Chapter IV
Biodiversity Management of the Lakshadweep Islands

4.1 Introduction

India with its coastline extending over 7,500 kilometers and subtropical climatic conditions has very few coral reef areas. The absence of reef in the Bay of Bengal is attributed to the immense quantity of freshwater and silt brought by the rivers (Seawell R.B.S 1932: 449-465). Heavy monsoonal rains and huge population density along the coastline is another restricting factor for the growth of coral reefs there (Arthur R. 1996). The major reef formations in India are restricted to the Gulf of Mannar, Palk Bay, Gulf of Kutch, Andaman and Nicobar Islands and the Lakshadweep Islands. Among these the Lakshadweep Islands are atolls while the others are the fringing reefs (Hoon Vineeta 1997: 1).

In India, there are patches of reef in the intertidal areas of the central west coast of the country. Various coral patches have been recorded in the intertidal regions of Ratnagiri, Malvan and Redi, south of Bombay and at the Gaveshani Bank, 100 Km west of Mangalore (Hoon Vineeta 1997: 1). Hermatypic corals along the shore are reported from Quilon in the Kerala coast to Enayem in Tamilnadu. Corals also occur on the east coast between Parangipettai (Porto Novo), south of Cuddalore (10°50'N, 79°80'E) and Pondicherry but these communities have not been surveyed (Hoon Vineeta 1997: 1).

4.2 Distribution of Coral Reefs in India

In India all the major types of reefs are found. Over the south eastern coast mainly fringing reefs and barrier reefs are found whereas over the south western coast atolls are found. Patchy coral growths of wave cut platforms on subsided land are seen along the Saurashtra coast in Gulf of Kutch. Deep water coral formations are reported from the Maharashtra and Karnataka coast. Typical atoll formations are in Lakshadweep. Fringing and Barrier formations are in Andaman and Nicobar Islands (Pillai C S G 1997:15-17). The coral diversity of Lakshadweep Islands is next only to that of Andaman and Nicobar Islands.

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4.3 The Lakshadweep Islands

The Lakshadweep is the tiniest Union Territory of India. It is like an archipelago situated in the Arabian Sea between 8° N and 12° 30" N latitude and 71° E and 74° E longitude and at a distance of 220 - 440 km from the west coast of India (Planning Commission Report 2007: 18). The length of the coastline is 132 km, which is approximately 1.6 % of India's total coastline. The islands have a lagoon area of about 4000 sq. km., territorial waters covering an area of 20,000 sq. km, continental shelf of 4000 sq. km and the spread of islands is such that it extend the exclusive economic zone of India by another 0.4 million sq. km (MoEF Report 2008: 1).

The Lakshadweep group of islands lies on the northern edge of the 2500Kms long North-South aligned submarine Lakshadweep-Chagos ridge. The ridge is separated from the Malabar shelf by the Lakshadweep Sea and merges with the shelf between 11 ° N to 14 ° N latitude (Bhatt S. C., Bhargava G. K. 2006: 15). The ridge rises from a depth of 2000 to 2700 meters in the Lakshadweep Sea and about 4000mts in the Arabian Sea (Bhatt S. C., Bhargava G. K. 2006: 15). A large number of atolls and some large banks are situated on this extensive ridge.

The ridge is supposed to be a continuation of the Aravali Mountain and the islands are believed to be remnants of the submerged mountain cliffs (Venkataraman K. 2006: 9). The islands are flat, rarely rising more than two meters, and consist of fine coral sand and boulders compacted into sand stone. Most atolls have a northeast, southwest orientation with an island on the east, a broad well developed reef on the west and surrounding lagoon within them connected to the open ocean by one or more channels (Venkataraman K. 2006: 2). It consists of 36 islands, 12 atolls, 3 reefs and 5 submerged coral banks (McClanahan T.R. et al. 2000: 324).

All the islands are geometrically similar in shape (Chandramohan, P. et al.1993: 198). They are wider at the north and narrowing down towards the south except Androth Islands. The height of the island is above 1-2 meters above sea level. These 36 islands comprise of 11 inhabited islands, 16 uninhabited islands attached islets and 5 submerged reefs (IUCN Report 1988: 90). Of these, only eleven islands viz. Agatti, Amini, Andrott, Bangaram, Bitra, Chetlat, Kadmat, Kalpeni, Kavaratti, Kiltan and Minicoy are inhabited (Pillai C.S.G. 1997: 9). These islands comprise the only atolls
Map 4.1: Location Map of Lakshadweep Islands
in the Indian territorial waters. The coral reefs of the islands are mainly atolls except one platform of Androth. Androth has no lagoons where as Bangaram island lies in the centre of the lagoon.

Map 4.2: Lakshadweep Islands

All the islands are small in size ranging from 0.1 to 4.4 sq. km in area and are encircled by fringing reefs with the formation of lagoon on the western side. Androth is the largest island whereas Bitra is the smallest in terms of land area. The total land area of Lakshadweep is 32 sq km and the total extent of lagoon is about 420 sq km (Chandramohan,P. et al. 1993 : 199). The southernmost atoll, Minicoy which is oval shaped, is separated from the rest of the islands by a 180 km wide stretch of sea known as the nine degree channel. The reef slopes on the seaward side. The seaward side reef has a steeper slope and a well defined wave cut platform extending 50-100
meters seawards from the reef margin. Depths of more than 60 m are reached within a short distance. The lagoon slopes bordering the islands are usually smooth. The lagoons have sandy bottoms with scattered coral boulders and pinnacles followed by extensive sea grass beds at the landward side (Hoon Vineeta1997: 9). The central parts of the lagoons are rugged due to outcrops of coral at the edge of the reefs. The eastern shore in all the islands (except Kadmat, Agatti, Bangaram and Cheriyakara) is marked by storm beaches, of coral pebbles and boulders piled up well above the high tide mark by the storms moving in from the east (IUCN Report 1988: 91).

4.4 Climatology and Oceanography

The Lakshadweep Islands have a tropical humid, warm monsoonal climate. The islands enjoy four seasons (Nag P. 2005: 3). They are the

a) hot summer season from March to May
b) the south west monsoon season from June to September
c) the northeast monsoon season from October to December and
d) a cool and salubrious climate during January and February

The southwest monsoon period is the main rainy season which lasts from late May to early October. Rainfall in the southern islands is more evenly distributed than over the northern islands. The number of rainy days during the southwest monsoon season is more in the north than in the south. Both the southwest and northeast monsoons contribute significantly to the total annual rainfall. The mean annual rainfall ranges from 1626.7 mm in Amini to 1934 mm in Androth of which 80 percent is distributed from May to November (Nag P. 2005: 11). The humidity is very high throughout the year. From January to April humidity is lower with typical value ranging between 75-78 percent while it is 85 to 87 percent during June to August. Rainfall in the southern islands is relatively more evenly distributed in comparison to the northern islands (Nag P. 2005: 12).

Temperatures are generally uniform over the territory, increasing slightly from the south to the north. The months of March, April and May are the hottest in the year. Evaporation is highest during the month of April and May while it is minimum during the month of November. Winds are light to moderate during October to March.
Towards late summer, winds begin to strengthen and continue to be strong in the southwest monsoon season. Potential evapotranspiration is less than the rainfall in all the islands in the rainy months from June to September. The islands face depressions, storms and cyclones which are maximum from October to December.

4.5 Human Ecology of the Lakshadweep Islands

The interrelationship between the living organisms and the natural environment has always been very crucial. This relationship is mutual and delicate. To a large extent this mutual relation determines the health of the ecology of the islands. By decreasing the environmental stressors some aspects of living being can be improved upon. This relationship is very intricate and delicate in the Lakshadweep Islands as well. Most of the human beings are dependent on the natural environment for their survival. It is important to understand the relationship between local populations and the reef resources to understand the human ecology of the coral reef islands. With the support of Global Coral Reef Monitoring Network (GCRMN) the socioeconomic profiling of the community was started very lately in the 1999.

4.5.1 Population

In the Lakshadweep Islands more than 93 % of the population is indigenous (Lakshadweep Development Report 2008: 42).

