Chapter 5

Biodiversity and Environment Protection

Current Status and Challenges

Lying well within the tropics and extending to the equatorial belt, these islands have a tropical humid, warm and generally pleasant climate, becoming more equatorial in the southern islands of the territory. From the point of view of temperature, the climate is equable and without any distinct or well marked seasons. The Southwest monsoon period is the chief rainy season which lasts from late May to early October. The humid tropical monsoon climate with mean monthly temperature ranging from 25-30^{0}C is very ideal for harvesting of sunshine, utilisation of moisture and biomass growth throughout the year. Desirable seawater temperature also promotes growth of fishes, aquatic flora and fauna throughout the year to provide a high level of hydrobiological productivity. The hot humid climate, however, brings in a lot of diseases and pest problems. The landmass, coastline, lagoons and the reefs of Lakshadweep, along with the surrounding ocean, form a continuum of biodiversity that defy being treated in isolation. There is a close and complex interaction of coral reefs, lagoons and the sea.

The Lakshadweep islands consist of coral formations built upon the Laccadive-Chagos submarine ridge rising steeply from a depth of about 1500 m to 4000 m off the west coast of India. These islands are coralline in origin and lie on the north-south Lakshadweep ridge. They are considered to be a continuation of the Aravalli system of rocks of Rajasthan and Gujarat. A majority of the islands are blessed with large lagoons on the western side. The eastern sides are replete with rocky relicts consisting of fossiliferous, clayey conglomerates of sandstone and are subjected to heavy action of waves and wind. This area is usually devoid of any plants. On the whole, the islands are flat and scarcely rise more than three metres. They are vulnerable to storms and sea erosion.

The soil of Lakshadweep is poor, the top layer consisting chiefly of finely disintegrated coral, forming a white sandy layer with an admixture of vegetable humus. Since there is very little cultivation, except for coconut, the soil is rarely turned over, with the result that the humus layer does not go very deep. In certain islands such as Agatti, Kavaratti and Andrott, it does not exist at all since the islanders are in the habit of burning the humus. Such soils are open to wind erosion. The depth of the sand layer varies from island to island. In general, the soil is shallow in the beach and deeper towards the centre. The usual depth is about 1.0-1.75 m. At this depth there is a compact but porous crust of limestone conglomerate of about 30 cm thickness. In the islands of Minicoy, Kalpeni, and Agatti, this crust is not so well formed, being soft and powdery but in the other islands it is very hard, quarried out and used for building. On boring through the conglomerate, there is a bed of fine sand through which potable water infiltrates.

The warm tropical climate and high relative humidity are conducive for good plant growth. The vegetation of the islands is described as 'strand coral'. Absence of hills and river systems coupled with shallow soil severely limits the variety of plants that can grow in these islands, yet, nearly 400 species of plants have been reported from these islands. No endemic plants have been reported. The vegetation comprises plants of Sri Lankan, African, American, Australian, Burmese, West Indies, Chinese and Polynesian origin.

Ecologically these islands cannot be treated in isolation. There is the interaction of coral reefs, lagoons and the sea. These ecosystems harbour varieties of fauna and flora. The mucus produced by the coral plays a significant role in the coral ecosystem. These form an important food item for reef invertebrates, fish and

shrimps. There are over 600 species of marine fish, of which 300 are ornamental. Seventy eight species of corals, 82 of seaweeds, 52 of crabs, 2 species lobsters, 48 of gastropods, 12 bivalves, 41 species of sponges, 10 species of echinoderms, 4 species of turtles, 601 species of fishes and 101 species of birds have been reported from these islands. The uninhabited Pitti Island is a breeding ground for many migratory birds.

The green cover of the island is mainly due to coconut groves which occupy 80-85 per cent of the green cover. The coconut cultivation and fishing activities have led to the establishment of cottage industries for rope and *copra* making and tuna fish (*mas*) making. The population of the island, which was only 13,882 in 1901, has increased to 31,810 in 1971 and 60,650 in 2001.

Corals are very fragile organisms. They indicate the health of the land, lagoon and the sea. Global factors such as climate change, pollution caused by oil spills, pesticides, sewage, dredging the reef to create wider entry points will adversely affect the coral population.

