favoured locations for reef fishing by net operators and
are used extensively by the fishermen during the monsoon season (Hoon and Shamsuddin, 2002).

**Lakshadweep**

In the Lakshadweep Islands, a collaborative fishing operations, known as *Bala Fadal*, involving 25–30 men is carried out around three times a week during the monsoon season mainly to provide food for household consumption (Hoon, 2003).

In the Gulf of Kutch, there are shallow patchy reefs growing on sandstone platforms that surround 34 islands. The reefs experience high salinity, frequent emersion, high temperature fluctuations and heavy sedimentation.

The Gulf of Mannar reefs on the other hand are developed around a chain of 21 islands (Two former islands are now submerged, probably due to coral mining and erosion) that lie along the 140 km stretch between Tuticorin and Rameswaram. These islands are located between latitude 8°47′ N and 9°15′ N and longitude 78° 12′ E and 79° 14′ E. The islands lie at an average distance of 8 km from the main land. They are a part of the Mannar Barrier reef, which are 140km long and 25km wide between Pamban and Tuticorin. Different types of reef forms such as shore, platform, patch and fringing type are also observed in the Gulf of Mannar. The islands have fringing coral reefs and patch reefs around them. Narrow fringing reefs are located mostly at a distance of 50 to 100 m from the islands. On the other hand, patch reefs rise from depths of 2 to 9 m and extend to 1 to 2 km in length with width as much as 50 m. Reef flat is extensive in almost all the reefs in the Gulf of Manner. Reef vegetation is richly distributed on these reefs. The total area occupied by reef and its associated features is 94 sq km. Reef flat and reef vegetation including algae occupies 65 and 14 sq km, respectively (D.O.D. and S.A.C., 1997). Usually monsoons, coral mining and high sedimentation load affect the visibility. These reefs are more luxuriant and richer than the reefs of Palk Bay.

**Coastal protection**

Coral reefs play a critical role in providing a physical barrier against wave energy, thus reducing coastal erosion and the impact of storms. For all coastal communities living in the shelter of coral reefs, the reef barrier protects their homes, agricultural land and public infrastructure from the erosive forces of waves, currents and storms. It has been estimated that 1 km² of coral reef prevents 2000 m² of erosion per year (Berg et al., 1998). The shelter provided by reefs is widely recognised by coastal communities, in the village of Thavukadu in the Gulf of Mannar, India, where it has even been incorporated into local myth. In locations where local communities equate their surrounding natural landscapes with their own ancestors and identities, the significance of the protection provided by coral reefs, may be even greater.

The Andaman & Nicobar group of Islands is located in the SE of the Bay of Bengal, between 6°-14° N latitude and 91°-94° E longitude. They are the emerged part of a mountain chain and lie on a ridge that extends southward from the Irrawaddy delta area of Burma, continuing the trend of the Arakan Yoma range. The Andaman and Nicobar consist of 530 islands, with extensive fringing reefs which are mostly in good condition. of which only 38
are inhabited along with a number of exposed islets and rocks. The principal of these is the North Andaman, Middle Andaman with Ritchies archipelago to the east, South Andaman, little Andaman, Baratang and Rutland Island. The coral reefs are of fringing type and except for a few investigation reports, the reefs of the area still largely remain unknown. A deep oceanic ridge along 10°N separates the Andaman Group and the Nicobar group islands. The orientation of the chain of islands groups is north south. In these island groups there are two Marine National Parks viz., Mahatma Gandhi and Rani Jhansi Marine National Parks. The coral fauna is diverse when compared to other parts of India.

<table>
<thead>
<tr>
<th>Andaman Islands</th>
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<tbody>
<tr>
<td>In the Andaman Islands, the coral reefs can be accessed by non-mechanised boats and the gear required (hand-lines) is simple and cheap and can be easily procured, unlike the alternative of nets which can often only be acquired with loans or credit. For the new immigrant household on the Andamans, with limited financial resources and limited access to loans or credit, hand-lines are an accessible option. In addition to the low investment required for gear, operating costs in terms of time and fuel, are also lower for reef-based fisheries, with many of the reef fishing grounds closer to shore, particularly those used during the rough weather season.</td>
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</table>

(From: Singh and Andrews, 2003)

Corals have also been reported from Gaveshani Bank about 100 km offshore from Mangalore, and several areas along the eastern and western coast of mainland India, e.g. the Malvan Coral Reef Sanctuary near Mumbai.

Large areas of coral reefs of India, with the exception of the Andaman and Nicobar Islands, were severely affected by the 1998 coral bleaching event. Reef resources are heavily exploited, particularly in the Gulf of Mannar and Gulf of Kutch and to a lesser degree in the Lakshadweep and Andaman and Nicobar Islands.

**CORAL REEF STATUS AND BIODIVERSITY**

A total of 262 species of hard corals, 145 species of soft corals and 1,087 species of reef fish have been recorded from Indian coral reefs, but diversity varies significantly between areas.

The coral reefs of India exhibit extraordinary biodiversity. Until 1998 it was thought that the diversity of corals including hermatypic and ahermatypic corals amounts to 245 only. The Government of India and UNDP GEF field mission (2001 diving studies) reported a total of 234 species of scleractinian corals from Andaman group of Islands of which 111 are supposed to be new records to India (on verification with other studies only 94 species are found to be new records and this also includes some non-scleractinian corals). Also the underwater field mission revealed that the coral reefs of the Andaman Islands are globally significant in terms of coral reef diversity. The reefs around the islands were more diverse coral species than expected and less impacted than the other reefs of Indian Ocean region. The diversity is also comparable with numbers of coral reef species in the Philippines, Indonesia and Papua New Guinea, which are areas considered to be the world centers of coral diversity. The Andaman Islands have around 80% of the global maximum for coral diversity, suggesting a final count could reach 400 species of coral. Other major coral reef in India such
moderately rich diverse Lakshadweep and high diverse Gulf of Mannar have 100+species each excepting Gulf of Kutch where the diversity is minimum (36 species).

<table>
<thead>
<tr>
<th><strong>LOCALLY EXPLOITED MEDICINAL PROPERTIES OF MARINE SPECIES</strong></th>
</tr>
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<tbody>
<tr>
<td><strong>Crab varieties</strong> Kan nandu crab is useful for coughs and colds, while Kuzhi crab is used to reduce urea.</td>
</tr>
<tr>
<td><strong>Fish</strong> Soodai and Mural fish have high iron content and are used to prevent anaemia.</td>
</tr>
<tr>
<td><strong>Sea horses and sea lizards</strong> are believed to help heart problems</td>
</tr>
<tr>
<td><strong>Sea turtle meat</strong> is used to treat piles.</td>
</tr>
<tr>
<td><strong>Dugong</strong> the fat is believed to control digestive disorders, while the meat is thought to help muscle development.</td>
</tr>
<tr>
<td><strong>Shark</strong> the meat is believed to help muscle development.</td>
</tr>
<tr>
<td><strong>Island herb</strong> the Anjalai herb is used to treat sea snakes bites. (from Rengasamy et al., 2005)</td>
</tr>
</tbody>
</table>

There are 104 hard coral species in the Gulf of Mannar, with dominant families being the Acroporidae, Faviidae and Poritidae, and more than 538 fish species. The 1998 coral bleaching event did not cause major losses in the Tuticorin group, and current live coral cover is 26%, dominated by massive coral species.

<table>
<thead>
<tr>
<th><strong>Gulf of Mannar</strong></th>
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<tbody>
<tr>
<td>200 species are known to be commercially exploited in the Gulf of Mannar (DOD, 2001). A rapid survey of 3 coastal villages revealed 74 locally named and commonly exploited reef products, including 41 local varieties of fish, 19 local varieties of crustacean and 4 varieties of seaweed (Rengasamy et al., 2003)</td>
</tr>
</tbody>
</table>

In the Andaman and Nicobar Islands, there are 203 hard coral species with Porites spp. being dominant in the northern and southern Andaman Islands, while Acropora spp. dominates the middle Andaman and the Nicobar Islands. The 1998 bleaching had far less effect on corals in the archipelago compared to other parts of the region. Currently live coral cover averages 65% and about 1,200 fish species have been recorded. The diversity of the Andaman and Nicobar Islands has greater affinity to Southeast Asia than to other reef areas in the South Asian Region due to the currents in the north-eastern Indian Ocean promoting larval exchanges with Southeast Asia.
### Andaman Islands

In the Andaman Islands, reef fish are often used as a means of paying school tuition fees or gaining a favour from an official. (Singh and Andrews, 2003)

The Andaman reefs contain about 80% of the maximum coral diversity found anywhere in the world, making them the richest coral reefs in the Indian Ocean and an area of global significance (Turner et al., 2001; Vousden, 2001). From satellite imagery Turner et al. (2001) calculated the total reef area for the islands as 11,939 km², which compare with estimates by Wafar (1986), who reported the total reef area used in reef fisheries yield calculations for the Andaman Islands as 11,000 km². The reef structure around the Andaman Islands, as described by Turner et al. (2001), is mainly offshore coral growth on exposed banks, shallow gradual sloping fringing reefs on the windward shores, reef patches in bays, and steep sloping channel reefs in sheltered narrows. Fringing reefs consist of gradual reefs sloping seaward off moderate reef flats, sometimes with extensive flats. Reef slopes rarely exceed 20 m depths levelling off to a sand base colonized by massive coral colonies. Offshore reefs consist of an elevated plateau occasionally bordered by steep slopes into deeper water. Interestingly, the most diverse reef areas identified by Turner et al. (2001), coincide with the main fishing areas for fishers from North, Middle and South Andaman Islands.

The Lakshadweep Archipelago experienced severe coral mortality in 1998, and the live coral cover in the reef lagoons was reduced to less than 10%, with some variation between areas. Today the live coral cover is about 20%, with the previously severely damaged Kadmat and Agatti atolls showing good recovery.

### Lakshadweep

In many coastal communities of the world, local knowledge has accumulated through centuries of reef dependency and is demonstrated by both the men and women who exploit the reef. An example of the level of local or indigenous knowledge is revealed in local naming systems, or folk taxa. The Lakshadweep islanders, have knowledge of numerous different types of fish and where they can be found according to the tide or lunar cycle. (Hoon, 2003)

### REEF BIODIVERSITY IN LAKSHADWEEP

The National Institute of Oceanography (NIO), the Zoological Survey of India (ZSI) and the Central Marine Fisheries Research Institute (CMFRI) have undertaken several studies in this region during the past nine decades. The ZSI carried out extensive surveys in 1982–1987 and published in 1991 a volume on the fauna of Lakshadweep (ZSI, 1991). The CMFRI carried out a survey from January to March 1987 to study the fishery potential, which culminated in the publication of a special issue on Lakshadweep (CMFRI, 1989). The coral fauna of Lakshadweep is known to harbour a total of 134 species (Pillai, 1996; Rodrigues, 1996). The lagoon and reef flat fauna are dominated by Acropora spp., Pocillopora spp., Porities spp., and massive and encrusting favids. Psammocora spp. is common in the northern islands. There is a profusion of blue coral (Helipora coerulea, Millepora spp.) which forms the dominant coral in the lagoon (Pillai, 1996). Eighty-six species of macrophytes, 10 species of Anomuran crabs, 81 species of Brachyuran crabs, 155 species of gastropods, 24 species of bivalves, 13 species of sea stars, 6 species of brittle stars, 23 species of sea cucumbers, 15 species of sea urchins
and 120 species of fish are found in Lakshadweep (Rodrigues, 1996). The green turtle and the hawksbill turtle are also found in all the islands – they graze on the seagrass beds and frequent the bar area and lagoon area. Many of the species, as listed below, are now officially notified as endangered by the Government of India and their extraction is totally banned.

<table>
<thead>
<tr>
<th>List of notified endangered species found in Lakshadweep</th>
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<tbody>
<tr>
<td>Reptiles: HAwkbill Turtle Green Turtle</td>
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<tr>
<td>Cetaceans: Dolphins</td>
</tr>
<tr>
<td>Fish: Sharks and Rays Sea Horse Grouper</td>
</tr>
<tr>
<td>Birds: Sooty, Noddy and Large Crested Terns</td>
</tr>
<tr>
<td>Molluscs (shells): Cone shells Cowrie shells (<em>Cyprae tigris, moneta, etc.</em> )</td>
</tr>
<tr>
<td>Echinoderms: Sea Cucumbers (all Holothurian)</td>
</tr>
<tr>
<td>Sponges (all Calcareaens)</td>
</tr>
<tr>
<td>Corals: Reef building coral (all Scleractinians)</td>
</tr>
<tr>
<td>Sea Fan (all Gorgonians)</td>
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</tbody>
</table>

The fringing coral reefs in the Gulf of Kutch generally have low diversity, with around 42 hard coral species and 10 soft coral species. Live coral cover is generally low, currently about 20%.

**THREATS TO CORAL REEFS AND MANAGEMENT ISSUES**

The threats to the coral reefs vary among the countries and reef areas in South Asia. In mainland India there is continual damage to coral reefs from human activities such as the use of destructive fishing methods, over harvesting of resources, development and pollution, while in the Andaman and Nicobar Islands, Lakshadweep, these threats are much lower. However, climate change poses a serious threat to all reefs in the region.

All coral reef areas continue to be under stress, especially in the Gulf of Mannar and Gulf of Kutch, where coral mining and destructive fishing practices are most prevalent. Sedimentation and pollution pose major threats.

<table>
<thead>
<tr>
<th>Gulf of Mannar</th>
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<tr>
<td>In Thavukadu locals believe the Gulf of Mannar to be a male sea, due to the nature of its rough waves, which hit against the reef belt and subside in force by the time they arrive at the shore. In contrast, Palk Bay is believed to be a female sea, where like a woman the waters are calmer most of the time, but once they awake due to wind or storms the damage is heavy for there is no reef belt to control the action of the waves.</td>
</tr>
</tbody>
</table>

(From: Rengasamy et al., 2003)

India developed a National Biodiversity Strategy Action Plan in 2004 which includes a conservation strategy for coral reefs. This complements the legislation banning the collection of corals and reef-associated fauna (sea cucumbers, molluscs, gorgonians, sponges, seahorses, pipefishes and sharks) under the Wildlife Act of 1972 and 2002. The plan also aims to regulate coastal resource access and benefit sharing.

The Gulf of Mannar Trust was formed in 2003 to undertake a UNDPGEF project on management of coral reefs in Gulf of Mannar, and an implementation office was opened at Ramanathapuram.
**Gulf of Mannar**

Marine protected areas in India focus on biodiversity, conservation and tourism values placing the coral reefs within them ‘off limits’ for local fishery activities. In the Gulf of Mannar Marine Biosphere Reserve (GOMMBR), access and exploitation of shallow reef and seagrass areas surrounding the 21 coralline islands in the Gulf is prohibited and the Wildlife Protection Act (1972) prohibits the collection of many reef species. For the majority of poor reef stakeholders living along the coast of the Gulf of Mannar, these restrictions place severe and impossible restraints on their livelihoods. With no viable alternatives, poor reef stakeholders are reported to continue to access prohibited reef resources at great risk and increasing transaction costs.

(From: Rengasamy et al., 2003)

**Gulf of Mannar**

In the Gulf of Mannar, products from the reef and near-shore areas are widely used in systems of exchange for other products or services, which is considered as a way of life. In some instances, poorer households, particularly female-headed households, undertake activities such as net mending, in order to obtain free fish or other assistance.