Figure 4.1: Trend of Population growth in Lakshadweep since 1901

Data Source: Census of India 2001
The entire indigenous population has been classified as Scheduled Tribes because of their social and economic backwardness. According to the Scheduled Castes and Scheduled Tribes list (modification orders), 1956, the inhabitants of Lakshadweep who themselves and both of whose parents were born in these islands are treated as Scheduled Tribes. There are no Scheduled Castes in this Union Territory (Saigal Omesh 1990: 35). The population density of the Lakshadweep Islands is 1652 per sq km next only to Delhi and Chandigarh.

4.5.2 Agriculture

Agriculture in the Lakshadweep Islands is mostly rudimentary in nature. With such a high population density and limited agriculture land there is very little scope for large scale cultivation on the island. This high population density has mounted immense pressure on the resources which are available on the island. The high density of population is also a reason that there is no cultivable waste on the islands\(^1\). More than 90% of the population of the island is dependent on agriculture.

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\(^1\) This category includes land available for cultivation, whether actually cultivated or not, for one reason or the other or once taken up for cultivation but not cultivated again for more than 5 years in succession. Such land may be fallow or covered with bushes or jungle which may be put to any use. Lands under thatching grass, bamboo, bushes, miscellaneous tree crops, etc., which are not included under forests have been considered as cultivable waste. All grazing lands which are permanent pastures, meadows, village common lands and grazing lands within the forests have also been covered under this classification.
The cropping pattern of the Lakshadweep Islands did not have any cereal cultivation. As per the Agricultural Census data of 2001, Lakshadweep had a total area of 2,579 hectares, consisting of 10,209 operational holdings of which nearly 87.35 percent have an area of less than 0.5 hectares each, while another 8.16 percent are in the size class of 0.5 to 1.0 hectares group. The operational holdings in the size class of up to 0.5 hectare being 87.35 percent of the total holding possess only 46.23 percent of the total operated area (Lakshadweep Development Report 2008: 30).

Coconut is the main agriculture crop. The trend of the landholding pattern shows rapid fragmentation and huge pressure on the land. Its economy is mainly based on the cultivation of coconut. Except coconut, the cropping pattern of Lakshadweep is very poor. Coconut productivity is very high in the island and it plays an important role in improving the economic status of the islands. The coconut productivity has also reached to the level of saturation. Coconut is the lifeline of the economy of the region. In order to meet the requirements of the growing population for a comfortable life, income generated from copra alone will not suffice the increasing demand (Saigal Omesh 1990: 171). Hence there is an attempt to go for product diversification and value addition. Each part of the coconut tree is very useful and various products are made through diversification and value addition. The islands lack the cereal cultivation. It is rice alone that determined the islander’s relationship with outside world and in the process made them victims of great commercial exploitation (Nag, P.2005: 54).

To increase the standard of life of the people of the island and to counter the increase in the population the focus should be more upon the high value agriculture through product diversification and value addition. Jowar, ragi, sweet potatoes, sorghum and banana are the other products of cultivation in Lakshadweep Islands. Most of these crops are grown here after the rains. Otherwise, coconut cultivation is the main occupation of the people of the Lakshadweep Islands.

The agriculture department of the islands has recently introduced certain schemes for the development of agriculture. Out of these, the coconut development programme is the most important one. The focus is to increase the production to meet the external demands. The other programs are related to agricultural engineering services; inter crop management, water conservation management, etc. The main
products of Lakshadweep agriculture that are transported from here to the other parts of the country are the medicinal plants like dried fenari, dondhi and thaluthama. Plated coconut leaves, coconut planks, jaggery, vinegar and cowries are also transported from the Lakshadweep group of islands. There are certain constraints lie in the environment which restrict the production and diversification of the agriculture sector in the island.

4.5.3 Industry

The islands of Lakshadweep are not very well developed in terms of industrialisation. It is basically centred on coir and fish. The fisheries industry is developing very fast in the islands. Tuna fish is the most important catch here leading to the establishment of Tuna Canning factory at Minicoy. The problem faced by this factory is the inadequate supply of fish. The development of fishing industry is largely restricted by the technology used in catching fish and its storage and transport. The lack of shore based infrastructure facilities and lack of skilled man power make the problem even more severe and limit the volume of fish catch. Boat building is also a flourishing industry here. The islanders are traditionally known for their boat making skills. Infusion of proper technology may add great economic value to it. Cultivation of coconut also plays a very vital role in shaping up industrial sector of the islands. It is related to the livelihood of the people of the island in many ways. Coconut husk is the main raw material available for the development of the cottage industries (Nag, P.2005:65). The production in the industry correlated to the coir sector is also quite high. Tourism industry is also developing very fast and it is expected to be the most important industry in the years to come.

High cost of manufacturing, processing and value addition coupled with high transport costs to the mainland makes most of the economic activities commercially non viable especially when the product is to be used outside the islands.

4.5.4 Tourism

The Lakshadweep Islands have great potential for tourism sector which is still not very well explored. The islands have great natural locational advantage for the growth of tourism sector. It is considered to be one of the most spectacular tropical
island systems of the world. It has a pleasant climate despite its nearness to the equator and experiences moderate temperature throughout the year. It is described as a coral paradise. It has, therefore, the prospect of becoming one of the topmost destinations for beach tourism and water sports. It is also the home to many rare species of marine life and is perhaps the biggest natural underwater zoo in the world (Lakshadweep Development Report, Planning Commission 2008: 58).

Tourism in the islands has not only the potential for creating employment opportunities and taking off the pressure from the limited land resources but it can also generate huge foreign exchange. However the unplanned growth of tourism in the islands can harm the delicate ecological system of the region in the long run. Therefore the approach to the growth and development of tourism should keep in focus the need to maintain and nurture ecological balance of the region as well as the local culture and traditions (Lakshadweep Development Report, Planning Commission 2008: 59).

### Figure 4.3: Number of Tourist Arrivals in Lakshadweep

![Graph showing tourist arrivals from 1992 to 2007](http://lakshadweep.nic.in)

Data Source: [http://lakshadweep.nic.in](http://lakshadweep.nic.in)

### 4.6 Threats to the Lakshadweep Islands

The livelihood of the local community is very much dependent on the environment. Any alteration in the natural environment of the island will severely
affect the survival of local communities. The resources of the reef have traditionally been the lifeline of the inhabitants. Because of its geographical remoteness, ecological fragility and extreme vulnerability to the environmental deterioration, biodiversity of the Lakshadweep Islands are severely threatened.

4.6.1 Sewage Disposals

Sewage disposal is one of the serious problems of the Lakshadweep Islands. The islands have very porous sand so that the discharges from the soak pits of present septic tanks contaminate the ground water (DST Lakshadweep 2009). Sewage is basically a mixture of human faeces and urine in water, and may include domestic wastes. The main contaminants in sewage are biological wastes, nutrients, surfactants and dispersants suspended solids in hypo-saline freshwater.

