The Lakshadweep : Islands of Ecological Fragility, Environmental Sensitivity and Anthropogenic Vulnerability

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Abstract

The delicate balance between the environment and development in Lakshadweep islands is greatly hinged on to the complex fragile ecosystems with the livelihoods of the islanders being dependent on coconut, fish and the coral reefs which are the lifelines of the islands. The perceived environmental threats to the islands, development and population growth might tend to weaken the symbiotic relationship between the society and the environment, necessitating effective implementation of the Environment Impact Assessment (EIA) Notification 2006.

The islands of Lakshadweep need an enlightened and science-based conservation effort. The present widely disparate and incoherent approaches at coral reef research in the country need to be coordinated and brought under an umbrella of an exclusive Institute for Coral Reef Research and Management, with the ultimate goal to ensure the preservation of the delicate ecology and the dependent livelihoods of people of the island territories of the country.

Introduction

The Union Territory of Lakshadweep, a group of 11 inhabited and 25 uninhabited tiny islands, is geographically isolated and segregated at 200-400 km. from the Malabar Coast along the west coast of India. The only atolls in the Indian Union, they attracted the attention of naturalists for centuries. In view of the vast marine resources of the region, the Central Marine Fisheries Research Institute (CMFRI) Cochin established a centre for research at the Minicoy Island in 1958.

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Jones and Kumaran (1980) published a monumental treatise on fishes of the Laccadive archipelago. The marine fisheries research conducted in the Archipelago up to 1986 was briefly reviewed in a series of articles incorporated in a special issue on Lakshadweep (Anon, 1986). Fisheries and marine biological features and the pole and line tuna fishery in Lakshadweep were described by James, *et.al.* (1987 a and b). History of marine research in Lakshadweep was reviewed by **James** (1989). The CMFRI carried out a comprehensive survey of the fishery potential of the islands from January to March 1987 and published the results in a bulletin (Anon, 1989) I n the following years and till date, the institute and several other institutions, organization and individuals have contributed significantly to the scientific knowledge of terrestrial and aquatic resources and development of the islands. Taking into consideration these recent observations as well as the earlier background and personal knowledge and experience of the author, the present paper attempts to highlight some important ecological, environmental and human impacts on the islands.

Ecological Fragility

The archipelago consists of 12 atolls, three reefs and five submerged banks. There are 36 islands, covering an area of 32 sq.km., which are geographically isolated and segregated from the mainland (08^{0} 00' N and 12^{0} 30' N lat. and 71^{0} 00' E and 74^{0} 00'E long), about 200-400 km from the Malabar Coast, the coral formations rising from depths ranging from 1500-4000m. The islands scarcely rise 2m above the surface of water.

Except Androth, which is the biggest island, all the islands have a lagoon. Bitra is the smallest island with a large and magnificent lagoon. Among the uninhabited islands, Suheli is a coconut growing and fishing centre. Pitti or the bird island is a small reef with a sand bank visited by thousands of birds for nesting, is designated a bird sanctuary. The islands range in area from one ha. to nearly 440 ha.

The oceanic islands have a continental shelf of about 4336 sq.km, the lagoon area of about 4200 sq.km, territorial area of 20,000 sq.km and the EEZ of 4,00,000 sq.km accounting for 20% of the Indian EEZ.

Lakshadweep is one of the world's most spectacular tropical island ecosystems. The marine ecosystem is extremely diverse, attributed to

geomorphologic and climatic variations along the coast. The precious heritage of ecology and culture is supported by the extremely fragile ecosystems. The major components are the coral reefs, logoons, seagrasses, seaweeds, algae and mangroves. These delicate ecosystems are inhabited by a wide variety of fishes, tunas, live-bait, octopus, crabs, molluscs, sponges, echinoderms, other invertebrates, reptiles, dolphins and whales. From the terrestrial side, the coconut plantations, rodents and the birds play their roles. Brief notes on a few important ecosystems are given below:

Coral reefs: Pillai and Jasmine (1989) identified a total of 103 species of corals fewer than 37 genera from Lakshadweep; and Pillai (1996) dealt with the coral reefs of India, their conservation and management. Hoon Vineeta (1997) reviewed the extent, conditions, research and management status of the coral reefs of India.