(Rengasamy et al., 2003)

**Gulf of Mannar**

For the small-scale fisherfolk of the Gulf of Mannar, the most important organisation at the village level is the Fisheries Union, with 80% of small-scale fishers (men and women) being active members. The union provides the only common channel through which problems and issues can be voiced at higher levels by local fisherfolk. Participation and reliance on unions has strengthened in recent years in response to degrading reef resources, increasing conflicts with commercial fishing operations and the restrictions imposed by the Gulf of Mannar Marine Biosphere Reserve (GOMMBR). Local participation in the Fisheries Union has empowered the small-scale fishers, and brought about a number of successful local management measures, including:

- The restriction of commercial trawling activities within the ‘trapped sea’ between the islands and the mainland coast, thereby safeguarding the resource for the local small-scale fishers and reducing overall conflict in the fishing industry.
- A locally agreed ban on dynamite fishing and coral mining (reinforcing the official government ban), and a ban on the use of a metal tool for seaweed harvest. These were in recognition of the danger and damage caused by these activities, an awareness which was the product in part of efforts associated with the GOMMBR, as well as individuals’ personal observations of the impacts of destructive practices.

(From: Rengasamy et al., 2003)

A UNDPGEF project on land use patterns, biodiversity conservation and management in the Andaman Islands is in the final stages of preparation, awaiting endorsement by local authorities and approval by GEF. In May 2004, the Ministry of Environment and Forests sanctioned grant funds to organisations to undertake coral reef studies in the Andaman Islands and Gulf of Kachchh. Projects on Integrated Coastal Zone Management with specific
reference to development of tourism have been implemented in the Andaman Islands by the
Institute of Ocean Management, Anna University, Chennai and in the Lakshadweep Islands
by the Centre for Environmental Science Studies, Thiruvananthapuram. A series of projects
including coral reef surveys and restoration, socio-economic assessments in reef dependent
villages, and awareness raising efforts on the Tuticorin Coast, Gulf of Mannar are being
implemented by the Suganthi Devadason Marine Research Institute (SDMRI), with support
from the CORDIO Program. Additional options for income diversification for 60 families
have been provided through this program that started in early 2002. The Centre of Action
Research on Environment, Science and Society (CARESS) is establishing a community based
coral reef socio-economic monitoring program in the Lakshadweep Islands in 2003. This
project is also supported by CORDIO, and is a continuation and expansion of a GCRMN pilot
project in 2001.

<table>
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<tr>
<th>REEF RESOURCES AS A COPING MECHANISM AGAINST FAMINE</th>
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<td>A 52-year-old man on Agatti Island, with no education, belongs to the caste whose profession is to climb coconut trees and harvest coconuts for tree owners. He is committed to work for four households on Agatti Island. In return he can tap the sweet nectar <em>neera</em> from their trees and convert it into vinegar and <em>jaggery</em>. His family has always relied on local natural resources for their survival. He recalls that once there was a famine when he was a little boy. The yield from the coconuts was very low and they did not have any money to buy food. He recalls that his father used to catch <em>Karatty</em> or Trigger fish everyday from the reef. They ate the fish and used the liver oil to light lamps in the house after dark.</td>
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<tr>
<th>TRAINING AND CAPACITY BUILDING</th>
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<tr>
<td>In India, an Australia-funded training and capacity building program has trained 25 scientists in scuba diving, taxonomy and GCRMN monitoring methods. The training was carried out during pilot monitoring of coral reefs in the Andaman and Nicobar Islands and the Lakshadweep islands in 2003. In 2004, India held a stakeholder workshop at Port Blair, Andaman Islands, to identify gaps in coral reef management. The CORDIO program has provided 3 PhD research scholarships in Tuticorin, Gulf of Mannar for coral reef research.</td>
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<th>AWARENESS RAISING</th>
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<tr>
<td>The ‘Handbook on Hard Corals of India’ (2003), and the ‘Bibliography and checklist of corals and coral associated organisms of India’ (2004), were published by the Zoological Survey of India to encourage researchers to study the diversity of Indian coral reefs. Twenty-nine posters on marine animals and coral reef associated organisms were also published to create awareness among Indian school children. SDMRI has published a Field Guide on stony corals of Tuticorin, and implemented coral reef education programs for fisher women in the Gulf of Mannar.</td>
</tr>
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VALUES OF CORAL REEF

USE VALUES
- Direct Use Value
  - Coral Mining
  - Shell Collection
  - Fish Collection
  - Pharmaceutical
- Indirect Use Value
  - Tourism
  - Recreation
- Consumptive Use
- Non Consumptive Use
  - Storm Surge
  - Fish Nursery
  - Food Chain
  - Sand for beach Nourishment

NON USE VALUES
- Option Value
- Viewing
- Recreational Use
- Existence Value
- Biodiversity
- Recreational
- Bequest Value
- Biodiversity
- Recreational amenities

Gulf of Mannar
Among the coastal communities of the Gulf of Mannar locals believe that Appa Island is the home of an island God (Santhanamariamman) and by pleasing this God they will be protected from evil spirits when they stay on the island. It is also believed that another god (Muniyasamy) resides in a coral mound just near the island and close to an area known for dangerous currents and an underwater cave. Fisherfolks are warned that in order to escape from the wrath of deities they should not approach this area.
(Rengasamy et al., 2003)

RECENT CORAL BLEACHING IN SOUTH ASIA

Minor coral bleaching was observed in South Asia in March - April 2003 and 2004; the same months as massive bleaching occurred in 1998. This time coincides with the warm weather prior to the southwest monsoon. Coral bleaching was observed in India on some islands of the Gulf of Mannar, with 10 - 20% of massive corals bleached, but the majority recovered in the second half of the year. Some bleaching primarily of Porites colonies was also recorded in 1998.
STATUS AND MANAGEMENT OF MARINE PROTECTED AREAS

India has 36 MPAs, including 3 Man and Biosphere reserves. Management remains inadequate in most MPAs in South Asia, particularly in India. While sufficient legislation, regulatory frameworks and management plans exist in most cases, they are frequently not up to date or fully appropriate. Enforcement and implementation are inadequate. Primary causes for this include a lack of technical and financial capacity, inefficient coordination between various government and non-government bodies, as well as corruption in some institutions. A lack of alternative livelihoods for coastal populations, that use resources in MPAs in breach of regulations, compounds the problems.

THE GULF OF MANNAR MARINE BIOSPHERE RESERVE (GOMMBR)

GOMMBR was the first marine biosphere reserve not only in India but also in South and Southeast Asia. The IUCN Commission on National Parks and WWF identified the reserve as being an area of ‘particular concern’ given its diversity and special multiple use management status. As the first marine biosphere reserve declared in India, this area has long been a national priority.

The GOMMBR was declared on 18 February 1989 by the Government of India and the State of Tamil Nadu. The intention of declaring the 21 islands and surrounding sea, including 6.4 m depth on the bay-side to 9.1 m depth on the seaward side, as a marine biosphere reserve is for the purpose of protecting marine wild life and its environment. The main objectives of the GOMMBR are:

- Conservation and management of representative marine ecosystems
- Protection of endangered and important marine living resources
- Provision of long-term conservation of genetic diversity
- Promotion of basic and applied research work and its monitoring
- Dissemination of information through education and training.

(Source: DOD, 2001)

Coral Reef Status – Past, Present and Future

100 Years ago: Reefs in South Asia were mostly in ‘pristine’ condition. Some fisheries, e.g. chank and sea cucumber collection in the Gulf of Mannar in the 1920s, as well as coral mining had damaged the reefs closer to large human settlements. However, the lower human populations meant that over-extraction of reefs, and destructive fishing methods such as seine nets with rollers and bombs were not used. Consequently the reefs recovered relatively quickly from large-scale or localized damage caused by storms. Mass-disturbances such as the bleaching event in 1998 were not reported.

In 1994, many reefs in remote areas that had low human populations were still relatively healthy. However, some areas, such as the Andaman Islands, showed some damage from increased sediment levels caused by logging and deforestation. The effects of mining, over-fishing and destructive fishing were apparent in many reef areas, especially in India, largely due to population growth in poor reef-dependent communities. The tourism boom was gaining momentum and posing threats to the reefs. In addition to tourism, new and growing markets such as the trade in aquarium species, sea cucumbers, and lobsters for tourist restaurants, reduced populations of these reef resources and altered fish communities. Reefs that were plagued by COTS in the early 1990s were recovering relatively well by 1994, but
there was little effective management. In India, there was minimal recognition of coral reefs by the Government, the major reef studies were taxonomic, and there were no MPAs or conservation measures in place.

In 2004, the effects of the mass bleaching in 1998 are still visible in virtually all parts of the region that were affected. The combination of high mortality and continued high stress, such as over-fishing, destructive fishing, mining and land-based activities, has further degraded reefs particularly in India where there are large reef areas with dead coral colonies covered in algae. A third to half of coral reefs in the region are now effectively dead, and a further 30% are threatened. Some more remote reef areas are still in relatively good health, with some showing encouraging signs of recovery. There has been considerable growth in human populations, resulting in continuous increases in pressure on the reefs for provision of food and livelihoods. Many reef associated biota such as sea cucumbers and lobster, show clear signs of over-harvesting or population crashes. Minor bleaching was reported from India in 2004. However, most of the affected corals recovered relatively well within a short period. The region established a strong coral reef monitoring network in 1996 and all countries have active monitoring programs in most of their coral reef regions. India established the Indian Coral Reef Initiative and a parallel monitoring network, and is making major efforts to conserve and manage their coral reefs. They produced an outstanding handbook on the corals of India in 2004.

Predictions for 2012: Unless the current rates of over-exploitation and destructive harvesting are controlled, particularly in India, the coral reefs in the region will continue to deteriorate and many will degenerate completely. The major pressures on reefs are the rising levels of poverty among increasing coastal populations, and local economic conditions that often drive reef destruction. For example, as long as reef mining is more profitable in the short term than other reef uses by coastal people, and authorities fail to enforce regulations, reefs will continue to be mined. Pressure is also increasing from external market demand, which is driving the harvesting of ornamental fish, sea cucumbers and other resources. Without improved controls, it will be difficult to divert the livelihood strategies of communities away from dependence on reef exploitation.

<table>
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<tr>
<th>LEGISLATING THE USE OF CORAL FOR CONSTRUCTION</th>
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<td>Recognising the construction needs of the islanders and because no other building material is available on the islands, the Lakshadweep administration permitted collection of coral shingle for house construction on a permit basis, but continued the ban on the collection of coral boulders. In 1996 a notification was passed that people could collect shingle by obtaining a permit from the environment wardens. Non-permit holders would be regarded as offenders. Despite this, illicit collection of boulder coral continues. In 1996, 22 permits were issued to collect a total of 4325 bags of shingle. In 1997, 45 permits were issued to collect 11,400 bags of shingle. The applicants had applied for double that quantity. A man who had recently built his house stated that while he had received a permit for 150 bags, he had collected around 300 to complete his house construction. It is therefore safe to assume that at least some islanders collect exactly the amount they need, irrespective of what is allowed in the permit. In 1998, another notification was issued which stated that people wishing to collect shingle need to apply for a permit and remit Rs. 5 per 20 kg bag that they wished to collect. It is interesting to note that the number of permit applicants abruptly declined. Field observations show that</td>
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shingle collection has carried on regardless. The administration therefore no longer has a record of how much shingle is collected nor receives as much remittance for shingle collection. Island stakeholders explain that one needs a minimum of 400–500 bags of shingle in order to construct a modest two-bedroom house. Each bag of shingle weighs 20 kg, which means 8–10 tons of shingle is required per house constructed. Islanders also estimate that a minimum of 20 houses are constructed every year. By a conservative estimate this would mean that at least 200 tons of shingle are collected and used within the island annually. This estimate is supported by the data collected by monitoring shingle collection. More recently, license arrangements for the collection of shingle has been abandoned and instead shingle collection has been totally banned. The community must now either continue collection illegally or purchase expensive alternative construction materials.

**Local perceptions**

The people perceive coral shingle collection as their right and are unable to see how this can destroy the island. They explain that shingle is like the broken and dead twigs and branches of a tree that wash ashore. This is part of a cycle of life and is utilised for construction on the islands itself. When the houses break the shingle will return to the island for island building and hence there can be no harm in collecting shingle.

They want an explanation for the disappearance of the small Parralli III Island. They made the point that no person had ever collected a shingle or boulder from there and yet it disappeared. The islanders said that before the law people only collected the amount of shingle they needed for their own construction purposes. Now because of the permit system, only some have the privilege of collecting shingle. These people tend to hoard shingle and sell it at a premium. Shingle sells for Rs.15–20 per bag. Currently around 12 people supplement their livelihood income through shingle collection alone. The recent change in legislation, completely prohibiting shingle collection, has made some locals very angry and only time will tell what will happen. (From: Hoon et al., 2002)

Improved management could increase the resilience and resistance of the coral reefs by helping to facilitate recovery from the 1998 event, and improve the chances of withstanding another similar event; which appears inevitable based on current predictions. Direct pressures on the reefs are lower than elsewhere in the region, but these archipelagos are probably more vulnerable to damage from climate change. Another severe heating event like 1998 would be even more damaging to the reefs and may result in localized extinctions of coral species, from recovering reefs. However, there are also early indications of increased resilience to bleaching in some areas and some species. Thus, the prediction for reefs in areas currently under high levels of stress is not good, while reefs in more remote areas have a better chance of recovering from the 1998 bleaching and withstanding other perturbations. However, there is a risk that over-harvesting of reef resources will shift to these remote areas, if the resource stocks collapse in heavily exploited areas. Greater focus on developing alternative livelihoods that are sustainable and realistic options for coastal people is essential.
LOCAL PERCEPTIONS OF THE REEF RESOURCE

Fisherfolk have an integrated and holistic perception of the ocean. Reefs are perceived as part and parcel of the ocean. So when fisherfolk reveal that they are dependent on the sea, this includes all the different resources associated with the sea. The reef is recognised as being highly productive and fishermen expressed this on many occasions:

‘It is the reef from where everything sprouts and spreads throughout the entire sea’

‘The reef is a natural nursery’

‘It is because reefs are there and its fertility, we get different varieties of fish to catch and we have to keep different nets’

(Quotes from villagers).

Priority ingredients for success

Wells (2000) notes that the priority ingredients for success are:

- Involving local communities in decision-making and management;
- Ensuring appropriate livelihoods for those immediately dependent on reefs for their income;
- Developing integrated coastal management frameworks for coral reef management;
- Involving the tourism and dive industries;
- Identifying mechanisms for sustainable financing;
- Promoting training and capacity building;
- Establishing long-term monitoring programmes.

STRATEGIES FOR CONSERVATION OF CORAL REEF ECOSYSTEMS IN INDIA

Analyzing the Shortcomings in Coral Reef Conservation in India

- Understand the problems facing coral reefs by assembling information from within India and nearby countries.
- Determine the true economic value of reefs so that rational decisions can be made on the cost of management.
- Transfer that understanding via education to the principal users, the public and decision makers.
- Focus management around the user to ensure compliance with and assistance in resource management.
- Incorporate reefs into marine protected areas to buffer the reefs against outside damaging influences.
• Control damaging practices and monitor the effectiveness of control.
• Promote sustainable uses to realise the full economic potential of healthy reefs.
• Monitor the effectiveness of management so that procedures can be adjusted to ensure long-term sustainability.

Understanding the Coral Reef Problems

• The coral reef areas in India should be determined using satellite and aerial images with ground truthing. Assistance may be needed from large agencies such as the National Aeronautics and Space Application Centre.
• These data should be used to find out the status of the coral reefs and how they are changing.
• National programmes to monitor the status of coral reefs should be implemented.
• The knowledge base of scientists, tourists operators, SCUBA divers and local users should be combined to determine the status of reefs and how they have changed during living memory.
• Central and State Government may convene national and local committees including user groups, local government authorities, tourism developers, scientists and Non governmental organizations (NGOs) to advise on sustainable management of coral reefs.