In general, the strand coral vegetation consists of various groups of plants such as algae, fungi, lichens, mosses, pteridophytes and angiosperms. Shallow reliefs are dominated by algal elements and seaweed. *Cymodocea isoetifolia, Syringodium isoetifolium* and *Thalassia hemprichii* are the three species of sea-grasses reported from there. The foreshore is free from vegetation being sandy and the backshore is composed of creepers and herbaceous plants, intermixed with shrubs and treelets in coconut groves. Broadly speaking, these plants may be grouped into herbs, shrubs, climbers/twiners, treelets and trees. Many of these are exotic. Vegetation in many of these areas is very much denuded owing to anthropogenic factors and also by grazing of goats. The islands are also home to many medicinal plants.[1]

There are several types of primary producers in the coral ecosystem. The zooxanthellae live symbiotically with the coral polyps, take up their nutritional requirements from the coral excreta and translocate nitrogen back to the corals in a quick recycling process of about four hours. Borrowing filamentous algae and calcareous algae are also associated with the corals. The latter are secondary frame builders in the reef. Benthic macroalgae like the sea-grass are the most prolific primary producers.

1. A list of the common flora of these islands may be seen in Annexure A-27 and of the medicinal plants in Annexure A-28.

The islanders draw resources from the land, the lagoon, reefs and the deep sea. The reefs and lagoons provide the islanders with their basic energy needs. These include construction materials, food and cash income. Fishing and coconut cultivation are the mainstay of the economy and are important sources of protein. Scuba diving tourism is an emerging industry. Fisheries comprise commercial fishing in the deep sea and subsistence fishing in the lagoon using a variety of traditional methods. The island households use all the ecosystems within their vicinity but they put nothing back in terms of management of these free natural resources. The problems of managing these resources have been well discussed by Vineeta Hoon (2002). The human population which was 13,882 in 1901 rose to 31, 810 in 1971 and to 60,650 in 2001. The increase in population has created an ecosystem of its own in these islands. This man-made ecosystem had to depend on the natural ecosystem involving land, lagoon and sea for meeting its livelihood.

The biodiversity of the Lakshadweep Islands faces a variety of pressures and challenges from various quarters. These include the pollution of the oceans owing to the discharge of wastes and fumes from the navigating shipping vessels, while the reefs and lagoons face a similar onslaught from the ferryboats. Overexploitation of the fishery resources in the adjoining reaches and poaching by the foreign vessels add to these problems.

It is necessary to strengthen the arrangements for protection of the biodiversity of the region. This calls for augmenting the monitoring mechanism and periodic updating of the database relating to the ecology of the region. Involvement of the people in these efforts by way of awareness building measures and by giving suitable powers, and responsibilities, to the local bodies, may also be considered.

Threats to the Land and Water Bodies

The wild marine biodiversity of Lakshadweep faces many threats which can be mitigated easily. But there has to be a complete rethinking and an honest, critical dialogue between planners, the people, scientists and other groups interested in the survival of the islands. The threats to the biodiversity of the islands will be presented based on the ecological habitat ecosystem zonation.

The land, which is a thin strip of coral sand, faces multifaceted problems. These include collection of jelly (accretion deposits of coral sand/boulders) for

construction, loss of natural vegetation including stragglers like *Mulli* (*Spinifex*) and *Ipomoea* which prevent erosion, monoculture of coconut which takes away all the nutrients, use of pesticides and chemicals which causes toxicity of the soil and the fragile ground water, construction activities which bring more land under concrete, and erosion of the beach.

The availability of sweet water bodies in these islands too is being subject to a variety of stresses. Some of these have been identified as the non-regeneration of water lens, highly extractive usage of ground water with pumps and tanks, pollution with diesel from the electricity generating units, concretisation of land which reduces the area available for percolation of rainwater, wastage of water and mixing of the sewage with freshwater lens.