An extensive study from 1987 to 2005 on coral reefs of Mombasa (Kenya) by the Wildlife Conservation Society and the University of California at Santacruz, made a comparison of overfished reef systems and fishery closed reef. In the former, sea urchins were the dominant grazers where their predators, trigger fish and wrasses, were largely absent. The grazing sea urchins reduced the abundance of crustose coralline algae, a species of algae that produce calcium carbonate. Coralline algae contribute to reef growth. By contrast, reef systems closed to fishing have fewer sea urchins- the result of predatory fish keeping urchins under control. Reefs with more sea urchins grew significantly slower, than ones with more complete fish communities. Herbivorous fish like the surgeonfish and parrotfish did impact the growth rates of coralline algae in reef systems. They also remove fleshy algae that compete with coralline algae. According to the study (published in Ecology, Dec.2010), the grazing effect was found to be stronger and more persistent than the strong El Nino that devastated coral reefs throughout the tropics in 1998.

Management of coral reefs is included in the National Biodiversity Strategy Action Plan 2004. The Wildlife Act of 1972 and 2002 prohibit collection of corals and coral reef associated fauna. A few other Acts also deal with conservation and management of coral reefs. The management of coral reef ecosystems has also been affirmed in India's

National Conservation Strategy and Environment Action Plan (UNDP, 1997). The Indian Coral Reef Monitoring Network and the Indian Coral Reef Initiative established in the 1990s also cover coral reef management.

Lagoons: All the islands have lagoons, except Androth. The lagoon ecosystem supports a wide variety of animals and plants that support the livelihoods of people. They provide access to the islands through navigation, which requires constant dredging to maintain the depth of navigating channels. While it is an essential activity, it caused irreparable damage to corals and other fauna and flora by accumulation of silt and resultant sedimentation leading to chocking of corals and ultimate mortality. The live-baits, important for tuna pole and line fishing in the islands, abound in the lagoons and are collected by fishermen. Reports indicated the live-bait resources declined over the years, but attributed the damage to lagoon ecology through human activities and pollution of the lagoon waters. High human population pressure is said to have a direct effect on lagoon resources. Hydrobiology of the lagoons indicated surface water temperature ranged between 32 and 38^{0}C, salinity 36 and 39.39% and dissolved oxygen 2 and 6ml per litre. In most of the lagoons, secondary production was very poor but biomass of zooplankton from the seaward side of the lagoons was slightly higher, suggesting that the oceanic zooplankton might be nourished by coral reef community.

Seagrasses: Seagrass zones are conspicuous in the lagoons of all atolls except Bitra and Kiltan, forming dense beds alongside the islands in calm zones (0.50-3.00 m depth). Six species of seagrasses, namely *Cymodocea rotundata, C.serrulata, Halodula uninervis, Halophyla ovate, Syringdium isoetifolium* and *Thalassia hemprichii*, the last species being the most dominant (Vijay Anand, 1994) and Vijay Anand and Pillai (2005; 2007).

Several associated marine plants and animals utilise seagrass habitat for food, shelter and nursery grounds. According to Vijay Anand and Pillai (2007), the most dominant fishes that occurred on seagrass beds in juvenile stages belong to Acanthuridae, Apogonidae, Carangidae, Chaetodontidae, Holocentridae, Labridae, Lutianidae, Mullidae, Scaridae and Siganidae. Seagrasses act as safe habitats for young

fishes and they generally occur in shallow waters in Lakshadweep, with large predators normally keeping away from shallow waters. In the transitional stage, juveniles migrate from seagrass beds to adult habitats (rubble, live and massive corals) after they have transformed enough. Seagrass bed nurseries are susceptible for disturbance by the operation of fishing nets and this may result in decline in the steady supply of sub adults on to the adult-reef-habitats after transforming from their juvenile stages (Vijay Anand & Pillai (2007). The structure of major seagrass beds from three coral reef atolls (Agatti, Kavaratti and Kalpeni) was studied by Jagtap (1998).