Determination of the true Economic Value of Coral Reefs in India

• Direct ‘extractive’ values like fisheries, aquarium fish and other animals, ornamental products and sand production.
• Potential ‘extractive’ values like pharmaceutical drugs and species developed for future Mariculture activities.
• Direct ‘non-extractive’ uses such as tourism and educational and research values.
• ‘Indirect use ‘values such as the commercial species that migrate to other areas the physical barrier, role in protecting the shoreline, the value in extending Exclusive economic zone.
• As well as the less tangible ‘non use and aesthetic ‘values of high biodiversity habitats for endangered species and roles as part of the global environment.
• Determination of coral reef fisheries, how these are being exploited (catch per unit effort) and the dependence by local fishermen on reef fisheries.
• Determination of other values of coral reefs and potential economic losses if these values are foregone through reef degradation.
• Assessment of the current and potential future income from coral reef tourism and the contribution of health of reefs towards attracting tourists to India.
Coral Reef Conservation Education

- Information on the nature and value of coral reefs should be provided to all users, students and public using appropriate methods. e.g. many fishermen will not read written material whereas videos and talking are effective.

- Summaries of the status of coral reef resources and sustainable management methods should be prepared for decision makers and development agencies donors and banks.

Focusing the management of coral reef around the stakeholder

- National and state governments of India should devolve sufficient responsibility for the management of coastal resources to local authorities at the village level.

- Legislation for coastal reef resource management should include the involvement of the users especially fishermen.

- Developers especially those involved in tourism should consult directly with local users on resource management and then employ local people to compensate for restrictions on resource use.

More Coral Reefs in Marine Protected Areas

- Large areas of relatively undamaged marine habitat including good coral reefs should be designated as marine protected areas and management plans developed to involve all users.

- Assistance for training, planning and management of MPAs should be requested from international donors, particularly to staff, local authorities with education officer and MPA Range officers.

- Tourism operators should be involved in the management of MPA and be prepared to fund some of the management.

Management Practices

Pollution:

- Emphasize the treatment of sewage at the source or divert them away from coral reef onto the land or as deep ocean outfalls.

- New domestic and industrial development should be ‘encouraged’ to treat sewage as it is cheaper to install sewerage lines and systems during construction.

- Tourism developments near coral reefs should have full secondary or tertiary treatment and adequate methods for removing garbage

- Guidelines should be provided to governments, villagers and developers on the range of appropriate methods for treating sewage at all scales.

Sedimentation

- Government should request that developers and farmers minimize the amount of sediment that is lost into rivers and the ocean.
Overfishing
• Fishermen should be discouraged from using destructive methods (dynamite, cyanide, bleach, poisons) through education, local cooperative discussion and where possible be provided with other employment.
• Anchor damage should be minimized either by encouraging anchoring on sandy areas, or with better designed anchors, or through the installation of permanent mooring buoys for tourist operators in Lakshadweep and Andaman and Nicobar Islands.
• Remote reefs require special protection through international treaties to control damaging practices that destroy parent fish stocks and poaching.

Promotion of sustainable uses
• Selective Sustainable Fishing and Harvesting in all the coral reef areas in India.
• Controlled harvesting or aquarium fish in all the coral reef areas of India.
• Mari culture of reef species for stock enhancement.
• Limited fish cage culture and rack culture of pearl shell edible oyster and algae.
• Removal of the excess production of sand in coral reef areas especially Andaman and Nicobar Islands.
• Snorkeling and scuba diving and other tourism activities.
• Advice on sustainable methods of establishing tourism ventures should be given to developers, which may require government interventions to ensure that environment departments and universities are involved.
• Reef users require information on sustainable harvesting practices and assistance to develop markets for those products.

Monitoring the Effectiveness of Coral Reef Management in India
• A committee of experts by the National Coral Reef Committee should monitor all MPAs and other managed areas in India for the effectiveness of management particularly to assess whether the health of reefs is stable.

Recommendations from International Bodies
Recommendations outlined here are the outcomes of the deliberations of the South Asia regional caucus meetings held during the Third International Tropical Marine Ecosystems Management Symposium, in Cozumel, Mexico, October 2006. The South Asia caucus was composed of members of national government institutions, NGOs and civil society organizations, and represents the views of practitioners, researchers and decision makers on marine ecosystem issues from across the region where India had a major role to play. The group revisited recommendations emerging from ITMEMS 2, 2002, reviewing and updating these as appropriate. The recommendations are targeted at governments, NGOs and civil society alike, and represent priority actions that need to be taken in order to safeguard the future of important marine ecosystems and resources.
• Recommend the establishment of a South Asia Coral Reef Unit to facilitate implementation of various regional and international initiatives in the management of coral reef.

What has been achieved to date:

Though a Coral Reef Unit (CRU) or similar body has not yet been established, the concept has recently been taken forward under a project in the region. Relevant stakeholders from the governmental, NGO and research sector involved in the project agreed on the principle of a CRU in September, 2006. ToR and formal name of the CRU are to be agreed on by early 2007.

Recommendations for the future:

• Governments as well as other organizations are asked to support the CRU and to ensure its operations are maintained beyond the lifetime of the project. Provisions should be made to ensure that the CRU will be financially and institutionally sustainable. Other initiatives and organizations in the region operating on a national or a regional level and relevant to the CRU should be supported and their interaction with the CRU facilitated.

• Promote the involvement of stakeholders in identifying viable alternative employment options, opportunities and resources in order to reduce pressure on coral reef ecosystems.

What has been achieved to date:

This is an area that needs continuous input and support. Implementation has been sporadic, e.g. various alternative livelihood projects implemented via non-governmental as well as governmental organizations. Such activities have been implemented on a larger scale after the tsunami, mostly through humanitarian agencies. This has also increased the involvement of local stakeholders.

Recommendations for the future:

The involvement of stakeholders is the key for successful identification of viable, environmentally as well as economically sustainable livelihood options, and should be the basic principle for all livelihoods enhancement or diversification activities.

• Recommend the strengthening of effective enforcement mechanisms and improve capabilities within countries to fulfill requirements under all treaties and conventions.

What has been achieved to date:

Frequently laws are not implemented or enforced. Progress has been made in some areas, including through enforcement capacity building. There are also changes at the policy level, such as the India Biodiversity Act 2002, which includes provisions for the protection of reef resources outside Pas. In the aftermath of the Indian Ocean Tsunami 2004 a Coastal Management Plan has also been taken forward. Communication and networking on a local-national level is insufficient, even within institutions, both vertically and horizontally.
Recommendations:

- Capacity building and awareness raising targeted at a range of stakeholders, including the judiciary and those involved in policy formulation
- Ensure more effective use of scientific and monitoring data to inform the development of new laws and policies
- Improve communication and networking of stakeholders involved in enforcement issues using mechanisms such as the future CRU and coastal management planning processes
- Improve enforcement capability by developing the capacity to enforce regulations through supply of equipment such as boats, communications equipment etc.
- Improve funding for biophysical and socio-economic monitoring, restoration, capacity building, establishment or improvement of databases, networking including sharing of information and experiences.

What has been achieved to date:

There has been some progress made but it is limited and there is a need both for needs not only more funding but also more efficient use of existing funding, including within national monitoring programmes. Socioeconomic and community based monitoring appears to be less developed, and less resourced than biophysical monitoring, and socioeconomic monitoring work underway is often not brought to a broader audience (e.g. in GCRMN Status reports). Work done outside the ICRI/GCRMN sphere is not being effectively fed into these processes, including e.g. many activities implemented on site, municipality, province and state level. Improvements in data management are still needed. Private sector involvement and support is currently well below potential, e.g. the utilization of dive center based monitoring and connecting this to national monitoring programmes. It was noted that private sector engagement can extend beyond reef monitoring to e.g. water quality monitoring.

Recommendations:

- Ensure relevant monitoring and capacity building activities carried out by ‘non-traditional’ partners are integrated into the ICRI, GCRMN and related coordination processes
- Continue to build capacity in biophysical and socio-economic monitoring as well as data management and analysis for improved reliability and use of the data
- Increase commitment to socioeconomic and community based monitoring
- Strengthen private sector partnerships in monitoring (as well as other aspects of management)
- Governments are requested to ensure that capacity built for management of marine and coastal areas is not lost through the currently common staff rotation systems, e.g. through the creation of marine units in management authorities
- Support restoration of degraded ecosystems where necessary, and in accordance with internationally agreed policies and approaches such as the ICRI resolution
Recommend the implementation of MPA concept and the application of long-term monitoring results in decision making for effective conservation and management of coral reef ecosystems.

What has been achieved to date:

There is still a need for more MPAs in many parts of the region and establishment of a representative network of MPAs, as reflected in IUCN WCPA appraisals and other assessments. The current MPA situation is well below internationally agreed targets. Enforcement remains problematic, with illegal activities still taking place in several MPAs, and management plans are frequently not implemented. There is a need for more private sector involvement and buy-in, e.g. tourism operators benefiting from MPA could be more directly involved in MPA management.

Recommendations:

- A regional network of well managed, representative MPAs should be established, with the support and input from relevant organizations including e.g. WCPA Marine
- MPAs should be better integrated into broader coastal and marine management strategies
- Continue to build management capacity among MPA staff
- Enforcement of MPA regulations should be strengthened, but this should be coupled with suitable consultative processes to address the needs of local communities and other stakeholders
- Recommend the strengthening of education and awareness programmes at all levels to ensure sustainable use of coral reefs.

What has been achieved to date:

Several successful education and awareness activities have been implemented in the region. However, there is a lack of continuity, and initiatives are limited by project lifetimes. Education and awareness needs to be a continuous, ongoing process and built more firmly into conservation and management activities. There is a lot of existing education and awareness material that is not always reaching those that could benefit from it, as much of it is applicable to the region with some adaptation. In some cases existing materials are not sufficient, and there is still the need to develop new materials.

Recommendations:

- Successful programmes from other regions should be replicated and the use of exchange programmes supported
- Strengthen networking regionally and inter-regionally
- Develop school based conservation programmes, including appropriate resource materials
- Integrate coastal systems, into school curricula, including information on their benefits, conservation and sustainable use
- Establish resource centers for the general public
- Ensure that conservation projects always have awareness component, including dissemination mechanisms

* * * * *
Living in two worlds at once, mangroves protect coastlines from wave energy and protect offshore ecosystems from terrestrial sediments flowing downstream. Throughout the tropics mangroves exist in intertidal areas and are utilized as a habitat by thousands of animal species and as fuel, medicine, food and timber by human coastal populations.

As human populations have grown over recent decades, increasing pressure has been placed on mangrove resources. Simultaneously, mangrove research has boomed, unveiling the importance of the ecological, economic and protective role that mangroves fulfill. Governments, non-governmental organizations and local communities have made concerted efforts to protect and regenerate remaining stands. However, overwhelming pressures continue to take their toll.

Mangrove areas have a high level of productivity as they receive nutrients from both sea and land. Detritus is the primary energy source in tropical estuaries and mangroves are often the producer of this organic litter. Sixty per cent of leaf material in tropical estuaries originates from mangroves. Gross primary production in mangroves is seasonally variable but generally comparable to sea grasses and more than coral reefs. Unfortunately little work has centered on energy transfer in mangrove ecosystems and consequently we do not have a complete understanding of trophic relationships and food webs.
If mangroves are felled, offshore coastal areas, such as coral reefs, receive even more sedimentation. Already the effects of excessive nutrient loads and sediment discharge can be seen as breaks forming in fringing reefs opposite river mouths.

The effects of climate change will be felt across the region as patterns of rainfall, coastal weather, atmospheric pressure and evaporation adjust. Anticipated effects of climate change are increased temperatures, changes in hydrology regimes, a rise in sea level, increased magnitude and frequency of storms and increased carbon dioxide concentration. There will be positive and negative effects on mangroves and it is highly uncertain exactly what the net outcome will be as local variability will be very high and effects site specific. As temperatures rise mangroves may start to colonize higher latitudinal areas. A warmer climate may result in an increase in frequency and strength of tropical storms and previously sheltered areas, suitable for mangrove growth, may become exposed. Conversely, any reduction in temperature could shrink mangrove range. Any changes in temperature, salinity, storm frequency or precipitation will have effects on flora and fauna composition within mangrove forests.

It is difficult to predict the exact consequences of sea-level rise as many scenarios are dependent on sedimentation fluxes from river catchments and coastal topography or land composition. Generally opinion seems to agree that rising sea levels will lead to mangroves shifting landward, as long as the rate of rise does not exceed mangrove growth and there are no obstructions to inland expansion.

### What causes mangrove areas to change?

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<tr>
<td>Before mangroves can be used to monitor changes in global processes such as <em>climate change</em> and <em>sea level</em>, we need to know what these changes are and how the changes are a response to external influences.</td>
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<tr>
<td>• Shoreline development (<em>e.g.</em> coastal urbanisation and industrialisation and conversion to aquaculture) and changes in local hydrology are the biggest threats to mangrove habitat and some specific threats include:</td>
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<tr>
<td>1. Baffling by mangrove root systems provides a physical trap for fine sediment with loads of heavy metals and other toxicants.</td>
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<td>2. Changes in pH, redox potential (<em>dissolved oxygen</em>) and <em>salinity</em> can render these toxicants more available to keystone <em>mangrove animals</em>, including crabs.</td>
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<tr>
<td>3. Increases in heavy metals can also lead to inhibition of <em>photosynthesis</em> and <em>respiration</em> in mangroves, causing die back.</td>
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<tr>
<td>• Mangroves are susceptible to oil pollution.</td>
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<tr>
<td>1. Floating oil deposits on mangrove roots when the tide drops and contaminates the sediment.</td>
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<tr>
<td>2. Mangroves die from the suffocating or toxic effects of the oil, or from the oiling of keystone <em>burrowing animals</em> (crabs and worms), which are essential to the <em>health</em> of the system.</td>
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<td>• Rotting drift algae from <em>algal blooms</em> and wrack from <em>seagrass areas</em> can smother mangrove pneumatophores.</td>
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52
• Trampling can decrease the density of pneumatophores and the biomass of epiphytic algae causing a change in habitat structure.

• Increased tidal amplitudes, caused by dredging and climate change, and changes in riverine nutrient and sediment loads, can cause the expansion of mangroves into saltmarsh areas.

• A reduction in the duration of the wet season can lower water tables, and increase salinity stress.

• Genetic modification of the mangrove genome due to pollution; causes changes in species composition and fitness of mangroves.

A rational use of mangrove forests has to be embarked upon to ensure the long-term survival of the forests and all creatures, human and animal alike that rely on them. This will mean changes to present approaches in mangrove management. Past problems facing mangrove forests have been the lack of community input into management approaches, high levels of poverty within indigenous coastal communities and a general lack of awareness of the true value of mangroves. These issues and the regeneration of mangrove forests should be included in future mangrove management plans. Management changes are not the all-encompassing solution as current knowledge of many aspects of mangrove ecosystems needs to be improved. Techniques for natural and artificial regeneration need to be investigated further as do mangrove faunal interactions, mangrove fisheries, hydrology, and growth and development. We would then better understand how felling and other human activities are affecting mangrove ecosystems. Only then will efficient and sustainable management regimes be attainable.

A general problem for coastal ecosystems is the increasing water pollution from upland sources. High levels of zinc, iron and other heavy metals have been recorded in mangroves, located just opposite and the opening of the river where many pollutants exit the river system. Mangroves are remarkably tolerant of high metal concentrations. Mangrove wildlife, however, is not as resilient. Heavy metals have been recorded as accumulating in soft body parts and shells of fish and gastropod species and this extra metabolic pressure may affect growth rates and survival. Zinc is particularly toxic to invertebrate and fish larvae.

Since the publication of the first Global Status of Mangrove Ecosystems (Saenger et al., 1983), about twenty-five years ago, the causes and consequences of mangroves
destruction have been clearly identified and most recommendations made at that time to international, regional and national organizations and Ministries still remain valid today.

What has been progressively changing is:

1. the ability of the scientific community to explain and to demonstrate through formal models, the exceptionally high productivity of these ecosystems and

2. the awareness of the fact that millions of people use mangrove products and mangrove environments and that mangroves underpin social and economical welfare in numerous coastal areas.

For these reasons, most international organizations have paid a special attention to mangrove communities.