Afforestation Measures

The vegetation of Lakshadweep is conspicuous by the absence of forests of any kind and the overall pattern of vegetation is almost uniform with a few exceptions in the cases of Androtт and Minicoy. The plant diversity is not large. The most common cultivated crops are coconut (*Cocos nucifera*), drum stick (*Moringa* sp.), bread fruit (*Artocarpus* sp.), banana (*Musa* sp.), colocasia (*Colocasia* sp.), chilli (*Capsicum* sp.) and cucumber (*Cucumis* sp.). Of late, plants like pepper (*Piper* sp.) and tapioca (*Manihot* sp.) have been introduced. Plants such as sea-grass namely *Thalassia* sp. and *Cymondocea* sp. grow abundantly in the surrounding lagoons. The common flora of coral sands, according to Sivadasan and Joseph (1981) are *Pemphis acidula, Cordia subcordata, Scaevola laccada, Thespesia populnea, Suriana maritime, Dodonaea viscose, Guettarda speciosa,* etc. Coconut is the only crop of economic importance in Lakshadweep and the density of trees is very high (Plate-2). Most of the vegetable crops are cultivated in coconut gardens as intercrop. *Cassytha filformis,* a noteworthy slender parasitic twiner, seems to be a potential threat to the coastal plants. *Mikania micrantha* is yet another weed spreading gregariously on fences and agricultural crops at Androtт. The flora of Lakshadweep are not very rich and almost all the plants of these islands are available in the mainland of India as well. A majority of the plants that are found growing in these islands are naturalised exotics and intruders. Nearly 400 species of plants have been collated so far.

The cumulative effect of several factors such as topography, salinity of water, wind, wave action and precipitation influence the ecology of the islands. The overall climate of Lakshadweep is humid tropical monsoon type. The monsoon is governed by cyclonic depressions which develop in the south Arabian sea and in the Bay of Bengal. In association with these, strong winds and heavy rain also occur. The mean annual rainfall ranges from 1715 (Amini) to 1934 mm (Androtт) of which 80 per cent is distributed from May to November. June is the rainiest month contributing 25 per cent of annual rainfall. As in the case of rainfall, the number of rainy days during the southwest monsoon season is also greater in the north than in the south. The length of the dry period ranges between five and six months (November to April). The temperature is generally uniform over the territory. April and May are the hottest months in the year. Mean annual temperature ranges from 27.3 to 27.9°C and the relative humidity ranges from 70-75 per cent. Throughout the year, the air is humid. Any plantation programme in the islands should be carefully programmed since the geology and soils are peculiar in many aspects. Geologically Lakshadweep islands are considered to be a continuation of the Aravalli system of rocks of Rajasthan and the Gujarat hills and not much is known about their submarine geology. Their tops are built up of coral reefs and accumulation of corals is being continued even now. The coral atolls are very rich in phosphate deposit of low grade (13.4 per cent P_2O_5). The phosphate reserve is estimated as 0.12 million tonnes and it is also reported that a large deposit of calcium carbonate exists in the surrounding lagoons.

Existing information reveals that there are no forestry resources available for the well-being of the local community. Further, on the basis of per capita requirements, the expected demand for fuel wood could be around 1,75,000 tonnes of fuel wood and for fodder the expected demand could be approximately 70,000 tonnes. The supply of fuel wood is expected to be only 20–30 per cent or even less, particularly from the agricultural residues including the supply of fuel materials from coconut plantations. Similarly, only 15-20 per cent of fodder requirement can be met from the existing biological sources. However, introduction of forestry components having potential of fuel wood, small timber, medicinal values, biofuel, etc. can be envisaged for sustainable development in this island ecosystem. The main islands are covered with green vegetation mainly comprising coconut and this green cover is 80-86 per cent.

Traditional forestry activities are not feasible in Lakshadweep as most of the landmass is already covered

with coconut plantations. However, there is adequate scope for agro and farm forestry which would help in generating the islands and provide environment protection. The suggested species are jatropha *curcas* (for biofuel), *casurina equisetifolia* (for fuel, poles and pulpwood), and medicinal plants such as *emblica* (*amla*), *sesbenia*, *gloriosa*, etc.

While it is imperative to introduce a variety of measures for the economic and social growth and development of the people and the region of Lakshadweep, it is also very important to ascertain the possibility of adverse impact, if any, of such measures on the delicate ecology of these islands. This may be attained by subjecting the developmental programmes and projects to detailed appraisal before launch as also during the course of implementation. Side by side, a conscious policy to recycle the various waste products and to ban the use of non-recyclable items, is definitely called for.