There is no proper mechanism for the disposal of sewage. Changing life style and the increasing population pressure have also led to increased generation of sewage and solid wastes (Planning Commission Report, Government of India 2008: 8). Improper sewage disposal system adds to the menace. Lack of proper disposal mechanism of human waste results into serious pollution of coastal waters around beaches, reefs and lagoons. There is a unanimous feeling that one has to take proper control for sewage disposal. The contamination from fecal matter and kitchen waste in the lagoons alone can take its toll on the coral reefs (Hoon Vineeta 1997: 10) The influence of the market economy has resulted in the increasing use of non-biodegradable plastics, bottles and metal based equipments and industrial effluents/oil spills resulting in problems associated with their disposal after they become unusable (Lakshadweep Development Report, Planning Commission 2008: 111). Plastic dumping is another hazard which kills sea turtles, crabs, shrimps and other crustaceans. Sites littered with plastic and linen trash is a major threat to these islands and strict laws need to be implemented to ban plastics, metals and batteries as waste/sewage disposal in the islands is a serious issue which needs much attention. These wastes are damaging the ecological setup of the island very badly. They are also contributing to serious health and pollution problems. There is an urgent need of addressing the sewage problem to ensure the health of the reef islands.
Lakshadweep Islands lie on the trade route. There has been a dramatic increase in both passenger and cargo traffic on this route along with passengers and cargo transported by sailing vessels. This increases the mobility of islanders and increases cargo demands. Since these vessels cannot enter the shallow lagoons so the passengers have to be transported to the jetty via small mechanized boats, catamarans which were introduced as they could enter small lagoons and berths eliminating the boat journey but studies have found that the use of catamarans epitomized the degradation of corals due to technological advances in mode of transportation (MHA Report, GOI 2005: 23). These passenger and cargo ships also unload untreated waste into the sea around the islands and release waste oil as well which causes severe pollution. A major case of crude oil spill occurred at Kiltan Atoll in northern Lakshadweep in 1974, though the mortality of corals on the reef was negligible (Pillai, C.S.G. 1997: 16). Lakshadweep also falls along the main route for oil tankers between the Middle East and East Asia. The Coral Reef system in the Lakshadweep Islands is facing a threat from oil-spillage and fuel discharge caused by an increase in the passage of vehicles and the number of generators being used by the islanders for power generation. The reefs of Lakshadweep and Nicobar Islands are considered to be the most polluted in the Indian Ocean because the seas around them serve as major routes for oil tankers (Bakus G.J (ed.) 1994: Bulletin No 43). Oil spillage can cause severe adverse effects on water, air and social environment by damaging fishes, planktons and other organisms, sea birds, tourist beaches and shoreline etc.

A study titled 'Coral Reef Ecosystem of Lakshadweep - a Bio-Geochemical Facsimile, undertaken by the Cochin University of Science and Technology (CUSAT) has found that 25% of the outer cells in the reefs were dead due to the prolonged trapping of sediment on the coral. The study also found a high concentration of metals like Cadmium, Lead, Mercury, Aluminium, Zinc and Vanadium in the reefs here (Giji Marykulam. Indian Express, 06/01/04).

Lead and Cadmium were found in all the study areas, with their concentrations being above one mg per liter. Cadmium concentration was found to be 26.70 mg per liter. The study also reported that the anti-fouling bottom paints used by boats contributed to the formation of toxic concentrations of tributyl tin and other harmful
chemical compounds. The study was conducted in Kavaratti, Kadamat, Kiltan, Androth, Agathy and Minicoy islands (Giji Marykulam. Indian Express, 06/01/04).

4.6.3 Overfishing

The coral reefs are critical to the food security of local population who are very much dependent on it for their survival. Coral reefs are considered the most productive among the marine ecosystems, annually yielding about 9% of the world fisheries (Smith, S.V. 1978: 225-226). The reefs are important for the local population mainly in terms of fisheries. Fishing from the reefs and the lagoons provides fish for consumption to the local population. Fishing in the adjacent high seas for tuna and sharks provides cash for the population to buy other essentials and luxury items (MoEF Report 2009). According to Lakshadweep Development Report, modern boats and destructive fishing practices, targeting of spawning aggregation sites, and the overharvesting of target species have adverse impacts on the region's marine biodiversity resulting in steady reduction of the productive potential of the coastal fisheries, one of the most important sources of protein for subsistence (Lakshadweep Development Report, Planning Commission, GOI 2008: 111). Further analysis of fishery statistics of the island reveals that the annual fisheries yield of Lakshadweep is around 9000 tonnes, of which tunas constitute 7000 tonnes and though the total fish catch has only tripled since 1980, its value has increased sixteen folds (Rodrigues, C.L. 1997 : C 81). In the absence of refrigeration facilities, most of the tuna catch is parboiled, smoked and dried to produce mas (dried tuna) (Rodrigues, C.L. 1997 : C 81). The increase in fishing activities over time may certainly affect the reef adversely in the Lakshadweep Islands. In the recent years, there have been consistent complaints from the local population that lagoon fish stocks have declined considerably. The loss of coral cover in the lagoon could be a cause for decline in the fishery.

4.6.4 Population Pressure and Urbanisation

According to the provisional population data sheet of the 2001 Census, Lakshadweep has a population of 60,595 persons. The density of population is third highest in the country and indicates enormous population pressure over the resources of the islands. The population in most of the islands has tripled in the last two decades and the supply is not adequate to satisfy the demand. Changing life style due to
urbanisation has led to enormous generation of solid and sewage wastes. On such islands, groundwater is the only source of fresh water for the islanders. The demand for groundwater is increasing every year due to the growing population and escalating urbanisation. As a consequence of indiscriminate exploitation, the quality of water in some parts of these islands has already started deteriorating (Sarwade D. V. et al. 2007:1475–1483). This enormous exploitation of groundwater has also led to the intrusion of saline water in some parts.

For example, the Androth Island, which is thickly populated among the group of Lakshadweep Islands, groundwater occurs as thin lens floating on the seawater in coral limestone. On this island, the major problem experienced by the islanders is the less availability of fresh water. The scarcity of fresh water is due to the unsuitable conditions (Mondal et al. 2009: 217–229). There is no provision of surface water storage on the island which in turn increases the pressure on groundwater resource. There is also an increase in demand of potable water in the recent years as a consequence of increase in urbanisation which again has led to the increase in the exploitation of ground water resource.

This increase in population has also result into degradation of lagoon and coral ecosystems (eutrophication) through developmental activities and land based pollutants. The changing population pattern coupled with resource harvest from the reefs has exposed many reefs in the Lakshadweep to varying degree of stresses. The effect on marine biodiversity which is associated with loss of habitats gets reflected in the livelihood options and choices available for the people. Furthermore, there has not been much scientific study based on the capacity studies of any of the islands of Lakshadweep.

4.6.5 Coastal Erosion

Coastal erosion is a serious problem faced by the islands resulting in the loss of land every year. Erosion takes place on account of natural causes like wave action as well as due to destruction of coral reefs. Similarly, the high-speed wind and huge waves hitting the seashore lead to sea erosion resulting into reduction of the size of the islands. Even otherwise, during the southwest monsoon season, sea erosion takes place and many low-lying foreshore regions of the islands are washed out (MHA
Due to damage or death of reefs the shores become more vulnerable and they are not very good at breaking up the waves. This means that coastlines are getting hit with larger swells than they can handle. When a series of large waves hit the shore region they erode the rocky part of the coastline as the reef’s ability to break the wave is either not there or reduced. Sometimes it also leads to flooding in the coastal regions which directly affects the population living close to the shores. The people of Lakshadweep need the reefs to control the powerful waves (Chandramohan P., 1992: 198-202).

Maximum erosion was observed over a period of last 35-40 years were in the range of 28 meters to 44 meters (Planning Commission Report 2008: 9). Like other islands, the Lakshadweep group of islands has also suffered from serious problem of coastal erosion. Studies on baseline data on erosion and the accretion cycle were carried out by the Center for Earth Science Studies (CESS), Thiruvananthapuram, in four islands viz. Kavaratti, Agatti, Amini and Bangaram during the period of 1990-1993 and for other four islands viz. Kadmat, Chetlet, Kiltan and Bitra during 1997-2001. These studies reveal net accretion of 21.43-m3/m in Kadmat and 11.05 m3/m in Chetlet Islands during the study period. The Kiltan Island showed net accretion as well as seasonal erosion at certain stretches. Major part of the Kiltan Island has been undergoing erosion on the east coast (MHA Report 2005: 2). Recession of the shorelines was found on a few of the islands like Bitra, Chetlet, and Kiltan. Other islands showed accretion or growth. This means that the waves are thinning out the shoreline so it is actually making the islands larger and closer to sea level. The study further predicts that there will be shoreline changes in the future. The wave profile of the Lakshadweep region is influenced by the southwest monsoonal winds, which occur during monsoon season (October-December) and by storm surges that mostly occur in April-June. During these times the islands are at the highest risk of erosion. Although the waves cannot be 'turned off,' they can be slowed down by coral reefs that surround the island coasts. If the reefs continue to be degraded by climate change and human influences, the coastal erosion could worsen (MHA Report 2005: 16).
4.6.6 Sedimentation

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 (MHA Report 2005: 24). Excessive amount of sediment deposition has been observed on coral colonies in the lagoon of Kavaratti Island resulting in the mortality of massive corals adjoining the island. A study of dredge spoil disposal of the Kavaratti Island describes the movement of sediment plume while dredging and disposal. It indicates that for the present disposal location, the sediment plume settles down before reaching 50 m water depth, whereas shifting the disposal location to a distance of 1000 m from the reef, would cause the sediments to settle down before 200 m water depth. The study confirms that there is no settlement of dredge spoil in the lagoon bed or on the reef (Chandramohan P. et al. 1996: 67-70). Dredging is done to widen the lagoon to maintain the navigation passage and the increasing numbers of ships keep pressure over widening of lagoon regularly. However, dredging in and around coral formations are not permitted under the guidelines of the Coastal Regulation Zone of the Environment Protection Act (1986).