This ISME Mangrove Action Plan focuses on key issues impeding the sustainable management of mangroves. It is presented in such a way that it should encourage the development of new projects by an array of institutions working either at a local or at a national level, avoiding the classical polarization opposing conservation and rational use of the resource.

Mangroves have always been considered as exceptional ecosystems for at least three main reasons. First, the global mangrove area presently does not exceed 180,000 sq. km, which is a relatively modest area extent for a natural ecosystem. Second, their discontinuous distribution, at the land and sea interface of tropical and subtropical coastlines, is primarily characterised by tidal regimes, creating unique forest habitats. Third the generally wide fluctuations of environmental factors (dissolved oxygen, salinity, organic and inorganic suspended matter) have induced in mangrove flora, a complex range of adaptations, lacking in other woody species, unable to compete or to survive in these highly variable and adverse environmental conditions (low oxygen content in soils, sulphate toxicity, high NaCl in water and soils, exposure to hurricanes and surges, unconsolidated soils, etc.). Despite these conditions, these ecosystems are highly productive with an average primary productivity often higher than that of neighbouring terrestrial forest ecosystems. Although the mangroves of the world are known to consist of approximately 70 exclusive species of trees and shrubs belonging to nearly 20 families of Angiosperms, the floristic structure of mangroves vary from more than 30 species along the richest coasts of Southeast Asia and Australia, to only one species recorded today in most of the arid coastal world of the Middle East, West Africa and North Western America.

In any case, mangrove forests create a wide diversity of niches, which serve as suitable habitats for feeding, breeding, spawning and hatching of sedentary and migratory species. In particular, they are an important nursery habitat, for fish and crustaceans of commercial value. The mangrove trees provide firewood, charcoal, timber and raw materials for paper and chipboard.

The forest also provides other socially and economically important materials such as fodder for livestock, medicines, and dyes. Mangroves are also important for their role as biological filters and a sink for several pollutants. With the advent and current acceleration of climate change, mangroves are being increasingly seen as carbon sinks and carbon stores. Additionally, due to their strategic location, mangroves protect coastlines from wave energy, and offshore ecosystems from terrestrial sediments flowing downstream. Dense mangrove
stands protect shorelines from storm and surges damage and increase coastal stability. In cyclone prone areas, they play a dominant role for the protection of human beings and property.

The mangrove ecosystem therefore yields goods and services of high economic value and earns tremendous foreign exchange for the producing country without compromising its ecological and environmental integrity when properly managed. The complex, multi-faceted and often long-term nature of these benefits means that they have sometimes been overlooked in simple economic models

**Responses/activities:**

- Recognizing that mangroves can be utilised in a sustainable manner, we need to evaluate the effectiveness and support the application of controlling use through zoning with a range of reserved areas, alongside sustainable use areas e.g. commercial mangrove forest operations such as those already established in India, Bangladesh, and others.

- Support a network of strict no-use zones (e.g. Southeast Asia Biosphere Reserve Network (SeaBRnet), East Asian Biosphere Reserve Network (EABRN), etc.), including ecological and cultural sites such as sacred forests, and encouraging community involvement with the view to enhancing local benefits such as fisheries, coastal protection and biological filtering.

- Encourage the planning and use of localised management plans. We need to control use by supporting community stewardship and management. In some countries, (e.g. Fiji and Samoa) there is strong evidence that traditional resource stewardship has led to considerable levels of protection. Such a form of traditional stewardship may greatly help toward protection (e.g. Philippines and Vietnam) where central governments are limited in terms of appropriate management.

- Encourage, where appropriate, development schemes that support replacement of mangrove fuel wood with alternate fuel sources.

- Enforce the principle of “no-use without replacement,” to have the situation where every time a tree is harvested other are planted.

- Encourage monitoring, on a regular basis, of the state and health of mangrove ecosystems.

- Encourage laws or policies that prevent the total clearance of new areas of mangroves and match local socio economic requirements with environmental realities of the local mangroves.

Mangrove vegetation is found in the tropical and subtropical coasts. Mangroves consist of a number of species of trees and shrubs that are adapted to survival in the inter-tidal zone. They are basically land plants growing on sheltered shores, typically on tidal flats, deltas, estuaries, bays, creeks and the barrier islands. The best locations are where abundant silt is brought down by rivers or on the backshore of accreting sandy beaches. Their physiological adaptation to salinity stress and to water-logged anaerobic mud is high. They require high solar radiation and have the ability to absorb fresh water from saline/brackish
water. Mangroves occur in variety of configurations. Some species (e.g. *Rhizophora*) send arching prop roots down into the water. While others (e.g. *Avicennia*) send vertical “Pneumatophores” or air roots up from the mud. In size, mangroves range from bushy stands of dwarf mangroves found in Gulf of Kutch, to 30 meters or taller stands found in the Sunderbans. Mangroves propagate by producing water borne “propagules”, which are not seeds but rather embryonic plants.

**BENEFITS OF MANGROVES**

- Mangroves are a source of firewood, of wood products such as timber, poles and posts, and of non-wood produce such as fodder, honey, wax, tannin, dye and plant materials for thatching.
- Mangrove wetlands and forests act as a shelter belt against cyclones. (In Orissa state a few years ago, villages surrounded by mangrove forests survived the fury of cyclones, unlike other villages). They also prevent coastal erosion.
- They provide feeding, breeding and nursery grounds for a number of commercially important fish, prawn, crabs and mollusks.
- They serve as good webs and enhance the fishery production of nearby coastal waters by exporting nutrients and detritus.
- They provide habitats for wildlife ranging from migratory birds to estuarine crocodiles, tigers etc.
- They are sites of accumulation of sediment and they act as ‘sink’ for carbon and nutrients.
- The filtering effects of mangrove forests protect vital coral reefs and sea grass beds from damaging siltation.

<table>
<thead>
<tr>
<th><strong>Belief</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>No wonder some coastal populations, regard mangroves as sacred. At the Lord Nataraj temple at Chidambaram in Tamil Nadu, India, the mangrove tree <em>Excoecaria agallocha</em> locally known as Thaillai, has been worshipped as a temple tree (Sthala vruksha).</td>
</tr>
</tbody>
</table>

Dr. M. S. Swaminathan’s Committee Report (2006) has emphasized regeneration of mangrove wetlands for ecological and livelihood benefits. Carbon sequestration through coastal bio-shields will make an important contribution to promoting a balance between carbon emission and absorption, in addition to offering protection during coastal storms calamities like Tsunami. It is also stressed in the Committee Report that no further time should be lost in initiating a national coastal bio-shield movement along the coast of mainland of India as well as islands; this can be a priority task under the National Employment Guarantee and Food for Work Programmes.

The protective role of mangroves from tsunami was backed by two important scientific papers published. Kathiresan and Rajendran (2005) of Annamalai University Tamil Nadu studied the effects of the 2004 tsunami on 18 coastal hamlets on the east coast of India. They concluded that the distance of a hamlet from the sole elevation and the amount of dense
vegetation between the hamlet and the sea, are effective protection against human death and loss of property. The Nordic Ager Development and Ecology (NORDECO) in Copenhagen, Denmark, published a data from the same coastline and found that mangroves and coastal casuarinas protected against tsunami damage (Danielsen et al., 2005).

The mangrove swamp harbours a complicated community of animals, which are not evident. The roots provide a rich substratum of variety of attached animals, especially barnacles, bivalves, worms and truncates. Fish, mollusks and crustaceans find shelter in between roots. In the mud there are large numbers of burrowing crabs, mollusks and fishes. The branches of the trees are evidently habitats of insects, lizards, snakes and birds, including the migratory ones. All the animals depend on the leaves and detritus which when carried by the estuary contribute to the production of organic matter, which is the basic food available to other animals and plants. Plankton and other micro organisms, which proliferate in the mangrove and its surroundings, are eaten by fishes, prawns, crabs and mollusk larvae. Many of them are commercially important, such as king prawns, mud crabs, mackerel, mullet, and bream. Mangroves provide the nutrients and rich feeding grounds for many marine species from various tropic levels. The fertility generated by the mangroves extend also to the marine areas. Hence many productive fishing grounds of the world are found adjacent to mangrove areas. The mangrove forest is also a special nurturing ground for the juveniles of many important species of finfish and crustaceans.

**The importance of mangroves**

Mangroves offer many benefits to both natural systems and humans, and their removal has several economic consequences.

- Shoreline protection and sediment accretion; mangroves buffer the shoreline from the erosive impact of storms and waves.
- Trap and bind sediments; reducing coastal turbidity and making cleaner waters.
- Major source of primary productivity in the form of plant materials; supporting many important trophic pathways by providing a source for food chains that support many terrestrial and marine organisms.
- Provide habitat for both marine and terrestrial organisms; a home for both plants and animals.
- Provide nurseries for commercially important fish and prawn stocks; replenishing estuarine and coastal fisheries.
- Mangroves are a sink for atmospheric carbon; helping to reduce global carbon dioxide levels and global warming.
Mangroves capture effluents from terrestrial runoff; providing a buffer for nutrients, metals and other toxicants entering coastal waters.

Source of timber and wood products; used for light construction and home energy in certain areas.

And more recently, changes in mangroves have been proposed as a means to monitor change in coastal environments as indicators of global warming, climate change, storm effects, sea level change, pollution, and sedimentation rates.

Almost the entire Indian Coast was rich in mangrove vegetation till the resent past. Significant mangroves are still available in Sunderbans (West Bengal), the deltaic regions of Mahanadi of the Bhitaranika area (Orissa), the Krishna and Godavari delta in the Andhra Pradesh, fringing coast in Andaman and Nicobar islands, on the coral reefs and fringing the mainland in the Gulf of Kutch, the deltaic regions of Kori creek in Gujarat coast and Pichavaram-Vedaranyam of the Tamil Nadu coast. Compared to the estimate of mangrove spread of the late eighties of 6740 Sq. km, the present estimate of 4120 sq.km. show that the mangroves are fast degrading in the country. They are destroyed due to their use as fuel, fodder and conversion of these areas for agricultural, aquacultural and industrial purposes.

The mangroves of Sundarbans are the largest single block of tidal holophytic mangroves of the world. The major species of this dense mangrove forest include Herbiteria fames, Rhizophora spp., Bruguiera spp., Ceriops decandra, Sonneratia spp. and Avicennia spp., Nypa fruticans are found along the creeks. This mangrove forest is famous for the Royal Bengal Tiger and crocodiles. Mangrove areas are being cleared for agricultural use. The mangroves of Bhitaranika (Orissa), which is the second largest in the Indian sub-continent, harbours high concentration of typical mangrove species and high genetic diversity. Mangrove swamps occur in profusion in the intertidal mudflats on both sides of the creeks in the Godavari-Krishna deltaic regions of Andhra Pradesh. These and the well-developed mangroves of Pichavaram and Vedaranyam are degraded mainly due to construction of aquaculture ponds and salt pans.

On the west coast of India, mangroves, mostly scrubby and degraded occur along the intertidal region of estuaries and creeks in Maharashtra, Goa and Karnataka. The mangrove vegetation in the coastal zone of Kerala is very sparse and thin. In Gujarat (north west coast) mangroves Avicennia marine, Avicennia officinalis and Rhizophora mucronata are found mainly in Gulf of Kutch and the Kori creek. Mangroves are of scrubby type with stunted growth, forming narrow, discontinuous patches on soft clayey mud. The condition of the mangroves is improving especially in the Kori creek region, which is paleodelta of the Indus river. On the Andaman & Nicobar Islands, the small tidal estuaries, neritic inlets and the lagoons support a dense and diverse undisturbed mangrove flora.

In addition to the diversity of the habitat, the mangroves play an important role in a sediment repository, stabilizes shoreline, a buffer against storm surges (that would otherwise have a more damaging effect on the coast. Its positive impact was noticed in the Bangladesh cyclone of 1991. In the recent Gujarat and Orissa cyclones the devastation was reported to have been lesser where sufficient mangrove buffers were present. The mangrove ecosystems provide a safe and favourable environment for breeding, spawning, rearing of several fish and
shell fish, reptiles and mammals. Some of the shell fish and fishes are highly economically important.

THREATS TO MANGROVE ECOSYSTEMS

While mangrove forests have specific ecological role in the coastal ecosystem and they provide a life support system and income for millions of people, thus destruction is widespread for shorter economic benefits. This happens because mangroves are too often considered wastelands of little or no value unless they are “developed.” In the recent times there has been increased ingress to convert them into agricultural areas. The irony of the situation is that the conversion of mangroves for aquaculture is detrimental to the very same activity as the shrimp fry (baby shrimp) availability decreases, as the mangroves are the natural wild fry collection habitats. The overdose of chemical fertilizers and pesticides not only destroy the aquaculture farms but also become detrimental to the remaining mangrove ecosystems in the vicinity. Even in the case of capture fisheries low recruitment will consequently affect production. With the fishing grounds already overexploited, mangrove destruction can only further reduce stock recruitment and production.

In general, the mangroves are resistant to much of environmental perturbations and stresses. However, mangrove species are sensitive to excessive siltation or sedimentation, stagnation, surface water impoundment and major oil spills. Salinities high enough to kill mangroves result from reductions in the freshwater inflow and alterations in flushing patterns from dams, dredging and bulk heading. Seawalls, bunds and other coastal structures often restrict tidal flow, resulting in the killing of mangroves.

It is important to recognize that many of the forces, which detrimentally alter mangroves, have their origin outside the mangrove ecosystem. Traditional settlers of the mangrove area normally do not cause destruction to the system.

MANAGEMENT APPROACH

The value of the mangrove resource in terms of its marketed products can be expressed in economic terms. The “free” services provided by the mangroves are difficult to measure and consequently are often ignored. These “free” services would cost considerable energy, technology or money if provided from other than natural resources. Since these values are seldom taken into account in the governmental decision process, the total value of the mangrove resource is most often quite significantly understated.

With the purpose of conserving the remaining mangroves, the CRZ declared total prohibition on development in the mangrove areas. This has created awareness on its importance. Afforestation programmes are initiated at least in a few locations. Substantial reduction in the conversion of mangrove forest into aquaculture farms was noticed particularly after the Hon’ble Supreme Court’s intervention in 1994-95. Mapping and research on mangroves improved. The management issues include developers consider the ban on mangroves as a threat and destroy them directly and indirectly reducing its coverage, the Sunderbans mangrove biosphere area which has about 3 lakh resident population has to be given special provisions for certain developmental activities.
The committee recognizes the importance of mangroves in protecting the coastal areas and the coastal communities from storm, cyclones, flooding, etc. Government should take up aggressive programmes to conserve the existing mangroves and initiate intensive mangrove plantation programmes at identified mangrove potential sites so as to develop bioshields.

Mangroves are salt-tolerant forest ecosystems of tropical and subtropical intertidal coastal regions near river mouths. Between latitudes 30°N and 30°S, the shoreline marsh vegetation is replaced by ‘mangals’ (a community of mangroves is termed as mangal). They form highly productive ecosystems since the inorganic nutrients, brought in by the incoming freshwater from land run-off, are trapped to form the source of energy for many organisms. A mangrove ecosystem constitutes a reservoir, refuge, feeding ground and nursery for many useful and unique plants and animals confined to this region. Through the export of decomposable organic matter into adjacent coastal waters, the mangroves provide an important nutrient input and primary energy source for many tropical estuaries. The mangrove ecosystem also protects coastal areas from sea erosion and from the violent effects of cyclones and tropical storms. The warm, calm waterways of mangroves provide shelter and rich food for many juveniles and larvae of finfish and shellfish.