Seagrass beds harbour producers (seagrasses, gastropods, rays, sharks) and grazers (urchins), suspension feeders (clams and tube worms) detritus feeders (clams, worms), carnivores, (gastropods, rays, sharks), other fish, turtles and dugongs. They also contribute to transportation of organic materials to adjacent regions which form food for other communities.

Seagrasses are threatened by several human and environmental impacts. Seagrass beds constitute coastal ecosystems of great value but are seldom given the attention or protection they deserve. Adequate public awareness has to be created for conservation and management of seagrass beds.

Seaweeds: Altogether 114 species under 62 genera of seaweeds were recorded from Lakshadweep (Kaliaperumal *et.al.* 1989). The CMFRI demonstrated seaweeds can be cultured at Minicoy Island. Siltation, sedimentation, erosion, accretion, dredging, construction, effluent discharge, sewage, grazing by fish and overexploitation are known to cause damage to seaweeds.

Mangroves: These are limited to Minicoy Island only, on the southeastern and southwestern sides of the island. Two species, *Bruguiera cylindri* and *Ceriops tagal* occur. One site is land locked and the other inundated by seawater (Nasser *et.al.*1999). In Lakshadweep, the terrestrial activities are likely to impact the coastal ecosystems. Reduction of these inimical impacts would depend on development of suitable land use patterns. Transplantation of mangroves to Kalpeni, Kavaratti, Bangaram and Suheli was suggested for their beneficial attributes.

Marine ornamental fishes: Extensive observations were made on these fishes by Vijay Anand (1994) and Murty (2002).He described the distribution in space and time and determined stock sizes and catch quotas of 165 species of fishes with the possibility of fishing a total of 8.6 million fishes per year. The lagoons are very shallow and easily accessible. Therefore there are chances of overexploitation of ornamental fishes within a short period and also cause damage to corals and the environment. Only non-destructive methods like trap fishing and hand net fishing by diving for capture of ornamental fishes are suggested (Murty, 2002).

Birds: The birds of Lakshadweep play an important role in the functioning of ecosystems. The common birds include the terns, grey heron, curlew, golden plower and others. In an ornithological expedition to the archipelago, various islands, sand flats and reefs were surveyed in March 2006 by Satish Pande *et.al.* (2007). According to them, Pitti and Cherbaniani islands attract local residents for guano collection, during which time, eggs and nestlings of pelagic birds are poached. Because of extensive coconut plantations on Bitra, Parli 1 and 2, Tinnakara, Suheli Veliakara and Cheriakara, the nesting sites on these islands were abandoned. Due to the growing human population and increased pressure on available land, uninhabited islands are being opened for human activities to the detriment of bird populations.

Ecosystem functioning: There are several components of the island ecosystem which maintain the food chain. Particularly off the Minicoy Island, upwelling takes place during the south-west monsoon period (July-Sept), bringing up nutrient rich waters from the deep to the surface which supports abundant life near the surface. A zone of sinking causes loss of nutrients found in the open ocean. Runoff from the land also enriches coastal waters. Excreta of oceanic birds, especially the terns, form an important source of nutrients in the euphotic zone of the sea increasing primary production through photosynthesis. Euphasids form the staple food of small fishes, such as sprats which in turn become the prey of tunas. The highly productive and diverse coral formation of the islands help in land building and providing ideal habitats for complex communities of the sea, corals themselves living symbiotically with the unicellular

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zooxanthellae. Crab populations, including the hermit crabs, abundantly found in coastal areas and the shores play key role in scavenging on the discarded and decomposing bodies of animals, recycle the nutrients, thus forming a vital link in the food chain. They also form prey of eels and other animals.

According to an ecological survey of the lagoons by Rodrigues (1996) corals on reef flats and lagoons of uninhabited island were diverse and dense. Most of the inhabited islands can be classified as endangered.