4.6.7 Coral Extraction

Coral mining and coral extraction are also practiced in the Lakshadweep Islands which puts a serious impact on the reefs of the islands. Corals are often removed and used to produce lime and built houses. Even local population is quite dependent on these materials which come free from the sea to build their houses. So the coastal populations, even if they do not live off the reefs, will have an effect on the reef habitat merely by their presence. The basic problem is that these populations do not differentiate between the dead and the live corals and hence do not limit themselves to dead corals for extraction. If the removal is only moderate and restricted only to dead corals then probably the impact could be minimized. One also has to take into account corporate sector such as cement and lime industries and their exploitative extraction of reef and the new sector that is coming up in live ornamental fish and reef fish trade. The extraction on an industrial scale could be catastrophic for future of the reef. Although these activities are quite restricted now but still enough damage has been done already and the islands have lost substantial coral cover.
4.6.8 Crown of Thorns Starfish

Crown of thorns starfish feed exclusively on live corals. They are predators of live corals and their increase in population can be very devastating for the coral reefs. There population outbreaks can destroy whole reefs with up to 90% mortality of corals. Crown-of-thorns was first noticed at Agatti island in the year 1977 (Sivadas, P. 1977: 179-180). Since then, its population has multiplied substantially and it has spread to all the islands now. The black band and the white band diseases have been observed in many of the shallow water corals (Raghukumar, C. and Raghukumar, R., 1991: 251-260). Although the impact of crown of thorns in the region has not been widely reported historically due to the lack of monitoring programmes but now it is being monitored on a regular basis.

4.6.9 Tourism

Tourism sector has also posed problems of garbage and sewage disposal, collection of souvenirs, anchor damages by tourist boats etc. Developmental and recreational activities along with blasting and dredging in lagoon for navigational channels lead to coral mortality. Like any other small islands the Lakshadweep Islands are also vulnerable to the negative impacts of the tourism which can influence the delicate ecosystem of the islands. There are further plans to promote tourism in the islands which are bound to bring some adverse impact if they are not planned carefully and effectively. Careless attitude of the tourists coupled with their unawareness about the sensitivity of the ecology of the fragile reef ecosystem can disturb the habitats of corals due to activities like walking on the reefs, anchoring of boats, disposal of non-biodegradable solid wastes etc. Continuous diving operations in the islands have also been one of the reasons which have disturbed the delicate coral reef ecosystem of the islands. The worst aspect is that there is no comprehensive tourism master plan which may help the islands in tapping their tourism potential as well as keeping the islands away from the adverse impacts of tourism.

4.6.10 Lack of Alternative Livelihood Options

The people of Lakshadweep Islands are dependent on the nature for their survival. They are mostly reliant on the cultivation of coconut, coir making and
fishing for their survival. There are not many options left to the people of these islands which put enormous pressure on the natural ecosystem of these islands. Moreover during the occurrence of any natural calamity or hindrance, the main livelihood of the islands i.e. coconut cultivation and fishing gets disrupted and affect the people directly. Development of alternative sources of livelihood would certainly reduce this pressure and will help to manage the ecosystem in a sustainable way.

4.6.11 Climate Change

Although most of the nations will ultimately suffer adverse consequences from climate change but islands are going to face most dire and immediate consequences. Of these islands the tropical islands are predicted to face the most serious impacts. Low lying coastal areas of all the islands are especially vulnerable to a rising sea level. The sea level could swell as a result of increase in global temperature which may inundate the coastal areas resulting into loss of habitation for the people of these islands. It would also result into loss of freshwater supplies. Moreover this rise in temperature and inundation of coastal lands are going to adversely affect the ecological balance of the region by disturbing the marine life of the coastal region. Substantial loss of marine flora and fauna would seriously affect the biodiversity of the island region. Most of the marine flora and fauna live within narrow temperature regimes where even a short term temperature increase can adversely affect them as temperature also regulates the distribution of flora and fauna. In the past two decades short term extreme high temperature has contributed to decline of coral reefs throughout the tropics. This has also significant impacts on organisms, such as fish, that depend on the living coral structures.

During the last few decades, climate change has emerged as a critical factor responsible for increased stress on coral reefs resulting in bleaching of corals in many parts of the world, including the Lakshadweep atolls in India. The impacts of climate change are more hazardous for small islands and the Lakshadweep Islands would not be an exception to this global problem. The low level of Lakshadweep Islands make them very sensitive to sea level rise and therefore the foremost future threat to these island chain is potential global climate change. The IPCC projects an increase in global mean surface temperature of 1-3.5 degree Celsius by the year 2100. Its best estimate of sea level rise is 50 cms over the next century, but it could be as high as
one metre. Climate change and a resultant rise in the sea level may result in the
disappearance of the reef building corals along the Lakshadweep Islands. Global
warming caused by increasing CO2 levels has retarded the growth of these corals,
leading to fears that they might eventually disappear. The hard corals of Porite
species, found in abundance in the blue-water lagoons of the picturesque
Lakshadweep Islands, are facing a threat to their existence. Around 25 per cent
decrease in the growth rate (calcification rate) of two hard corals was observed
between 1993 and 2003 in studies conducted along the lagoon of Kavaratti Island, by
scientists of the National Geophysical Research Institute (NGRI) (Y. Mallikarjun, The
Hindu, 1 Aug 2009). S. Masood Ahmad, the head of the paleo-climate group at
NGRI, who led the study said that while the Porites corals grew by two cm every year
from 1920 to 1992, the growth rate decreased to 1.25 cm per year between 1993 and

The potential socio-economic impacts of climate change may also create
devastating impact for the people of the islands. Depending on the worst case scenario
(one meter sea level rise), the studies suggest that sea level rise will have negative
impacts on tourism, freshwater availability and quality, aquaculture, agriculture,
human settlements, financial services and human health. These catastrophes would
result in economic and social costs and threaten the very existence of small atoll
islands. Shifts in rainfall regimes and any increase in tropical cyclone intensity and
frequency will greatly amplify the impact of sea level rise. A rise of average sea level
by one meter, when superimposed on storm surges, could easily submerge low-lying
islands (UNESCAP Report 2010).

4.6.12 Coral Bleaching

Like many other coral islands, the Lakshadweep Islands have also been
adversely affected by coral bleaching. Coral bleaching was common in Lakshadweep
reef. Fully and partially bleached colonies were frequency noticed. Bleached colonies
under water are easily identifiable by their white skeleton which is devoid of
pigments. Colonies showing bleaching were observed to secrete excess mucus. While
the fully-bleached colonies appeared totally white, partially-bleached ones showed
moderate loss of their original colour and were also observed to secrete excess mucus.
The rise in sea surface temperature has affected the corals as these corals are quite sensitive to temperature changes. Even a minor change in sea temperature would cause great damage to the coral islands as was evident in the 1997-1998 El Nino Southern Oscillation (ENSO) events which have elevated sea surface temperatures of tropical oceans by as much as three degrees centigrade. Though this 1998 bleaching episode occurred worldwide but the most palpable effect has been in the Lakshadweep Islands, with bleached coral comprising 82 percent of the total coral cover in the lagoon reefs, with a bleaching related mortality of 26 percent. Much of the living corals were destroyed in the bleaching event of 1998. The prolonged bleaching of corals has also adversely affected their skeletal growth and decline in reproductive fitness and ability to resist competition from algae or other invertebrates. Among the islands of Lakshadweep Islands the Kavarati, Amini, Minicoy, Kadmat, Bangaram, and Androth Islands was one of the worst affected (DST Lakshadweep 2009).