India has only 2.66% of the world’s mangroves, covering an estimated area of 4827 sq km. Out of India’s total area under the mangroves, about 57% are found on the East Coast, 23% on the West Coast and remaining 20% on the Bay Islands (Andaman and Nicobar). The insular mangroves are present in Andaman and Nicobar Islands, where many tidal estuaries, small rivers, neritic islets, and lagoons support a rich mangrove flora. The coastal zone, in general, and the mangroves in particular, are used for multiple purposes like recreation, tourism, forestry, agriculture, aquaculture, housing and commercial fishing. The knowledge on occurrence and distribution of mangrove species is inadequate. The mangroves of India comprise of 69 species excluding salt marshes and other associated species, under 42 genera and 27 families. The mangroves serve as a wildlife sanctuary especially in Sunderbans, Orissa and Andaman and Nicobar Islands.

NATIONAL MANGROVES CONSERVATION AND MANAGEMENT SCHEME

The main objectives of the programme are as follows:

(i) Conservation and management of mangroves and coral reefs;
(ii) Eco-restoration and afforestation in potential and also in degraded coastal areas;
(iii) Maintenance of genetic diversity especially of the threatened and endemic species; and,
(iv) Creation of awareness among the people on importance of these ecosystems leading to their conservation

The Government seeks to sustain and augment the mangrove forests in the country by both regulatory and promotional measures.

Regulatory

The Coastal Regulation Zone Notification (1991) under the Environmental Protection Act (1986) recognizes the mangrove areas as ecologically sensitive and categorizes them as
CRZ-I which implies that these areas are afforded protection of the highest order. Under the promotional measures, the Government has identified 38 mangrove areas on a country-wide basis for intensive conservation and management

**Promotional**

An amount of Rs. 13/- crore was released to the concerned State Governments/Union Territories for implementation of the Management Action Plans for Mangroves & Coral reefs during the Ninth Five Year Plan. During the last three financial years i.e, 2002-03, 2003-04, 2004-05 and 2005-06; a sum of approximately Rs. 18/- crore was released to Coastal States / Union Territories for activities like Survey and Demarcation, Afforestation, Restoration, Alternative / Supplementary Livelihoods, Protection Measures, Research and Education & Awareness.

The draft NEP, 2006 calls for mainstreaming the sustainable management of mangroves into the forestry sector regulatory regime, ensuring that they continue to provide livelihoods to local communities.

**DISTRIBUTION**

*State/UT wise Mangrove Cover as per ‘State of Forest Report 2003 of Forest Survey of India*

<table>
<thead>
<tr>
<th>S. No.</th>
<th>State / UT</th>
<th>Very Dense Mangrove</th>
<th>Moderately Dense Mangrove</th>
<th>Open Mangrove</th>
<th>Total</th>
<th>Change w.r.t. 2001 Assessment</th>
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<td>329</td>
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<td>2</td>
<td>Goa</td>
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<td>64</td>
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<td>10</td>
<td>Andaman &amp; Nicobar</td>
<td>262</td>
<td>312</td>
<td>97</td>
<td>671</td>
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<td>11</td>
<td>Daman &amp; Diu</td>
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<td></td>
<td>1,162</td>
<td>1,657</td>
<td>1,642</td>
<td>4,461</td>
<td>-21</td>
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</tbody>
</table>
** A decrease of 118 km has been reported in the mangrove cover of A&N Islands in 2003 assessment as compared to 2001 assessment. This is not a real loss of Mangrove Forests. This has happened mainly because of correction of classification in interpretation during 2003 assessment. Considerable forest area adjoining mangrove vegetation in Andaman Islands had been earlier classified as mangrove. In 2003 assessment, there has been refinement in the methodology of mangrove delineation where SWIR (short Wave Infra-Red) band has been used which improves delineation of mangroves from adjoining vegetation. Those areas which were earlier classified as mangroves have now been correctly classified as forest cover, resulting in an apparent decrease in mangrove area. This is only an internal change from mangrove area to forest cover. This is evident by the fact that forest cover (which also includes mangrove areas) of Andaman & Nicobar Islands has not shown any decrease. Rather there is a marginal increase by 34 km in forest cover in 2003 assessment.

The coastal zone of the mainland of India and Andaman and Nicobar Islands endowed with the presence of extensive and diverse mangrove wetlands. On a macro scale geomorphic settings of the mangrove ecosystems of the east coast of India are different from those of the west coast. The coastal zone of the west coast is narrow and steep in slope, due to the presence of the Western Ghats. Secondly, there is no major west-flowing river. As a result, mangrove ecosystems of the west coast of India are small in size, less diversity and less complicated in terms of tidal creek network. On the other hand, the presence of larger brackish water-bodies and a complex network of tidal creeks and canals characterize the mangrove ecosystems of the east coast. This is mainly due to the large deltas created by east-flowing rivers and the gentle slope of the coast.

Not all coastal areas are suitable for mangrove plantation as mangroves require appropriate mixture of saline & freshwater, and soft substrate like mudflats to be able to grow and perpetuate. Mangrove plantation is to be perceived as only one of the important components of Integrated Coastal Zone Management.

**THREATS TO MANGROVES**

Mangroves face several abiotic and biotic pressures as listed below:

**Abiotic**
- Cyclones
- Earthquakes
- Tsunami
- Pollution from point and non-point sources resulting in deterioration of quality
- Poor flushing by tidal waters and consequential high saline condition

**Biotic**
- Habitat destruction
- Encroachment resulting in shrinkage of area
- Anthropogenic pressures resulting in habitat destruction and loss of biodiversity
- Uncontrolled dredging resulting in succession changes
- Hydrological interventions resulting in loss of aquifers
- Uncontrolled siltation and weed infestation. The spread of the invasive *Prosopis juliflora* is a threat to the future of the mangroves.
- Uncontrolled discharge of waste water, industrial effluents, surface run-off etc. resulting in proliferation of aquatic weeds which has detrimental effect on flora and fauna

Indian researchers have found out that the mangroves in India experience some 17 threats in different maritime states of our country. The most significant threat is of human pressure on mangrove-resources of forestry, fishery products and salt farming. Hence, the Ministry of Environment & Forests has given priority for sustainable management of the mangrove resources, with the local peoples’ participation.

### Threats to Mangroves of Various Maritime States of India

<table>
<thead>
<tr>
<th>Major Threats</th>
<th>West Bengal</th>
<th>Orissa (Bhitarkanika)</th>
<th>Andhra Pradesh</th>
<th>Tamil Nadu</th>
<th>Andaman &amp; Nicobar</th>
<th>Gujarat</th>
<th>Maharashtra</th>
<th>Goa</th>
<th>Karnataka</th>
<th>Kerala</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle/Goat/Deer/Camel grazing</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+++</td>
<td>+</td>
<td>++</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Tree felling for firewood &amp; wood products</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+++</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Over exploitation of fishery resources</td>
<td>+++</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
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<td>-</td>
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</tr>
<tr>
<td>Reclamation for agriculture</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Reclamation for salt farming</td>
<td>≈</td>
<td>≈</td>
<td>≈</td>
<td>≈</td>
<td>≈</td>
<td>+</td>
<td>≈</td>
<td>≈</td>
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</tr>
<tr>
<td>Aquaculture</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
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<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>For urban development /human settlement</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
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<tr>
<td>Lack of fresh water due to bridge construction or sand bar formation</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>++</td>
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<td>++</td>
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<tr>
<td>Shoreline/Geomorphic changes</td>
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<td>++</td>
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<td>Pollution &amp; discharge of effluents</td>
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<td>+++</td>
<td>++</td>
<td>+</td>
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<tr>
<td>Port/Harbour development</td>
<td>+</td>
<td>-</td>
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</tr>
</tbody>
</table>
**Major Threats**

<table>
<thead>
<tr>
<th>Major Threat</th>
<th>West Bengal</th>
<th>Orissa (Bhitarkanika)</th>
<th>Andhra Pradesh</th>
<th>Tamil Nadu</th>
<th>Andaman &amp; Nicobar</th>
<th>Gujarat</th>
<th>Maharashtra</th>
<th>Goa</th>
<th>Karnataka</th>
<th>Kerala</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>-</td>
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<td>-</td>
</tr>
<tr>
<td>Lack of local peoples’ participation</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>Hyper salinity</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>++</td>
<td>-</td>
<td>++</td>
<td>-</td>
<td>-</td>
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<td>-</td>
</tr>
<tr>
<td>Natural calamities (Cyclone &amp; Sea level rise)</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>+++</td>
<td>++</td>
<td>-</td>
<td>-</td>
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<td>-</td>
</tr>
<tr>
<td>Siltation and sedimentation</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>++</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total Number</strong></td>
<td><strong>20</strong></td>
<td><strong>8</strong></td>
<td><strong>17</strong></td>
<td><strong>21</strong></td>
<td><strong>10</strong></td>
<td><strong>25</strong></td>
<td><strong>9</strong></td>
<td><strong>5</strong></td>
<td><strong>2</strong></td>
<td><strong>11</strong></td>
</tr>
</tbody>
</table>

+ = Intensity of threat; - = Insignificant threat; ≈ = Studies not undertaken

**LEGAL AND REGULATORY APPROACH**

At present, the mangroves are protected through a range of regulatory measures. Mangroves located within the notified forest areas are also covered under the Indian Forest, 1927 and Forest (Conservation) Act, 1980.


**INSTITUTIONAL MECHANISM**

**Present Status**

Taking into consideration the complexity of the issue, the State Steering Committees have been constituted under the Chairmanship of Chief Secretaries/Additional Chief Secretary/Principal Secretary (Forests & Environment) as the case may be with the members from all concerned Departments. The Committee is also expected to have representatives from communities, NGOs and academicians. The officer from nodal Department acts as a Member-Secretary of the Committee. The Ministry of Environment and Forests is represented on the State level Steering Committee.

**Proposed Status**

The National Committee is chaired by Secretary (E & F) or his nominee. The Committee has representatives of Coast Guards, Department of Ocean Development, Central Marine Fisheries Research Institute, Space Application Centre, as well as expert scientists...
from Universities and Institutions. The overall mandate of is to assist Government on policies and action programme for conservation of mangroves, coral reefs and related ecosystems.

State Governments need to consider constitution of National Resource Conservation Authorities so that experts from various Departments undertake conservation activities in a more scientific and sustainable manner. It is imperative to have multi-disciplinary, holistic and integrated approach for achieving long term sustainable mangrove conservation and management measures.

**BROAD APPROACH TO SUSTAINABLE MANAGEMENT – INTEGRATED MANAGEMENT ACTION PLANS**

The Central Government gives 100% assistance for research on Mangroves as well as for the implementation of approved Management Action Plans (MAP). The Research and the MAP components are stated below:

**Research**

Without proper research inputs, no Management Action Plan can be successful. The research aspect should supplement Management Action Plan for proper implementation. These research inputs should help in formulation of MAP and should be application-oriented.

Research proposals on prioritized areas are requested from State Governments and various academic institutions which are discussed in Research & Eco-generation (RE) Division on Mangroves & Coral Reefs.

The general guidelines on procedural aspect as brought out by Research & Eco-generation (RE) Division of the Ministry are at the Web-site of the Ministry.

**Approval of Research proposals by Research sub-Committee**

There is a Research Sub-Committee, a Sub-Committee of National Committee for consideration of various Research projects. All the Research projects submitted by the State Governments / academic institutions / research organizations are sent to referees for their comments. There is a departmental examination of all the projects on the basis of comments received. These are put up before the Research sub-Committee.

**Management Action Plan (MAP)**

The issues which merit careful attention with reference to conservation and management of mangroves are stated below:

**Admissible Components for Assistance**

The Ministry provides assistance on 100% grant basis for the following components:

a) Survey, Assessment and Demarcation
b) Capacity Building : Staff Training and Skills
c) Shelter Belt Development
d) Protection & Monitoring
e) Restoration and Regeneration Measures
f) Alternate and Supplementary Livelihoods
g) Community Participation
h) Mangrove Afforestation/Plantation (Degraded areas and open mud flat coverage by plantation)
i) Biodiversity Conservation
j) Sustainable Resource Development
k) De-silting
l) Weed Control
m) Pollution Control
n) Environmental Education & Awareness
o) Impact Assessment through Concurrent & Terminal Evaluation

(a) Survey, Assessment and Demarcation

Survey & inventorization should taken into consideration on identification of different human activities, effect of effluents both industrial & domestic, and information obtained through remote sensing with attached accuracy estimates to be verified with the ground truth data.

This component includes mapping of catchments through revenue records, survey & assessment and land use pattern using Remote Sensing and GIS techniques, with emphasis on drainage pattern, vegetation cover, siltation cover, encroachment, conversion of mangrove areas, human settlements, total area encroached, human activities and its impact on catchments and water body.

(b) Capacity Building: Staff Training and Skills

Capacity building is a major tool without which no conservation activity is possible. We need to have good infrastructure, trained people, and documentary record to teach values and functions of mangroves in an integrated and multi-disciplinary manner. Holding workshops on region-wise basis and in-service training with Research organizations and Managers should be an on-going feature with a view to promote value & benefits from Mangroves.

(c) Shelter Belt Development

These plantations (e.g. *Casuarina* sp.) should be beneficial to local community for helping them in raising their socio-economic level.

(d) Protection and Monitoring

A list of illustrative activities to be taken up by the respective State Government(s) for protection measures is indicated below:

- Parameters for monitoring to be identified and frequency of observations to be stated with justification
- Patrolling and surveillance
- Setting up of watchtowers and patrolling by motor boats
• Removal of encroachments
• Habitat improvement
• Socio-economic development through community participation

(e) **Restoration and Regeneration Measures**

A list of illustrative activities to be taken up by the respective State Governments for restoration measures is indicated below:

• Maintenance of biological diversity
• Rehabilitation of endangered and endemic species
• Fisheries development without mangrove destruction
• Enhancing floral & faunal diversity
• Nursery & plantation

(f) **Alternate and Supplementary Livelihoods**

Mangroves provide settlement and livelihood for a large number of local communities. We have to involve local people in the conservation and management of natural resources. Ways and means have to be found for the alternate and sustainable livelihood of the local people, in case their activities are detrimental to the health of the mangroves. This can be achieved through various activities such as piggery, animal husbandry like goat & cattle rearing, cultivating better varieties of crops or change in cropping pattern & agricultural practices, duckery, small cottage industries, tailoring, carpet weaving, mushroom cultivation, seed collection, apiculture, and honey collection, pearl and pisciculture, fishing and ecotourism. This will not only provide sustenance to local communities but will also be an asset for conserving mangroves.

(g) **Community Participation**

No decision making is complete without participation of local people who livelihood depends upon wetland resources. People have been using mangrove areas since times immemorial in traditional manner. We have to blend both traditional and latest scientific technologies to achieve long-term conservation goals. Participatory Rural Appraisal exercise involving local communities should be the main ingredient of community participation. It should also take into consideration issues of gender sensitization & involve women in the management issues.

The main constituents of this component should include:

• Assessment of resource availability by surveys and participatory rural appraisal of the site
• Stakeholder analysis
• Contact with external institutions for resource and technical advice
• Additional alternate income generation programmes such as handloom, handicrafts, integrated farm management techniques & other measures to reduce pressure on mangroves
• Highlighting of gender-related cross-cultural, governance-related practices and other special concerns for assessment and change by community
• Fishery and aquaculture in backwater

(h) **Mangrove Afforestation / Plantation (Degraded areas and open mud flat coverage by plantation)**

This is the most important, seminal component of the scheme. The idea is to replant mangroves in areas where they previously existed as well as increase the mangrove coverage where feasible. The State/UT Government are provided 100% Central assistance for raising the mangrove plantations as per the models and cost norms proposed by the Untawale Sub-Committee Report.

(i) **Biodiversity Conservation**

Marine biodiversity is a relatively neglected area in mangrove ecosystems. Though sporadic studies have been made with regard to various aspects of floral and faunal diversity, yet these efforts have still to be consolidated to give an overall picture of biodiversity. There is urgent need for preparing a state-wise data-base on mangrove ecosystems of the country to give insight about status of flora & fauna in terms of their vulnerability and possible conservation measures through ex-situ and in-situ methods. Studies need to be undertaken to identify species under threat, and factors responsible for their depletion.