Agroforestry for Sustainability

The entire economic as well as the social set up of Lakshadweep depends upon, directly or indirectly, the availability of natural resources (including forest) of the mainland. Agroforestry, in this context holds great promise in augmenting wood production without any adverse effect on agriculture, land or environment. Agroforestry is a sustainable land management system which increases the overall yield of land combined with the production of crop (including tree crop). The salient features of agroforestry would be to raise fuel wood, timber and fodder, increase production of food crops, promote production of fruits, vegetables, pulses, milk and meat; conserve soil and moisture, check soil erosion and enhance soil nutrient status; and improve microclimate by enhancing the area under tree cover. It plays an important role in meeting the growing requirement of fuel, fodder and timber while maintaining an ecologically, balanced environment (Plate-3). Agroforestry is one of the best-suited systems as well as a sustainable one, for Lakshadweep islands to meet the people's demand for fuel, fodder and small timber.

In addition, based on the recent report of the Task Force on Conservation and Sustainable Use of Medicinal Plants, the Planning Commission, Government of India, has listed about 25 plant species, which are most commonly used in India which are to be evaluated for their suitability to the islands. Other nodal agencies such as CDRI, Lucknow, CIMAP, NMPB, FLHRHT, NOVOD, etc. also actively promote the use and cultivation of medicinal plants.

Tree Farming

Policy plays a vital role in providing incentives for farmers to invest in tree farming and other farm forestry systems. According to Place and Dewees (1999), policy issues on any natural resource management practice by decision makers play a major role in adoption of the concept, technology and implementation of the target. Farm forestry also involves improved technologies including multipurpose trees (MPTs) that are appropriate for the environment and consumers (farmers). This requires enhancing the partnership between researchers and farmers. Farmers also need to play a lead role in the development and testing of MPT technology, assessing on-trials, conducting researcher designed and farmer-designed trials and providing feedback to researchers on their experience. Creation and organisation of proper marketing facilities/ mechanisms for small growers and evolving minimum mandatory standards for quality control for wood based products of farm forestry origin have also to be seriously considered. Financial institutions like NABARD have a major role in promoting industries catering to value addition of agroforestry products and to strengthen institutional capabilities towards achieving this objective. This can be done only through innovative policies in the farm forestry sector, which reflect ground realities and changing priorities as well as harmonising divergent demands. Research organisations like ICFRE should provide the necessary inputs to frame such policies. According to the National Forest Policy 1988 document (GoI, 1988), forest conservation programmes cannot succeed without the willing support and cooperation of the people.

Action Plan for Greening the Islands

As mentioned earlier, the islands have a crown cover of high density, mainly with coconut crown (trees). Therefore, further greening of the islands should be need based; taking various factors into consideration such as availability of land, people's demand, species suitability including medicinal plants, marketability of the products, etc. Species of economic, social and environmental value are of importance in this context. As suggested in the earlier paragraphs, agroforestry practices are some of the best approaches for sustained production as well as to enhance the green cover of the islands. Agroforestry models which could be adopted include the following:

***Casurina equisetifolia* based Agroforestry Models**

Casurina equisetifolia is an ideal tree for agroforestry owing to its multipurpose nature to meet the

requirements of fuel, poles, shelterbelts, etc. as well as its nitrogen fixing ability. It is an excellent fuel wood with high calorific value. Casurina can be introduced in the agroforestry system with already existing crops. Casurina because of its particular silvicultural characteristics and fast growth is arguably an ideal species for coastal plantations and has adapted well to the low to medium rainfall areas.

Medicinal Plants based Agroforestry Models

Introduction of important medicinal plants, which are readily marketable in agroforestry models, can meet the demand of medicinal products to a greater extent. Inter-planting medicinal herbs under the trees can be a better option to improve economic returns and ecological environment. Further, agroforestry systems play an important role in domestication and commercialisation of medicinal trees. In various places, medicinal trees incorporated in home gardens improve the diversity in the fringe areas. Development of appropriate techniques for raising medicinal trees in agroforestry and other farming systems will help in conservation of many species. Introduction of medicinal plants and trees in agroforestry systems is a novel idea and *ex-situ* conservation of important medicinal plants and trees. Medicinal trees that have high NTFP value not only provide drugs to the rural population but also generate additional employment opportunity. Establishing agroforestry models (multistorey system) with medicinal plants will enhance the production of raw material, additional income to farmers, optimum land use and one of the indirect methods of species conservation.