In the Lakshadweep Islands, 95 hard coral species were reported prior to the bleaching in 1998, which destroyed between 43% and 87% of the live corals and then coral cover declined to about 10% around Kadmat Island, and current coral cover in shallow areas is about 1% (Rajasuriya, A et al. 2002 :101-121). Atolls suffered different levels of coral mortality as Kadmat and Agatti were severely damaged with new evidence of rapid recovery, while Kavarati was affected less in 1998 and not much has changed since 2000. Reef recovery is better on the western side of the atolls e.g. many new coral colonies were observed in 2000 on the eastern side of the islands, but were lost by 2002, due to the higher wave energy (Rajasuriya, A et al. 2002 :101-121). This resulted into overall environmental deterioration of the Lakshadweep islands especially in terms of its biodiversity.

4.7 Biodiversity Management of the Lakshadweep Islands with reference to Policies, Approaches and Institutional Arrangements

Environmental policy and planning is a relatively new concept in the Indian system of governance. Before India’s independence in 1947, several environmental legislations existed but the real impetus for bringing about a well-developed framework came only after the UN Conference on the Human Environment at Stockholm, 1972. Under the influence of this declaration, the National Council for
Environmental Policy and Planning within the Department of Science and Technology was set up in 1972. This Council later evolved into a full-fledged Ministry of Environment and Forests (MoEF) in 1985 which today is the apex administrative body in the country for regulating and ensuring environmental protection.

In India the management of coral reefs comes under the jurisdiction of the Department of Forests and Wildlife. The Department of Forests and Wildlife is responsible for monitoring, management and conservation of the fragile coral reef ecosystem. The Ministry of Environment and Forests is responsible to develop an action plan to manage the reef resources and issue guidelines for the sustainable utilisation of coral reefs (Hoon Vineeta 1997: B -18). India's National Conservation Strategy and Environment Action Plan have acknowledged the importance of management of coral reef ecosystems. The policies related to conservation and management of coral reefs are advised and looked after by the National Committee for Conservation and Management of Wetlands and Mangroves. The Constitution of India also directs states to protect the natural environment. Under the Article 48-A, the State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country. Article 51 (g) also imposes a similar responsibility on every citizen to protect the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures. So it is the constitutional obligation of the State and duty of the citizens to protect and preserve the reef environment.

4.7.1 Administrative and Institutional Framework

The Union Territory of Lakshadweep comes directly under the administrative control of Ministry of Home Affairs. The Union Territory of the Lakshadweep Islands is without any legislature and hence the rules of the central governments are followed in the islands. The Department of Environment and Forests started functioning independently under the Lakshadweep Administration with effect from April 1, 1999 after bifurcation of the erstwhile Department of Science, Technology and Environment (http://lakshadweep.nic.in/depts). The department is headed by an Indian Forest Service officer.
Figure 4.4: Organisational Structure of Department of Environment and Forest

Administrator

Secretary Environment & Forest

Deputy conservator of forests and chief wild life warden

Kavarattii Env. Warden
Kadmat Env. Warden
Androth Env. Warden
Kiltan Env. Warden
Kalpeni Env. Warden

Source: http://lakshadweep.nic.in/depts/forest/hierarchy.htm
4.7.2 Indian Coral Reef Monitoring Network (ICRMN)

In the line with the Global Coral Reef Monitoring Network (GCRMN), on the recommendations of the National Committee on Mangroves and Coral Reefs, the Ministry of Environment and Forest, Government of India launched Indian Coral Reef Monitoring Network (ICRMN) in the year 1999. The objective of ICRMN was to provide a framework for monitoring the health of coral reefs in India through research activities, infrastructure development, strengthening institutions for effective management of coral reefs, creation of database and training and capacity building. The aim of establishing ICRMN is to develop sustainable management of coral reef resources and to improve livelihood dependent on them.

4.7.3 CORDIO (Coastal Oceans Research and Development in the Indian Ocean)

In the backdrop of the event of coral mass bleaching of 1998, the Coastal Oceans Research and Development in the Indian Ocean (CORDIO) was initiated in 1999 in the Indian Ocean focusing initially on Eastern Africa, Western Indian Ocean Islands and South Asia. The objectives of CORDIO are to promote research on coastal and ocean ecosystems, strengthen social and economic assessment and research for integrated coastal management processes to improve the livelihoods and well-being of coastal populations by the means of better formulation of policies and the use of scientific and technical information in local to national and regional policy (CORDIO 2010). It relies on capacity and partnership building and participation of the local communities to achieve these objectives. The CORDIO project on community based monitoring of reef resource use, originally initiated with GCRMN support, is continuing in the Lakshadweep Islands, implemented by the Centre for Action Research on Environment Science and Society (CARESS) (ICRI 2010 : 2).

4.7.4 Statutory Provisions Related to Conservation of Coral Reef Ecosystem in India

In India, there are few statutory provisions which give support for the conservation of coral reefs. Initially the coral reefs did not come under the purview of the Wildlife (Protection) Act (WPA), 1972. It was enacted to provide protection for wild animals, birds and plants. But later on the Ministry of Environment and Forests
through its notification of 11 July 2001 has included following species of corals viz. Reef Building coral, Black coral, Organ Pipes, Fire coral and Sea Fan in the Schedule I Part IVA of the WPA (Srivastava Nidhi 2005: 5-6). The list also offers protection to species that share a close interdependence with coral reefs such as sharks, sea horses, groupers, sea cucumbers and fifty-two species of mollusc. Once these species are included in the list of wild animals they can be protected from overuse and exploitation by industry and trade (Srivastava Nidhi 2005: 5-6). The other laws that would have a bearing on coral reef areas are the Indian Forest Act, 1927, the Forest Conservation Act, 1980 and the Indian Fisheries Act which is of vintage origin (Panini Devaki 1997:15-17). Apart from this Environment (Protection) Act (EPA), 1986 and the Coastal Regulation Zone Notification (CRZ) of 1991 are directly related to the conservation of coral reefs. Various state fisheries acts are also relevant for conservation and management of coral reef areas.

The Environment Protection Act (EPA), 1986 is the umbrella legislation for the protection and improvement of environment and for matters connected therewith. The protection of coral reef biodiversity also comes under its purview. It provides a framework for the Central Government to coordinate activities of various authorities set up under different Acts. Under this act the Central Government is empowered to take steps to protect the environment. It is under this act that it issued notifications like Coastal Regulation Zone Notification (CRZ) of 1991.

The Coastal Regulation Zone Notification (CRZ) of 1991 offers the four categories of coastal regulation zones. CRZ 1 category covers the coral reefs and CRZ 4 category covers the islands of Andaman, Nicobar and Lakshadweep. Section 7 (2) also states that the construction of beach, resorts/hotels shall not be permitted in ecologically sensitive areas such as marine parks and coral reefs (Hoon Vineeta 1997: B -18). Various activities like dredging and underwater blasting is also prohibited in and around the coral formations.

4.7.5 Coastal Zoning in the Lakshadweep Islands

Ministry of Environment and Forests (MOEF), Government of India declared coastal stretches including bays; estuaries etc that are affected by tidal action as coastal regulation zone (CRZ) and regulated activities in CRZ. The notification was
issued in the year 1991, under Environment protection act of 1986. The coastal stretches from High Tide Line (HTL) to 500 mts. towards the land and the stretch between HTL and Low Tide Line (LTL) towards the sea were demarcated as Coastal Regulation Zone (CRZ) and various restrictions were placed on various economic activities (Lakshadweep Gazette Extra Ordinary Vol. XXXIII. No. 40). For implementation of this zoning plan, it was necessary to delineate the HTL and LTL along more than 7516 km long coastline of India. Naval Hydrographic Department (NHD) of India was entrusted by the MOEF to prepare charts for delineation of high tide line and low tide line. NHD was also asked to verify coastal regulation zone plan prepared by states for precise depiction of HTL, LTL and control marks.