Activities under Biodiversity Conservation should include:

• Identification of floral and faunal biodiversity and bio-prospecting
• Conservation of sensitive species through in-situ and ex-situ methods
• Role of floral and faunal elements in the context of ecosystem processes and the control of exotic species
• Ecology of rare and endemic species as well critically endangered, vulnerable species following IUCN criteria

(j) **Sustainable Resource Development**

Unless and until we use our resources in a wise manner, goals of mangrove conservation cannot be achieved. We must pass on our mangrove areas to future generation in a much better form after wisely using them in a sustainable manner. The components of sustainable resource development should include:

• Assessment of current resource utilization patterns and its impacts
• Economic valuation of mangroves to determine and allocate resources
• Enhancement of mangroves resources for meeting the demands of people to sustainable fisheries development, food, fodder, fuel etc.
• Utilization of mangroves for eco-friendly recreational purposes (eco-tourism)

(k) De-silting

As most of the rivers and backwaters are silted heavily, regular exchange seawater and fresh water is crucial for the proper health of mangroves. To cite an example in Muthupet, the mouth of the Mulliplam lagoon, which is the only for exchange of water, is getting narrower as well as shallower due to shifting silt from the southern areas. The mouth needs to be cleared if the health and fishery production in the mangroves is to be maintained. It is therefore, suggested that the Dredging Corporation of India be addressed to carry out desilting of the lagoon mouth.

(l) Weed Control

Weed infestation is now a major problem in many mangrove areas. Sufficient financial provision may be provided to eradicate weed from the mangrove area e.g. in case of Muthupet, Prosopis can be uprooted and be converted into charcoal by the local people.

(m) Pollution Control

A large number of mangrove areas in the country are subjected to domestic sewage, solid waste and other industrial effluents. Similarly, fertilizer and pesticide run-off from agricultural lands also augment the pollution load. All these factors are responsible for accelerating the process of eutrophication.

The pollution control measures need to take into account the following aspects:
• Identification of point and non-point sources of pollution
• Number of effluent treatment plants set up in the vicinity and whether they are functional
• Sewage treatment methods, if any, in existence (only biological)
• Use of weeds as means of nutrient removal (whether in existence)
• Water quality parameters, soil texture and soil analysis (whether in existence or not)
• Status of heavy metal pollution, if any
• Pollution due to domestic sewage, number of entry points
• Whether fish existing in water body contains any amount of metal contamination. If yes, sources of contamination
• Methods of solid waste management, whether in existence, if yes, what methodology is adopted to remove solid waste
• Amount of agricultural run-off, pesticides, insecticides in water
• Whether there are mining areas in the upstream of estuary like ores of Fe, Mn etc. The concentration of these heavy metals/minerals are to be checked.
• Remedial measures taken to minimize the pollution
Petrol, diesel or oil pollution is also harmful to mangrove flora and fauna. Any leakage, or release of these products to be noted.

Release of raw sewage although does not harm mangroves, however, it gives rise to manifold biological productivity due to nutrients.

(n) **Environment Education & Awareness**

Mangrove ecosystems are Centres of major global biodiversity. They also provide unique habitat for rare, endangered and threatened species and as such are, repository for gene pools. Mangroves provide transitional zones (Ecotones) between land and water and thus they support communities both from aquatic and terrestrial habitats.

One of the important components which could work as a catalyst is building of awareness about values and need for conservation of mangroves. Under Management Action Plans, financial assistance to be provided to the State Governments for building up awareness within all target groups through audio-visuals, posters, nature camps, films etc. Several programmes have been initiated by the State Governments for involving people in the conservation of mangroves.

The Ministry of Environment and Forests conducts the National Environmental Awareness Campaign every year for creating environmental awareness and consciousness at the national level. This campaign uses the communication skills of both conventional and non-conventional methods to get across the desired message. During the campaign, non-governmental organizations like schools, colleges, universities, professional bodies, women and youth organizations participate.

The activities under this component may include:

- Workshops held on various environmental education themes
- Training provided to disseminate education values of wetlands
- Construction & furnishing of Interpretation Centre
- Hoardings, signage and electronic interactive means in local language and language understood by broad based segments and stakeholders concerned
- Non-formal education for illiterate and adults
- Organization of painting competitions, exhibitions, poetry, contests on environmental themes
- Documentaries made on various wetland issues and their impact on public
- Brochures and posters made on various environmental themes
- Creation of environmental consciousness through folklore, street theatre and padyatras

(o) **Impact Assessment through concurrent and terminal evaluation**

The executing department needs to undertake assessment of the impact of the scheme in terms of various parameters through concurrent and terminal evaluations. The State Government is requested to select an impartial outside technical agency for evaluating the progress of the work to be carried out under the activity. The State Government is requested
to undertake survey for preparation of baseline data i.e. pre-project status in terms of various relevant parameter particularly extent area coverage by plantation, species density and dive performance of various species, biomass yield levels, existing nursery, spawning breeding grounds for mangrove associated fauna, extent of obnoxious weeds, moisture content, quality of water, groundwater levels, range and variety biodiversity in terms of flora and fauna including birds & fish, supplement alternate livelihoods, social & infrastructural facilities, capacity levels of staff, awareness generation.

The executing department, during and after conclusion of the project will undertake assessment of impact of the scheme in terms of all the above parameters. This can be done through concurrent and terminal evaluations engaging independent professional agencies such as eminent academic institutions, renowned consultancy organizations and research organizations within or outside the State. The Ministry of Environment & Forests and State Governments will draw up boards of external agencies for evaluation.

The Joint Forest Management Committee (JFMC) also referred to as Village Protection Committee (VPC) or Eco-Developmental Committee (EDC) is expected to play an active role in conservation and management of mangroves.

**Mechanism for formulation of Management Action Plans (MAP)**

Though sufficient information maybe available with the field officers, it is however that it might be beyond the normal capacity of most field officers to prepare a proposal without extensive research inputs. Necessary financial provision has to be made from engaging a competent research body to collect the inputs as mentioned in the guidelines. As different mangroves areas have adopted different management and conservation techniques, it would be mutually beneficial if linkages among the various mangrove areas are established. There also needs to be regular interaction among the managers of different mangrove areas in the country. Field visits could also be arranged to various mangrove areas of the country and an annual conference of mangrove managers shall be held with financial support from MOEF for knowledge sharing.

State Governments are encouraged to make long-term comprehensive Management Action Plans preferably for 3 to 5 years, coinciding with the plan period. The State Governments are advised to define objectives taking into consideration the factors responsible for degradation of the mangrove areas. The Action Plan should also have short-term objectives to cater to immediate problems confronting wetlands and to go in for immediate rectification measures. The MAP should cover the following aspects:

(a) Location, area, altitude, latitude, longitude, depth, ecological features, inflow-outflow pattern, zonation, if any, geological and climatic features

(b) Baseline data, i.e., pre-project status in terms of various relevant parameters

(c) Land-use pattern in the catchments including vegetation, human settlements, agriculture, major and minor industries etc.

(d) Sources of qualitative and quantitative inflow of effluents, sewage, pesticide, chemicals and other sources entering into mangroves

(e) Flora including distribution of macrophytes, plankton, benthos etc.
(f) Fauna including details of major animal groups like birds, fishes, reptiles, mammals. Details regarding invertebrate fauna should also be included

(g) Population/families directly dependent on mangrove resources

(h) Socio-economic survey of mangroves through questionnaire

(i) Cultural and indigenous practices of mangrove resource utilization

(j) Jurisdiction of various concerned Departments dealing with mangrove conservation

(k) Existing conservation measures taken

(l) Interface with Researchers to incorporate relevant research findings in MAP

(m) Involvement of people up to Panchayat level in decision making

(n) Wise use practices of mangrove research, if any in existence

(o) Monitoring mechanism at local & State levels

**Identification of new sites**

New mangrove areas are identified on the basis of preliminary information sent by various State Governments which include map of mangrove areas, geographical/ecological features, problems confronting the mangrove areas, use of mangrove areas for the local people and suggestive management for remedial measures. On the basis of this preliminary information group of experts consisting of representatives of Ministry of Environment & Forests, BSI, ZSI, State Governments and one or two representatives from University or Research organizations having expertise in the field of mangroves visit the site to assess the feasibility of its inclusion under the National Mangrove Conservation Programme. However, while the concept of integrated coastal zone management has been endorsed, by many an institution the legal and institutional frameworks necessary for this purpose are totally lacking or in their relative infancy (Shine and de Klemm, 1999). Moreover, we do not yet understand all the consequences of disturbances to mangrove forests and therefore we cannot yet define acceptable limits of harvesting of mangrove resources that can be used to formulate management policies (Ewel et al., 1998). Ecosystem services provided by the natural systems cannot be substituted by man-made capital. Therefore it is trivial to ask their value to humankind. Their value is infinite in total (Costanza et al., 1997).

* * * * *
Chapter 4: Wetlands

Wetlands are transitional zones between land and water, a collective term for marshes, swamps, bogs and similar areas. They have been described as the “kidneys” of the landscape as they filter sediments and nutrients from surface water. Wetlands are often referred to as “biological supermarkets” because they support all life forms through extensive food webs and biodiversity (Mitsch and Gosselink, 1993). They help regulate water levels within watersheds, improve water quality, reduce flood and storm damages, provide habitat for important fish and wildlife, support hunting, fishing, other recreational activities and perform some useful functions in the maintenance of ecological balance.

Dense human population in catchments, urbanisation, and various anthropogenic activities has resulted in over exploitation of wetland resources, leading to degradation in their quality and quantity. Now, there is increasing concern to conserve and restore perishing wetlands and endangered habitats to achieve ecological sustainability.

SIGNIFICANCE OF WETLANDS

Wetlands are among the most productive ecosystems. They directly or indirectly support millions of people and provide goods and services to them. They support important processes like the movement of water into streams and oceans; decay of organic matter; release of nitrogen, sulfur, and carbon into the atmosphere; removal of nutrients, sediment and organic matter from water moving into the wetland; and the growth and development of all organisms dependent on them. The direct benefits of wetlands are in the form of fish, agriculture, fuelwood, recreation and water supply, etc. and their indirect benefits arise from functions occurring within the ecosystem such as flood control, ground water recharge and storm protection. The mere existence of wetlands may have great significance to some people, as they are a part of their cultural heritage. Water is required for various purposes like drinking and personal hygiene, fisheries, agriculture, navigation, industrial production,
hydropower generation and recreation. Apart from these, some socio-economic values also accrue through water supply, fuel wood, medicinal plants, livestock grazing, tourism, etc.

Wetlands are areas of land where the water level remains near or above the surface of the ground for most of the year. The association of man and wetlands is ancient, with the first signs of civilization originating in wetland habitats such as the flood plains of the Indus, the Nile Delta and the Fertile Crescent of the Tigris and Euphrates rivers. Wetlands cover about 6% of the earth’s land surface. There are several kinds of wetlands such as marshes, swamps, lagoons, bogs, fens and mangroves. They are home to some of the richest, most diverse and fragile of natural resources. As they support a variety of plant and animal life, biologically they are one of the most productive ecosystems.

**Wetlands of India**

India has a wealth of wetland ecosystems distributed in different geographical regions. Most of the wetlands in India are directly or indirectly linked with major river systems such as the Ganges, Cauvery, Krishna, Godavari and Tapti. India has totally 27,403 wetlands, of which 23,444 are inland wetlands and 3,959 are coastal wetlands. According to the Directory of Asian Wetlands (1989), wetlands occupy 18.4% of the country’s area (excluding rivers), of which 70% are under paddy cultivation. In India, out of an estimated 4.1 mha (excluding irrigated agricultural lands, rivers, and streams) of wetlands, 1.5 mha are natural, while 2.6 mha are manmade. The coastal wetlands occupy an estimated 6,750 sq km, and are largely dominated by mangrove vegetation. About 80% of the mangroves are distributed in the Sunderbans of West Bengal and the Andaman and Nicobar Islands, with the rest in the coastal states of Orissa, Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, Goa, Maharashtra and Gujarat.

Wetlands in southern peninsular India are mostly manmade and are known as yeris (tanks). They are constructed in every village and provide water for various human needs, besides serving as nesting, feeding, and breeding sites for a large variety of bird species. Point Calimere in Tamilnadu; Ashtamudi,
Sasthamkotta and Vembanad Kol lakes in Kerala; and Kolleru lake in Andhra Pradesh are some of the natural wetland sites in South India.

India’s wetlands are generally differentiated into 8 categories depending on their regional presence (Scott, 1989):

- The reservoirs of the Deccan Plateau in the south, together with the lagoons and other wetlands of the southwest coast
- The vast saline expanses of Rajasthan, Gujarat and the Gulf of Kutch
- The freshwater lakes and reservoirs from Gujarat eastwards through Rajasthan (Keoladeo Ghana National Park) and Madhya Pradesh
- The delta wetlands and lagoons of India’s east coast (Chilka Lake)
- The freshwater marshes of the Gangetic Plains and the floodplains of the Brahmaputra
- The marshes and swamps in the hills of northeast India and the Himalayan foothills
- The lakes and rivers of the mountain region of Kashmir and Ladakh
- The mangroves and other wetlands of the Andaman and Nicobar Islands

**Importance of wetlands**

Wetland systems directly and indirectly support lakhs of people, providing goods and services to them. They help check floods, prevent coastal erosion and mitigate the effects of natural disasters like cyclones and tidal waves. They store water for long periods. Their capacity during heavy rainfall to retain excess floodwater that would otherwise cause flooding results in maintaining a constant flow regime downstream, preserving water quality and increasing biological productivity for both aquatic life as well as human communities of the region. Inundated wetlands are very effective in storing rainwater and are the primary source for recharging ground water aquifers.

Many wading birds and waterfowl like egrets, herons and cranes nest in wetlands. Wetlands also provide food and shelter for mammals. They act as natural filters and help remove a wide range of pollutants from water, including harmful viruses from sewage and heavy metals from industries. Wetlands retain nutrients by storing eutrophic parameters like nitrogen and phosphorus and accumulating them in the sub-soil, thereby decreasing the potential for eutrophication.

Mangrove forests are valued for production of fish and shell-fish, live-stock fodder, fuel and building materials, local medicine, honey and bees-wax and for extracting chemicals used in tanning leather, farming and fisheries production have replaced many mangrove areas.
Moreover, significant socio-economic values like constant water supply, fisheries, fuelwood, medicinal plants, livestock grazing, agriculture, energy resource, wildlife resource, transport, recreation and tourism are noteworthy.

<table>
<thead>
<tr>
<th>Rice cultivation Anaimalai, Tamil Nadu, India</th>
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<tbody>
<tr>
<td>Effective management of wetlands is an investment for people and wildlife. Between 300 and 400 million people live close to - and depend on - wetlands.</td>
</tr>
</tbody>
</table>

Wetland ecosystems are often mistakenly undervalued. Few people realize the range of products derived from freshwater habitats such as wetlands - food such as fish, rice and cranberries, medicinal plants, peat for fuel and gardens, poles for building materials, and grasses and reeds for making mats and baskets and thatching houses.

**WETLAND LOSS AND DEGRADATION:**

Wetlands are dynamic ecosystems and are estimated to occupy 8 million km² (6.4 %) of the earth’s surface with about 5 million km² in the tropics and sub-tropics. The major proportion is made up of bogs (30%), fens (26%), swamps (20%) and floodplains (15%). This estimation was compared with the area that existed in the 19th century and it was found that around 50% of the world’s wetlands have disappeared during the last century. The impact on wetlands may be grouped into five main categories: loss of wetland area, changes to water regime, changes in water quality, overexploitation of wetland products and introduction of exotic or alien species. The primary factors causing degradation are sedimentation, eutrophication, pesticide pollution, salinity, heavy metal pollution, weed infestation, low dissolved oxygen and pH (UNEP, 1994).