Multistorey Agroforestry Systems

Multistorey plantations, which will serve as shelterbelts also will be an ideal approach, in addition to what has been already mentioned (agroforestry/ home gardens, etc). Development of multi-tiered agroforestry systems will not only be highly economical but also eco-friendly as well as sustainable. It encompasses a set of land use practices which aim to realise the benefits from growing woody and herbaceous species together. Shade loving crops such as pepper and betel leaf, can be introduced in this multistoreyed system. Succession of vegetation *vis-à-vis* soil amelioration under this multistoreyed agroforestry system will be a stepping stone for introducing a greater number of species such as *Anona squamosa*, vanilla, pineapple, cocoa, cinnamon, cloves, etc.

Agroforestry Systems with Multipurpose Trees

Other species of multipurpose nature (including medicinal plants) such as Agatti (*Sesbania sesban*), *Morinda tinctoria*, tamarind, cashew, *Acacia auriculiformis*, *Thespesia populnea*, *Adothoda vesica*, *Aloe vera*, *Vinca rosea*, etc. are of greater importance in view of the output with reference to value added products. Greening the islands by adopting home garden strategies with MPTs will be yet another ideal approach (Plate-7). This agroforestry practice is commonly through incorporation of tree species in the already existing coconut plantations after thinning of coconut trees. Recommendations from the Regional Institute of ICAR can be taken for carrying out thinning in the existing coconut groves. In the openings created, suitable MPTs can be introduced to diversify the farms and to sustain the farm income. Growing trees along with crops and livestock is postulated to enhance crop yield, conserve soil and recycle nutrients while producing fuel wood, fodder, fruit and timber.

As an interface between agriculture and forestry, agroforestry is considered to be a promising approach to land use, particularly in small holdings, and as an important part of agricultural development and ecosystem management. Ecologists and environmentalists consider it as a superior land use and land management system that integrates all components of a stable ecosystem combining conservation with production. Foresters tend to look up on it as a potential line of defence against unabated depletion of forest under pressure of population. Planners and donor agencies have seen it as an answer to rural needs for fuel, fodder and timber. However, agroforestry, farm forestry, community forestry and home gardens are the most important terms that have become prominent among those representing tree planting efforts on farms, community land, wasteland, etc. In practice all these refer directly or indirectly to growing and using trees to provide a variety of products and services. By greening the islands, a favourable change in microclimate/environment is also expected which in turn will play a significant role in the conservation of the environment.

As mentioned earlier, since the island ecosystems are peculiar in many aspects designing plantations for environmental protection needs special attention. Multistorey plantations, which will serve as shelterbelt also will be an ideal approach, in addition to what have been already mentioned (agroforestry/home garden, etc.). Windbreak establishment, considered to be a form of farm forestry, is reported to increase crop and

productivity. It increases crop development, yield and quality, primarily by their favourable effects on moisture conservation and energy budgets and secondarily by reducing incidence of abrasion by sand particles, canopy damage and negative influence on ecology of pests and disease causing organisms. Hence, not surprisingly, windbreaks have been recognised as a tool to provide shade, shelter and productive microclimate for environmental conservation. Planting of windbreaks is also seen as a way to arrest land degradation while maintaining or even improving agricultural productivity. Suitably designed windbreaks even have the potential to alter mean wind speed, wind duration and turbulence of air flow.

In addition to the direct effects of wind breaks such as reduction in wind erosion, physical damage to vegetative and reproductive tissues due to sand blasting, 'intermittent' effects such as protection against crop lodging in case of severe storm and 'incremental' effects because of decreased evapo-transpiration (ET), and improved water use efficiency (WUE) owing to shelter afforded by windbreaks need to be considered which can result in increased yield economic benefits during a crop growth season.

Since windbreaks present a porous obstacle to approaching airflow, forcing the air to flow over the trees at reduced speed and forcing it to accelerate over the top, deriving maximum benefit from wind breaks is a complex and challenging task. In this context, design of the wind break becomes critically important. Some of the important features that need to be considered have been outlined along with suggestions for deriving maximum benefit from them for enhanced crop productivity. *Casurina equisetifolia* with its particular silvicultural characteristics and fast growth is arguably an ideal species for coastal plantations and has adapted well to the low to medium rainfall areas.