Environmental sensitivities

Being oceanic, small and far removed from the mainland; geographically isolated and exposed, environment could be cruel to the islands at times. Since they are surrounded by the vast open ocean, they are subjected directly to storms, cyclones and heavy rains. Their low level makes them vulnerable to sea level rise (even by about two meters and the consequent impact) as an effect of the potential global warming and climate change. The islands also face the risk of inundation of sea water due to storm surges as well as tsunami waves. Kalpeni and Androth were devastated, several people died and coconut trees were destroyed during the great cyclonic storm of April 1847 (Mannadiar, 1997).

According to a national task force appointed by the Government of India in 2005 for a special study of Lakshadweep to assess vulnerability to various hazards and suggest mitigation / prevention measures. In 1891 a violent storm struck Kavaratti, Agatti and its attached islets and the Amindivi group of islands. Other major storms were recorded in 1922 (Kalpeni), 1941 (Kavaratti), 1963 and 1965 (Androth), and 1977 (Kalpeni). The cyclone from 5-7 May 2004 affected Kavaratti, Amini, Kiltan, Agatti and Kadamat. Low lying areas of some of these islands were inundated. On the east coast, breaches 10-30m in width and 1-1.5m depth were reported. They also impacted the physical and social infrastructure and became a set back to the pace of development of the islands. It was stated, within 115 years, 27 storms and depressions affected Lakshadweep during the Apr-Dec. period. The tsunami of 2004 which affected several countries across the globe had also caused minor impacts in Minicoy and Androth indicating the vulnerability of Lakshadweep also to such phenomena.

Though earthquakes have not been reported from Lakshadweep, information indicates the islands have moderate seismic activity.

Coastal erosion is one of the serious natural problems being faced by Lakshadweep. About 200 running km of sea shore is stated to be subjected to severe erosion according to the Centre for Earth Sciences Studies (CESS), Thiruvananthapuram. The Space Application Centre (SAC) mapped coral reefs and atolls of the entire Union Territory. Lakshadweep is influenced by south-west monsoon winds. During southwest monsoon, the maximum height of waves is 5m and in non-monsoon time 1.4 m (CESS study). Data of the India Meteorology Department indicate mean wind speed in Lakshadweep in May-Sept. ranges between 6.10-9.25 knots in Minicoy and 7.35-12.54 knots in Amini. Average annual rain fall is about 1640 mm (Minicoy) and 1504 mm (Amini).

Lakshadweep is on the trade route between Africa, Arabia and west coast of India (Malabar). There has been a drastic increase in passenger and cargo traffic across the seas when untreated wastes and waste oil are discharged from oil tankers and ships into the sea. These cause heavy pollution, resulting in damage to the coral reefs. Toxic ocean pollutants, marine garbage, non-point pollutants like runoff from land also add to environmental damage. According to a study by the National Geophysical Research Institute (NGRI), Hyderabad, around 25% decrease in growth rate (calcification rate) of hard corals (*Porites* sp.) was observed between 1993 and 2003 attributed to global warming caused by high levels of carbon dioxide.

In a study by the James Cook University, Australia (Ph.D. thesis), the EL Nino southern oscillation of 1998 caused mass mortality of corals in Lakshadweep due to anomalies in sea surface temperature (SST). The observations indicated mixed pattern of recovery amongst corals depending on the degree of exposure of sites to seasonal monsoonal storms. Relatively low level of fishing despite high human population densities has significant but completely unintended positive consequences for the resilience of the reef. In a study by Rohan Arthur (2005), four years after an EI Nino induced coral mass mortality in Lakshadweep atolls, an event of unprecedented severity in 1998, in six atolls to check if there were geographic trends in recovery patterns

across the archipelago. It was found live coral cover was relatively low on most atolls and thin algal turfs dominated the benthos. Clear benthic differences were apparent between eastern and western aspects of reefs, pointing to the importance of local hydrodynamic conditions in determining recovery rates. Where recovery was the most apparent, it was dominated by fast growing and bleaching-resistant coral genera. High herbivorous fish abundance was likely responsible in controlling macrophyte levels and may be crucial for further benthic recovery in these reefs.