**Threats to wetlands**

The Wildlife Institute of India’s survey reveals that 70-80% of individual freshwater marshes and lakes in the Gangetic flood plains have been lost in the last five decades. At present, only 50 percent of India’s wetlands remain. They are disappearing at a rate of 2% to 3% every year. Indian mangrove areas have been halved almost from 700,000 hectares in 1987 to 453,000 hectares in 1995 (Sustainable Wetlands, Environmental Governance-2, 1999). A recent estimate based on remote sensing shows only 4000 sq. km area of mangrove resource in India.

The loss of wetlands leads to environmental and ecological problems, which have a direct impact on the socio-economic benefits of the associated populace. Serious consequences, including increased flooding, species decline, deformity, or extinction and decline in water quality could result. Wetlands are also important as a genetic reservoir for various species of plants including rice, which is a staple food for 3/4th of the world’s population.
Urbanization

Wetlands near urban centres are under increasing developmental pressure for residential, industrial and commercial facilities. Urban wetlands are essential for preserving public water supplies.

Anthropogenic activities

Due to unplanned urban and agricultural development, industries, road construction, impoundment, resource extraction and dredge disposal, wetlands have been drained and transformed, causing substantial economic and ecological losses in the long term.

Agricultural activities

Following the Green Revolution of the 1970s, vast stretches of wetlands have been converted to paddy fields. Construction of a large number of reservoirs, canals and dams to provide for irrigation significantly altered the hydrology of the associated wetlands.

Hydrologic activities

Construction of canals and diversion of streams and rivers to transport water to lower arid regions for irrigation has altered the drainage pattern and significantly degraded the wetlands of the region.

Deforestation

Removal of vegetation in the catchment leads to soil erosion and siltation.

Pollution

Unrestricted dumping of sewage and toxic chemicals from industries has polluted many freshwater wetlands.

Salinization

Over withdrawal of groundwater has led to salinization.

Aquaculture

Demand for shrimps and fishes has provided economic incentives to convert wetlands and mangrove forests to develop pisciculture and aquaculture ponds.

Introduced species

Indian wetlands are threatened by exotic introduced plant species such as water hyacinth and salvinia. They clog waterways and compete with native vegetation.

Climate change

Increased air temperature; shifts in precipitation; increased frequency of storms, droughts, and floods; increased atmospheric carbon dioxide concentration; and sea level rise could also affect wetlands.

All of the above have contributed to the decline in the diversity of flora and fauna, migratory birds and productivity of wetland systems. Simultaneously, several thousand species have become extinct.

The Ramsar Convention

Many people consider wetlands as unproductive areas and hence destroy or drain them for developmental activities. However, the importance and usefulness of wetlands was first brought to the notice of the world through a Convention on Wetlands held at the Iranian city Ramsar, in the year 1971.

The Ramsar Convention on Wetlands is an inter-governmental treaty with 150 contracting parties. The Mission statement of the Convention says – "The convention’s mission is the conservation and wise use of all wetlands through local regional and national
actions and international cooperation as a contribution towards achieving sustainable development throughout the world." (Ramsar, 2002).

There are 1585 wetland sites totaling 134 million hectares, designated for inclusion in the Ramsar List of Wetlands of International Importance. India too is a signatory to the Ramsar Convention especially on the Waterfowl Habitat.

To mark the date of the signing of the convention on wetlands, 2nd February of each year is observed as World Wetlands Day (WWD). It was celebrated for the first time in 1997 and the beginning was quite encouraging. Each year a theme is suggested for the day. It was celebrated for the first time in 1997 and the beginning was quite encouraging. Chilka Lake (Orissa) and Keoladeo National Park (Bharatpur, Rajasthan) have been designated under the Convention of Wetlands of International Importance (Ramsar Convention) as being especially significant waterfowl habitats.

As a part of the conservation strategy a data book called Montreaux Record is kept of all those wetlands that require international help for conservation. The inclusion of a site in this list makes it eligible for a global package for conservation related activities. An annual ‘International Ramsar Convention Award’ carrying a cash prize of $ 10,000 and commendation is given to the best conservation efforts.

On the brighter side the Chilka Lake which was on Montreaux Record of Ramsar due to adverse changes in its ecological character caused by pollution and other anthropogenic pressure was removed from the list. Subsequently it bagged the International Ramsar Conservation Award for what the award committee has called as "the outstanding work in the field of conservation and wise use of wetlands involving local committees". It is interesting to find that it was chosen from among 59 entries for the cash prize- a remarkable achievement indeed, considering the fact that it was in the black list.

Efforts to conserve wetlands in India began in 1987 and the main focus of Governmental efforts was on biological methods of conservation rather than adopting engineering options. A national wetland-mapping project has also been initiated for an integrated approach on conservation. In certain wetland sites it is heartening to see the Government, NGOs and local community coming together to save our wetlands and thus realize the objectives of Ramsar Convention.

The National Committee on Wetlands, Mangroves and Coral Reefs, constituted for advising the Government on appropriate policies and measures to be taken for conservation and management of the wetlands, has identified 93 wetlands for conservation and management on priority basis.

19 Ramsar Sites had been designated in India. As the pressures on these and other important lake wetland sites continue to increase, the need for conservation and promotion of ‘wise use’ requires immediate attention. Many of the sites have not yet developed integrated management plans while others have ample room for improvement.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name of Wetland</th>
<th>State</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ashtamudi Wetland</td>
<td>Kerala</td>
<td>61,400</td>
</tr>
<tr>
<td>2</td>
<td>Bhitarkanika Mangroves</td>
<td>Orissa</td>
<td>65,000</td>
</tr>
<tr>
<td>Sr. No.</td>
<td>Name of Wetland</td>
<td>State</td>
<td>Area (ha)</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------------------------</td>
<td>------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>3</td>
<td>Bhoj Wetland</td>
<td>Madhya Pradesh</td>
<td>3,201</td>
</tr>
<tr>
<td>4</td>
<td>Chilika Lake</td>
<td>Orissa</td>
<td>1,16,500</td>
</tr>
<tr>
<td>5</td>
<td>Deepor Beel</td>
<td>Assam</td>
<td>4,000</td>
</tr>
<tr>
<td>6</td>
<td>East Calcutta Wetlands</td>
<td>West Bengal</td>
<td>12,500</td>
</tr>
<tr>
<td>7</td>
<td>Harike Lake</td>
<td>Punjab</td>
<td>4,100</td>
</tr>
<tr>
<td>8</td>
<td>Kanjli</td>
<td>Punjab</td>
<td>183</td>
</tr>
<tr>
<td>9</td>
<td>Keoladeo National Park</td>
<td>Rajasthan</td>
<td>2,873</td>
</tr>
<tr>
<td>10</td>
<td>Kolleru Lake</td>
<td>Andhra Pradesh</td>
<td>90,100</td>
</tr>
<tr>
<td>11</td>
<td>Loktak Lake</td>
<td>Manipur</td>
<td>26,600</td>
</tr>
<tr>
<td>12</td>
<td>Point Calimere Wildlife and Bird Sanctuary</td>
<td>Tamil Nadu</td>
<td>38,500</td>
</tr>
<tr>
<td>13</td>
<td>Pong Dam Lake</td>
<td>Himachal Pradesh</td>
<td>15,662</td>
</tr>
<tr>
<td>14</td>
<td>Ropar</td>
<td>Punjab</td>
<td>1,365</td>
</tr>
<tr>
<td>15</td>
<td>Sambhar Lake</td>
<td>Rajasthan</td>
<td>24,000</td>
</tr>
<tr>
<td>16</td>
<td>Sasthamkotta Lake</td>
<td>Kerala</td>
<td>373</td>
</tr>
<tr>
<td>17</td>
<td>Tso Morari</td>
<td>Jammu &amp; Kashmir</td>
<td>12,000</td>
</tr>
<tr>
<td>18</td>
<td>Vembanad-Kol Lake</td>
<td>Kerala</td>
<td>1,51,250</td>
</tr>
<tr>
<td>19</td>
<td>Wular Lake</td>
<td>Jammu &amp; Kashmir</td>
<td>18,900</td>
</tr>
</tbody>
</table>

India has designated six new wetlands to the Ramsar Convention on Wetland’s list of international importance. The wetland areas include the: Hokersar Wetland and Surinsar-Mansur Lakes in the north-western Himalayan province of Jammu & Kashmir; Chandertal Wetland and Renuka in Himachal Pradesh; Rudrasagar Lake in the northeastern state of Tripura; and Upper Ganga River in Uttar Pradesh. The designations, announced on World Wetlands Day, bring the number of Ramsar sites in India to 25.

The concerned State Governments have set up Steering Committees constituting representatives from government departments, universities and research institutions for effective implementation of these policies. Nodal research / academic institutions have been drawn up for most of the identified wetlands.

Wetlands jurisdiction is diffused and falls under various departments like agriculture, fisheries, irrigation, revenue, tourism, water resources and local bodies. For instance, all mangroves in the country fall under the direct control of forest department. The lack of a comprehensive wetland policy, with each department having its own developmental priorities, works against the interests of conservation of wetlands resulting in intended or unintended spill-over that further aggravates the problem.
Wetland ecosystems are interconnected and interactive within a watershed. In India, unplanned urbanization and a growing population have taken their toll on wetlands. To counter these, management of wetlands has to be an integrated approach in terms of planning, execution and monitoring. Effective tie-ups of trained academicians and professionals, including ecologists, hydrologists, economists, watershed management specialists, planners and decision makers must be linked with local expertise for overall management of wetlands. All these would increase knowledge and understanding of wetlands and evolve more comprehensive and long-term conservation and management strategies. Spreading awareness by initiating educational programs about the importance of wetlands in local schools, colleges and among the general public in the vicinity of the water bodies, besides constant monitoring of wetlands for their water quality, would provide vital inputs to safeguard the wetlands from further deterioration.

**Conservation issues and strategic solutions for birds of Indian wetlands**

- **CONVERSION TO AGRICULTURE** ➤ Maintain patches of wetland
- **WETLAND EXPLOITATION** within agricultural landscapes
- **DAMS AND IRRIGATION** ➤ Encourage wet rice cultivation
- **SILTATION AND FLOODING** to provide additional breeding
- **DEVELOPMENT** habitat for birds
  - (Urban, Industrial, etc.) ➤ Develop government regulations and policies for wetland conservation, and remove wetlands from the ‘wasteland’ category in the current land classification
  - ➤ Plant nest trees or erect artificial nest platforms for birds
  - ➤ Manage wetlands created by dams and irrigation to maximise their value for waterbirds
  - ➤ Assess the environmental impact of proposed dam projects, especially on important rivers for threatened waterbirds
  - ➤ Control flow regimes below dams
  - ➤ Regulate human activities at key wetlands to minimize disturbance
  - ➤ Limit use of agrochemicals, and encourage traditional organic farming methods
  - ➤ Improve management of fish stocks, and ban fishing with chemicals


PHOTO: TIM LOSEBY
The scheme on conservation and management of wetlands was initiated in 1987. The main activities under the Programme are data collection and survey, identification of problems, mapping of wetlands, landscape planning, hydrology, control of encroachments, eutrophication and abatement, aquatic weed control, wildlife conservation, fisheries development, environmental awareness and research on various aspects of wetland processes and functioning.

With the above objectives in mind, a National Committee on Wetlands was constituted. Based on the recommendations of the National Committee on Wetlands in different meetings, 71 wetlands have been identified so far. The National Committee also reviews and monitors the progress of activities under the scheme. A Research sub-Committee on Wetlands has also been constituted to identify more wetlands of national importance and to supplement management action plan for intensive conservation on thrust areas of research.

**Significant achievements**

- Number of wetlands under Wetland Conservation Programme increased from 27 since 1987 to 71, an increase of 44 wetlands during X Five Year Plan. Another 30 wetlands are expected to be included in the list of identified wetlands by end of current Plan.

**LIST OF WETLANDS IDENTIFIED UNDER NATIONAL WETLAND CONSERVATION PROGRAMME**

<table>
<thead>
<tr>
<th>Name of Wetland</th>
<th>State/UT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Wullar</td>
<td>J&amp;K</td>
</tr>
<tr>
<td>2. Tso Morari</td>
<td>J&amp;K</td>
</tr>
<tr>
<td>3. Tisgul Tso</td>
<td>J&amp;K</td>
</tr>
<tr>
<td>4. Renuka</td>
<td>Himachal Pradesh</td>
</tr>
<tr>
<td>5. Pong Dam</td>
<td>Himachal Pradesh</td>
</tr>
<tr>
<td>6. Chandratal</td>
<td>Himachal Pradesh</td>
</tr>
<tr>
<td>7. Harike</td>
<td>Punjab</td>
</tr>
<tr>
<td>8. Ropar</td>
<td>Punjab</td>
</tr>
<tr>
<td>9. Kanjli</td>
<td>Punjab</td>
</tr>
<tr>
<td>10. Chilka</td>
<td>Orissa</td>
</tr>
<tr>
<td>11. Kabar</td>
<td>Bihar</td>
</tr>
<tr>
<td>12. Sambhar</td>
<td>Rajasthan</td>
</tr>
<tr>
<td>13. Kolleru</td>
<td>Andhra Pradesh</td>
</tr>
<tr>
<td>14. Loktak</td>
<td>Manipur</td>
</tr>
<tr>
<td>15. Ashtamudi</td>
<td>Kerala</td>
</tr>
<tr>
<td>16. Sasthamkotta</td>
<td>Kerala</td>
</tr>
<tr>
<td>17. Ujni</td>
<td>Maharashtra</td>
</tr>
<tr>
<td>18. Nalsarovar</td>
<td>Gujarat</td>
</tr>
<tr>
<td>No.</td>
<td>Name</td>
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</tr>
<tr>
<td>19</td>
<td>Deepar Beel</td>
</tr>
<tr>
<td>20</td>
<td>Rudrasagar</td>
</tr>
<tr>
<td>21</td>
<td>Hokersar</td>
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<tr>
<td>22</td>
<td>Mansar-Surinsar</td>
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<tr>
<td>23</td>
<td>Pangong Tsar</td>
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<td>24</td>
<td>East Calcutta</td>
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<tr>
<td>25</td>
<td>Sunderbans</td>
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<td>26</td>
<td>Point Calimer</td>
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<tr>
<td>27</td>
<td>Kottuli</td>
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<td>28</td>
<td>Palak</td>
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<tr>
<td>29</td>
<td>Tamdil</td>
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<tr>
<td>30</td>
<td>Barilla</td>
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<tr>
<td>31</td>
<td>Kusheshwar Asthan</td>
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<tr>
<td>32</td>
<td>Ban Ganga Jhilmil Tal</td>
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<tr>
<td>33</td>
<td>Rewalsar</td>
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<tr>
<td>34</td>
<td>Ahiron Beel</td>
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<tr>
<td>35</td>
<td>Rasik Beel</td>
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<tr>
<td>36</td>
<td>Nawabganj</td>
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<tr>
<td>37</td>
<td>Sandi</td>
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<tr>
<td>38</td>
<td>Lakh Bahoshi</td>
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<td>39</td>
<td>Samaspur</td>
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<td>40</td>
<td>Sultanpur</td>
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<td>41</td>
<td>Bhindawas</td>
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<tr>
<td>42</td>
<td>Magadhi</td>
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<tr>
<td>43</td>
<td>Gudavi Bird Sanctuary</td>
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<tr>
<td>44</td>
<td>Bonal</td>
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<tr>
<td>45</td>
<td>Hidkal and Ghataprabha</td>
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<tr>
<td>46</td>
<td>Kaliveli</td>
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<tr>
<td>47</td>
<td>Pallikarni</td>
</tr>
<tr>
<td>48</td>
<td>Great Rann of Kachh</td>
</tr>
<tr>
<td>49</td>
<td>Thol Bird Sanctuary</td>
</tr>
<tr>
<td>50</td>
<td>Khijadiya Bird Sanctuary</td>
</tr>
<tr>
<td>51</td>
<td>Little Rann of Kachh</td>
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<td>52</td>
<td>Pariej</td>
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<tr>
<td>53</td>
<td>Wadhwana</td>
</tr>
<tr>
<td>54</td>
<td>Nanikakrad</td>
</tr>
</tbody>
</table>
55. Barna M.P.
56. Yashwant Sagar M.P.
57. Wetland of Ken River M.P.
58. National Chambal Sanct. M.P.
59. Ghatigaon M.P.
60. Ratapani M.P.
61. Denwa Tawa wetland M.P.
62. Kanha Tiger Reserve M.P.
63. Pench Tiger Reserve M.P.
64. Sakhyasagar M.P.
65. Dihaila M.P.
66. Ranjitsagar J&K
67 Govindsagar M.P.
68. Udhwa Jharkhand
69. Santragachi W. Bengal
70 Kadulandi Kerala
71 Vembnad Kol Kerala