In addition to species of agroforestry importance which have been already listed, some of the economically, ecologically important species which can be tried are *Tounefortia, Pandanus, Calophyllum, Salvadora,* etc. in the fringes of the islands and *neem,* cashew, *Acacia auriculiformis, Thespesia populnea,* bamboo as avenue planting. Other species that may be included are *Aegle marmalos, Saraca ashoka, Emblica officinalis, Azardiracta indica, Terminalia arjuna* and *Terminalia chebula*. Some of the important herbs and shrubs include *Andrographis paaniculata, Cassis ungustifolia, Embelia ribes, Gymnema sylvestre, Withania somnifera, Plantago ovata, Phyllanthus niruri, Asparagus racemosus,* etc. These plants should ideally be taken up for cultivation as an agroforestry component and suitable marketing strategies developed. Agroforestry is an eco-friendly land use system, which ensures biodiversity and mimics the natural ecosystem wherein another eco-friendly economic venture such as bee keeping can be successfully practised. Agroforestry and apiculture are complementary to each other. Tree growing and bee keeping can be easily combined because beekeeping is primarily a forest-based activity. Inclusion of apiculture in agroforestry helps to enhance the productivity, stability and sustainability of the total system. Inclusion of beekeeping paves the way for supplementary income.

Shore Protection

The coastline of the islands of Lakshadweep is subject to erosion and accretion as a natural phenomenon, besides due to human interventions. Protection of the coast is necessary and is, in principle, supported by the provisions of the Coastal Regulations. However, implementation of the CRZ provisions is constrained by practical difficulties in view of the minuscule geographical area of these islands. Therefore, civil construction has continued in the islands well within the 500 metre zone from the high tide mark. This calls for careful and sustained protection of the shores.

The PWD has undertaken shore protection works by placing large boulders or specially designed concrete tetrapods, besides hollow blocks and coir bags.[2] The problem with such works is that they restrict the access to and enjoyment of the beaches and the coastlines. Accessible coastlines are essential for the normal life of these islands, apart from the development of tourism. Therefore, suitable technology needs to be evolved to break the ferocity of the waves away from the coast so that the beaches remain undisturbed as far as possible. Eco-friendly techniques for shore protection such as growth of sea-grass also need to be explored.

The option of placing shore protection devices such as tetrapods on the reef instead of on the shores, may also be studied, as this will enable unhindered access to the shores. The traditional approach of *casurina* plantations on the shores needs to be reviewed as there are concerns that these plantations inhibit turtle nesting, besides causing restrictions for fishermen to access the shores and the sea.

2. The PWD has undertaken shore protection works stretching over 50.33 km over the past 10 years, costing, on average, Rs. 15,000 per metre or, Rs. 1.50 crore per km.

The Coral Reef and the Lagoons

The Lakshadweep archipelago consists entirely of coral reefs. The coral diversity of Lakshadweep is second only to that of the Andaman and Nicobar islands. The mucus produced by the coral plays a significant role in the coral ecosystem. These form an important food item for reef invertebrates, fish and shrimps. Coral genera such as *Montipora, Pavona, Porites, Favia, Favites, Goniastrea, Platygyra, Hydnophora* and *Symphillia* are common here. Some subgenera like *Psammocora* (*Plesioseris*) and *Psammocora* (*Stephanaria*) are found only in Lakshadweep.

On lagoon shoals and windward and leeward sides of the reefs, genera such as *Pocillopora, Acropora, Porites, Goniastrea* among the *Scleractinians* and the blue coral *Heliopora* are found. In some of the lagoon reefs and shoals (Minicoy, Chetlat) at least 80 per cent of the reef surface and lagoon floor is occupied by blue coral, which makes large hemispherical colonies. *Psammocor* is another common genus found especially in Kadmat and Chetlat. The lagoons of Minicoy show species found in Maldives like *Lobophyllia* and *Diploastria*. A total of 78 species of *Scleractinian* corals divided among 31 genera have so far been reported from Lakshadweep. Out of these, 27 genera with a total of 69 species are hermatypes and the remaining 4 genera with 9 species are ahermatypes.

The Community Structure of Corals

The various habitats in the reefs and lagoons of Lakshadweep show coral association and assemblages which are unique. Three distinct coral communities have been identified:

a. *Porites*: *Porites lutea* and *P. solida* are found in the inner lagoon reef community. Faviids like *Favia, Favites, Platygyra* and *Goniastrea* are found along with *Pocillopora* and *Acropora* species.

b. *Acropora*: Various species of *Acropora* predominate the lagoon coral diversity. This community forms the most ideal habitat for many reef fishes including important live-bait fishes.

c. *Heliopora*: *Heliopora* is a common coral both in lagoon reef and open reef flat. Many fungiids and faviids are also found here. There is a paucity of reef fishes here.