Rucha Karkarey (2010) conducted a study to understand the effects of loss of structure of reefs after the 2010 mass bleaching event on the diversity and distribution of apex predators (groupers) in Lakshadweep. In Lakshadweep, the mainstay of commercial fishing is skipjack which has caused a great reduction in fishing pressure on coral reefs. Due to low fishing pressure ambush predators like the groupers (usually not targeted by fishers) are the dominant apex predators on these reefs. Bleaching related loss of habitat may negatively affect abundance and distribution of apex predators such as groupers that use ambush for capturing their prey and thus rely heavily on structure of reefs.

Coral bleaching or loss of colour from corals which are under stress due to environmental conditions, especially the high water temperature, probably due to global warming, was studied by the Cochin University of Science and Technology (CUSAT) in Lakshadweep. Corals live in symbiotic relationship with zooxanthellae which give them a peculiar colour but expel them under stress. The corals get a lighter colour or become completely white. They continue to bleach even if the stresser is removed, taking weeks or months to revive. They may be recolonised by the same species or others. Large massive coral (*Porties lobata*) withstand extreme temperatures while branching corals (*Acropora*) are far more susceptible to thermal stress following bleaching event. Bleach resistance, coral tolerance, reef recovery, patchy bleach shade are factors that protect corals against mass bleaching. A stream of cold water can reduce risk of bleaching and also health and genetics of coral and zooxanthellae can influence risk of bleaching. Bleaching stress was also found in soft corals, *Tridacna* (giant clam) and some sponges. Other ecological causes

triggering bleaching in corals according to the study include seawater temperature drops or increase, seasonal cold air outbreaks, solar irradiance, subaerial exposure, low tides, sea level drops, freshwater dilution, inorganic nutrients, diseases, chemical contaminants, etc.

Heavy metal partitioning in five species of massive, ramose and foliaceous corals was studied by Anu *et.al.* (2007). Highest concentrations of all the trace metals (except Zn) were reported for ramose corals in their skeletons. In tissues, all the metals showed highest concentrations in the same corals. Results also showed significant differences between metals and between species leading to high skeleton / tissue- species interaction as well as skeleton / tissue metal interaction.

Climatic conditions biofouling and bioerosion by boring sponges, mollusks and sea-cucumbers cause extensive damage to corals. Environmental damage sets in motion a chain of actions and reactions, leading to depletion of coral and coral associated organisms and proliferation of algae and other animals that thrive on dead and decaying corals which also form a base for borers and bioerosion. The resultant calcium sediments fill up the lagoons. Destruction of corals impacts availability of live bait on which the pole and ling tuna fishery depends. Fortunately, no large scale grazing by urchins on calcareous algae was so far reported from Lakshadweep because there has been no intense fishing on the reefs except for sustenance fishing during monsoon. Amongst the predators of corals, the crown of thorns starfish, *Acanthaster plancii*, although reported from Lakshadweep, as well as from the Andamans, their populations have so far not been reported to explode, as in some other countries.

Recolonisation and ecosystem improvement depends on several factors like water currents, availability of planulae larvae, modification of habitat and scale of destruction of corals etc. In Lakshadweep, in order to rejuvenate and recolonise corals, there should be no further interference with the reefs, dredging should be abandoned, erosion should be effectively controlled and destruction of live corals should be avoided.

The large scale mortalities of corals caused by El Nino in 1998 and 2010 across the globe, including Lakshadweep, call for rejuvenation,

recolonisation and restoration of coral habitats on similar lines as done by the U.S in the Gulf of Mexico to re-establish the oyster beds devastated by oil pollution in April 2010 since livelihoods of people of the islands are hinged on to the resources of the atolls. Steps are required to restore lost grounds by well known methods already demonstrated by the Japanese for artificial propagation of corals.