Under this notification various activities such as industries, disposal of hazardous substances, fish processing, effluent discharge, land filling, land reclamation, mining, harvesting ground water, construction and landscape alteration are banned within CRZ with a few exclusive exceptions. Activities of national importance that compulsorily require water front were only allowed as exceptions. Permissions were required to carry out such activities on case to case basis. Such activities included building of ports and harbours, defense installations like jetties, power plants etc.

For regulating coastal zone activities, coastal stretches within 500 meters of high tide line on the landward side are classified into four categories.

**CRZ-I** covers areas that are ecologically sensitive areas like marine parks, national parks, sanctuaries, mangrove areas, wildlife habitats, heritage areas and as well as the intertidal zone between low and high tide line. No new construction shall be permitted here except for extremely critical necessities.

**CRZ-II** covers areas that have already been well developed with all infrastructure like roads, sewerage lines, water supply pipes etc. laid out, such as within urban and municipal limits. No new constructions on the seaward side of the road can come up here and reconstruction of existing structures will be restricted.

**CRZ-III** covers areas that are relatively undisturbed and not falling under the above two zones. Here, up to 200 meters there is no development zone; 200 to 500 meters
can be used for hotels and beach resorts temporarily under permission while traditional rights of fisherman to build small structures are honoured.

**CRZ-IV** covers areas in islands, Andaman and Nicobar and Lakshadweep, except those designated in CRZ I, II and III. Building activities are restricted within 200 meters from the HTL and after that more than 2 floors are not allowed. Exploitation of corals and sands, dredging and underwater blasting are prohibited.

CRZ Plan puts restriction on almost all development and human activities in all areas that are considered to be ecologically fragile and sensitive. However, that plan was conceived when wide stretches of coastal landscapes were already developed into urban and industrial structures. So the plan had to accommodate those activities in the form of CRZ-II. However, restrictions were imposed on further construction activities especially towards the seaward side. The plan also attempts to be flexible as there are provisions for building projects of national importance like defence installations.

However, this zoning plan had some glaring flaws. First of all, the plan failed to take into consideration the disparities within the coastal zones in India. No socio-economic impact assessment was conducted before issuing the notification. As a result of this many well established economic activities like brackish-water aquaculture were rendered illegal even without the knowledge of communities dependent on such activities (Ramachandran A. et al. 2005 : 632). Coastal Regulation Zone was restricted to 500 metres on the landward side. Moreover, any activity taking place outside this narrow stretch of 500 mts, did not come under purview of any regulation.

This zoning plan puts a blanket restriction on construction activities including those that are necessary for the purposes of mitigation of erosion like sea walls etc. This approach also gave rise to a host of litigations in the zone. Moreover, the clearance authority of CRZ was vested in the central government. This made any necessary construction within the zone a cumbersome and lengthy process.

In context of Lakshadweep only two categories are relevant CRZ-I and CRZ-IV. Administration of the Union Territory (UT) of Lakshadweep by a notification in
1996 declared Coastal Zone Management Plan (CZMP), identifying and classifying the Coastal Regulation Zone (CRZ). This plan designated certain areas under CRZ-I as those areas belonged to the category of sensitive and fragile ecosystem. This category mainly consisted of lagoon and islets and all coral atolls and sand dunes. All construction activities within these zones were prohibited. However, already existing traditional rights were recognized and customary uses were also allowed. These rights and uses were not defined further (Lakshadweep Gazette Extra Ordinary Vol. XXXIII. No. 40).

Rest of the coastal zone was categorized under CRZ-IV (Lakshadweep Gazette Extra Ordinary Vol. XXXIII. No. 40). The widths of ‘No Development Zone’ for each island with Lakshadweep UT were defined separately. The NDZ for majority of cases is 50 metres beyond the HTL. However, in case of some islands it is 20 metres on the non-lagoon or smaller lagoon side. In the CRZ areas where the NDZ has been reduced from 50 metres to 20 metres, construction for non-residential use in this zone is not permitted (Lakshadweep Gazette Extra Ordinary Vol. XXXIII. No. 40).

Certain activities were also prohibited under CRZ-IV. These are:

- Setting up of new industries and expansion of existing industries except under certain specified circumstances
- Manufacture or handling or storage or disposal of hazardous substances
- Setting up of fish processing units and even natural fish drying activities
- Discharge of untreated wastes and effluents from industries and settlements.
- Dumping of waste from industries including power plants for land filling or otherwise.
- Construction of structures that may interfere with natural flow of water except under certain specified circumstances
- Mining sand and rock or any other substrata material, except the ones not found in outside the UT
- Extraction of ground water within 200 metres of HTL and between 200 to 500 metres line only manual extraction is allowed
• Altering of natural geomorphic units like sand dunes for beautification or recreational purpose except under specific circumstances

Other than these activities, there are other activities that are restricted and are governed by specific laws. Some of these are:

• New buildings or extension of the existing buildings shall not be permitted within the ‘No Development Zone’.
• No new jetties shall be built in the lagoon without the approval of the Ministry of Environment and Forests.
• The design and construction of buildings shall be consistent with the surrounding landscape and local architectural style
• No blasting is permitted in the lagoons except dredging of those existing navigation channels which have already been approved by the MOEF and dredging material is not allowed to be disposed within CRZ

Ironically, the CRZ notification is applicable to coastal areas (500 m, from the High Tide Line and the land lying between the Low Tide Line and the High Tide Line) and corals, coral reef areas would be included in CRZ 1, it means that the restrictions imposed in CRZ 1 (ecologically sensitive and important areas) and CRZ IV (Andaman and Nicobar and Lakshadweep Islands) are restricted only to the landward side. Under this scheme seaward side areas do not enjoy any protection. In a place like Lakshadweep, where there is no Marine National Park, there is a need to give coral reef areas a special legal status, in order to regulate and prevent harmful activity (Panini D. 1997).

One of the reasons for the exploitation of coral reefs is the use of coral blocks as cheap construction material. Coral islands like Lakshadweep, where there is dearth of alternative material for construction, coral reefs are exploited rampantly. Though under the current legal provisions mining coral is illegal, exploitation is mainly restricted to collection of dead coral shingles from the beaches, which has left the structures of the beaches very weak (McClanahan T. R et al. 2000 : 313.).

CRZ system came under severe criticism for being ineffective due to various reasons. In 1998, following an order of the Supreme Court of India, MOEF
constituted the State Coastal Zone Management Authorities (CZMAs) and a National Coastal Zone Management Authority to ensure the implementation of the notification. The idea was that each coastal state should draw up State Coastal Zone Management Plan which should be approved on the basis of its concurrence with the CRZ notification. However, implementation of the notification remained far from what was desired as almost none of the states had a fully approved CZMP. Moreover, CRZ notification was amended several times to accommodate for various activities on the coast that led to substantive dilution of the notification. In absence of a well coordinated plan at the state level, the state administrations found it difficult to bring the violators to book (Sridhar A., Shanker K 2006: 7)

Keeping all these issues in view Swaminathan Committee was formed to reformulate coastal area management in the whole country on the basis of sound scientific principles, without compromising the livelihood concerns of farming and fishing communities. This Committee submitted its report in February 2005, which suggests an alternative structure for coastal zone management.

First of all, the report moves away from coastal restriction of development of coast to a broader and holistic concept of coastal zone management based on ecological principles, vulnerability to natural disasters and socio-economic concerns of the countries. This report also suggests a new institutional framework for integrated management of the coastal resources. This approach included a wider stretch in the definition of coastal zone that includes offshore waters within 12 nautical miles from the coastline. The committee suggests that suitable provisions should be made for the participation of the civil societies in policy making. The management should be based on precautionary approach to deal with the uncertainties regarding the negative impact of human activities on the coast. This report encouraged regeneration depleted coastal resources like coral reefs. There is also a proposal for establishment of a National Institute for Sustainable Coastal Zone Management with two regional centers for the Andaman & Nicobar Islands and Lakshadweep Islands.