Coral Status Matrix: Based on the above discussions, the coral status matrix of different islands is as below:

Agatti	(+)	Satisfactory	(+)
Amini	(- -)	Good	(++)
Andrott	(++)	Very good	(+++)
Bangaram	(-)		
Bitra	(+)	Unsatisfactory	(-)
Chetlat	(++)	Bad	(- -)
Kalpeni	(++)	Critical	(- - -)
Kavaratti	(- -)		
Kadmat	(+)		
Kiltan	(- - -)		
Minicoy	(- -)		
Suheli	(+++)		

The above account pertains to the state of coral before the 1998 bleaching event. The bleaching episode resulted in the massive mortality of corals, up to 80 per cent in various islands. Continuous monitoring of the recovery since then has shown that the present coral cover is generally between 10 and 20 per cent. Some islands like Kavaratti and Bitra shows a better recovery, up to 35 per cent at certain sites. A list of corals occurring in the Lakshadweep region is given in Annexure A-29. The *Lakshadweep Biodiversity Strategy Action Plan Report* (2002) points out the problems in conservation of coral reefs and the action plan required for their conservation.

The Destruction of the Reef/Coral Death and Diseases

The coral reefs around the Lakshadweep islands have been adversely affected from time to time by global climatic factors like El Nino and the 1998 bleaching affect. Of late, the reefs face threats from the modern development that has brought with it a host of synthetic products such as rubber, plastics, cement and metals. These seem to impede coral growth and lead to crumbling of the coral colony. The collection of corals and shingles from the reef for construction activities and fishing causes destruction to the reef. It is also felt that continuous diving operations lead to disturbance within the coral reef ecosystem. There is also the view that the coral debris, which collects on the shore by a natural process, could be utilised in a controlled manner. If this is not collected and removed, excessive deposition of the coral shingle will adversely affect the fragility of the islands.

Corals, the major denizens of the reef, are deteriorating due to global factors such as climate change including

coral bleaching, presence of predators like crown-of-thorns starfish, dredging of the reef to create wider entry points for navigation, pollution (oil spills, sewage), etc. and overexploitation of certain resources for example, the drop in the number of live-bait fishes.

Corals represent the health status of the ecosystem. Any activity in the land, lagoon, reef and sea will have an effect on the population of the corals. Dredging in the lagoons, building jetties, collection of shingles, boulders, sand, movement of boats, will have direct impacts on the coral reefs. The local people are sceptic about use of tetrapods in controlling soil erosion. Disturbance to the corals with the movement of human beings in the reef for gleaning, dragging fishing nets will affect the growth of young corals.

Coral Reef—National and International Initiatives

The world over, island ecosystems are critically threatened. Lakshadweep Islands are characterised by their small size and distance from the mainland shore. Most of these islands have the sea on the east and reef on the west. These islands are built of coral reefs from the late tertiary times. Accumulation of coral is continuing even now. The exposed coral rock erodes into white coral sand and adds to the formation of land.

Coral reefs are among the world's most fragile and endangered ecosystems. Although they cover just about 0.02 per cent of the ocean floor, they are home to a quarter of the known marine plant and animal species. The net benefit from these coral reefs to society is estimated to be around US $ 30 billion. However, 11 per cent of the world's coral reefs have already been lost due to human interference. In 1998, 16 per cent were severely damaged as a result of El Nino and warming of the oceans. It is expected that 32 per cent of the reefs may be lost in the next 30 years if the threats are not reduced. Loss of healthy coral reefs will lead to elimination of primary sources of food, income and employment for millions of people around the world, as well as the extinction of many fascinating and beautiful marine species.

At the global level, many international agencies are working together to protect and conserve the corals. The International Coral Reef Action Network (ICRAN) maintains a database of corals and provides guidelines for monitoring the health of corals. GCRMN—Global Coral Reef Monitoring Network—is a worldwide programme jointly promoted by four international agencies: the Intergovernmental Oceanographic Commission (IOC), the United Nations Environment Program (UNEP), The World Conservation Union (IUCN) and the World Bank.