Taking into consideration, the carrying capacity of the islands, the rich biodiversity and the geologically unstable zones, certain Environment Impact Assessment (EIA) norms were prescribed in the Ninth Five Year Plan period (1997-2002) for Lakshadweep. Development and population growth on the islands tend to weaken the symbiotic relationship between the society and the environment. The islands need enlightened and science based conservation efforts. Clean environment in the islands can be maintained by adhering to the EIA norms and implementation of the Provisions of Environment Impact Assessment (EIA) Notification of 2006.

Anthropogenic Vulnerability

The islands and the reefs support the livelihoods of people, providing food, income, employment, shelter and protection. However, the economic development of the islands over the years brought in its wake, several anthropogenic vulnerabilities to the islands. Thus, the delicate ecosystems and the unpolluted environment were brought face to face with developmental activities. Land is very scarce but the seas surrounding the islands are expansive. It would therefore be imperative to carefully deal with land and land resources, develop water resources sustainably. In the Lakshadweep, the inland and coastal ecosystems are intimately connected. Terrestrial activities like agriculture, deforestation, raising domestic animals, construction, road laying and runoff from land lead to degradation of coastal ecosystems. Thus, development of land use practices has a strong bearing on ecosystem health.

The major economic activity is oceanic tuna fishing around the islands. Pole and line tuna fishing is dependent on live bait collection from the reefs and lagoons which are common property resources to be shared by all. The reef fisheries were diverted for tuna fishing with certain incentives and training. This indirectly helped the

conservation of reefs and their animal communities. The short term goal should be to protect the reefs, fauna and flora and the long term objective is to rebuild and extend the reefs for their sustainability. However, quantitative studies on various aspects of corals and coral reef communities are still lacking in Lakshadweep (Bakus, 1994). These and other lacunae justify the establishment of an exclusive institute for coral reef research and management in Lakshadweep as proposed by the author about two decades ago to the Central government. Hopefully, the crucial role such an institute could play for the development of island territories would be realized someday.

While diverting away intense fishing activities from the reefs in Lakshadweep helped to protect and preserve them, the fisheries resources of the islands are grossly underexploited, mainly due to the operation of only pole and line for tunas. The total fish production in the year 2009-10 (CMFRI Annual Report) in Lakshadweep was 10,189t of which tunas accounted for 8,254t and other fishes 1,925t., whereas the total potential yield was estimated to be 1,00,000 t (tunas 50,000t and other fishes 50,000t) according to the document on integrated perspective plan for fisheries development of Lakshadweep (CMFRI, CIFT, ICAR and Department of Fisheries, Lakshadweep). The document also indicated average annual fish landings to be 11,000t of which tunas formed an average of 6,000t (1995-2004). About 50% of total tuna landing is used for *masmin* production, a boiled, smoked and sun-direct product. The rest is consumed fresh.

Although pole and line fishing for tuna is internationally acknowledged to be environment-friendly, it is constrained by inadequate and inconsistent supply of live-bait fish, which is crucial for its success. Therefore, for making full use of the national resources, fishing in oceanic areas around Lakshadweep as well as in international waters needs to be diversified and intensified, especially by operating longlines, troll lines and gill nets to increase the tuna catch (skipjack, yellowfin, frigate tuna and little tunny) and also of other related fishes, sharks, perches, halfbeaks, fullbeaks, seerfish, carangids, barracudas, red mullets, flying fish, cephalopods and others. For harvesting these resources, necessary fishing vessels, processing facilities and other modern infrastructure are required to be developed.

Blasting and dredging the lagoons for deepening the navigational channels damage the reefs and cause coral mortality. Removal of corals from the shore and shingle extracted from the reefs and lagoons endangered the reefs. Disturbing the surface soil, and mining of sand stone were done for human needs. On the land, construction activity, removal of vegetation, introduction of exotic plants, introduction of cattle and goats, excessive application of pesticides on land and their washing into the lagoons impacted the coastal waters. Throwing of fish processing wastes and other organic matter into the lagoons and on the shore upsets the pH of the water (turning acidic), thus affecting the flora and fauna in lagoons. The isolated island economy is affected by population pressure estimated to be around 1616/ sq.km. The discharge from toilets entering the lagoons and open sea creates unhygienic conditions for people and upsets the balance in nutrients in the lagoons causing algal growth to compete with reef growth. Dumping of garbage, plastic, batteries, electric glass bulbs, bottles, cigarette cartons, cans etc. is prevalent on bird nesting islands of Pitti and Cherbaniani. Lagoons tend to concentrate toxic wastes as they are cut off from the sea.