The Ministry of Environment and Forests issued fresh notification on coastal regulation zone on 6th January 2011. It also issued a separate Island Protection Zone (IPZ) notification for the Andaman and Nicobar Islands and Lakshadweep Islands. Under this notification, the Lakshadweep Islands Administration shall, within a period
of one year from the date of this notification, for the purpose of integrated sustainable
development of the Lakshadweep Islands Protection Zone, prepare the IIMPs,
*interalia*, specifying therein the areas indicating all the existing and the proposed
developments, conservation and preservation schemes, dwelling units including
infrastructure projects such as, schools, markets, hospitals, public facilities (MOEF: 2011).

4.8 Measures Taken for the Biodiversity Management in the Lakshadweep Islands

Detailed analyses of the account of biodiversity in all the islands are still lacking. Though many studies have been conducted but very few of them focus on the issues related with the conservation and sustainable development of the reef resources.

The earliest study on the Lakshadweep Islands was carried by Gardiner in 1903 who described the Minicoy atoll. There were also studies carried out by different research institutes viz. CMFRI, NIO, CESS on the biological, physical and chemical properties of these islands pertaining to specific objectives dealing with single issues but these studies proved to be sporadic and piecemeal as there were no continuities of observation. Till late there was no effective monitoring and management programme for the biodiversity management of the Lakshadweep Islands.

The negative incidence of massive coral bleaching episode of 1998 has put an alarm and led to recognition of need for continuous monitoring of the island reef ecosystems. Earlier it was not possible to cover all the islands for surveys for benthos and surveys were restricted only to few island sites which are easily accessible because of the lack of expertise and training to carry out these surveys. In a subsequent development to the hazardous event of 1998 coral bleaching, the government has launched Management Action Plan (MAP) for coral reefs in India under the purview of Ministry of Environment and Forests (MoEF).

The MAP design adopted for the Lakshadweep Islands by the MoEF has a five pronged approach (DST Lakshadweep 2009).

1. Biophysical Surveys
2. Infrastructure Creation
3. Capacity Building
4. Protection Measures
5. Awareness Creation

4.8.1 Biophysical Surveys

The biophysical surveys were done to check the health of the coral reefs and for the generation of data on the basis of which a regular monitoring of these islands could be done. These surveys were carried out on the ten inhabited and two uninhabited islands of the Lakshadweep Islands. Different methods of surveys were adopted to explore and create the data base. Line intercept transects methods were used to assess the sessile benthic community of coral reefs. The community was categorized using life form categories, which provide a morphological description of the reef community (DST Lakshadweep 2009). The manta tow technique is used to assess broad changes in the benthic communities of coral reefs. It enables visual assessment of large-scale disturbances such as those caused by cyclonic storms, coral bleaching and outbreaks of Acanthaster (crown-of-thorns starfish). The technique is also useful for selecting sites that are representative of large areas of reef (DST Lakshadweep 2009).

Figure 4.5: Status of live coral covers in 12 islands of Lakshadweep (2007)

![Bar chart showing status of live coral covers in 12 islands of Lakshadweep (2007)](chart)


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These surveys indicate the parameters like extent of live coral cover, dead coral with algae, algal assemblage and sea grass, soft corals, sponge and other animals, abiotic (sand, rubbles and rocks) and dead corals across the island. Apart from this it also reflected the devastation carried out by the mass coral bleaching event of 1998 over the islands.

4.8.2 Infrastructure Creation

The term infrastructure creation basically refers to the infrastructures which are important for carrying out the surveys and regular monitoring of these reefs. This includes not only biophysical surveys at standard depths but also include environmental monitoring (temperature, nutrients, salinity, biodiversity components etc.) and socio-economic monitoring of the region. It is on this pattern that the LCRMN (Lakshadweep Coral Reef Monitoring Network programme) was modeled. A LCRMN laboratory was also developed as a central analytical facility at Kavaratti to analyse the water and biological samples collected at regular intervals and to help the research work on the scientific monitoring of the region. The diving gears, compressors and boats were used to carry out these surveys.

4.8.3 Capacity Building

The most important limitation in the survey and coverage of benthic and fish biodiversity has been the lack of trained manpower and SCUBA gear. The capacity building was basically aimed at facilitating these surveys and monitoring. In order to conform to the pattern adopted by the Global Coral Reef Monitoring Network the biophysical surveys needs to be done at 10 m depth. This leads to the capacity building at two levels; first training in SCUBA diving and secondly training in biophysical survey methods. For this training in SCUBA was imparted to scientist and islanders. They were also taught to recognize the different corals and algae forms.

4.8.4 Protection Measures

The main causes of damage to reefs were identified and protection measures were taken. The Union territory of Lakshadweep has banned the collection or removals of dead and live corals as the removal of coral blocks and collection of
shingles were the major reason for the degradation of the reef. Strict rules were developed for quarrying of limestone. The department of Environment has started strict vigilance and patrolling of the islands and lagoons. Further measures were also taken to keep lagoons clean from the human solid wastes and negative impacts of tourism. Lagoon cleaning campaign was launched across the islands with the help of voluntary organisations.

4.8.5 Awareness Creation

The campaign for lagoon cleaning was also used as a measure to create awareness among the people that how certain human activities are detrimental to the reef ecosystem. For awareness creation, the following measures were taken:

- A set of 101 questions on corals were developed in a book form to create awareness and distributed among the people. These questions reflect the importance of corals, threats to the corals and many other aspects of it and what we can do to help them survive. This book was a good success at creating awareness among a broad section of the society.

- A set of skilled traditional knowledge of society in that were handed down through generations on navigation, fisheries, water movement and currents and sensitivity to biodiversity components in the reef were documented in a form of book to create awareness about the traditional practices.

- The environmental wardens in each island were deputed to hold public meetings and explain to the locals the harmful effects of plastics. Paper bags were distributed free of cost to discourage use of plastic bags. It also help to generate additional employment opportunities for manufacture of paper bags in the islands as well as a cleaner environment.

- The means of mass media were also used to create awareness among the islanders by distributing leaflets etc. informal discussions were also held with the public to discuss the biophysical surveys, condition of reefs etc.
4.8.6 Project Giant Clam:

Project Giant Clam\(^3\) was launched as a model to develop marine protected areas in small islands and to incorporate scientific understanding and local indigenous knowledge into their management. This initiative was launched first in the Agatti Island. The island also has the most significant giant clam population in Lakshadweep. Due to their long life span and ecological requirements, giant clams can be used as a measure of the health of the coral reef. Giant Clam helps a large part of aquatic fauna to survive through their life cycles. Fast depletion of these reefs was also causing disappearance of the entire fauna in the area. Any changes in the health of the giant clam population can indicate problems elsewhere in the coral reef, including in the bait fish population. A healthy giant clam population reflects a healthy reef, which is good news for the local people making a living from the reef.

The main objective of the project was to establish India’s first marine community reserve in Agatti Island. The proposed reserve will serve the following purposes:

1. Conserve the Giant Clam population.
2. Conservation of degraded coral reef and associated flora and fauna. Special emphasis will be on conservation of baitfish population in the reef lagoon. Decline in baitfish population has led to livelihood crisis for local fishermen dependent on tuna fishing.
3. Enhance the livelihood prospects of the local communities.

The Agatti Conservation Reserve resulted from collaboration between Bombay Natural History Society, Lead International, and funding from the Darwin Institute, U.K. Intensive ecological and social surveys were conducted under this project on all of Lakshadweep’s 11 inhabited, and 14 uninhabited islands. Agatti was chosen for protection for its unique biodiversity and the pressing livelihood needs of Agatti’s fishing community who directly depended on declining baitfish population for tuna fishing. Agatti Island has healthy coral reefs with the most significant giant clams.