There are four coral reef regions in India. They are the Gulf of Kutch, the Gulf of Mannar, Andaman & Nicobar Islands and Lakshadweep Islands. To monitor the various aspects of coral reef conservation ICRMN—the Indian Coral Reef Monitoring Network was initiated in 1999 by the Ministry of Environment and Forests, Government of India with active support from the Departments of Science and Technology, Biotechnology, Ocean Development and Space, the Ministry of Agriculture and the University Grants Commission. In order to implement these action plans and to strengthen the conservation of the coral reefs, a Coral Reef Task Force under ICRMN needs to be constituted. This task force can also work out a specific strategy action plan for conservation of the coral reefs of Lakshadweep.

The Lagoons

The lagoon and atolls of Lakshadweep also abound in a variety of marine *macrophyte* or algae. They belong to *Chlorophyta* (Green Algae), *Phaeophyta* (Brown algae) and *Rhodophyta* (Red algae). The sea grass community of the lagoon contributes to the benthic plant biomass of islands. The predominant seaweeds observed are *Enteromorpha, Ulva, Codium, Laminaria, Turbinaria, Sargassum, Padina, Gelidium, Gracilaria, Hypena* and *Ceramium*. There are potentially useful seaweeds. The survey done by CMFRI (1977-1979) collected 82 species of seaweeds. It has been estimated that the agarophyte resource with an abundance of *Gelidiella acerosa* can be utilised for starting an Agar-agar unit. Agatti and Kadmat islands have more agarophytes. *Caulerpa, Dictyota* and *Laurencia* can be used as food in different forms. Seaweed also grows on the coral reef. Blue-green algae like the *Lyngbya majuscula, Anabaena* and *Oscillatoria* species were observed in the lagoon in many islands associated with sea-grasses. The branching coral beds support seaweed growth to a large extent. The lagoon is also home to a wide variety of organisms such as crabs, lobsters, and molluscan fauna including gastropods and bivalves, octopuses, sponges, turtles, surface living *holothurians*, cowries, sea cucumbers and dolphins. A brief description is given in Annexure A-30. There were qualitative assessments about the changes in frequency of sightings and capture of the above species. The general observation is that though there was a sharp decline a while ago, now the

population is picking up. There were comments about the size of the tiger cowries and octopus. It was also noted that the increase in the number of turtles in the lagoon has caused a depletion of sea-grasses, which in turn has affected the live-bait fish population. The people are generally aware of the fact that these are protected species but concepts of the population dynamics and reef ecology are not clearly understood.

The lagoon is also susceptible to influences both from the sea and the land. The major threats to the lagoon are sewage and pollution, use of detergents, pesticides and fertilisers which causes eutrophication, excessive use of propeller boats and speed boats which causes turbidity, dumping of plastics and other waste in the lagoon and tourism related damages.

The Department of Science and Technology and the Department of Environment and Forests should enforce the laws[3] that ensure protection of the species. There must be continuous awareness programmes by which people become the real stewards of the reef. Oil spillage in the sea, use of plastics on land, pollution of the reef with sewage, use of pesticides and detergents will indirectly affect the growth of corals.

The Lakshadweep Biodiversity and Strategy Action Plan (2002) identified many strategies; of which the ones relevant to conservation of corals are listed below:

- The Department of Environment and Forests and the Department of Science and Technology have to work together and enforce laws that reduce the reasons for the destruction of the reefs.
- The Building Materials Board has to become more active in supplying building materials at subsidised rates for the public.
- There is no in-depth study about the status of the corals and the lagoons. This has to be initiated by the Department of Environment and Forests and Department of Science and Technology.
- There has to be a strict ban on the disposal of non-biodegradable toxic materials like plastics and batteries.
- There should be a comprehensive plan to enforce stoppage of disposal of pollutants by ships and pollutants from the islands.
- People have to be made aware of the laws which pertain to the protection of corals. There is a popular misconception that coral debris and shingles are dead remains and can anyway be disposed of as these do not contribute to the equilibrium of the coral reef ecosystem. This calls for more intense awareness programmes which the Department of Environment can initiate in every island.
- There have to be constant awareness programmes, which will instil the need for conservation of the reef. Environmental education programmes should be initiated from the primary level onward so that a child grows up sensitive to the island environment.

These steps need to be pursued in a time bound manner.

3. A list of the laws and regulations is placed at Annexure A-31.