Coconut production is the life-line of Lakshadweep. The industry tops in productivity and output of copra and coconut oil, with highest copra and coconut oil production in the world. The sector provides livelihood and food security to over 61,000 people and protection to coastal ecosystems. About 68% of cultivable land in the islands is under coconut cultivation. The growth of the industry is reported to be stunted mainly due to lack of allied manufacturing units, marketing and value addition. Although rodent attack on the palms is rampant, excessive use of rodenticides, (zinc compounds) was found ineffective on the ground and when leached out into the soil and water, was found to be toxic. It was suggested that coconut plantations should not be permitted on uninhabited islands, especially the Pitti and Cherbaniani islands which are important for bird nesting. Extensive coconut plantations on Bitra, Parli1 and 2, Tinnakara, Suheli Veliakara and Cheriyakara resulted in their being abandoned as nesting sites by the birds (Satish Pande, *et.al.*, 2007). Frequent visits by tourists and fishermen to Suheli Pitti Island drove away nesting pelagic birds. Poaching of eggs of marine turtles is also known. Turtles are killed by

fishermen for oil used for painting fishing boats. Cutting of indigenous vegetation decreases the availability of sandy beaches for turtle nesting. It was recommended to declare some of the uninhabited islands as sanctuaries, conduct monitoring and surveillance of bird populations, disallow habitat modifications, ensure effective monitoring by Coast Guard and their exposure to ecology of the islands ban the use of rodenticides, control pollution of land and water through waste disposal and create public awareness of the importance of ecology of the islands (Satish Pande, *et.al.*, 2007).

Tourism development offers immense potential in the islands. The islands are endowed with the beauty of the coral reefs, sandy beaches, lagoons and unpolluted clear water. The reefs teem with colourful organisms of various kinds providing opportunities for recreation, sport, fishing, rowing, diving, snorkeling and other waterborne activities. However, only tourism that is consistent with the ecology and fragile nature of the surroundings can be promoted. Since the island ecology is very sensitive, monitoring of environmental impact of coastal tourism is essential. The perceptions of coral reefs differ according to the priorities of the people in contact with the reef. Navigators, tourists, industrialist and others view the reefs differently and use them accordingly. These common property resources can generate conflicts and hence require monitoring and management (Hoon Vineeta, 1997).

The interactions between the community and the coral reef ecosystem raise questions as to who are the main stakeholders and whether conflicts are arising due to different priorities of the users (Hoon Vineeta, 1997). Declaration of sanctuaries, biospheres and marine protected areas (MPAs) could conflict with the interest of the communities. Participation of the reef stakeholder's in planning and implementation of MPAs is essential for their long term success. The poor are often excluded from programmes on coastal resource management and conservation although they depend on these resources in complex ways. Coastal Regulation Zone (CRZ) notification 1991 is the only legal protection to the reefs. Under the CRZ-IV, there are restrictions on materials to be used for construction, dredging and blasting, beach resorts / hotels etc. However, there are

implementation problems of the regulations, lack of trained man power and difficulties in monitoring reefs underwater. The marine protected areas are under the forest department who have very little knowledge of coral reef ecology. Corals are not yet covered under the Wildlife Protection Act 1972. There is a recent move to exclude the Andaman and Nicobar Islands and Lakshadweep from the CRZ notification 1991 and bring them under a separate Island Protection Zone notification with no specific regulatory provisions for tourism. Tourism should come under strict control of the law to protect the fragile ecosystems in Lakshadweep (Hoon Vineeta, 1997). The present author is also of the opinion, even if some safeguards have been put in place by the administration, careful monitoring of all human activities, including those of tourists and strict implementation of rules and regulations are essential for the prosperity of Lakshadweep.

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