\(^3\) Project Giant Clam was jointly by LEAD international and the Bombay Natural History society with financial assistance from the Darwin initiative, UK.
clam (*Tridacna maxima, T. squamosa*) populations of all the surveyed islands in Lakshadweep.

The project focuses on co-management of the islands by both the government and the local community. In this project the local community will have a stake in the conservation and management of the coral reefs and surrounding seas and lagoons. It also focuses upon developing the capacity of the local population from the islands. A team of young leaders from the island was formed. The project was launched for three year duration in 2005. This term was divided into community consultations, research work, environmental education and sustainable tourism studies. The team carried out various household surveys, face to face discussions and group meetings with the island community. The team undertook intensive ground work, visiting various islands in the Lakshadweep and generating scientific data. This information provided a foundation for community consultations that engaged 55% of Agatti’s adult population (LEAD 2009 : 348) The decision was made after considering and discussing various aspects of the island including biodiversity, use of reef resources, tuna fisheries, livelihood issues and tourism and accordingly decisions were taken. The project was a success in terms of making local people aware of the ideas of sustainable resource use to the traditional community of the islands.

Further, inspired with the success of Project Giant Clam, the Lakshadweep Marine Research and Conservation Centre (LMRCC) was founded in January 2008. The Lakshadweep is the only atoll in the country and earlier there was no institutional support dealing exclusively with the islands. Most of the institutes were mainland based. There was an urgent need to set up a Centre for Biodiversity and Conservation on the islands that has a broad mandate to deal with all research, documentation, training, and development of management plans, development planning policy, education and awareness. It was in this background that the LMRCC was founded.

The LMRCC was dedicated to marine research and conservation. The basic aim was to carry forward the results of Project Giant Clam. It was first of its kind in the Lakshadweep Islands with the objective to develop a centre of excellence in marine research, promote natural conservation through sustainable community development.
4.8.7 Tourism Management

There is need to design the tourism and to strike a balance between tourism promotion and environmental conservation in order to maximise the benefits to the local community in a sustainable manner. The objectives and policies with regard to tourism promotion are looked after by the Department of Tourism and a society named Society for Promotion of Nature Tourism and Sports (SPORTS), which is the tourism promotion agency of the Lakshadweep Administration (Lakshadweep Tourism, GOI 2009).

The Lakshadweep administration has taken certain corrective measures to promote sustainable tourism which reflect their commitment to the ecology of the islands. For example only those islands have been chosen for the promotion of tourism which can have carrying capacity to sustain the pressure of tourism so that it does not adversely affect the environment of the island region.

The Union Territory of Lakshadweep has formulated policies and guidelines to promote sustainable tourism. It focuses upon the impacts of tourism on physical environment, ecological environment, human use values, and the quality of life.

Tourism involves many activities which can affect the environment adversely. Many of these activities which affect the environment are linked with the construction of general infrastructure such as roads, tourism facilities like resorts, hotels etc. Though these activities has been more or less restricted by the zoning management in case of the Lakshadweep Islands but still the administration needs a comprehensive policy to deal with such negative impacts which can gradually destroy the environmental resources on which it depends. The quality of the environment, both man-made and natural, is essential to tourism. The relationship of tourism with the environment is a complex one. The zoning management ensures that the tourist activities do not adversely impact upon the physical environmental region. This is one of the most fundamental reasons behind the selective promotion of tourism in certain islands which can bear the pressure of tourism and can sustain it.
The tourism services are needed to be developed in such a way that they do not result into the loss of biodiversity. For this certain measures has been taken by the tourism department of the Lakshadweep Islands which includes:

1. Development activities are not permitted in geologically unstable zones.
2. Construction of high-rise structures are banned. The policy is to allow structures that are in harmony with nature. It is ensured that construction materials and methods are compatible with environment and height, shape and location of building merge with the natural vegetation.
3. Adequate buffer zone has been provided between development and existing shoreline.

Further various tourism schemes are analysed in terms of their impact over the environment and certain norms were issued. These norms were issued in order to protect the environment of the region from tourism related infrastructure activities such as construction of thatched roofs or tiled sloping roof, installation of bio-toilets, rain water harvesting to conserve fresh water, minimal use of pump sets, better waste disposal systems, plantation of trees, plants and shrubs, creating awareness among the tourists etc has been taken up.

The idea behind such measures is to promote sustainable tourism which is eco friendly and the attempt is to promote quality tourism and not quantity tourism which is high value-low volume tourism. Private investment has also been involved in the creation of tourism in certain islands viz. Agatti and Bangaram. The involvement of private players has been done very cautiously and only those credible players have been involved who are best in the field and have concern for ecology and quality and not for quantity tourism. It also helps in mopping up the resources.

The tourism policies are to be designed in a way that they preserve the local culture and social fabric of the region and also conserve the ecological and environmental structure. Tourism has the potential to create beneficial effects on the environment by contributing to environmental protection and conservation. It is a way to raise awareness of environmental values and it can serve as a tool to finance protection of natural areas and increase their economic importance.
4.9 Conclusions

Marine biodiversity management is a relatively new policy development in the Indian context. Coral reefs are unique and fragile ecosystems which are under tremendous pressure due to anthropogenic and climate induced stressors in the recent times. There is a consensus all over the world that preservation and management of these unique systems are necessary. However, in India there is very little awareness on these issues. There is no specific legal or institutional measure that deals with the issue of conservation of coral reefs. India’s National Conservation Strategy and Environment Action Plan acknowledge the importance of coral reefs as the most productive marine ecosystem and need for effective management of these systems. However, this has not led to any significant change in the institutional set up of the management of coral biodiversity in India.

Among the coral ecosystems of India, the Lakshadweep Islands are only atoll reefs and the rest are all fringing or barrier reefs. Lakshadweep is also the one of the most densely populated Union Territories of India. Due to lack of resources on the small area of islands, large section of the population depends on sea for sustenance. Almost 90% of the population depends on coconut cultivation, which is the only significant crop. However, dependence on the sea for fishing, coral collection for limestone, trade in ornamental coral and reef fishes also take place side by side that leads to degradation of the reef systems. Sewage disposal, oil spills, dredging etc add to the problem of ecological devastation.

There is no integrated policy to address the issues of biodiversity management and offer a sustainable solution for livelihood issues. The only legal measure that has limited efficacy is the guidelines issued under Coastal Regulation Zone. Under these guidelines, building activities near the coast, untreated sewage and waste disposal in the reef lagoons, alteration of geomorphological structures like sand dunes etc are prohibited. Most coral reefs and reef lagoons are also declared as ecologically sensitive areas. However, there are no clear cut policy guidelines to protect these areas. The traditional rights of the local people are recognized in principle. Though this traditional rights have not been defined any further in any policy guideline.
Lack of scientific knowledge about the functioning of this intricate ecosystem also limits the effectiveness of the measures adopted. Only after the massive bleaching event in 1998, the Ministry of Environment and Forests launched the Management Action Plan for Lakshadweep Islands. There have been consistent efforts to conduct large-scale biophysical surveys for the effective monitoring of marine biodiversity. The Lakshadweep Coral Reef Monitoring Network (LCMRN) was framed with these objectives. However, the capacity to conduct large-scale underwater surveys is still very limited. Unless the functioning of the ecosystems is understood in all its dimensions it is almost impossible to adopt an integrated management approach for the region.

For better biodiversity management of the whole of Lakshadweep Islands, it should be declared as a Marine Protected Area. This will bring about integration in the sporadic and piecemeal efforts of biodiversity preservation in this area. Planning efforts should be conceived and carried out at the ecosystem scale. Active participation of the local population will be necessary to solve the livelihood issues that will reduce the pressure on the whole ecosystem. Lakshadweep being a UT without legislature, all rules and regulations are made by the Centre. Under these circumstances, it is necessary to incorporate local knowledge and ensure community participation at every stage of policy planning and development. Development of non-exploitative uses of reef resources like eco-tourism and other alternative livelihood options may go a long way to save the reefs.