- 9 States are new entrants to National Wetland Conservation Programme. Number of states covered moves up from 13 to 22.
- Xth Plan allocation of Rs 30 crores is almost double the IXth Plan period of Rs 14.00 crores.
- Guidelines for the preparation of comprehensive management action plans for identified wetlands have been formulated.
- Management action plans have been prepared for 32 wetlands.
- 40 research projects have been approved to supplement these management action plans.
- Nine Regional Workshops on Wetlands have been organized in different parts of the country, viz., Gujarat, Kerala, Orissa, Manipur, Bhopal, Srinagar, Lakshadweep, Sikkim and Agra to sensitize people about values and functions of wetlands, to make them aware why there is need to conserve wetlands and above all to involve communities in conservation efforts along with policy planners, govt. officials, academicians, research organizations, non-governmental organizations, stakeholders etc.
- Lay down policy guidelines for implementing programs of conservation and management of wetlands in the country,
- Identify priority wetlands for intensive conservation measures,
- Monitor implementation of the Programme of conservation, management and research,
• Prepare an inventory of Indian wetlands
• Conservation and protection of the wetlands, Mangrove Ecosystem from further degradation;
• Afforestation of degraded wetlands ;
• Maintenance of genetic diversity especially of the threatened and endemic species;
• Creation of awareness among the people on importance of Wetland Ecosystems and the need for their conservation.
• Involving communities for improving their livelihood
• Wise use of wetlands
• Create capacity building to train different target groups

For Ramsar Convention

(i) 19 wetlands were designated as Ramsar sites in 2002. Six more sites from India, viz. Upper Ganga (Uttar Pradesh), Surinsar-Mansar & Hokerasar (Jammu & Kashmir) Rudrasagar (Tripura) Renuka and Chandertal (Himachal Pradesh) have been declared as Ramsar sites on 8th November at the start of the COP9 meeting raising the total tally of Indian Ramsar sites to 25. This also fulfilled our commitment made at COP7 at Costa Rica in May, 1999 to include 25 sites covering an area of 6,67,131 ha. from our country as Ramsar sites of International Importance.

(ii) India got special recognition at World Park Congress held at Durban during 2003 for designating maximum sites (13) during a single year.

(iii) Ramsar Conservation Award has been given to Chilka Development Authority in 2002 for ecological intervention of Chilka Lake. This is for the first time that any Asian country has been given such award.

(iv) India was also nominated to the Board of Directors of Wetland International. Meeting of Board of Directors of Wetland International was held in India from 19-20 October, 2005 at Manesar on request of Wetland International. 23 countries participated. India chaired one of the sessions. Efforts made by India for wetland conservation were highly appreciated by all the countries.

(v) During Xth Five year Plan, two meetings of Contracting Party of Ramsar Convention have been attended by India held at Valencia in 2002 and Uganda in 2005.

Developing long-term, integrated management plans for wetlands in India through the use of tools such as Geographic Information Systems (GIS) and remote sensing technologies was accepted. Guidelines for integrated wetland management adopted at the Ramsar COP-8 meeting in Valencia, Spain in November 2002 and ways in which these were applicable to our own situations is being developed. An important aim was to establish a mechanism for networking within India, connected to a global network, so that wetland site managers can
share experiences and lessons learned. In addition to creating the national network, the following recommendations may also be looked into:

1. States to undertake short-term strategic plans and long-term integrated management plans for wetlands adapting the management planning guidelines of Ramsar Bureau;
2. Wetland development authorities need to be set-up for effective management in all the states as in the case of Chilika and Loktak;
3. Remote sensing and GIS need to be used as a management tool;
4. Minimum conservation pool level and the environmental flow assessment to maintain the ecological integrity of the wetland ecosystem must be maintained;
5. Stakeholder participation in management has to be ensured right from the start

For 2007-2008 and ongoing

- Wetlands have been identified as thrust area for livelihood, support of people living in fringe area and biodiversity. Water conservation becomes a major area of concern in the Common Minimal Programme. Unlike marine resource like mangrove and coral reefs, the wetlands are not biogeographical and species oriented specific ecosystems. They are ubiquitous and play a critical role in flow nutrient and energy.
- Inclusion of more wetlands under National wetlands conservation Programme. 23 new wetlands have been identified under this programme making total to 94.
- To concentrate on multi sectoral approach to address to various conservation activities in place of ad hoc approach to get desired results.
- Training various stakeholders/planners/managers through various training programmes at regional level involving various bio-geographic regions.
- Involvement of local communities in management and to intrigue traditional knowledge for effective management.
- Emphasis on hydrological aspects and control of prolific growth of aquatic weeds through latest methods.
- Capacity building to develop technical and managerial capabilities.
- Emphasis on integrated approach in place of sectoral approach.
- Water management through integrated water resource management through river basin approach to address flood plain wetlands which originate from oxbow type of rivers.
- Organisation of training programmes for wetland managers.

* * * * *
Chapter 5: Recommendations

Islands

- Detailed scientific research needed to document and understand the changes in the coastal systems in the islands in the aftermath of the tsunami.
- Reassessment and calibration of the new High Tide Line (HTL) on account of change of the coastal profile of the islands due to the earthquake of December 2004 and also climate change.
- Review the working and the outputs of the Island Development Institute (IDI). Create an autonomous structure for the IDI; augment its resources and capacities.
- Long term monitoring on biodiversity using bio-indicator species e.g. dugong for seagrass communities, corals, megapode for coastal forests of Nicobar islands, wild pig/Andaman teal/sea eagle for Andamans, Hornbill for Narcondam islands
- Impact of invasive species on Island biodiversity: Management perspectives.
- Comprehensive mapping of forest areas to map all existing forest areas, forest types and land uses, using a combination of satellite imagery and ground truthing for identification of priority areas for conservation and help achieve management objectives, changes in forest structure due to logging, evaluate the natural regeneration areas and impact on forests and regeneration due to browsing by introduced herbivores like Spotted Deer.
- Systematic studies on the geographical distribution, habitat and propagation of rare and endangered species of plants.
- Creation of effective / strong awareness modules for tourists in the form of films, booklets, pamphlets.
- Strengthen Marine capabilities of the Forest Department, both in terms of research and protection enforcement.
- Training in scuba diving, marine life identification for research purposes and wildlife management.
- Augment timber, cane and bamboo treatment facilities as per SC directions to ensure longer life during use and a reduction in dependance on freshly cut timber / forests for local use.
- Augment, strengthen shipping services to bring it on par with the best in the world. Good shipping should be one of the primary developmental inputs in island systems.
- Promote decentralized water harvesting including roof top water harvesting, watershed development, construction / digging of tanks as is seen in many parts of the Andamans.
• Management of invasive species, eradication of existing invasive species, complete ban on introduction of any invasive species.

• Need to incorporate traditional knowledge in management practices and impart scientific training to augment traditional knowledge of especially the Nicobari for biodiversity research, management and conservation initiatives.

• Issues of the local environment (tropical rainforests, coral reefs, mangroves etc) be made an integral part of school curriculum.

• Extend the jurisdiction of CRZ to include the inter-tidal area in all zones.

• Implementation of the CRZ notification on established legitimate development activities following all due legal regulatory procedures.

• A study to identify existing building norms (Panchayat and Municipal regulations) are effective enough to protect the island’s populations and natural resources and the extent to which environmental considerations are built into them and advocate for necessary changes in the present regulations and their implementation.

• Establishment of a Hazard Safety Cell with adequate manpower and infrastructure to act as a multi disciplinary, multi approach organization.

• Creation of a well-trained pool of manpower and organization including voluntary organizations in dealing with disaster.

• Formulation of awareness campaigns and strategies for implementation for Risk Mitigation activities.

• Upgrading the IT infrastructure. Enhancing the communication infrastructure capabilities, which would include a mix of VSAT communication, video conferencing and other satellite based communication systems.

• Establishment of an Emergency Operation Centre (EOC) at Car Nicobar, Great Nicobar, Andaman and Kavaratti.

• To enhance the scope of Shelter Belt plantation through Community Participation using suitable species of plants which can bind and stabilize the sand at identified locations using shore protection measures for erosion prone areas identified by ‘Centre for Earth Science Studies.

• Scheme for enhancing the existing Fire Fighting mechanism on all the islands with suitable trained manpower and enhancing the existing medical facilities and suitable mechanism for storage and distribution of medicines during an emergency.

• Augmenting the existing transport facilities from mainland to the selected islands through increase in aircraft capacity and number of flights. Extension of the existing landing facilities and expansion of airport at Port Blair and Agatti, provision of additional landing facilities at Car Nicobar, Great Nicobar, avaratti and Kadmat and provision of helipads with helicopters having accommodation of about 25 persons each.

• The existing connectivity through the sea should be improved by providing more number of vessels with additional frequency and carrying capacity both for the passengers and
cargo. Additional facilities for provision of Ramps as well as Ro-Ro facility with the cranes and other equipment's' may be provided at least on all islands in Andaman & Nicobar and Lakshwadeep to help transport the boats from sea to the mainland during the time of calamity.

- Studies on Storm Surge modelling, Tsunami Wave Propagation Modelling, Inundation Mapping and Areas of Inundation at different scenarios to be taken up through the institutions actively involved in these activities in collaboration with India Meteorological Department (IMD), Department of Ocean Development (DOD), and Geological Survey of India (GSI).

Coral Reefs

- Initiatives on conservation, development and poverty reduction in coastal areas need to be more effectively integrated, reflecting their inter-connectedness and ensuring problems that are linked are not addressed in isolation.
- Development of sustainable alternative livelihoods and viable options for coastal populations to reduce the pressure on reef resources.
- Development of suitable approaches and tools for livelihood diversification that are poverty focused and integrated with wider coastal development and poverty reduction strategies.
- Build capacity in the region to address sustainable livelihoods development for reef users, monitoring the effectiveness, including development of methodology and identifying and undertaking research needed to support the above activities.
- Management of coral reef areas be improved by increasing the efficiency in use of funding.
- Increase funding and technical capacity to key institutions, while ensuring that they operate transparently and efficiently.
- Increase enforcement of existing laws such as those relating to coral mining, while ensuring that populations are not deprived of livelihood options;
- Establish a representative network of MPAs in the region, through an analysis of ecological coherence and connectivity in present MPAs, identification of gaps and declaration of new MPAs as needed (this includes all forms of protected areas, i.e. including fish refugia, fisheries management areas etc.).
- Research into current conservation status of food fishes, lobsters, chanks, sea cucumbers, ornamental fishes and other reef-associated biota.
- Appropriate regulation mechanisms to ensure that fisheries are sustainable, possibly though introduction of licenses and certification schemes.
- Increase ecological and socio-economic monitoring and research, to provide reliable data and information to meet national and regional requirements.
- Develop mechanisms for managing coral reef information, including monitoring data, and ensure that these are available to coral reef managers and decision makers.
• Strengthen and upgrade the National Coral Reef Institute located in Andaman & Nicobar in the office of the Zoological Survey of India.

• Coral reef management should be seen much more ‘as a way of life’ rather than a series of short-term projects.

Mangroves

• To assess existing, and if applicable develop new, methodologies and guidelines for assessing qualitative and quantitative aspects of mangroves.

• To assess existing, and if applicable develop new, criteria and indicators for sustainable management of mangrove ecosystems.

• To implement sustainable mangrove management and establish protected mangrove areas, including buffer zones surrounding and influencing such areas.

• To prepare and implement mangrove management plans.

• To establish bilateral and multilateral arrangements for transboundary conservation and management areas.

• To rehabilitate degraded mangroves.

• To maintain, expand and improve access to existing mangrove information databases in collaboration with other organizations [e.g. The global mangrove database and information system (glomis)]

• Update/revise the Indian mangrove atlas along the line of the world mangrove atlas

• To publish and disseminate mangrove information in local languages

• To conduct assessments, monitoring, mapping, boundary demarcation, etc., where reliable information on mangrove resources is lacking.

• To carry out work to assess the contribution of mangroves to, and impacts of mangrove degradation on, local communities and to generate sustainable socio-economic benefits from mangroves for local communities.

• To document and promote use of traditional systems of knowledge and management for mangroves.

• To conduct valuation studies of wood and non-wood goods and services from mangrove areas.

• To undertake studies and projects to improve understanding of mangrove forest ecosystem structure, growth and function.

• To undertake systematic research and monitoring activities to be used to assess the health of mangrove species and their habitat including, inter alia, the effects of climate change/sea-level rise.

• To undertake studies of ecological impacts of wood harvesting and other human actions (e.g., hydrological alterations, creating shrimp ponds) on different types of mangrove ecosystems and innovative technologies for reducing the adverse impact of human uses.
• To provide training and fellowships, with the intention of sharing and increasing awareness, understanding and skills relating to mangrove ecosystems.

• To establish national mangrove committees (natmancoms) to coordinate all activities relevant to mangrove ecosystems.

• To increase mangrove management capacity for extension workers, government officials and local community leaders.

• To encourage and support cooperative relations between all stakeholders (e.g. National and international bodies, local communities, private sector, environmental ngos) with responsibility for the conservation and sustainable utilization of mangrove ecosystems through networking, workshops, etc.

• To formulate appropriate laws and policies on mangroves with participation of all stakeholders and ensure their enforcement.

• To conduct analyses of existing laws/policies and their impacts on mangrove management/conservation.

**Wetlands**

• Preparation of Management Action Plans (M.A.P.) of identified wetlands (60-80 Nos.) and Evaluation & monitoring of on-going Management Action plans.

• Organizing training programme and workshop on wetland conservation and management.

• Research projects in the field of wetland conservation and management.

• Finalization of guidelines for Wetland Conservation for the benefit of user agencies.

• Setting up of regulatory mechanism for wetland conservation on the basis of usage of wetlands.

• Framing a National Wetland Conservation and Sustainable Use Act for protecting wetlands in the country, deciding ownership and adequate scope for sustainable harvesting of the resources.

• Creation of a National Wetland Authority.

• To develop a National Wetland Biodiversity Register.

• Prioritization of wetlands at three hierarchical levels - international, national and local significance.

• To establish and develop a National Wetland Inventory and Sustained Monitoring Programme for all major wetlands in the country.

• To include the Annual Waterfowl Census in the National Annual Action Plan.

• To develop an economic evaluation of Indian Wetlands and integrate it with National Resource Accounting (NRA).

• To establish a National Wetland Information System.
• To undertake capacity building in monitoring, management planning, EIA and wetland restoration.

In addition the following recommendations will be common for all the ecosystems for the Eleventh Plan for the Islands, Corals, Mangroves and Wetlands:

• To Create a Biodiversity Conservation Atlas for Islands, Corals, Mangroves and Wetlands.

• To create a Biodiversity Information System for Islands, Coral, Mangroves and Wetlands by a consolidated and easily accessible database of all recorded species and existing specimens of plants and animals located in various herbaria, museums and other collections.

• To establish a Mangrove Research and Management Institute as recommended by the Swaminathan Committee on CRZ.

• To establish an Oceanarium on the lines of those existing at the Great Barrier Reef, and at Sydney and at Florida.

• To establish a National Wetland Authority.

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92


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